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Abstracts

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Р 65 **Розширюючи** обрії: зб. тез двадцятого міжнар. форуму студ. і молодих учених, 21 – 25 квітня 2025 р., м. Дніпро/ за ред. Л.В. Павленко; М-во освіти і науки України; Дніпровська політехніка. – Д.: ДП, 2025. – 343 с.

Подано матеріали міжнародного форуму студентів і молодих учених, який відбувся 21 – 25 квітня 2025 р. в Національному технічному університеті «Дніпровська політехніка», м. Дніпро (Україна).
Розглянуто нагальні проблеми економіки, інженерії, інформаційних технологій, охорони навколишнього середовища, наук про землю, гуманітарних наук.
Також приділено увагу сучасному законодавству, спрямованому на вирішення цих проблем. Матеріали згруповано у розділи, що відповідають секціям форуму і відображають сучасні тенденції та інноваційні розробки молодих учених, представників різних країн світу в різних галузях економіки.

Відповідальність за достовірність фактів, цитат, власних імен та інших відомостей несуть автори публікацій.

Foreword

Dear Students and Young Scientists,

This Forum is a unique opportunity for each of you to plunge into the world of science, exchange ideas and participate in the creation of new knowledge.

The modern world requires us to constantly develop and innovate. Science is the foundation on which our future is built. It opens new horizons, helps solve complex problems and improves the quality of life. We live in a time when scientific progress is crucial to the development of society, and your contribution to this process is extremely important.

In this context, it is important to develop all fields of knowledge equally, because each has its place in the great puzzle of science, and none of them can be ignored. From the exact sciences to the humanities, from technology to the arts, they all make important contributions to our understanding of the world and our progress.

Science is a tool that helps to find clarity in complex issues and opens up new possibilities. Your ability to adapt and see perspectives in changing conditions is one of the key success factors.

Furthermore, learning is a lifelong process. Never stop learning, look for new ideas and approaches, be ready to adapt to change. In today's world, where the speed of change is lightning fast, this approach to learning becomes even more necessary.

I wish you inspiration and perseverance in your studies and research. Let this Forum become for you a source of new ideas, knowledge and contacts that will help you develop as scientists and as individuals. Remember that each of you can make a unique contribution to science, and this is a great privilege and responsibility.

I wish you success, self-development and vivid impressions from participating in this Forum.

With best regards,
Artem Pavlychenko
The first Vice-rector, Dnipro University of Technology

TABLE OF CONTENTS

Section 01 Energy Saving and Efficient Alternative Energy Usage, Environmental Problems and their Solutions

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Meeting energy efficiency goals by optimizing vector control algorithms of BLDC motors

Industrial electric motors account for 30-40% of the world's electricity consumption, and in line with global trends toward electrification the demand for systems powered by electric motors is expected to grow significantly [1].

Electric motors, however, are used not only for industrial applications but also in appliances, transportation, heating, ventilation, and air conditioning. This also adds significantly to global electricity consumption. Multiple ways to improve energy efficiency have been introduced so far.

One of the ways widely used for industrial applications now is matching the output of a motor to the maximum power required for a task. Here comes assistance the brushless DC electric motors (BLDC) and permanent-magnet synchronous motors (PMSM) due to their higher efficiency (compared to DC electric motors (DCM) and alternating current induction motors (ACIM)) and better torque characteristics (compared to ACIM). Technological advancements in recent years in materials and semiconductors allowed the replacement of the less efficient DCMs and ACIMs in certain industrial and consumer applications. However, the main issue with the further introduction of BLDC and PMSM motors is the need for rotor position feedback due to these types of motor designs.

On the one hand, it is easy to introduce the position sensor to the system, but on the other, the introduction of such a sensor creates additional failure points, increases the bill of materials (BOM), and limits the scope of possible use cases for the BLDC or PMSM-based electric drives. This issue has been thoroughly researched since the late 1970s [2] and the result was the invention of sensorless algorithms for PMSM and BLDC motor control.

However, scalar and vector sensorless control algorithms for PMSM and BLDC motors fail to perform at low speeds. The situation is worsened if the load is introduced at the motor's start. In that case, traditional open-loop start procedures will drastically increase power consumption, despite overall high system efficiency at a steady high-speed operation.

Some achievements have been made in the research of this field by independent researchers (using the Sliding Mode Control) [3], STMicroelectronics (ZeST – zero speed full torque algorithm), and Microchip Corporation (ZS/MT – zero speed maximum torque algorithm), at present, however, most of the commercial applications of the technology are proprietary and not available for the general public for further analysis. So, the importance of this study lies not only in possible economic effects but in stimulating wider discussion on this issue.

The study aims to investigate the ways of increasing vector BLDC/PMSM control efficiency not only at a steady high-speed operation but during the start-up too. This approach may allow for energy consumption reduction between 15% and 40% (for an application with a cyclic operation mode).[4] Based on a literature review, the high-frequency voltage injection (HFI) method for low-speed operation efficiency optimization was selected [5], and the increase of the observer's sensitivity for efficiency improvements during the high-speed operation. Lower power consumption, in this case, will result in a lowered inrush current of the PMSM/BLDC motor without sacrificing much of the start torque unlike when conventional soft-start methods are used. Further improvements may include:

- custom FPGA-based signal processor design, which will allow the parallel computation and will lower the system latency;
- the best inverter commutation strategy and frequency range, which is aimed at reducing commutation losses.

In conclusion, the field of electric motor research is significant at a time when electricity demand is growing disproportionally to generating capabilities. Many electric motors in use today are older, less efficient designs, and are often oversized for their tasks, which wastes even more energy. Considerable efficiency gains may be achieved simply by using higher-efficiency motors or replacing legacy DCM and ACIM solutions with BLDC/PMSM-based. Further efficiency improvements will require not only the application of more sophisticated control algorithms (e.g. FOC) and their improvement for robust sensorless operation in highly dynamic load environments but also the use of advanced commutations algorithms that adapt to selected applications, minimizing commutation losses.

References:

1. International Energy Agency. World Energy Outlook 2018; IEA: Zurich, Switzerland, 2018. (https://iea.blob.core.windows.net/assets/77ecf96c-5f4b-4d0d-9d93-d81b938217cb/World_Energy_Outlook_2018.pdf)
2. A. B. Plunkett and F. G. Turnbull, "Load-Commutated Inverter/Synchronous Motor Drive Without a Shaft Position Sensor," in *IEEE Transactions on Industry Applications*, vol. IA-15, no. 1, pp. 63-71, Jan. 1979, doi: 10.1109/TIA.1979.4503613.
3. V. Repecho, J. B. Waqar, D. Biel and A. Dòria-Cerezo, "Zero Speed Sensorless Scheme for Permanent Magnet Synchronous Machine Under Decoupled Sliding-Mode Control," in *IEEE Transactions on Industrial Electronics*, vol. 69, no. 2, pp. 1288-1297, Feb. 2022, doi: 10.1109/TIE.2021.3062260.
4. https://www.st.com/content/dam/static-page/events/apec-2024/demo-apec-24-sensorless-motor-control-digital-pwr.pdf
5. Lihui Sun, Low speed sensorless control method of brushless DC motor based on pulse high frequency voltage injection, Alexandria Engineering Journal, Volume 61, Issue 8, 2022, Pages 6457-6463, ISSN 1110-0168, https://doi.org/10.1016/j.aej.2021.12.005.

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The use of hybrid inverters in private households in order to save electricity in the presence of a two-zone tariff

With increasing awareness of environmental issues and rising electricity prices, more households are beginning to switch to renewable energy sources. Hybrid inverters become an integral part of this process. Switching to a system that uses solar energy allows reducing costs as well as ensuring sustainable development.

In today's world, energy efficiency is becoming an increasingly important topic in the face of rising electricity prices and the need to reduce carbon emissions. Private households seeking to reduce their electricity costs are beginning to pay attention to technologies that optimize electricity consumption. One such solution is the use of hybrid inverters in combination with dual-zone tariffs.

A hybrid inverter is a device that converts direct current from solar panels or batteries into alternating current used by household electrical appliances. The difference from traditional inverters is the possibility of simultaneous connection to the mains, batteries and solar panels which provides greater flexibility in the distribution of electricity [1].

The main advantage of such inverters is the ability to accumulate excess electricity. When the solar system generates more energy than necessary, it can be stored in batteries for later use. This is especially advantageous under the conditions of a two-zone tariff when the cost of electricity varies depending on the time of day.

Two-zone meters used for commercial metering of electric energy enable the company to stimulate the use of electric energy at night in order to reduce the demand for electric energy during peak hours [2].

Usually, the electricity use and regulation mechanism uses financial incentives to shift peak electricity consumption to another part of the day, but the electricity consumption of its volume and nature is mostly typical and depends mainly on the lifestyle of individuals, who are economic entities. These business entities can be divided into groups of current consumers, which include water supply equipment, including drinking water filtration and heating, as well as sanitary equipment, such as washing machines, air conditioning systems, underfloor heating systems, and household items related to kitchen appliances, such as electric kettles, microwave ovens, dishwashers and ventilation systems. Not to generalize, lighting is the basic current sink of a household. Household receivers include irons and steamers, and the use of these devices depends on the lifestyle. So how can we move to peak electricity consumption without changing our lifestyle and household habits?

One of the effective approaches to transferring peak electricity consumption without changing the usual everyday habits is the use of programmable timers and smart electrical appliances. These technologies allow you to automate the switching on and off of devices at a certain time, which allows you to use electricity during low-cost hours. For example, you can set up a washing machine or dishwasher to run at night when electricity rates are lower. Or you can use the delayed start function for the heating system so that it works when the price of energy is optimal. It is also important to consider the possibility of switching to more energy-saving devices. For example, replacing old refrigerators or air conditioners with new A++ models can significantly reduce overall household electricity consumption.

Another option is to use intermediate electric energy accumulators, such as hybrid inverters with a battery, where it is possible during the hours of the cheaper night tariff to accumulate the required amount of energy in kWh, which in the future, by changing the settings of the hybrid inverter, can be used during peak hours, when electric energy is more expensive. That is, in fact, the transfer of accumulated energy to the consumption mode from the battery, thereby reducing consumption from the network at times when electricity is more expensive and without changing the lifestyle of the consumer.

So, in addition to the uninterruptible power supply function, systems with electricity storage devices are able to provide the necessary level of electricity consumption from previously accumulated volume, thereby reducing the peak load on the power grid and making electricity consumption cheaper for the end user due to preliminary accumulation at night. The following parameters are the obvious advantages of hybrid systems:

- easy implementation into existing power grids
- ability to balance the accumulation and consumption of electricity
- possibility of uninterrupted power supply in case of absence of voltage in power grids
- introduction of alternative power sources (solar panels, wind generators) [3].

The use of a hybrid inverter in combination with a two-zone tariff can significantly save money on electricity, using cheap night electricity and solar energy during the day. This is an ideal solution for private households seeking energy independence and financial benefits.

References:

1. ДБН В.1.2-11:2021 Основні вимоги до будівель і споруд. Енергозбереження та енергоефективність. URL: https://dbn.co.ua/publ/gibridni_invertori/39-1-0-1382
2. М. Кузнецов, О. Кармазін OPTIMAL PLANNING OF HYBRID POWER SYSTEM AT DIFFERENT ELECTRICITY TARIFFS. DOI: https://doi.org/10.36296/1819-8058.2022.3(70).6-18
3. Густий Д.О. Системи комбінованого електропостачання з відновлюваними джерелами енергії. URL: https://ela.kpi.ua/handle/123456789/69211

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LSCS: New Opportunities for Green Energy

What is LSCs?

Despite the advances in renewable energy, solar energy accounts for only less than 0.001% of its theoretical potential. At the moment, we have many different discoveries in this area, and one of them is dealing with solar concentrators.

A luminescent solar concentrator (LSC) is a device that has luminescent molecules embedded in a polymeric or glass waveguide to generate electricity from sunlight via a photovoltaic cell attachment. The LSC device can function in diffused light as well as direct light, and may provide a variety of colors, shapes and transparencies. Therefore, the LSCs can be employed both in small and large scale projects and is independent in terms of the direction or angle of the surface with respect to the sun. In comparison with traditional PV systems LSCs are easily can be integrated into urban environments and design choice is extended [1].

How does it work?

A LSC is a simple light energy absorber, converter, and concentrating device consisting of a thin slab of a transparent material of an ideally high refractive index with embedded low concentration of luminescent emitters (luminophores or fluorophores). LSCs' emitters absorb a substantial portion of the sun radiation spectrum being re-emitted later at longer wavelengths via the photoluminescence (PL) process. PL is a photochemical process that occurs in many optical and semiconductor organic and inorganic materials. The optical LSC characteristics should be performed by illuminating the LSC top surface with an intensity-calibrated light source and measuring the emitted light during exposure at the edge with an integrating sphere coupled to a detector. The key parameter extracted is the external photon efficiency or optical efficiency [2]:

$$\eta_{opt} = \frac{\int_0^\infty \eta_{opt}(\lambda)\phi_s(\lambda)d\lambda}{\int_0^\infty \phi_s(\lambda)d\lambda}.$$

In some modern designs you can even find a combination of luminophores and chromophores. Thus, in some solar concentrator systems it is possible to use both luminophores to convert light into a different spectrum and chromophores to transfer its energy into a more suitable form for generation. It can be explained by the fact that luminophores are used to improve the spectral characteristic of light increasing the concentrator efficiency and widening the possibility of its use with photovoltaic cells, and chromophores are used to absorb light and transfer energy to photovoltaic cells for energy generation.

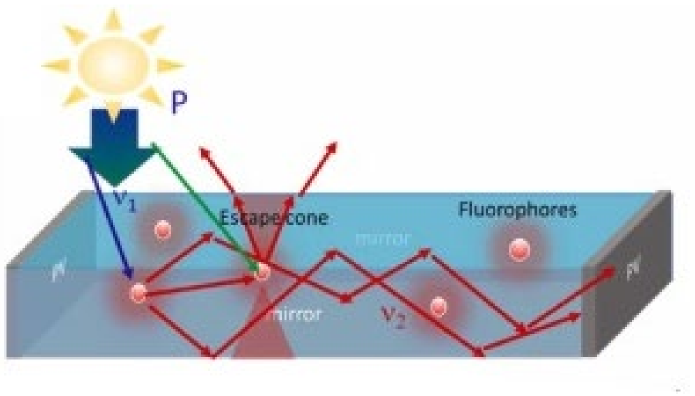

Fig.1. Illustration of LSCs work [2]

LSCs background

LSCs became scientifically significant from their inception in 1977 till approximately 1988 and was followed by the pause in its application due to the reduced price of oil and PV systems. The process of its application renewed in 2000 owing to the advent of quantum dots (QDs) providing a red-shift emission and progressed very slowly till 2006; then from 2007 to 2008 till now new fluorescent materials have emerged (CdSe/CdS QDs and Carbon dots, C-dots) and other PV cells were employed (CuInSe, GaAs).There was an intensive research of polymers and their testing as a host material, and new architectures based on plasmonic and photonic structures and alternative applications in buildings were identified[2].

Why can it be helpful?

During the last decade, the global energy crisis has been experiencing an unprecedented shortage in energy sources spurring on price increases in raw materials such as gas, coal, and oil. In 2021, the International Energy Agency (IEA) witnessed the largest increase in global electricity demand causing blackouts in some countries and leading to a historic increase in prices as well as CO_2 emissions[3]. That is why the demand for green energy has grown even more than in the early 2000s, when there was a significant demand for renewable energy.

In this case LSCs look like unprocessed amber, which is expensive but still needs to be polished. Although this source has not been developed and popular as others, in particular, solar or wind energy, but it also has no less potential, does not interfere with them, and has the capability to complement them. By using these concentrators, we will be able to almost “generate electricity from nothing” without significant environmental damage. This is possible to be realized as they can be used as ordinary glass, window panes, panoramic roofs, stained glass windows to generate electricity without requiring major changes in infrastructure and can be installed almost all over the planet, as they are not dependent on climatic conditions. Moreover, LSCs do not require any modifications of the PV electronics and can be directly connected with existing constructs.

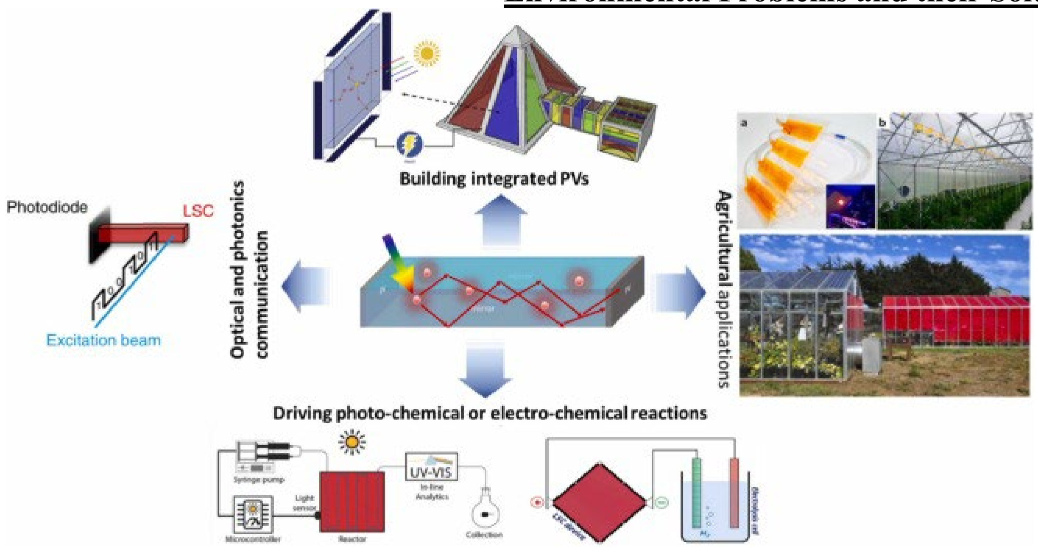

Fig. 2. Main foreseen applications for LSCs such as BIPV, agricultural applications, optical communication, photochemical), and electrochemical reactors [2]

Concentrators can be also useful to produce CO_2. Coal gasification, biomass thermochemical processes, steam methane reforming (SMR), and pyrolysis of natural gas are the most used technological methods to produce hydrogen fuel. All these methods require high temperatures, high pressure, and excessively large amounts of CO_2 emissions. In contrast, hydrogen production via water electrolysis from photovoltaics presents an alternative eco-friendly solution to these problems.

It should be concluded that involving luminescent solar concentrators (LSCs) as a renewable energy source is more reasonable and promising solution to water-splitting technology for hydrogen production. In addition to the low cost, simplified fabrication, structural flexibility, aesthetic compatibility, and design flexibility of LSCs, generating electricity for hydrogen production by water splitting occurs without any greenhouse gas emissions. Green hydrogen is, therefore, not only a reliable energy storage solution, but also provides possibility to reduce pollution and health risks in built-up environments [3].

Conclusions

Even though, the LSC offers many advantages over existing technologies, it has not yet been commercialized. To achieve this, proper understanding and exploration of not only technical aspects, but also insights into its presentation, design and appearance is needed [1]. It is very important to develop the strategy of advanced research and applications of LSCs in terms of their industrialization. To achieve this task setting some measurement standards of their performance and establishing road maps is required [3]. Extended application of LSC will help to integrate renewable energy production in urban areas and promote the production quality of various kinds through the integration of production with the LSC. Moreover, there is no need to modify current PV electronics due to LSCs application.

References:

1. Luminescent Solar Concentrator URL: https://www.4tu.nl/bouw/Education/PDEng/Luminescent%20Solar%20Concentrator/ (date of access 1.04.2025).
2. Stefania Castelletto, Alberto Boretti «Luminescence solar concentrators: A technology update» URL: https://www.sciencedirect.com/science/article/pii/S2211285523001052 (date of access 1.04.2025).
3. Othmane Essahili, Omar Lakbita, Mouad Ouafi, Omar Moudam «Overview of advanced research in luminescent solar concentrators for green hydrogen production» URL: https://www.sciencedirect.com/science/article/abs/pii/S0038092X23004929 (date of access 1.04.2025).

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Prospects for the Implementation of Energy-Saving Technologies in Urban Rail Electric Transport

The problem of improving the energy efficiency of urban rail electric transport is crucial in the context of modern urban infrastructure development. Although electric traction is already the most efficient mode of urban transport, its widespread application is limited by significant infrastructure costs and high electricity consumption. The share of rail electric transport in the overall urban mobility system remains lower than its potential due to economic and technical constraints. The main challenges include high energy losses in traction power systems, insufficient efficiency of regenerative braking, and the need for new control optimization systems that would rationalize energy consumption and reduce operational costs.

The relevance of the study is heightened by the reduced generating capacity of Ukraine's power system due to external aggression. Under conditions of limited energy supply, urban electric transport must become more energy-efficient to reduce the load on the power grid and ensure the stable operation of transport infrastructure. This necessitates the development of innovative technologies and solutions to enhance the energy efficiency of urban transport systems.

Various methods and technologies are being applied to address these challenges. One key approach is the implementation of Driver Advisory Systems (DAS), which analyze data on speed, terrain, schedule, and other parameters to provide drivers with optimal operating modes to save energy. Studies indicate that using such systems can achieve up to a 28% reduction in energy consumption.

Another promising direction is improving regenerative braking technologies. In modern urban electric transport, kinetic energy during braking can be returned to the power grid. However, the efficiency of this process is often limited by the low energy absorption capacity of the grid, necessitating the development of innovative solutions, such as the use of supercapacitors to store excess energy.

Research findings also emphasize the need for more precise consideration of energy losses in traction systems. Instead of using a fixed efficiency coefficient, applying regression models allows for a more accurate estimation of energy consumption, leading to an additional 2.3% increase in transport efficiency. Combining this approach with advanced optimization algorithms enables the development of effective control strategies adaptable to various operating conditions.

A particular focus is placed on transport motion optimization algorithms. The use of dynamic programming methods helps determine optimal speed profiles that minimize energy consumption. This method relies on iterative solutions that identify the best movement trajectories while considering speed limits, track inclines, and schedule constraints. Additionally, regression modeling of powertrain losses provides even more accurate energy consumption predictions. Integrating these algorithms into DAS ensures interactive driver support and allows for adaptive movement mode adjustments based on real-time operational conditions.

Thus, the comprehensive implementation of intelligent control systems and regenerative braking technologies significantly enhances the energy efficiency of urban rail electric transport. Future research in this field should focus on further optimization of control methods and the integration of new energy storage technologies. These advancements will help further reduce energy consumption and ensure the reliability of the transport system under conditions of limited energy resources.

References

1. Albrecht A., Howlett P., Pudney P., Vu X., Zhou P. The key principles of optimal train control – Part 1. Formulation of the model, strategies of optimal type, evolutionary lines, location of optimal switching points // Transportation Research Part B: Methodological. 2016. Vol. 94. P. 482–508. doi: 10.1016/j.trb.2015.07.023.
2. Campillo J., Dahlquist E., Danilov D. L., Ghaviha N., Notten P. H. L., Zimmerman N. Battery Technologies for Transportation Applications // In Technologies and applications for smart charging of electric and plug-in hybrid vehicles. Cham: Springer International Publishing, 2017. P. 151–206. doi: 10.1007/978-3-319-43651-7_5.
3. Ghaviha N., Bohlin M., Holmberg C., Dahlquist E., Skoglund R., Jonasson D. A driver advisory system with dynamic losses for passenger electric multiple units // Transportation Research Part C: Emerging Technologies. 2017. Vol. 85. P. 111–130. doi: 10.1016/j.trc.2017.09.010.
4. Gkortzas P. Study on optimal train movement for minimum energy consumption (Unpublished master's thesis). Mälardalen University, School of Innovation, Design and Engineering, 2013.

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Klimadiplomatie: Wie können sich die Länder einigen?

Wir leben in einer Zeit des globalen Wandels. Die Klimakrise ist keine Frage der Zukunft, sondern eine Realität, mit der jede Region, jede Gemeinschaft, jedes Land konfrontiert ist. Steigende Temperaturen, extreme Wetterereignisse, schmelzende Gletscher, Wüstenbildung - all dies erfordert nicht nur wissenschaftliche Lösungen, sondern auch einen wirksamen internationalen Dialog. Es handelt sich um eine besondere Form der Interaktion zwischen Staaten, die die Interessen von Wissenschaft, Ökologie, Politik und Wirtschaft zusammenführt. Wie kann man einen Konsens zwischen Entwicklungs- und Industrieländern erreichen? Wie kann man gemeinsam realistische, aber ehrgeizige Emissionsreduktionsziele festlegen? Meiner Meinung nach stellt der Klimawandel heutzutage ein großes globales Problem dar. Aus diesem Grund sollten sich alle Länder zusammenschließen und gemeinsam Maßnahmen ergreifen, um das Klima zu retten. Klimadiplomatie spielt dabei eine entscheidende Rolle, da nur durch internationale Zusammenarbeit effektive und nachhaltige Lösungen gefunden werden können.

Zuerst möchte ich klären, was eigentlich Klimadiplomatie ist. Es gibt keine universelle Definition der Klimadiplomatie. Mir gefällt die von der Europäischen Kommission vorgeschlagene Definition der Klimadiplomatie. Die Europäische Kommission definiert **vier Stränge** der Klimadiplomatie auf politischer Ebene:

1. Bekenntnis zum Multilateralismus in der Klimapolitik, insbesondere zur Umsetzung des Pariser Abkommens.
2. Die Auswirkungen des Klimawandels auf Frieden und Sicherheit angehen.
3. Beschleunigung nationaler Maßnahmen und Steigerung globaler Ambitionen.
4. Stärkung der internationalen Klimazusammenarbeit durch Lobbyarbeit und Öffentlichkeitsarbeit.

In diesem Sinne umfasst Klimadiplomatie den Einsatz diplomatischer Instrumente, um die Ambitionen und das Funktionieren des internationalen Klimaregimes zu unterstützen und die negativen Auswirkungen der Klimawandelrisiken auf Frieden, Stabilität und Wohlstand abzumildern. Darüber hinaus nutzt Klimadiplomatie den Klimawandel zur Förderung anderer außenpolitischer Ziele wie Vertrauens- und Friedensbildung oder der Stärkung des Multilateralismus. Klimadiplomatie erfordert die Entwicklung geeigneter Strategien zur Risikobewertung und zum Risikomanagement auf globaler strategischer Ebene.

Klimadiplomatie bedeutet auch, dem Klimaschutz mit Partnern weltweit Priorität einzuräumen – in diplomatischen Dialogen, in der öffentlichen Diplomatie und in außenpolitischen Instrumenten. Dazu gehört auch, bilateral auf Partnerländer zuzugehen und sich für ehrgeizigere Klimaschutzmaßnahmen einzusetzen.

Durch die Berücksichtigung übergreifender Themen trägt die Klimadiplomatie den Auswirkungen des Klimawandels auf Sicherheit und Stabilität

Rechnung. Frühzeitiges Handeln gegen die Sicherheitsrisiken des Klimawandels erfordert ein starkes Partnernetzwerk, darunter Vertreter der Zivilgesellschaft und des Privatsektors. Internationale Umwelt- und Klimadiplomatie, bilaterale Umweltzusammenarbeit sowie Umweltpolitik können Dialog und Vertrauensbildung fördern und so zur regionalen Stabilität beitragen. [9]

In der internationalen Klimadiplomatie lassen sich mehrere Phasen unterscheiden. Kurz nach Ende des Kalten Krieges wurde im Jahr 1990 der erste Bericht des Weltklimarats IPCC veröffentlicht. Es herrschte eine "Can do"-Stimmung und die Länder der Welt beschlossen, sich nun der Umweltprobleme des Planeten anzunehmen. Beim Erdgipfel in Rio de Janeiro im Jahr 1992 begann dann die Ratifizierung der UN-Klimakonvention. Diese teilt die Staaten in zwei Gruppen ein: in Industrie- und Entwicklungsländer. Nur drei Jahre später fand in Berlin die erste Konferenz der Vertragsparteien (COP) statt, auf der beschlossen wurde, einen Vertrag zur Rettung des Klimas auszuhandeln und weitere zwei Jahre später im japanischen Kyoto zu verabschieden. [1]

Einige Aspekte im Anschluss an die COP29 Konferenz und den wichtigsten Erkenntnissen der Klimadiplomatie: Die 29. UN-Klimakonferenz (COP29), die im November 2024 in Baku stattfand, brachte einige Fortschritte, aber auch erhebliche Herausforderungen in der internationalen Klimadiplomatie zutage. Ein bedeutender Erfolg war die Vereinbarung über ein neues kollektives Finanzierungsziel: Industrieländer verpflichteten sich, bis 2035 jährlich mindestens 300 Milliarden US-Dollar für Klimafinanzierung bereitzustellen. Diese Summe soll durch öffentliche und private Quellen aufgebracht werden und insbesondere Entwicklungsländern helfen, sich an den Klimawandel anzupassen und Emissionen zu reduzieren. Allerdings wurde dieses Finanzierungsziel von vielen Entwicklungsländern als unzureichend kritisiert, da der tatsächliche Bedarf auf etwa 1,3 Billionen US-Dollar pro Jahr geschätzt wird. Die "Baku-to-Belém-Roadmap" wurde ins Leben gerufen, um diesen Bedarf bis zur COP30 in Brasilien zu adressieren. Ein weiterer Fortschritt war die Einigung auf die vollständige Umsetzung von Artikel 6 des Pariser Abkommens, der den internationalen Handel mit Emissionszertifikaten regelt. Dies könnte den Weg für einen globalen Kohlenstoffmarkt ebnen. Insgesamt zeigt COP29, dass internationale Zusammenarbeit und Solidarität entscheidend sind, um den Klimawandel effektiv zu bekämpfen. Die Klimadiplomatie steht vor der Herausforderung, ambitioniertere Ziele zu setzen und diese auch umzusetzen. Die kommenden Verhandlungen, insbesondere bei COP30, werden zeigen, ob die Weltgemeinschaft bereit ist, die notwendigen Schritte zu gehen.

Die Klimakrise ist eine der größten Herausforderungen des 21. Jahrhunderts – die geopolitischen Folgen sind erheblich. Wir steuern auf eine deutlich wärmere Welt zu. Die Auswirkungen auf unsere außenpolitische Agenda sind erheblich, und daher ist eine stärkere Rolle der Außenpolitik in der internationalen Klimapolitik erforderlich – insbesondere durch Klimadiplomatie. [9]

2022 war ein schwieriges Jahr für die Klimadiplomatie. Im dritten Jahr der Covid-Pandemie hat Russlands Angriffskrieg gegen die Ukraine eine Schockwelle durch die Weltpolitik geschickt und den geopolitischen Status quo ins Wanken gebracht. Die multiplen Krisen infolge der Pandemie und des Krieges resultieren in Gegenwind für die Klimadiplomatie. [7]

Die Frage „Wie können sich die Länder im Bereich der Klimadiplomatie einigen?“ ist zentral für den globalen Klimaschutz – und zugleich äußerst komplex. Damit Einigung gelingt, braucht es ein Zusammenspiel aus politischem Willen, fairer Verantwortungsteilung, konkreten Anreizen und langfristigem Vertrauen. Damit internationale Klimapolitik erfolgreich ist, müssen sich Länder auf gemeinsame Ziele und konkrete Maßnahmen einigen. Klimadiplomatie bietet hierfür den notwendigen Rahmen, indem sie Dialog, Vertrauen und Zusammenarbeit zwischen Staaten fördert. Zentrale Prinzipien sind dabei Gerechtigkeit, Solidarität und gemeinsame, aber unterschiedliche Verantwortlichkeiten – vor allem im Verhältnis zwischen Industrie- und Entwicklungsländern. Ein effektiver Ansatz besteht darin, dass alle Länder transparente und überprüfbare Klimaziele definieren, aber auch flexible Mechanismen nutzen, um unterschiedliche wirtschaftliche und soziale Ausgangslagen zu berücksichtigen. Plattformen wie die UN-Klimakonferenzen oder multilaterale Partnerschaften wie die ‚High Ambition Coalition‘ zeigen, dass sich Länder auf freiwilliger Basis zusammenschließen können, um ambitioniertere Maßnahmen umzusetzen. Zudem ist die Klimafinanzierung entscheidend: Nur wenn wohlhabendere Länder ärmere Staaten finanziell und technologisch unterstützen, kann die globale Transformation gerecht gestaltet werden. Vertrauen entsteht durch Verlässlichkeit – also durch die Einhaltung gemachter Zusagen und eine offene Kommunikation. Langfristig wird Einigung im Rahmen der Klimadiplomatie nur möglich sein, wenn Staaten erkennen, dass Klimaschutz kein Nullsummenspiel ist, sondern ein gemeinsames Interesse an einer lebenswerten Zukunft für alle.

Quellen

1. https://www.klimareporter.de/klimakonferenzen/eine-neue-phase-der-klimadiplomatie
2. https://www.zdf.de/nachrichten/politik/petersberger-klimadialog-klimadiplomatie-100.html
3. https://unfccc.int/cop29
4. https://cop29.az/en/home
5. https://www.wwf.de/themen-projekte/klimaschutz/un-klimakonferenzen/cop29-in-baku
6. https://www.fes.de/themenportal-die-welt-gerecht-gestalten/klimawandel-energie-und-umwelt/artikel-in-klimawandel-energie-und-umwelt-1/weltklimakonferenz-cop28-klimadiplomatie-in-heissen-zeiten
7. https://www.ecologic.eu/de/19065
8. https://www.iwd.de/artikel/neuer-schwung-in-der-klimadiplomatie-489724/
9. https://climate--diplomacy-org.translate.goog/what-climate-diplomacy?_x_tr_sl=en&_x_tr_tl=de&_x_tr_hl=de&_x_tr_pto=rq#

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Critical minerals for batteries and different methods of extracting them

Batteries have become one of the most essential technologies of modern life. They power everything from smartwatches and smartphones to electric vehicles and large-scale renewable energy storage systems. Most batteries are made using critical raw materials such as lithium, cobalt, and nickel. These elements are finite so we should make choices before it is too late.

Now, 80% of the global supply of cobalt is mined in the Democratic Republic of the Congo. After extraction, about 75% of cobalt used for batteries is sent to China for refining. Meanwhile, most of lithium is mined in Australia and Chile, and a large portion of that supply also ends up in China for processing and battery production.

According to William Tarpeh, assistant professor of chemical engineering in the School of Engineering, the main problem with batteries is that we will run out of raw cobalt, nickel, and lithium in the next decade [1]. As the demand for electric vehicles and renewable energy storage rises rapidly, the pressure on these limited resources is increasing. This trend raises not only environmental issues but also questions of energy security and geopolitical dependence. In response, researchers and companies are exploring alternatives to traditional mining.

There are now multiple methods for refining and recovering critical minerals for batteries, each aiming to make the supply chain more sustainable, affordable, and less harmful to people and the planet.

E-trash is a different name for recycling e-waste, this method is developed by a research team at the Department of Energy's Pacific Northwest National Laboratory. This team's mission is to develop an environmentally friendly separation process to recover valuable minerals from e-waste. It allows to separate and recover nearly pure rare earth elements cheaply and quickly.

The method works by taking advantage of how different metals behave when placed in a chemical reaction chamber with various flowing liquids. These metals form solid particles at different rates over time, making them easier to separate.

A clear example of this is the recovery of nearly pure manganese (greater than 96%) from a solution designed to mimic dissolved lithium-ion battery waste. Elias Nakouzi, a PNNL materials scientist on the team, noted, “The beauty in this process is its simplicity.” and Nakouzi adds "Rather than relying on high-cost or specialty materials, we pared things back to thinking about the basics of ion behavior. And that's where we found inspiration."[2].

This technology significantly reduces the environmental impact of discarded electronics while also helping to address the global shortage of rare earth metals. It opens a path toward more sustainable and efficient recycling methods within the electronics industry. Furthermore, by making mineral recovery more accessible and cost-effective, it may encourage broader adoption of circular economy practices in tech manufacturing.

According to Justin Mackey, a researcher at the National Energy Technology Laboratory and PhD student in the lab of Daniel Bain, associate professor of geology and environmental sciences in the Kenneth P. Dietrich School of Arts and Sciences, researchers in the lab can already extract lithium from water with more than 90% efficiency [3]. This breakthrough is especially important as the U.S. government aims for all lithium to be produced domestically by 2030. Currently, researchers who recover lithium from wastewater are capable of meeting 30% to 40% of the country's lithium needs.

This method involves capturing lithium from sources such as industrial wastewater or waters near mineral-rich places like Marcellus shale, turning waste streams into valuable resources. It not only reduces reliance on foreign imports but also lowers the environmental impact of traditional mining practices.

By integrating this approach into existing water treatment infrastructure, the process becomes more scalable and economically feasible. It represents a promising step toward building a more sustainable and self-sufficient supply chain for critical battery minerals. As demand for electric vehicles and renewable energy continues to grow, innovations like these will play a key role in meeting future energy needs while preserving natural ecosystems.

Environmental benefits: The study has quantified the environmental footprint of battery material recycling processes and found that they emit less than half the greenhouse gases (GHGs) and use about one-fourth of the water and energy compared to mining new metals. This represents a major step forward in reducing the environmental toll of battery production.

As William Tarpeh stated, “We can design the future of battery recycling to optimize the environmental benefits. We can write the script.” [1] His words highlight the opportunity to rethink and redesign how we handle battery life cycles, from production to disposal. With the growing global demand for batteries and the visible shortage of critical minerals, innovative approaches such as recycling e-waste (E-trash) and extracting lithium from wastewater are becoming essential. They help create a circular economy that keeps valuable minerals in use longer and supports a more resilient, eco-conscious industry.

References:

1. Golden M. Recycling lithium-ion batteries cuts emissions and strengthens supply chain. URL: https://www.sciencedaily.com/releases/2025/01/250131194431.htm (accessed 31.01.2025)
2. Hede K. Critical minerals recovery from electronic waste. URL: https://www.sciencedaily.com/releases/2024/04/240423184756.htm (accessed 23.04.2024)
3. Jefferson B. Making batteries takes a lot of lithium: Some could come from gas well wastewater. URL: https://www.sciencedaily.com/releases/2024/05/240515164301.htm (accessed 15.05.2024)

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AI's Influence on Energy Demand

AI technologies, such as machine learning, deep learning, and data analytics, are increasingly being utilized in various industries, including healthcare, finance, manufacturing, transportation and many others.

Nowadays, artificial intelligence is most often associated with Large Language Models (LLMs) like ChatGPT or Microsoft Copilot. The rapid advancements of these models come with significant resource consumption, requiring substantial computational power and energy to support their training and operation.

As AI becomes more integrated into daily life and business it’s becoming crucial to understand its influence on energy consumption and environmental impact.

The estimated worldwide power consumption of AI in 2023 was 4.5 gigawatts or eight percent of total power consumption in data centers that year. AI's power consumption is expected to grow significantly in the following years. Schneider Electric predicts that AI power consumption will increase each year and will reach 14 - 18.7 gigawatts in 2028 [1]

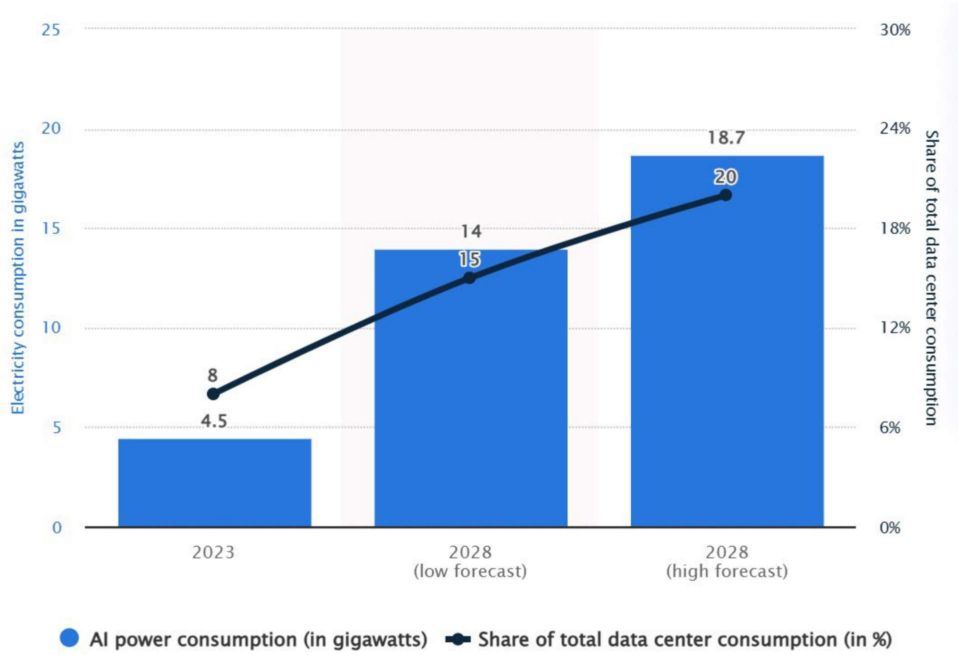

Figure 1: AI power consumption forecast [2]

The life cycle of any AI model can be divided into two phases: an initial training and inference. The training phase often considered the most energy intensive and indeed it requires substantial amount of electricity. For instance, the estimated amount of power consumed for GPT-3 training is 1287 MWh [3]. But let's take a closer look at the inference phase. The table 1 below shows the average energy required to perform a certain task 1000 times [4]

Table 1: Average energy consumption

Task type	Average energy consumption for 1000 inferences, Wh
text classification	4,39
image classification	1
object detection	3,36
text generation	294,67
summarization	6,94
image captioning	104,8
image generation	519,04

Considering that popular models like the ubiquitous GPT or Gemini deal with millions of queries each day it becomes obvious that it is the inference phase that is energy hungry. According to an analysis by SemiAnalysis, ChatGPT's operational needs necessitated approximately 28,936 NVIDIA A100 GPUs, organized into 3,617 HGX server systems. This configuration is estimated to consume around 564 megawatt-hours of energy daily [5]

While the exact future of AI-related electricity consumption remains difficult to predict due to advancements in hardware efficiency, changes in AI model architectures, and the increasing use of renewable energy sources, it is clear that AI's energy demands are rising. It is estimated that the data centers power demand will grow by approximately 165% by the end on the decade and AI is expected to represent around 20% of the total energy consumption [6]; [7].

References:

1. V. Avelar and P. Donovan, “The AI Disruption: Challenges and Guidance for DataCenter Design”.
2. “AI global power consumption forecast 2028,” Statista. [Online]. Available: https://www.statista.com/statistics/1536969/ai-electricityconsumption-worldwide/
3. A. de Vries, “The growing energy footprint of artificial intelligence,” Joule, vol. 7, no. 10, pp. 2191–2194, Oct. 2023, doi: 10.1016/j.joule.2023.09.004.
4. “AI Energy Score Leaderboard - a Hugging Face Space by AIEnergyScore.” [Online]. Available: https://huggingface.co/spaces/AIEnergyScore/Leaderboard
5. “The Inference Cost Of Search Disruption – Large Language Model Cost Analysis,” [Online]. Available: https://semianalysis.com/2023/02/09/the-inference-cost-of-search-disruption/
6. “AI to drive 165% increase in data center power demand by 2030.” [Online]. Available: https://www.goldmansachs.com/insights/articles/ai-todrive-165-increase-in-data-center-power-demand-by-2030
7. L. D. Roucy-Rochegonde and A. Buffard, “AI, Data Centers and Energy Demand: Reassessing and Exploring the Trends”.

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The European Green Deal: Leading the World in Climate Action

The European Green Deal is a key strategy of the European Union aimed at achieving climate neutrality by 2050. This initiative was undertaken to make structural changes in such areas as energy, industry, transport, and agriculture to reduce greenhouse gas emissions and promote the development of a circular economy.

However, the implementation of the Green Deal has faced and is still facing certain challenges. One of them is public awareness and support for environmental initiatives. In addition, the transition to a sustainable economy requires significant investments, particularly in renewable energy and green technologies. But at the same time, according to researchers , economic instability and political factors will slow down this process.

According to the Google Search Trends Analysis (JRC, 2021), there are different levels of interest in climate policy in EU member states, which indicates the need to improve communication and engagement strategies [1]. In addition, a study by Nature (2024) emphasizes the technological and economic challenges that hinder the transition to clean energy, emphasizing the importance of innovation and financial support [2]. Financial Times (2025) reports indicate a decline in green investment in Europe, raising concerns about the EU's ability to maintain its leadership in the global climate fight [3].

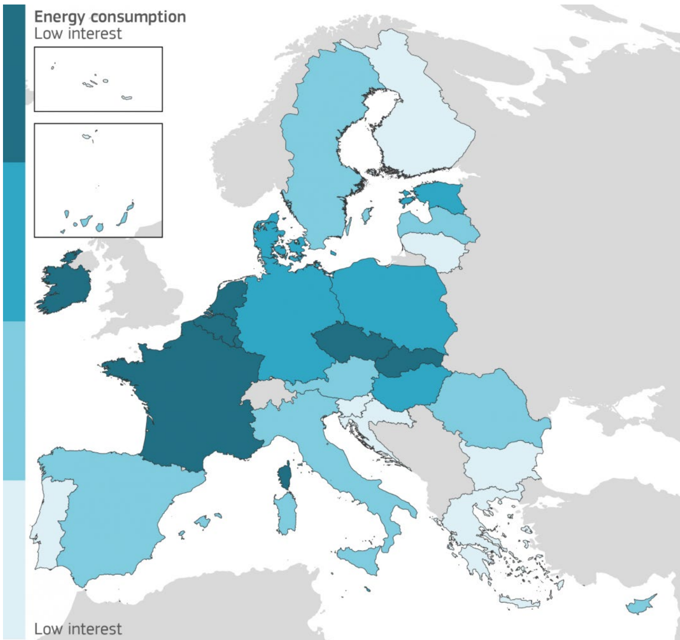
This paper examines the key challenges and opportunities of the European Green Deal by analyzing public engagement, economic policy, and investment trends. Understanding these factors is crucial to ensure that the EU remains at the forefront of global climate leadership.

The European Green Deal (EGD) is a comprehensive strategy aimed at making Europe the first climate-neutral continent by 2050. It has set ambitious targets for reducing greenhouse gas emissions, promoting renewable energy, and transforming economic sectors in line with sustainable development goals. The EGD now serves as a model for other regions, demonstrating how large-scale policy initiatives can integrate climate action into economic growth.

One of the key aspects of the Green Deal is the pursuit of **carbon neutrality**, which requires systemic changes in many sectors, including energy, transport and industry.Achieving carbon neutrality is not just an environmental goal, but a prerequisite for Europe's economic, social and energy security. A critical component of this transformation is the transition from fossil fuels to renewable energy sources, as well as the development of energy efficient technologies. The European Union (EU) has also introduced the “Fit for 55” package, with the goal of reducing emissions by at least 55% by 2030 compared to 1990 levels. According to the journal

Nature (2024), "achieving carbon neutrality requires sustained financial investment and technological innovation, especially in renewable energy and storage" [2].

The second point we should include is **public perception and engagement**, which plays a crucial role in the success of climate policy. According to an analysis of Google search trends, interest in the Green Deal varies across EU member states, reflecting differences in environmental awareness, economic conditions, and political priorities (JRC, 2021) [1]. Countries in Western and Northern Europe, such as Germany and Scandinavian countries (Sweden, Norway, Denmark, and Finland), show a higher level of interest in sustainable development initiatives. In these nations, environmental protection is a top political priority, and governments actively promote green policies, renewable energy, and eco-friendly lifestyles.



Interest in energy consumption in the 27 EU countries (2015-2019 average).

This photo illustrates the level of interest of EU citizens in energy consumption, which is directly related to the awareness of environmental issues and support for green initiatives.[1]

In Scandinavian countries, ecology is deeply integrated into national policies. Governments invest heavily in clean energy, sustainable transport, and waste reduction. For example, Norway leads in electric vehicle adoption, Denmark focuses on wind energy, and Sweden promotes a circular economy. Citizens in these countries also demonstrate high environmental awareness, supporting strict regulations and eco-friendly innovations. Meanwhile, countries in Southern and Eastern Europe, such as Italy and Poland, show a lower level of engagement in climate issues. This may be due to economic challenges, dependence on fossil fuels, and lower public awareness. This disparity indicates the need for better communication and educational campaigns to ensure broad support for climate policy across all EU member states.

Moreover, an interesting fact is that public engagement often increases in response to significant climate events or policy changes. For example, during the COVID-19 pandemic, there was a surge in online interest in energy consumption and renewable energy solutions, which highlights the role of crises in shaping environmental awareness. "During periods of uncertainty, such as a pandemic, public interest in sustainable energy solutions increases dramatically, reflecting increased awareness of energy security and climate issues" (JRC, 2021) [1]. Making climate policy accessible and well communicated is essential to maintaining momentum in achieving the Green Deal goals. The more people are interested in this topic, the more it will be promoted in the international arena.

Despite its ambitious goals, the Green Deal has faced and continues to face significant economic and technological obstacles. In all articles, researchers write that the transition to a green economy requires significant investments in infrastructure, research, and innovation. The high cost of renewable energy technologies, the need for energy storage solutions, and the restructuring of traditional industries pose obstacles to rapid implementation. One of the key challenges of the European Green Deal is the growing energy demand of EU countries, which renewable sources cannot yet fully cover. Demand for electricity is increasing due to industrial modernization, electrification of transport, and digitalization of the economy. However, solar and wind power are weather-dependent, which creates instability in supply. This forces the EU to seek a balance between the development of green energy and backup sources such as gas plants or nuclear power.

In addition, financial constraints pose challenges, especially in the context of economic uncertainty and instability that the EU is facing. Reports show a decline in green investment in recent years, raising concerns about the EU's ability to maintain its leadership in the global fight against climate change. According to the Financial Times (2025), “green energy investment in the EU has fallen by 6.5%, with the UK seeing a sharper 12% drop, largely due to policy uncertainty and infrastructure problems” [3].

Although policies such as the Just Transition Mechanism (JTM) are a financial and political instrument of the European Union aimed at supporting regions and workers affected by the transition to a climate-neutral economy. It is part of the European Green Deal and helps to mitigate the socio-economic impacts of the phase-out of fossil fuels and other environmentally harmful industries) aimed at supporting regions and industries most affected by the transition to sustainable development, maintaining investor confidence and ensuring stable financial support remain critical.

It is also important that the European Green Deal positions the EU as a global leader in climate policy, influencing international agreements and encouraging other countries to adopt similar strategies. Through diplomatic efforts and financial incentives, the EU promotes sustainable development beyond its borders, especially in developing countries. “The EU's commitment to climate action extends beyond its member states, influencing international trade policy and global sustainable development efforts” (Nature, 2024) [2].

However, maintaining this leadership requires consistent policy implementation, increased funding, and strong public support. As other global powers such as the US and China develop their climate policies, the EU must continue to adapt and strengthen its strategies to remain at the forefront of climate action.

In conclusion, the European Green Deal represents a transformative approach to addressing climate change by integrating sustainable development into economic and social policies. Despite challenges such as uneven public awareness, financial constraints, and technological barriers, the EU's commitment to climate neutrality sets an important precedent for global action. Ensuring sustained investment, public engagement and international cooperation will be crucial to achieving long-term climate goals and strengthening Europe's role as a global leader in sustainable development.

References:

1. European Union. Tracking EU citizens' interest in EC priorities using online search data - Publications Office of the EU. Publications Office of the EU. URL: https://op.europa.eu/en/publication-detail/-/publication/b5ee8919-7008-11eb-9ac9-01aa75ed71a1
2. Assessing the sustainability of the European Green Deal and its interlin kages with the SDGs / P. Koundouri et al. npj Climate Action. 2024. Vol. 3, no. 1. URL: https://doi.org/10.1038/s44168-024-00104-6 .
3. Mundy S. European investment in the energy transition is stalling. Financial Times. URL: https://www.ft.com/content/a08742d9-f94c-46d8-8e17-e1fdaffc7ea3

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The Influence of Climatic Conditions on the Efficiency of Heating Devices

When designing buildings and selecting equipment to supply them with thermal energy, a number of regulatory documents are used, which take into account the minimum temperature for a specific region [1, 2]. For example, when choosing equipment, it is necessary to consider the minimum temperature for a specific region. However, under current conditions, the values of this temperature are changing compared to previous years [3], which may affect the results of calculations when selecting energy equipment. For example, about 10 years ago, the temperature was lower [4], so heating systems were designed for different temperatures. Figure 1 shows the change in temperature over the past 10 years.

As illustrated in fig. 1, over the past decade, the minimum temperatures have increased by approximately 2–4 °C. Based on this observation, it is reasonable to adopt a design minimum temperature of -16 °C for thermal load calculations, whereas

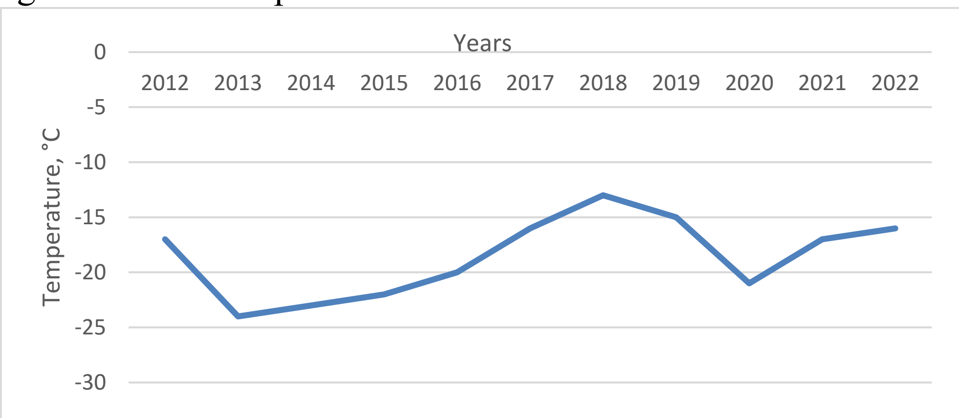

Figure 1 – Temperature changes during the coldest period over the last decade in Dnipro.

current regulatory documents still recommend -24 °C [2, 5].

This study presents a theoretical and calculation-based analysis of the impact of minimum outdoor temperature on the heating load of a private residential building located in the Dnipro city. The calculations were carried out following the methodology outlined in [6]. The results are presented in fig. 2.

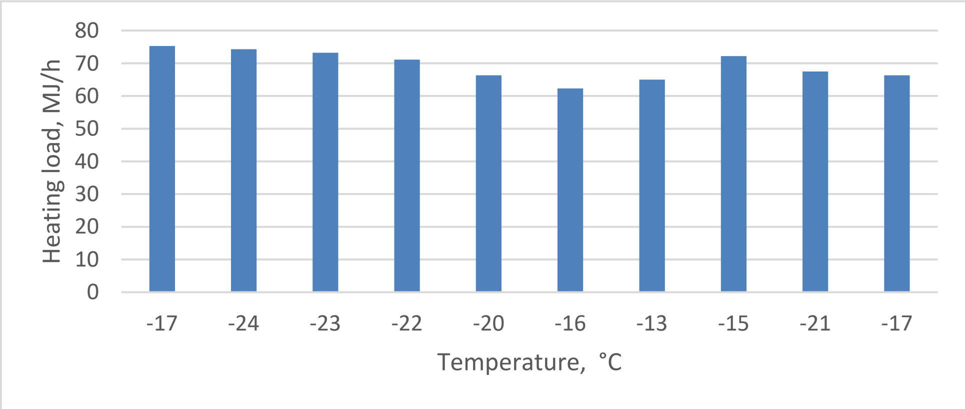

Figure 2 – The impact of temperature on heat load of the building

Based on the obtained results, the required capacity of the boiler unit was determined to fully meet the building's heating demand during the coldest period of the year. Since the capacity of thermal equipment depends on the building's heat load, this study includes calculations of the relationship between these parameters, as illustrated in fig. 3.

The capacity of energy equipment affects the amount of fuel burned, which in turn influences the level of emissions released into the environment. Therefore, this study investigates the relationship between fuel consumption in the boiler unit and its capacity, as shown in fig. 4.

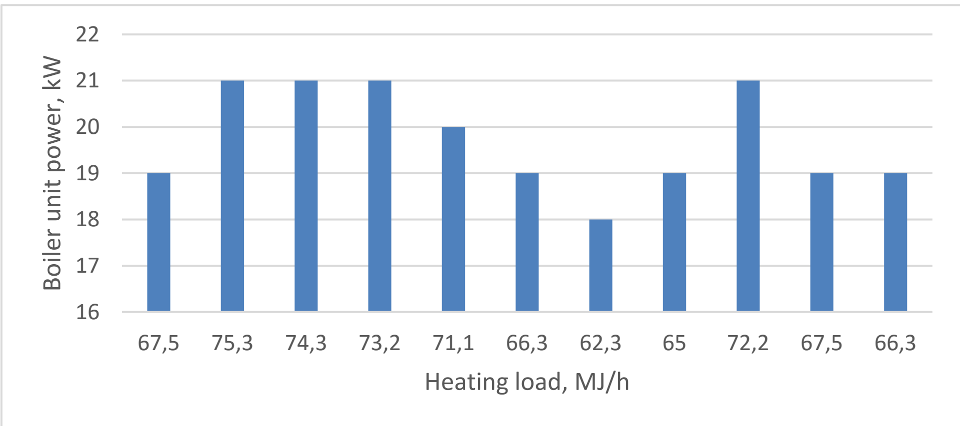

Figure 3 – Impact of heat load of the building on boiler unit capacity

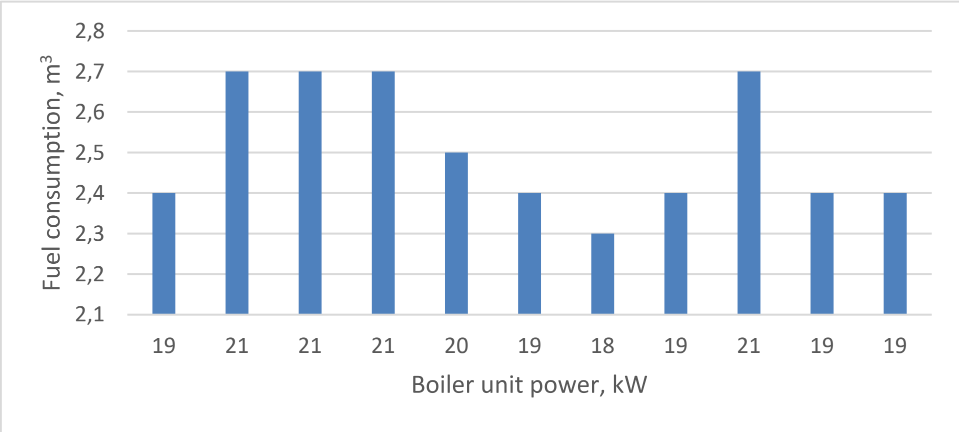

Figure 4 – Impact of boiler unit capacity on fuel consumption

As shown by the presented results, a decrease in boiler unit capacity leads to a reduction in fuel consumption, which in turn results in lower emissions of harmful substances into the environment. Given the global need to reduce greenhouse gas emissions [7] and transition toward carbon-neutral [8] energy production, reducing the amount of fuel burned directly supports these objectives.

Thus, it can be concluded that climate change, accompanied by rising temperatures during the cold season, leads to a decrease in the required capacity of energy equipment and, consequently, a reduction in harmful emissions.

References:

1. State building standards of Ukraine V.2.5-67:2013 "Heating, ventilation and air conditioning", [online] Ministry of Regional Development, Construction and Housing and Communal Services of Ukraine dated 01/25/2013 No. 24 and dated 08/28/2013 No. 410 https://e-construction.gov.ua/laws_detail/3074971619479783152?doc_type=2
2. State standards of Ukraine-N B V.1.1-27:2010 Building Climatology [online] Ministry of Regional Development and Construction of Ukraine. – Kyiv: Ukrarchbudinform, 2011. – 123 p. https://finance.smr.gov.ua/files/%D0%95%D0%BD%D0%B5%D1%80%D0%B3%D0%BE%D0%B7%D0%B1%D0%B5%D1%80%D0%B5%D0%B6%D0%B5%D0%BD%D0%BD%D1%8F/dstu-n-b-v11-27-2010-budivelna-klimatologiya.pdf
3. “The impact of climate change in Ukraine”[online] 06-12-2021 https://mepr.gov.ua/wp-content/uploads/2023/07/2_Vplyv-zminy-klimatu-v-Ukrayini.pdf
4. https://weatherspark.com/ - meteorological source
5. State standards of Ukraine B A.2.2-12:2015.[online] Energy efficiency of buildings. Method for calculating energy consumption for heating, cooling, ventilation, lighting and hot water supply. K. Minregionalbud of Ukraine, 2016. -205 p. https://dbn.co.ua/load/normativy/dstu/dstu_a_2_2_12/5-1-0-1781
6. Methodological instructions for the implementation of the course project “Calculation of a centralized heating system for residential and industrial

areas" in the discipline "Heating networks" for students of specialty 144 Heat and power engineering / Yu.V. Shyshko. – Dnipro: UDUNT, 2022. – 43 p.

7. "Carbon dioxide levels are at a record high. Here's what you need to know."[online] by Christina Nunez, May 13, 2019 https://www.nationalgeographic.com/environment/article/greenhouse-gases
8. "Carbon neutral energy" [online] From: Bioresource Technology, 2008 https://www.sciencedirect.com/topics/earth-and-planetary-sciences/carbon-neutral-energy#:~:text=Bioenergy%20produced%20from%20biomass%20is,2).

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Optimization of energy resource consumption in the mining industry: key criteria and tasks

Pneumatic systems have become indispensable in various industries due to their efficiency and cost-effectiveness, offering a range of benefits that can significantly enhance a company's productivity. However, it is important to recognize that these systems may encounter certain challenges that, if not addressed, can impact on their overall efficiency.

Pneumatic systems play a crucial role in modern industry, supporting a wide range of technological processes. Nearly **90% of industrial enterprises** use compressed air energy, making its production a significant source of energy consumption, accounting for **8% to 20%** of total industrial energy costs. At **metallurgical plants** and **mechanical engineering enterprises**, compressed air production consumes approximately **5% to 10%** of electricity. In **mechanical engineering plants**, this figure ranges from **5% to 20%**, while in the **mining** industry, it can be as high as 30%.

This highlights the urgent need to implement measures for optimizing the efficiency of **compressed air production** in Ukrainian industries. Addressing this challenge requires a **systematic approach** that ensures the optimization of all aspects of **compressor station operations** within pneumatic systems while providing a comprehensive solution to key issues.

First and foremost, it is necessary to **analyze the main types of energy consumption** associated with compressed air production, identify **ways to improve energy efficiency**, explore the potential application of **modern energy-saving technologies, improve production and technological processes**, and ultimately **make an optimal selection of equipment**.

An essential step in **reducing energy costs** is conducting a **comprehensive energy audit** not only for individual production units but for the entire enterprise. This is because the **efficiency of equipment and specific production areas** can be enhanced by systematically assessing the potential for utilizing **secondary energy resources** across the facility. In **certain cases, waste heat energy can be repurposed to produce valuable energy resources, which may even be sold outside the company.**

Systematic analysis reveals two main factors influencing energy losses in compressed air production at mine and pit compressor stations:

- Losses related to climatic conditions
- Inefficiency of water cooling systems used for cooling air in intermediate and final intercoolers.

One of the key factors affecting compressor efficiency is climatic conditions. During summer, daytime ambient temperatures can reach 30-35°C, leading to an increase in air temperature at the compressor inlet. As a result, compressor performance decreases, which in turn leads to higher electricity consumption.

The second factor is the existing cooling system for compressor units, which has several significant operational drawbacks. The thermal energy absorbed by the cooling water from the compressed air is released into the atmosphere via cooling towers, representing a direct loss of thermal energy. Additionally, cooling tower efficiency is also affected by climatic conditions. In summer, their effectiveness decreases by 15% to 20% compared to the winter period.

Modern science and technology offer several solutions for **reducing energy losses** in cooling systems by implementing **heat recovery technologies** to utilize the thermal energy released into the atmosphere by cooling towers.

One of the **most effective methods** for recovering this **waste heat** is the **integration of heat pumps** into **compressor station systems**. This modification allows enterprises to **use recovered heat for industrial and domestic needs**, thereby **reducing production costs** and improving overall **energy efficiency**.

At the same time, an integrated approach to thermal energy utilization within the overall energy balance of an company requires a structured understanding not only of the sources of losses and methods of recovery but also of an effective and practical way to use the recovered energy.

An analysis of typical energy balances in the mining industry reveals several promising applications for recycled secondary heat energy from compressor stations. These include meeting sanitary and domestic needs such as heating during the winter and hot water supply, preheating the gas-air mixture in sintering machine furnaces, heating raw materials in lime kilns, and other industrial processes.

Thus, reconstruction of the basic operating schemes of equipment of compressor stations taking into account minimization of losses of thermal energy using heat pump technology, justified selection of equipment for implementation of new technological schemes, as well as their optimization for specific climatic and other operating conditions of a particular mining or processing enterprise can significantly reduce the cost of production, and will also lead to a reduction in heat and greenhouse gas emissions.

References:

1. R. Saidur, N. A. Rahim, and M. Hasanuzzaman, "A review on compressed-air energy use and energy savings," Renewable and Sustainable Energy Reviews, vol. 14, no. 4, pp. 1135-1153, May 2010. [**Google Scholar**] [**CrossRef**].
2. R. S. Foss, "Optimizing the compressed air system," Energy Engineering, vol. 102, no. 1, pp.49-60, 2005. DOI:10.9734/bpi/nfpsr/v6/2979C
3. F. W. Schroeder, "Energy efficiency opportunities in mine compressed air systems," M.Eng. dissertation, North-West University, Potchefstroom, South Africa, 2009. DOI: 10.1038/s41598-023-33736-5
4. W. Booysen, M. Kleingeld, and J. F. van Rensburg, "Development of an energy management solution for mine compressor systems," in Proceedings of the Seventh Conference on the Industrial and Commercial Use of Energy, 2010, pp. 39-42. https://www.researchgate.net/publication/267955820_DEVELOPMENT_OF_AN_ENERGY_MANAGEMENT_SOLUTION_FOR_MINE_COMPRESSOR_SYSTEMS

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Improving efficiency of water resource usage at mineral processing plant: modern approaches

Considering global modern tendencies in mining industry we can admit that water plays crucial role in most production processes, from mineral processing and dust suppression to ore beneficiation and slurry transportation. However, mining activities significantly impact water quality and availability, prompting the industry to prioritize sustainable water management practices. With increasing environmental regulations and growing societal demand for resource conservation, mining companies must adopt advanced water treatment solutions to minimize their ecological footprint and operational costs [1].

Finding new ways to alleviate recourse expenditures, especially related to water, is crucial in modern days circumstances for any full-scale mining processing enterprise.

The water life cycle at processing plant begins with water sourcing, where water is obtained from surface sources, groundwater, or municipal supplies. This is followed by transportation, where pipelines deliver the water to processing sites.

Once onsite, the water is directed to storage facilities, such as dams or tanks, designed to ensure a stable supply. During usage, water supports various processes, related to ore processing and enrichment, of which crushing, grinding and classification are most water-intensive. Post-usage, the water undergoes treatment, where contaminants like heavy metals, particulates, and chemicals are removed. Finally, the treated water is either discharged into the environment, adhering to regulatory standards, or recycled back into the system to minimize freshwater dependency and environmental impact [2].

One of the most important technological processes at ore beneficiation plants is the grinding of raw ore. It consumes almost half of the electricity used by the facility, and about 40-60% of its total water supply.

Grinding circuits that include a ball mill in the first stage and a single-spiral mechanical classifier operating in a closed cycle have become the most widespread. As a result, significant attention has been paid to the performance of such grinding cycles. However, despite these efforts, they often do not operate in an optimal mode, leading to excessive consumption of water and electricity, grinding balls, and mill liners, while failing to produce the required amount of finished product [4].

Improving water usage efficiency during the grinding stage of ore processing at a mineral processing plant is crucial for reducing water consumption, minimizing environmental impact, and enhancing overall operational efficiency. Some prospective ways to achieve this include, but not limited to [3]:

- using High-Pressure Grinding Rolls (HPGR), which can reduce water consumption compared to traditional ball mills by improving ore liberation at lower moisture content;
- implementing more advanced classification systems, like replacing conventional spiral classifiers with hydrocyclones or modern screening systems and even using dry classification where it’s possible;
- enhancing water recycling and reuse through installing thickening and filtration units to recover processed water from tailings before disposal;
- applying chemical additives, like grinding aids or flocculants for improving material flow;
- real-time process control and automation though integrating sensor-based monitoring for water flow rates, slurry density, and grinding efficiency;
- optimizing ore-to-water ratio and maintaining the optimal balance between solid and liquid content to ensure efficient grinding without excessive water use.

While each of listed approaches can significantly improve efficiency of water usage, some of them require far more substantial investment, both in terms of resource and effort, then others. On the other hand, methods related to improving process control, automation and parameters optimization can be introduced with considerably less expenditures while bringing comparable benefits. Thus, these methods look like much more promising field of upcoming research.

In the work [4], it is noted that the optimal productivity of the ball mill, at which the highest yield of the final product is achieved, can only be obtained under specific loading conditions and a certain ore-to-water ratio. At the same time, while working at the optimal productivity mode, the ball mill doesn't consume excessive amount of water which is crucial for reducing and optimizing facility overall water consumption.

Currently, depending on the conditions, the amount of water in the mill is determined by the operator. However, he cannot steadily maintain required water flow rate under manual control, as the technological parameters of the incoming raw material and the process itself are constantly changing. This happens due to the lack of technical means for monitoring and automatic forecasting of the ore-to-water ratio in the ball mill.

The prediction of the ore-to-water ratio in a ball mill with circulating load is determined by several parameters, including the moisture content of classifier sands, ore density, volumetric flow rate of water into the classifier sand launder, mass flow rate of ore and water into the mill, and the volumetric flow rate of slurry in the classifier sand launder. The accuracy of identifying the ore-to-water ratio depends on the precision of each of these parameter measurements [5].

The challenge in prediction lies in the fact that, unlike the other mentioned parameters, measuring the volumetric flow rate of slurry in the classifier sand launder with sufficient accuracy is quite difficult. Therefore, mathematical predictive models are used to estimate it. The application of machine learning

algorithms and artificial intelligence for data analysis appears to be highly promising in addressing this issue. But such fully operational, industrially scalable solutions are to be developed yet.

Efficient water management in mineral processing plants is not only a critical operational factor but also a necessity for sustainable and cost-effective mining practices. As discussed, water plays a pivotal role throughout ore beneficiation processes, with grinding being one of the most water-intensive stages. Excessive water consumption not only increases operational costs but also amplifies environmental concerns and regulatory compliance challenges.

To mitigate these issues, several modern approaches have been explored, including the adoption of High-Pressure Grinding Rolls (HPGR), advanced classification systems, enhanced recycling methods, and the integration of real-time monitoring and automation. Among these, process optimization and automated control appear to be the most cost-effective solutions that can be implemented with minimal capital investment while delivering significant efficiency improvements.

One of the key challenges remains the precise control of the ore-to-water ratio in ball mills, as manual adjustments by operators lead to inconsistencies due to fluctuating raw material properties and process dynamics. Addressing this issue requires the development and implementation of predictive models capable of dynamically adjusting water input. The integration of machine learning algorithms and artificial intelligence offers promising prospects in this area, enabling real-time adjustments based on continuous data analysis.

Ultimately, improving water usage efficiency at mineral processing plants requires a combination of technological advancements, process optimization, and strategic investment in innovative solutions. As the mining industry continues to evolve, embracing these modern approaches will be essential for ensuring resource conservation, regulatory compliance, and long-term sustainability.

References

1. Rankin, P.W., Kelebek, S., Di Feo, A., Taylor, J.R. (2023). Water Recycling and Seasonal Water Quality Effects in Mineral Processing. In: Proceedings of the 61st Conference of Metallurgists, COM 2022. COM 2022. Springer, Cham. https://doi.org/10.1007/978-3-031-17425-4_106 2. M. Shoko. Water management at mines – every drop counts // Modern mining. August 2020. C. 30-33. URL: https://user-54716422671.cld.bz/Modern-Mining-August-2020/32/ (дата звернення: 14.03.2025).

3. The Importance of Water Treatment in the Mining Industry: A Comprehensive Guide // Water treatment news. August 2023. URL: https://nuwater.com/water-treatment-in-the-mining-industry/ (дата звернення: 14.03.2025).

4. Kondratets V.O. Identification of the ore-to-water ratio at the inlet of the ball mill / V.O. Kondratets, O.M. Serbul // Technology in Agricultural Production, Industrial Engineering, Automation: Collection of Scientific Papers of KNTU. – 2006. – Issue 17. – P. 265-272.

5. Serbul O.M. Justification of an approach to improving the accuracy of ore-to-water ratio identification in ball mills with circulating load / O.M. Serbul, V.O. Kondratets // Technology in Agricultural Production, Industrial Engineering, Automation: Collection of Scientific Papers of KNTU. – 2009. – Issue 22. – P. 24-28.

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Energiesparen und effiziente alternative Energienutzung

Einleitung

Die Diskussion um Energiesparen ist in Deutschland mehr als eine Reaktion auf steigende Strompreise oder klimapolitische Ziele. Sie zeigt uns eine grundlegende gesellschaftliche Herausforderung die uns in Zukunft immer mehr beschäftigen wird: Wie kann ein hochindustrialisiertes Land seinen Energiebedarf decken, ohne dabei dauerhaft ökologische Probleme zu verursachen? Relevant ist dabei nicht allein die Frage nach Technologien oder Fördermitteln, sondern ebenso nach Verhaltensweisen im Alltag von jedem, Strukturen und politischer Kommunikation.

Diese Arbeit zeigt zentrale Entwicklungen im Bereich Energieeffizienz und erneuerbarer Energienutzung auf und konzentriert sich auf die alltägliche Ebene. Es geht nicht nur um technische Details, sondern größtenteils um die Frage, wie sich politische Zielsetzungen in konkrete Handlungen übersetzen lassen – in Haushalten, Gebäuden, Städten.

Politische Rahmenbedingungen und technische Fortschritte

Mit dem Gebäudeenergiegesetz und dem Erneuerbare-Energien-Gesetz hat Deutschland klare Vorgaben geschaffen. Neue Heizsysteme etwa sollen zukünftig zu mindestens 65 % mit erneuerbaren Energien betrieben werden [1]. Gleichzeitig existieren Förderprogramme, die den Umstieg erleichtern sollen. Die staatliche Unterstützung ist dabei nicht nur symbolisch – sie kann, sofern sie genutzt wird, Investitionsentscheidungen maßgeblich beeinflussen. Auch technisch gibt es viele Innovationen und neue Trends. Wärmepumpen, Photovoltaikanlagen und Smart-Home-Systeme zur Steuerung des Energieverbrauchs sind längst keine unwichtige Nischenprodukte mehr. Allein die Zahl der Solaranlagen stieg 2023 laut Statistischem Bundesamt auf über drei Millionen – ein deutlicher Beleg für die zunehmende Verbreitung dieser Technologie [2]. Trotzdem bleiben große Potenziale ungenutzt wie zum Beispiel auf Mehrfamilienhäusern oder bei älteren Gebäuden mit hohem Verbrauch.

Alltagstauglichkeit und wirtschaftliche Perspektiven

In der öffentlichen Wahrnehmung erscheinen viele Maßnahmen zunächst sehr teuer und aufwändig. Und tatsächlich: Wer heute in Wärmedämmung, neue Fenster oder ein emissionsarmes Heizsystem investiert, steht vor einer großen Anfangsinvestition. Allerdings zeigt sich, dass diese Ausgaben in vielen Fällen langfristig zu Einsparungen führen – sowohl ökonomisch als auch ökologisch. Laut Bundeswirtschaftsministerium verursachten klimabedingte Schäden in Deutschland zwischen 2000 und 2021 Kosten in Höhe von über 140 Milliarden Euro [3]. Daraus ergibt sich ein deutliches Argument für rechtzeitiges Handeln und präventive Maßnahmen. Auf individueller Ebene sind es jedoch oft kleine Entscheidungen, die große Wirkung entfalten. Die Absenkung der Raumtemperatur um einen Grad spart im Schnitt sechs Prozent Heizenergie [4]. Das klingt gering, wird aber bei Millionen Haushalten zu einer relevanten Menge. Ähnliches gilt für den Stromverbrauch: Der bewusste Austausch veralteter Geräte, die Vermeidung von Standby-Betrieb und die Nutzung effizienter Beleuchtung sind einfache, aber wirksame Maßnahmen.

Individuelle Spielräume und gesellschaftliche Dynamik

Die Frage, wie viel Einfluss Einzelne tatsächlich auf den Energieverbrauch haben, ist nicht neu und wird unterschiedlich beantwortet. Manche sehen die Verantwortung primär bei der Politik oder der Industrie. Andere betonen die Rolle individueller Konsumentscheidungen. Wahrscheinlich liegt die Wahrheit dazwischen: Der Wandel gelingt nur im Zusammenspiel beider Ebenen.

Was feststeht: Der Handlungsspielraum ist größer, als oft angenommen wird. Neben dem Energiesparen im engeren Sinne, also der Reduktion von Verbrauch, gewinnen auch andere Ansätze an Bedeutung. Dazu zählt etwa die dezentrale Energieerzeugung, sei es durch Balkonkraftwerke, Solartechnik auf dem Dach oder Beteiligung an Bürgerenergieprojekten. Auch die Mobilität bietet Möglichkeiten, den Energieeinsatz effizienter zu gestalten – etwa durch den Umstieg auf ÖPNV oder E-Bikes, wo es praktikabel ist.

Fazit

Energieeffizienz und alternative Energienutzung sind keine technischen Randthemen, sie sind wichtige zentrale Fragen des Zusammenlebens, der Verantwortung und der Zukunftsfähigkeit. Deutschland verfügt über die nötige Infrastruktur, über politische Instrumente und technologische Lösungen. Was es braucht, ist die konsequente Verbindung dieser Elemente mit gesellschaftlicher Beteiligung. Der Beitrag jedes Einzelnen mag klein erscheinen. In der Summe jedoch kann er jene Dynamik entfalten, die notwendig ist, um große Ziele zu erreichen – realistisch, pragmatisch und Schritt für Schritt.

Entscheidend ist dabei, dass Energiesparen nicht als kurzfristige Reaktion auf Krisen verstanden wird, sondern als dauerhafter Bestandteil eines verantwortungsvollen Alltags. Es geht weniger um Verzicht als vielmehr um kluge Entscheidungen, die langfristig Vorteile bringen – finanziell, ökologisch und gesellschaftlich. Der Wandel hin zu mehr Energieeffizienz ist kein Selbstläufer, aber er ist machbar – wenn politische Rahmenbedingungen verständlich und stabil sind, wenn Technologien zugänglich bleiben und wenn Menschen sich als Teil des Prozesses begreifen. Langfristig wird die Energiewende nur gelingen, wenn sie nicht von oben verordnet, sondern gemeinsam getragen wird. Das setzt Vertrauen, Transparenz und konkrete Alltagstauglichkeit voraus – in Gebäuden, im Verkehr, im Umgang mit Ressourcen. Energiesparen ist nicht nur eine technische, sondern auch eine kulturelle Herausforderung. Und genau deshalb ist es so wichtig, dass es gelingt.

Quellen:

1. https://www.bundesregierung.de/breg-de/aktuelles/faq-energiewende-2067498.
2. https://www.destatis.de/DE/Presse/Pressemitteilungen/2024/07/PD24_N038_43.html.
3. https://www.bundesregierung.de/breg-de/aktuelles/faq-energiewende-2067498.
4. https://www.umweltbundesamt.de/themen/energiesparen-im-haushalt-0.

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Energy Saving and Efficient Use of Alternative Energy Sources

The rapid depletion of fossil fuel resources, the growing demand for energy, and environmental challenges necessitate the implementation of advanced energy-saving technologies and the integration of renewable energy sources into the global energy system. Energy efficiency directly impacts the sustainability of energy production, transmission, and consumption. The combination of innovative energy-saving technologies and high-performance alternative energy systems enables significant reductions in energy losses and greenhouse gas emissions.

Modern energy-saving technologies are based on improving energy conversion efficiency, minimizing energy losses in industrial processes, and optimizing energy distribution networks. One of the most effective approaches is the implementation of high-efficiency heat recovery systems, such as regenerative heat exchangers and absorption heat pumps, which allow the utilization of waste heat in industrial and residential sectors. Supercritical CO_2 cycles used in thermal power generation enhance the efficiency of heat engines by reducing the irreversibility of thermodynamic processes. The use of magnetocaloric materials in refrigeration systems minimizes energy losses by employing solid-state cooling technologies instead of traditional vapor-compression cycles.

In the electrical engineering sector, significant efficiency improvements are achieved through the use of silicon carbide (SiC) and gallium nitride (GaN) semiconductors in power electronics, reducing energy losses in electrical grids and renewable energy systems. The implementation of high-temperature superconductors (HTS) in power transmission lines reduces resistive losses and improves grid stability. Smart grid technologies, including real-time energy management systems based on artificial intelligence and machine learning, optimize energy distribution and reduce peak loads, leading to lower overall energy consumption.

Efficient utilization of alternative energy sources requires advancements in energy conversion technologies and storage systems. In photovoltaic (PV) energy, the development of perovskite solar cells has significantly increased energy conversion efficiency, exceeding 30% in laboratory conditions. Multi-junction solar cells, utilizing tandem structures, further enhance efficiency by capturing a broader spectrum of solar radiation. In wind energy, direct-drive permanent magnet synchronous generators (PMSG) eliminate the need for gearboxes, reducing mechanical losses and maintenance costs while increasing efficiency.

One of the major challenges in large-scale deployment of renewable energy sources is the intermittency of power generation, which necessitates the development of high-performance energy storage technologies. Solid-state lithium-metal batteries, with higher energy density than conventional lithium-ion systems, increase storage capacity and improve charge-discharge cycles. Redox flow batteries (RFB) based on vanadium or organic electrolytes provide scalable energy storage solutions for grid applications. Hydrogen energy storage, utilizing proton exchange membrane (PEM) electrolyzers for hydrogen production and solid oxide fuel cells (SOFC) for electricity generation, offers a long-term solution for balancing renewable energy fluctuations.

The integration of alternative energy into existing energy systems is facilitated by advanced hybrid technologies. Concentrated solar power (CSP) with thermal storage, using molten salts, ensures continuous electricity generation even during non-sunny hours. Hybrid renewable energy systems (HRES), combining wind, solar, and bioenergy with energy storage, enhance grid reliability and efficiency. The application of power-to-X (P2X) technologies, which convert excess renewable electricity into synthetic fuels or hydrogen, enables surplus energy utilization in transportation and industrial processes.

The transition to a sustainable energy system is further supported by regulatory measures and digital optimization strategies. Carbon capture, utilization, and storage (CCUS) technologies, particularly direct air capture (DAC) and bioenergy with carbon capture and storage (BECCS), help reduce CO_2 emissions from industrial sources. Blockchain-based energy trading platforms enable decentralized energy distribution, increasing market efficiency and supporting the integration of distributed renewable energy sources.

Future research directions focus on improving the efficiency of quantum dot solar cells, enhancing the conductivity of advanced superconducting materials, and developing nuclear fusion technologies. The combination of these innovations with energy-saving strategies will accelerate the global transition to a low-carbon economy and ensure the long-term sustainability of energy systems.

References:

1. International Energy Agency (IEA). World Energy Outlook 2023. Paris: IEA, 2023.
2. Intergovernmental Panel on Climate Change (IPCC). Sixth Assessment Report: Mitigation of Climate Change. Geneva: IPCC, 2023.
3. REN21. Renewables 2023 Global Status Report. Paris: REN21, 2023.
4. Smil, V. Energy and Civilization: A History. MIT Press, 2017.
5. Jacobson, M. Z. 100% Clean, Renewable Energy and Storage for Everything. Cambridge University Press, 2020.
6. Liu, W., Lund, H., Mathiesen, B. V. Smart Energy System Transition from Fossil Fuels to Renewable Energy: Status and Outlook. Renewable and Sustainable Energy Reviews, 2023.
7. Zhao, Y., Wang, Y., Li, X. Advancements in Energy Storage Technologies for Renewable Energy Integration. Energy Reports, 2023.
8. European Commission. The Role of Hydrogen in Europe’s Green Transition. Brussels: European Commission, 2023.
9. U.S. Department of Energy (DOE). Grid Modernization Initiative: Smart Grid Technologies. Washington, DC: DOE, 2023.
10. Fraunhofer Institute for Solar Energy Systems. Next-Generation Photovoltaic Technologies and Efficiency Improvements. Freiburg: Fraunhofer ISE, 2023.

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The role and development prospects of solar energy in the context of distributed power generation

Solar energy is gaining increasing importance in the context of global climate change and the need to reduce greenhouse gas emissions. In this regard, distributed generation (DG), particularly through solar panels, is becoming a crucial element in the transformation of energy systems. Installing solar power plants directly at consumption sites helps reduce the load on centralized grids, optimize energy transportation costs, and enhance energy independence. The prospects for the development of solar energy in the context of distributed generation include not only economic and environmental benefits but also significant technological innovations that contribute to the growth of efficiency and accessibility of this renewable energy source.

The global push for sustainability, as highlighted by the United Nations Sustainable Development Goals (SDGs), places significant emphasis on improving the energy sector. SDG 7 specifically aims to ensure universal access to affordable, sustainable, and modern energy, where distributed energy integration plays a crucial role. It also indirectly supports the achievement of SDG 11. The International Panel on Climate Change (IPCC) emphasizes the need for transformative changes in global energy systems to combat climate change. Replacing fossil fuels with renewable energy is considered essential, with the IPCC recommending annual investments of $2.4 trillion in sustainable energy systems through 2035. Distributed Energy Systems (DESs) align well with the global renewable energy initiatives, particularly as many off-grid DESs rely on renewable sources. These systems can integrate diverse energy resources and technologies and can function both on-grid and off-grid. As a result, distributed generation systems are rapidly advancing in both technology and policy, contributing to substantial growth in installed capacity. Renewable energy technologies, which dominate global distributed generation, are becoming increasingly efficient, versatile in deployment, and economically viable compared to traditional energy systems. Worldwide, renewable capacity rose significantly from 1,430 MW in 2019 to 1,668 MW in 2020, with distributed generation contributing a major portion of this expansion [1].

When operating such systems, it is important to consider that solar, wind, and other types of power plants using renewable energy sources may not provide a constant output. Therefore, it is necessary to understand this variability and implement proper regulation. It is also necessary to ensure the cooperation of power plants that operate on renewable energy sources.

In the solar energy sector, reliability challenges stem from various unpredictable factors that are not consistently present. While historical data can help alleviate this inherent limitation in specific contexts, solar irradiation forecasts often carry a considerable degree of inaccuracy. On the other hand, wind energy is particularly affected by a high level of uncertainty due to its fluctuating and unstable density. This variability makes it difficult to apply fixed generation strategies, necessitating the use of probabilistic methods to resolve conflicts in generation scheduling. The intermittent nature of wind energy further complicates generation planning and raises concerns about the protection of the system as a whole. It is crucial to highlight that the development of renewable energy sources (RES) has introduced viable alternatives to traditional generation methods, primarily driven by the significant cost reductions seen over the past few decades. DG poses a challenge for electrical grids and distribution companies because a large number of these systems can be connected to medium-voltage networks. Analyzing load flow is a vital component when evaluating power systems.

Despite the widespread adoption of distributed generation systems with solar power plants, there are still pressing challenges that hinder their integration into energy systems. One of the main issues is the uneven energy production due to dependence on weather conditions, which creates difficulties in forecasting and load balancing. The intermittency of solar energy, such as periods without generation at night or during cloudy weather, also poses challenges for maintaining grid stability. Additionally, the large number of distributed energy sources can complicate grid management, particularly during emergencies. Energy storage to compensate for these fluctuations remains an expensive and complex task. Regulatory and technical barriers, as well as the lack of standards for connecting solar systems to the grid, also slow their development. All these factors call for new approaches to grid management and infrastructure development to ensure the efficient use of solar energy in distributed networks.

For the effective integration of generators into medium-voltage networks, it is necessary to reassess the operating parameters and characteristics of energy distribution. Therefore, conducting comprehensive research using advanced software is crucial. Such studies allow for data analysis, modeling of new distributed generation (DG) integrations, and accurately determining the behavior of the distribution network under steady-state conditions and in various scenarios. For each specific situation or network condition, parameters such as voltage and current can be precisely identified. Additionally, fault modeling can be performed to assess potential short-circuit currents that the transmission network and all protection, operation, and control equipment might encounter [2].

The technical evaluation of distributed energy systems involves several critical components. It starts with analyzing different types of distributed energy sources, including solar, wind, and bioenergy, to understand their technical features and potential applications. A key element is system integration, which emphasizes seamlessly connecting distributed energy with conventional power grids and microgrids using established technical standards and interface protocols.

Additionally, the design and optimization of energy management systems (EMSs) play a crucial role, integrating demand response strategies and energy storage solutions. The economic assessment focuses on determining the project's feasibility by examining return on investment, operational costs, and the influence of policy incentives, while also accounting for environmental impacts such as greenhouse gas emissions. Assessing technological maturity provides insights into market readiness and development progress. Moreover, safety and reliability assessments are essential for maintaining operational stability, and regulatory frameworks and standards significantly affect the adoption of these technologies. [3]

Another approach to the successful implementation of distributed generation is to focus on the efficient management of generation stations, ensuring stable and balanced network operation. This involves not only technological solutions but also clear regulation through legislative initiatives that promote the integration of renewable energy sources. Legislation can establish clear rules for connecting and operating such systems, setting standards that help reduce costs and improve resource efficiency.

Furthermore, it is essential to properly integrate new systems into existing energy infrastructures to avoid issues with grid stability and efficiency. To achieve this, modern technologies should be implemented to effectively coordinate the operation of various generators and reduce the intermittency of renewable energy sources, such as solar and wind power plants. In particular, automated control systems can provide optimal load management and predict changes in energy production. All these measures will contribute to increasing the share of "green" sources in the overall energy mix and ensure the resilience of the power system. A key aspect is the continuous improvement of the legislative and regulatory framework to support the further development of renewable generation in the future.

References:

1. Nadeem, T. B., Siddiqui, M., Khalid, M., & Asif, M. (2023). Distributed energy systems: A review of classification, technologies, applications, and policies. https://doi.org/10.1016/j.esr.2023.101096

2. Serrano Guerrero, X., Barragán-Escandón, A., & Clairand, J.-M. (2024, November 20). Transient and Steady-State Evaluation of Distributed Generation in Medium-Voltage Distribution Networks. Energies, 17, 5783. https://doi.org/10.3390/en17225783

3. Cheng, Q., Zhang, Z., Wang, Y., & Zhang, L. (2025). A Review of Distributed Energy Systems: Technologies, Classification, and Applications. Sustainability, 17(4), 1346. https://doi.org/10.3390/su17041346.

Section 02 Innovations in Engineering and Earth Sciences (Geology, Geodesy, Land Management, Geography, Archeology etc)

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Advanced Materials in Industry: Driving Innovation, Efficiency and Sustainability

1. Economic Imperative of Material Innovation

In today's industrial landscape, advanced materials have become strategic assets driving both performance and profitability. Industries now prioritize materials that deliver measurable economic returns through:

-Extended product lifecycles
-Reduced maintenance costs
-Improved energy efficiency

The aerospace sector demonstrates this perfectly with carbon fiber composites. These materials offer a strength-to-weight ratio five times superior to steel, enabling fuel savings so significant that Boeing calculates every kilogram reduced in aircraft weight translates to $3,000 in lifetime fuel cost reductions.

2. Durability Revolution in Heavy Industries

Corrosion-resistant materials are transforming capital-intensive sectors. Duplex stainless steels have become game-changers for offshore energy infrastructure, extending operational lifespans from 7 to 25+ years while slashing maintenance costs by 40%. Similar breakthroughs are occurring in construction, where self-healing concrete promises to reduce infrastructure repair budgets by up to 50%.

3. Next-Generation Materials Creating Markets

Emerging materials aren't just improving products - they're enabling entirely new categories. Graphene can be applied as:

-Ultra-fast charging batteries (5x faster than lithium-ion)
-Flexible electronics with 97.7% light transparency
-Water filtration systems with unmatched efficiency

Smart materials like shape-memory alloys are revolutionizing manufacturing. BMW's implementation in vehicle doors eliminated 12 assembly steps, saving €4.7 per car in their 3-series production line while improving reliability.

4. Sustainability as the Catalyst for Material Innovation

Sustainability is reshaping material science, driven by regulations, consumer demand, and corporate ESG goals. Eco-friendly materials are no longer optional, they are a competitive edge.

The packaging industry shows this shift clearly. Polylactic acid (PLA) bioplastics, made from renewable sources, now dominate a third of Europe's food packaging market despite higher costs. Their success comes from meeting strict plastic bans and consumer preferences for compostable solutions.

In automotive manufacturing, recyclable thermoplastics are cutting waste while improving efficiency. Tesla's battery designs, for example, use composites to reduce weight and simplify recycling. Similarly, cement alternatives with industrial byproducts lower carbon emissions while maintaining strength.

The next step is materials designed for circularity. New polymers can break down into reusable feedstock, turning waste into resources. As carbon pricing grows, these innovations will shift from premium options to industry standards—making sustainability key to long-term success.

5. The Future: Intelligent Material Systems

Material science is entering an era of built-in intelligence:

-Self-healing polymers that automatically repair damage

-Phase-change materials for dynamic thermal regulation

-AI-designed alloys with optimized properties

These innovations will increasingly incorporate circular economic principles, with materials designed for complete lifecycle management - from enhanced performance to effortless recyclability.

To sum up, advanced materials have evolved from passive components to active value creators. They simultaneously address engineering challenges, cost reduction targets, and sustainability mandates.

As industries face increasing pressure to do more with less, these materials will become the differentiators separating market leaders from followers. The companies that master material innovation will gain unprecedented control over their product performance, environmental impact, and ultimately - their bottom lines.

References

1. Ashby, M.F. (2021). *Materials Selection in Mechanical Design*. Elsevier.
2. Boeing Technical Report (2023). *Composite Materials in Commercial Aviation*.
3. *Offshore Technology Journal* (2022). Corrosion Solutions for Marine
4. Environments.*Nature Materials* (2023). "Graphene Applications in Energy Storage."
5. Samsung White Paper (2023). *Next-Generation Battery Technology*.
6. *Automotive Engineering International* (2022). Smart Materials in Vehicle Production.

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Geological Landmarks of the Dnipropetrovsk Region as a Potential for Tourism Development

One of the modern challenges for humanity is the preservation and restoration of natural resources. With the development of technological processes, the growth of agglomerations, the construction of new factories and plants, this issue is becoming increasingly relevant.

Geotourism is a relatively new branch of ecological tourism. This term was first introduced by British researcher Thomas Hose. Geotourism represents a combination of aesthetic impressions with the acquisition of knowledge about the area and the geosystem visited by tourists [3].

The main missions of geotourism are nature conservation and obtaining geological and historical information about the area. Geotourism focuses on exploring the uniqueness of the region's relief features, preserving geological natural monuments, and studying history and geography [1].

The present study investigates the potential of geological landmarks in the Dnipropetrovsk region for the development of tourism. It is hypothesised that a focus on natural objects would lead to a revitalisation of the tourism sector in the region.

The Dnipropetrovsk region is located in the eastern part of the Ukrainian Shield, which determines the presence of crystalline rock outcrops, significant ore deposits, as well as aesthetically attractive natural formations such as cliffs, canyons, and exposures.

The method employed encompassed a comprehensive analysis of extant scientific literature and regional geological tourism resources. Currently, there are 38 geotouristic sites in the Dnipropetrovsk region [2]. Most of these landmarks are located in the area of the Kryvyi Rih iron ore basin and in the valley of the Dnipro River and its major tributaries.

The Kryvyi Rih iron ore basin is the largest in Ukraine in terms of iron ore reserves and one of the largest in the world. The layers of iron quartzites represented in the Kryvyi Rih basin not only allow the study of geological processes but also serve as a visual demonstration of mineral formation for tourists [4].

The Nikopol manganese ore deposit is one of the largest in the world and is therefore important for the industrial sector as well as for educational tourism.

In addition to industrial deposits, the Dnipropetrovsk region also has many natural geological formations: Orlyne Hnizdo (MOPR Cliffs), Mavrynskyi Maidan, Tokiv granites (Tokiv massif), Monastyrski cliffs, etc.

Each of these objects is a unique geological monument and has the potential to become a popular place for excursions, hiking, historical lectures, or other types of active or educational tourism, including:

- Industrial tourism: visiting active or abandoned quarries and mines;
- Active tourism: hiking and expeditions;
- Ecological tourism: based on harmonious coexistence between humans and nature;
- Scientific and educational tourism: focused on gaining knowledge about the territories visited.

The results obtained show that these natural sites have a high capacity for attracting various categories of tourists. The study provides strong evidence that geological tourism can become a driver of regional development.

Currently, the level of tourism in the Dnipro region has declined due to objective reasons. Some sites that once had industrial-tourism status have been damaged or destroyed. The aim of this study was to highlight natural geotourism landmarks as those that can provide a stimulus for tourism development in the region, attract tourists, investments, labor resources, and support the Ukrainian economy.

References:

1. Dowling, R. K. (2013). Global Geotourism – An Emerging Form of Sustainable Tourism. Czech Journal of Tourism, 2(2), 59-79
2. Heolohichni pamiatky Ukrainy (za red. V.I. Kalinina, D.S. Hurskoho). V chotyrokh tomakh. Kyiv, 2007. Tom II. 320 s.
3. Hose, T.A. (1995). Selling the Story of Britain's Stone. Environmental Interpretation, 10(2), 16-17.
4. Sicheslavshchyna : kraieznavchyi almanakh. Vyp. 4. Skarby Prydniprovskoho stepu / red. K.H. Shvydko. – Dnipropetrovsk : [DOUNB], 2002. - 87 s.

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Innovative Technologies For Lithium Extraction From Alternative Sources: Prospects And Implementation Possibilities In Ukraine

In the context of rapid development of electromobility and renewable energy, lithium has become one of the most strategically important metals of our time. Its unique electrochemical properties make it an irreplaceable component in the production of lithium-ion batteries - a key element of modern energy storage systems. According to forecasts, global lithium demand will increase 6-10 times by 2050 compared to current levels, primarily due to the expansion of the electric vehicle market and stationary energy storage systems.

Traditional lithium sources, such as mineral raw materials and salt lakes, can no longer fully meet the growing demand, and their development is often associated with significant negative environmental impact. This drives the search and development of innovative technologies for lithium extraction from alternative sources, among which geothermal waters, oil field produced waters, and technogenic brines attract particular attention.

For Ukraine, which has significant potential in alternative lithium sources, the development of extraction technologies has strategic importance for meeting domestic needs in critically important raw materials and strengthening energy independence. In this paper, we examine modern technological solutions for lithium extraction from alternative sources and evaluate the prospects for their implementation in Ukraine.

A recent review by Saleem et al. provides a comprehensive analysis of direct lithium extraction (DLE) technologies and their potential applications in lithium-ion battery recycling processes [1]. As emphasized in this work, the supply of lithium from secondary sources will play a crucial role in meeting the growing demand from electric vehicles (EVs). The European Union has set ambitious recycling targets, aiming to achieve 50% lithium recycling by 2030 and 80% by 2035, requiring efficient extraction technologies.

The authors systematically evaluated various DLE technologies, including solvent extraction, ion-exchange resins, adsorption, nanofiltration, and electrochemical lithium pumping [1]. Their findings indicate that the optimal pre-treatment route for the lithium recycling process from EVs should be determined based on lithium recovery rates and losses through various combinations of dry and wet grinding followed by flotation for anode and cathode separation. This analysis showed that the combination of flotation with dry grinding was the most efficient process, minimizing lithium losses during pre-treatment stages.

The study provides particularly valuable information regarding the selectivity of various DLE methods when applied to recycling streams containing several competing ions. The authors identified ion-exchange resins, nanofiltration, and solvent extraction as the most promising options for selectively recovering lithium from complex battery waste streams.

Nikkhah et al. present a detailed comparison of traditional and novel lithium extraction technologies from alternative sources, including seawater, produced waters, geothermal brines, and salt lakes [2]. Their quantitative comparative analysis of all technologies considered factors such as cost, commercial maturity, operational lifespan, and environmental impact.

An important conclusion from this study is that DLE technologies, characterized by higher selectivity and reduced environmental impact, show significant potential for extracting lithium from geothermal brines. In contrast, membrane processes are identified as more suitable for seawater and salt lake brines, offering cost-effective options despite challenges with selectivity and membrane fouling.

The authors provide a comprehensive analysis of various lithium extraction methods from alternative sources, exploring both laboratory experiments and large-scale industrial processes. Their research on solvent extraction, chemical precipitation, and membrane processes shows that each technology has specific advantages for particular types of raw materials. For example, solvent extraction systems using tributyl phosphate (TBP)-$FeCl_3$ as a co-extractant demonstrated 99.42% lithium recovery from salt brine, highlighting the efficiency of this technology for high-concentration sources.

The study emphasizes that geothermal and salt lake brines could potentially provide a global lithium production capacity of over 1 million metric tons LCE per year by 2025, which could help meet short-term demand despite various environmental and social challenges faced by some lithium extraction projects.

A promising technology to consider for implementation in Ukraine is electrochemical lithium extraction. As described in a recent study by Li et al. in their article "Electrochemical Lithium Extraction from Brines: Principles, Materials, and Engineering Perspectives," this method uses electrical potential to selectively extract lithium ions through specialized membranes or electrodes [3]. Key advantages of this approach include minimal chemical consumption, reduced environmental impact, and the ability to operate continuously. The process can be powered by renewable energy sources, making it particularly suitable for integration with Ukraine's growing renewable energy sector. Additionally, the modular nature of electrochemical systems allows for scalable implementation that can be adapted to different lithium concentrations found in Ukrainian resources.

The technical details provided in the reviewed articles reveal critical aspects of the practical implementation of DLE technologies. Schematic representations of various DLE methods demonstrate the fundamental principles underlying each extraction approach.

For solvent extraction, the mass transfer operation is based on the immiscibility of the solvent and aqueous phase, where an organic solvent with extractants is mixed with the lithium-containing aqueous stream. Extraction efficiency significantly depends on pH control, with studies showing that lithium can be selectively extracted at levels exceeding 94% at alkaline pH (>12).

Ion-exchange resins function through specific functional groups (typically sulfonated polymers) that have higher selectivity for lithium ions. They can achieve high concentration factors when properly optimized. Studies have shown that most commercial organic ion-exchange resins lose their selectivity for lithium in the presence of competing cations, but certain inorganic adsorbents such as H_2TiO_3 (hydrogen titanate), aluminum hydroxides, and manganese oxides have demonstrated promising selectivity [1, 2].

Membrane technologies, including nanofiltration (NF) and reverse osmosis (RO), offer possibilities for continuous operation but face challenges with membrane fouling and pressure requirements. Electrochemical lithium pumping represents an innovative approach with separate capture and release cycles, potentially achieving high selectivity for lithium compared to competing ions [1, 3].

Ukraine has significant potential for implementing DLE technologies due to its geological resources and industrial infrastructure. Based on the reviewed literature, several approaches may be particularly relevant to Ukrainian conditions. Western regions of Ukraine, especially the Carpathian Basin, have geothermal potential that could be explored for lithium content. As noted by Nikkhah et al., geothermal brines are an attractive alternative to traditional ores with less environmental impact, comprising 62% of total lithium resources in some regions. Ukraine's rich mining history has resulted in significant amounts of technogenic waste that could potentially contain lithium suitable for extraction. The DLE technologies discussed by Saleem et al. could be adapted to extract lithium from these secondary sources. Various Ukrainian industries produce wastewater that may contain lithium. Implementing ion-exchange or adsorption technologies could simultaneously address environmental issues and recover valuable lithium resources. With the increasing number of electric vehicles, creating infrastructure for recycling lithium-ion batteries in Ukraine would comply with European

directives and create a domestic secondary source of lithium. The optimal pre-treatment and extraction methods identified by Saleem et al. could serve as the technical basis for such facilities.

The reviewed technological solutions for extracting lithium from alternative sources demonstrate significant potential for application in Ukraine. Direct lithium extraction methods offer more environmentally friendly alternatives to traditional mining operations, potentially providing access to previously untapped lithium resources.

However, successful implementation of these technologies in Ukraine will require further research to adapt these methods to specific local conditions. Several key factors need to be addressed: comprehensive assessment of potential lithium-containing resources in Ukraine, including geothermal waters, oil field brines, and technogenic waste; pilot testing of the most promising DLE technologies under Ukrainian conditions; economic analysis considering local infrastructure, energy costs, and market conditions; development of a regulatory framework to support sustainable lithium extraction; integration with existing industries to create synergistic relationships.

Although the technological solutions presented in the reviewed articles are promising, their practical implementation in Ukraine will require a coordinated approach involving scientific research institutions, industrial partners, and government support. Further research focusing specifically on Ukrainian resources and conditions is essential for determining the most suitable extraction methods and establishing a sustainable lithium production sector in the country.

References:

1. Saleem, U., Wilhelms, A., Sottmann, J., Knuutila, H. K., & Bandyopadhyay, S. (2023). Direct lithium extraction (DLE) methods and their potential in Li-ion battery recycling. Separation and Purification Technology, 121215.
2. Nikkhah, H., Ipekçi, D., Xiang, W., Stoll, Z., Xu, P., Li, B., & McCutcheon, J. R. (2024). Challenges and opportunities of recovering lithium from seawater, produced water, geothermal brines, and salt lakes using conventional and emerging technologies. Chemical Engineering Journal, 486, 152549.
3. Li, Y., Zhang, Q., Zhang, L., & Li, J. (2023). Electrochemical Lithium Extraction from Brines: Principles, Materials, and Engineering Perspectives. Advanced Energy Materials, 13(15), 2203489.

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Modern Approaches In Geological And Geochemical Exploration For Skarn Deposits And Rare Earth Elements: A Comprehensive Review

The exploration and discovery of mineral resources, particularly skarn deposits and rare earth elements (REEs), represent a cornerstone of modern economic development. As easily accessible deposits become depleted, the mining industry faces increasing challenges in identifying new resources, especially those in complex geological settings or at greater depths. This review aims to synthesize and evaluate the current state of geological and geochemical exploration methodologies that have evolved to address these challenges.

The significance of this topic cannot be overstated in today's context. Rare earth elements have become indispensable in numerous high-technology applications, from renewable energy technologies to advanced electronics and defense systems. Similarly, skarn deposits, which often host valuable metallic minerals including copper, gold, and tungsten, continue to be vital sources of these essential resources. The growing global demand for these materials, coupled with their strategic importance in industrial and technological sectors, underscores the need for more effective and reliable exploration techniques.

Recent decades have witnessed significant advancements in exploration methodologies, integrating traditional geological approaches with cutting-edge technologies such as remote sensing, 3D modeling, and sophisticated geochemical analysis. These integrated approaches not only enhance the accuracy of deposit identification but also provide deeper insights into the genesis and evolution of mineralization systems. Understanding these formation processes is crucial for developing predictive models that can guide exploration efforts toward concealed or previously overlooked deposits.

This review seeks to examine the full spectrum of modern exploration methods, evaluating their effectiveness, limitations, and complementary applications in the context of skarn deposits and rare earth elements. By analyzing case studies and recent research findings, we aim to identify the most promising approaches for future exploration activities, contributing to more efficient and sustainable resource discovery practices in an era of increasing mineral demand and complex extraction challenges.

Modern geological and geochemical exploration methods have evolved significantly to address the challenges of discovering increasingly elusive mineral deposits. The integration of traditional field techniques with advanced technologies has revolutionized how geologists approach the exploration of skarn deposits and rare earth elements.

Skarn deposits represent an important resource for sustainable economic development worldwide. These deposits have been explored in recent years using diverse methodological approaches, including clarifying genetic processes, geochemistry, and geophysical techniques [1]. However, conventional geological methods have often proven incomplete, necessitating the development of a comprehensive scientific methodology.

Remote sensing techniques have demonstrated remarkable effectiveness in geological mapping and mineral exploration. Satellite imagery provides valuable data that can be analyzed to identify surface features and spectral characteristics of altered and mineralized zones. Combining geochemical and petrographic survey data with remote sensing helps determine anomaly and prospective zones, particularly for elements in surface dispersion halos [1]. This integration of methods clarifies the sources of magmatism and evolutionary processes in skarn mineralization and associated minerals.

Three-dimensional modeling has emerged as a critical tool in modern mineral exploration. As Ibrahim and Kotel'nikov note, "Geophysics can provide vital input for mineral exploration and understanding of skarn models improvements" [1]. These 3D models integrate geological and geophysical data to accurately represent ore deposits and the mechanisms of ore-forming fluids. Examples shown in their research illustrate how predictive models of sedimentary fans in SEDEX deposits and 3D models of ore zone occurrence can significantly enhance exploration success rates [1].

Metallogenic theories integrated with different methods provide key insights into mineralization genesis and indications of rare elements existence. The application of geophysics methods has proven particularly effective for mineral resources in recent years [2]. Investigation methods exploring relationships between mineralization, genesis, geology, geochemistry, and general features of skarn deposits have yielded valuable insights into magma and fluid sources.

Geostatistical analysis has become increasingly important in exploration geochemistry. As highlighted in recent research, "Geostatistical analysis will be applied to support the results using many techniques which take into account locality associated with objects in cluster analysis" [3]. These methods transform observations into meaningful quantitative relationships among members of individual groups or distinguishable from members of other groups across years. Multivariate statistical analysis is widely utilized in exploration geochemistry for various purposes, particularly with data that consists of sets of some sets of measurements on a variety of individual samples or objects [3].

The application of factor and cluster analysis techniques to geochemical data from study areas helps understand the predominant element associations responsible primarily for mineralization and ore deposits environment. Geochemical background based on pathfinders and multivariate statistical methods have been used extensively in geochemical exploration, bedrock mapping, and the identification of pathfinder elements for numerous deposits [3].

Integration of geophysical modeling with field observations provides crucial insights into genetic exploration models. As demonstrated by various researchers, gold genetic models based on ore-forming sources—whether metamorphic models with low-depth crustal sources, hydrothermal models from intermediate depth, or metamorphic models [2]—serve as valuable frameworks for predicting mineralization potential. These models clearly articulate the ore-forming mechanism and the metallogeny of ore mineralization, having significant impact in executing prospecting about potential ore for mineral extraction.

Understanding more about elemental systems and their mobilization requires comprehensive regional area studies. Dispersion halos and altered rock provide vital insights about mineralization distribution; therefore, holistic genetic models address not only metallic ore gold deposits prediction but also rare earth elements associated with these mineralization processes [2].

Multiple geological exploration methods such as geochemistry, geophysics, and remote sensing, when combined with field observation, provide comprehensive insights about genetic exploration models and deeper understanding of mineralization mechanisms. The integration of these approaches not only enhances the accuracy of deposit identification but also contributes to more sustainable and efficient resource discovery practices in an era of increasing global demand for strategic minerals.

References

1. Ibrahim, M.A.E., & Kotel'nikov, A.E. (2022). Geological and Geochemical exploration methods for mineral resources (skarn deposits and rare earth elements). Earth sciences, 2(66), 7-15.
2. Li, J., & Zhang, Y. (2020). Advances in geophysical modeling for mineral exploration: Focus on skarn deposits. Journal of Applied Geophysics, 175, 104-112.
3. Wang, H., & Chen, Q. (2021). Geostatistical approaches to rare earth element exploration: Methods and applications. Ore Geology Reviews, 128, 103856.

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Forecasting and early detection of high-deformation zones, recommendations for the reuse of workings

The current state of the mining industry in Ukraine, particularly in the Western Donbas region, is characterized by an urgent need to enhance the efficiency and safety of coal extraction, making the reuse of mine workings a promising direction that can significantly reduce costs and improve work safety amidst the long-term process of decarbonizing the energy sector. However, the deterioration of mine workings over time leads to increased expenses for their maintenance and repair, as well as elevating the risk of injuries, with up to a quarter of mine accidents being related to the condition of these workings.

Existing traditional monitoring methods, such as visual inspections and geodetic measurements, are rather labor-intensive and do not provide the necessary accuracy for effectively controlling the condition of workings intended for reuse. Therefore, there is a need to implement modern monitoring technologies, including electronic methods and 3D scanning, which offer higher precision and productivity; among the 3D scanning methods, laser triangulation and structured lighting are particularly noteworthy, each with its specific advantages and disadvantages regarding accuracy, scanning speed, and sensitivity to environmental conditions.

An effective system for the early detection of deformations in mine workings intended for reuse should include several key components: firstly, the optimal collection of data on the condition of the workings using modern technologies such as laser scanning, electronic sensors, and wireless systems, ensuring the acquisition of large volumes of real-time data while considering the complex conditions of the mine environment; secondly, modeling and forecasting using artificial intelligence (AI), for example, neural networks, to analyze the collected data, identify complex dependencies, and perform highly accurate deformation forecasting, which is significantly more efficient than traditional methods; and thirdly, the generation of practical recommendations based on the obtained data and forecasts regarding the selection of optimal support methods, the development of repair schedules, and the implementation of early warning systems for potential hazards.

In the global mining industry, there are already successful examples of integrating 3D technologies for monitoring the condition of mine workings, and for effective deformation forecasting, 3D scanning must be used in conjunction with numerical methods and artificial intelligence for in-depth analysis of the obtained models; future scientific research should focus on developing a comprehensive approach to forecasting deformations and generating recommendations for mine workings intended for reuse, with mandatory consideration of the specific conditions of the Western Donbas mines.

The implementation of such a comprehensive approach is expected to lead to increased efficiency in the reuse of mine workings, the provision of a higher level of safety for miners, a significant reduction in infrastructure maintenance costs, and the minimization of negative environmental impact.

References:

1. Про схвалення Енергетичної стратегії України на період до 2050 року : Розпорядження Кабінету Міністрів України від 13 квітня 2023 р. № 605-р. URL: https://zakon.rada.gov.ua/laws/show/373-2023-%D1%80#Text
2. Кобзар, Ю.І. Обґрунтування параметрів перекріплення горизонтальних виробок глибоких шахт в обводнених породах: автореф. дис. ... канд. техн. наук: 05.15.04. Алчевськ: Донбаський ДТУ МОН України, 2009. 17 с.
3. GMK Center. П'ять ключових трендів розвитку гірничодобувної галузі України у 2023 році. URL: https://gmk.center/en/opinion/five-key-trends-in-the-development-of-ukraines-mining-industry-in-2023/
4. Global Energy Monitor. URL: https://globalenergymonitor.org/projects/global-coal-plant-tracker/
5. Brunel. Гірничі тренди 2024. URL: https://www.brunel.net/en/blog/mining/mining-trends-2024

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3D Scanning and CAD Technologies in Dental Prosthetics

Despite technological progress, many dental prosthetics still suffer from poor durability and inaccurate fitting. This often results in discomfort for patients and frequent replacements, which can be both costly and inconvenient. Traditional methods rely on manual impressions, which may not always capture the precise structure of a patient's mouth, leading to ill-fitting prosthesis. To address these challenges, experts are turning to digital technologies that can offer more reliable and efficient solutions. Therefore, the role of biomedical engineering in this area is becoming more essential than ever.

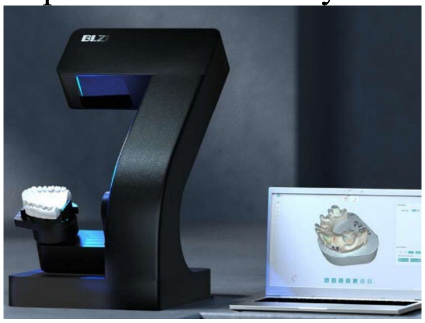
One of the most significant modern advancements in the field of prosthetics is the integration of 3D scanning and computer-aided design (CAD) technologies. These innovations provide a precise and efficient approach to manufacturing prosthetic devices, ensuring better fit, comfort, and longevity for patients meeting the increasing demand for high-quality dental care,

Innovative Approaches to Dental Prosthetics

1. **Advanced Materials.** For strength and longevity, metal crowns are a reliable option, especially for back teeth. However, for aesthetic appeal and biocompatibility, zirconia or all-ceramic crowns are superior, particularly for front teeth. Zirconia crowns stand out as a top choice due to their combination of durability and aesthetics, making them a preferred solution in modern dentistry.

2. **3D Scanning and CAD Technology.** In the field of biomedical engineering, digital tools like 3D scanning and CAD modeling are transforming the way prosthetics are designed and produced. These technologies allow for highly customized solutions, tailored to the specific needs of each patient. Moreover, digital workflows significantly reduce production time and improve overall efficiency in dental laboratories. By leveraging these innovations, professionals can ensure a higher standard of patient care and treatment outcomes.

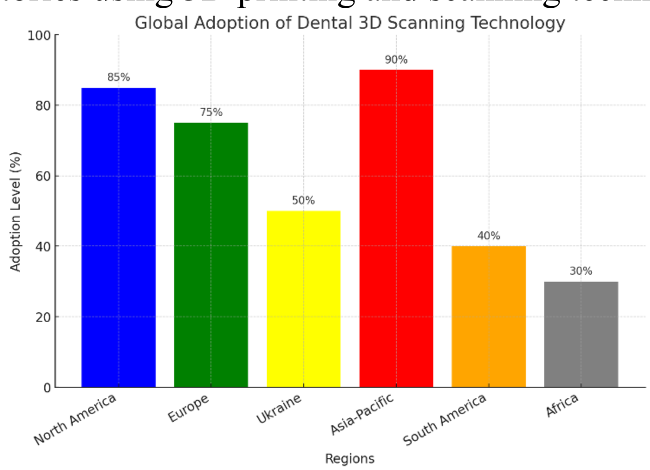
The picture below demonstrates BLZ Dental LS100, an advanced 3D scanner that improves the accuracy and speed of dental prosthetics production.



The key characteristics of this 3D scanner include:

- High Precision: up to 8 microns, meeting ISO 12836 standards.
- Fast Scanning: a full arch scan takes 10 seconds, and a complete workflow is done in 2 minutes.
- Color Scanning: helps match tooth shades and textures.
- Multi-Object Scanning: scans multiple items simultanuously, saving time.

The following bar chart compares the use of 3D dental technology in different regions, including Europe and Ukraine. It shows the percentage of dental clinics and laboratories using 3D printing and scanning technologies.



According to this data the Asia-Pacific Region has the highest percentage with around 90% of dental facilities using 3D technologies. This means that modern digital tools are widely accepted and integrated into dental care in this region. In North America and Europe this percentage is also high, showing strong adoption of 3D printing in the developed countries.

In Ukraine, the percentage is lower, at about 50%. Though the country is actively adopting digital dentistry, traditional methods are still more common. The main reasons for slower adoption are high equipment costs, lack of specialists, and the need for more training programs. However, the situation is improving as more dental clinics start using 3D scanners and printers. South America and Africa demonstrate a growing trend due to new investments.

Overall, the chart highlights that 3D dental technology is very popular in the countries with the developed economy where investments in technology are always much higher. At the same time, some developing regions, like Ukraine and South America, still face challenges in its full implementation due to the lack of financial resources and professional training. More investment in education and technology can help improve the situation.

Another problem is data privacy. When a body is scanned, sensitive digital information is created. This data must be properly protected both technically and legally. Also, sometimes scanners are not very accurate, and this can cause mistakes.

Therefore, the introduction of 3D scanning and CAD technologies has revolutionized the dental industry, offering a new level of precision and quality in prosthetic manufacturing. As biomedical engineering continues to evolve, these innovations will play an even greater role in improving the functionality and comfort of dental prosthetics. Investing in advanced digital tools is not just a step forward for dentistry, it is a significant advancement in patient care.

References

1. What to look for in laboratory dental 3D scanner. Internet source. Available at: https://www.blz-dental.com/what-to-look-for-in-laboratory-dental-3d-scanner-ls100-l/
2. Innovations in dental technology: what to expect in the future. Internet resource. Available at: https://truesmileworks.com/innovations-in-dental-technology-what-to-expect-in-the-future/#:~:text=AI%20is%20poised%20to%20play,health%20conditions%20with%20remarkable%20precision.
3. The frequency of dental material use for fixed prostheses. Internet resource. Available at: https://pubmed.ncbi.nlm.nih.gov/35003771/
4. Martelli, N. et al. (2016). Advantages and disadvantages of 3D printing in surgery: A systematic review. Surgery, 159(6), 1485–1500. https://doi.org/10.1016/j.surg.2015.12.017
5. Klein, G. T., Lu, Y., & Wang, M. Y. (2013). 3D printing and neurosurgery—ready for prime time? World Neurosurgery, 80(3-4), 233–235. https://doi.org/10.1016/j.wneu.2012.07.041

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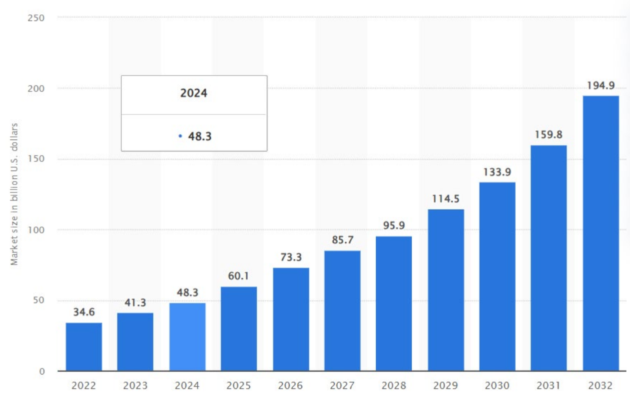
Biomedical Engineering In Regenerative Medicine

Injuries, diseases, and age-related changes lead to damage and loss of tissues and organs. The biggest problem is that traditional transplantation has limitations connected with the lack of donor organs, the risk of rejection and complications. But modern regenerative medicine potential can fundamentally change the way of improving human health by restoring, maintaining and improving organ and tissue functions by means of therapeutic cloning, 3D bioprinting and cell therapy.

The regenerative medicine modern market is growing rapidly. The chart below shows the forecast of the regenerative medicine market worldwide which demonstrates an expected growth to over 190 billion U.S. dollars by 2032 [5].



In general, regenerative medicine consists of various directions. The first innovative field deals with *stem cells*, which are considered the cornerstone of this field due to their unique ability to renew and differentiate into different types of specialized cells. Their extraordinary potential lies in their ability to repair, replace and regenerate damaged tissues and organs in the body. Stem cells can be grown in a laboratory where they are manipulated to grow into specific cell types – heart muscle cells, nerve cells, or blood cells. These cells are implanted into a patient repairing muscles and tissues that are injured or dysfunctional.

Stem cells used for cell therapy can be divided into three categories: pluripotent stem cells (PSCs), adult stem cells (ASCs) and cancer stem cells (CSCs). PSCs include embryonic stem cells (ESCs), epiblast stem cells (EpiSCs), embryonic germ cells (EGCs) and induced pluripotent stem cells (iPSCs), which are obtained by direct reprogramming of postnatal/adult somatic cells in vitro.

ASCs, having more limited self-renewal and differentiation potential, replace lost cells or promote cell healing or growth, giving rise to progenitor cells and, ultimately, differentiated cells.

CSCs are found in solid and blood tumors and derived from normal stem or progenitor cells by means of mutations, gene transfer, epigenetic changes, and microenvironmental factors. CSCs possess self-renewal, differentiation, metastasis, and immunosuppressive properties and play an important role in cancer growth, metastasis, relapse, and resistance to chemotherapy and radiation therapy.

The second area is *tissue engineering* that refers to combining scaffolds, cells and biologically active molecules into functional tissues. Its goal is to assemble fully functional constructs that restore or improve damaged tissue or a whole organ. The cells used to grow tissue can be obtained from the patient, another donor, or other biological sources. To enable these cells to grow and form the needed structure, they are planted on special scaffolds - three-dimensional matrices made of biocompatible materials such as collagen or synthetic polymers. The ideal scaffold has biocompatibility, non-toxicity, biodegradability, adequate physical and mechanical properties, ability to promote cell adhesion and maintain cells metabolic functions.

The process of creating a tissue implant consists of selection and cultivation of a cellular material; development of a matrix based on biocompatible materials; application of cell culture to the matrix and cell multiplication in a bioreactor with special cultivation conditions; direct implantation of the graft into the affected organ.

The third area is *3D bioprinting*, a state-of-the-art technology for manufacturing biological structures with a hierarchical architecture similar to their native counterparts. The development of living functional tissues by artificial means can satisfy the unmet need for tissue replacement and organ transplantation.

The overall process of 3D bioprinting can be accomplished through three separate steps: pre-bioprinting, bioprinting, and post-bioprinting. The initial stage includes model formation and materials selection. It begins with the extraction of a tissue biopsy, providing the biological model to be reproduced. At this stage, computer tomography (CT) or magnetic resonance imaging (MRI) are used. The images obtained are reconstructed to produce 2D images. The required cells are selected and multiplied. The cell mass is mixed with oxygen and other nutrients to keep them viable.

The second step is the actual bioprinting process, where the bioink is placed in the printer to form the 3D structure. The mixture of cells, nutrients and matrix, forming the bioink, is then placed on the printer cartridge, which applies the material based on the prepared digital model. The formation of biological structures involves depositing bioink onto a scaffold in a layer-by-layer approach to create a three-dimensional tissue structure. It is a complex process, as it requires the formation of different types of cells depending on the type of tissue and organs to be formed.

Post-bioprinting is the last step, which is important to ensure the stability of the printed structure. Physical and chemical stimulations are required to preserve the structure and function of biological matter. These stimulations provide signals to cells to reorganize and support tissue growth. The absence of this step leads to the material structure disruption, which then affects the functioning of the material.

3D bioprinting is divided into several types. *Extrusion-based 3D bioprinting* uses either semi-solid extrusion or fused deposition modeling. It is widely used in various biomedical sectors and allows for the production of models that mimic soft tissue and bone structures, which in turn enables possible implants.

Inkjet-base bioprinting is a non-contact method based on the ejection of liquid droplets onto a substrate using thermal, electrostatic, or piezoelectric forces. This technique is relatively more affordable and compatible with living materials. *Pressure-assisted bioprinting* is based on extruding biomaterials from a printer nozzle to make a three-dimensional biological structure that allows room temperature processing and direct incorporation of homogeneous cells onto a substrate. *Laser-assisted bioprinting* applies biomaterials to a surface using a pulsed laser beam as an energy source.

However, despite its rapid development, there are still key challenges and knowledge gaps in the field of regenerative medicine. The main one is immunological compatibility - the body is not always able to accept stem cells or cell therapy without the risk of rejection. Another critical issue is safety: cells derived from stem cells must be genetically stable and not pose a risk of tumor formation after transplantation. The production of cell therapies also remains a problem, requiring a controlled, standardized and cost-effective process, especially in cases of scale-up. In addition, regenerative medicine is accompanied by ethical challenges, including the use of embryonic cells, compliance with international restrictions on embryo experimentation, and ensuring reasonable patient access to experimental treatments. Embryos have a moral status that is sometimes critical because different countries have different rules regarding the use of embryos.

To sum up, regenerative medicine based on stem therapy, tissue engineering and 3D bioprinting is a revolutionary approach to treating tissue damage and repairing organs. These technologies offer promising alternatives to traditional methods such as transplantation, providing personalized solutions with a lower risk of rejection and greater accessibility. Despite the challenges of clinical application, high research costs, and ethical constraints, constant research is pushing the boundaries of what is possible in regenerative medicine. Further developments in these technologies have the potential to revolutionize healthcare by enabling the repair of human tissues and organs with precision and efficiency.

References:

1.Mao, A. S., & Mooney, D. J. (2015). Regenerative medicine: Current therapies and future directions. Proceedings of the National Academy of Sciences. https://www.pnas.org/doi/10.1073/pnas.1508520112

2. Harvard Stem Cell Institute (HSCI). "What Are Drugs? 5: Cell Therapies." Available at https://www.hsci.harvard.edu/translation/what-are-drugs-5-cell-therapies
3. Wang, C., Huang, X., Wu, Y., Li, X., & Wu, Y. (2022). Advances in 3D bioprinting for tissue engineering. International Journal of Molecular Sciences. https://www.sciencedirect.com/science/article/pii/S2772665722000010
4. Papaioannou, T. G., Manolesou, D., Dimakakos, E., Tsoucalas, G., Vavuranakis, M., & Tousoulis, D. (2019). 3D bioprinting methods and techniques: Applications on artificial blood vessel fabrication. Journal of Clinical Medicine https://pmc.ncbi.nlm.nih.gov/articles/PMC6533576/
5. Global market size for regenerative medicine https://www.statista.com/statistics/800676/global-market-volume-for-regenerative-medicine

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The relevance of assessing the reliability of geodetic networks

Reliability became a separate industry in 1950. At that time, scientific schools with a certain methodology were formed, scientific literature on the reliability of technology appeared, as well as the first Reliability Assessment Standards [1-6]. Scientific schools dealt with the issue of reliability assessment, the study of failures and factors affecting the failure of technical systems.

The concept of reliability is complex and, according to DSTU 2860-94 [1], has the following properties: durability, reliability, maintainability, and availability.

Readiness, unlike other properties, is inherent only to renewable technical systems.

The relevance of the problem of reliability assessment is currently significantly increasing due to the complexity of technical systems. Reliability analysis methods are used to predict the reliability, durability, maintainability, availability of technical systems and measures to ensure the safety of the facility, as well as to compare the consequences of the prediction with the specified requirements. The use of quantitative methods of reliability analysis allows:

– determine quantitative reliability indicators and establish the possibility of meeting reliability level requirements;

– perform a comparative analysis of the reliability of several designed options;

– predict and optimize reliability taking into account established requirements, maintenance and repair strategies, and measures taken to improve reliability.

It has been established that 40-45% of failures occur due to errors in the design of technical systems or devices; 20% – failures due to production errors; 30% – errors during operation by service personnel; 5-7% – failures due to degradation of materials during operation and storage of devices and elements (aging of elements, temporary failures). Therefore, the largest number of failures occurs at the design stage of technical systems, and to eliminate them, it is important to perform a preliminary reliability assessment when the system doesn't yet exist.

Preliminary reliability assessment of various technical systems is performed in various fields of science and technology. It allows, at the stage of system design, to calculate predicted reliability indicators and select the optimal technical system variant among the proposed technical projects.

Currently, there are standards that contain general requirements and provisions for calculating reliability, durability, maintainability, etc. at the design stage. Based on state standards, industry-specific regulatory and methodological documentation is being developed for reliability calculation methods for a specific technical system.

Geodetic networks (GN) are also technical systems that, at first glance, can be attributed to static technical systems. However, such assumptions are erroneous, since over time the spatial position of geodetic points shifts under the influence of both man-made and natural factors.

Specialized Standards for assessing the reliability of telecommunications and radio-electronic systems (MIL-217, PRISM, FIDES, etc.) contain formulas for calculating failure rates for ideal conditions and for real conditions (taking into account the influence of various factors). However, the formulas given in these Standards are oriented towards radio electronic devices, contain a set of specific influence factors and cannot be applied to geodetic networks. Therefore, there is a need to develop criteria with the selection of appropriate coefficients to correctly take into account the failure intensity of geodetic points. Although this approach of taking into account the complex influence of various factors on the functioning of the geodetic network requires a lot of resources to perform calculations, at the GN design stage it allows you to identify the real values of the failure intensity of geodetic points, obtain the total value of the failure intensity, and knowing it, you can obtain the average operating time before failure or the probability of failure-free operation.

Preliminary reliability assessment of GN is the process of calculating predicted reliability indicators: total failure rate (λ), mean time to failure (MTTF), and probability of failure-free operation R(t) for a given operating interval as a set of predicted failure indicators of components, taking into account the modes and conditions of their operation, the environment, etc. As a result of a preliminary assessment of the reliability of the GN at the design stage, quantitative reliability indicators are obtained and the ability to assess how well the GN reliability assurance measures proposed at the design stage meet the technical requirements. At the same time, a preliminary reliability assessment allows for a comparison between different designed GN schemes and the selection of the most appropriate option. The purpose of a preliminary reliability assessment of GN is:

- determining the potential (fail-free operation) of the GN to meet the requirements for its reliability;
- life cycle cost assessment of GN;
- identification of GN components (geodetic points), the failure of which leads to a loss of GN reliability;
- the ability to select optimal values of reliability indicators, maintainability and inspection (repair) intervals of GN to achieve a given level of readiness.

Factors that determine the accuracy of the preliminary assessment of GN reliability include:

1. relevance of data on failure rates and selected environmental factors;
2. accuracy of the mathematical model.

The failure rate of GN under ideal conditions (without the influence of various factors) can be calculated by the formula:

$$\lambda_j = \sum_{i=1}^{n} \lambda_i \tag{1}$$

where λ_j – is the failure intensity of the i-th element (geodetic point) according to the averaged long-term observations of the j-th geodetic network;

n – number of elements of the jth geodetic network.

In this case, the total intensity of GN failures will be:

$$\Lambda = \sum_{k=1}^{m} \lambda_{jk} \tag{2}$$

In real conditions, when predicting the failure rate of GM, we recommend taking into account a number of factors whose influence reduces reliability, but at the same time it is possible to obtain real values of the failure rate of geodetic networks. The formula (3) proposed by the authors allows us to calculate the real failure rate (λp). This formula takes into account the influence of both natural and man-made factors, with the help of each coefficient, each factor is expressed by the corresponding coefficient:

$$\lambda_{\text{р}} = \lambda_{\text{i}} \cdot \pi_{\text{ст}} \cdot \pi_{\text{дт}} \cdot \pi_{\text{р}} \cdot \pi_{\text{г}} \cdot \pi_{\text{гг}} \tag{3}$$

where, $\pi_{\text{ст}}$ – is the factor of static technogenic load;

$\pi_{\text{дт}}$ – dynamic man-made load factor;

$\pi_{\text{р}}$ – landscape factor;

$\pi_{\text{г}}$ – geological factor;

$\pi_{\text{гг}}$ – hydrogeological factor (groundwater level).

References

1. DSTU 2860-94 Dependability of technics. Terms and definitions. URL: https://www.ksv.biz.ua/publ/dstu/dstu_2860_94/3-1-0-1102
2. DSTU 2861-94 Dependability of technics. Dependability analysis. Basic principles. URL: https://www.ksv.biz.ua/publ/dstu/dstu_2861_94/3-1-0-1103
3. DSTU 2862-94 Dependability of technics. Methods of determination. Dependability predictions. URL: https://www.ksv.biz.ua/publ/dstu/dstu_2862_94/3-1-0-1104
4. DSTU 2863-94 Dependability of technics. Dependability support programme. Common requirements. URL: https://www.ksv.biz.ua/publ/dstu/dstu_2863_94/3-1-0-1105
5. DSTU 2864-94 Dependability of technics. Industrial product dependability reliability. Experimental determinating and complinating. Basic principiles. URL: https://www.ksv.biz.ua/GOST/DSTY_ALL/DSTY3/dsty_2864-94.pdf
6. DSTU 3004-95 Dependability of technics. Methods of estimation dependability by operating data. URL: https://www.ksv.biz.ua/publ/dstu/dstu_3004_95/3-1-0-156

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Collaborative Robots in Manufacturing Systems – Challenges, Benefits, and Research Perspectives

In recent years, there has been growing interest in human interaction with digital work environments, particularly in the context of collaboration with robots designed to work alongside humans (cobots). These robots enable a shift from isolated automation processes to intelligent human-machine partnerships, where the robot not only avoids collisions but also understands situations, communicates, and adapts to human behavior [1]. The socio-technical imaginary of cobots often assumes high levels of collaboration, but in practice—especially in manufacturing—actual human-robot interaction is still limited, with robots primarily used for efficiency and labor substitution rather than deep cooperation [3].

Unlike traditional industrial robots, cobots are designed to be safe, flexible, easy to reprogram, and relocate. Their goal is not to replace the human worker but to complement their physical strength and endurance, improving workplace comfort and efficiency. They are especially valuable for supporting workers with physical limitations or an aging workforce [2]. However, empirical studies reveal that this vision is often not fully realized in industrial practice; instead, robots are frequently deployed to reduce labor costs under automation logics, with human well-being and ergonomic benefits taking a back seat [3].

Key implementation challenges include safety, human motion prediction, adaptive behavior, and cognitive understanding. To address these, researchers apply discrete control barriers, artificial intelligence, machine learning, and advanced machine vision systems [1]. Moreover, recent findings suggest that successful adoption depends not only on technological capabilities but also on organizational factors—such as change management, innovation culture, and internal capabilities for translating robot functionality into workplace benefits [3].

An essential element in designing collaborative systems is the interaction scenario. The chosen scenario affects workspace layout, worker load, and the level of automation. However, industrial deployments often prioritize efficiency without sufficient engagement with broader socio-technical concerns like employee feedback, inclusiveness, or process adaptability [3].

To evaluate collaboration effectiveness, a variety of methods are used: mathematical modeling, simulations, frameworks, and comparative case studies. Commonly analyzed criteria include productivity, safety, ergonomics, cost, and flexibility. Productivity remains the most widely studied metric, while ergonomics is still relatively underexplored [2].

Recently, there has been increasing attention to hybrid decision-support systems that combine real-time data, human feedback, and AI-based recommendations for optimizing human-robot collaboration. These systems allow dynamic reconfiguration of tasks on the shop floor in response to changing conditions such as bottlenecks, operator fatigue, or product variability [2]. This reflects a broader approach known as "positive-sum automation," which focuses on enhancing both productivity and organizational adaptability—contrasting with the more traditional “zero-sum” logic of mere cost-cutting [3].

Digital Twins are playing an increasingly vital role in modeling robot systems before real-world deployment. They enable simulation, real-time monitoring, predictive maintenance, and adaptive control. By creating virtual models of both robot and human behavior, Digital Twins improve system design and operational decisions [2].

Task allocation between humans and robots involves multi-criteria decision-making, including task complexity, safety, cost, physical strain, and operator fatigue. Modern approaches increasingly rely on real-time data—via sensors or Digital Twins—to dynamically adjust workflows and reduce human stress [1, 2].

In addition to safety and productivity, trust has emerged as a critical psychological factor in human-robot interaction. Studies show that workers are more willing to engage with robots when systems are transparent, predictable, and responsive to human input [2].

Despite recent progress, many open questions remain. There is still a lack of comprehensive studies that integrate ergonomics, role-sharing, emotional interaction, collaboration scenarios, and sector-specific adaptation. This points to the need for more interdisciplinary research in the field [2]. Furthermore, developing a more balanced socio-technical imaginary—one that includes diverse stakeholder perspectives, robust policy support, and empirical case validation—is necessary to fully realize cobots' potential [3].

References:

1. Faccio, M., & Cohen, Y. (2023). *Intelligent cobot systems: Human–cobot collaboration in manufacturing*. *Journal of Intelligent Manufacturing*, 35, 1905–1907. https://doi.org/10.1007/s10845-023-02142-z
2. Keshvarparast, A., Battini, D., Battaia, O., & Pirayesh, A. (2023). *Collaborative robots in manufacturing and assembly systems: Literature review and future research agenda*. *Journal of Intelligent Manufacturing*, 35, 2065–2118. https://doi.org/10.1007/s10845-023-02137-w
3. Channa, N. A., Hearn, G., & Casali, G. L. (2025). *When socio-technical imaginaries meet the reality of adoption: Cobots in manufacturing. Futures*. https://doi.org/10.1016/j.futures.2025.103596

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Some Peculiarities of the Ghorabi Iron Ore Deposit Geological Structure (Bahariya Region, Egypt)

The Ghorabi iron ore deposit, located in the Bahariya region of Egypt, represents a significant iron-rich formation with a complex geological history shaped by sedimentary, tectonic, and geochemical processes. This study provides an in-depth analysis of the deposit's geological structure, mineralogical composition, and ore formation mechanisms, integrating field observations, laboratory analyses, and geophysical data. The research investigates the key lithostratigraphic units hosting iron ore, emphasizing their spatial distribution, mineralization patterns, and genetic characteristics.

The geological structure and formation of the Ghorabi iron ore deposit, situated in the Bahariya Oasis, Western Desert, Egypt, represent a complex interplay of sedimentary, tectonic, and geochemical processes spanning from the late Cretaceous to the middle Eocene. This region's geology provides invaluable insights into the dynamics of iron ore genesis under unique climatic and geological conditions. The Bahariya Oasis occupies a strategically significant geological position within the Western Desert, characterized by its arid climate conditions that include extremely high temperature variations and scarce precipitation. These climatic features have directly influenced regional geomorphological and hydrological processes, shaping the area's distinctive geological landscape [5].

Sedimentary processes in the Ghorabi region have historically been unstable, with frequent shifts between continental and marine depositional environments. These fluctuations have generated notable heterogeneity in the texture and structural characteristics of the iron ore deposits. Predominantly, the iron-rich sedimentary sequence consists of sandstone, clay shale, and limestone hosting significant concentrations of hematite, goethite, and magnetite. During the Late Cretaceous period (specifically the Cenomanian age), conditions were particularly favorable for iron ore formation through chemical precipitation. The deposit primarily consists of Upper Cretaceous and Paleogene sedimentary formations, which serve as the main ore-bearing horizons. These formations were influenced by marine transgressions and regressions, leading to the accumulation of iron-bearing sediments in coastal and shallow marine environments [4]. The mineralogical composition of the deposit is dominated by goethite, hematite, and magnetite, with secondary phases such as hydrogoethite, hydrohematite and siderite. These minerals originated through a combination of chemical precipitation, diagenetic transformations, and later hydrothermal enrichment [1].

Tectonic processes played a substantial role in localizing and structuring the iron ore deposits at Ghorabi. The region underwent considerable tectonic activity due to wrench tectonics and rifting processes associated with the broader geological event of Gondwana's breakup. These tectonic movements facilitated deformation, manifesting through folding, faulting, and shearing, which contributed to secondary redistribution and concentration of iron ores. Such structural deformation significantly enhanced the economic feasibility of exploiting these mineral resources. Furthermore, during the Cretaceous-Eocene unconformity, intensive chemical weathering under tropical climatic conditions gave rise to the development of enriched lateritic iron ore horizons. These horizons underwent significant lateritization processes, resulting in increased concentrations of economically valuable iron minerals [3].

Our research indicates, that the geochemical evolution of the Ghorabi deposits is characterized by complex mineralogical transformations driven by secondary mineralization processes. These processes predominantly include oxidation and hydration reactions, leading to the formation of secondary iron minerals such as lepidocrocite, hydrogoethite and hydrohematite. This secondary mineral assemblage significantly influences ore quality, posing both beneficial and challenging implications for ore processing and metallurgical practices. Notably, the secondary minerals have introduced impurities, such as increased clay content and carbonate minerals, complicating extraction and beneficiation processes. Geochemical analyses conducted on the Ghorabi deposits indicate substantial hydrothermal influences during ore formation. Elevated levels of phosphorus and manganese within the ore deposits provide clear evidence of marine water interactions and suggest the influence of hydrothermal fluids during the mineralization phase. Additionally, isotopic studies on oxygen and hydrogen isotopes support the critical role of subsurface fluid circulation in the secondary enrichment of iron ore, reinforcing the importance of hydrothermal activity in shaping the deposit's current geochemical characteristics [2].

Further detailed stratigraphic and mineralogical investigations reveal that iron ore formation at Ghorabi occurred in distinct stages, each marked by different environmental conditions and geochemical processes. Initially, iron-rich minerals precipitated directly from chemical processes in marine settings, later undergoing substantial secondary modifications under subaerial weathering and pedogenic conditions. This multiphase mineralization process has resulted in a diverse range of ore textures and mineralogical associations, contributing significantly to the geological complexity of the deposit. The structural framework of the Ghorabi deposit, defined by numerous faults and deformation structures, reveals the considerable influence of regional tectonics on ore body geometries. Large-scale faults and associated tectonic structures have governed the distribution patterns of the iron-bearing horizons, significantly influencing the accessibility and quality of these ores. Structural studies indicate that the deformation processes related to Alpine orogeny events particularly affected the distribution and characteristics of iron ore bodies, further complicating extraction and beneficiation practices [3].

From an applied geological perspective, understanding the detailed mineralogical composition and structural setting of the Ghorabi deposit is essential for optimizing extraction methodologies. Advanced mineralogical analyses and geochemical studies are recommended to refine the processing techniques, particularly addressing the challenges posed by secondary mineral impurities. Future research should also explore the economic implications of structural controls on ore quality and distribution, aiming to enhance extraction efficiency and resource recovery.

In summary, the Ghorabi iron ore deposit exemplifies a geologically intricate mineral system formed by multiple sedimentary, tectonic, and geochemical processes. Its complex history, characterized by distinct depositional phases, tectonic deformation, and extensive hydrothermal alteration, presents numerous scientific and practical challenges. Continued interdisciplinary research integrating geological, mineralogical, and geochemical studies is vital to effectively exploit this significant iron ore resource, supporting sustainable and economically viable mining operations in the Bahariya Oasis region.

References:

1. Abouzeid A. M., Khalid A. A. Mineral Industry in Egypt-Part I: Metallic Mineral Commodities. Natural Resources. 2011. Vol. 2, No. 1. P. 35–53. DOI: 10.4236/nr.2011.21006.

2. Baioumy H. M., Khedr M. Z., Ahmed A. H. Mineralogy, geochemistry and origin of Mn in the high-Mn iron ores, Bahariya Oasis, Egypt. Ore Geology Reviews. 2013. Vol. 53. P. 63–76. DOI: 10.1016/j.oregeorev.2012.12.009.

3. El Aref M. M., Abd El-Rahman Y., Zoheir B., Surour A., Helmy H. M., Abdelnasser A., Ahmed A. H., El-Ahmadi Ibrahim M. Mineral Resources in Egypt (I): Metallic Ores. The Geology of Egypt. Switzerland: Springer Nature, 2020. P. 1–67. DOI: 10.1007/978-3-030-15265-9_14.

4. El Aref M. M., El Sharkawi M. A., Khalil M. M. Geology and genesis of the stratabound and stratiform Cretaceous-Eocene iron ore deposits of El Bahariya region, Western Desert, Egypt. Geology of the Arab World (GAW4): Proceedings of the International Conference. Cairo: Cairo University, 1999. Vol. 1. P. 450–475.

5. Liakhov Yu. V., Pavlun M. M., Tsikhon S. I. Geology of Mineral Deposits. Part 1: Ore Genesis: textbook. Lviv: Ivan Franko National University of Lviv, 2012. 286 p.

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Improving the efficiency of raise boring in Kryvbas iron ore mining

Improving the efficiency of mining and metallurgical enterprises during Ukraine's transition to a post-war economy can be achieved through the implementation of innovative technologies. This is particularly relevant for the Kryvyi Rih iron ore basin (Kryvbas), which annually produces about 30 million tons of marketable ore through underground mining, accounting for nearly half of the country's metallurgical raw materials. One of the most labor-intensive production processes in underground iron ore mining is the preparation of blocks for stoping, which accounts for 40-50% of total mining costs. Half of these costs are associated with raise boring operations. Annually, approximately 70,000 meters of raise workings are constructed in Kryvbas mines, with an average labor productivity of 1.26 m³ per worker-shift and a cost of 130.89 UAH per meter. The low technical and economic indicators are caused by the widespread use of small-hole drilling methods with wooden platforms and ladder passages. With this technology, manual labor accounts for over 80% of the development cycle.

The purpose is to improve the efficiency of raise boring by developing an advanced technology that rationally combines drilling and explosive breaking while considering energy and social factors. The concept is to examine the technological processes of raise boring using drilling-and-blasting and mechanical methods element by element, and to create an effective technology that ensures the destruction of the rock mass along the entire height of the excavation in a single blasting operation, while reducing energy consumption and manual labor.

Currently, several methods of raise boring are used in Kryvbas mines [1]. The majority of raise boring, accounting for 78.9% of the total volume, is performed using temporary platforms and ladders. Additionally, 17.8% of the operations involve self-propelled complexes, while 3.3% utilize raise boring machines, and only 0.2% rely on sectional blasting of deep boreholes. The height of the workings varies from 10 to 80 meters, with the majority (62.3%) falling within the 10-40 meter range. Notably, approximately 94% of all raises are constructed using drilling and blasting methods. While machine boring offers a high degree of mechanization, it is economically viable mainly for raises around 80 meters high in rock formations with a strength of up to f=12. In contrast, the drilling-and-blasting method is more versatile but is associated with lower work safety standards and increased manual labor costs.

A promising approach from the perspective of technology and labor reduction is the unmanned method of raise boring using borehole charges detonated toward an uncharged borehole of increased diameter (compensation cavity). The essence of this method is to drill a set of boreholes within the projected contour of the working to its full height. One borehole is enlarged to a larger diameter—serving as a compensation cavity. The other boreholes in the set are filled with explosives and detonated with delays. The development of raise boring technologies in Kryvbas mines presents several promising directions for improvement, primarily aimed at increasing efficiency, enhancing safety, and reducing manual labor [1]. One of the key advantages of modernized methods is the elimination of multiple cycles of drilling, charging, blasting, and ventilation, which streamlines the construction process and minimizes downtime. Additionally, the possibility of organizing cohesive operation between equipment and personnel enhances overall workflow efficiency and ensures better coordination. Improved equipment utilization further contributes to increased productivity, while the mechanization of main operations, such as drilling, reaming, and charging, reduces the reliance on heavy manual labor. As a result, these advancements not only optimize operational performance but also significantly improve work safety by minimizing exposure to hazardous conditions.

Research in the field of raise boring aims to enhance efficiency, reduce energy consumption, and optimize technological processes in Kryvbas mines. A key area of investigation focuses on analyzing the energy consumption of different raise boring methods to identify opportunities for reduction. Additionally, studying the characteristics of rock destruction during borehole reaming provides valuable insights into improving drilling performance. Another important aspect is determining the influence of an additional limited exposure plane on the nature of explosive rock destruction, which can lead to more controlled and efficient blasting techniques. Justifying a highly efficient raise boring technology tailored to Kryvbas conditions is essential for improving operational outcomes. Furthermore, industrial testing and implementation of research results play a crucial role in transitioning from theoretical developments to practical applications. Finally, the development of standards for raise boring advancement rates ensures consistency, reliability, and improved productivity in mining operations.

Significant qualitative and quantitative changes in the energy consumption of technological processes have been identified when using different methods of raise boring. The study has proven the dependence of the speed and energy consumption of creating compensation cavities in rocks with a strength of f=10-12 and higher on the level of thermal impact on the walls of the advance borehole. Furthermore, the relationship between the diameters of blast holes and compensation cavities, as well as the breakthrough distance between them, has been determined, taking into account the physical and mechanical properties of the rocks. Additionally, the nature of the dependence of raise boring speed in various mining and geological conditions on their height has been established, with different boring methods showing varied outcomes based on the specific conditions of the mine.

The following developments [2] have been made: a new, effective, unmanned, combined technology for raise boring that significantly reduces energy consumption, increases productivity and mechanization levels by 1.5 times, and improves sanitary and hygienic working conditions. Additionally, methods and means for mechanical and thermomechanical reaming of advance boreholes have been developed, reducing the cost of creating compensation cavities during raise boring by 30-40%. Standards for raise boring advancement rates have also been established. The implementation of these research results and developments in mines provides an annual economic effect of approximately 152 million UAH [2].

The proposed technology of unmanned raise boring using compensation cavities allows for a rational combination of mechanical and explosive methods of rock destruction, which ensures increased labor productivity, reduced energy consumption, decreased manual labor, and improved safety conditions in Kryvbas mines. The developed methodologies for calculating the main technological parameters of raise boring allow for optimization of the process according to specific mining and geological conditions.

References

1. **Shchokin V.** Investigation into near-contour stresses in stoping with backfilling by the polarization-optical method / Stanislav Kulish, Vadim Shchokin, Vladimir Moshinskiy, Igor Karapa, Andrii Karnaukh // *3RD International conference on*

sustainable futures: environmental, technological, social and economic matters, 24–27 May, 2022, Kryvyi Rih, Ukraine.
2. **Shchokin V.** The example of application of the developed method of Neuro-Fuzzy rationing of power consumption at JSC "YuGOK" mining enrichment plants / Vadym Shchokin, Olga Shchokina, Sergiy Berezhniy // *Metallurgical and Mining Industry*. – 2015. – № 2. – C. 19–26.

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Specifics of the Statistical Correlation Between Aluminum And Vanadium Concentrations In Oils of the Dnipro-Donetsk depression

High metal content is a serious problem during the processing of petroleum raw materials, as it leads to irreversible deactivation of catalysts. In addition, metal compounds formed during oil refining cause the spread of high-temperature corrosion on the surface of equipment, a decrease in the service life of turbojet, diesel, and boiler plants; gas corrosion of active elements of gas turbine engines and an increase in environmentally harmful emissions into the environment. Among the metal impurities in oils, aluminum, and vanadium are particular priorities in terms of industrial and environmental significance.

Great attention to the problems of the geochemistry of metals, including aluminum and vanadium in oils, is generally associated with the possibility of their industrial extraction in the process of processing and further sale, as related raw material, relevant scientific and technical issues of the genesis of hydrocarbons, as well as the need to determine the environmental and technological risks of using liquid hydrocarbons as raw materials for the production of petroleum products. The study of these issues will contribute to developing a set of predictive criteria for hydrocarbon accumulations and the scientific substantiation of their use's geological, economic, technological, and environmental assessment, which determines the relevance and practical value of the research conducted.

Considering that, in general, the concentration of impurity elements in the composition of oils is a geochemical indicator of their general ontogenesis, the study of the geochemistry of aluminum in oils from the Dnipro-Donetsk depression is of additional relevance [1-2].

The factual basis of the research was the analyses results of the content of aluminum and vanadium metals in oils from 36 deposits: Bakhmachske, Prylukske, Krasnozayarske, Kachalivske, Kremenivske, Karaikozovske, Korobochkynske, Kulychykhinske, Lipovodolynske, Monastyryshchenske, Matlakhivske, Malosorochynske, Novo-Mykolaivske, Perekopivske, Prokopenkivske, Radchenkovske, Raspashnovske, Sofiivske, Sukhodolivske, Solontsivske, Solokhivske, Talalaivske, Trostianetske, Turutynske, Zakhidno-Kharkivtsivske, Shchurynske, Yuriivske, Yaroshivske, Khukhrianske, Sahaidatske No.1, Sahaidatsk No. 13, Kybytsivske No. 5, Kybytsivske No. 51, Kybytsivske No. 52, Kybytsivske No. 56, Kybytsivske No.1 and their fundamental geological and technological indicators. These deposits were selected based on the principles of the availability of maximum completeness of geochemical information, their location in different oil and gas-bearing areas of the Dnipro-Donetsk depression, different composition of the oil system, different geological types of traps, different structure of deposits and various ages of oil reservoir rocks.

According to the results of correlation and regression analysis and taking into account the Chedok scale, in oil samples from the considered deposits, a high direct correlation between the concentration of aluminum and vanadium was established; the correlation coefficient is 0.86, the graph of the linear regression equation is shown in Fig. 1.

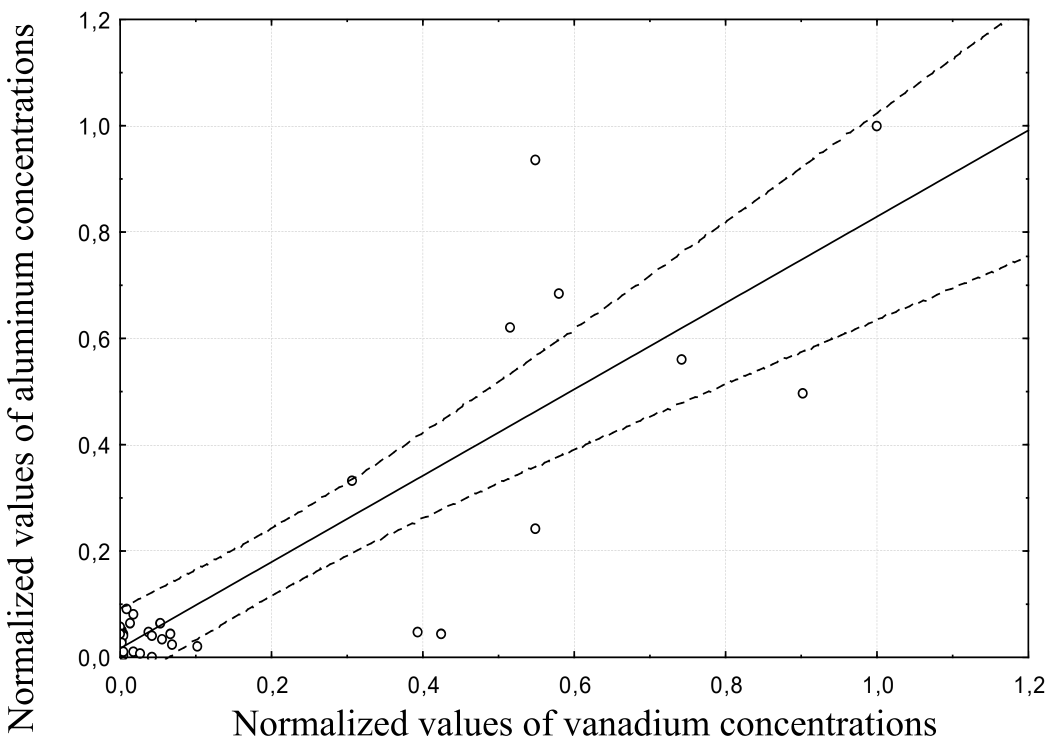

Fig. 1. Graph of the regression equation between the normalized values of aluminum and vanadium concentrations

Linear regression equation between the concentration of aluminum and vanadium in oil deposits: Al = 0.0169 + 0.8121 x V.

The practical value of the research is to establish the concentrations and the possibility of predicting the concentration of aluminum in oils from the Dnipro-Donetsk depression, which in turn provides an opportunity to solve such urgent practical problems.

References

1. Ishkov V.V., Kozii Ye.S., Kozar M.A. (2023). Development of classifications of oil deposits by the content of metals (on the example of the Dnipro-Donetsk depression). Mineral resources of Ukraine. No. 1, 23-34. https://doi.org/10.31996/mru.2023.1.23-34

2. Ishkov V., Kozii Ye., Kozar M., Yerofieiev A., Bartashevskiy S., Dreshpak O. (2023). Peculiarities of the total content of metals in oil deposits of the Dnipro-Donetsk depression. Collection of Research Papers of the National Mining University. No. 72. pp. 98-114. https://doi.org/10.33271/crpnmu/72.098

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Modern Approaches To Epithermal Gold Deposit Research: Classification, Genesis, And Exploration Prospects

Epithermal gold deposits represent one of the most significant categories of gold-bearing formations worldwide, developing at shallow depths (up to 1-2 km) in volcanic regions. The study of these deposits is critical for the global mining industry as they contribute a substantial portion of the world's gold production. The relevance of epithermal deposit research is driven by several factors: first, the growing global demand for gold as a strategic metal; second, the depletion of traditional reserves, stimulating the search for new deposits; and third, the need to improve exploration methods to enhance the efficiency of geological prospecting.

Contemporary geological research has classified epithermal deposits into two main types: high-sulfidation (HS) and low-sulfidation (LS), each characterized by specific mineralogical, geochemical, and structural features. Understanding these differences is fundamental for developing effective exploration and extraction strategies.

In this review article, we systematize the key characteristics of epithermal gold deposits, analyze their geotectonic formation conditions, mineralization and alteration patterns, and examine modern approaches to their detection and evaluation. Special attention is given to the comparative analysis of HS and LS deposit types and the examination of specific case studies, such as the McLaughlin deposit in California.

Epithermal gold deposits predominantly occur in volcano-plutonic arcs associated with subduction zones, typically within 100 km of active volcanic fronts [1]. The tectonic framework governing these deposits shows that subduction-induced magmatism and associated hydrothermal activity tends to migrate trenchward over time in several arcs. Studies of deposits in the western Pacific indicate formation during the late Miocene, Pliocene, and Quaternary periods, while deposits in the western Americas and Caribbean formed earlier, from early Cretaceous to late Miocene [2].

The geotectonic environment plays a crucial role in determining deposit characteristics. Gold deposits are primarily hosted in volcanic rocks and contemporaneous volcanogenic sedimentary rocks. While associated igneous rocks commonly consist of subareal volcanic rocks with calc-alkaline andesite-dacite-rhyolite composition, shoshonitic or alkalic igneous rocks may occur in mature intraoceanic arcs and continental regions [1]. In specific regions like Kyushu, New Zealand, and Indonesia, gold deposits form in volcano-tectonic depressions (grabens) resulting from strike-slip fault movement, highlighting the importance of structural controls in epithermal mineralization [2].

Alteration minerals serve as critical indicators for epithermal systems due to their stability over limited temperature and pH ranges [1]. Mapping the distribution of these minerals allows for the reconstruction of thermal and geochemical zonation, providing insights into the paleohydrology of extinct hydrothermal systems. This approach is fundamental for distinguishing between LS and HS deposit styles.

In LS deposits, alteration is produced by near-neutral pH thermal waters, with temperature decreasing with depth and distance from fluid conduits. Paleoisotherms can be reconstructed by mapping alteration mineralogy, particularly clay minerals [3]. The neutral pH alteration characteristic of LS systems often produces assemblages including illite, smectite, and adularia, which provide valuable information about paleodepth and temperature conditions.

Conversely, HS deposits contain acid-stable minerals such as alunite, kaolinite, dickite, pyrophyllite, diaspore, and zunyite [1]. These minerals form the advanced argillic alteration assemblage developed during initial leaching in the HS environment. The most acid-altered rock in these systems is a silica residue termed "vuggy quartz," commonly the ore host with a halo of

advanced argillic alteration zoned outward to illite, illite/smectite, or smectite, depending on the paleotemperature [3].

The temperature stability of hydrothermal minerals provides valuable insights into formation conditions. As illustrated in Figure 3.1 from the source material, minerals like alunite and kaolinite indicate acidic conditions, while minerals such as adularia and wairakite suggest alkaline environments [1]. The presence of specific mineral assemblages can thus guide exploration efforts by indicating the potential for epithermal mineralization.

The fundamental characteristics of epithermal ore deposits include the form of the orebody and its mineralogy [1]. While both LS and HS deposits show considerable overlap in characteristics, they exhibit distinctive features that reflect their different formation environments.

LS deposits typically display a variety of textures including banding, cavities filled by colloform quartz, and multiple generations of breccia [2]. Open-space veins dominate, with stockwork ore being common. The ore mineralogy in LS systems commonly includes pyrite, electrum, gold, sphalerite, galena, and arsenopyrite. Gangue minerals typically include quartz, chalcedony, calcite, adularia, and illite, indicating near-neutral pH conditions [1].

In contrast, HS deposits show less textural variation, with the characteristic feature being massive bodies of residual (vuggy) quartz formed by leaching in acidic (pH <2) environments at temperatures around 250°C [1]. These deposits commonly contain Cu-As minerals, particularly high-sulfidation state sulfosalts like enargite and luzonite. Such sulfides, including the relatively high-sulfidation state mineral tennantite, are rare or absent in LS deposits [3].

The distribution of ore and gangue mineral textures further distinguishes the deposit types. In HS systems, disseminated ore dominates with replacement ore being common, while stockwork ore is minor with veins commonly subordinate. This contrasts with LS deposits where open-space veins dominate and stockwork ore is common [1].

Advances in understanding epithermal systems have led to improved exploration methodologies. The recognition that alteration mineralogy reflects specific temperature and pH conditions allows for more targeted exploration efforts [1]. Mapping techniques that identify the distribution of key minerals such as alunite, kaolinite, and adularia have become essential tools for delineating potential mineralization zones [3].

Geophysical methods, including gravity surveys with uplifted basement blocks and Schlumberger vertical soundings, have proven effective in estimating the depth to basement and identifying resistivity structures associated with hydrothermal alteration [2]. The combination of geological, mineralogical, and geophysical approaches provides a comprehensive framework for identifying and evaluating epithermal gold deposits.

The systematic analysis of epithermal gold deposits demonstrates their complexity and variability in terms of geological settings, alteration patterns, and mineralization styles. The classification into high-sulfidation and low-sulfidation types provides a valuable framework for understanding their formation processes and developing effective exploration strategies.

Further research is needed to refine exploration models, particularly in areas with complex geological histories or where epithermal systems may be partially preserved due to erosion. Additionally, the potential relationship between epithermal and porphyry systems warrants continued investigation, as this connection may provide additional exploration targets at depth beneath epithermal deposits.

References

1. Lindgren W., White N.C., et al. Epithermal Gold Deposits: Characteristics, Genesis and Exploration. Economic Geology Special Publication, 2023.
2. Simmons S.F., White N.C., John D.A. Geological Characteristics of Epithermal Precious and Base Metal Deposits. Economic Geology 100th Anniversary Volume, 2022.
3. Hedenquist J.W., Arribas A., Gonzalez-Urien E. Exploration for Epithermal Gold Deposits. Reviews in Economic Geology, 2024.

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The growing necessity of GNSS-based monitoring of geological hazards in open-pit mines in Ukraine

According to the National Reports on the State of Technogenic and Natural Safety in Ukraine, geological emergencies — including ground subsidence, landslides, and sinkholes — continue to cause significant material damage each year. These deformations of the earth's surface pose serious threats to infrastructure and human safety, particularly in areas affected by active or abandoned mining operations. High-profile cases, such as those at the Kalush-Golynske and Stebnytsia potash deposits, demonstrate the severe consequences of poor geological risk management and the absence of effective long-term monitoring strategies.

Given this context, the demand for accurate and timely monitoring of geodynamic processes is steadily increasing. Traditional methods (geodetic, geophysical) remain important, but they often require significant human and time resources. In response, modern research and practice in Ukraine have turned to the integration of Global Navigation Satellite Systems (GNSS) as a more efficient and accurate alternative.

Recent Ukrainian studies, such as "Rapid Daily Processing of Observation Data from Ukrainian Permanent GNSS Stations" (2021) and "New Challenges in the Exploitation of Continuously Operating Reference Stations (CORS)" (2024), emphasize the growing role of satellite-based monitoring technologies in addressing geotechnical and environmental hazards. These works highlight the development of national GNSS infrastructure and the growing use of high-frequency observation data to improve real-time geodetic measurements. The System.NET GNSS network, operating in Ukraine since 2011, has been essential in supporting high-precision RTK positioning, which is now actively used in engineering, construction, and increasingly — in mining.

Therefore, the application of GNSS technology in open-pit mines should no longer be viewed merely as a potential innovation. Rather, it represents a critical tool already being implemented to improve safety, optimize monitoring, and support sustainable development in areas prone to geological hazards.

One of the most illustrative examples is the situation at the Kalush-Golynske and Stebnytsia potash deposits, where poor decisions on the development of reserves and the liquidation of mine tunnels disrupted the geo-environmental balance. This resulted in sinkholes, the destruction of houses, salinisation of groundwater and afterwards the announcing of certain areas as an ecological emergency zone.

Such cases confirm the need for up-to-date and precise monitoring of geodynamic processes. Under current circumstances, traditional methods (geodetic, geophysical) are effective, but they often require significant resources and a long time to process data. That is why the usage of innovative observation technologies, in particular global navigation satellite (GNSS) systems, is becoming more and more urgent.

In the mining industry, it is crucial to detect changes in the geometry of the earth's surface in a prompt manner. GNSS technologies help to determine the coordinates of control points in real time with high accuracy. This, in turn, makes it possible to record shifting deformations on time, predict the development of threatening processes and prevent accidents.

When it comes to stable and safe operation of open pits, the implementation of modern GNSS technologies is not only a new technological achievement, but also a tool for improving the efficiency of risk management. Thus, the study of the growing implementation of GNSS systems for monitoring landslides in quarries is extremely relevant from both a scientific and practical point of view.

In view of these problems, the use of GNSS, which provide high accuracy of coordinates and can be effectively used for monitoring, is becoming increasingly important. Several major GNSS systems are currently in operation: GPS (USA), Galileo (EU), BeiDou (China) and the regional QZSS system (Japan). To ensure the high positioning accuracy required for geodetic and mining purposes, GNSS systems are complemented by ground infrastructure - base stations that allow the transmission of differential corrections. Such corrections come either from geostationary satellites (e.g., WAAS, EGNOS) or directly from ground stations, which provides greater accuracy.

One of the most effective methods of improving accuracy is the use of RTK (Real Time Kinematic) technology. It allows achieving accuracy to the centimetre scale, which is critical for monitoring landslides, rock deformations and engineering structures. Ukraine has a national GNSS base station network, System.NET, which has been providing high-precision positioning services based on RTK corrections since 2011. Its use helps significantly reduce the cost of geodetic measurements, increase labour productivity, and ensure real-time measurement accuracy control.

Due to the integration of GNSS with mobile networks and the Internet, it is now possible to work with coordinates even in hard-to-reach areas. This opens up new opportunities for monitoring unstable areas, particularly in areas with sinkholes or active landslides.

One of the ways to improve accuracy is to estimate and compensate for pseudorange errors based on the analysis of intersatellite communications. Such a strategy helps maintain the stability of the navigation solution even in rough conditions where the number of visible satellites decreases. Studies have shown that the application of these methods can significantly reduce the DOP (Dilution of Precision) and provide stable positioning even in complex geo-environmental zones.

Compared to traditional surveying methods such as tacheometry and levelling, GNSS systems have several significant advantages. Firstly, it is the high accuracy and speed of data collection. Tacheometry and levelling, although accurate, often require significant time and resources for field measurements and processing of results. GNSS systems, thanks to their real-time capabilities, allow obtaining data much faster, which significantly reduces costs and increases work efficiency.

There is growing implementation of GNSS systems in Ukrainian mining. Since most deposits have complex geological conditions, such systems can help monitor areas subject to deformation. In the long term, the active implementation of GNSS systems in Ukraine will help ensure the safety and efficiency of operations at quarries, significantly reducing the risk of technogenic disasters.

In light of Ukraine's ongoing challenges with geological hazards in mining regions, the growing implementation of GNSS technologies represents a timely and necessary advancement. These systems offer real-time, high-precision data collection that significantly enhances the ability to monitor ground deformation, predict dangerous shifts, and mitigate the risks of accidents. Case studies such as the Kalush-Golynske and Stebnytsia deposits underscore the urgent need for more reliable and continuous observation methods. With national infrastructure like the System.NET network already in place and actively supporting RTK positioning, Ukraine is well-positioned to expand the use of satellite-based monitoring across its mining sector. Compared to traditional methods, GNSS provides superior efficiency, accuracy, and cost-effectiveness — key factors in improving safety and sustainability in open-pit operations. As technological integration continues, GNSS-based monitoring will play an increasingly vital role in reducing the impact of geodynamic threats and supporting the long-term development of Ukraine's mining industry.

References:

1. Dorosh L. I. Monitoring of technogenically hazardous objects by means of radar interferometry: dissertation. 2021. URL: https://ena.lpnu.ua/handle/ntb/56707.
2. Understanding GPS: Principles and applications. 2nd ed. Boston, MA : Artech House, 2006. 703 p.
3. Modern methods of improving the accuracy of GPS positioning. Technical engineering. 2024. № 1(93). С. 415-419. URL: https://doi.org/10.26642/ten-2024-1(93)-415-419.

4. Bong J. H., Kim D., Jeong S. GNSS performance enhancement using measurement estimation in harsh environment. *PLOS ONE*. 2023. Vol. 18, no. 9. P. e0292116. URL: https://doi.org/10.1371/journal.pone.0292116.
5. Khoda O., Ishchenko M. Rapid daily processing of observation data at the Ukrainian permanent GNSS stations for monitoring of their stability. International Conference of Young Professionals «GeoTerrace-2021», м. Lviv, Ukraine,. 2021. URL: https://doi.org/10.3997/2214-4609.20215k3014.
6. New challenges for exploitation of continuously operating reference GNSS stations during hostilities. Case study of Ukraine / I. Brusak та ін. Geodesy, cartography, and aerial photography. 2024. Т. 99,2024, № 99. С. 28–37. URL: https://doi.org/10.23939/istcgcap2024.99.028.

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Automation And Artificial Intelligence In Modern Mining Industry

The mining industry is actively implementing automation and artificial intelligence (AI) systems, fundamentally transforming traditional mineral extraction methods. This technological revolution aims to increase productivity, improve workplace safety, and reduce negative environmental impacts.

Digital transformation of the mining sector could generate an additional $320 billion in value by 2025 and significantly reduce CO_2 emissions. The Pilbara region in Western Australia has become a key testing ground for innovative solutions in iron ore mining, including autonomous trucks, robotic drilling systems, and advanced analytical tools.

This review analyzes contemporary approaches to utilizing automation and AI in the mining industry across various stages of the extraction process—from geological exploration to transportation and processing of raw materials. The economic, environmental, and technological aspects of implementing these innovations are examined, along with outlining prospects for further industry development in the context of digitalization.

The integration of automation and AI technologies in mining operations represents a significant paradigm shift in the industry's approach to resource extraction. Leung, Hill, and Melkumyan [1] provide a comprehensive overview of how these technologies are being applied in open-pit iron ore mining operations in the Pilbara region of Western Australia. Their research demonstrates that the mining lifecycle—from exploration and geological assessment to production, transportation, and processing—is being transformed through technological innovation.

In the exploration phase, AI-driven geological modeling has become instrumental in locating and assessing ore deposits. Traditional methods of geological assessment are being enhanced with probabilistic approaches that incorporate Gaussian Processes for hyperspectral imaging, geostatistics, and boundary modeling [1]. These technologies enable mining companies to create more accurate models of potential ore bodies, reducing the uncertainty associated with exploration activities. The development of Time Dynamic Warping with Gaussian Processes has allowed for better identification of stratigraphic boundaries in ore deposits, significantly improving the efficiency of exploration efforts.

The planning and development phase benefits from intelligent mine planning systems that optimize pit design and operational sequencing. These systems consider multiple variables simultaneously, including geological data, economic factors, and operational constraints. Automated modeling and tracking convert gathered information into knowledge that is usable by both humans and machines. The integration of real-time data with predictive models allows for continuously updated understanding of the mining environment, enabling more informed decision-making processes.

Autonomous operations have revolutionized production drilling and blasting activities. Zhang and Liu [2] explored how autonomous drilling systems have improved operational efficiency by maintaining consistent drill patterns, optimizing blast outcomes, and enhancing safety by removing operators from hazardous environments. Their research indicates that automated drill rigs can achieve 30% higher utilization rates compared to conventional equipment, with significant improvements in hole accuracy and blasting effectiveness.

The transportation of ore and waste material has seen perhaps the most visible advancement in automation technology. Autonomous haulage systems have been widely implemented in large-scale mining operations. Singh and Patel [3] conducted a detailed analysis of autonomous trucks in multiple mining operations globally, finding that these systems can operate continuously with consistent performance levels, resulting in productivity increases of up to 20%. Their study also noted a 15% reduction in fuel consumption and a significant decrease in maintenance costs due to the consistent and optimized operation of autonomous vehicles.

Material processing represents another area where AI and automation are making substantial impacts. Leung et al. [1] describe how ore car dumping, stockpiling, blending, and screening processes are increasingly managed by intelligent systems that maintain precise control over product quality. The complex logistics of port operations are now managed according to product type and quality control plans, with traveling wheels and reclaimer units working in coordination to load the ships efficiently.

A critical aspect of mining automation is the comprehensive networking and interconnection of all stages in the mining chain. This integration facilitates real-time decision-making, allowing for adaptive responses to changing conditions. Singh and Patel [3] emphasize that the true value of automation is realized when data flows seamlessly across operational boundaries, enabling a system-wide optimization approach rather than isolated improvements in individual processes.

The implementation of these technologies is not without challenges. All three studies highlight that successful integration requires significant capital investment, workforce retraining, and organizational culture adaptation. Concerns about job displacement are partially offset by the creation of new, higher-skilled positions focused on managing and maintaining automated systems. Additionally, regulatory frameworks and standards for autonomous mining operations are still evolving, presenting legal and compliance challenges for early adopters.

Environmental benefits of mining automation include improved resource utilization efficiency and reduced energy consumption. Zhang and Liu [2] found that optimized operations can reduce the environmental footprint of mining activities through more precise extraction that minimizes waste material. Similarly, autonomous equipment typically demonstrates more efficient fuel usage patterns, contributing to lower greenhouse gas emissions.

The reviewed research demonstrates that automation and AI technologies are fundamentally transforming mining practices, offering substantial improvements in safety, efficiency, and environmental performance. The integration of intelligent systems throughout the mining lifecycle is enabling more precise resource extraction, optimized operations, and better-informed decision-making.

While the benefits are significant, further research is needed to address remaining challenges in several key areas. These include improving the interoperability between various automated systems, developing more robust AI algorithms capable of handling the extreme variability of mining environments, and creating effective frameworks for human-machine collaboration in semi-automated operations.

As these technologies continue to mature, their adoption is likely to accelerate, potentially reshaping the global mining industry. Future studies should focus on long-term impacts of automation on mining communities, comprehensive sustainability metrics for automated operations, and strategies for effectively managing the transition to increasingly autonomous mining systems.

References

1. Leung R., Hill A.J., Melkumyan A. Automation and AI Technology in Surface Mining: With a Brief Introduction to Open-Pit Operations in the Pilbara. IEEE Robotics & Automation Magazine, 2023.

2. Zhang L., Liu Y. Autonomous Systems in Mining: Performance Analysis and Future Directions. Journal of Mining Engineering, 2022; 43(2): 156-172.

3. Singh M., Patel K. Implementation Challenges of Autonomous Haulage Systems in Global Mining Operations. International Journal of Mining Science and Technology, 2023; 33(1): 89-104.

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Innovative Approaches To The Utilization Of Fallen Leaves: Experience In Producing Organic Fertilizers, Biogas, And Biodegradable Materials

Fallen leaves are a major type of organic waste that accumulates in large quantities annually. Traditional disposal methods, such as burning or landfilling, pollute the environment. However, modern approaches enable their effective and eco-friendly utilization.

This study explores innovative methods for processing fallen leaves into organic fertilizers, biogas, and biodegradable materials. Vermicomposting enhances soil fertility by transforming leaves into valuable compost. Anaerobic digestion allows for biogas production as a renewable energy source. Additionally, processing technologies create biodegradable materials, such as disposable tableware, reducing plastic dependency.

A comprehensive approach to fallen leaf utilization minimizes waste and contributes to the development of a circular economy, providing both ecological and economic benefits.

The production of biogas from fallen leaves is a promising technology that enables the use of biomass as an energy source. The main process involves anaerobic digestion, where organic matter decomposes under the influence of microorganisms, producing biogas consisting mainly of methane and carbon dioxide. A crucial aspect is the pre-treatment of raw materials, including shredding, moisturizing, and adjusting the carbon-to-nitrogen ratio to enhance digestion efficiency. Optimizing process parameters contributes to an increased gas yield and improved composition (Table 1). This technology helps reduce the amount of waste ending up in landfills while also providing an environmentally friendly alternative to conventional fuels.

Table 1. Biogas composition and production of fallen teak leaves [1]

Biogas Composition	Yield
CH_4, %	55,47
CO_2, %	43,57
NH_3, %	0,96
Biogas Production	
CH_4	0,5964 m^3
CO_2	0,4675 m^3
NH_3	0,0101 m^3
Biogas	1,0740 m^3/kg

A case study of woody leaf litter vermicomposting demonstrates its potential as a sustainable waste management practice. Various studies indicate that the decomposition rate of woody litter depends on multiple factors, including the presence of earthworms, microbial activity, and environmental conditions.

Experimental results show that woody litter, though more resistant to decomposition than non-woody organic matter, can still be efficiently processed through vermicomposting when combined with suitable substrates. The process leads to improved nutrient availability and enhances soil quality, making it a viable approach for organic waste recycling.

We can see the effect of different vermicompost extracts on the root growth of wheat seeds and potato shoots. It clearly demonstrates how different types of compost, especially poplar leaf vermicompost (PPLVerm), affect root development. The data show that PPLVerm significantly increased root weight in wheat and potato samples compared to the control group (tap water) and horse manure-based vermicompost (PMVerm) (Fig. 1).

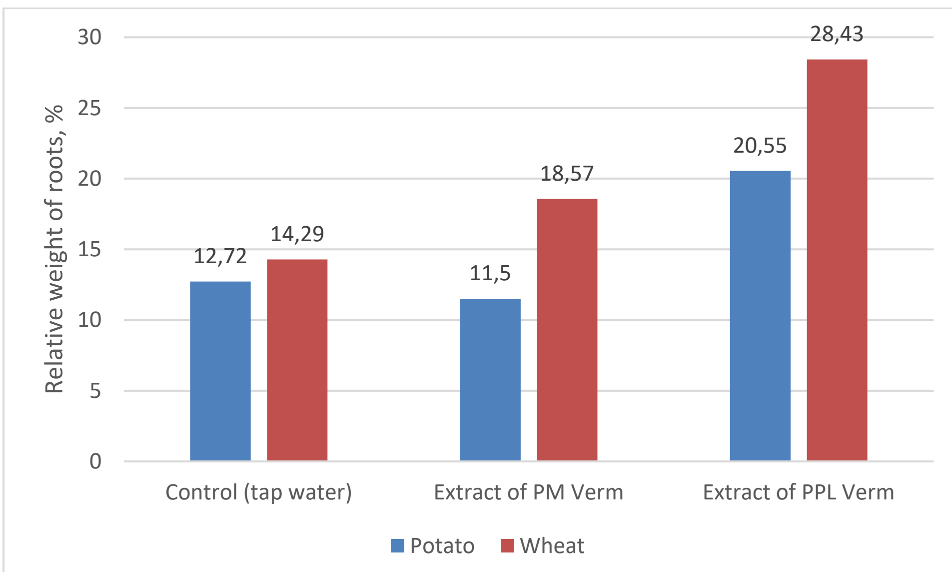

Fig. 1. Variation of relative root weight of wheat seeds and isolated potato shoots depending on the kind of food substrate, used in vermicomposting [2]

Fallen leaves serve as a promising raw material for the production of disposable tableware due to their ecological and physicomechanical properties. Pulp yields can vary considerably depending on the type of fallen leaves used as raw material (Fig. 2). The manufacturing process involves cleaning, drying, and pressing the leaves under high pressure, resulting in a durable, water-resistant, and biodegradable material. This tableware is resistant to moisture and temperature changes, contains no harmful chemical additives, and fully decomposes after use, leaving no environmental pollution.

Utilizing fallen leaves as a raw material helps reduce plastic waste and promotes the principles of a circular economy.

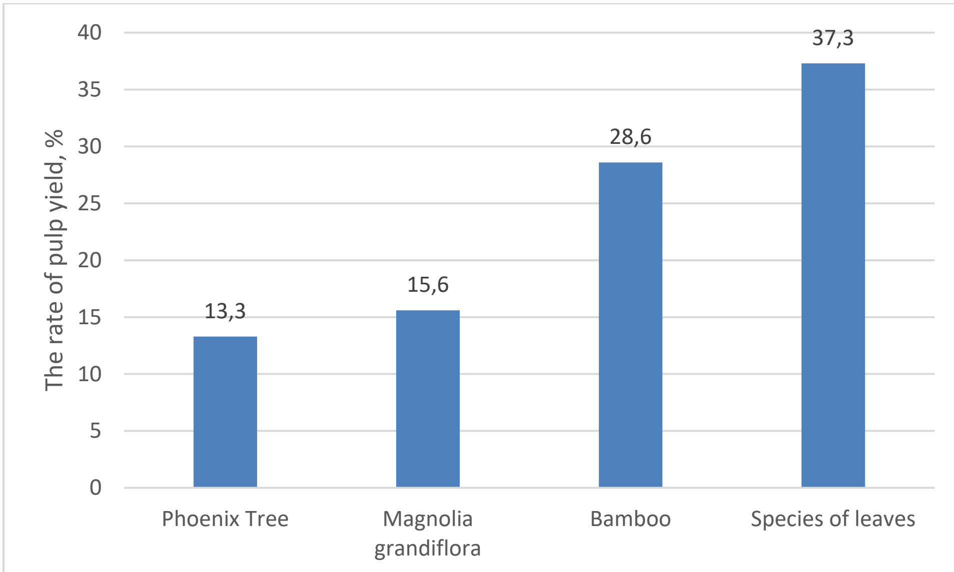

Fig. 2. Comparison of pulp yield rate among different leaves [3]

Fallen leaves represent a valuable resource that can be effectively utilized in various environmentally friendly technologies. Biogas production enables energy extraction from biomass while reducing waste accumulation in landfills. Vermicomposting enhances soil fertility by converting leaves into organic fertilizer. Additionally, processing leaves into biodegradable materials, such as disposable tableware, offers a sustainable alternative to plastic and supports the circular economy. The implementation of these technologies not only ensures efficient organic waste utilization but also provides both ecological and economic benefits.

References

1. A. Wannapokin, Y. Unpaprom. An investigation of biogas production potential from fallen teak leaves (Tectona grandis): Emergent Research Journal. Thailand, 2017. 1-10. Available: https://www.emergentresearch.org/uploads/38/3150_pdf.pdf.

2. Petrochenko, K., Kurovsky, A., Godymchuk, A., Babenko, A., Yakimov, Y., & Gusev, A. (2019). A case study of woody leaf litter vermicompost as a promising calcium fertilizer. Bulgarian Journal of Agricultural Science, 25(4), 646–653.

3. Bo-Fan Liu et al. Study of pulping technology on disposable tableware using withered leaves as raw material. 2020 IOP Conf. Ser.: Mater. Sci. Eng. 711 012056. Available: https://doi.org/10.1088/1757-899X/711/1/012056.

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Intelligent Adaptive Control System For The Classification Process Of Fine Screening Of Iron Ore Slurry

Fine screening through high-frequency vibrating screens with mesh openings down to 0.1 mm is recognized as one of the most effective methods for classifying iron ore slurry, routinely achieving separation efficiencies in the 70–80 % range—significantly outperforming hydrocyclones in many operating regimes [1]. In practice, however, key driving parameters—vibration frequency, water flow rate, slurry solids concentration, and screen loading—fluctuate dynamically due to variations in feed characteristics and operational conditions. Manual or fixed-parameter control schemes are unable to maintain optimal separation performance under such variability, leading to increased iron losses, elevated energy and water consumption, and more frequent maintenance interventions.

Existing screening circuits rely on either static settings or simple PID loops that cannot adapt to rapid changes in feed particle size distribution or density. As a result, mesh blinding, uneven wear, and sub-optimal cut sizes occur, reducing overall plant throughput and concentrate quality. Moreover, installing a dense network of physical sensors to monitor every relevant variable is both economically and logistically impractical. There is therefore a pressing need for an intelligent control architecture that [1] fuses data from a minimal set of "hard" sensors (e.g., vibration accelerometers, flow meters, density probes) with "soft" sensor estimates, and [2] continuously adjusts operating parameters in real time.

Proposed a hierarchical, adaptive control system composed of three integrated layers:

1. **Sensory and Soft-Sensor Layer**
   - Hard sensors measure vibration amplitude/frequency, water flow rate, and bulk slurry density.
   - Soft sensors—implemented via data-driven models—infer unmeasured states such as near-screen solids concentration and effective pulp viscosity, leveraging neural network predictors trained on historical operating data [1].

2. **Low-Level Control Layer**
   - Fuzzy-augmented PID controllers adjust vibration frequency and water dosing in response to setpoints provided by the higher-level modules.

- Feed-forward compensation uses a dynamic screen model to mitigate mechanical resonance and prolong mesh life, following insights from laboratory stabilizing methods [3].

3. **Supervisory AI Layer**
   - A neural network–based optimizer analyzes real-time sensor and soft-sensor outputs to compute optimal setpoints that maximize separation efficiency while minimizing water and energy usage.
   - A supervisory module tunes learning rates and fuzzy membership functions online to maintain robustness against feed variations, drawing on delay-compensation techniques from grinding circuit control [2].

The proposed intelligent adaptive control system addresses the core limitations of current fine screening processes by fusing minimal hard-sensor inputs with advanced soft-sensor estimates and AI-driven setpoint optimization. Its hierarchical architecture ensures both rapid local adjustments and strategic supervisory tuning, leading to more stable, efficient, and automated operation. Successful pilot implementation will lay the groundwork for full-scale deployment across beneficiation plants, contributing to the digital transformation of the iron ore industry.

References

1. T. A. Oliynyk, V. V. Nevzorov, "Fine screening as a solution to technological challenges in the production of high-quality iron ore concentrates," Bulletin of Kryvyi Rih National University, vol. 57, pp. 80–88, 2023. doi: 10.31721/2306-5451-2023-1-57-80-88.
2. D. V. Shvets and V. V. Shvets, “Automatic control of the iron ore grinding cycle with feed transport delay compensation,” *Mining Bulletin*, no. 112, pp. 101–105, 2024.
3. M. Stupnik, V. Kalinichenko, S. Pysmennyi, M. Fedko, and O. Kalinichenko, “Method of simulating rock mass stability in laboratory conditions using equivalent materials,” *Mining of Mineral Deposits*, vol. 10, no. 3, pp. 46–51, 2016. doi: 10.15407/mining10.03.046.

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Hydrogen Production from Municipal Solid Waste

Humanity began to face the problem of a huge amount of solid household waste 30-40 years ago. Landfills, garbage, accumulation and disposal of waste are components of the reality of large cities, where annually secondary raw materials are collected in the tens of billions of tons. The well-known methods of waste disposal and incineration are environmentally hazardous and have never contributed to the economical use of raw materials. However, modern technologies allow us to consider alternative options where solid household waste is a source of energy, in particular hydrogen.

The purpose of this work is to compare such methods as gasification and pyrolysis. These methods are used to extract hydrogen from household waste. Gasification provides an opportunity to obtain synthesis gas, from which hydrogen can be isolated. Pyrolysis, in turn, provides an opportunity to obtain pyrolysis gas, where one of the components is hydrogen.

This article shows that using solid household waste to produce hydrogen not only reduces waste but also contributes to the development of a circular economy, combining environmental and economic benefits. This approach opens up new prospects for the implementation of sustainable technologies in waste management.

Gasification is a high-temperature process that converts carbon-containing materials, such as coal, biomass, or MSW, into synthesis gas (a mixture of H_2, CO, CO_2, and CH_4) under controlled oxygen supply (air, oxygen, or steam). The process typically takes place at temperatures ranging from 1000 to 2000 °C. Gasification enables the production of gas with a high content of hydrogen and CO, and achieves high energy efficiency. This method underpins many modern sustainable energy technologies [1].

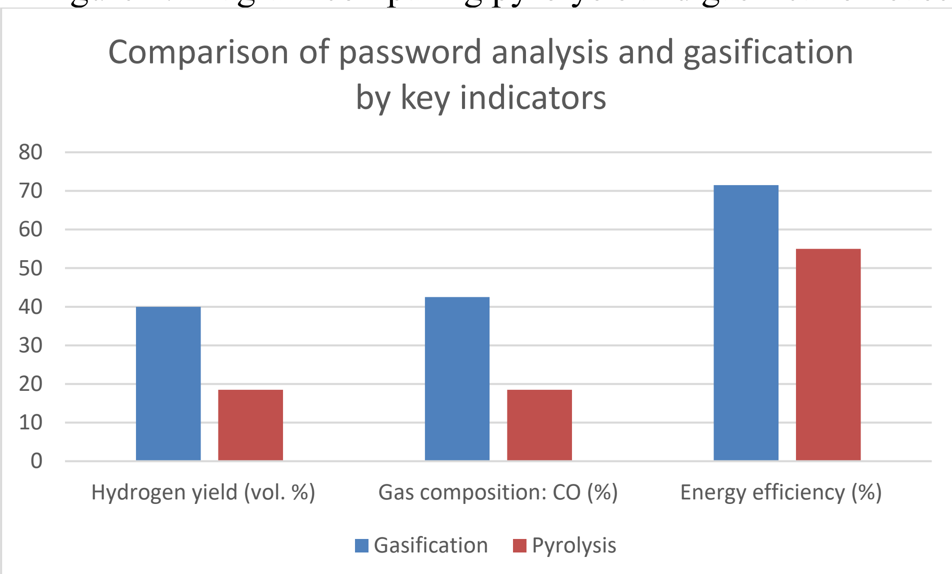
Pyrolysis is the thermal decomposition of organic or polymeric materials in the absence or near absence of oxygen. The material is heated to 400–600 °C, resulting in the formation of gaseous products, liquid hydrocarbons, and solid residues. The use of catalysts improves the decomposition efficiency and increases the yield of target components, particularly hydrogen. This method is widely used for the conversion of plastic waste and biomass into fuel gases with relatively low concentrations of CO and CH_4 [2].

Pyrolysis and gasification are two promising thermochemical methods for converting carbon-rich feedstocks into hydrogen-rich synthesis gas. Although they share certain principles, these technologies differ significantly in operating conditions, energy consumption, and the composition of the resulting gases. Table 1 below presents a comparative overview of pyrolysis and gasification of waste. Figure 1 visually illustrates the comparison of key indicators such as H_2 yield, CO content, and energy efficiency.

Table 1. Comparative characteristics of pyrolysis and gasification [1, 2]

Indicator	Gasification	Pyrolysis
Process temperature (°C)	1000–2000	400–600
Typical feedstock	coal, biomass	plastic waste, biomass
Hydrogen yield (vol. %)	35–45	15–22
Gas composition: CO (%)	29–56	15–22
Gas composition: CO_2 (%)	12–30	11–15
Gas composition: CH_4 (%)	< 0.1–11	1–2.5
Energy efficiency (%)	60–83	45–65

Figure 1. Diagram comparing pyrolysis and gasification based on key indicators



Pyrolysis and gasification are both effective thermochemical technologies for converting carbon-rich materials into hydrogen-containing synthesis gas. Pyrolysis typically occurs at lower temperatures and is better suited for the processing of polymeric and organic waste. However, it results in lower hydrogen yield and energy efficiency compared to gasification. Gasification is more energy-intensive but enables the production of synthesis gas with higher CO and H_2 concentrations, making it more attractive for industrial applications.

Both technologies hold promise in the transition to low-carbon energy systems. The choice between them should depend on available feedstock, technical feasibility, environmental regulations, and target products. Further research into catalyst development, process optimization, and integration with other energy systems could greatly enhance the efficiency of both methods.

References

1. Matveev D., Zinenko A., Polishchuk V., Bohatov V., Popovych V. *The current state of the problem of manufacture and using synthesis gas based on the carbon gasification reaction. Part 1. Analysis of the gasification process and its practical application* [Text] / D. Matveev, A. Zinenko, V. Polishchuk, V. Bohatov, V. Popovych. – Available at: https://www.researchgate.net/publication/343269079
2. Samoilenko V., Nedilko S., Novikova V., Shapoval O., Didyk M. *Catalysis of Low Temperature Pyrolysis of Polymeric Waste* [Text] / V. Samoilenko, S. Nedilko, V. Novikova, O. Shapoval, M. Didyk. – Available at: https://www.researchgate.net/publication/356883303
3. Bondarenko V.O., Bondarenko O.O., Bondarenko O.V., Bondarenko O.V. *Hydrogen production via conversion of solid fuel* [Text] – Available at: https://www.researchgate.net/publication/342633709

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System Dynamic Modeling For Optimization Of Drilling And Blasting Operations In Open Pit Mines

In the mining industry, drilling and blasting are critical operations that determine the efficiency of open pit mines. The relevance of optimizing these processes is driven by economic challenges, deepening pits, and strengthening environmental requirements.

Traditionally, these operations were optimized separately, but an integrated approach provides better results. It is important to consider technical parameters (borehole diameter, rock properties), economic factors (costs, equipment price), and environmental aspects (emissions).

Accounting for uncertainties inherent in the mining industry is particularly important. System dynamics methodology allows modeling complex interrelationships between system components and evaluating different scenarios under uncertainty.

This article systematizes modern approaches to integrated optimization of drilling and blasting operations using system dynamic modeling and outlines promising research directions.

System dynamic modeling has emerged as a powerful methodology for understanding complex mining systems by representing the interconnections between various components. The approach, developed in the 1950s to assist managers in strengthening their understanding of processes and strategies, has found significant application in mining engineering in recent years [1]. The strength of system dynamics lies in its ability to capture the behavior of systems over time by incorporating key variables, their interactions, and feedback loops that characterize complex systems.

In their seminal work, Abbaspour et al. [1] proposed a system dynamic model (SDM) for drilling and blasting operations that integrates all related technical, economic, and environmental parameters. Their approach recognizes that drilling and blasting operations should be considered as a system consisting of three different subsystems: technical parameters (burden, spacing, depth, bit or drill hole diameter, penetration rate), economic parameters (drilling costs, blasting costs, equipment costs), and environmental parameters (gas emissions, dust). The authors demonstrate that these subsystems are internally related and interact with each other in various ways.

A key innovation in Abbaspour's work is the use of stock-flow diagrams to model the relationships between variables. Stocks represent accumulated quantities over time, such as total drilled length and total blasting production, while flows represent rates of change, such as penetration rate and blasting production rate. The model incorporates both positive feedback loops, where variables reinforce each other's effects, and negative feedback loops, which stabilize the system by counteracting changes.

The study demonstrates the application of the model through a hypothetical copper mine case study that needs to produce 30 million tonnes of waste and 2.5 million tonnes of ore based on an annual planning. The optimization was performed under both deterministic and uncertainty conditions, with particular attention to finding the optimal bit diameter. Under deterministic conditions, the model showed that a bit diameter of 8.333 in. was optimal for achieving production targets while minimizing costs. However, the study's most significant contribution lies in its handling of uncertainty conditions, where parameters like Uniaxial Compressive Strength (UCS), Rock Density (SG), Bit Life (BL), and Hourly Drilling Cost (HDC) were treated as distributed functions rather than fixed values [1].

Building on the foundation laid by Abbaspour et al., Gholamnejad and Azimi [2] expanded the application of system dynamics to incorporate mine reclamation planning and environmental impact mitigation. Their work introduces additional feedback loops that connect extraction activities with rehabilitation processes, creating a more comprehensive model of the mining lifecycle. The authors

argue that viewing reclamation as an integral part of the mining system rather than an afterthought leads to more sustainable and economically viable operations.

The model proposed by Gholamnejad and Azimi accounts for the time delays between extraction and reclamation activities, and demonstrates how early planning of reclamation can reduce overall costs and environmental impacts. By incorporating variables such as topsoil availability, waste rock characterization, and progressive rehabilitation rates, their system dynamic model provides a framework for optimizing both production and reclamation activities simultaneously. Their case study demonstrated that integrated planning could reduce total project costs by approximately 15% compared to traditional sequential approaches [2].

The third significant contribution to the field comes from Moradi and Osanloo [3], who focused on water management in mining operations using system dynamic modeling. Their work addresses one of the most critical environmental and operational challenges in modern mining—water usage and management. The authors developed a comprehensive model that integrates water flows within mining operations, including processing requirements, dust suppression for drilling and blasting, dewatering activities, and water recycling opportunities.

Moradi and Osanloo's model is particularly valuable for its ability to simulate the impact of water management decisions on overall mining performance, including drilling and blasting effectiveness. Their research demonstrated that optimized water management strategies could improve drilling performance by ensuring adequate water for dust suppression while reducing overall water consumption through recycling. The model also proved effective for predicting the impact of seasonal variations in water availability on mining operations and planning appropriate mitigation strategies [3].

The study showed that integrated water management could reduce freshwater consumption by up to 30% while maintaining production levels, and in some cases, improving drilling performance through better dust management. This work highlights the importance of considering resource inputs such as water as integral parts of the mining system rather than external factors.

System dynamic modeling offers a powerful framework for understanding and optimizing complex mining operations, particularly drilling and blasting activities. The reviewed studies demonstrate that integrated models incorporating technical, economic, and environmental parameters can lead to improved decision-making and operational performance. By explicitly accounting for uncertainties and system interconnections, these models provide more robust solutions than traditional optimization approaches.

However, further research is needed to expand the scope of these models, incorporate real-time data capabilities, and more comprehensively address environmental and social impacts. As mining operations face increasing challenges from deeper deposits, stricter regulations, and economic pressures, the continued development and application of system dynamic modeling approaches will be essential for sustainable and efficient resource extraction.

References

1. Abbaspour, H., Drebenstedt, C., Badroddin, M., & Maghaminik, A. (2018). Optimized design of drilling and blasting operations in open pit mines under technical and economic uncertainties by system dynamic modelling. International Journal of Mining Science and Technology, 28(6), 839-848.

2. Gholamnejad, J., & Azimi, Y. (2020). A system dynamics approach for integrated mine planning and reclamation. Journal of Cleaner Production, 252, 119708.

3. Moradi, G., & Osanloo, M. (2019). Developing a water management model for mining operations using system dynamics approach. Journal of Cleaner Production, 232, 1075-1092.

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AI in Mechanical Engineering: Process Optimization and Innovation Perspectives

Artificial Intelligence (AI) has emerged as a transformative force across various industries, including mechanical engineering. In this field, AI technologies are revolutionizing traditional approaches to design, manufacturing, and maintenance. AI-powered tools enable engineers to generate optimized designs more efficiently, improve production workflows, and ensure higher equipment reliability. These advancements ultimately lead to enhanced product performance, reduced development cycles, and lower operational costs [1].

AI encompasses a wide range of technologies such as machine learning, deep learning, natural language processing (NLP), and robotics. These techniques allow machines to learn from data, make informed decisions, and perform tasks that previously required human intelligence – such as image recognition, complex analysis, and adaptive control. The integration of AI into mechanical systems has opened new frontiers in engineering design, system diagnostics, and automation [2].

One of the key areas of AI application in mechanical engineering is design and optimization. Engineers traditionally relied on time-consuming iterative testing to achieve optimal product configurations. Now, machine learning algorithms can rapidly analyze large datasets to generate and evaluate numerous design variations. AI-based generative design tools allow users to define specific goals—such as strength, weight, material usage, or cost – and then explore thousands of viable design options automatically. This accelerates innovation while reducing development time and material waste [2].

Maintenance strategies have also undergone significant transformation due to AI. Conventionally, equipment in industrial environments is serviced according to fixed schedules, known as time-based or preventive maintenance. While such methods can prevent some failures, they often lead to unnecessary part replacements or missed early signs of wear. For example, a hydraulic pump might be disassembled and inspected every six months regardless of its actual condition, resulting in wasted labor and resources.

AI-driven predictive maintenance, on the other hand, uses real-time data from sensors to monitor parameters like vibration, temperature, pressure, and acoustic signals. Machine learning algorithms analyze this data to detect patterns that signal early signs of malfunction – such as bearing wear or misalignment – allowing maintenance to be scheduled exactly when needed. This approach minimizes unplanned downtime, extends equipment lifespan, and reduces maintenance costs. Over time, AI systems become more accurate as they learn from operational data, making predictions increasingly reliable [1].

A rapidly growing field where AI has had a profound impact is additive manufacturing (AM), commonly known as 3D printing. Unlike traditional subtractive methods, AM builds parts layer by layer from digital models, enabling high customization, material efficiency, and geometric flexibility. The integration of AI into AM further enhances its capabilities [3].

In the area of AI-powered 3D printing design, algorithms such as topology optimization and generative design help engineers create lightweight yet strong components with minimal material use. This is particularly valuable in aerospace and automotive sectors, where reducing part weight directly impacts fuel efficiency and performance. Engineers can define mechanical and material constraints, and the AI will output a spectrum of optimized solutions, significantly cutting down design iterations [3].

Real-time quality assurance in 3D printing is another key innovation. Traditional quality control methods rely on post-production inspections, which are often time-consuming and may not catch internal flaws. AI-enabled computer vision systems can monitor each layer during the printing process, detecting issues like warping, delamination, or voids as they occur. This not only ensures higher print quality but also reduces material waste and rework [3].

AI also enhances the maintenance of 3D printers themselves, using predictive analytics similar to those employed in broader industrial settings. Sensors embedded in the printers continuously collect operational data, which AI algorithms analyze to anticipate potential failures – such as nozzle blockages or platform misalignments – before they disrupt production. As a result, maintenance can be scheduled efficiently, reducing equipment downtime and increasing throughput [3].

Beyond 3D printing, AI supports smart manufacturing systems more broadly through robotics and intelligent automation. AI-driven robots can adapt to dynamic production environments, perform precision tasks, and maintain consistent quality across batches. Combined with the Internet of Things (IoT), AI allows for seamless communication between machines and real-time process adjustments based on sensor feedback. Moreover, AI-based simulations and digital twins enable engineers to test complex processes virtually, optimizing outcomes before implementation [2].

Through these innovations, AI is reshaping the landscape of mechanical engineering. It empowers companies to be more agile, precise, and efficient in both product development and production. As these technologies continue to evolve, it is crucial for engineers to develop the necessary skills to harness their full potential and ensure responsible, ethical use [1].

In conclusion, the integration of AI into mechanical engineering represents a pivotal shift toward intelligent, data-driven decision-making. From design and production to real-time monitoring and predictive maintenance, AI enhances innovation and operational efficiency. Addressing the accompanying challenges—such as ethical concerns, workforce reskilling, and regulatory compliance – will be key to maximizing the long-term benefits of AI in the engineering domain [2].

References:

4. Adhithya, P. Impact of Artificial Intelligence on Mechanical Engineering: A Comprehensive Overview, 2023. URL: https://www.researchgate.net/profile/Prasanna-Adhithya/publication/382830346_Impact_of_Artificial_Intelligence_on_Mechanical_Engineering_A_Comprehensive_Overview/links/66adfe7e299c327096a7a811/Impact-of-Artificial-Intelligence-on-Mechanical-Engineering-A-Comprehensive-Overview.pdf (accessed: 02. 04. 2025).
5. Mondal, S., Goswami, S. S. Rise of Intelligent Machines: Influence of Artificial Intelligence on Mechanical Engineering Innovation, *Sustainable Engineering and Mathematical Sciences*, 2024. URL: https://www.sems-journal.org/index.php/sems/article/view/17 (accessed: 06. 04. 2025).
6. Lodhi, S. K., Gill, A. Y., Hussain, I. AI-Powered Innovations in Contemporary Manufacturing Procedures: An Extensive Analysis, 2024. URL: https://media.neliti.com/media/publications/591908-ai-powered-innovations-in-contemporary-m-8d3a6eb6.pdf (accessed: 08. 04. 2025).

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Development of an Intelligent Decision Support System for Automated Hydroponic Gardening

Sustainable agriculture stands today as an urgent need because of urbanization and worldwide food security issues. Hydroponics represents a soilless agricultural practice that shows great potential for efficiency and large-scale implementation. The majority of hydroponic systems need manual oversight to function, yet this requirement hampers their efficiency and increases their complexity for novice operators.

This paper introduces a Smart Intelligent Decision Support System (IDSS) designed to automate key functions in hydroponic farming. The system employs Internet of Things devices with cloud-based monitoring and real-time data analysis to achieve better agricultural precision alongside increased reliability and scalability for small growers.

Hydroponic farming gets praise for its resource efficiency, but its need for manual monitoring and control leads to variable outcomes. The four environmental parameters of temperature, humidity, light and water levels need continuous adjustment to create optimal conditions for plant growth. Human error risks increase when operators perform manual adjustments because inexperienced agricultural workers show a high probability of mistakes.

An intelligent and autonomous system must be developed to create user-friendly operations and stable performance.

A research project aims to develop an Intelligent Decision Support System (IDSS) specifically for hydroponic farming before its implementation as a prototype. The research aims to achieve three primary objectives:

- Real-time monitoring of environmental conditions using low-cost sensors.
- A sensor feedback system controls both irrigation systems and lighting automation.
- Data communication operates through the MQTT protocol, which uses Arduino Uno R4 Wi-Fi and Raspberry Pi 5.
- AWS IoT Core allows remote data access and visualization and long-term storage through its integration with the system.

Current research indicates that agriculture benefits significantly from automated data analysis solutions. IoT systems have proven effective for improving precision and resource management through their successful implementation.

Digital agriculture projects such as the MIT OpenAg initiative and commercial FarmBot platforms demonstrate promising potential but require expensive installations. The current solutions that exist today do not provide adequate user-friendly interfaces with intelligent decision-making functions for smaller operations.

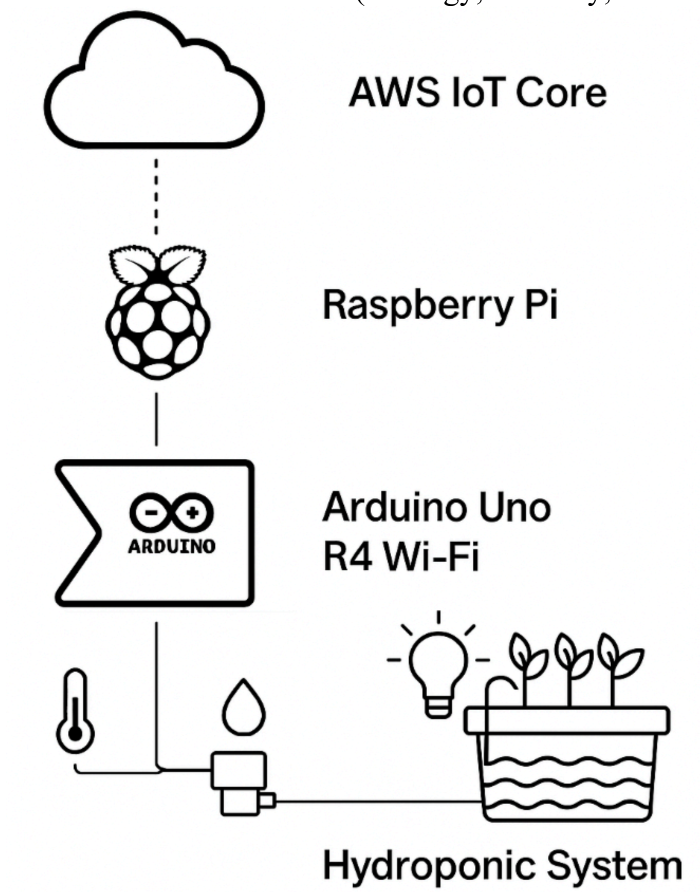
This project resolves these issues through an accessible and scalable intelligent hydroponic support system.

The proposed system uses hardware and software elements that work together to create autonomous environmental control:

The hardware setup includes an Arduino Uno R4 Wi-Fi board which connects to environmental sensors measuring temperature, humidity, light and water level alongside Raspberry Pi 5 as MQTT local broker and Deep-Water Culture (DWC) hydroponic system with artificial grow lights and submersible water pumps.

Software: Arduino C++ code is used to interface with the sensors. A Python script on the Raspberry Pi processes and relays data to AWS IoT Core using the MQTT protocol. AWS services use cloud resources to store and display data.

Workflow: Data flows from Arduino through the local MQTT broker (Raspberry Pi) to AWS IoT Core before analysis and dashboard visualization.



The initial implementation of the prototype within a hydroponic greenhouse proved the following:

- The system ensures ongoing real-time acquisition and logging of data.
- The system performs dependable automatic management of irrigation systems along with lighting control.
- The system buffers sensor data locally while offline before synchronizing it with the cloud when the connection returns.
- Operation consistency improves through this system while the need for manual intervention decreases.
- These results affirm the system's effectiveness in supporting autonomous cultivation.

The prototype IDSS demonstrates that intelligent automation is able to simplify hydroponic farming. The system's modular design makes it adaptable to different scales and plant types and its open-source components enhance affordability along with community-driven development.

AWS IoT Core integration provides a foundation for advanced analytics as well as machine learning applications. These applications could include predictive models for nutrient cycles or environmental stress detection which would enhance precision agriculture for both urban and rural areas.

The research reveals that incorporating Internet of Things technology with cloud computing solutions in hydroponic gardening produces major improvements in system operational efficiency and dependability. The Smart IDSS achieves two critical benefits by reducing human interaction needs and providing precision agriculture access to all users through its user-friendly platform.

Smart systems demonstrate their wider importance in developing sustainable urban food production systems through these research findings. The research should advance by implementing AI technology to enable advanced autonomous decision systems and broaden support for various crop species.

References

1. V. Sharma, A. K. Tripathi, H. Mittal. "Technological revolutions in smart farming: Current trends, challenges & future directions."
2. Y. Song, J. Bi, X. Wang. "Design and implementation of a cloud-based intelligent greenhouse monitoring system."
3. OpenAg Initiative by MIT Media Lab – https://openag.media.mit.edu/
4. AWS IoT Core Documentation – https://docs.aws.amazon.com/iot/
5. Hiroki Koga. "The sweet future of vertical farming"

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Laser Scanning Technologies In Underground Mining: Current State And Development Prospects

The implementation of laser scanning in underground mining significantly changes approaches to ensuring safety and improving the efficiency of mining operations. Laser scanning technologies, particularly Terrestrial (TLS) and Mobile (MLS), provide engineers with high-precision three-dimensional data even in challenging underground mine conditions, where dust, moisture, and limited access are present.

As mining operations reach greater depths and geological conditions become more complex, traditional monitoring methods become insufficient. Laser scanning allows for obtaining detailed information about the condition of excavations, structural characteristics of the rock mass, and potential hazards, which is critically important for making informed engineering decisions.

The economic effect of using these technologies is reflected in reduced downtime, improved mapping accuracy, and minimized risk of accidents. Particularly promising is the integration of laser scanning with automation systems in the context of "smart mining" development.

This review combines current knowledge on the application of laser scanning in underground mining operations, addressing key challenges of data acquisition in GNSS-denied spaces, point cloud processing methods, and practical implementation across various mining domains.

Laser scanning systems operate on LiDAR (Light Detection and Ranging) principles, where the time-of-flight difference between emitted and reflected signals determines distances between sensor and target objects [1]. Modern mining operations utilize 3D imaging data collected through these systems to address industrial, laboratory, and numerical research problems. However, the implementation of laser scanning in underground environments faces unique challenges.

Singh et al. [1] highlight that despite significant advancements in mobility and mapping capabilities, coherent data collection in underground mines remains constrained by inherent environmental factors. Dust, moisture, and irregular surface properties significantly affect the quality of point cloud data. The accuracy of generated maps depends heavily on sensor specifications, including beam divergence and inertial measurement unit (IMU) bias. In mobile scanning applications, a primary source of error comes from inertial sensors that accumulate drift over time, resulting in discrepancies between measured and actual positions.

Environmental factors such as ambient illumination levels cause laser sensors to saturate, affecting their sensitivity to precisely detect return pulses. Water vapor or moisture tends to attenuate laser pulses by absorbing near-infrared (NIR) wavelengths typically used in laser scanners. Additionally, dusty conditions at mine sites contribute to noise that requires complex post-processing steps using filters like statistical outlier removal [1].

Laser scanning has found diverse applications across multiple mining domains. According to Novák et al. [2], the technology has proven particularly valuable for structural stability assessment. Their research demonstrates that high-resolution point clouds enable precise monitoring of deformation in underground excavations, allowing engineers to detect potential failure zones before they become critical hazards. The authors conducted case studies in several European mines, showing that millimeter-level deformation could be detected through repeat scanning sessions over time.

The monitoring of temporal changes represents one of the most significant applications of laser scanning in underground mines. Williams and Roberts [3] investigated the application of mobile laser scanning (MLS) systems for routine monitoring of large areas. Their findings indicate that MLS solutions provide adequate accuracy for change detection, deformation monitoring, object detection, and localization, with permissible error margins of a few centimeters. This level of accuracy proves sufficient for most operational requirements in underground mining contexts.

Across various mining domains, laser scanning applications extend to ventilation control, mine excavation monitoring, structural discontinuity analysis, mine planning, road condition assessment, logistics monitoring, and blast impact evaluation [1]. The technology enables comprehensive monitoring of shaft, stope, trench, contour, and pit conditions, as well as structural discontinuities that might pose safety risks. It also facilitates the collection of geological, geotechnical, meteorological, and topographical data essential for effective mine planning and design.

Despite their potential, laser scanning technologies face several integration challenges in underground mining environments. The GNSS-denied nature of these environments necessitates alternative referencing methods, which often introduces complexity in data registration and alignment [1]. The accurate integration of point clouds collected from different scanning positions remains a technical challenge, particularly in feature-deficient environments like coal mines where walls are often coated with shotcrete or mesh.

Sensor characteristics significantly influence mapping errors. Factors such as beam divergence, IMU drift, sensor bias, and calibration errors contribute to inaccuracies in the generated point clouds [1]. Environmental factors, including lighting conditions, water, dust, multipath reflections, and surface roughness, further complicate accurate data collection. Dynamic elements in operational areas, such as vehicles or machinery, can also impact point cloud registration.

Williams and Roberts [3] note that processing large volumes of point cloud data presents computational challenges, requiring sophisticated algorithms and substantial computing resources. Their research emphasizes the importance of optimizing data processing workflows to make laser scanning more practical for routine use in underground mining operations.

The current state of laser scanning technologies in underground mining indicates promising potential but also highlights areas requiring further research and development. Integration with other sensing technologies, such as infrared imaging and ground-penetrating radar, could enhance the comprehensive understanding of underground environments [2]. Additionally, the development of more robust algorithms for automatic feature extraction and classification would improve the efficiency of data processing and interpretation.

Novák et al. [2] suggest that machine learning approaches hold promise for automating the analysis of temporal changes in point cloud data, potentially enabling real-time hazard detection systems. Miniaturization of scanning devices and improvement in power efficiency would also facilitate more widespread deployment throughout mining operations.

The advancement of mobile laser scanning platforms, including drone-based and wearable solutions, represents another important direction for future research. These platforms offer enhanced flexibility and access to areas that might be unsafe or impractical for human operators [3].

Laser scanning technology has matured significantly for applications in underground mining, providing valuable capabilities for change detection, clearance measurements, structural mapping, and autonomous navigation. Although challenges remain in terms of data transfer, processing capacity, and environmental influences, the increasing affordability, accuracy, and mobility of laser scanners support their widespread adoption.

Further research should focus on developing more robust data processing algorithms, integrating multiple sensing technologies, and adapting systems to the specific challenges of different types of underground mines. The continued advancement of these technologies will contribute significantly to improving safety, efficiency, and sustainability in underground mining operations.

References

1. Singh, S.K., Banerjee, B.P., Raval, S. A review of laser scanning for geological and geotechnical applications in underground mining. Journal of Mining and Environment, 2023.
2. Novák, P., Štroner, M., Urban, R. Applications of laser scanning in underground mining operations. Journal of Sustainable Mining, 2022.
3. Williams, J., Roberts, D. Mobile laser scanning systems for rapid monitoring in underground environments. Mining Technology, 2021.

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Structure and Properties of Nanopowders

In recent decades, nanotechnology has emerged as a rapidly developing field that has revolutionized materials science and engineering. At the core of this advancement are nanopowders, which are ultrafine particles typically measuring less than 100 nanometers in size. Due to their extremely small size and high surface area-to-volume ratio, nanopowders exhibit a range of unique physical, chemical, and mechanical properties not found in their bulk counterparts. These materials have found widespread applications in industries such as electronics, medicine, energy, and aerospace. Understanding the structure and properties of nano powders is essential for their practical application and integration into new technologies. In this report, we will explore the fundamental structural characteristics of nanopowders, discuss their distinctive properties, and highlight their significance in modern technological development.

Nanopowders consist of particles so small that quantum effects and surface phenomena become dominant. Their structure can be either crystalline, amorphous, or a combination of both. In crystalline nanopowders, atoms are arranged in a well-ordered pattern, similar to bulk materials, but often exhibit defects and grain boundaries due to the high surface energy. Amorphous nanopowders, on the other hand, lack a long-range atomic order and are typically synthesized through rapid cooling or chemical reactions.

One key structural feature of nanopowders is their high specific surface area. As the particle size decreases, the surface area increases dramatically. This property enhances reactivity, diffusion rates, and catalytic behavior, making nanopowders highly efficient for use in chemical reactions and sensors. Additionally, nanopowders may exhibit a core-shell structure, where a particle consists of a core made of one material and a shell of another. This allows engineers to tailor material properties such as conductivity, thermal resistance, or biocompatibility. The core-shell structure is particularly useful in biomedical applications, such as targeted drug delivery or imaging, where functionality and control over interactions with biological environments are critical.

When it comes to properties, nanopowders demonstrate several characteristics that distinguish them from bulk materials. Mechanical properties such as hardness, strength, and elasticity are often enhanced due to the small grain size and the resulting grain boundary strengthening. This makes nanopowders suitable for use in reinforced composites and coatings that require wear resistance. Termal properties of nanopowders are also of interest. Nanopowders may exhibit lower thermal conductivity compared to bulk materials due to the scattering of phonons at grain boundaries. This feature is beneficial in thermoelectric devices, where controlling heat transfer is essential. From an electrical perspective, nanopowders can show increased electrical conductivity or even changes in electrical behavior, such as semiconducting or metallic transitions, depending on the material and synthesis method. This is particularly important in the production of electronic components, batteries, and supercapacitors. Chemical reactivity is often significantly increased in nanopowders. This is due to the large number of atoms located at or near the surface, which are less tightly bound and more available to participate in chemical reactions. This makes nanopowders excellent candidates for use in catalysts, including those for environmental cleanup or industrial chemical synthesis.

Despite their advantages, nanopowders also pose certain challenges, such as agglomeration, where particles tend to stick together due to high surface energy. This can reduce the effectiveness of the nanopowder and complicate processing. Additionally, safety concerns such as inhalation risk and toxicity must be considered, especially when nanopowders are used in consumer products or biomedical applications.

Nanopowders are a remarkable class of materials whose structure and properties open up a world of possibilities in modern science and industry. Their unique structural features, such as high surface area and potential for engineered configurations, lead to improved mechanical, thermal, electrical, and chemical performance. These properties allow nanopowders to outperform conventional materials in a wide range of applications, from catalysis and electronics to medicine and energy storage. However, further research is essential to optimize their synthesis, prevent aggregation, and address safety concerns. As technology continues to evolve, the study and application of nanopowders will undoubtedly remain at the forefront of innovation, offering solutions to complex scientific and engineering challenges.

References

1. Nktechnic. Nanopowders production. https://www.nktechnic.com/en/products/nanopowders – Електронний ресурс [Режим доступу] – (дата звернення 08.04.2025).
2. ScinceDirect. Nanopowders. https://www.sciencedirect.com/topics/materials-science/nanopowder – Електронний ресурс [Режим доступу] – (дата звернення 08.04.2025).
3. AZO nano. Nanopowders – A Brief Definition and Applications of Nanopowders. https://www.azonano.com/article.aspx?ArticleID=1833 – Електронний ресурс [Режим доступу] – (дата звернення 08.04.2025).

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Deep-sea Mining: Current Status and Challenges

The world is changing so rapidly every day that we barely have a chance to slow down and reflect on whether it is truly heading in the right direction. Digitalization and the transition to green and AI-based technologies are accelerating. These emerging trends, along with global population growth, have driven increased demand for metals. According to Roland Berger report, demand could outstrip supply to 2050. In this case, the mining industry has turned its attention to a possible alternative site, which is not far from us yet much deeper – the seabed.

Deep-sea mining refers to the extraction of valuable minerals from polymetallic nodules, ferromanganese crusts, and seafloor massive sulfides located hundreds to thousands of meters below the sea surface. These deposits are rich in essential metals like cobalt, nickel, copper, manganese, and rare earth elements, which are increasingly critical for modern technologies. Polymetallic nodules, those with high concentrations of nickel and copper, are of the greatest commercial interest and mostly found in a region called the Clarion-Clipperton zone (CCZ) in the Pacific Ocean.

Technology model of deep-sea mining includes (1) a subsea collector with caterpillar tracks and hydraulic or mechanical systems for collection and transfer of nodules, (2) a riser airlift system for conveying the harvested ore to the (3) production support vessel that dewaters and stores minerals for further processing.

To date, no commercial-scale deep-sea mining operations have taken place, but they are being intensively discussed. In recent years, several prototype systems of seabed exploitation were developed and tested by different companies:

1. Patania II – a nodule collector vehicle was tested in 2021 in the CCZ at depths of ~4,500 m by Global Sea Mineral Resources NV.

Outcome: Patania II collected valuable data but lost communication and had to be retrieved manually.

2. Collector prototype – a nodule collector vehicle with riser and lifting system aboard the converted vessel Hidden Gem was tested in late 2022 in the CCZ at ~4,000 m depth by The Metals Company.

Outcome: a total of 4,500 tons of nodules were successfully collected and transferred to the surface by the nodule collector vehicle.

3. Pioneer II – a nodule collector was tested in July 2024 in the Western Pacific Ocean with 4,102.8 m depth by Shanghai Jiao Tong University.

Outcome: Pioneer II completed deep-sea trial and successfully retrieved nodules.

4. Varaha-3 – a collector system for manganese nodules was tested in October 2024 in the Andaman Sea at ~1,200 m depth by National Institute of Ocean Technology.

Outcome: Varaha-3 collected nodules and operated stably under pressure conditions.

5. Eureka II – an autonomous underwater vehicle (AUV) with AI-based vision to avoid marine life and gently pick nodules with robotic arms was tested May 2024 at ~1,600 m depth by Impossible Metals.

Outcome: Eureka II is the first successfully proven autonomous navigation capability in the deep ocean.

The controversy surrounding this topic arises from many unresolved issues that cannot be addressed by theory alone. The seabed remains one of the most unexplored areas on Earth. Any seabed intervention must be justified by significant benefits to ensure that «the cure is not worse than the disease».

The environmental impacts of deep-sea mining are inevitable; however, their full scale must be determined. Since nodules provide habitat for a variety of unknown organisms, their removal could lead to ecosystem destruction and biodiversity loss, affecting essential ecological functions. Despite this, waste management is still a critical gap in current mining practices. Sediment plumes discharged into the ocean lack toxicity assessments and may disrupt marine species' movement and migration. This requires the use of effective filtration systems and continuous water monitoring. Noise and light pollution generated by mining equipment are equally harmful to sensitive ocean creatures. Coastal communities may face cultural disruptions. The social and economic costs and benefits to Pacific Island economies are unclear.

The regulation of seabed mining is a broad and complex issue. It is governed by the United Nations Convention on the Law of the Sea (UNCLOS), International Seabed Authority (ISA) and national legislation. The provisions of the UNCLOS regulate the use of marine areas depending on the place of extraction and define the responsibility of states for environmental protection. In turn, ISA regulates all mineral-related activities in international waters and grants exploration licenses. The main rules for resource extraction in different zones are shown in Table 1.

Table 1. Rules for resource extraction

Zone	Resource ownership	Extraction regulation	Key features
Territorial waters (up to 12 nm)	Coastal state	Coastal state	Full sovereignty
Exclusive Economic Zone (up to 200 nm)	Coastal state	Coastal state	Must follow UNCLOS rules.
Continental shelf (up to 350 nm)	Coastal state	Coastal state and partially ISA	Must pay ISA if mining beyond 200 nm.
The Area (beyond national jurisdiction)	Common heritage	ISA	No state ownership

The ISA has granted 31 licenses for mineral exploration in areas beyond national jurisdiction, the majority of which are held by China. At the same time, the ISA is developing the Mining Code – a set of rules for prospecting, exploration and exploitation of marine minerals in the Area. The deadline for the regulations was missed in June 2023 and, as of now, still not fully finalized. This means that no company can begin mining operations until the ISA establishes clear guidelines for extraction, environmental impact control and the distribution of benefits between countries. Discussion and finalization of the Mining Code are scheduled for completion by July 2025.

Significant delays in the regulatory process have forced companies to rely on the United States. As the only country that has not signed the UNCLOS agreement, the United States may not be subject to its rules. The US administration has expressed a desire to speed up the extraction of critical minerals by granting its own mining permits from the US National Oceanic and Atmospheric Administration (NOAA). However, ISA notes that such a move would be a violation of international law and calls for the cancellation of any such permits.

To summarize, the new frontier of mining still needs to be explored, and its potential is just as great as the challenges it presents. With the increasing global demand for metals on the world market, deep-sea mining is a promising industry, but it lacks transparency. Given that its challenges span across multiple scientific fields, it needs to be addressed from an interdisciplinary perspective to provide a responsible and clear vision for the future.

References:

1. How subsea mining can close the growing demand-supply gap for some critical minerals / W. Bernhart et. al. Rolandberger.com. 31.03.2025. URL: https://www.rolandberger.com/en/Insights/Publications/Deep-sea-mining-a-promising-critical-mineral-solution.html

2. Lunde Trellevik L.-K. Exploring Deep-Sea Minerals Systems modeling for an emerging industry and unknown futures : Thesis for the degree of Philosophiae Doctor (PhD). Bergen, 2023. 194 p.

3. Ma, W.; Zhang, K.; Du, Y.; Liu, X.; Shen, Y. Status of Sustainability Development of Deep-Sea Mining Activities. J. Mar. Sci. Eng. 2022, 10, 1508. https://doi.org/10.3390/jmse10101508

4. Deep-sea mining. Wikipedia: The Free Encyclopedia URL: https://en.wikipedia.org/wiki/Deep_sea_mining

5. Hokkala N. Deep-sea mining: Understanding the contemporary discourse : Bachelor's thesis / Tampere University. Finland, 2023. 39 p.

6. Baraniuk C. Deep-sea mining tech advances but doubts remain. *BBC*. 07.03.2025. URL: https://www.bbc.com/news/articles/cg45zwe0v0ro

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Peculiarities Of The Geological Structure Of Oxidized Ferruginous Quartzite Deposits In Kryvbas

The Kryvyi Rih iron ore basin (Kryvbas) is one of the largest iron ore deposits globally, containing significant reserves of oxidized ferruginous quartzites, which play a crucial role in the Ukrainian mining sector. These deposits are formed primarily within Proterozoic sedimentary formations and consist of iron-rich quartzites that have undergone intense processes of weathering and oxidation. Minerals such as hematite, goethite, limonite, and quartz dominate the ore composition. [2]

The aim of this study is to analyze the structural and mineralogical peculiarities of oxidized ferruginous quartzite deposits in Kryvbas in the context of their economic and geodynamic significance. The research applies a combination of field observations, petrographic analysis, and geophysical modeling to interpret the geological structure and ore characteristics.

The geological development of Kryvbas is associated with complex tectonic activity, particularly within the Ukrainian Shield. Folding and faulting events facilitated the flow of mineralizing fluids, resulting in the metasomatic replacement and mineralogical heterogeneity observed across the region. The formation of ore bodies with lenticular and layer-like morphologies significantly impacts the strategies used for mining. [2]

Significant scientific interest in the oxidized varieties of ferruginous quartzites is driven by their unique mineral composition and favorable properties for direct metallurgical use. These ores are often low in impurities such as sulfur and phosphorus, making them especially valuable. [3] In addition, their high iron content, sometimes exceeding 60–70%, reduces the need for beneficiation, which is economically beneficial for industrial use.

Tectonic structures such as the Kryvyi Rih anticline serve as a structural foundation for ore distribution and are key to understanding the geological framework. The deposits are found at varying depths, with many oxidized varieties occurring closer to the surface. This spatial arrangement allows for more cost-effective extraction using open-pit methods. [1]

The combined effects of exogenous weathering and hydrothermal activity have played a critical role in transforming primary magnetite ores into oxidized quartzites. These processes were active throughout different geological epochs, including the Archean and Proterozoic periods, resulting in varied ore quality and distribution. [2]

Given the strategic and economic significance of Kryvbas, continued geological studies and geophysical modeling are essential. Integrating methods such as magnetic and electrical resistivity surveys enhances our ability to predict ore body locations and develop sustainable mining practices.

Despite the region’s high resource potential, challenges remain, including the need for modernization, environmental protection, and effective waste management. Implementing cleaner technologies and managing industrial impacts on air, soil, and water resources are vital for ensuring sustainable development.

Further interdisciplinary research combining geology, geochemistry, and remote sensing is necessary to refine models of ore genesis and predict new zones of mineralization. Kryvbas is not only an important industrial hub but also a unique geological structure offering insights into the Earth's early crustal development.

Furthermore, the Kryvyi Rih region holds critical importance not only in terms of mineral extraction but also for scientific understanding of Proterozoic sedimentary basins. Its long-term geological evolution serves as a natural laboratory for studying the effects of tectonic compression, metasomatism, and oxidative weathering on ferruginous rocks. Understanding these transformations allows geologists to reconstruct past geodynamic environments and contributes to predictive models in other shield regions.

Advanced 3D geological modeling is increasingly being applied in Kryvbas to assist with mine planning and ore body visualization. This includes integration of seismic data, borehole logging, and geostatistical interpolation, allowing for better control over resource estimation and operational efficiency. [2] Such technologies not only improve safety and precision but also facilitate long-term planning and sustainability assessments.

Environmental considerations remain vital as mining continues. Kryvbas has experienced extensive land alteration, and modern extraction practices require strict adherence to environmental regulations. Rehabilitating mined-out lands, controlling dust emissions, managing wastewater, and reducing energy consumption are among the top priorities for sustainable operations. The development of green technologies and more efficient beneficiation processes are crucial directions for future improvements. [1]

Educational and research institutions in Kryvyi Rih also play a central role in supporting mining development. Their collaboration with industry partners ensures that up-to-date scientific knowledge is implemented in practice, promoting innovation and workforce training in geology, mining engineering, and environmental protection.

As a strategic region, Kryvbas stands at the intersection of economic necessity and environmental responsibility. Continued support for research, infrastructure modernization, and the implementation of international best practices in geological surveys and mining operations are essential to preserve its role as a global iron ore leader.

In conclusion, oxidized ferruginous quartzites of Kryvbas represent not only a valuable resource for Ukraine's economy but also a geological formation of significant scientific interest. Their study contributes to understanding the tectonic evolution of the Ukrainian Shield and offers insights into mineralization processes in ancient sedimentary environments.

References

1. Open-pit mining / National Technical University of Ukraine "Kyiv Polytechnic Institute"; [compiled by: Kosenko T. V., Frolov O. O.; deputy editor V. G. Kravets]. Kyiv: NTUU "KPI", 2014. 56 p. (In Ukrainian).
2. Ivanik O. M., Nazarenko M. V., Khomenko S. A. Modeling of geological processes and structures. Kyiv: Kyiv University, 2014. 115 p. (In Ukrainian).
3. Kovalchuk V. A., Kovalchuk T. M. Planning of mining operations in pits. Kryvyi Rih: Publishing Center of KTU, 2009. 211 p. (In Ukrainian).

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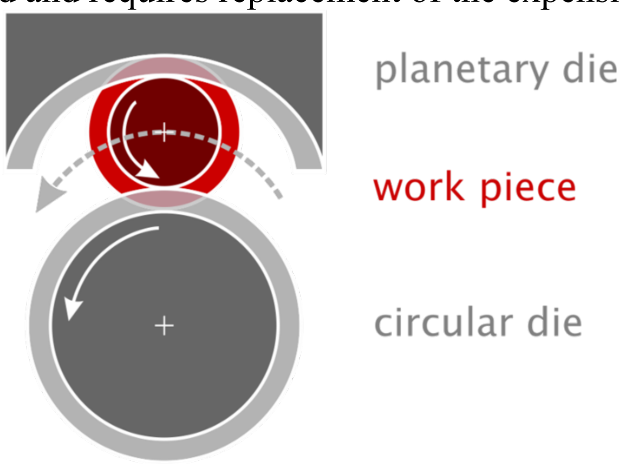
Increasing the service life of planetary thread rolling tools by means of restoration

Planetary Thread Rolling – the Most Productive Method for Producing Threaded Surfaces [1].

The tooling set for planetary thread rolling machines consists of a cylindrical thread rolling roller with a multi-start thread and a thread rolling segment that has a multi-start thread on its concave surface. Blanks fed from the hopper are periodically supplied by the loading device so that one or several blanks are always present in the rolling zone, simultaneously undergoing all stages of thread formation. During operation, the working surfaces of rollers and segments wear out, which reduces the quality of the formed thread and requires replacement of the expensive tooling.



Schematic Diagram of Planetary Thread Rolling [2]

Since tooling for planetary thread rolling is highly material-intensive, a significant part of its cost is determined by the price of the material. Therefore, the overall cost of the tooling can be significantly reduced by repeated restoration of worn tools.

While the restoration of thread rolling rollers is relatively straightforward (it involves undercutting the worn profile on a thread grinding machine), the restoration of segments is a more technologically challenging task.

Several methods were considered during the analysis of potential restoration technologies for the segments, but all were deemed either technologically unfeasible or economically impractical.

1. Laser Cladding: This method is less suitable for segment restoration due to the risk of thermal distortions and residual stresses. It also requires precise control and post-machining, making it inefficient for large components.

2. Electrical Discharge Machining (EDM): The process is time-consuming and inefficient for large-scale removal or reshaping, especially for larger surface areas like those found on segments.
3. Internal Thread Grinding:This method is limited to fine-tuning internal threads and is not effective for restoring external features or large surfaces on segments. It's also not cost-effective for significant wear or reshaping.

A compromise method was developed: First, the segment's hardness is reduced through annealing to facilitate mechanical processing. Next, reference surfaces are ground on a surface grinding machine to eliminate distortions from heat treatment. Then, a CNC milling machine is used to remove the worn thread profile and mill a new one, matched to the restored roller's diameter. Finally, hardening is performed in a vacuum furnace to achieve the required surface hardness.

It is also important to note that undercutting the profile while maintaining the number of thread starts slightly increases the helix angle. This causes the workpiece to shift axially relative to the tool during thread rolling. Calculations show that more than two restorations with the same number of thread starts may lead to tool failure. However, restoration can still be performed by reducing the number of thread starts on both the roller and the segment equally.

If a tool set of original dimensions is required, and several worn tool sets are available, one can combine parts from different size tools (e.g., make an M10 roller from an M12 roller, or an M10 segment from an M8 segment).

The restoration of planetary thread rolling tools represents a highly effective strategy for reducing production costs in mass manufacturing environments. By reconditioning worn segments and rollers instead of replacing them entirely, manufacturers can achieve cost savings of up to 40–60%, depending on the number of successful restoration cycles.

This not only extends the service life of expensive tooling but also contributes to sustainable production practices by minimizing material waste and reducing the demand for new raw materials. Furthermore, when implemented correctly, the restoration process maintains high thread-forming quality, ensuring that performance is not sacrificed for the sake of economy.

Given the rising costs of tool steel and increasing demands for cost-efficiency, the integration of restoration technologies into production workflows proves to be both economically and technologically sound. This approach offers manufacturers a competitive advantage while supporting long-term resource optimization.

References:

1. Thread rolling techniques. *WIRE*. URL: https://umformtechnik.net/wire/Content/Reports/Thread-rolling-techniques

2. Planetary rolling dies - profiroll technologies. *Homepage - Profiroll Technologies*. URL: https://www.profiroll.com/dies/planetary-rolling-dies.html.

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Rare Earth Elements: Occurrence, challenges and source diversification

The global energy landscape is undergoing a significant transformation, marked by a gradual shift from traditional fossil fuels towards sustainable alternatives such as solar cells, wind turbines, and electric vehicles. Concurrently, advancements across diverse sectors including medicine, agriculture, defense, aerospace, and automotive industries rely heavily on sophisticated high-tech products and devices. Central to these technological advancements is a group of critical materials known as Rare Earth Elements (REEs). Consequently, the demand for REEs has experienced a rapid surge, highlighting their strategic importance in the 21st century.

The International Union for Pure and Applied Chemistry (IUPAC) defines REEs as the group of 17 elements encompassing the 15 lanthanides (La-Lu) plus Yttrium (Y) and Scandium (Sc). Functionally, they are categorized into two sub-groups light rare earth elements (LREEs: La-Eu) and heavy rare earth elements (HREEs: Gd-Lu + Y), generally LREEs are more abundant than HREEs. Scandium (Sc) is usually considered separately [1]. Contrary to their name, REEs are not geologically rare; their average abundance in the Earth's crust (150-220 ppm) is comparable to or greater than many common industrial metals like copper (55 ppm) or zinc (70 ppm) [2]. The term 'rare' historically refers to the difficulty in finding them concentrated in economically viable ore deposits and the challenges associated with their separation and purification. REEs do not exist in native metallic form but are found within various mineral forms (phosphates, carbonates, silicates, oxides, halides), making their extraction inherently complex and expensive [3].

RE deposits are classified into primary and secondary types. Primary deposits are predominantly associated with alkaline-peralkaline igneous rocks and carbonatites. Secondary deposits, including placer sands and ion-adsorption clays (notably found in China), result from the weathering and erosion of these primary sources [4]. The distribution of LREEs and HREEs varies among mineral types. LREEs tend to concentrate in carbonate and phosphate minerals, while HREEs are often enriched in oxides and certain phosphates [5]. The most significant mineral sources for REEs, particularly LREEs, are bastnäsite [$(Ce,La)CO_3(F,OH)$] and monazite [$(Ce,La,Nd,Th)PO_4$]. Bastnäsite deposits, primarily located in China and the United States, represent the world's largest REE resource. Monazite deposits, found in countries like Australia, Brazil, China, India, Malaysia, South Africa, Sri Lanka, Thailand, and the United States, constitute the second-largest segment. Significant sources for HREEs include minerals such as xenotime (YPO_4), apatite, cheralite, eudialyte, and loparite, as well as ion-adsorption clays [6]. Other geological settings containing potentially economic REE concentrations include placer deposits, residual deposits from deep weathering, pegmatites, iron oxide copper-gold (IOCG) deposits, and marine sedimentary phosphorites. Understanding the genesis and mineralogy of these varied deposits is crucial for assessing the feasibility of mining operations, processing, and refining strategies.

Beyond conventional ore deposits, research is increasingly focused on identifying and exploiting alternative or secondary REE sources. REEs have been detected, although at low concentrations 0.002–0.8% of Ge, Ga, Se, and Li, in coal seams and associated sedimentary rocks. Despite these low initial concentrations, the vast volumes of coal processed globally mean that coal and its by-products (like coal ash) could represent significant, potentially expanding REE reserves and production capabilities [7]. Fly ash, a major by-product of coal combustion in power plants and incineration of municipal solid waste (MSWI), has garnered particular attention. Globally, hard coal fly ashes contain an average of approximately 445 mg kg^{-1} (ppm) total REEs. Bottom ashes from MSWI facilities also contain REEs, estimated at around 110 mg kg^{-1}, with La, Ce, and Nd being relatively dominant (>20 mg kg^{-1}) [8]. While these concentrations are typically two to three orders of magnitude lower than those found in primary REE ores, the sheer volume of fly ash generated annually presents an opportunity for recovery if economically viable extraction technologies can be developed. Mine tailings and other industrial waste streams are also being investigated as potential secondary REE sources.

The extraction of REEs from primary ore bodies like bastnäsite and monazite is a multi-stage, complex, and often costly process. It typically involves mining, grinding the ore, chemically 'cracking' the minerals to produce mixed rare earth oxides (REO) concentrates, followed by intricate separation and purification steps to yield individual REEs of industrial grade. A significant complication arises because REE-bearing minerals frequently occur alongside radioactive elements, primarily uranium (U) and thorium (Th), particularly in minerals like monazite. This necessitates careful handling and disposal of radioactive waste, adding environmental burdens and costs to the extraction process. The high costs associated with mining and processing primary REE resources, coupled with the fact that high-grade deposits are geographically concentrated in a limited number of countries, create significant supply chain vulnerabilities. China currently holds a dominant position across almost the entire REE value chain, from mining and processing to refining. This near-monopolistic control grants significant influence over global supply and pricing, posing strategic risks for REE-consuming nations [9].

Rare Earth Elements are fundamental building blocks for the green energy transition and a wide array of modern technologies, leading to escalating global demand. However, securing a stable and sustainable supply faces considerable hurdles. These include the geological reality that economically concentrated deposits are scarce, the technical complexity and high cost of extraction and separation, the environmental challenges associated with co-occurring radioactive elements, and significant geopolitical risks stemming from the concentration of supply chains. Addressing these challenges requires a multifaceted strategy. Firstly, renewed exploration efforts are needed to identify new viable REE mineral deposits globally. Re-opening and re-evaluating previously closed mines using modern techniques could also contribute to supply diversification. A thorough understanding of REE occurrence, deposit genesis, and mineralogy is paramount for optimizing exploration and extraction feasibility. Secondly, significant research and investment are crucial for developing and scaling up economically viable and environmentally sound technologies to recover REEs from alternative and secondary resources, such as coal fly ash, MSWI ash, mine tailings, and other industrial wastes. Thirdly, nations heavily reliant on REE imports should prioritize the development and implementation of innovative and efficient REE recycling processes, potentially integrating them with conventional techniques to create circular economy pathways for these critical materials.

In conclusion, overcoming the current REE supply challenges necessitates concerted efforts from governments, industry, and the research community. Diversifying primary sources through domestic investments, unlocking the potential of secondary resources, and closing the loop via advanced recycling are essential steps to mitigate supply risks and ensure the continued availability of these critical elements for future technological innovation and sustainable development.

References:

1. McLemore, V.T., 2015. Rare earth elements (REE) deposits in New Mexico: Update. New Mex. Geol. 37, 59–69.
2. King, H.M., 2017. REE: Rare Earth Elements and their Uses. Geol. News Inf. https:// geology.com/articles/rare-earth-elements/ (accessed: 13.07.2019).
3. Jordens, A., Cheng, Y.P., Waters, K.E., 2013. A review of the beneficiation of rare earth element bearing minerals. Miner. Eng. 41, 97–114. https://doi.org/10.1016/j.mineng.2012.10.017
4. Goodenough, K.M., Schilling, J., Jonsson, E., Kalvig, P., Charles, N., Tuduri, J., Deady, E.A., Sadeghi, M., Schiellerup, H., Müller, A., 2016. Europe's rare earth element resource potential: an overview of REE metallogenetic provinces and their geodynamic setting. Ore Geol. Rev. 72, 838–856. https://doi.org/10.1016/j.oregeorev.2015.09.019
5. Kanazawa, Y., Kamitani, M., 2006. Rare earth minerals and resources in the world 412, 1339–1343. https://doi.org/10.1016/j.jallcom.2005.04.033
6. Long, K.R., Van Gosen, B.S., Foley, N.K., Cordier, D., 2010. The geology of rare earth elements. Republished from: The Principal Rare Earth Elements Deposits of the United States. USGS Scientific Investigations Report.
7. Rozelle, P.L., Khadilkar, A.B., Pulati, N., Soundarrajan, N., Klima, M.S., Mosser, M.M., Miller, C.E., Pisupati, S.V., 2016. A study on removal of rare earth

elements from US coal byproducts by ion exchange. Metall. Mater. Trans. E, 1–12. http://doi.org/10.1007/s40553-015-0064-7
8. Ketris, M.P., Yudovich, Y.E., 2009. Estimations of Clarkes for carbonaceous biolithes: world averages for trace element contents in black shales and coals. Int. J. Coal Geol. 78, 135–148. https://doi.org/10.1016/j.coal.2009.01.002
9. Voncken, J.H.L., 2016. The Rare Earth Elements: An Introduction. Springer.

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Use Of ELISA Method For Determination Of Mycotoxins In Food Products

Mycotoxins are secondary metabolites of mold fungi that cause biochemical poisoning of humans and animals. According to the Food and Agriculture Organization of the United Nations (FAO), about 25% of all food resources in the world are annually contaminated with mycotoxins.

Consumption of products affected by mycotoxins has a destructive effect on cells, tissues and organs of humans and animals. This can cause carcinogenic, mutagenic, teratogenic, neurotoxic, immunosuppressive, allergenic and embryotoxic effects [3, 4].

Mutagenic effects are produced by mycotoxins, causing long-term changes in genetic material; teratogenic effects include all malformations of the embryo or fetus (structural changes, impaired activity, developmental delay, decreased fetal weight, premature birth); neurotoxic causes disorders of the central and peripheral nervous system; immunosuppressive - damage to immune cell receptors and, as a result, reduced resistance to infectious diseases; carcinogenic - the formation of malignant tumors [3, 4].

The use of products containing mycotoxins poses a significant threat to both human and animal health and the economy, as their spread causes crop losses, reduces product quality and requires additional costs for safety control. It is estimated that economic losses in Europe from mycotoxin contamination exceed 5 billion euros per year.

Mycotoxins are biological natural contaminants of cereal grains, legumes, sunflower seeds, as well as vegetables and fruits. They can be formed during storage in many food products because of the development of microscopic fungi in them.

For rapid assessment of mycotoxin content in raw materials and food products, there was a need to use a relatively inexpensive screening method, namely the enzyme-linked immunosorbent assay (*ELISA*).

It is based on the interaction of an antigen (a compound to be detected) with an antibody (a protein molecule synthesized by immune system cells in response to the introduction of a specific antigen). The binding of antibodies to an antigen occurs because the active center of the antibody molecule is complementary in its conformation to the determinant groups of the antigen [5].

Enzyme-linked immunosorbent assay (*ELISA*) arose at the interface of two sciences - immunochemistry and engineering enzymology and has become one of the most common research methods.

Thanks to the successes of biotechnology and genetic engineering, it is possible to obtain highly purified protein-antigens, various poly- and monoclonal antibodies of given specificity and affinity, enzyme-markers and conjugates of enzymes with antigens and antibodies.

The entire process of enzyme-linked immunosorbent assay can be divided into three main stages: the formation of a specific antigen-antibody complex (immunochemical process), the introduction of a label into it (attachment to it) and its detection (visualization).

The most common solid-phase method of ELISA (enzyme-linked immunosorbent assay, *ELISA*) was first developed in 1971. It is based on the principles previously used in radioimmunoassay (RIA), where radioactive labels are used; in the case of ELISA, an enzyme label is used instead of a radioactive one.

The enzymes used in ELISA are characterized by a long half-inactivation period (at 4°C they are stored for more than 12 months); they do not create a radiation hazard and make it possible to obtain quantitative and visual qualitative tests for mass analysis of samples [5-8].

The method is based on the specific binding of an antibody to an antigen. An important difference from other serological reactions is that one of the components is conjugated with an enzyme, mainly secondary antibodies. As a result of the reaction of the formed complexes with the corresponding chromogenic substrate, a colored product is formed, the amount of which can be determined spectrophotometrically [5-8].

Theoretically, ELISA is based on the data of modern immunochemistry and chemical enzymology, knowledge of physicochemical laws and the basics of interaction (hydrophobic, ionic, van der Waals and water bonds), antigen-antibody reactions, as well as on the main principles of analytical chemistry.

The sensitivity and specificity of ELISA, and the time spent on its conduct are determined by three main factors:

- kinetic,
- thermodynamic characteristics of the antigen-antibody reaction,
- the ratio of reagents, their incubation time in solution, the ability to enzyme activity and the resolution of its detection methods [5-8].

In general, the formation of an antigen-antibody complex according to the «lock-key» principle can be described by a simple scheme:

$$[AT] + [AG] \leftrightarrow [ATAG]$$

Any ELISA method contains 3 mandatory stages:

1. The stage of recognition of the tested compound by an antibody specific to it, which leads to the formation of an inseparable immune complex.

2. The stage of formation of a conjugate bond with the immune complex or with free binding sites.

3. The stage of conversion of the enzyme label into a registered signal that can be detected using various methods (photometric, spectrophotometric, fluorometric, chemiluminescent, electrochemical, etc.) [5-8].

Enzyme immunoassay compared to other methods of antigen and antibody detection has the following advantages: high sensitivity; specificity and reproducibility of results; possibility of using minimal volumes of biological fluid samples; availability and stability of reagents; simplicity and speed of the reaction; instrumental recording of final results and automation of almost all stages of ELISA; possibility of mass analysis and, last but not least, relatively low cost of diagnostic kits.

Among the disadvantages, the following should be highlighted: there is a possibility of a human factor; automated systems for performing ELISA without human intervention are relatively expensive; it is not a direct method of research, because it detects the consequences of the disease, and not the pathogen itself [5-8].

Due to its low cost and environmental safety, ELISA has become a standard, «routine» analysis.

It should be noted that although there are several variants of ELISA (direct, indirect, competitive, «sandwich»), they all use an enzyme conjugate with specific or anti-species antibodies or antigens and a developer (a mixture of substrate and chromogen); because of the enzymatic reaction with the substrate using the chromogen, the reaction mixture is colored. This allows you to visually or automatically assess the presence of antigens or antibodies in the material under study [5-8].

For the determination of mycotoxins in food products, *competitive ELISA* is quite often used - this is a type of reaction in which a labeled analogue of the analyte is introduced into the reaction mixture, which competes with it for a limited number of specific binding sites. In *competitive ELISA*, the optical density of the reaction products is inversely proportional to the concentration of the analyte in the extract [5-8].

In *competitive ELISA*, at the first stage, the analyzed compound and its analogue, labeled with an enzyme, are simultaneously present in the system.

During the reaction, labeled (secondary) and test antibodies compete for the active sites of the antigen immobilized on the solid phase.

After incubation and removal of the reacted components, an enzymatic reaction is performed, the results of which are inversely proportional to the number of antibodies in the test sample (Fig. 1) [5].

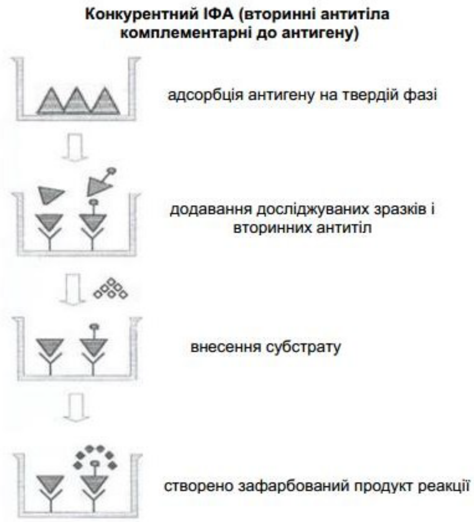

Fig. 1. Schematic representation of a competitive ELISA

As already mentioned above, enzyme-linked immunosorbent assay (ELISA) in food analysis is an accurate analytical tool characterized by high sensitivity, selectivity, the ability to determine polar and water-soluble compounds, ease of implementation, low cost, and does not require complex purification of the extract.

It is in the analysis of mycotoxins that ELISA has the advantage that, due to characteristic cross-reactions, it can be used to search for other derivatives. In this case, ELISA complements standard methods of chemical analysis and can be used for screening and identification of mycotoxins [1, 2].

Modern commercial ELISA test systems are mainly adapted for the determination of mycotoxins, but only when studying food products that have an intensely pronounced color, namely: red wine, ground paprika, ground coffee or solution, etc. When working with such samples, difficulties arise in preparing samples for research, since false-positive results were often obtained.

To solve the problem of studying such samples, sample preparation is modernized, which includes purification of the sample extract with solvents, and in some cases the use of sorbents [1, 2].

The use of immunophilic columns may be appropriate for use in industrial laboratories, for example, coffee factories, etc.

To evaluate the result, the maximum absorption index is used, which is defined as the ratio of the optical density of the sample extract to the optical density of the negative control, expressed in percent.

Simultaneously with the sample extracts, positive and negative standard samples are analyzed. To increase the accuracy of measurements, sample extracts and standards are added to several wells of the plate [1, 2].

When conducting a qualitative assessment of the research results, two answer options are provided: the result is positive or negative, i.e. mycotoxins of the above groups are detected or not. During semi-quantitative assessment, three answer options are provided: the substance being determined is contained in the extract in a larger, equal or smaller amount than in the standard sample.

When conducting an enzyme immunoassay, it is possible for the test system to recognize positive samples as negative and vice versa, i.e. obtaining false positive and false negative results. The sensitivity of the test system is expressed as the ratio of positive results to the sum of positive and false negative (not recognized by the test system) results [1, 2].

Therefore, regular monitoring of mycotoxins is a key element in ensuring the quality and safety of food products. The enzyme immunoassay method allows operating. It is possible to detect even low concentrations of toxic substances, which makes it possible to respond to potential threats in a timely manner.

The enzyme-linked immunosorbent assay method can be used for screening and quantitative determination of mycotoxins. In cases where the detection of the presence of a specific known substance must be carried out accurately, quickly and inexpensively, this method has a great advantage over other analytical methods, since it is characterized by high specificity and sensitivity. Currently, ELISA is the simplest and most accessible method for determining mycotoxins for any laboratory.

Such screening control is important for preserving the health of animals, plants and end consumers, which makes ELISA an important step in ensuring product quality in Ukraine.

References:

1. Клінічні лабораторні дослідження: підручник (ВНЗ I-III р. а.) / Т.І.Бойко. – 2-е вид., переробл. і допов. – К.: Медицина, 2015. – 352 с.

2. Лаповець Л.Є. Клінічна лабораторна діагностика: Підручник для студентів медичних ЗВО, лікарів-інтернів, фахівців лабораторної діагностики / під заг. ред. Лаповець Л.Є. – К.: Медицина, 2021. – 472 с.

3. Мікробіологія, вірусологія, імунологія: підручник для студ. стомат. ф- тів вищих мед. навч. закл. III–IV р. а. / [В.В. Данилейченко, С.І. Климнюк, О.П. Корнійчук та ін.] ; за заг. ред. В.В. Данилейченка, О.П. Корнійчук. – Вінниця : Нова Книга, 2017. – 376 с.

4. Мікробіологія: підруч. для студентів вищ. навч. закл. / Н.І. Філімонова, Л.Ф. Сілаєва, О. М. Дика та ін. ; за заг. ред. Н. І. Філімонової. – 2-ге вид. – Харків: НФаУ : Золоті сторінки, 2019. – 676 с.

5. Філіпова, Т.О., Гудзенко, Т.В., Галкін, М.Б., Зінченко, О.Ю., Ямборко, Г.В. & Русакова, М.Ю. (2018). Імунологічні методи: метод. вказівки до проведення лабораторних занять з курсу «Імунологія». Одеса: Одес. нац. ун-т ім. І.І. Мечникова.

6. Chaudhari, G.N., Kavil, S.P. & Ullal, D.P. (2014). An overview on ELIAS techniques for analyte detection to new levels: a review. Inter J of Multidisciplinary Edu Res (3, 6 (1)). 172-206.

7. Mandy Alhajj; Muhammad Zubair; Aisha Farhana (2023). Enzyme Linked Immunosorbent Assay. https://www.ncbi.nlm.nih.gov/books / NBK555922.

8. Suleyman Aydin (2015). A short history, principles, and types of ELISA, and our laboratory experience with peptide/protein analyses using ELISA. Peptides. (72) 4-15. https://doi.org/10.1016/j.peptides. 2015.04.012.

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Construction Automation: The limits of what is possible for 3D Printing

Today, the processes associated with the active implementation of information technology have a significant impact on all spheres of human life, while its full implications remain to be thoroughly explored. However, we are already observing certain trends in such an important aspect of construction as 3D printing. The expanded use of this technology is prompting a rethink of the traditional approach to organizing labor on construction sites. Given that modern 3D printers can perform numerous tasks faster, more accurately, and more efficiently than humans, our study will attempt to determine the limits of the possibilities of using 3D printers to reduce human involvement in the construction process and consider the realism of the idea of "construction without human intervention." The capabilities of 3D printers currently cover a wide range of tasks, including the manufacture of residential buildings, structural elements, as well as insulation and finishing works. Thus, 3D printers are becoming a key tool in transforming traditional construction methods, unlocking new possibilities for process automation and optimization.

McKinsey (2022) estimates that up to 30% of work can be automated, reducing labor and material costs. However, this process is not limited to financial benefits. Installing and maintaining sophisticated equipment requires significant upfront investment, which can be an obstacle for small businesses. In addition, it is worth considering the ongoing costs of materials and maintenance in the budget of each project. Full automation may be accessible only to large companies, creating market inequality. The use of 3D printers in construction poses an important social problem for society: how to provide jobs for those who have lost their jobs due to automation. Singapore, for example, has begun to actively use this technology to reduce its dependence on foreign labor. However, this also leads to an increase in unemployment among local construction workers. This issue is the focus of the PILLARS research team, which has conducted a comprehensive analysis of the impact of innovative technologies on various sectors of the economy and professional activities. The research developed strategies to overcome challenges in automation and labor market transformation. The findings emphasize the need to implement proactive policies, in particular, to encourage employers to invest in the development of human resources, as well as to improve the social protection system to ensure effective management of changes in the employment structure. [1]

Despite the advantages of 3D printing, technical limitations prevent full replacement of human labor. 3D printers can effectively perform functions related to the construction of load-bearing structures, walls, and partitions, but the full cycle of construction work remains impossible without the involvement of qualified specialists. Processes such as installing telecommunications systems, roofing, electrical work, plumbing, and finishing tasks continue to rely on manual specialized labor. It is also worth noting that automated processes require constant quality control, as even minor deviations in printing parameters can cause serious structural defects that negatively affect the performance of structures. The problem of defining the boundaries of the possibilities of using 3D printers to reduce human involvement in the construction process has attracted the attention of many scientists. For example, Behrokh Khoshnevis, a professor at the University of Southern California and the developer of Contour Crafting technology, emphasizes that despite the possibility of significant cost savings and productivity gains, 3D printing in construction cannot exist without integration with traditional methods. [2]

The prospects for the construction industry are likely to be based on close interaction between humans and automated systems, which implies the transformation of traditional professional roles. According to Professor Helena Richardson (University of Cambridge), “construction workers will become process managers rather than manual laborers.” In such circumstances, the future belongs to hybrid solutions, where a person is responsible for strategic aspects and machinery is responsible for performing specific tasks. This approach helps not only to reduce injuries on construction sites but also to improve the quality of construction work. According to a 2021 study by the Organization for Economic Cooperation and Development (OECD), the introduction of new technologies is creating new professional roles, such as 3D printer operators, software engineers, and quality management experts who can manufacture, maintain, and operate these machines. [3]

At the same time, Norbert Wiener argued that automation compels us to rethink our roles with machines. [4]

Thus, full automation of the construction process at the present stage remains unattainable, as there are still a number of aspects that require direct human involvement. 3D printing significantly increases the speed and accuracy of construction, but it is still regarded as an additional tool. The main factors that complicate full automation are complex finishing work, quality control, logistics, and the need for adaptability. It is likely that the further development of the construction industry will be based on the integration of automated technologies with human labor, where 3D printers perform routine tasks and specialists control complex processes.

References:

1. Guznajeva, T., Garcia Gutierrez, J., Konstantynova, A., Zeqo, K., Nausedaite, R., & Kooijmans, O. (2022). Pathways to inclusive labour markets: Discussion of impacts of automation technologies on the labour market. Technopolis. 25 p.
2. Khoshnevis, B. (2019). Integration of 3D printing with traditional construction methods. Automation in Construction, 105, pp. 103–115.
3. Georgieff, A., & Milanez, A. (2021). What happened to jobs at high risk of automation? OECD Social, Employment and Migration Working Papers, No. 255. pp. 1–9.
4. Norbert Wiener. (1954). The Human Use of Human Beings: Cybernetics and Society. 224 p.

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Application of Bionic Design in Mechanical Engineering

Bionic design is an innovative approach based on the adaptation of natural forms and structures to solve complex engineering challenges. Its main goal is to use solutions created by nature over millions of years of evolution to develop strong, lightweight, and energy-efficient technical structures. In the field of mechanical engineering and other technical disciplines, this approach fosters the technological innovations that meet contemporary requirements for sustainable development [1].

One of the core principles of bionic design is the optimization of structure geometry through the adaptation of natural forms such as bone tissue, mollusk shells, or honeycombs (fig. 1). For example, the porous forms of bone structures have inspired engineers to create components that combine lightness with strength [2]. In the automotive industry, this allows for a significant reduction in the weight of vehicles, which directly contributes to lower fuel consumption and reduced carbon dioxide emissions [3].

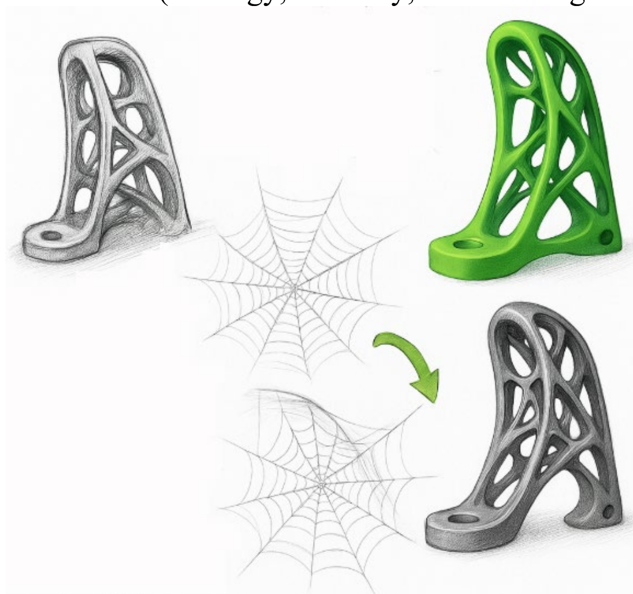

Figure 1: Design of structural bracket inspired by spider web

The bionic approach is also actively used in the aviation sector. Bird wings, which provide an ideal balance between lift and aerodynamic efficiency, have served as inspiration for creating adaptive aircraft structures [3]. As a result, advanced aircraft are able to minimize air resistance and use energy more efficiently. In the development of gliders and unmanned aerial vehicles, this approach helps achieve high performance during long flights.

Robotics is another field where the principles of bionic design are actively implemented. Mechanisms inspired by snake movements are used in rescue robots and underwater exploration, demonstrating exceptional maneuverability in hard-to-reach areas. Robots that mimic animal limbs are employed to navigate uneven surfaces and perform tasks in challenging environments. For instance, devices based on the principles of a cheetah’s paw exhibit excellent speed and stability even on rough terrain [3].

This study examines the implementation of bionic design in mechanical engineering, particularly its principles and practical applications. It has been established that the adaptation of natural forms makes it possible to reduce the weight of components while increasing their strength and energy efficiency [1, 2]. Additive technologies have been identified as a key tool for realizing complex structures inspired by nature.

At such a technological background incorporating bionic design into education and research frameworks also fosters a deeper understanding of natural systems and their applications in technology. Furthermore, this approach cultivates a student mindset geared toward problem-solving that prioritizes efficiency, resilience, and environmental harmony, empowering the next generation to tackle global issues with bioinspired ingenuity.

In the scope of this work, a thorough investigation was conducted into how bionic design principles are being applied in modern mechanical engineering. This included a comprehensive analysis of natural structures that inspired engineering solutions, as well as specific examples of their integration into vehicles, aircraft, and robotic systems. Particular attention was given to how additive manufacturing (3D printing) is being used to bring complex bionic geometries into reality. A practical evaluation of several engineering projects showed measurable gains in performance and sustainability when bionic design was applied. These results clearly demonstrate the viability and advantages of nature-inspired engineering in addressing contemporary technical challenges.

References:

1. Zhezheria, O. V. *Bionic Principles in Design: Synthesis of Form and Function/* O. V. Zhezheria // Bulletin of Lviv National Academy of Arts. – 2021. – Issue 46. – pp. 114–122.
2. Kemp, Ch., Tenenbaum, J. B. The discovery of structural form/ Ch. Kemp, J. B.Tenenbaum // PNAS. August 5, 2008. 105 (31). 10687-10692; https://doi.org/10.1073/pnas.0802631105
3. Dickinson, M. H. *Bionics: Biological Insight into Mechanical Design /* M.H.Dickinson // *Proceedings of the National Academy of Sciences of the United States of America* – 1999. – Vol. 96. – No. 25. – pp. 14208–14209.

Section 03 Computer Science and Solutions in IT

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How an Entirely Digital Currency System Can Improve Daily Life

In today's fast-changing world, digital technology affects almost every part of our daily lives – from the way we communicate to the way we work, learn, and travel. One of the biggest changes we can see is the way people pay for things. More and more often people are using digital methods like mobile phones, bank cards, and online banking instead of carrying cash. This growing trend has made many people think: should we stop using cash completely and move to a fully digital currency system?

This is not just a question of convenience – it is about the future of our financial systems. A fully digital currency system could bring many changes to the economy, businesses, and everyday life. Some people believe that going cashless would make life easier, faster, and safer. Others are not sure, and they worry about what we might lose if we stop using cash.

In this paper, I will explain why I believe a fully digital currency system is a good idea. Digital payments can make daily life easier, faster, and safer. They also help manage money better and reduce unnecessary costs. While there are some challenges, I see more benefits and believe that moving away from cash is a smart step into the future.

1. Convenience and Speed of Transactions

Digital payments offer a level of convenience that cash cannot match. Transactions through mobile apps, contactless cards, and online banking can be completed almost instantly, which saves time and effort for consumers and businesses. In situations where quick payment is necessary, such as public transportation or retail shopping, digital transactions significantly reduce waiting times and make purchases simpler.

2. Enhanced Security and Fraud Prevention

Carrying cash makes you an easy target for criminals. Digital transactions are often protected by encryption, two-factor authentication, and other security measures, which make it harder for criminals to access funds or manipulate financial data. Additionally, digital transactions leave an electronic record, which can assist law enforcement in tracking fraudulent activities and prevent crimes such as money laundering and tax evasion.

3. Reduction in Government and Business Expenses

Handling physical cash comes with significant expenses for both businesses and governments. The process of printing, transporting, and securing cash is costly and time-consuming. Businesses need to store the money, get more when they run out, deposit cash when they have too much on hand, and in some cases, hire companies to transport cash safely.

Governments spend resources on printing, replacing, and protecting currency from counterfeiting. Spending time and resources moving money around and protecting large sums of cash could become a thing of the past in a cashless future.

4. Increased Transparency and Accountability

In a fully digital currency system, every transaction is recorded electronically, which could lead to greater transparency in financial dealings. This transparency can help reduce corruption, improve tax collection, and discourage illegal transactions. Supporters argue that this transparency would make the economy more stable and reliable.

5. Digital Payments Help People Manage Their Money Better

When people use digital payments, they can easily track how much they spend and where their money goes. Most banking and payment apps show a clear history of all transactions. This helps users understand their spending habits, plan their budget, and save more effectively. Cash, on the other hand, disappears without a trace – it is hard to remember what you spent it on. With digital money, people have more control and can make smarter financial choices. It is especially useful for young people and families who want to improve their financial literacy.

6. Digital Currency Can Improve Access to Financial Services

In many parts of the world, people still don't have access to traditional banks. Opening a bank account can be difficult in rural areas or for people with low income. However, digital wallets and mobile banking services are changing this. Even a basic mobile phone can give users access to payments, savings, and transfers. This allows more people to take part in the economy, receive payments for work, send money to family, and build financial stability. A cashless system helps reduce inequality by making financial services available to everyone, no matter where they live.

After considering the arguments, moving to a fully digital currency system has many clear benefits. It makes payments faster, safer, and more convenient. It helps reduce costs and makes financial systems more honest and transparent. At the same time, cash is slower, less safe, and not suitable for a modern digital life. That is why we should stop using cash and move forward to a smart and fully digital future.

References:

1. The Pros and Cons of a Cashless Society. URL: https://www.thebalancemoney.com/pros-and-cons-of-moving-to-a-cashless-society-4160702
2. Digital Money: What It Is, How It Works, Types, and Examples. URL: https://www.investopedia.com/terms/d/digital-money.asp
3. The Advantages and Disadvantages of Cash Payment. URL: https://paycomplete.com/advantages-and-disadvantages-of-cash/

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Comparative analysis of Python libraries for GUI development

The graphical user interface plays a key role in modern software applications. It provides an intuitive way for users to interact with the application. Python is a universal programming language that offers several libraries specifically for GUI development, which have both advantages and disadvantages. When choosing a suitable framework, you should take into account that it will affect the efficiency and usability of the application. In addition, it is important to take into account the peculiarities of each library, its performance, and the possibility of integration with other technologies, which can significantly affect the final result of development.

The purpose of this research is to compare the Python libraries for GUI development, namely PyQt, Tkinter, Kivy and wxPython.

QT documentation 2024 [1] describes PyQt as one of the most popular Python libraries for the graphical user interface. It is built around the Qt framework, which is cross-platform and is used to create software applications on different platforms. The PyQt library is cross-platform and can be used on various platforms such as Mac, Windows, Linux, iOS, and Android. The QtGUI and QtDesigner modules of this library have visual elements that can be implemented using drag and drop. You can also choose to create an element using code, which allows you to develop both small and large-scale projects. PyQt has the following advantages: universality of coding, various user interface components, several learning resources, and a wide range of native platform Application Programming Interface (API) for networking, database management, etc. The disadvantages include the large size of the libraries, which can affect performance and the difficulty of learning for beginners.

The Tkinter Documentation 2024 [2] defines Tkinter as an open-source, multi-platform GUI development library. It is known for its simplicity and is included in the standard Python library, which allows you to work with it without installing additional modules. Visual elements are called widgets and each of them has different levels of customization. It also offers a massive range of frequently used elements, such as frames, buttons, labels, and dialogue boxes, which simplifies the development process. This library has such advantages as: flexibility and stability, ease of use, simple syntax. Its disadvantages are minimal customization, low performance when creating complex applications, and an imperfect interface.

The Kivy Documentation 2024 [3] says that Kivy is an open-source library with more than 20 widgets. It was designed to use a mixture of Python and Cython, which helps to develop one of the most intuitive natural user interfaces (NUIs). Kivy allows UI developers to program on multiple platforms, and the built-in support for OpenGL ES 2 provides modern graphics. Its advantages: code written once can be used on all devices, easy-to-use widgets with multi-touch support, deployment on multiple platforms. Its disadvantages: difficult to set up, high resource consumption, poor support for native OS elements.

The wxPython Documentation 2024 [4] argues that the wxPython library allows Python developers to create their own user interfaces at no additional cost, as it is a standard Python library. Like other libraries, it runs on a variety of platforms such as Mac OS, Windows, Linux and Unix-based systems. WxPython has a lot of widgets and this is its biggest advantage. Also, this library looks great on any platform without requiring any special changes. The advantages of wxPython are a large library of interaction elements, a practical look, and great flexibility. As for the disadvantages, they are as follows: unstable operation on different operating systems, lack of a full-fledged GUI editor, library updates are slow.

Let's compare the above libraries by the following factors: ease of use, functionality, cross-platform compatibility, and efficiency.

The easiest libraries to use are Tkinter and wxPython, as they require less time to master than PyQt and Kivy. Speaking about the functionality factor, PyQt is the best because it provides the widest range of features and also supports multimedia and database work. As for the cross-platform factor, all of the above applications support work on different platforms, but Kivy is more adapted to mobile devices. From the point of view of efficiency, it is more appropriate to use Tkinter and wxPython libraries for the development of simple software products, and PyQt and Kivy for more complex ones.

The following conclusions can be drawn from the research conducted. Each of the libraries has its advantages and disadvantages, but the expediency of using each of them depends on the tasks set when developing a graphical interface. Among the other libraries, we can single out the PyQt library, which is the most flexible, widely functional and has a large base of possibilities for customizing the interface. It is suitable for the implementation of complex projects, while for smaller projects it is better to use Tkinter. When developing modern touch interfaces, it is advisable to use the Kivy library, and for intuitive applications, wxPython. In addition, the choice of a suitable library is determined not only by its technical characteristics, but also by the requirements for performance and compatibility with modern operating systems. Further research could focus on analyzing the performance of libraries in real-world scenarios and adapting them to the latest technological trends.

References:

1. Qt Documentation. (2024). Retrieved from https://doc.qt.io/
2. Tkinter Documentation. (2024). Retrieved from https://docs.python.org/uk/3.13/library/tkinter.html/
3. Kivy Documentation. (2024). Retrieved from https://kivy.org/doc/stable/
4. wxPython Documentation. (2024). Retrieved from https://wxpython.org/

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Cyberattacks: recognize, prevent and defend

Almost 68% of the world's population uses the Internet on electronic devices. As electronic devices are not always secure, people suffer from cyberattacks.

The cyberattack is an attempt, made by malicious individuals, to penetrate a computer system, network, or device in order to steal, damage, alter, or block information. The goal of such attacks is to gain profit, to harm a company or a person, to paralyze a system operation, or to steal data.

Cyberattacks can be of different types and include:

- **Malware** – a software or a programming code designed to cause unauthorized access, disruption, theft of data, or damage to computer systems and networks. This widely popular broad type of malicious software consists of *viruses,* which infect files; *worms,* which spread without human intervention by exploiting network vulnerabilities through malicious software code; masqueraded *trojans* stealing data or taking control over a device; *ransomware* which encrypt files and demand a ransom; and *spyware* covertly collecting personal data.
- **Phishing** - a common type of cyberattack in which criminals use emails, SMS, phone calls, and other means of communication to trick users and get access to financial data, login credentials, or other sensitive information. Except for a standard and targeted phishing, hackers also use smishing by means of SMS or a high-profile where attackers pretend to be trusted individuals, encouraging the victim to provide confidential information.
- **Man-in-the-middle attack (MITM)** in which an attacker intercepts the communication between a user's computer and a recipient altering the messages with a potential aim to gain access to the victim's personal information.
- **Denial of service (DoS)** and **district distributed denial of service (DDoS)** attacks disable a computer or service by flooding it with false requests. This flood is so large that the server simply 'chokes' and stops working, or slows down dramatically. While DoS attack originates from a single source, DDoS attack comes from multiple sources.
- **A password attack** uses various algorithms to find the password in the shortest time possible. Such algorithms include *a brute-force attack* during which a hacker tries to decipher a password by trying every possible combination of characters; *a dictionary attack* where hackers use a list of the most common passwords from user behavior patterns obtained from previous security breaches; or *a rainbow table attack* in which a rainbow table, like a

decoder, matches scrambled hashes back to the user's original password, allowing the attacker to break in.

Such a big number of various insecurities raises the question how to minimise a risk of a cyber attack. The simplest recommendations include the following tips:

- *Install an antivirus* that will protect your device and help reduce the damage.
- *Use VPN* especially while working with a public Wi-Fi. VPN can encrypt your connection and protect your privacy.
- S*trong passwords* reduce the chances of a cyberattack. It also refers to a home Wi-Fi in which login credentials set by the manufacturer must be changed.
- *Download apps only from reputable sources* that perform extensive checks, minimizing the chance of malicious software.
- *Do not click on unfamiliar links*. If you really need to follow a link, hover your mouse over it before clicking.
- *Scan emails before opening.* It prevents users from being harmed by any dangerous cyber threats embedded in emails.

Following these basic rules can help a user to keep his system more secure. However, there's still the risk of becoming a victim of a cyberattack.

The signs of a hack include the increase amount of spam, locked accounts, system update challenges, slow performance, unusual noises, disabled antivirus, excessive pop-ups, blocked websites, unknown purchases, or new programs.

If you've been hacked, take these steps:

- *Get Your Accounts Back.* For hacked accounts, recover through platform-specific processes. Carefully check links in any recovery emails.
- *Tell your friends and family.* Warn your friends and family about the hack. Advise them to ignore any suspicious messages or links from your accounts.
- *Check your bank accounts for fraudulent transactions.* If you see unauthorized purchases, even small ones, contact your bank to cancel your card.
- *Update your security software and scan for viruses.* Viruses can steal passwords and lock you out. Scan your computer with antivirus software to remove malware.
- *Change your passwords to keep your accounts safe.* Use strong passwords with a mix of letters, numbers, and symbols. Don't reuse old passwords or use the same one for different accounts.

In the context of the dynamic development of digital technologies, artificial intelligence AI is extremely important in the field of cyber defence. Its significance lies in the fact that it not only helps to increase the level of security of information systems, but is also, unfortunately, used by attackers to develop new, more sophisticated and dangerous attacks.

Using AI to strengthen cyber defences

With the ability to analyse large amounts of data to identify a variety of potential attacks, AI can automate threat identification and response processes. Machine learning algorithms are able to predict future vulnerabilities and respond quickly to incidents, which improves security efficiency.

AI in the hands of attackers

Attackers are also using AI to automate hacking processes, create more convincing phishing messages, and develop sophisticated malware to obtain sensitive information. This makes such attacks more difficult to detect and neutralise.

Recommendations for protecting yourself in the age of AI

Given the growing role of AI in cyber threats, it is recommended that you:

- Use modern AI-based defences that can adapt to new types of attacks.
- Keep up-to-date with the latest threats and defence methods, as attackers adapt quickly to change.
- Conduct regular training for yourself and your family or employees to increase awareness

To sum up, cyberattacks pose a serious risk in the digital world, but strong security practices can help prevent them. Staying cautious online, using protective measures, and responding quickly to threats are essential for safeguarding personal and professional data.

References:

1. Trimailova K. Різні типи кібератак та як не стати їх жертвою URL: https://nordvpn.com/uk/blog/shcho-take-kiberataka/
2. Invensis Learning Cybersecurity Threats. Types of Cybersecurity Threats. URL: https://www.youtube.com/watch?v=awhqnSskWjU
3. Babaee A. What to do if you get hacked. URL: https://www.money.co.uk/guides/the-7-things-you-need-to-do-if-you-get-hacked
4. Goodman C. AI in Cybersecurity: Transforming Threat Detection and Prevention. URL: https://www.balbix.com/insights/artificial-intelligence-in-cybersecurity/?utm_source=chatgpt.com
5. Fortinet Artificial Intelligence (AI) In Cybersecurity. URL: https://www.fortinet.com/resources/cyberglossary/artificial-intelligence-in-cybersecurity?utm_source=chatgpt.com

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Using Artificial Neural Networks to Predict and Mitigate Risks in Project Management

Artificial neural networks are a powerful tool for automation of risk management processes in project management. The use of these technologies enables effective risk prediction, analysis of their impact on the project's progress, and the development of strategies to mitigate them. Automating these processes improves project management efficiency, reduces time and resource costs, and ensures more accurate and timely responses to potential threats.

Project management is a complex and multifaceted process involving numerous stages, where risk management is one of the most important aspects. Traditional methods of risk assessment and management are often not effective enough to consider all possible variations and interactions of factors that may affect a project. The use of neural networks, which can also adapt to new conditions, allows for a timely response to changing project circumstances.

Thanks to the use of neural networks, the automation of risk management processes allows project managers to obtain more accurate and timely information for decision-making, which leads to a reduction in time and resources, as well as an increase in the likelihood of successful project implementation.

Among the main advantages of using neural networks in risk management are:

- Prediction of the possible risks and assessement of their impact on the project.
- Identification of complex dependencies between different risk factors.
- Automation of the risks minimization strategies development.
- Adaptation to new conditions and model updates in real time.

[1] For mathematical modeling of the risk prediction process using neural networks, a model based on a multilayer neural network (e.g., a multilayer perceptron, or MLP) can be considered. A neural network can be used to predict the probability of a risk occurring based on numerical project parameters, such as task completion time, budget, amount of resources, changes in customer requirements, etc.

[2] Let $x_1, x_2, \dots x_n$ – are input parameters (risk factors) affecting the probability of risk occurrence in the project. Each parameter is normalized and passed to the neural network. The model can be represented through several layers of neurons, where each neuron on each layer is responsible for a specific combination of inputs.

Suppose we have a neural network with L layers, where each layer contains a certain number of neurons hl, and the output layer consists of a single neuron y y, which represents the probability of a risk occurring. Each neuron in each layer computes a linear combination of input values from the previous layer and then applies an activation function for nonlinearity.

Linear calculation on each layer:

$$z_1 = W_l * a_{l-1} + b_l$$

where:

- W_l - is the matrix of weights on l-th layer,
- a_{l-1} - activation of the previous layer (for the first layer $a_0 = x$),
- b_l - is the vector of displacements by l-th layer,
- z_l - vector of linear combinations for the layer l.

[2] Activation function: At each layer, we apply the activation function f, such as a sigmoid or ReLU:

$$a_l = f(z_l)$$

In the initial layer we have:

$$y = \sigma(W_l * a_{L-1} + b_L)$$

Where σ is an activation function (e.g., a sigmoidal function for probability that gives a value from 0 to 1). The probability of risk occurrence y can be interpreted as the probability that a certain risk (e.g., project delay or budget overrun) will occur at a certain stage of the project. The probability is usually calculated using historical data, expert judgments, or a combination of both. It is influenced by several factors, including the complexity of the project, external conditions, and the effectiveness of the risk mitigation strategy. The value of y is a crucial factor in risk management, enabling project managers to prioritize actions and allocate resources effectively to minimize the likelihood and impact of identified risks.

The use of neural networks to automate risk management in project management is a powerful tool that allows you to accurately predict risks and develop strategies to minimize them. This approach significantly improves the efficiency of project management, reduces time and resources, and allows for quick adaptation to changes. The practical application of these technologies helps to reduce the likelihood of errors and increases the competitiveness of organizations, making project management more intelligent and efficient.

References

1. Bussmann, N., Giudici, P., Marinelli, D., & Papenbrock, J. (2020). Explainable AI in Fintech Risk Management. *Frontiers in Artificial Intelligence,* 3. https://doi.org/10.3389/frai.2020.00026.

2. Khalid, J., Mi, C., Altaf, F., Shafqat, M., Khan, S., & Ashraf, M. (2024). AI-Driven Risk Management and Sustainable Decision-Making: Role of Perceived Environmental Responsibility. *Sustainability*. https://doi.org/10.3390/su16166799.

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Virtual environments as a tool for training the skills of future cybersecurity professionals

In this era of the world's rapid digitization, the intensity and methods of cyberattacks have been at record-breaker scales and alarmingly rapid paces. According to Statista, the cost of cybercrime will probably stand at $10.5 trillion in 2025 and is of paramount importance in shaping capable cybersecurity professionals.

Virtual environments have become a revolutionizing feature of cybersecurity training. It provides a safe and flexible solution to imitate real-life situations where learners experiment with some defending tactics with no impact on real systems[1-5]. This study contributes towards developing hands-on competencies for future cybersecurity professionals in terms of security, efficiency, and usability in educational and work processes.

One of the key advantages virtual environments have brought is that they formulate a secure environment for training in cybersecurity. For example, virtual labs can simulate scenarios of ransomware attacks: one can dissect the attack vector, scan vulnerabilities, and apply countermeasures without actually putting real environments at stake. In a similar scenario, a DDoS attack can be emulated to research the traffic and develop proper countermeasures for it. All such scenarios provide hands-on training in fighting critical events with an overall, complete, and full disconnection from real networks. Besides, virtual environments have high scalability, from the virtualization of a single computer to complex corporation networks in which students can practice both simple and complex cybersecurity solutions. To create virtual labs we can use tools like VMware, VirtualBox, and cloud platforms such as Amazon Web Services (AWS).

Realistic simulations have a substantive role in creating skill development in practice. Virtual environments allow critical thinking and quick decision-making – a key skill in cybersecurity. TryHackMe and Hack The Box, for example, are instances in which one has first-hand experience with labs that one can try during a different cyberattack. These platforms actually have challenges in terms of difficulty level, starting from simple reconnaissance and moving towards complex exploit development, hence allowing incremental learning.

Aside from technical skills, virtual environments shape soft skills, including collaboration and communications. That is during a group work-simulated attack such as a red hat versus a blue hat team when one team attacks the network and the other team provides countermeasures. This type of training, in addition to practical skills, develops the ability to work as a team to eliminate the consequences of an attack more quickly and effectively.

Virtual environments could seamlessly integrate into academic courses in educational institutions where subjects like ethical hacking, digital forensics, and malware analysis are studied. Virtual labs could even integrate with training programs in companies to update and equip their employees with solutions to new forms of threats. It is even less costly compared with the physical environment. To begin with, it saves costly infrastructure and hardware in that virtual labs could simply be run over a cloud platform or a single device. For that reason, it can become accessible for students, instructors, and even small-scale academies with a limited budget. The virtual environment's adaptability is even supported by requirements for real-time cybersecurity training with growing social acceptance in cases of increased use of remote and blended learning forms. Virtual environments make it easier by providing effective hands-on training for learners who could possibly be geographically scattered.

To summarize the above, virtual environments can represent a revolution in cybersecurity training, offering an opportunity for training skills without risks to real systems. This approach is safe, flexible and much cheaper than using real laboratories with equipment for this kind of tasks. Their capability to emulate sophisticated attacks and defense scenarios renders learners with hands-on skills in effectively dealing with real scenarios. With the ever-changing character of cyberspace threats, the incorporation of virtual environments in cybersecurity training and educational programs simply cannot be overemphasized. An area for future research could be the use of artificial intelligence in virtual environments to provide a more flexible and skill-adaptive approach.

References:

1. Almutairi, D. A. A. (2021). Effective Virtual Environments. *International Journal of Engineering and Computer Science*, *10*(4), 25312–25315. https://doi.org/10.18535/ijecs/v10i4.4574

2. Dogan, A. Z., & Sorguc, A. G. (2023). Sound perception in virtual environments. *INTER-NOISE and NOISE-CON Congress and Conference Proceedings*, *268*(6), 2660–2671. https://doi.org/10.3397/in_2023_0388

3. Hahn, J. F. (2018). Virtual reality learning environments. *Information and Learning Science*, *119*(11), 652–661. https://doi.org/10.1108/ils-07-2018-0069

4. Olishevskyi, I., Gusev, O., & Olishevskyi, H. (2023). Automated methodology of calculating parameters for non-traditional technology of heating mode of hydro-storage power plant station. *Electrical Engineering and Power Engineering*, (1), 36–42. https://doi.org/10.15588/1607-6761-2023-1-4

5. Олішевський І.Г. ПЕРСПЕКТИВИ ЗАСТОСУВАННЯ ТЕХНОЛОГІЙ ШТУЧНОГО ІНТЕЛЕКТУ В СФЕРІ КІБЕРБЕЗПЕКИ/ І.Г. Олішевський, В.О. Устименко // МОЛОДЬ: НАУКА ТА ІННОВАЦІЇ: матеріали X Міжнародної науково-технічної конференції студентів, аспірантів та молодих вчених, Дніпро, 23–25 листопада 2022 року / Національний технічний університет «Дніпровська політехніка» – Дніпро : НТУ «ДП», 2022 – С. 375–377.

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Innovations in My Field of Study

Innovation is a key driver of human progress, and in the modern era, few fields have experienced such rapid and transformative development as computer science and programming. The advancements we see today are not only revolutionizing technology but also reshaping industries, influencing the global economy, and redefining the way we live, work, and communicate. Staying informed about these innovations is crucial for anyone involved in technology, as the pace of change demands continuous learning and adaptation.

One of the most prominent and impactful areas of innovation is Artificial Intelligence (AI) and Machine Learning (ML). These technologies have moved beyond experimental stages and are now deeply embedded into our everyday lives. AI systems enable machines to analyze vast amounts of data, recognize complex patterns, and make decisions with minimal human intervention. For example, virtual assistants like ChatGPT, Siri, and Alexa have dramatically changed the way people interact with technology, offering personalized help, automating tasks, and even engaging in natural, conversational dialogue.

Beyond virtual assistants, AI is powering computer vision technologies used in self-driving cars, where vehicles interpret visual information from their surroundings to navigate safely. Facial recognition systems are now common in smartphones, airports, and security settings. In the medical field, AI assists in early diagnosis of diseases, improving patient outcomes and saving lives. Businesses rely heavily on predictive analytics, a form of AI that analyzes customer behavior and market trends, helping companies make informed, data-driven decisions and provide tailored experiences for their clients.

Another major pillar of innovation is cloud computing. The ability to access computing resources and store data remotely via platforms like Amazon Web Services (AWS), Microsoft Azure, and Google Cloud has fundamentally changed how businesses operate. Cloud computing provides scalability, flexibility, and cost-effectiveness that traditional IT infrastructures cannot match. Companies can now deploy services globally within minutes, innovate faster, and focus on core activities rather than maintaining complex hardware.

Closely related is the rise of edge computing, which processes data closer to the device or user instead of relying solely on distant data centers. This approach reduces latency and enables real-time processing, which is essential for technologies such as smart homes, wearable devices, industrial automation, and autonomous vehicles. For instance, a smart thermostat or a self-driving car must process information instantly to make decisions in real-time, and edge computing makes this possible.

As technology becomes increasingly integral to every aspect of life, the need for strong cybersecurity has never been more urgent. Innovative solutions are continually being developed to address new and evolving threats. Blockchain technology stands out as a major breakthrough, offering secure, transparent, and decentralized ways to store and transfer data. Initially associated with cryptocurrencies like Bitcoin, blockchain is now finding applications in supply chain management, voting systems, healthcare, and beyond.

Additionally, the Zero Trust Security model is transforming how organizations approach cybersecurity. Unlike traditional models that trust users inside a network, Zero Trust operates on the principle of "never trust, always verify," requiring authentication for every device and user attempting to access resources. Meanwhile, AI is also being harnessed in cybersecurity to detect and respond to threats in real-time, making it possible to prevent breaches before they cause significant harm.

Another frontier with enormous potential is quantum computing. Unlike classical computers that use bits (0s and 1s), quantum computers use qubits, which can represent and process multiple states simultaneously due to the principles of quantum mechanics. This capability allows quantum computers to tackle problems that would take even the fastest supercomputers billions of years to solve. While still largely experimental, companies like IBM, Google, and D-Wave are making significant strides. In the future, quantum computing could revolutionize areas such as cryptography, material science, pharmaceuticals, and complex system modeling, opening possibilities beyond our current imagination.

The way we develop software is also undergoing significant innovation. The introduction of low-code and no-code platforms is making application development more accessible to non-programmers, democratizing technology creation. Tools like OutSystems and Appgyver allow users to create sophisticated apps through simple visual interfaces, accelerating development processes and reducing costs.

Moreover, even experienced developers are benefitting from new tools. AI coding assistants, such as GitHub Copilot, can suggest code snippets, detect errors, and automate repetitive tasks, allowing programmers to focus more on problem-solving and innovation. This shift not only improves productivity but also encourages cleaner, more efficient code practices.

In conclusion, innovations in artificial intelligence, cloud and edge computing, cybersecurity, quantum computing, and software development are collectively reshaping the world as we know it. They are making systems smarter, faster, and more secure, while also creating exciting new career opportunities across diverse industries. However, with rapid innovation comes the responsibility to stay informed, continually update skills, and approach technology ethically. In such a dynamic field, lifelong learning is not just an advantage—it is a necessity. The future belongs to those who are willing to evolve alongside the technologies they help to create.

References:

1. Marr B. The 10 Biggest Artificial Intelligence (AI) Trends In 2024 Everyone Must Be Ready For, 2024 URL: https://www.forbes.com/sites/bernardmarr/2024/01/08/the-10-biggest-artificial-intelligence-ai-trends-in-2024/
2. Google Cloud. What is Cloud Computing?, 2023 URL: https://cloud.google.com/learn/what-is-cloud-computing
3. Schneier B. The Future of Cybersecurity, 2023 URL: https://www.schneier.com/blog/archives/2023/06/the-future-of-cybersecurity.html
4. IBM Quantum. What is Quantum Computing?, 2024 URL: https://www.ibm.com/topics/quantum-computing
5. Microsoft. The Future of Programming: Low-Code and AI-Powered Development, 2023 URL: https://techcommunity.microsoft.com/t5/low-code-apps-blog/the-future-of-programming-low-code-and-ai-powered/ba-p/3792987
6. Nature. Computer Science Innovations: Trends and Challenges, 2023 URL: https://www.nature.com/articles/s41586-023-06287-w

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Some Emerging Research Directions in the Use of AI Agents

An AI agent (or an intelligent agent) is a system capable of perceiving its environment, analyzing data, making decisions, and taking actions to achieve its goals often autonomously and adaptively.

This brief overview highlights several examples of how AI agents are being used and interact across different research domains.

To start with, an AI agent can be introduced as [1] the AI-Generated Science (AIGS) system that is capable of autonomously conducting the full scientific research cycle and discovering new scientific laws. A key focus is the integration of hypothesis falsification, which the authors view as essential to the scientific method and critical for ensuring rigor and transparency in AIGS systems.

To achieve this, they developed a multi-agent system that autonomously generates research ideas and methodologies, executes experiments, analyzes outcomes, provides feedback, and performs hypothesis falsification through ablation studies and discovery verification.

The system demonstrated high levels of creativity (though sometimes producing irrelevant ideas) and nearly 100% success in implementing proposed experiments.

This kind of full-cycle automation holds great promise for accelerating research across diverse fields provided the quality and depth of outcomes continue to improve.

Then, AI agent can be represented [2]in ABIDES-Economist, a simulation platform designed for modeling economic systems. Its main goal is to simulate interactions among economic agents to analyze production, consumption, and monetary processes.

The research uses Agent-Based Modeling (ABM), incorporating household and firm agents, as well as central bank and government agents. It also integrates reinforcement learning (RL) and models external shocks and interactions.

This work lays a solid foundation for developing autonomous systems that simulate economic processes, combining advanced AI techniques and economic theory. It enables realistic testing of various economic scenarios and policy interventions.

In the experiment “Project Sid: Many-agent simulations toward AI civilization” [3], the authors explored the behavior of large groups of autonomous AI agents simulating processes of civilizational development. The main goal was to create large-scale simulations—ranging from 10 to over 1,000 agents to investigate whether such agents can independently develop specialized roles, follow and modify collective rules, and engage in cultural and religious transmission, thereby approaching the formation of AI civilizations.

To achieve this, the authors developed the PIANO (Parallel Information Aggregation via Neural Orchestration) architecture, which enables agents within the Minecraft environment to interact with humans and each other in real time.

As a result, the agents were able to make significant progress in Minecraft, collecting an average of 17 unique items within 30 minutes and up to 320 unique items over 4 hours in larger groups. Agents equipped with social awareness modules could accurately recognize and respond to the emotional states of other agents, forming stable social relationships.

Specialization into various roles such as farmers, miners, and guards was observed within agent groups, contributing to more efficient task execution and the emergence of civilizational structures. Agents were also able to follow taxation laws and even modify them through democratic processes, reflecting the influence of opinion leaders. In large-scale simulations, agents successfully transmitted cultural memes and religious ideas.

A deep understanding of the mechanisms behind social interaction, role distribution, and “cultural” phenomena offers powerful new tools for studying the evolution of communities and modeling complex social systems.

Next, in the research [4] there was developed the Agent Forest method ,and it was demonstrated that increasing the number of agents significantly improves the performance of an AI system. There were also investigated the types of tasks that benefit most from this effect, and the overall applicability and compatibility of the proposed method with existing approaches were assessed.

The Agent Forest method consists of two main stages:

1. Sampling: In this stage, N different responses are generated by querying the same input multiple times from agents (LLMs).
2. Voting: After generating the response set, their similarity is evaluated. The final answer is selected as the one with the highest total similarity to all other responses in the sample.

This study confirms that simply increasing the number of agents is a powerful technique for boosting AI system performance, especially for complex tasks. As a result, scaling a single model to extreme sizes isn't always the most effective path. Instead, using multiple smaller models collaboratively can yield better results and do so more cost-effectively.

Finally, in work [5], there was proposed the Internet of Agents (IoA), a new framework for flexible, scalable collaboration among autonomous agents based on large language models (LLMs).

The main goal is to overcome limitations in current multi-agent systems, such as isolated ecosystems, single-device simulations, and hardcoded communication channels. The IoA concept envisions a network where agents can discover each other, form teams, and manage communication streams similar to the Internet itself.

IoA outperforms leading solutions like AutoGPT and Open Interpreter, effectively coordinating agents with different tools, architectures, and knowledge bases to solve complex tasks that require diverse expertise. It is also scalable and well-suited to distributed environments, including the Internet of Things (IoT).

Multi-agent systems are in growing demand, and IoA serves as a "universal bus" for integrating diverse agents seamlessly.

Research into AI agents is progressing rapidly across multiple dimensions. We're witnessing advances in agent collaboration, autonomous system design, cognitive capabilities, efficiency, and ethical standards. Together, these directions point toward increasingly powerful, adaptable, and responsible AI systems ready to tackle real-world challenges.

References:

1. Zijun Liu, Kaiming Liu. AIGS: Generating Science from AI-Powered Automated Falsification. URL: https://arxiv.org/abs/2411.11910
2. Kshama Dwarakanath, Svitlana Vyetrenko. ABIDES-Economist: Agent-Based Simulation of Economic Systems with Learning Agents. URL: https://arxiv.org/html/2402.09563v1
3. Altera.AL, Andrew Ahn. Project Sid: Many-agent simulations toward AI civilization. URL: https://arxiv.org/abs/2411.00114
4. Junyou Li, Qin Zhang. More Agents Is All You Need. URL: https://arxiv.org/abs/2402.05120
5. Weize Chen, Ziming You. Internet of Agents: Weaving a Web of Heterogeneous Agents for Collaborative Intelligence. URL: https://arxiv.org/abs/2407.07061v2

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How does MANRS (Mutually Agreed Norms for Routing Security) work and importance

Internet is a tremendously complex system consisting of thousands and thousands of autonomous systems (AS) that interact using the Border Gateway Protocol (BGP). Despite its essential importance, BGP has several vulnerabilities that can lead to data leaks, routing failures or attacks such as BGP hijacking. To address these issues, the MANRS (Mutually Agreed Norms for Routing Security) project was established in 2014, an global initiative that helps reduce the most common routing threats [1].

MANRS defines four primary measures to enhance routing security:

1. Route filtering – controlling inbound and outbound routes prevents leaks and the spread of incorrect prefixes. That is achieved by using RPKI (Resource Public Key Infrastructure), which allows route verification and prevents unauthorized announcements.

2. Prevention of IP address spoofing – implementing BCP38 (Best Current Practice 38) allows blocking traffic with fake IP addresses, which are often used in DDoS attacks.

3. Improved coordination between operators – quick information exchange in relation to routing changes and incidents through IRR (Internet Routing Registry) databases and communication platforms among providers.

4. Increased transparency – publishing reliable information about network policies and using PeeringDB to document relationships between networks.

Implementation of MANRS provides several benefits:

- Reduced risk of attacks. BGP hijacking and route leaks can evoke widespread internet failures.
- Improved overall internet resilience. Adhering to MANRS standards raises trust among network operators.
- Lower financial losses. Routing failures can lead to crucial financial losses for companies due to idle time or data breaches.
- Enhanced cooperation among providers. Increased coordination among operators allows faster response to incidences and prevents the spread of incorrect routes [2].

Many international organizations support MANRS, which leads to increasing its magnitude in cybersecurity and network overall. To evaluate the effectiveness of MANRS, an analysis was conducted on implementating this initiative among the 100 largest autonomous systems from 2018 to 2023 [3]. Data was collected on the frequency of BGP hijacking, route leaks, and other incidents in networks that implemented MANRS, compared to those that have not implemented these measures.

The results of the study showed the following:

- The number of BGP hijacking cases in networks that implemented MANRS decreased by 65%, indicating a tremendous improvement in security.
- The average response time to incidents in MANRS-compliant networks was reduced by 40%, ensuring faster mitigation of potential threats.
- Interaction levels between network operators increased by 30%, demonstrating a quicker exchange of critical routing information [3].

In 2022, RIPE NCC conducted a large-scale study on the impact of MANRS on the frequency of BGP route leaks [4]. Over 500 autonomous systems were analyzed, with 200 actively using MANRS and the rest not implementing it. The result of the study says, that MANRS-compliant AS were four times less likely to experience route leaks. Further findings showed that networks which implemented MANRS, resolved misrouting issues 50% faster, which is especially fateful for critical infrastructure services.

In 2023, Cloudflare analyzed the stability of MANRS participants' networks [5]. The study included data from 300 autonomous systems and an analysis of their behavior during abnormal routing changes. The results indicated that MANRS networks were 70% less likely to experience unusual changes due to attacks or configuration errors. Another essential finding was that MANRS networks demonstrated 40% lower latency during BGP updates, directly impacting the stability of internet connections. Additionally, Cloudflare's log analysis showed that networks adhering to MANRS were significantly less frequently subjected to BGP hijacking, making them more secure for users and businesses.

MANRS is an essential initiative that enhances the security, resilience and reliability of the internet. Expanding MANRS and involving new participants is an important step towards a more secure and reliable global network.

References:

1. Mutually Agreed Norms for Routing Security (MANRS) - Official Website (https://manrs.org/).
2. Internet Society (ISOC) – MANRS Implementation and Case Studies (https://www.internetsociety.org/issues/manrs).
3. BGP Stream (by Cisco Umbrella) – Real-time Routing Incidents Data (https://bgpstream.com).
4. RIPE NCC Research on MANRS and Routing Security (https://www.ripe.net/publications).
5. Cloudflare Blog – Routing Security and MANRS (https://blog.cloudflare.com).

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Optimization of IT Infrastructure Using IaaS, PaaS and SaaS Cloud Models

Modern software solutions require a reliable IT infrastructure, including a public server that can adapt to changes in workload at different stages of project development. This requires planning the infrastructure with a margin of safety, which increases its cost, as well as maintenance by system administrators to ensure its smooth operation and protection. If the project operates under a high load or with a variable number of users, the infrastructure must be able to scale quickly, which makes it even more expensive.

Until the beginning of the 21st century, traditional infrastructure dominated the information technology industry. With the growing need to effectively manage these systems and reduce implementation costs, cloud technologies emerged as an alternative solution that greatly simplified this process. With the help of these tools, businesses were able to rent computing power and software via the Internet, which cost much less than real premises and additional equipment. The history of cloud technologies is described in more detail in the publication “Cloud Learning Technologies: Origins” [1].

One of the founders of this trend was Amazon, which launched the Amazon EC2 web service (first released in 2006). This network solution was a major step towards the development of “IaaS” – “Infrastructure as a Service” – a cloud computing model that provides users with basic resources for computing via the Internet. These can include virtual machines, data storage, and network components, which are necessary for running applications and processing data.

This cloud service has several significant advantages, including virtualization, scalability, flexibility, and security. With access to virtual machines, users have the ability to manage CPU, memory, and disk space. In addition, it is possible to change the amount of resources much faster depending on the application, which optimizes costs. Moreover, IaaS allows you to choose the operating system and customize the network and computing instance configuration. This technology also provides automatic backups that protect against data loss, encrypt data, perform multi-factor authentication, and secure the network.

Of course, IaaS also has disadvantages, including the fact that all software settings on virtual machines are performed by the user, dependence on the Internet and the provider, as well as scaling costs in case of heavy load, which can be significantly higher than on-premises solutions due to the tariffs for the resources used [2, 3, 4].

IaaS customers are system administrators of companies [5].

Despite all the advantages of IaaS, managing virtual machines, configuring servers, and administering infrastructure still required considerable technical knowledge. This led to the emergence of the next level of cloud services - PaaS (Platform as a Service). This solution provides a platform and environment for developing, testing, deploying, and maintaining applications. Users focus on writing code, while the provider manages servers, storage, and computing power, and offers certain platforms and tools to optimize them. “Fotango” is considered to be the first company to develop a product of this type, called “Zimki”, in 2005. However, PaaS became widely recognized after the launch of Google App Engine in 2008, which significantly influenced the development of this cloud computing model [6, 7].

Among the disadvantages of Platform as a Service are a limited set of tools and certain project scaling limits, as these aspects are regulated by the service provider. In addition, using a shared platform increases the risk of security issues. There may also be performance issues due to the platform being overloaded with a large number of users. In general, integration with existing systems can be difficult, especially if they are incompatible with each other [8, 9].

PaaS customers are software developers [5].

However, not all users need direct control over the platform or infrastructure. Over time, businesses and ordinary users increasingly needed ready-made solutions for work and collaboration. That's how the SaaS (Software as a Service) model emerged, allowing users to use full-fledged applications directly through a browser without installing them on local devices.

All updates and support in this cloud service are performed by the provider, and the client receives a ready-to-use software solution that does not require additional configuration or administration of the server infrastructure. You can work with this technology anywhere; the main requirement is the Internet. SaaS also frees up a lot of time by allowing you to configure, manage, and update the software yourself. This model is used in popular web services, including email clients, graphic and text editors, website editors, messengers, data warehouses, social networks, etc. One of the first examples of SaaS is Salesforce, founded in 1999, which offered a CRM system that works over the Internet [3, 9, 10, 11].

The advantages of SaaS are that it is the simplest cloud service model for end users. The provider fully ensures the operability of the cloud service, and business owners can save money on the labor costs of developers, network engineers, and system administrators.

The disadvantages of this system are the limited ability to customize the interface according to user preferences, data storage on third-party servers, which creates risks of information leakage, and possible difficulties in integrating with third-party software [9].

The main customers of PaaS are the regular software user [5].

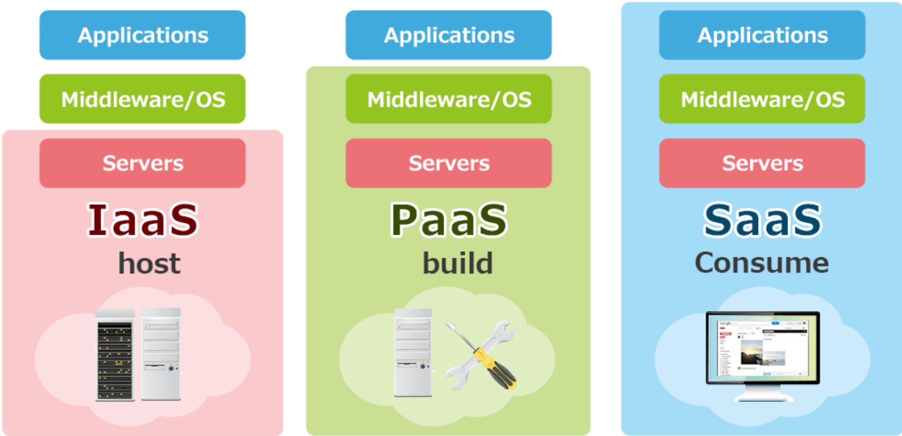

Figure 1 An example of the distribution of areas of responsibility for each of the cloud services [12]

On average, the cost of renting or purchasing a midrange server in a typical data center starts at UAH 10,000 [13, 14, 15, 16]. While a cloud solution from Google (Google Cloud Platform) starts at UAH 1000 [17], Microsoft Azure – UAH 2 500 [18] and Amazon Web Services – UAH 6 500 [19].

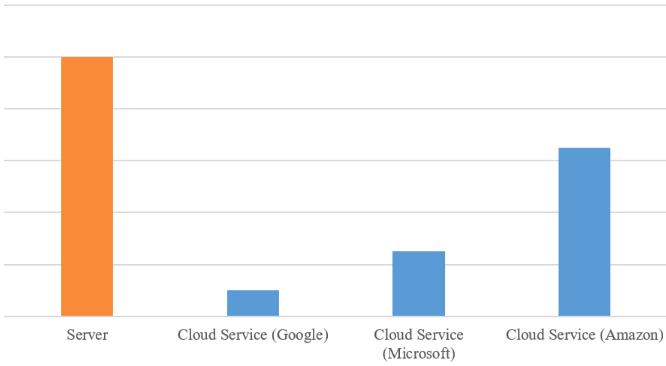

Figure 2 Comparison of the cost of monthly server rental and cloud solutions

Today, cloud computing has become a key element in modern IT solutions, significantly impacting business processes. They allow businesses and end users to reduce costs, easily scale resources, and access the latest technologies without the need for significant upfront investments. The introduction of cloud platforms has somewhat changed the approach to software development, simplified workflows and stimulated innovation in the industry. Cloud computing models, such as IaaS, PaaS, and SaaS, offer effective solutions to meet a variety of technology needs. IaaS provides a basic infrastructure for system administrators, PaaS provides a ready-made environment for developers that simplifies the process of creating programs, and SaaS provides end users with access to ready-made software products. The choice of a particular model depends on specific business objectives or user requirements, as each has its own advantages and limitations that should be taken into account when making decisions.

References

1. Markova O.M., Semerikov S.O., Stryuk A.M. Cloud technologies: origins: Information technologies and learning tools, Vol. 46., №2, 2015; [in Ukrainian]

2. Hanna Sukhorukova IaaS, PaaS, SaaS: which cloud model should businesses choose? URL: https://hub.kyivstar.ua/articles/iaas-paas-saas-yaku-hmarnu-model-obraty-biznesu; [in Ukrainian]

3. Oleg Maksymovych IaaS, PaaS, SaaS: Choosing the most relevant solutions for your business URL: https://cloudfresh.com/ua/cloud-blog/iaas-paas-saas-vibirayemo-najbilsh-relevantni-rishennya-dlya-vashogo-biznesu/; [in Ukrainian]

4. A Lunavian The History of Cloud Computing: How Did We Get to Google Apps and IaaS? URL: https://www.lunavi.com/blog/the-history-of-cloud-computing-how-did-we-get-to-google-apps-and-iaas; [in English]

5. IaaS, PaaS, SaaS, BaaS: what do popular abbreviations mean and how do they differ? URL: https://fintechinsider.com.ua/iaas-paas-saas-baas-shho-oznachayut-populyarni-abreviatury-ta-v-chomu-riznyczya-mizh-nymy/; [in Ukrainian]

6. What is PaaS and who needs it? URL: https://wezom.com.ua/ua/blog/scho-take-paas-i-komu-vin-potriben; [in Ukrainian]

7. The evolution of platform-as-a-service (PaaS) URL: https://www.outsystems.com/application-development/platform-as-a-service-definition-and-examples; [in English]

8. Leonid_SaaS Platform as a service: advantages and disadvantages URL: https://saascompany.com.ua/platforma-yak-servis-perevagy-ta-nedoliky; [in Ukrainian]

9. IaaS, SaaS та PaaS: what it is, the difference and examples URL: https://blog.colobridge.net/uk/2022/08/iaas_saas_paas_ua; [in Ukrainian]

10. What is SaaS (software as a service)? URL: https://www.oracle.com/ua/applications/what-is-saas; [in Ukrainian]

11. Yulia Shaleva What is Salesforce and why it is interesting for experienced developers URL: https://dou.ua/lenta/articles/what-salesforce-is/; [in Ukrainian]

12. IaaS, PaaS, SaaS what the various definitions of "as a service" mean URL: https://www.managedserver.eu/iaas-paas-saas-what-the-various-definitions-of-as-a-service-mean/; [in English]

13. Renting a server rack in a data center URL: https://denovo.ua/data-center/data-center-rack; [in Ukrainian]

14. Renting server racks in a data center URL: https://server.ua/ua/colocation-rack; [in Ukrainian]

15. Dedicated server rental URL: https://besthosting.ua/ua/priceservers.php; [in Ukrainian]

16. Renting server racks in a data center URL: https://kievline.net/data-centr/; [in Ukrainian]

17. Google Cloud Pricing: How Much Will It Cost You in 2025 URL: https://www.websiteplanet.com/blog/google-cloud-pricing/; [in English]

18. Azure Pricing: The Complete Guide URL: https://spot.io/resources/azure-pricing/the-complete-guide/; [in English]

19. Amazon Aws: prices and services URL: https://supporthost.com/amazon-aws-price/. [in English]

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Quantum computing can revolutionize cybersecurity

Quantum computing is a rising technology trend that is predicted to become a revolution for the cybersecurity field. Development of quantum computers will create completely new ways of protection and transmission of data. Quantum cryptography has a potential to become way more secure than modern encryption algorithms and even theoretically unhackable [1]. On the other hand, a global spread of such a strong instrument as a quantum computer can lead to extreme security problems.

Quantum computers represent a completely new paradigm in computing. They are ought to solve problems beyond the ability of even the most powerful classical computers. Designed on the principles of quantum mechanics, quantum computers are able to process massively complicated problems way faster than supercomputers. While classical devices traditionally rely on binary bits, quantum computers are powered by qubits - manipulated quantum particles that use a state of superposition, which allows them to solve difficult numerical problems much more quickly.

The topic of revolutionary power of quantum computers and types of threat they pose first became apparent almost 30 years ago. A reason for that became the discovery that they could potentially break asymmetric cryptographic protocols, such as Rivest Shamir-Adleman (RSA) - a public-key cryptosystem that enables any user to encode data in such a way that it can be read only by those who know a private key [2]. Theoretically, in the future quantum computers will be able to break RSA-2048 - a current high-security version of RSA with a 2048 bit-long key. However, the development of a quantum computer, capable of doing this, might take another three or even more decades.

Therefore, it is safe to assume that quantum computers that exist today are not a threat to public-key cryptography. In fact, many engineering, physical and mathematical problems must be overcome to develop a large, general-purpose quantum computer. At the same time, the possibilities of such devices may create another great risk for worldwide security. Quantum computers will allow hackers to decrypt the information that is not accessible to them now. Nonetheless, such a threat will affect only asymmetric algorithms, as security of symmetric cryptography is not significantly impacted by quantum computers [3].

Despite posing a threat to already existing encryption systems, quantum computing can itself become a great tool for data security. As an example, quantum cryptography and quantum key distribution represent new methods of encryption that have potential to create fully protected communication channels. These technologies provide secure communication between two parties by using properties of quantum mechanics to generate and distribute cryptographic keying material. Both quantum key distribution and quantum cryptography keep complete privacy between all communication channels and detect any attempts of eavesdropping [4].

After the development of cryptographically, the relevant quantum computer will be completed and the need for a new encryption system will be crucial. Post-quantum cryptography will be able to solve this problem. Algorithms of this encryption must be based on math problems that would be difficult for both conventional and quantum computers to solve. In comparison with quantum cryptography that relies on natural laws of physics, post-quantum cryptography uses different types of encryptions to create quantum-proof security. For example, experts believe that employing lattice-based and hash-based cryptographies into post-quantum encryption algorithms will make math problems much harder to solve for quantum computers [5].

Although the benefits of the mentioned technologies have been proven, there are many technological limitations preventing their widespread adoption. For example, some of the technologies, like quantum key distribution, which are based on physical properties, require special purpose equipment as it cannot be implemented in software or easily integrated into existing network equipment. Additionally, the realization of new cryptographic systems can be challenging as the exact timeframe for the development of quantum computers with the ability to break current encryption is uncertain.

In conclusion, quantum computing has a potential to change the cybersecurity field, appearing both as a helpful tool and a destructive force. Even though now this technology is still undergoing major developments, the future of quantum computing is approaching.

References:

1. What is quantum computing?. *IBM*. 2024. URL:https://www.ibm.com/think/topics/quantum-computing
2. Yaakov Weinstein, Brandon Rodenburg. Quantum computing: quantifying the current state of the art to assess cybersecurity threats. *MITRE*. 2025. URL:https://www.mitre.org/sites/default/files/2025-01/PR-24-3812-Quantum-Computing-Quantifying-Current-State-Assess-Cybersecurity-Threats.pdf
3. Preparing for Quantum-Safe Cryptography. *National Cyber Security Centre.* 2020. URL:https://www.ncsc.gov.uk/whitepaper/preparing-for-quantum-safe-cryptography#section_3
4. Quantum Key Distribution (QKD) and Quantum Cryptography (QC). *National Security Agency/Central Security Service*. URL:https://www.nsa.gov/Cybersecurity/Quantum-Key-Distribution-QKD-and-Quantum-Cryptography-QC/
5. What Is Post-Quantum Cryptography? *NIST*. 2024. URL:https://www.nist.gov/cybersecurity/what-post-quantum-cryptography

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Voice Authentication Systems For Distribution Of Authorities

This article provides an in-depth analysis of voice authentication systems as a means of delimiting authority. Modern approaches to biometric identification and their application in cybersecurity are described here. The results of an experimental study are presented. They also include an analysis of the system's accuracy, its resistance to attacks and the influence of external factors. Current problems of voice authentication are discussed, such as vulnerability to using fake voice attacks, acoustic interference, and the possibility of adapting algorithms to real-life operating conditions.

Voice authentication is one of the key areas of development of biometric systems that ensure the digital environment security. Taking into account the growth of cybersecurity threats and the need for reliable user identification, this method is gaining increasing importance. The use of voice characteristics to distribute access allows not only to simplify the authentication process but also to increase the level of data protection. However, the method has certain disadvantages, including the possibility of compromising the voice print and low resistance to acoustic interference [1].

Modern approaches to voice authentication are based on the use of neural networks, spectral analysis methods and statistical algorithms. Dynamic voice authentication, which is based on parameters such as intonation, speech rate and spectral characteristics of the voice, demonstrates high accuracy in identifying users. Studies have also shown that the use of deep convolutional and recurrent neural networks significantly improves the system's ability to adapt to changes in speech and noise environment. The main threat remains the possibility of an attack using synthesized or recorded voice, which requires the implementation of additional protection mechanisms [2].

One of the most dangerous attacks on voice authentication systems is the use of deepfake voice when an artificial voice is generated using neural networks that imitate the voice of the account owner. There are also playback attacks, which use pre-recorded user phrases to bypass the system. To counter these threats, algorithms for detecting synthetic speech and checking the presence of a live voice (liveness detection) are being developed [3].

During testing, the accuracy of the system was analyzed in different conditions:

- without noise
- with low noise
- with high noise

Deep neural networks (DNN), dynamic time-varying (DTW) and spectral analysis (MFCC) approaches were used for testing. Table 1 shows the comparative results of their performance [4].

Table 1 – Comparative effectiveness of voice authentication methods

Method	Accuracy (%)	Noise resistance	Protection against recorded voice attacks
DTW	85	Medium	Low
DNN	96	High	Medium
MFCC	91	High	High

Voice authentication is widely used in banking systems to verify a customer's identity during support calls. It is also used in corporate security to restrict access to critical resources. In particular, companies such as HSBC, CitiBank and Barclays are implementing voice identification to improve the security of customer data.

Voice authentication is an effective tool for delimiting user authority. The use of modern voice analysis methods, in particular neural networks and spectral analysis, allows for a high level of accuracy. At the same time, the problem of protection against attacks using a fake voice remains open. Further research should focus on the development of algorithms that increase the reliability of authentication and ensure its adaptation to actual operating conditions.

Reference

1. How Safe Is Voice Authentication Technology. https://www.gnani.ai/resources/blogs/how-much-safe-secure-is-voice-authenticationtechnology/#:~:text=Voice%20authentication%20is%20more%20secure,security%20data%20systems%20and%20identifiers.

2. An Overview and Analysis of Voice Authentication Methods. https://courses.csail.mit.edu/6.857/2016/files/31.pdf

3. Real-time Detection of AI-Generated Speech for DeepFake Voice Conversion // arXiv, 2023, https://arxiv.org/abs/2308.12734

4. Using Machine Learning to Augment Dynamic Time Warping Based Signal Classification, 2022. https://arxiv.org/abs/2206.07200

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Wetware AI: The Future of Energy-Efficient Intelligence Beyond Silicon

Artificial intelligence (AI) has gained significant traction over the past three years, becoming crucial in sectors like healthcare, finance, and entertainment. However, this surge in popularity has led to substantial energy demands. Training large AI models requires immense computational power, contributing to an increase in electricity consumption.

According to the International Energy Agency, the power demand for AI and data centers is projected to double by 2026, with AI's energy footprint growing faster than that of traditional search systems.

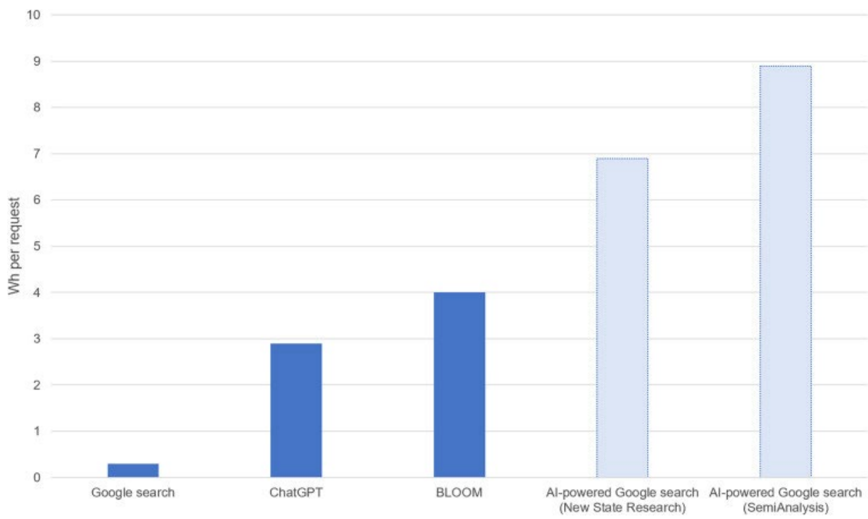

Figure 1 – Power consumption per hour of various search systems [1]

Training advanced models like OpenAI's, GPT-4 and Meta's Llama 3.1 consumes around 30 megawatts each. By 2030, AI data centers could account for up to 17% of U.S. electricity consumption.

To mitigate this, researchers are exploring sustainable alternatives, such as Organic AI, also known as wetware computing. This approach integrates biological components, like neurons, to emulate the human brain's efficiency, potentially reducing energy consumption.

Recent advancements in wetware computing have shown promise in enhancing both energy efficiency and learning speed. For example, in late 2021, researchers successfully integrated human brain cells into digital systems, allowing them to learn to play Pong faster than traditional machine learning models—though at a lower skill level. Additionally, Intel's Loihi neuromorphic chip has demonstrated remarkable energy efficiency, consuming up to 1,000 times less power than conventional computing systems when training neural networks.

These breakthroughs highlight the potential of wetware computing to surpass traditional electronic systems, offering notable benefits in learning speed and energy consumption.The human brain, composed of approximately 86 billion neurons, operates on a mere 20 watts of power. This exceptional efficiency has inspired researchers to explore wetware computing as a way to leverage the computational power of biological neurons and create more energy-efficient AI systems. By integrating living neurons into computing systems, wetware computing seeks to emulate the brain's efficiency, offering the possibility of reducing the substantial energy consumption seen with traditional AI models.

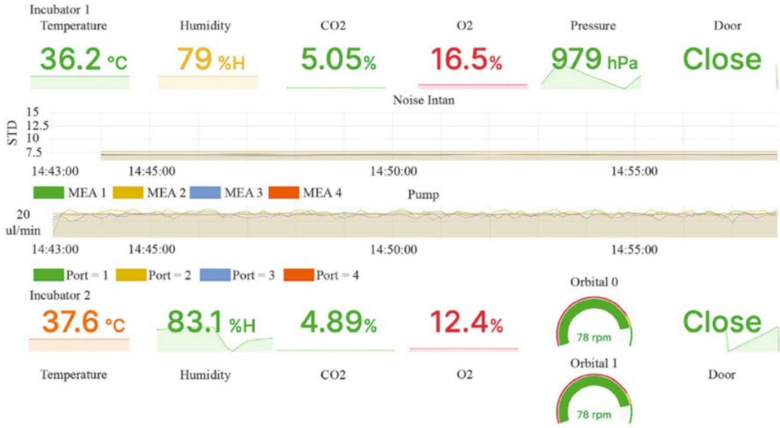

Figure 2 - Environmental parameters of incubators [5]

Despite its potential, wetware AI is not yet widely available due to several factors. The use of living neurons raises significant ethical concerns regarding the manipulation of biological materials and the potential for consciousness within these systems.

Neurons also require a specific environment to thrive, which complicates their use in computing systems. This includes maintaining high humidity levels and a stable temperature of around 37°C (98.6°F) to prevent dehydration and ensure optimal metabolic activity. Neurons also need a continuous supply of nutrients and oxygen, typically provided by specialized culture media. The pH level must be kept around 7.4 to support enzymatic activities, and a sterile environment is essential to prevent contamination from microorganisms.

Additionally, neurons operate through electrochemical signals, requiring an appropriate ionic composition (e.g., sodium, potassium, calcium) in their environment for proper neuronal firing and synaptic transmission. These factors contribute to the complexity of integrating biological components into AI systems, limiting the widespread adoption of wetware AI at present.

In conclusion Wetware AI represents a groundbreaking shift in artificial intelligence, offering a promising alternative to traditional silicon-based computing. By leveraging biological neurons, researchers aim to develop energy-efficient AI systems that emulate the brain’s exceptional processing capabilities. While recent advancements, such as neuromorphic chips and neuron-integrated systems, demonstrate the feasibility of this approach, significant challenges remain. Ethical concerns, environmental constraints, and the complexity of maintaining biological components hinder widespread adoption. However, with continued research and technological progress, wetware AI could redefine the future of artificial intelligence, providing sustainable solutions to the growing energy demands of machine learning and data processing

References:

1. AI energy demand and sustainability. [Electronic resource]. Available: https://www.sustainabilitybynumbers.com/p/ai-energy-demand.
2. Generative AI energy consumption soars. [Electronic resource]. Available: https://www.polytechnique-insights.com/en/columns/energy/generative-ai-energy-consumption-soars/. Accessed on: March 12, 2025.
3. Intel's new neuromorphic chips are 1,000 times faster than normal CPUs. [Electronic resource]. Available: https://www.unite.ai/intels-new-neuromorphic-chips-are-1000-times-faster-than-normal-cpus/. Accessed on: March 12, 2025.
4. Wetware computing: Brain cells powering the future of AI. [Electronic resource]. Available: https://www.linkedin.com/pulse/wetware-computing-brain-cells-powering-future-ai-sreejith-sreedharan-jvlhc. Accessed on: March 16, 2025.
5. Artificial intelligence and the brain. [Electronic resource]. Available: https://www.frontiersin.org/journals/artificial-intelligence/articles/10.3389/frai.2024.1376042/full. Accessed on: March 16, 2025.

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Music and Programming: Two Languages of One Creativity

At first glance, music and programming seem to be completely different fields. The former is about art, feelings and inspiration. The latter is about numbers, logic and accuracy. Combining theory and experience, this research is based on my 15 years of professional piano study.

Since I started learning to code, I have encountered the saying “Musicians made good programmers” many times. The deeper I dive into the code, the more connections I find with music and art.

Music is logic, but with emotions. Programming is logic, but with problem-solving. In both cases, there are strict rules and structures.

- **In code,** there are loops, functions, algorithms.
- **In music**, there are rhythms, forms, harmonies.

“You might not think that programmers are artists, but programming is an extremely creative profession. It’s logic-based creativity” - John Romero [1]. A good programmer, in fact, is a creator. He is able to create beauty, while demonstrating a huge amount of knowledge, honed skills and resourcefulness. He knows not only how to impress, but also to radically change the course of life. This is similar to how talented artists, writers, musicians affect people with their works [2].

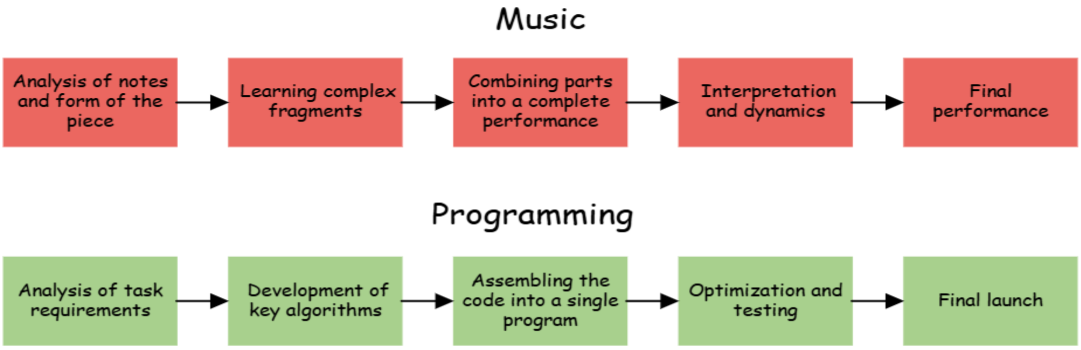

Fig. 1 Block-cheme of parallelism between processes

Playing the piano, especially improvisation, requires the same skills as writing code. Both processes require deep immersion and the ability to keep an integral picture in mind. The pianist does not see the notes, but the composition. A programmer does not see the lines of code, but the system as a whole.

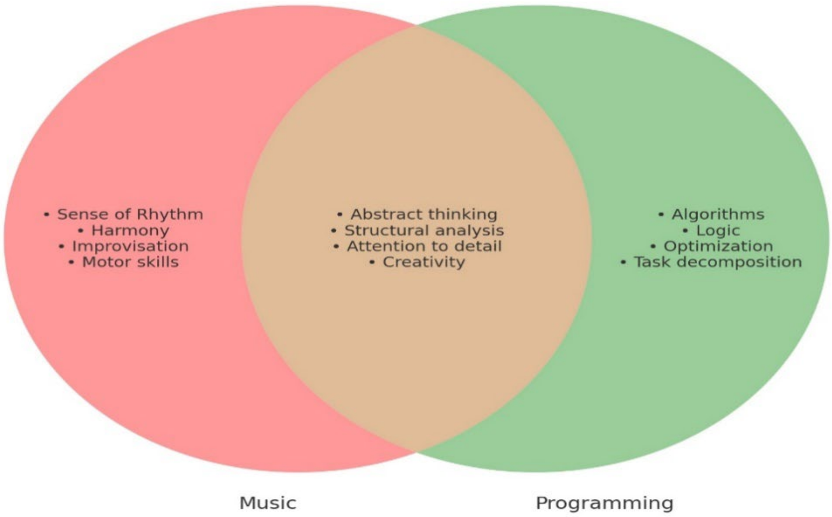

Fig. 2 Venn diagram shows skills common to music and programming

Also, in both music and programming, the ideal is unattainable and there is always something to learn. “You can’t write perfect software. Did that hurt? It shouldn’t. Accept it as an axiom of life. Embrace it. Celebrate it. Because perfect software doesn’t exist. No one in the brief history of computing has ever written a piece of perfect software. It’s unlikely that you’ll be the first. And unless you accept this as a fact, you’ll end up wasting time and energy chasing an impossible dream” [3].

Learning and moreover constant learning are key concepts in both disciplines as the variety of tools that exists is endless. With programming, there are a million different languages and frameworks you can learn but also different technologies that allow you to do a myriad of different things, all available for you to use. With music, they are instruments, styles, scales, DAW etc. and the learning curve is not always straightforward as you still have to go back to re-learn basics sometimes to understand new concepts [4].

Today, the connection between music and programming is enhanced by modern technologies such as neural networks and machine learning. Innovative tools like AIVA, Google Magenta, and MuseNet allow machines to compose original music, analyze existing pieces, and even collaborate with human musicians. These systems follow strict rules and algorithms, essentially "programming" the music they create. Programming skills can be used not just to support music, but to compose it.

To summarize, thanks to analytical thinking, musicians learn programming more easily. And programmers, having the skills of a systematic approach, can develop in music. Modern technologies like AI and machine learning open new doors for creativity. But even the most advanced AI cannot fully replace the human touch in art. Emotion, intention, and personal experience – these are things only people can bring into music.

References:

1. Anto (2021). *3 reasons why programming is a form of art.* https://antonimalki1990.medium.com/3-reasons-why-programming-is-a-form-of-art-da0ee14db492 (Access date 29 march, 2025)
2. *Programming is one of the forms of art, no less!* (2020). https://itproger.com/ua/news/programmirovanie-odin-iz-vidov-iskusstva-ne-inache (Access date 3 april, 2025)
3. David Thomas, Andrew Hunt «*The Pragmatic Programmer*». (Access date 1 april, 2025)
4. The Azuki team. *Music and programming, why and how are they similar ?* https://azukidigital.com/blog/2021/music-and-programming/ (Access date 3 april, 2025)

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Metaverses – the potential of virtual worlds

A universe free from physical limitations, where you can work, play, find friends from all over the world. This is how the Metaverse appears as the next stage of Internet development using augmented (AR) and virtual (VR) realities [1].

The concept of the Metaverse is the permanent existence of a virtual environment where people can interact in the same way as in the real world [2]. The word Metaverse is also used to describe game worlds where each user can have a virtual character to interact with the characters of other players. The Metaverse can be used for almost everything: work, study, healthcare, performances, concerts, etc., as shown in the figure 1 [3].

Figure 1. Metaverse applications in various sectors

Initially, the Internet only allowed people to send emails and chat on BBS (Bulletin Board System) [4]. In 1989, Tim Berners-Lee created the World Wide Web to connect to the Internet through a web browser [5], which allowed the creation of millions of different websites, and their number continues to grow every day. Later, Yahoo and Google were created, leading to the appearance of blogging, which later evolved into social media. The Metaverse is supposed to create new online spaces for more multidimensional human interaction, providing immersive experiences instead of just browsing. Today, we use apps, which allow us to interact with other people through our smartphones, such as Facebook, Twitter, Snapchat, Zoom, Instagram, etc. Metaverse is the future level of communication.

For a perfect immersive effect, you need a very high-speed internet connection, which is why it was not possible before. Nowadays technologies are improving very fast and we are getting towards a Super Smart society, called «Society 5.0 [6], as shown in the figure 2.

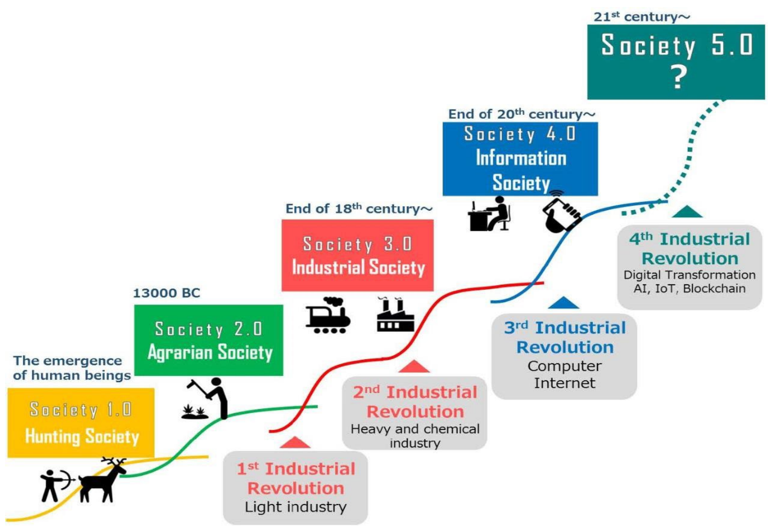

Figure 2 — Stages of development of society

The Metaverse looks like an advanced version of virtual reality, but it could be the Internet of the future. Instead of sitting in front of a computer and working, with Metaverse you can use a headset to enter the virtual world, connecting digital environments.

Like other technologies, the Metaverse will require the establishment of important technological standards. The ethics of interaction between the virtual and real worlds will be complex and may become one of the defining issues of the 21st century. Modern digital devices will require significant support for lag-free virtual and augmented reality using 5G and future technologies. Most of our digital interactions are based on two-dimensional images that change rapidly. The metaverse needs many innovations in modern technologies and protocols to make them functional in the real world.

The combination of all the new technologies creates a completely new virtual universe that can offer experiences on a different level. The Metaverse is a few years away from the point where it is truly pervasive and accessible to everyone. Once this is possible, AR and VR will be used in everyday life. Our current online communities and spaces form a beta version of Metaverse. However, this change will not happen too soon, as it will take time for this transition to an accessible, interactive, immersive world to become a reality. Since the Metaverse will involve data sharing, privacy and security also need to be at a high level to protect user data.

The Metaverse can provide new virtual business and collaboration opportunities for employees. Companies can create digital twins of real products or services for virtual demonstration and sale. The Metaverse will allow virtual meetings, conferences and training sessions, reducing travel and rental costs. Teams can collaborate in virtual workspaces regardless of their physical location.

The metaverse allows you to create interactive and immersive experiences for customers, which increases engagement and loyalty. Brands can create virtual stores where customers can try on clothes or test products before purchasing them. Overall, the metaverse has the potential to transform business, management and marketing, creating new opportunities for growth and development.

References:

1. Lombardi, J.; Lombardi, M. Opening the metaverse. In Online Worlds: Convergence of the Real and the Virtual; Springer: Berlin/Heidelberg, Germany, 2010; pp. 111–122.
2. Guan, J.; Irizawa, J.; Morris, A. Extended Reality and Internet of Things for Hyper-Connected Metaverse Environments. In Proceedings of the 2022 IEEE Conference on Virtual Reality and 3D User Interfaces Abstracts and Workshops (VRW), Christchurch, New Zealand, 12–16 March 2022; pp. 163–168.
3. Nover, S. The Meaning of the 'Metaverse,' and All the Terms You Need to Understand It. 2021. Available online: https: //qz.com/2089665/everything-youneed-to-know-to-understand-the-metaverse
4. LaRue, J. Sending Them a Message: Electronic Bulletin Boards. Wilson Libr. Bull. 1986, 60, 30–33.

5. Berners-Lee, T.; Cailliau, R.; Groff, J.F.; Pollermann, B. World-Wide Web: The information universe. Internet Res. 1992, 2, 52–58.
6. Rojas, C.N.; Peñafiel, G.A.A.; Buitrago, D.F.L. Society 5.0: A Japanese Concept for a Superintelligent Society. Sustainability 2021, 13, 6567.

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The importance of physical penetration testing in modern security infrastructure

Physical security is often overlooked in today's digital age, but it remains the crucial first line of defense against both cyber and physical threats.

In an era dominated by digital transformation and cyber threats, organizations frequently prioritize their cybersecurity measures while inadvertently neglecting the fundamental importance of physical security. This oversight creates a dangerous vulnerability in their security infrastructure, as physical security serves as the cornerstone of comprehensive organizational protection. The misconception that digital security alone can safeguard modern enterprises has led to a concerning trend where physical security measures are treated as secondary considerations rather than essential components of a robust security framework.

The intricate relationship between physical and digital security becomes particularly evident when examining real-world security breaches. Historical data reveals that a significant number of major cyber incidents originated from compromised physical security. For instance, the infamous target data breach of 2013, which resulted in the theft of 40 million credit card numbers, began with criminals gaining physical access to an HVAC system. This case exemplifies how bypassing physical security measures can render even sophisticated cybersecurity systems ineffective.

Modern physical security challenges have evolved significantly beyond traditional lock-and-key approaches. Today's threat landscape includes advanced social engineering techniques, sophisticated bypass methods, and hybrid attacks that combine physical and digital elements. Organizations face increasingly complex scenarios where attackers might use methods ranging from tailgating and impersonation to sophisticated tools for bypassing access control systems. The rise of Internet of Things (IoT) devices and smart building systems has further complicated the physical security landscape, creating new vulnerabilities at the intersection of physical and digital security.

The economic implications of inadequate physical security are often underestimated. While organizations might hesitate to invest in comprehensive physical security measures due to perceived high costs, the potential losses from a successful breach far outweigh the initial investment. Studies have shown that the average cost of a physical security breach can be several times higher than the implementation cost of preventive measures. This includes not only direct financial losses but also indirect costs such as reputational damage, legal liabilities, and loss of customer trust.

The effectiveness of physical security as the first line of defense manifests in multiple ways. Well designed physical security measures create crucial time barriers during attempted breaches, allowing security teams to detect and respond to threats before they escalate. Moreover, visible physical security measures often serve as powerful deterrents, preventing many potential attacks before they are even attempted. The psychological impact of robust physical security shouldn't be underestimated – it sends a clear message to potential attackers that an organization takes its security seriously.

Implementation of effective physical security requires a multi-layered approach. This begins with thorough risk assessment and extends to the deployment of various security elements including perimeter security, access control systems, surveillance, and environmental design. Modern physical security also incorporates advanced technologies such as biometric systems, AI-powered surveillance, and integrated security management platforms. However, technology alone is insufficient – human factors play a crucial role in maintaining security integrity.

The human element in physical security presents both challenges and opportunities. While employees can be potential vulnerabilities through susceptibility to social engineering or negligence, they can also serve as valuable assets in security maintenance when properly trained and engaged. Comprehensive security awareness programs, regular training sessions, and clear security protocols are essential components of an effective physical security strategy.

Regular physical penetration testing emerges as a critical tool for maintaining robust security. These tests simulate real-world attack scenarios, helping organizations identify vulnerabilities before malicious actors can exploit them. Physical penetration testing should encompass various aspects including technical security measures, procedural controls, and human factors. The results of these tests provide invaluable insights for security improvement and help organizations adapt their security measures to evolving threats.

The integration of physical and cybersecurity becomes increasingly crucial as technologies converge. Modern security systems often operate on networked platforms, creating potential vulnerabilities where physical and digital security intersect. Organizations must adopt a holistic approach that considers both aspects as part of a unified security strategy. This includes implementing security information and event management (SIEM) systems that can correlate physical and digital security events, enabling more effective threat detection and response.

The future of physical security continues to evolve with technological advancements. Emerging technologies such as artificial intelligence, machine learning, and advanced analytics are reshaping how organizations approach physical security. These technologies enable more sophisticated threat detection, automated response systems, and predictive security measures. However, organizations must carefully balance the adoption of new technologies with maintaining robust fundamental security practices.

In conclusion, while the digital age has brought unprecedented focus on cybersecurity, physical security remains an indispensable component of organizational protection. The interconnected nature of modern threats requires a comprehensive approach that acknowledges physical security as the crucial first line of defense. Organizations must invest in regular physical penetration testing, employee training, and integrated security solutions to maintain effective protection against evolving threats. As we continue to advance technologically, the importance of physical security will not diminish but rather evolve to meet new challenges in increasingly sophisticated ways.

Reference

1. Massive data breach. URL: https://www.computerworld.com/article/1517305/target-breach-happened-because-of-a-basic-network-segmentation-error.html
2. Integration of Cybersecurity into Physical Security Realm. URL: https://drj.com/journal_main/integration-of-cybersecurity-into-physical-security-realm/
3. Physical Penetration Testing: The Most Overlooked Aspect of Security. URL: https://www.isaca.org/resources/white-papers/2023/physical-penetration-testing

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Cybersecurity in Terms of Martial Law

In the modern world, cybersecurity is becoming critically important, especially under martial law. Martial law is a special legal regime introduced in Ukraine or in certain localities in the event of armed aggression or a threat of attack, a danger to the state independence of Ukraine, its territorial integrity, and provides for the granting to the relevant state authorities, military command, military administrations and local self-government bodies of the powers necessary to avert the threat, repel armed aggression and ensure national security, eliminate the threat of danger to the state independence of Ukraine, its territorial integrity, as well as temporary, due to the threat, restrictions on the constitutional rights and freedoms of man and citizen and the rights and legitimate interests of legal entities, with an indication of the term of validity of these restrictions [1].

Armed conflicts are no longer limited to physical combat, but are also taking place in cyberspace, where attacks on state institutions, critical infrastructure and information systems can cause no less damage than traditional military operations. Since the beginning of a full-scale war, Ukraine has experienced an unprecedented wave of cyber attacks aimed at destabilizing the economy, undermining communication systems and spreading disinformation.

Cybersecurity is the protection of the vital interests of a person and citizen, society and the state when using cyberspace, which ensures the sustainable development of the information society and the digital communication environment, timely detection, prevention and neutralization of real and potential threats to the national security of Ukraine in cyberspace [2].

In response, state and international institutions have stepped up efforts to strengthen cyber resilience by implementing innovative defense strategies, expanding cooperation with allies, and leveraging advanced artificial intelligence and threat analysis technologies.

In Ukraine, the issue of cyber defense under martial law is investigated by prominent scientists: Eduard Ryzhkov in his work "Formation of a cyber defense strategy under martial law" analyzes approaches to the development of a cyber defense strategy [3]. Mykyta Karpechenkov and Volodymyr Tulupov in the publication "Cybersecurity in War Conditions: What, Who, How" consider the issue of cyberspace security and provide recommendations for its protection [4]. Inna Kulchiy in the work "Cybersecurity of state authorities of Ukraine in the conditions of the legal regime of martial law" explores aspects of the protection of state institutions [5].

Mykola Ryltsev in his publication "Innovative Technologies and Cyber Defense Systems under Martial Law: Challenges and Opportunities" emphasizes the role of innovative technologies in cybersecurity [6]. Serhiy Babanin in his work "Cyber Security as a Component of Ukraine's National Security under Martial Law" analyzes the importance of cybersecurity for national security [7]. All these scientific works contribute to the understanding and improvement of cyber defense measures in the face of modern threats.

Studies of Ukrainian scientists in the field of cybersecurity under martial law play an important role in developing strategies for protecting state and critical information systems, introducing innovative cyber defense technologies and strengthening national security. At the same time, this scientific problem remains relevant and requires further thorough research, since the scale and complexity of cyber attacks are constantly growing, and the methods of their implementation are constantly being improved. The main challenges in this area are the shortage of highly qualified specialists, limited resource support for the introduction of advanced technologies, as well as the urgent need to expand international cooperation in the field of cybersecurity. Given these aspects, further development of research and practical solutions in the field of cyber defense is strategically important to ensure Ukraine's resilience to modern threats.

Cyberattack methods cover a wide range of techniques aimed at compromising information systems and gaining unauthorized access to confidential data. One of the most dangerous threats is SQL injection, which allows attackers to execute malicious SQL queries, which can lead to complete control over the database, deleting or modifying information, obtaining administrative privileges, etc. DDoS attacks are a tool for depleting and overloading server resources, often used to attack financial and banking institutions. The Man-in-the-Middle (MitM) attack is carried out by intercepting network traffic between two parties without their knowledge, which allows an attacker to receive or modify the transmitted data. The Malware category includes various types of malware, in particular viruses that spread by infecting files or systems. All these methods of cyber attacks pose a serious threat to information security, and their improvement necessitates the development of effective cyber defense strategies.

Under martial law, Ukraine is actively implementing comprehensive cyber defense strategies aimed at preventing, detecting and neutralizing cyber threats. The main methods of ensuring cybersecurity are multi-level protection of information systems, which includes the use of modern antivirus programs, firewalls (firewalls), intrusion detection and prevention systems (IDS/IPS), as well as data encryption to prevent unauthorized access. An important area is the protection of state information resources, which is carried out by strengthening control over critical infrastructure, the implementation of national security standards and centralized monitoring of threats through the State Service for Special Communications and Information Protection of Ukraine (SSSZI).

Special attention is paid to strategies for countering cyber attacks, providing for rapid response to threats, analysis of attacking tactics and the development of countermeasures. For this purpose, technologies of artificial intelligence and machine learning are actively used, which allow detecting abnormal activity in cyberspace and predicting potential attacks. Among the priority areas should also be noted the development of cyber literacy of the population. It is worth highlighting the creation of a cyber reserve, including the involvement of specialists in the IT sphere to protect the country's information resources and develop new technological solutions in the field of cyber defense.

Thus, effective cyber defense of Ukraine under martial law is based on a comprehensive approach that combines technological, organizational and educational activities, international cooperation and the development of innovations in the field of information security.

References

1. Law of Ukraine On the Legal Regime of Martial Law URL: https://zakon.rada.gov.ua/laws/show/389-19#Text (access date: 03/26/2025). [in Ukrainian].

2. Law of Ukraine On the Basic Principles of Ensuring Cybersecurity of Ukraine URL: https://zakon.rada.gov.ua/laws/show/2163-19#Text (access date: 03/26/2025). [in Ukrainian].
3. Ryzhkov E. V. Formation of a cyber defense strategy under martial law. URL:https://er.dduvs.edu.ua/handle/123456789/15032?utm_source=chatgpt.com (access date: 03/26/2025). [in Ukrainian].
4. Karpechenkov M. P., Tulupov V. V. Cybersecurity in Wartime: What, Who, How. Application of Information Technologies in Law Enforcement Activities: Proceedings of the Round Table. Kharkiv: KhNUVS, 2022. P. 104–108. URL: https://dspace.univd.edu.ua/items/b19ccbd3-6468-4f4c-b6ec 000d9a6b3dd8?utm_source=chatgpt.com (access date: 03/26/2025). [in Ukrainian].
5. Kulchiy I. Cybersecurity of Ukrainian state authorities under the legal regime of martial law / Inna Kulchiy // ICBuTS-2022, November 23-24, 2022. — T.: FOP Palanytsia V.A., 2022. — P. 151–153. [in Ukrainian].
6. Ryltsev, M. O. Innovative technologies and cyber defense systems under martial law: challenges and opportunities / Mykola Olehovych Ryltsev // Current problems of modern science in the research of young scientists, cadets and students: abstracts of the All-Ukrainian scientific and practical conference. NAPS of Ukraine. – Kharkiv: KhNUVS, 2024. – P. 617-620. [in Ukrainian].
7. Babanin S. V. Cybersecurity as a component of national security of Ukraine under martial law / S. V. Babanin // International and national security: theoretical and applied aspects: materials of the 8th International Scientific and Practical Conference. Dnipro: DDUVS, 2024. – P.530-531. [in Ukrainian].
8. Law of Ukraine On Information URL: https://zakon.rada.gov.ua/laws/show/2657-12#Text (access date: 03/26/2025).

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The Social and Ethical Issues of Large Language Models (LLMs)

This paper explores the nature of Large Language Models in modern age and describes potential social and ethical issues that could arise from misusing this technology. Consequently, following aspects such as misinformation, social media influence, data privacy, censorship and the future of job market in the context of current AI developments will be discussed in further paragraphs.

Social Impact of LLMs Firstly, the evergrowing capabilities of Large Language Models have led to vast improvements but at the same time to various unexpected problems. According to a recent article The Limitations and Ethical

Considerations of ChatGPT by Shangying Hua, Shuangci Jin, Shengyi Jian [10] Chat-GPT and other models may be prone to “Hallucinations”- a piece of text that may seem grammatically correct but actually contains no actual meaning. Such incidents serve as evidence that information generated by models should always be checked by specialists who have genuine expertise in given topic. Secondly, constant use of LLMs may result in cognitive skills impairment. According to Chris Stokel-Walker, generative AI tools can significantly affect the users critical thinking skills – people who use such tools more frequently may think less critically as they trust AI to do their task. Such cases are also present in academic environments and a recent article by Rob Weigh emphasizes this problem – according to a new study university students who constantly use generative AI tools “find themselves in a vicious circle where they don’t give themselves enough time to do their work and are forced to rely on ChatGPT, and over time, their ability to remember facts diminishes” [9]. Over time it could lead to severe memory loss and damage their logical, analytical skills.

Furthermore, a recent study reported that LLMs significantly affected job market, especially in fields such as content creation and customer service. Considering the fact that LLMs can automate numerous routine tasks such as copywriting and customer support (chatbots) it can be concluded that the need of human labor would be greatly reduced which could lead to job displacement in those fields [3].

Ethical Concerns of LLMs Additional point of equal importance is the ethical side of LLMs and potential risks of mistreating this technology. Every day models such as Chat-GPT process vast amounts of data from different users which could potentially contain sensitive data such as medical records or confidential company information for example. One such case happened in 2023 with Samsung, when several company employees unintentionally shared classified corporate data including proprietary code and internal meeting data while debugging code and summarizing meeting notes. As a result, Samsung completely banned the use of Chat-GPT to prevent future data leaks [5]. Another significant ethical concern regarding LLMs is their potential misuse for fraudulent activities - making models write deceptive content such as fake reviews, misleading news or phishing emails. Many bad actors, both businesses and individuals, have used generative AI tools to distort company image and mislead potential customers by artificially skewing the perception of their product or discrediting other companies’ solutions. Countless fake product reviews on Amazon or airline reviews serve as prime examples of such behavior. A study conducted by Originality.ai (2023) reports that the number of fake AI-generated airline reviews has increased by 189% since the release of Chat-GPT, emphasizing the ethical implications regarding artificially generated content [2]. Last but not the least is the political bias aspect of LLMs, as the models are inherently reliant on data given by developers and could be leaning to certain ideological views more than the others depending on the dataset, which could result in distorted responses favoring specific political view and having significant impact on public perception. For example, a study conducted by Tavishi Choudhary reports that Chat-

GPT consistently exhibits more progressive views while Google Gemini leans toward mixed and centrist stance [1; 6].

In summary, escalating usage of LLMs could result in significant changes in modern society including increased risk of unemployment in certain fields and potential harm to cognitive skills. Also widespread adoption of these models raises important ethical issues such as privacy breach, political bias and fraudulent activity with the help of generative AI tools. Following issues should be addressed by developers to prevent future harm and establish responsible use of LLMs.

References:

1. Choudhary, T. (n.d.) 'Political bias in AI-language models: A comparative analysis of ChatGPT-4, Perplexity, Google Gemini, and Claude'. Available at: https://www.techrxiv.org/users/799951/articles/1181157-political-bias-in-ai-language-models-a-comparative-analysis-of-chatgpt-4-perplexity-google-gemini-and-claude.
2. Originality.ai (2024) 'Fake AI-generated airline reviews have increased by 189% since the release of ChatGPT'. Available at: https://originality.ai/blog/analysis-airline-ai-fake-reviews.
3. International Journal of Informatics and Communication Technology (2024) 'ChatGPT's effect on the job market: How automation affects employment in sectors using ChatGPT for customer service'. *International Journal of Informatics and Communication Technology*, 13(1), pp. 116–122. doi:10.11591/ijict.v13i1.pp116-122.
4. Liao, Q.V. and Vaughan, J.W. (2023) 'AI transparency in the age of LLMs: A human-centered research roadmap'. *Microsoft Research*. Available at: https://www.microsoft.com/en-us/research/publication/ai-transparency-in-the-age-of-llms-a-human-centered-research-roadmap/.
5. The Hindu (2023) 'Samsung data breach: Leaked customer's personal information'. *The Hindu*, 4 April. Available at: https://www.thehindu.com/sci-tech/technology/samsung-data-breach-leaked-customers-personal-information/article67539615.ece.
6. Brookings Institution (2023) 'The politics of AI: ChatGPT and political bias'. *Brookings Institution*. Available at: https://www.brookings.edu/articles/the-politics-of-ai-chatgpt-and-political-bias/.
7. Meta Heuristic (2023) 'Data leaks in LLM: Sensitive information disclosure'. *Medium*. Available at: https://medium.com/@meta_heuristic/data-leaks-in-llm-02f85accbf58.
8. Associated Press (2023) 'The internet is filled with fake reviews. Here are some ways to spot them'. *Associated Press*. Available at: https://apnews.com/article/fake-online-reviews-generative-ai-40f5000346b1894a778434ba295a0496.
9. New Scientist (2025) 'Using AI tools like ChatGPT can reduce critical thinking skills'. *New Scientist*. Available at:

https://www.newscientist.com/article/2468440-using-ai-tools-like-chatgpt-can-reduce-critical-thinking-skills/.

10. Hua, S., Jin, S., & Jiang, S. (2024) The Limitations and Ethical Considerations of ChatGPT. Discontinuity in Technology, 6(1), pp. 201–216. Available at: https://direct.mit.edu/dint/article/6/1/201/118839/The-Limitations-and-Ethical-Considerations-of

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Ethical AI: Developing ethical principles for the use of artificial intelligence

The rapid development of artificial intelligence opens up many opportunities. It improves the quality of diagnostics in healthcare, automates tasks, increasing work efficiency. Artificial intelligence personally selects advertising for us, recommends content on social networks, films and music on streaming services, meets us on hotlines and in chatbots. It also tries to predict forest fires, diagnose oncology and analyse securities markets. It does the last two things not always successfully.

However, these rapid changes also raise serious ethical questions. They arise from the fact that, in the absence of ethical parameters, artificial intelligence systems can be used for purposes that pose a threat to humanity. Many people and experts express concerns about the unregulated use of systems that are thousands of times smarter than humans. Is this a serious issue and challenge or just technophobia?

In 2020, an F-16 piloted by AI defeated a human opponent in five simulated dogfights. At the end of 2022, the U.S. Department of Defence conducted the first successful test flight of an F-16 piloted by AI [1].

In an interview with Defence IQ, Col. Tucker Hamilton, head of the U.S. Air Force's AI Test and Operations Branch, said "We must face a world where AI is already here and transforming our society. AI is also very brittle, i.e., easy to trick and/or manipulate. We need to develop ways to make AI more robust and to have more awareness on why the software code is making certain decisions – what we call AI-explainability." [2]. AI developer Saurabh Bhatnagar says AI can kill a human if given the wrong task. For example, the problem of world hunger can be solved, among other things, by killing people" [3].

In the spring of 2023, the nonprofit Future of Life Institute issued a letter calling for the suspension of the development of advanced AI until common safety protocols for such projects are developed, implemented, and verified by independent experts. Among the signatories are Apple co-founder Steve Wozniak, Pinterest co-founder Evan Sharp, Stability AI CEO Emad Mostak, DeepMind researchers, Yoshua Bengio, often called one of the "godfathers of AI," and Stuart Russell, a pioneer in research in this field. They are calling for a six-month pause in the development of systems more powerful than OpenAI's recently launched GPT-4 [4].

Countries of different regions are identifying AI as strategic to their development and economy. Saudi Arabia is making AI a cornerstone of its economic development. Over the past 5 years, the Kingdom has made significant strides in establishing itself as an AI powerhouse, notably through the $100 billion Transcendence project. By 2030, AI could account for 12.4% of Saudi Arabia's GDP ($235.2 billion). The number of AI companies in the country has surpassed 240, and the number of patents has increased fivefold. Challenges and opportunities identified by the Saudis include: using AI to optimize business operations and create competitive strategies; developing a scalable infrastructure to support technology in companies; and demonstrating the importance of carefully implementing AI in all areas, including business and management [5].

Humanity has always had a technophobia that was clearly manifested during the Industrial Revolution, but never before have we created systems that are thousands of times smarter than us, and never before has there been an opportunity for someone other than a human to make key and important decisions regarding human life. This is exactly what should become the key focus of attention for people working on ethics for AI. The human factor and errors cannot be avoided. Not to mention open sabotage and criminal activity, so we need to work to ensure that AI does not carry out an erroneous or criminal order to destroy a person. This is the primary task for AI ethics. Having solved it, we will be able to use Artificial Intelligence safely and effectively, that will help us in business and management.

References:

1. Recording of a simulated battle in 2020. URL: https://www.youtube.com/live/NzdhIA2S35w?feature=shared
2. US air force denies running simulation in which AI drone 'killed' operator. URL: https://www.theguardian.com/us-news/2023/jun/01/us-military-drone-ai-killed-operator-simulated-test
3. Elon Musk among experts urging a halt to AI training. URL: https://www.bbc.com/news/technology-65110030
4. Saurabh Bhatnagar in "X". URL: https://x.com/analyticsaurabh/status/1641448950011150338?s=20
5. AI is powering Saudi Arabia's Vision 2030 transformation. URL: https://www.arabnews.com/node/2591863

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Data Science vs AI: allies or enemies?

As the tech industry continues to evolve, the influence of artificial intelligence (AI) on workforce dynamics has become increasingly clear. This shift has sparked widespread discussion across professional and academic circles. AI is significantly reshaping the tech job market, altering the criteria companies use when selecting candidates. Consequently, many organizations now prioritize applicants with AI-related skills and hands-on experience using AI tools and platforms. In recent years, even major tech companies have carried out large-scale layoffs. While factors such as high interest rates and over-hiring have contributed to this trend, the growing adoption of AI has also played a major role in workforce reductions. The effects of AI on white-collar jobs are becoming particularly noticeable. Automation is now a credible threat to various professional roles, including those in information technology and data science, which were once considered secure.

(image source: https://www.linkedin.com/pulse/businesses-prioritize-profit-jobsecurity-nicky-verd-vcw2f/)

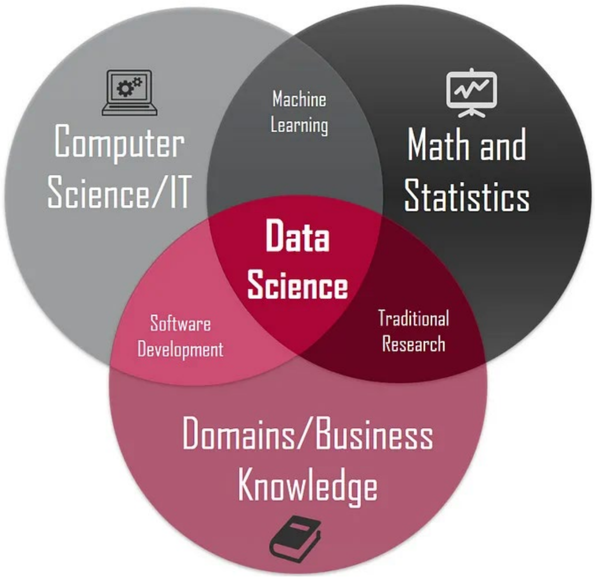
Data science is undoubtedly one of the most promising professions of the 21st century, both in terms of compensation and demand. It is widely considered one of the best career paths to pursue today. Nevertheless, many data scientists are increasingly concerned about their future prospects – particularly the risk of being replaced by AI in the nearest future.

(image source: https://www.linkedin.com/pulse/ai-replace-data-scientists-iabac-fkfoc)

Although AI has the potential to automate certain tasks involved in data analysis, it is highly unlikely to completely replace specialists in the field anytime soon. Most online resources – including forums, blogs, and articles for professionals and enthusiasts in IT – encourage viewing AI as a helpful ally in data science, rather than a threat to data scientists' job security. This viewpoint is supported by several key arguments. First things first, data analysis requires not only logical thinking, but also contextual understanding and, in some cases, emotional intelligence. These elements are crucial for accurately interpreting data. Since AI systems still lack such nuanced human capabilities, human expertise remains essential in the analytical process.

Data scientists also contribute domain knowledge, critical thinking, and contextual insight – all of which are necessary to properly analyze data and arrive at meaningful conclusions. These abilities remain difficult for AI to fully replicate. On another hand, data analysts spend a significant amount of time collecting and preparing data for analysis. While AI can assist in automating parts of this time-consuming process, human intervention remains essential to ensure the integrity and accuracy of the data. Apart from that, data scientists often face complex problems that cannot be solved without creative thinking and strong problem-solving skills. Although AI can provide certain recommendations or insights, the ability to think critically and creatively is still regarded as an invaluable human skill.

In addition to analyzing data, data scientists must communicate their findings to stakeholders, such as managers, decision-makers, and clients. To make the results of their research understandable to non-experts, data scientists need to translate complex data into actionable insights and present it in a clear and coherent manner. Soft skills, including effective communication, storytelling, and collaboration, are crucial to achieving this goal and still remain difficult for AI to replicate.



(image source: https://medium.com/@parasa.arunkoundinya/does-data-scientists-need-to-understand-domain-knowledge-8a3bd4927fce)

Data science and artificial intelligence are complementary fields that frequently work together to extract meaningful insights, automate processes, and make predictions or decisions. By collaborating, the two fields can produce the best possible outcomes while also saving time and energy that data scientists once spent on routine tasks, which can now be efficiently handled by AI. One key intersection between AI and data science is that data science essentially powers AI by providing the necessary data crucial for developing AI systems. This data is used to train models, make predictions, and automate decision-making processes.

Machine learning (ML), a core component of AI, relies on statistical techniques to enable machines to learn from data, and it is driven by data science. Data scientists are involved in building, training, and evaluating ML models to create intelligent systems capable of making predictions or classifications. Examples of such systems include recommendation algorithms, image recognition, and natural language processing, all of which are AI applications derived from ML and powered by data science.

AI algorithms require clean, structured, and relevant data for optimal performance. Data science provides specialized techniques for preparing data, such as cleaning, transforming, and feature engineering. These methods are essential for enhancing the performance of AI models. Data scientists apply techniques like data normalization, outlier removal, and addressing missing data to ensure that AI systems learn from high-quality inputs. In AI, models must be evaluated and optimized for accuracy, speed, and efficiency. Data science offers techniques such as cross-validation, accuracy metrics, and model tuning to enhance the performance of AI models.

While data science primarily focuses on understanding and generating insights from data, AI is more concerned with automating processes and making decisions based on those insights – AI, Data Science, and the Transformation of Scientific

Research [1]. By integrating the two, intelligent systems can be built that not only analyze data but also take actions based on the analysis. Moreover, this combination enables the achievement of optimal results in the shortest time possible, thanks to the assistance of AI. A prime example of the successful collaboration between these fields is predictive analytics. In this area, data science methods are employed to identify patterns, which AI models then use to make future predictions or decisions without human intervention.

Developing AI systems often involves experimentation with various models, algorithms, and datasets. Data scientists contribute to the development of these systems by applying their expertise to test hypotheses, conduct experiments, and analyze results to ensure continuous improvement. Additionally, data scientists utilize visualization techniques to interpret AI model performance, which is crucial for debugging and refining these systems. Big data technologies, which constitute another branch of data science, enable AI systems to handle vast datasets efficiently. AI systems, particularly deep learning models, thrive on large datasets [4]. Data science provides the necessary tools for storing, managing, and processing these extensive datasets, utilizing technologies such as Hadoop, Spark, and cloud-based platforms.

In conclusion, data science can be considered foundational to AI because it offers the tools and techniques essential for gathering, analyzing, and preparing data for AI models. As such, data science is indispensable to the development of AI systems. Data scientists will not only retain their positions but will likely experience higher demand, as their expertise is crucial for the advancement and refinement of AI technologies. While AI can automate certain aspects of data science, the field itself covers a broader range of activities, including data collection, domain knowledge, and business understanding. Therefore, AI and data science are complementary. A skilled team that integrates both data science and AI expertise is often the most effective way to leverage the full potential of data.

References:

1. AI, Data Science, and the Transformation of Scientific Research: A Primer. URL: https://grow.cals.wisc.edu/departments/front-list/ai-data-science-and-the-transformation-of-scientific-research-a-primer
2. Data Science Salaries & Job Market Analysis: From 2024 to 2025. URL: https://www.kdnuggets.com/data-science-salaries-job-market-analysis-2024-2025
3. Impact of AI on Tech Layoffs: Insights from 2024. URL: https://www.linkedin.com/pulse/navigating-impact-ai-tech-layoffs-insights-from-2024-archit-gupta-ojf5e
4. Will AI replace data scientists? URL: https://www.linkedin.com/pulse/ai-replace-data-scientists-iabac-fkfoc
5. Can-AI-and-data-science-work-together? URL: https://www.quora.com/Can-AI-and-data-science-work-together

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Blockchain Technology as the Future of Digital Decentralization

Digital decentralization is the process or state in which control, authority and data are distributed across a network (blockchain), rather than being concentrated in a single central entity [1]. This model transfer power from traditional centralized institutions, such as governments, corporations or service providers, to a network of participants, where each participant has some part of control or influence. By distributing control across a network of participants rather than relying on a central authority, blockchain creates systems that enhance security, efficiency and user autonomy. Digital decentralization will change how people will store and share information by creating systems that will be more secure and efficient, reducing the need for middlemen and giving people more control over their data.

According to a Deloitte report (2020), 55% of organizations consider blockchain to be critical to their businesses and are increasing their investments in it. This represents a 12% increase compared to their 2018 survey (figure 1). Trending upwards are also the general attitudes toward the adoption of blockchain within organizations, with 88% of respondents viewing blockchain technology as broadly scalable and achieving mainstream adoption [2].

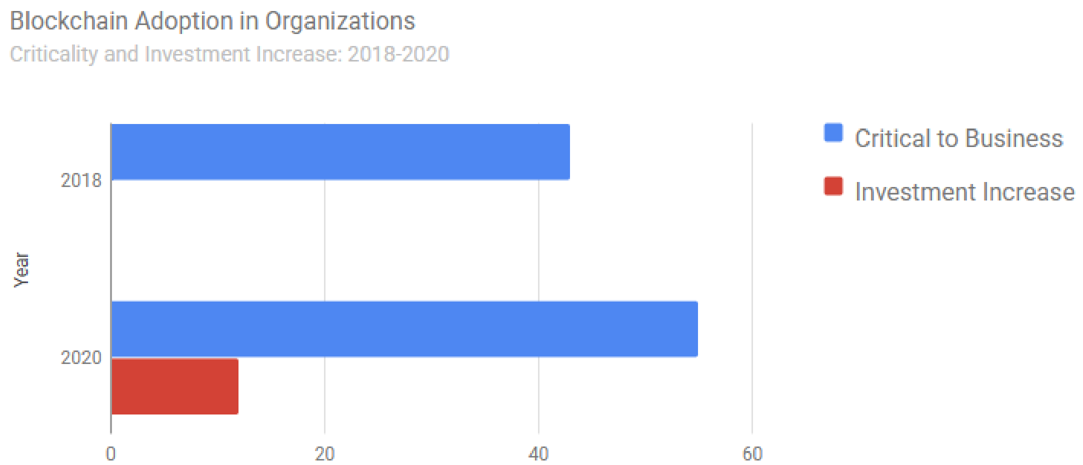

Figure 1 – Blockchain Adoption in Organizations (2018-2020 years)

Security and Efficiency One of the primary benefits of blockchain technology is its ability to ensure data integrity through cryptographic methods. Each transaction is recorded on a decentralized ledger, a record of all transactions on a network [3] maintained and updated by many independent nodes. Moreover, blockchain transactions frequently demonstrate greater speed and lower costs in comparison to traditional systems that depend on intermediaries. For instance, decentralized finance

(DeFi) platforms use smart contracts to automate processes that would typically require manual control, significantly enhancing transaction speed and minimizing fees [4]. Blockchain uses a unique approach to storing information, different from conventional databases that rely on tables or separate files. It works by linking blocks of data together in a continuous chain. Each block contains specific information, and once verified, it becomes permanently connected to other blocks making it impossible to change or delete. Every piece of data receives a timestamp for validation. Unlike traditional databases, blockchain maintains a continuous, sequential record where all participants in the network can access the complete history of information. Each user has private keys, which act as cryptographic signatures to access their data and authorize transactions. Without the key, encrypted information remains inaccessible, even if the hashes are visible to other participants on the blockchain [5]. The technology offers high efficiency, anonymity, transparency, traceability and security.

Reduced Dependence on Middlemen Blockchain technology effectively removes the need for intermediaries in various transactions. This shift not only streamlines processes, but also democratizes access to services. Smart contracts, self-executing contracts with the terms that directly written into code [6], allow automated transactions to be concluded without the need for third-party control. When transactions are recorded, no single entity owns the record. Data is not stored in one single location. The decentralized structure reduces the need for an intermediary middleman to transfer information between users [7].

One of the examples is financial sector. In the financial world, security and efficiency are key priorities, given that banks and other financial institutions deals with corporate and consumer finances. Functions such as accounting, transaction clearing and settlement and regulatory compliance are critical to healthy banks. But these processes can also be subject to runaway costs, particularly as banks try to control the expanding issues of fraud and cybersecurity risks. By implementing blockchain systems, banks could save significant sum on administrative costs while also securing their clients data and financial assets [7].

Users can control their data Another major advantage of digital decentralization is the expanding user rights through increased ownership and control over their data.

In centralized systems, users often hand over control of their personal data to corporations or governments, making it vulnerable to breaches and wrong use. In contrast, blockchain technology allows maintaining full control over data through decentralized storage solutions, which distribute data across a network. This empowers users to decide what information to share and with whom, creating a more transparent and secure environment. This solution not only enhances user privacy but also meets growing needs for data independence in an increasingly digital world. As for the example, platforms like Filecoin and Storj allow users to store files in a decentralized way [8; 9]. Users can upload their data, which is then encrypted and distributed across the network, ensuring that no single entity has access to all the information.

In supply chain management, decentralized access control can be employed to track origin of products while maintaining strict access controls. Each participant in the supply chain can define who can view or modify tracking information, ensuring that sensitive data remains protected while still being transparent.

Projects like Ocean Protocol enable users to share their data securely while retaining ownership and control over it. Users can monetize their data by sharing it with others under specific conditions defined by smart contracts [10].

Thus, the potential impact of digital decentralization is significant. It promises to change interactions with technology and with each other. As blockchain technology continues to grow, it is expected that further innovations will improve security, lower costs and give users more power.

Future trends may include greater use of decentralized applications (dApps) across various sectors, such as finance and healthcare. This will allow people to have more control over their information and interactions. The transition towards decentralized systems marks the beginning of a new era when trust will be placed not in centralized institutions, but in the underlying technology itself.

References:

1. Coinbase. *What are Decentralized Applications (DApps).* Available at: https://www.coinbase.com/learn/crypto-basics/what-are-decentralized-applications-dapps (Access date: 25.02.2025).

2. Deloitte. *Budman M., Bhat R., Bordoloi S. Deloitte's 2020 Global Blockchain Survey. From promise to reality.* Available at: https://www2.deloitte.com/content/dam/Deloitte/tw/Documents/financial-services/2020-global-blockchain-survey.pdf (Access date: 25.02.2025).

3. River. *Decentralized Ledger | River Glossary*. Available at: https://river.com/learn/terms/d/decentralized-ledger/ (Access date: 25.02.2025).

4. M. Javaid et al. Transactions on Benchmarks, Standards and Evaluations. *A review of Blockchain Technology applications for financial services. BenchCouncil*. 2022. Available at: https://doi.org/10.1016/j.tbench.2022.100073 (Access date: 16.03.2025).

5. CoinGeek. *Blockchain and Data Privacy in the Web3 Era: How to Secure and Protect Your Data.* Available at: https://coingeek.com/blockchain101/blockchain-and-data-privacy-in-the-web3-era-how-to-secure-and-protect-your-data/ (Access date: 25.02.2025).

6. Codezeros. Medium. *Best Practices for Smart Contract Development*. Available at: https://codezeros.medium.com/best-practices-for-smart-contract-development-84b35b3c62d4 (Access date: 25.02.2025).

7. Entefy. *Blockchain and the end of the middleman*. Available at: https://www.entefy.com/blog/category/uncategorized/page/6/ (Access date: 25.02.2025).

8. Filecoin Docs. *Store Data*. Available at: https://docs.filecoin.io/builder-cookbook/data-storage/store-data (Access date: 25.02.2025).
9. Storj dev. *Getting started with Storj: Enterprise-grade Cloud Object Storage*. Available at: https://storj.dev/dcs/getting-started (Access date: 25.02.2025).
10. Ocean Protocol. *Storage Specifications*. Available at: https://docs.oceanprotocol.com/developers/storage (Access date: 25.02.2025).

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The behind of the generative AI : Coding, Teaching, Operating costs and Accessibility

Generative AI is the hot topic of today, with almost limitless opportunities to be used and inquired for both the general public and tech giants. The market capitalization of generative AI technologies as of 2024 is more than 20.9 billion USD and is predicted to grow up to 136.7 Billion by 2030. Tech giants of the industry already house their own models or are on their way to acquiring one.

As of today, there are 4 main different types of generative AI: GANs, Multimodal models, Models based on transformers and VAE. GANs, or Generative adversarial networks, consist of multiple neural networks of generators and discriminators. Generators generate convincing results and discriminators distinguish the authenticity of created results. This type of model operates by combining the work of two different networks to create content. Multimodal models are the most sophisticated of the bunch because they can recognize and process multiple kinds of data. They are the ones that gain traction the most at this moment in time. Models based on transformers are the simplest of the bunch; they form the basis of most linguistic models. The transformer model is usually trained on a large dataset in which it tracks relationships in sequential data, thus learning context and acquiring a technique called self-attention, which allows the model to detect even the most subtle ways distant data elements depend on each other. The most common use of this model today is a translation in real-time or the diagnostics of cancer in patients' scans. The last of the bunch is VAE or Variational automatic encoder. They use the structure of two networks as in GAN, but instead of generators and discriminators, they use encoders and decoders. The encoder takes input data and packages it in a compact and simple way to feed it to a decoder. The decoder then takes that compressed package and builds it into a new package that is similar to the input but not identical.

The applications and benefits of those models could include automation of manual tasks such as writing, quicker and improved answers to technical queries, easy-to-read summarization of huge amounts of text, improved way to analyze complex big data with a possibility of finding new trends and relations of the said data or automating some tasks or processes completely.

Knowing how useful those AI`s could be to the people, the question arises: What is actually behind the creation of those models?

First, we need to define what constitutes generative AI in technical terms. Generative AI is a machine-learning model that either makes a prediction based on learning data or creates new data through **the** usage and combination of learning data. As an early example of those models, we could bring up a Markov chain model that was created by a mathematician in 1906, which could predict **the** next word in a sentence. It has long been used for tasks such as an autocomplete function in emails. Mostly, the difference between then and today is the sample size of the input data. Such simple models can only look so far, so their output is limited.

If the main principles behind generative AI are quite simple, does that mean anyone can create their own model? The answer to that question is quite complicated. The first step is coding the model, which can be achieved with Python, as it is easy to use and has a rich ecosystem of libraries and frameworks suited for AI development. In this case, libraries such as TensorFlow, Keras, PyTorch, NumPy and SciPy come to help.

TensorFlow is a powerful library for machine and deep learning that was created by Google Brain as a continuation of a closed project, DistBelief, for internal use, but in 2015, it became available for free under the Apache 2.0 license. TensorFlow is a second-generation deep machine-learning system based on CUDA architecture. Its predecessor saw a lot of success in its time and TensorFlow is a straight upgrade available to anyone interested. Keras runs on top of TensorFlow to simplify its usage. PyTorch is an open-source flexible library for machine learning based on a Torch library created by MetaAI, which is mainly used for scripting language based on Lua. PyTorch is usually used to process language or digital images. NumPy and SciPy are libraries used for computing to enable efficient mathematical and data operations. Coding the model itself is easy with those tools, but the hard part comes next – training the model.

To train the model, you need to gather and preprocess datasets, which could be found in the UC Irvine Machine Learning Repository and Google Dataset Search, or you can collect them yourself. While training the model, there are two very important things to consider: the size of the dataset and its quality. The amount of data a language model uses depends on its complexity and requests. For example, GPT-3 uses around 175 billion parameters for its tasks, or if we're talking about image creation from random noise, it requires a range from thousands to millions of images to satisfy the prompt. So, if you want its output to remain sophisticated, the number of parameters could drastically increase in case of a change in the complexity of the request or the maximum length. To collect and process so much data is nearly impossible for a regular person or a small company; that is precisely why the sophisticated Generative AIs are still limited to giants.

Even if you have the required amount of data and processing power to train the model, the results could vary because of the quality of the data. The data required has to be highly diversified and variable and still support a high level of quality. If you “feed” the model wrong or bad data, you could “poison” the model and get wrong answers, or if you accidentally include the output of another AI model in your dataset, it would just create a closed learning loop and completely stop new results. So not only do you need a lot of data, but it has to be high quality if you want to have a powerful and broad generative AI model.

The other important part of teaching such models is that the learning process is required to be completely uninterrupted; otherwise, the results would be lost. This requirement will drastically increase the cost of the whole teaching process, so the operating costs will fluctuate depending on the size of the training data. The only viable way to have the required infrastructure to operate such models is through cloud-based service providers such as AWS, Microsoft Azure, or Google Cloud. They charge on an hourly basis depending on the type of computer cluster that is used. As an example, we could use Microsoft's Azure Cloud, which charges $3 per hour for a single A100GPU supercomputer cluster. OpenAI uses this infrastructure to run its GPT model; their daily costs come in a range of 100 thousand to 700 thousand dollars, totaling 3 to 21 million dollars per month. All of the above costs are just daily spending on tech, and that does not include salaries of employees, costs of accidents, or situations in which the model's output drifts from desirable, so retracing and retraining are required.

In conclusion, we can see that Generative AI is highly efficient and desirable, and the ways to create one are quite simple. However, the training and operative costs are still too high for small companies or individuals to bear. Still, if a limited output is required (for example, finishing inputting data into documents or finishing emails), it’s quite affordable. As time goes on, the processing power of equipment will increase more and more, the algorithms of learning will become more efficient and there will be more breakthroughs in the neural AI sphere. The accessibility of simple generative AI models is going to increase and widen to more consumers and use cases. So, with AI being the hot topic of today and tomorrow, its usage skyrocketing, and it being so efficient, understanding the principles and work behind it could benefit everyone who works with any kind of data, from economists and general IT jobs to scientists, medics, teachers and etc.

References:

1. Elena Canorea (2024). Generative AI beyond: how it works and real use cases. URL:https://www.plainconcepts.com/generative-ai-guide/

2. Erika Balla (2023). Here’s How Much Data Gets Used By Generative AI Tools For Each Request. URL:https://www.datasciencecentral.com/heres-how-much-data-gets-used-by-generative-ai-tools-for-each-request/

3. Google Brain Team (2024). TensorFlow basics. URL: https://www.tensorflow.org/guide/basics

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The impact of AI on the work of programmers

With the rapid development of technology, artificial intelligence is becoming an increasingly integral part of our daily lives and professional activities. In particular, the impact of AI on the work of programmers has significantly influenced software development processes and created new opportunities for professional growth and innovation. However, it is worth considering how the use of AI is changing the profession of a programmer and what prospects and challenges will appear in the future.

Due to the great popularity of artificial intelligence, most people writing articles or conducting research neglect impartiality in order to gain more attention. As a result, we receive a lot of information that reveals only the good features of artificial intelligence, neglecting its shortcomings and peculiarities that arise when it is used in commercial activities and other areas.

Taking these facts into account, it is necessary to rationally approach the issue of artificial intelligence and the features that accompany it. Only such an approach ensures that the impact of AI on programmers' work can be assessed and a rough estimate of this impact can be made in the future.

Artificial intelligence is used in various areas of programmers' work. It is used to generate code, automate repetitive and tedious tasks, simplify error detection, and improve the efficiency of the DevOps process, and other tasks.

Let us consider the use of AI in automation and some types of software development tasks. For example, AI-powered tools can offer automatically generated code snippets, facilitate code refactoring, and help identify and fix bugs. This helps save time and focus on more complex tasks. But not in all cases, the automatically generated code will fit the program logic. Sometimes AI incorrectly predicts what the programmer wants to do, so even in such simple tasks, you need to check the AI's suggestions. Instead, static code analysis tools can thoroughly check the code without execution and identify potential errors and vulnerabilities before the software is running. This significantly improves the reliability and quality of programs and works much faster and more efficiently than a programmer checking a large amount of code in search of a defect.

Artificial intelligence has also affected testing processes. AI-based testing tools can analyze code to identify potential vulnerabilities and even automatically generate test cases. Machine learning methods are used to analyze the results of past tests and predict areas of the code where errors are likely to appear. This helps developers identify and fix problems early in the development cycle.

In addition, AI-based tools with predictive analytics capabilities can help make software applications more secure. For example, Darktrace helps software engineers identify and neutralize potential threats by detecting abnormal patterns in network traffic, thereby improving overall system security.

AI contributes to the development of DevOps practices and continuous integration/continuous delivery (CI/CD) pipelines. AI techniques can analyze code changes, test results, and production metrics to provide information about performance, quality, and potential issues that may arise. This helps to optimize the software development lifecycle, improve deployment processes, and increase the overall quality of the software.

But despite all the advantages of artificial intelligence, it is necessary to consider the risks that arise when using it. One of these risks resulted in a data breach at Samsung that became public in April 2023. It happened because the corporation's developers checked the written computer programs with the help of AI. However, they did not take into account that all data transferred to the database becomes publicly available.

The quality of artificial intelligence systems largely depends on the data set they are trained on. If the training data is biased or incomplete, AI models are likely to produce biased results. In software engineering, this can lead to unintentional discrimination, such as algorithms that favor certain demographic groups over others.

To overcome this problem, developers need to apply rigorous data preprocessing techniques that involve cleaning, filtering, and enhancing datasets to make them meet the standards for effective AI training. In addition, the process of obtaining the right data may require collaboration with other companies to gain access to wider and more diverse datasets.

Privacy can also become a significant issue, especially critical in software that processes sensitive data, such as fintech and healthcare platforms. To cope with this problem, you need to use reliable methods of encryption and data anonymization.

It can be said that artificial intelligence will not be able to completely replace programmers even in the future and all the outrageous headlines that can be seen in the media space are not true. AI has an impact on the work of programmers and in the future, it will most likely increase. But it will be more of a collaboration than a complete replacement, so developers will need to learn AI-based tools in addition to the necessary technology stack.

It is also worth focusing on what humans do better than AI. For example, all tasks that require a creative approach perfectly illustrate that a complete replacement of humans is impossible. The situation is similar with tasks that involve issues of ethics and morality. At the same time, AI copes well with routine tasks and labor-intensive, monotonous processes.

It can already be said that some large IT companies adhere to this policy. For example, Microsoft integrates Copilot into its IDE for more efficient work of the programmer and AI. In this case, the developer plays the leading role in the process, and the AI is like his assistant, performing small tasks that are given to him or searching for information that will help solve the problem.

All this suggests that the gradual introduction of AI into the development process can be effective with a rational and clear approach to the features of its use. Therefore, in my opinion, AI for programmers will not be a competitor, but a useful tool that the developer will need to add to his technology stack.

References:

1. Is There a Future for Software Engineers? The Impact of AI [2024]: https://brainhub.eu/library/software-developer-age-of-ai
2. Will AI Replace Programmers? Navigating the Future of Coding: https://extendedstudies.ucsd.edu/news-events/extended-studies-blog/will-ai-replace-programmers-navigating-the-future-of-coding
3. What are the Advantages and Disadvantages of Using AI in Development?: https://beetroot.co/ai-ml/what-are-the-advantages-and-disadvantages-of-using-ai-in-development/
4. Advantages and Disadvantages of Artificial Intelligence: https://sgs.upm.edu.my/article/advantages_and_disadvantages_of_artificial_intelligence-77932
5. Artificial Intelligence Pros and Cons: What are the Advantages and Disadvantages of AI: https://rockcontent.com/blog/artificial-intelligence-pros-and-cons/
6. Breaking down the advantages and disadvantages of artificial intelligence: https://www.ibm.com/think/insights/artificial-intelligence-advantages-disadvantages
7. Forget the Hype: AI Isn’t Taking Your Coding Job: https://medium.com/mop-developers/forget-the-hype-ai-isnt-taking-your-coding-job-9047f2d16171
8. Will AI replace Software Engineers?: https://www.wearedevelopers.com/en/magazine/340/will-ai-replace-software-engineers
9. What Does the Future of AI in Software Development Hold?: https://intellias.com/ai-in-software-development/
10. AI Is Driving An Evolution In The Role Of The Software Developer: https://www.forbes.com/sites/garydrenik/2024/07/09/ai-is-driving-an-evolution-in-the-role-of-the-software-developer/

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The Impact of Artificial Intelligence on Programming: Advantages and Challenges

Nowadays artificial intelligence (AI) is fundamentally changing the field of software development, automating routine tasks and improving the productivity of programmers. Machine learning-based tools assist in writing, optimizing, and testing code, which significantly reduces development time and errors.

However, along with the possibilities of AI come new challenges: issues of security, liability for AI-generated code, and its impact on the labor market. Therefore, this research explores how artificial intelligence is transforming programming, what its benefits and risks are, and the extent of its adoption in the IT industry.

One of the main directions of using AI in programming is the automation of code writing. With tools based on neural networks, such as OpenAI Codex, GitHub Copilot, ChatGPT, developers can quickly create new features, modify existing code, and fix bugs. According to IBM (2024), using AI to generate code can reduce development time by 30-50%, freeing programmers from repetitive tasks. In addition, platforms like SonarSource help automatically improve code structure and eliminate potential vulnerabilities, making software safer and more efficient.

The adoption of AI in software development has been growing steadily. According to the McKinsey Global Survey on AI, in 2024, 72% of companies have implemented AI in their business processes, particularly in software development. This is a significant increase compared to 47% in 2018. As shown in Figure 1, this trend shows stable growth.

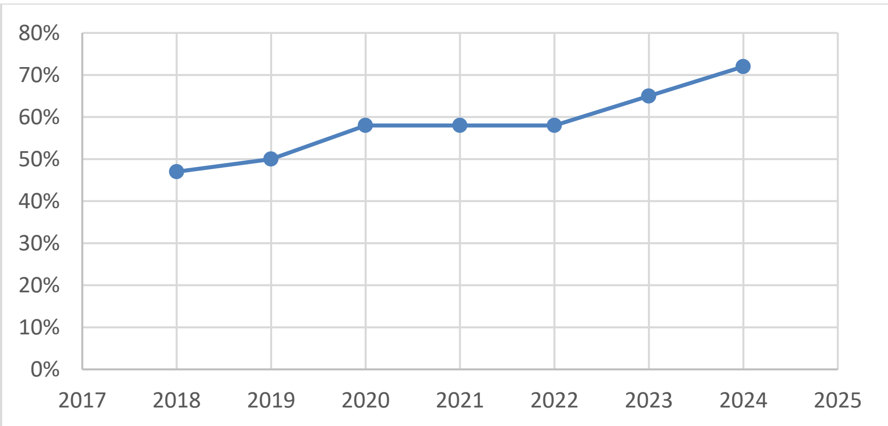

Figure 1. Share of organizations implementing AI in business processes (2018-2024)
Data from McKinsey Global Survey on AI

AI also plays a key role in software testing. Instead of manually creating test scenarios, algorithms can automatically find bugs and predict potential failures before the product even enters the market. For example, Pluralsight estimates that companies, which have integrated AI into their testing processes, have reduced the cost of fixing bugs by nearly 40%. This not only reduces development time, but also improves the quality of the final product. Moreover, AI is widely used in the field of cyber security. Algorithms analyze anomalies in source code, identify potential threats, and automatically suggest fixes. This helps prevent cyberattacks at the development stage.

It is also important that integrating AI into the workflow allows developers to work faster and more efficiently. As shown in Figure 2, 83% of programmers believe that AI has a positive effect on their productivity.

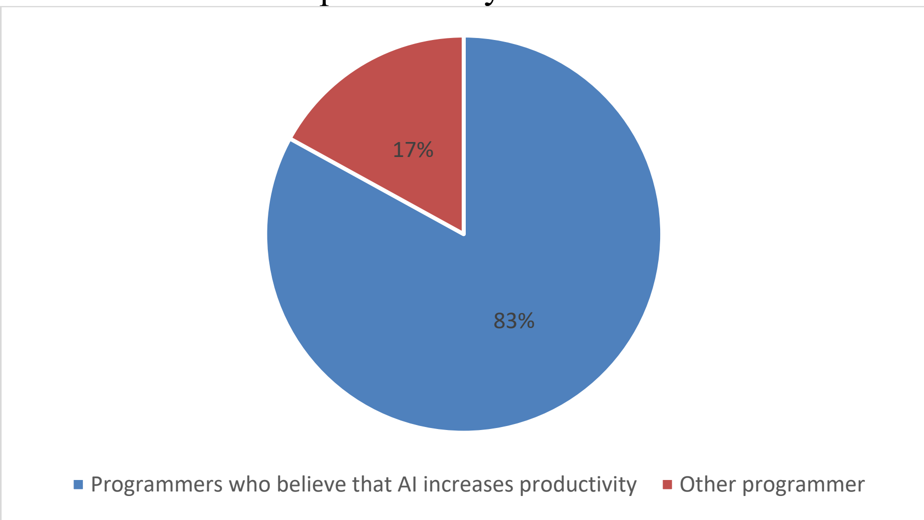

Figure 2. The impact of AI on programmers' productivity
Data from DAN.IT research (2024)

Despite its significant advantages, artificial intelligence in programming has certain risks:

1) Errors and bias. AI can generate code with errors or reproduce outdated programming methods, which is a security risk.
2) Dependence on a person. Algorithms cannot completely replace programmers because complex architectural solutions require human participation and creativity.
3) Legal and ethical issues. According to Forbes, there is growing concern about copyrighting AI-generated code. This is becoming an important topic for open source companies.

In conclusion, artificial intelligence is revolutionizing software development by speeding up coding, improving testing and overall productivity. At the same time, it creates new challenges related to security, copyright and the need for programmers to adapt to new technologies. It is clear that AI will not replace programmers, but will become an important tool in their work. Further development of this technology will help make programming even faster and safer, opening up new opportunities for developers and companies.

References:

1. **Forbes (2024).** *10 Key Ways Software Engineers Are Using AI.* https://www.forbes.com/sites/allbusiness/2024/12/30/10-key-ways-software-engineers-are-using-ai/
2. **IBM (2024).** *AI in Software Development.* https://www.ibm.com/think/topics/ai-in-software-development
3. **Pluralsight (2024).** *AI in Software Development: Key Opportunities and Challenges*. https://www.pluralsight.com/resources/blog/business-and-leadership/AI-in-software-development
4. **SonarSource (2024).** *AI Code Generation Benefits & Risks*. https://www.sonarsource.com/learn/ai-code-generation-benefits-risks/

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Influence of Trumps Tariffs on the IT industry and Tech World

Donald Trump’s trade war started because he wanted to fix what he thought was a bad trade between the U.S. and other countries, especially China. To do this, Trump introduced tariffs and taxes on goods coming into the country. His goal was to "Make America Great Again" by bringing manufacturing jobs back to the U.S. and reducing the amount of goods the country imported.

Trump believed that past trade deals hurt American workers, leading to lost jobs and closed factories. By raising the cost of imported goods, he hoped Americans would buy more U.S.-made products, which would boost local production and create jobs. The tariffs were also aimed at pushing other countries to make new trade deals that favored the U.S. more. Reducing the trade deficit, the gap between what the U.S. imports and exports, was the main goal.

However, the tariffs caused problems for the tech industry, which depends on parts and materials from around the world. Many items needed for things like smartphones and computer equipment became more expensive because of the tariffs. This made it harder and more costly for tech companies to produce their products. As a result, there were delays, shortages, and less money available for research and development.

Producing costs in tech went up, especially in the semiconductor industry. Since these parts often come from countries like China, the added costs from tariffs made products more expensive for consumers. This slowed down the industry and hurt innovation, as companies had to spend more on operations and less on developing new technologies.

The trade war also hurt relationships with other countries. Many responded with their own tariffs against the U.S., which increased tensions between everybody. Some countries began rethinking their trade relationships with America, seeing the U.S. as acting in its own interest instead of working together. Even Japan, China, and Korea, who have an extensive history with not-so-good relationships in the past, started working together so that they would have to trade less with the US. Even a simple sheet of rolled steel is much more expensive in the US than in Europe or China. That shows how much the tariffs actually hurt the Americans and not the other countries.

Because of this, there was a shift in global trade. Countries hit by U.S. tariffs started looking for new trade partners and strengthened existing ones. China, for example, built stronger trade ties with nations in Asia, Africa, and Europe. This reduced the U.S.'s power in the world. In the end, the U.S. became more isolated in global trade and with less leverage to manipulate the situation for others.

To fix the damage caused by the trade war, a few things need to be done. First, the U.S. should work to rebuild relationships with trade partners by making fair trade agreements. Second, the U.S. should invest in improving its infrastructure and supporting innovation in the tech sector.

Trump already started realizing the ramifications of his tariff actions. Recently it was announced that tariffs will not affect smartphones and computers. That means that even with all the tariffs, companies like Apple or Samsung will not have to drastically raise their prices to keep getting the same profit of their devices.

Finally, the U.S. should focus more on working together with other countries rather than fighting them over trade. Being active in global organizations like the World Trade Organization can help the U.S. influence future trade in a way that benefits everyone. If nothing is done soon, profits and revenues in the US will go down a lot and the country will be bogged down by all the economic stress. It feels like Trump is trying to punish other countries, but instead he just messes up the US, and no one else.

References:

1. "What are Trump's tariffs and is the US in a trade war with China?", 2025. URL: https://www.youtube.com/watch?v=DMmkbB8lKuE. Accessed 12 April 2025.
2. COOK, LORNE, and DAVID MCHUGH. "EU imposes new tariffs on $23 billion in US goods in retaliation for Trump's steel, aluminum tariffs", 2025. *URL:* https://apnews.com/article/tariffs-europe-trump-2c4f1519373803ac1f7c1744b69812d0. Accessed 12 April 2025.
3. Halpert, Madeline. "Trump exempts smartphones and computers from new tariffs", 2025. URL: https://www.bbc.com/news/articles/c20xn626y81o. Accessed 12 April 2025.

4. "Regulating Imports with a Reciprocal Tariff to Rectify Trade Practices that Contribute to Large and Persistent Annual United States Goods Trade Deficits", 2025. URL: https://www.whitehouse.gov/presidential-actions/2025/04/regulating-imports-with-a-reciprocal-tariff-to-rectify-trade-practices-that-contribute-to-large-and-persistent-annual-united-states-goods-trade-deficits/. Accessed 12 April 2025.

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Exploring the potential of using generative AI in cybersecurity

Artificial Intelligence (AI) has become one of the main trends of technological progress in the modern world, affecting almost all areas of life. Its application fields range from diagnosing diseases in healthcare to automating processes in education. Thanks to the rapid development of technology, artificial intelligence is becoming part of everyday life for millions of people, providing convenience, accuracy, and quickness in solving complex household tasks.

Currently, Generative AI (GAI) is one of the most rapidly developing and promising areas of artificial intelligence. GAI focuses on creating original content such as text, images, video, audio, or software code [1]. An outstanding example in this field is GPT-4 by OpenAI, one of the most powerful and productive large language models (LLMs). GPT-4, the basis of ChatGPT, utilizes a deep learning architecture based on transformers. It demonstrates exceptional abilities in processing and generation of text. The model can create complex scenarios, analyze huge datasets, adapt to new tasks, and provide solutions for highly specific queries. The rapid development of GAI emphasizes its potential as one of the key technologies of the 21st century, capable of transforming our perception of creativity and intellectual work.

However, as technology advances, so do the dangers. The modern world is facing an unprecedented increase in the number and complexity of cyberattacks. According to a report by Cybersecurity Ventures, global losses from cybercrime are expected to reach $9.5 trillion in 2024. The company expects global cybercrime costs to grow by 15% during 2025, reaching $10.5 trillion. The frequency and complexity of attacks are increasing, demanding new approaches to ensuring security. At the same time, there is a growing shortage of qualified professionals: more than 3.5 million unfilled cybersecurity jobs worldwide [2].

As companies increasingly face cyber threats, it is important to understand how GAI can be used for cybersecurity. This article explores the potential of GAI in addressing current challenges, including raising staff awareness, conducting penetration testing, threat analysis, and other areas.

Let's take a closer look at some key examples of GAI applications in cybersecurity that demonstrate its potential to automate and improve process efficiency. Figure 1 illustrates five key use cases: employee training, automating pen tests, reporting, real-time threat detection, and developing countermeasures against new types of attacks. The following sections provide a more detailed analysis of each use case.

Figure 1 - Ways to use generative AI in cybersecurity

Employee Training and Education

One of the key challenges in cybersecurity is raising employee awareness about threats such as phishing attacks. This is particularly important because the human factor is one of the main attack vectors. Employee mistakes caused by a lack of knowledge can lead to serious data breaches or compromised information systems. GAI can create realistic phishing scenarios that are used for staff training. For example, GPT-4 can be integrated into a corporate communication environment. This is implemented using the API that OpenAI provides. Prompt Engineering technology is used to configure the system to generate personalized phishing messages that mimic the behavior of an attacker. The model acts as the attacker and interacts with employees in real time. It can demonstrate various social engineering techniques and interact with users to persuade them to disclose confidential information. After completing such a simulation, the AI can generate a detailed report analyzing the employee's behavior. In addition, GAI can be used to create various training materials, such as interactive websites and online courses.

Automation of penetration testing

Testing systems for vulnerabilities requires a significant investment of time and human resources. GAI can automate a substantial portion of these tasks. Using Python and the GPT-4 API, you can set up a system that automatically performs vulnerability testing. For example, GPT-4 generates commands for network scanning, vulnerability detection, checking configurations, and more tasks. After executing each command, the AI analyzes the system's responses, adjusts its approach, adapts to the conditions of the testing environment, and continues searching for vulnerabilities. Another advantage of using GAI in testing is its ability to provide parallel explanations of its actions. The system can be configured so that one terminal executes commands while another outputs detailed explanations. This makes the process transparent and accessible, even for less experienced specialists.

Automating reporting

Generative AI streamlines the creation of comprehensive, understandable cybersecurity reports [3]. GAI can automatically generate detailed and well-structured reports based on data collected during analysis or from various sources. These reports can include graphs, charts, diagrams, and other visualizations that make them accessible to technical specialists and executives. The AI can tailor the content of reports to the target audience. For technicians, it includes detailed descriptions of identified issues, their causes, and technical recommendations. For executives it generates a summary version that focuses on key risks, financial aspects, and potential impacts, facilitating informed decision-making. Using GAI for report creation saves time and ensures greater accuracy.

Detecting threats in real-time

GAI is a powerful tool for real-time data analysis and identifying potential cyber threats. With its ability to process vast amounts of information (server logs, network traffic, and system events), GAI effectively detects suspicious activity and anomalies. The GPT-4-based system can be integrated into existing infrastructure to detect threats automatically. Upon detecting suspicious activity, the AI can immediately notify specialists and provide a detailed situation report. This reduces the time between incident detection and response initiation, which is critical for minimizing damage. GAI can build complex models to identify and predict unusual patterns that indicate cyber threats. By constantly learning from new data, GAI adapts to evolving attack methods. This proactive approach allows security systems to stay one step ahead of attackers. The use of generative AI not only increases the speed and accuracy of threat response but also reduces the risks of breaches by minimizing potential consequences.

Developing countermeasures against new types of attacks

Modern cyber threats evolve rapidly, and defending against them requires adaptive and innovative approaches. GAI can be used to develop defense mechanisms against new types of attacks. It can create realistic simulations of potential attacks, modeling their key stages. This approach allows organizations to study attacker behavior in a controlled environment and identify possible vulnerabilities in the system. Based on the analysis of these simulations, AI automatically generates recommendations to improve security. For example, it can suggest stricter firewall configurations, updates to access control policies, or improvements to monitoring system settings. Additionally, it can predict potential attack scenarios using data from already-known incidents and current trends. This proactive approach allows it to identify and mitigate potential threats before they materialize. The use of generative AI in developing defense strategies ensures organizations stay ahead in their security measures and can swiftly adapt to emerging challenges.

Generative artificial intelligence opens new horizons in the field of cybersecurity, providing innovative tools to address pressing challenges. Employee training, pen-testing, reporting, threat detection, and developing countermeasures against attacks demonstrate how GAI can improve the efficiency and adaptability of security systems. At the same time, the aforementioned applications do not encompass the full spectrum of possibilities for generative AI. Its flexibility and versatility open the door to integrating into a broader range of data protection and threat analysis processes. However, the use of generative AI also requires careful consideration of potential risks, such as false positives or the misuse of technology by malicious actors. In the future, further development and integration of GAI in cybersecurity will be an important step towards creating more resilient and intelligent defense systems capable of addressing the challenges of the modern digital world.

References:

1. IBM. What is Generative AI? | IBM. *IBM - United States*.
URL: https://www.ibm.com/think/topics/generative-ai (date of access: 23.01.2025).
2. Top 10 Cybersecurity Predictions and Statistics For 2024. *Cybercrime Magazine*.
URL: https://cybersecurityventures.com/top-5-cybersecurity-facts-figures-predictions-and-statistics-for-2021-to-2025 (date of access: 23.01.2025).
3. What Is Generative AI in Cybersecurity? *Palo Alto Networks*.
URL: https://www.paloaltonetworks.com/cyberpedia/generative-ai-in-cybersecurity (date of access: 24.01.2025).
4. Wen S. The power of generative AI in cybersecurity: Opportunities and challenges. *ResearchGate*.
URL: https://www.researchgate.net/publication/379076539_The_power_of_generative_AI_in_cybersecurity_Opportunities_and_challenges (date of access: 25.01.2025).

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Zero Trust Architecture

Modern cyberattacks are becoming increasingly sophisticated, and traditional security systems no longer provide an adequate level of protection. Previously, IT infrastructures were built on a model in which the corporate network was considered a secure zone, while threats originated externally. However, with the expansion of cloud technologies, remote work, and mobile devices, network boundaries are becoming blurred, making perimeter security ineffective.

Main issues for the traditional security model:

- users often fall victim to fraudulent emails, revealing their credentials;
- if an attacker gains access to an employee's account, they can freely move around the network;
- employees and partners may abuse their privileges or accidentally cause data leaks;
- connecting to the corporate network from personal devices increases the risk of malware infection.

Zero Trust Architecture (ZT) is a new cybersecurity concept based on the principle: "Never trust, always verify." In this model, every attempt to access data and resources, whether from inside or outside the network, requires strict verification.

Zero Trust is built on the following key principles:

1. The system never considers a user, device, or network as inherently secure. Every access request is checked against security policies.
2. Users and devices are granted access only to the resources necessary for performing their tasks.
3. Identity verification is conducted through multiple independent factors, such as passwords, biometrics, and one-time codes. This process is known as multi-factor authentication (MFA).
4. Even if an attacker gains access to the system, movement within the network is strictly limited, preventing lateral movement.
5. All system events are continuously monitored, analyzed, and compared with typical user behavior.

In traditional systems, once inside the corporate network, users could freely navigate between resources without needing to re-authenticate. In the Zero Trust model, every new request is validated regardless of the user's location.

Authentication occurs in multiple steps. First, the system verifies the user's identity, their device, location, and other parameters. Then, it assesses risk factors to determine if the request follows a typical pattern, for example, whether the country from which the request originates has changed. Based on this analysis, the system decides whether to grant or deny access, potentially requiring additional authentication.

Despite multiple verification steps, even after access is granted, the system continues to monitor all user activities to detect any suspicious behavior immediately.

Key benefits of Zero include

- protection against insider threats;
- defense against cyberattacks;
- flexibility and support for remote work;
- minimization of data breach consequences.

Despite its advantages, transitioning to a Zero Trust model requires significant resources and the development of a robust security architecture. One of the main challenges is the high cost, as modernizing IT infrastructure demands investments in new authentication, monitoring, and access control systems. Models like ZT are difficult to integrate because they are not immediately compatible with legacy systems and require adaptation. Additionally, monitoring logs and user behavior is necessary around the clock.

Despite these challenges, companies that implement Zero Trust gain long-term benefits, such as enhanced security and a reduced risk of data breaches.

Zero Trust is not just a new technology but a fundamentally different approach to data security. As cyber threats grow and remote work becomes more prevalent, this approach is becoming essential for modern enterprises.

Although implementing Zero Trust requires significant effort, it provides companies with the ability to protect their IT infrastructure, minimize hacking risks, and increase customer trust. In the coming years, this model is expected to become a cybersecurity standard.

References:

1. National Institute of Standards and Technology (NIST) – SP 800-207: Zero Trust Architecture. URL: https://nvlpubs.nist.gov/nistpubs/specialpublications/NIST.SP.800-207.pdf

2. Protect and modernize your org with a Zero Trust strategy. URL: https://www.microsoft.com/en-us/security/business/zero-trust

3. Forrester: The Business of Zero Trust Security. URL: https://www.forrester.com/zero-trust/

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AI and Security: Understanding the Risks in Large Language Models

The rapid advancement of generative artificial intelligence has brought significant transformations across industries, allowing businesses to automate tasks, generate content, and enhance interactive experiences. Unlike conventional AI systems that rely on predefined responses, Large Language Models (LLMs) have the capability to produce original text, enabling dynamic and context-aware interactions. However, the increased reliance on these models introduces numerous security risks that organizations must address to ensure their safe and ethical deployment.

Key security risks associated with LLMs include:

1. Prompt injection: Attackers manipulate an LLM's behavior by crafting deceptive inputs, potentially leading to unauthorized access, information disclosure, or the generation of harmful content. Malicious prompts can instruct models to override safety measures, extract restricted data, or generate inappropriate responses. This type of attack is particularly dangerous as it does not require direct access to the model's backend, making it difficult to detect and mitigate.
2. Exposure of confidential information: LLMs trained on extensive datasets might inadvertently reveal proprietary business information, personal data, or security credentials, creating privacy risks. These disclosures can occur through direct user queries or as a result of training models on improperly sanitized datasets. Organizations relying on LLMs must ensure robust data governance to prevent the leakage of sensitive information.
3. Supply chain vulnerabilities: The reliance on third-party pre-trained models and external data sources introduces risks of compromised datasets, backdoors, and biased models that persist throughout various deployments. If an attacker infiltrates a model's training pipeline, they can introduce subtle but harmful alterations that are difficult to detect, leading to vulnerabilities across multiple applications. As model dependencies grow, securing every stage of the AI supply chain becomes increasingly complex.
4. Data poisoning: Adversaries can introduce misleading or harmful information into a model's training set, influencing its outputs in unintended ways and leading to misinformation, biased decision-making, or security breaches. Attackers may exploit publicly accessible training data to inject biased or toxic content, ultimately skewing the model's behavior to align with malicious objectives. The consequences can be particularly severe in high-stakes domains such as finance or healthcare, where incorrect outputs can have real-world repercussions.
5. Improper output handling: Models generating content without adequate validation increase the risk of misinformation, offensive content, or even harmful

executable code. In environments where LLM outputs are integrated into automated decision-making processes, unverified responses can result in financial losses, reputational damage, or the propagation of incorrect information. The black-box nature of LLMs worsens this issue, as their reasoning processes are not always transparent.

6. Excessive autonomy: LLMs granted too much decision-making capability may unintentionally execute unauthorized actions, affecting enterprise security. Autonomous AI agents that interact with critical systems or sensitive data without strict oversight can cause disruptions, escalate privileges, or misinterpret commands, leading to unintended consequences. While AI-driven automation offers efficiency, unchecked autonomy introduces considerable risks in cybersecurity-sensitive environments.

7. System prompt leakage: Attackers who gain access to internal system instructions can extract sensitive information, reverse-engineer model behavior, or bypass established safety measures. Leaked system prompts can reveal operational logic, business policies, or security restrictions that adversaries may use to manipulate the model's outputs or evade safeguards. This risk extends to multi-tenant environments, where improper isolation can expose sensitive configurations to unauthorized users.

8. Embedding and vector weaknesses: Weaknesses in embedding-based AI models allow adversaries to manipulate stored knowledge or influence model responses. Attackers can modify vector representations to introduce misleading associations, enabling subtle manipulations in LLM behavior without altering direct prompts. Additionally, adversarial attacks can reconstruct training data from embeddings, exposing confidential or private information.

9. Misinformation and hallucinations: LLMs may generate fabricated or misleading content, often referred to as hallucinations, which can erode trust in AI-driven systems. Inaccurate responses can have serious implications in domains like healthcare, finance, and legal consulting, where AI-generated insights are relied upon for critical decision-making. Biases in training data further compound this problem, reinforcing stereotypes or misinformation if not properly mitigated.

10. Unbounded resource consumption: Denial-of-service (DoS) attacks can overwhelm LLMs with excessive automated queries, depleting computing resources and increasing the risk of model extraction by adversaries. Attackers may exploit API-driven models by submitting high-frequency requests, causing service degradation and financial strain on cloud-based deployments. The risk is particularly high for publicly accessible AI systems that lack rate-limiting mechanisms.

To mitigate these threats, organizations must implement comprehensive security measures that address both technical and procedural vulnerabilities. Secure model training and data management are paramount, involving the protection of model architectures, training pipelines, and data repositories. Encryption and access controls should be employed to minimize unauthorized access and data breaches. Regular audits and bias testing ensure that LLM outputs remain aligned with ethical standards, reducing the impact of adversarial attacks and inadvertent biases.

An additional layer of protection involves output verification mechanisms, ensuring that LLM-generated content undergoes thorough validation before being used in decision-making processes. Strong access control policies, including role-based authentication and API security, help prevent unauthorized usage and excessive resource consumption. Continuous monitoring and response plans are crucial for detecting anomalies, responding to emerging threats, and adapting defenses accordingly.

Ethical considerations must also be integrated into LLM security strategies. Privacy-preserving techniques such as differential privacy and federated learning help maintain data confidentiality while leveraging AI for cybersecurity applications. Transparency and accountability mechanisms should be established to address the black-box nature of LLMs, ensuring that AI-generated decisions can be audited and explained. Regulatory compliance, including adherence to data protection laws, is essential in maintaining ethical AI governance.

As LLMs continue to evolve and integrate into critical applications, their security implications must be at the forefront of AI deployment strategies. Addressing these risks proactively allows organizations to harness the full potential of generative AI while minimizing exposure to cyber threats. Establishing a strong foundation of security controls, ethical guidelines, and operational safeguards will ensure that LLMs remain valuable assets rather than sources of vulnerability in modern digital ecosystems.

References:

1. A Bird's Eye View Of Large Language Model Security. URL: https://www.forbes.com/councils/forbesbusinesscouncil/2024/02/07/a-birds-eye-view-of-large-language-model-security/
2. How To Get Started Using LLMs in IT and Network Engineering. URL: https://blogs.cisco.com/developer/how-to-get-started-using-llms-in-it-and-network-engineering
3. OWASP Top 10 for LLM Applications 2025. URL: https://owasp.org/www-project-top-10-for-large-language-model-applications/assets/PDF/OWASP-Top-10-for-LLMs-v2025.pdf

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Analysis of the effectiveness of web server monitoring and incident response systems based on hybrid system

In the modern digital era, web server stability and security are top priorities for organizations of all sizes. Therefore, there is a critical need for robust monitoring and incident response tools that can detect anomalies in real time and enable rapid recovery [1]. This paper discusses the integration and testing of a hybrid monitoring and incident response system using Zabbix, a Python-scripted Telegram bot, and an ESP32 device for remote power control.

There are numerous incident response and monitoring tools and technologies for web servers, ranging from hardware to open-source software solutions. This research compared and selected three major elements: Zabbix as a deep-level monitoring service, a for real-time alerts, and ESP32 for physical responses (e.g., remote power cycling) [2]. The performance of this integrated solution was assessed based on whether it effectively monitored server performance, detected critical events, alerted administrators in advance, and executed remote recovery procedures.

The test was conducted using a test configuration of a Nginx web server on a local host. It was monitored using Zabbix 6.0, with pre-defined templates and custom triggers for resource consumption (e.g., CPU, memory, disk space) [3]. The Telegram bot was implemented in Python, using libraries such as Telepot, Psutil, and Matplotlib [4]. The ESP32 board was made to react to power incidents. The study utilized a simulated incident database that contained high memory usage, DDoS-like traffic spikes, and power shutdowns to test the performance of the systems.

The ESP32 firmware was developed in C++ utilizing the Arduino IDE to facilitate Wi-Fi-based communication and GPIO management for power control. The effectiveness of the proposed system was evaluated using five key metrics [5]:

- Detection Accuracy: The ratio of correctly identified incidents to total incidents.
- Notification Latency: The time taken to deliver alerts via Telegram after an incident is detected.
- Response Time: The duration from incident detection to the initiation of a recovery action (e.g., reboot via ESP32).
- System Overhead: The resource consumption (CPU and memory) imposed by the monitoring tools.
- Recovery Success Rate: The percentage of incidents successfully resolved through automated or manual interventions.

Two monitoring scenarios were tested: (1) comprehensive monitoring with Zabbix tracking CPU load, memory usage, network traffic and (2) lightweight monitoring with the Telegram bot focusing solely on memory usage. The ESP32 was evaluated separately for its ability to perform remote power operations under various conditions, such as network disruptions and system hangs. The configurations for these scenarios are outlined in Table 1 and Table 2.

Table 1 – Comprehensive Monitoring Configuration with Zabbix

Metric	**Sampling Interval seconds**	**Threshold for 5 min**	**Notification Method**
CPU Load	30	>80%	Telegram
RAM	30	>90%	Telegram
Bandwidth	60	>1 Gbps	Telegram
Disk Space	300	<10% free	Telegram

Table 2 – Lightweight Monitoring Configuration with Telegram Bot

Metric	**Sampling Interval**	**Threshold**	**Notification Method**
Memory Usage	Configurable	Configurable (>90%)	Telegram Bot

The system evaluation results are presented in Tables 3 and 4, reflecting the performance of the two monitoring approaches and the ESP32-based response mechanism.

Table 3 – Results of Comprehensive Monitoring with Zabbix

Metric	**Value**
Precision	98%
Delay	3.2 sec
Speed	15 sec
Load	4% CPU, 150 MB RAM
Resilience	95%

Table 4 – Results of Lightweight Monitoring with Telegram Bot

Metric	**Value**
Precision	92%
Delay	2.8 seconds
Speed	10 seconds (manual)
Load	1% CPU, 50 MB RAM
Resilience	90% (with ESP32)

In conclusion, the evaluation indicates that the system with Zabbix, a Telegram bot, and ESP32 provides an effective web server monitoring and incident response solution. Zabbix is highly efficient in detailed monitoring with high detection efficiency at 98%. However, it causes high system overhead and extra setup for performance. The Telegram bot offers a lighter alternative with less resource consumption (1% CPU) and better notification latency (2.8 seconds). The ESP32 device performed highly in physical incident management, restoring system function in 95% of power-related incidents.

Based on these outcomes, the hybrid solution – the application of Zabbix for deep-level monitoring, the Telegram bot for real-time alerts, and ESP32 for physical responses – is harmonious and practical. It possesses low latency, high dependability, and support for automated as well as manual recovery tasks, thus fitting small to mid-sized web server installations.

References:

1. Smith, J., & Brown, T. "Web Server Monitoring: Tools and Techniques." Journal of Network Security, 15(3), 45-52 p. 2023
2. Kovalenko, O. "IoT-Based Solutions for Remote System Management." IoT Innovations, 8(2), 33-40 p. 2022
3. Zabbix SIA. Zabbix Documentation 6.0. Available at: https://www.zabbix.com/documentation/6.0/ 2024.
4. Python Software Foundation. "Python Libraries for System Monitoring." Python Journal, 12(1), 22-29 p. 2023
5. Esposito, F. "ESP32 Applications in IoT." Embedded Systems Review, 7(4), 15-23 p. 2021

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Cryptography in the Post-Quantum Era: Challenges and Advancements

With the rise of quantum computing, cryptography – a cornerstone of modern security – is undergoing a profound transformation. Quantum computers, capable of solving problems intractable for classical computers, pose an existential threat to current encryption systems.

Classical encryption methods, such as RSA and ECC (Elliptic Curve Cryptography), rely on the computational difficulty of problems like integer factorization and the discrete logarithm problem. These problems form the backbone of modern digital security. However, using algorithms like Shor's algorithm, quantum computers can solve these problems exponentially faster than classical computers. The security of RSA depends on the difficulty of factoring large numbers, but Shor's algorithm can break this in polynomial time. Similarly, ECC is vulnerable because quantum computers can efficiently compute discrete logarithms.

To address the quantum threat, researchers are developing post-quantum cryptographic algorithms. These algorithms rely on mathematical problems and are resistant to quantum attacks. The National Institute of Standards and Technology (NIST) is leading an initiative to standardize such algorithms. In 2022, NIST announced its selection of four algorithms — CRYSTALS-Kyber, CRYSTALS-Dilithium, Sphincs+, and FALCON.

CRYSTALS-Kyber is a lattice-based key encapsulation mechanism (KEM) designed for secure key exchange in post-quantum environments. It relies on the Learning With Errors (LWE) problem, which is hard to solve even for quantum computers. Kyber is efficient in terms of computation and memory, making it practical for real-world applications like securing TLS protocols. Its ability to generate compact ciphertexts and keys further enhances its utility in systems with limited bandwidth or storage.

CRYSTALS-Dilithium is a lattice-based digital signature scheme that is also built on the difficulty of the Learning With Errors (LWE) problem. It is designed for use in post-quantum cryptographic systems and is valued for its strong security guarantees, efficiency, and simplicity. Dilithium creates compact signatures, making it well-suited for digital identity verification and secure communication protocols. Its ease of implementation ensures its compatibility across various hardware and software platforms.

SPHINCS+ (Stateless Practical Hash-based INdifferentiable Signature Scheme) is a hash-based digital signature scheme that is quantum-resistant. Unlike lattice-based systems, SPHINCS+ relies solely on the security of cryptographic hash functions, making it fundamentally different. It offers strong security without relying on assumptions about quantum-resistant mathematical problems. However, its signature sizes are larger than lattice-based counterparts, which can be a trade-off in certain applications.

Lattice-based cryptography is emerging as a leading contender in the post-quantum world due to its strong mathematical foundations and efficiency. In geometry and group theory, a lattice in the real coordinate space is an infinite set of points in this space with the properties that coordinate-wise addition or subtraction of two points in the lattice produces another lattice point, that the lattice points are all separated by some minimum distance, and that every point in the space is within some maximum distance of a lattice point. The solution of the Shortest Vector Problem is needed to decrypt information decrypted with lattice-based ciphers. Solving systems of linear equations with added noise is a problem believed to be quantum-resistant. Furthermore, the lattice-based cryptography systems are easily scalable and can be implemented in different cases. These kinds of systems can also be used not only for information encryption but also for the digital signature of messages.

Another promising area is quantum key distribution (QKD). Unlike mathematical complexity-based cryptographic methods, QKD applies the laws of quantum physics, the no-cloning theorem, and the principle of uncertainty by Heisenberg to ensure security. The most widely used protocol, BB84, allows two parties to exchange encryption keys with perfect security, provided the system is correctly implemented. While a significant leap forward, QKD suffers from problems with cost, scalability, and infrastructure requirements that limit its widespread applicability.

Aside from technical considerations, policy and regulation are significant considerations in the transition to post-quantum cryptography. Governments and institutions worldwide must establish new standards, guidelines for compliance, and policies to ensure a seamless transition. Cybersecurity organizations and international organizations are involved in the process of creating guidelines that help businesses make the transition to post-quantum security protocols. This change does not affect only technology businesses but also banks, healthcare institutions, and government agencies that rely on encryption for security reasons. Shifting to a quantum-secure future requires significant investments in research, workforce development, and infrastructure upgrades.

Moreover, organizations must consider the trade-offs associated with post-quantum cryptographic algorithms. While they provide resistance against quantum attacks, they often require larger key sizes and increased computational resources, potentially affecting system performance. This shift could necessitate upgrading hardware, optimizing software, and even rethinking system architectures to accommodate the new cryptographic landscape. The challenge lies in balancing security with efficiency, ensuring that post-quantum solutions remain practical and scalable.

The transition to quantum-resistant cryptography is a monumental task requiring coordinated efforts across industries, governments, and academia. Replacing RSA/ECC with post-quantum algorithms involves updating software, hardware, and protocols worldwide. This situation is similar to the so-called Y2K or the problem of the year 2000 when the world economy experienced huge damage because many programming systems could not update data after 1999. By the time quantum computers are widely spread, it is crucial for anyone who owns informational resources to have a reliable way to secure them. So, a massive reorganization of security systems is needed. Furthermore, post-quantum algorithms often require larger key sizes and have higher computational overhead, affecting system performance, which may lead to the necessity of upgrading many pieces of hardware.

In conclusion, the potentially coming post-quantum era is reshaping cryptography, driven by the dual forces of opportunity and necessity. While quantum computers threaten the foundations of current encryption systems, advancements in post-quantum cryptography and quantum key distribution offer a path forward. The transition to quantum-resistant systems will require global cooperation and innovation to safeguard digital security in this transformative era.

References:

1. Daniel J. Bernstein and Tanja Lange (2017). Post-quantum cryptography - dealing with the fallout of physics success. URL: https://eprint.iacr.org/2017/314.pdf
2. Michele Mosca (2018). Cybersecurity in an era with quantum computers: will we be ready? URL: https://eprint.iacr.org/2015/1075.pdf
3. Mark Horvath (2024). Begin Transitioning to Post-Quantum Cryptography Now. URL: https://www.gartner.com/en/articles/post-quantum-cryptography
4. NIST (2024). NIST Releases First 3 Finalized Post-Quantum Encryption Standards. URL: https://www.nist.gov/news-events/news/2024/08/nist-releases-first-3-finalized-post-quantum-encryption-standards
5. National Institute of Standards and Technology (2024). Post-Quantum Cryptography. URL: https://csrc.nist.gov/Projects/Post-Quantum-Cryptography
6. Oded Regev (2009). On Lattices, Learning with Errors, Random Linear Codes, and Cryptography. URL: https://arxiv.org/abs/2401.03703

Section 04 Humanities: Challenges and Issues (Legal Studies, Social Studies, Philosophy, Pedagogics, Law, Applied Linguistics, Theory and Practice of Translation)

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Interactive Platforms for Learning English: The Path to Excellence (Case Study of Duolingo)

In today's world, proficiency in English is one of the most essential skills for personal and professional growth. With the advancement of digital technologies, numerous interactive platforms have emerged, enabling effective and engaging language learning. One of the most popular platforms is Duolingo. This application offers a gamified approach to learning [1], making the process of acquiring a language exciting and accessible to a broad audience. It rewards users with XP (Experience Points) and gems, the game's in-app currency for completing lessons, exercises, and daily challenges.

Duolingo is a free mobile and web-based platform that offers courses in multiple languages, including English. Its primary distinguishing feature is the use of game-like elements to enhance user motivation. Here are the key characteristics of Duolingo:

- **Gamification**. The learning process is structured like a game: users earn points, receive badges, and progress through levels, which encourages them to continue their studies.
- **Adaptability**. The platform analyzes mistakes and adjusts tasks according to the user's proficiency level.
- **Accessibility**. Duolingo is free, though it offers a premium version, Duolingo Plus, which removes ads and allows offline access.
- **Short Lessons**. Each lesson lasts only a few minutes, making it easy to integrate learning into daily life.[2]

Numerous studies confirm that using Duolingo helps improve English language proficiency. According to research conducted by the City University of New York (CUNY), 34 hours of learning on Duolingo are equivalent to one semester of university-level language classes [3]. The main advantages of the platform include:

- **Consistency in Learning**. The app's reminder mechanism encourages users to engage in language practice daily.
- **Diverse Exercises**. The platform offers activities focused on reading, listening, writing, and pronunciation.
- **Flexibility**. Users can study at any time and place without the need to attend offline courses.
- Despite its many advantages, Duolingo has certain limitations:

- **Limited Speaking Practice**. Although users can repeat words and phrases, the platform does not offer the level of communicative practice that real-life conversations provide.
- **Mechanical Memorization**. Some users report that the app emphasizes rote repetition of words and grammar patterns without deep contextual understanding.
- **Advertisements**. The free version contains ads, which can distract from learning [4].

Duolingo employs a scientifically driven approach to language learning. It uses spaced repetition, ensuring that learners review previously learned material at optimal intervals. This methodology aligns with cognitive science research on memory retention.

Moreover, Duolingo constantly updates its curriculum based on user feedback and linguistic research. The Duolingo English Test (DET), an accredited certification exam, further demonstrates the platform's commitment to high-quality language instruction. The DET is recognized by various institutions worldwide, making Duolingo not just a learning tool but also a credentialing service.

Another notable feature is Duolingo Stories, which enhances reading comprehension through short, interactive dialogues. These stories help users contextualize vocabulary and grammar in practical scenarios, thereby improving retention.

One of the platform's strengths is its community engagement. Users can participate in forums, where they discuss learning techniques and resolve doubts with fellow learners. Additionally, Duolingo fosters engagement through leaderboards, encouraging friendly competition among users, recreating the classroom bond while enhancing engagement through competition. From a technological standpoint, Duolingo leverages artificial intelligence and machine learning to refine its courses. The Duolingo Bird AI personalizes learning paths based on individual progress, ensuring that users receive the right level of challenge.

Duolingo stands out as one of the best interactive platforms for learning English due to its accessibility, effectiveness, and engaging format. It is suitable for beginners and those who want to maintain their language skills, though it cannot fully replace traditional learning methods or real-life conversational practice. Therefore, the optimal approach is to combine Duolingo with other learning methods, such as watching movies in English, reading books, and engaging in live conversations with native speakers.

References

1. **Nicole Teh. Duolingo PLG Strategy: The Growth Flywheel of Learning a New Language. Oct 9, 2023. URL: https://nogood.io/2023/10/09/duolingo-case-study/**
2. Official Duolingo Website – https://www.duolingo.com
3. Vesselinov, R., Grego, J. (2012). "Duolingo Effectiveness Study". City University of New York (CUNY) URL: https://theowlapp.health/wp-content/uploads/2022/04/DuolingoReport_Final-1.pdf
4. Duolingo Blog – https://blog.duolingo.com

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The Constitution of Ukraine during Martial Law

Under the conditions of martial law, introduced in Ukraine following the full-scale invasion by the Russian Federation in 2022, the issue of constitutional guarantees of the state's sovereignty, independence, and territorial integrity becomes particularly significant. According to Article 1 of the Constitution of Ukraine [1], Ukraine is a sovereign and independent state, and its territory is integral and inviolable. However, despite these principles, Russia violated them—first by annexing the Crimea in 2014 [2] and later by launching a full-scale invasion. All of this demonstrates a disregard for both national and international legal norms [3].

One of the most important international legal instruments that guaranteed Ukraine’s security was the Budapest Memorandum, signed in 1994[4]. Under this document, the Russian Federation, the United Kingdom, and the United States pledged to respect and protect Ukraine’s sovereignty and territorial integrity in exchange for its renunciation of nuclear weapons. However, Russia’s failure to comply with this agreement and the inability of the international community to ensure its enforcement has posed a serious threat to Ukraine’s constitutional order. The issue of Ukraine’s sovereignty and territorial integrity has clear legal reinforcement in the country’s Constitution. The primary legal document defining the principles of state governance is the Constitution of Ukraine [1], which contains fundamental provisions regarding independence and the inviolability of the territory.

According to Article 1 of the Constitution [1], Ukraine is a sovereign and independent state, and its territory is integral and inviolable. Article 2 states that Ukraine’s territory within its existing borders is unified and indivisible. Moreover, Article 17 stipulates that the defense of sovereignty and territorial integrity is the state’s most important function, and the Armed Forces of Ukraine are tasked with ensuring its protection. The constitutional enshrinement of these norms reflects a fundamental principle of international law. However, despite all of the above, Russia violated these provisions by committing military aggression against Ukraine.

Ensuring the security of our country depends not only on us but also on international agreements. The Budapest Memorandum [4] was one of the key documents aimed at providing comprehensive protection for Ukraine. In turn, Ukraine relinquished its nuclear arsenal in exchange for guarantees of independence and territorial inviolability.

However, as of today, none of these commitments have been fulfilled. The most striking examples are the events of 2014 and 2022. Russia, as one of the signatories of this memorandum, not only failed to uphold its obligations but also launched a war on Ukraine’s territory. This has had a significant impact on the country’s economy, infrastructure, and social sphere, causing widespread destruction and human rights violations. This situation has cast doubt on the effectiveness of international treaties and has necessitated a reassessment of approaches to protecting state sovereignty. One of the main violations committed by Russia is the use of force, which is a direct violation of the UN Charter [5], which prohibits threats or use of force against territorial integrity. This violation has had serious consequences on the international stage and has served as grounds for imposing sanctions against Russia.

International sanctions include asset freezes, restrictions on financial transactions, airspace closures, and bans on technology exports, all of which significantly weaken Russia's ability to wage war [6]. The damage inflicted on Ukraine as a result of Russian aggression serves as a basis for compensation. In this context, it is crucial to establish mechanisms for documenting the damage caused and determining how it can be compensated. This process may be long and complex, as it depends on the international community to ensure the effective implementation of decisions on this issue.

Taking all this information into account, Russia's aggression against Ukraine has led to serious violations not only of international law but also of the fundamental principles enshrined in the Constitution of Ukraine. The Constitution serves as the primary guideline in the fight to restore national dignity, security, and the protection of citizens' rights, which have been violated as a result of the war.

References

1. The Constitution of Ukraine – The Official Internet Representation of the President of Ukraine. URL: https://www.president.gov.ua/documents/constitution.
2. Occupation and Annexation of Crimea – Encyclopedia of Modern Ukraine. URL: https://esu.com.ua/article-74519.
3. Informational Materials on the Outbreak of the Russo-Ukrainian War and Russia's Full-Scale Invasion of Ukraine. 20.02.2025 https://uinp.gov.ua/informaciyni-materialy/zhurnalistam/informaciyni-materialy-do-pochatku-rosiysko-ukrayinskoyi-viyny-ta-povnomasshtabnogo-vtorgnennya-rf-v-ukrayinu.
4. Memorandum on Security Assurances in Connection… | dated 05.12.1994. https://zakon.rada.gov.ua/laws/show/998_158#Text.
5. Charter of the United Nations / Chapter I URL: https://www.ilsa.org/Jessup/Jessup15/UNCharterICJStatute.pdf
6. EU Sanctions Against Russia in Response to the Invasion of Ukraine. https://commission.europa.eu/topics/eu-solidarity-ukraine/eu-sanctions-against-russia-following-invasion-ukraine_uk.

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Machine Translation in the European Union: Latest Trends and the Role of the Human Factor

The European Union (EU) is a multilingual entity where 24 languages hold official status. Ensuring effective multilingual communication is crucial for the functioning of European institutions and international cooperation. With globalization and digital transformation, the demand for efficient, accurate, and fast translations has significantly increased. In recent decades, machine translation (MT) has become a powerful tool for overcoming language barriers, allowing organizations, businesses, and individuals to engage more effectively across linguistic divides. [2] However, despite these technological advancements, machine translation still faces limitations, necessitating human intervention to ensure quality and contextual accuracy. [6] This work explores the latest trends in the development of machine translation in the EU, the impact of artificial intelligence on the translation process, and the role of the human factor in maintaining translation quality.

Machine translation has undergone a significant transformation with the advent of neural machine translation (NMT), which has become the dominant technology in automatic translation. [4] Unlike earlier statistical and rule-based models, NMT utilizes deep learning algorithms to provide more fluent and contextually accurate translations. [1] The European Commission’s eTranslation system is one such example, widely used for translating official documents and facilitating communication between EU member states. Its continuous development reflects the EU's commitment to enhancing linguistic accessibility and efficiency. [2]

Another trend shaping the translation landscape is the growing use of hybrid approaches that combine machine translation with post-editing (MTPE). [1] This method reduces costs and increases efficiency while ensuring that professional translators refine output quality. Many European institutions and private organizations have adopted MTPE as a standard practice, allowing them to balance speed and accuracy while maintaining high standards in multilingual content production. [3]

Additionally, domain-specific adaptations of neural network models are becoming increasingly prevalent. Since different sectors require specialized terminology and contextual understanding, AI-based translation models are being fine-tuned for legal, medical, and technical documentation. [5] This adaptation minimizes mistranslations and enhances precision, making machine translation more applicable to official and industry-specific content. [4]

Moreover, the development of interlingual translation within the EU has gained traction. Traditionally, translations often relied on English as an intermediary language, but advances in NMT allow direct translation between less commonly used

European languages. This not only improves translation efficiency but also helps preserve linguistic diversity within the EU by promoting the use of minority and regional languages. [3]

Despite the rapid evolution of machine translation technologies, human intervention remains an essential component of high-quality translation. One of the primary roles of human translators is post-editing machine-generated text to correct errors related to grammar, syntax, and terminology. While NMT models provide impressive results, they are not infallible and often struggle with idiomatic expressions, ambiguous phrasing, and cultural nuances that require human judgment. [7]

A key challenge of machine translation is cultural and contextual adaptation. Automated systems frequently fail to account for the sociolinguistic aspects of communication, such as tone, formality, and culturally embedded references. [5] Human translators play a crucial role in adapting content to the intended audience, ensuring that translations are not only accurate but also contextually appropriate and engaging.

Another critical aspect is quality control and assessment. Machine translation outputs are evaluated based on fluency and adequacy, but automated evaluation metrics cannot fully replace human expertise. Linguistic professionals conduct rigorous quality assessments to refine translations and ensure that they meet the necessary standards, especially in sensitive fields like legal and diplomatic communications, where inaccuracies could lead to serious consequences.

Additionally, ethical and legal considerations must be taken into account when deploying machine translation in the EU. Data privacy, confidentiality, and compliance with copyright regulations are significant concerns, particularly when handling official EU documents and sensitive information. Human translators and legal experts work together to ensure that automated translation tools adhere to ethical guidelines and regulatory frameworks, safeguarding both linguistic and legal integrity. [6]

Furthermore, the integration of collaborative AI-human workflows is becoming more prominent. Rather than replacing human translators, AI is increasingly being used as an assistive tool, allowing professionals to work more efficiently. By leveraging AI for repetitive or high-volume translation tasks, human translators can focus on tasks that require deeper linguistic and cultural expertise. This symbiotic relationship between AI and human translators is shaping the future of the translation industry in the EU and beyond.

So, to sum up, machine translation in the EU is undergoing rapid advancements, significantly enhancing multilingual communication and accessibility. While neural machine translation has improved fluency and accuracy, it is not without limitations. Human expertise remains indispensable in ensuring precision, cultural relevance, and legal compliance in translations. The optimal approach in the European context is a hybrid model, where AI-driven translation tools are complemented by professional post-editing and quality control. By striking a balance between automation and human intervention, the EU can continue to support linguistic diversity, promote cross-border communication, and ensure high standards in multilingual content translation. [5] As machine translation technology continues to evolve, the role of human translators will also adapt, emphasizing higher-level linguistic, cultural, and ethical considerations that machines cannot fully replicate.

References

1. Cancedda, N., Dymetman, M., & Grangier, D. (2019). Hybrid Machine Translation: When and How to Combine Rule-based and Statistical MT. In Proceedings of the European Association for Machine Translation (EAMT). URL: https://aclanthology.org/volumes/2009.eamt-1/ (date of access: 30.03.2025)
2. European Parliament. (2022). Multilingualism and Translation in the EU: Challenges and Solutions. Policy Department for Citizens' Rights and Constitutional Affairs. URL: https://www.europarl.europa.eu/RegData/etudes/STUD/2022/690496/IPOL_STU(2022)690496_EN.pdf (date of access: 30.03.2025)
3. Gaspari, F., Toral, A., Nino, A., & Way, A. (2021). Balancing MT and Human Translation: Practices and Trends in the EU Institutions. Journal of Specialised Translation, 36, 78–102.
4. Koehn, P. (2020). Neural Machine Translation. Cambridge University Press. 393 p. URL: http://mt-class.org/jhu/assets/nmt-book.pdf (date of access: 01.04.2025)
5. Popescu-Belis, A. (2022). Explainable AI for Translation: Current Approaches and Open Challenges. Computational Linguistics, 48(4), 1023–1045.
6. Van der Meer, J. (2021). The Human Factor in Machine Translation: Post-editing in Practice. TAUS Insights. URL: https://www.ttt.org/wp-content/uploads/2021/11/2021-09-27-Rebuttal_Jaap_van_der_Meer_FULL_ARTICLE_Melby-Kurz.pdf (date of access: 30.03.2025)
7. Wilks, Y. (2019). Artificial Companions and Human Translators: The Future of the Human-AI Relationship in Language. AI & Society, 34, 491–498.

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Communication Skills in a Leadership Position within Public Administration

The ability to communicate effectively is arguably one of the most crucial skills for any leader, particularly within the context of public administration. In a professional context characterised by the need for leaders to engage with the public, manage teams, and coordinate with multiple institutions, the ability to articulate ideas with clarity, listen actively, and convey information transparently is of crucial importance. The possession of strong communication skills is of benefit to leaders in the establishment of trust, the enhancement of efficiency, and the fostering of collaboration both within and outside the organisation[1].

Active listening is considered to be one of the core communication skills that leaders must develop. It's about understanding the message, asking questions and making people feel heard. Active listening fosters a culture of respect and empathy, thereby engendering a sense of value among employees and stakeholders. True listening lets leaders understand problems and team dynamics better.

Another key skill is **clarity in communication**. Leaders must express thoughts simply, directly and in a step-by-step manner to avoid misunderstandings and confusion. This is especially important in public administration where processes are often complex. It helps with strategic decisions and consistent public service delivery [2].

Furthermore, leaders in public administration must also be **persuasive**. The ability to persuade is fundamental in a variety of professional contexts, including but not limited to: convincing stakeholders to support a policy, motivating employees to embrace change, or addressing the concerns of citizens. The art of persuasion is not merely a matter of eloquence; it necessitates a profound comprehension of the audience, a precise articulation of the message, and the emotional intelligence to connect with people's values and motivations [3].

The importance of communication extends beyond the internal structure of public organizations. Public sector leaders are frequently engaged with citizens, the media, non-governmental organisations, and other governmental bodies. This requires adaptability in communication style and medium, ensuring that messages are delivered appropriately to different audiences. A policy or message that has been communicated in an effective manner can inspire public confidence; however, poor communication can lead to distrust or even conflict [2].

In order to enhance their abilities as communicators, leaders must engage in practices that ensure **accessibility**. When leaders are open to conversations and feedback, they foster transparency and inclusion. In the context of public service, accessibility is indicative of leadership accountability and responsiveness to the needs of the community and its staff. This contributes to building credibility and legitimacy – two pillars that public leaders must uphold at all times [1].

In today's digital age, the employment of **multiple communication channels** is vital. Public leaders must adapt their methods to the situation, whether in emails, documents, social media or speeches.Each platform demands a specific tone and format, and knowing how to use them effectively increases the chances of reaching diverse audiences. Moreover, it is a valuable tool for the handling of crises, promoting new policies, and addressing public concerns in real time [3].

The development of **emotional intelligence** is another significant aspect of leadership communication. Leaders who possess high emotional intelligence are better able to understand, manage, and respond to their own emotions, as well as those of others. The establishment of such a system fosters a supportive work environment, enhances conflict resolution capabilities, and strengthens relationships with stakeholders. In the emotionally charged domain of public administration, where decisions can have a direct and significant impact on individuals, this skill is of particular value [2].

The success of public administration often depends not just on policies or resources, but on how well leaders can communicate. Good communication fosters collaboration, ensures smoother implementation of initiatives, and promotes accountability. It also enhances the ability of leaders to adapt to changes, deal with challenges, and align their teams toward a common goal [1].

In conclusion, it is important to note that communication should not be regarded as a soft skill in the context of public administration; rather, it should be considered a core leadership capability. Leaders in public administration must master the art of listening, expressing, persuading, and adapting their messages to various contexts. As public expectations evolve and administrative complexity grows, communication remains the bridge between vision and action. Leaders can build stronger institutions and better serve their communities by continuously improving these skills.

REFERENCES:

1. Narang, U. (2024). *Essential communication skills for leaders. LinkedIn.* URL: https://www.linkedin.com/pulse/essential-communication-skills-leaders-utkarsh-narang-wlpxc

2. Herrity, J. (2025). *Leadership communication skills and how leaders use them. Indeed.* URL: https://www.indeed.com/career-advice/career-development/leadership-communication-skills

3. Center for Creative Leadership. (2025). *1 idea, 3 facts, 5 tips for better communication. Leading Effectively.* URL: https://www.ccl.org/articles/leading-effectively-articles/communication-1-idea-3-facts-5-tips/

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Violations of Ukraine's Sovereignty and Human Rights by Russia

Ukraine's sovereignty and the protection of human rights have faced serious violations by Russia in the 21st century. The annexation of Crimea in 2014 and the ongoing conflict in Eastern Ukraine have drawn international attention to the breach of Ukraine's territorial integrity, sovereignty, and the rights of its citizens. This paper aims to analyze the violations of Ukraine's sovereignty and human rights by the Russian Federation, beginning with the annexation of Crimea and continuing with military aggression in Donetsk and Luhansk.

On March 18, 2014, Russia illegally annexed Crimea, a peninsula internationally recognized as part of Ukraine. This act of aggression violated international law, including the UN Charter, the Helsinki Accords, and numerous bilateral agreements between Ukraine and Russia. The annexation of Crimea was a direct challenge to Ukraine's sovereignty and was widely condemned by the international community.

The Kremlin justified the annexation by claiming it was protecting ethnic Russians in Crimea and referring to a disputed referendum that allegedly showed Crimea's desire to join Russia. However, considering the way Russia conducted similar referendums in other Ukrainian territories, it's clear that, if a referendum took place, it did not follow legitimate standards. These claims were rejected by the international community, and the UN General Assembly passed a resolution declaring Crimea part of Ukraine.

The illegal annexation led to a breach of Ukraine's territorial integrity and triggered multiple human rights violations [1]. Crimean Tatars, the peninsula's indigenous people, faced persecution, forced disappearances, and arrests by Russian authorities. Freedom of expression and political dissent were heavily restricted in Crimea: pro-Ukrainian activists and opposition figures were persecuted and detained. Russia effectively seized the peninsula and imposed its own regime.

After the annexation of Crimea, Russia supported separatist groups in eastern Ukraine, which led to a full-scale military conflict in Donetsk and Luhansk regions.

In April 2014, pro-Russian separatists declared the so-called Donetsk and Luhansk People's Republics (DPR and LPR), which were immediately recognized and backed by Russia, despite Ukraine's protests. As it turned out, neither Russia nor other countries cared much about Ukrainians' objections.

Although Russia initially denied its involvement in the conflict—as it later did in the 2022 war—there is substantial evidence that the Russian military, including regular troops, artillery, and equipment, directly supported separatists. Russia's actions in Donetsk further violated Ukraine's sovereignty and contradicted key international principles, as confirmed by multiple UN General Assembly resolutions and findings by international human rights organizations [2].

The human rights situation in Donbas was catastrophic: people were persecuted for their political beliefs, ethnicity, or support for the Ukrainian government. The country that Russia claimed to be "liberating" brought only suffering, sorrow, and complete lack of freedom. Political activists, journalists, and civilians expressing dissent were arrested, tortured, or extrajudicially executed. Both Russian and separatist forces were accused of war crimes, including using banned weapons and targeting civilian sites while making absurd excuses, such as claiming soldiers were stationed in hospitals, schools, and kindergartens.

One of the key international tools for addressing the violations of Ukraine's sovereignty and human rights has been the International Criminal Court (ICC) [3]. In 2014, Ukraine referred the situation in Crimea and Donbas to the ICC, requesting an investigation into possible war crimes and crimes against humanity committed by Russian forces and separatists [4].

Russia's violations of Ukraine's sovereignty and human rights are a stark reminder of the dangers of territorial aggression in today's world. The annexation of Crimea and the ongoing military conflict in Eastern Ukraine have caused immense suffering for the Ukrainian people and raised serious questions about international law and order. The breach of Ukraine's territorial integrity undermined the principles of sovereignty and self-determination, while mass human rights violations in Crimea and Donbas drew global condemnation.

The international community must continue pressuring Russia to end its unlawful actions and respect Ukraine's sovereignty. It is also essential to ensure justice for those responsible for crimes committed in Ukraine. The path to peace in Ukraine remains difficult, but international solidarity and a commitment to justice and human rights are crucial to resolving this ongoing crisis.

References

1. UN Office of the High Commissioner for Human Rights (2015). Report on the Human Rights Situation in Ukraine. https://www.ohchr.org/sites/default/files/Documents/Countries/UA/Ukraine_13th_HRMMU_Report_3March2016.pdf

2. United Nations (2014). UN General Assembly Resolution 68/262 on Ukraine's territorial integrity. https://www.securitycouncilreport.org/atf/cf/%7B65BFCF9B-6D27-4E9C-8CD3-CF6E4FF96FF9%7D/a_res_68_262.pdf

3. International Criminal Court (2014). Ukraine refers the situation to the ICC. https://www.icc-cpi.int/news/ukraine-accepts-icc-jurisdiction-over-alleged-crimes-committed-20-february-2014

4. Human Rights Watch (2015). Russia: War Crimes in the Donbas Conflict. https://www.hrw.org/world-report/2015/country-chapters/ukraine

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Reforming Electoral Legislation as a key factor in the democratization of society

The process of democratic development in any state depends significantly on the fairness, transparency, and efficiency of its electoral system. Electoral reforms have become an essential and urgent issue for Ukraine, as they ensure that the democratic process functions effectively, reflecting the will of the citizens. Ukraine's transition from a post-Soviet state to a democratic society requires adapting its electoral system to meet the changing political, social, and economic realities. This makes the reform of electoral legislation a priority for strengthening democracy and increasing public trust in political processes.

In Ukraine, electoral reforms are seen as a means of overcoming the legacy of flawed elections, electoral fraud, and manipulation that has plagued the country's history. Reforming the electoral framework is fundamental not only to enhance the quality of governance but also to restore faith in the political system and ensure that elections are free, fair, and inclusive [2].

As the country moves towards modernization and European integration, addressing electoral issues has become central to achieving these broader goals. Without addressing electoral flaws, the effectiveness of reforms in other sectors would be undermined, as the foundation of democratic legitimacy rests upon an equitable and just electoral system.

The electoral process plays a fundamental role in ensuring the democratic structure of the state, as it is through the electoral mechanism that citizens can exercise their political will and influence the formation of power. Elections are the most important tool of representative democracy, providing every citizen the opportunity to express their position regarding the future development of the state and society as a whole.

However, in recent decades, it has been clearly demonstrated that the electoral system in Ukraine requires significant reforms, as the existing shortcomings breed citizens' distrust in the honesty of the electoral process. This is evident in low voter turnout, numerous complaints about violations of electoral procedures, manipulation during voting, and issues with vote counting [4].

All of this creates the need for a deep analysis of the current electoral legislation and the introduction of changes that will contribute to strengthening democratic standards in the country. In particular, analyzing the key challenges facing Ukraine's electoral system, several critical aspects emerge that directly affect the public's trust in the elections [3].

Transparency in Electoral Campaign Financing

One of the most serious problems is the lack of transparency in the financing of electoral campaigns. Political parties and candidates spend significant sums on pre-election campaigning, organizing events, and advertising in mass media and social networks. However, the public often lacks access to complete information about the sources of these financial inflows, which creates preconditions for corruption schemes, shadow financing, and illegal influence on the electoral process.

The lack of transparency in financial flows during elections allows certain candidates to use significantly more resources than the law permits. As a result, this creates unequal conditions for election participants, as candidates with access to large financial resources can run more active campaigning, which influences voters' choices. For example, a candidate with a larger budget can afford to run a more extensive media campaign, reaching a wider audience than their opponents. Thus, the financial inequality between candidates can lead to an unfair advantage and distort the democratic process.

As researcher P. V. Romaniuk (2020) points out, the issue of reforming electoral legislation has been relevant since the declaration of Ukraine's independence. He emphasizes that the main challenges are related to the lack of effective control over the financing of election campaigns, which promotes corruption and abuse. He stresses the need for strong reporting mechanisms that will ensure transparency and allow citizens to see where the money for political campaigns comes from. To solve this problem, changes to the election laws are needed that will create a better system for financial reporting and control. This could include publishing detailed reports on all financial transactions, having independent checks on the finances, and making those who break the rules responsible [1]

The Influence of Mass Media and the Problem of Disinformation

Another important issue is the growing influence of mass media in shaping public opinion during elections. In the context of digitalization, the media space has become the main tool for political struggle. Social networks, news websites, and television are actively used for pre-election campaigning. However, this also creates the risk of spreading manipulative information, fake news, and disinformation that can influence voters' decisions [3].

A particular threat is from so-called "black" PR campaigns, which aim to discredit certain candidates or political parties. In some cases, mass media may be controlled by certain political forces, leading to biased reporting and distortion of facts. For instance, some media outlets may spread negative propaganda about a political figure, distorting the truth and leading to false perceptions. Thus, media manipulation can play a significant role in shaping voters' opinions in ways that are not based on facts. To overcome this problem, stronger controls on media activities during elections are needed. This might include creating an independent body to monitor whether the media is following principles of fairness and neutrality. Also, punishments should be introduced for spreading false information, especially during the pre-election period.

Voting by Citizens Abroad

Another major challenge in election laws is ensuring that citizens living abroad can vote. A large number of Ukrainians live and work outside the country, and they should also be able to vote. However, the voting process for these citizens is complicated, often leading to low voter turnout among people living abroad [5].

One possible solution is to introduce electronic voting, which would make it easier for citizens abroad to vote. However, this would also require strong security measures to prevent cyberattacks and fraud.

Conclusion

Therefore, Ukraine's electoral laws require important reforms to ensure the election process is transparent, fair, and equal for everyone. The key areas for improvement are increasing transparency in how election campaigns are funded, stopping fake news in the media, making it easier for Ukrainians abroad to vote, and creating stronger systems to control the election process. Only by thorough reforms can citizens trust the election process more and make democratic principles stronger in the country.

References:

1. Romaniuk, P. V. (2020). Reforming Electoral Legislation in Ukraine: Problems and Solutions. Kyiv: Academy of Legal Sciences of Ukraine.
2. Electoral Reform: A Decade-Long Journey / edited by O. Ayvazovska. Kyiv: OPORA, 2021.
3. Electoral Legislation of Ukraine: Features of Development and Current State // Legal Scientific Electronic Journal. – 2021. – No. 12. – P. 112–115.
4. Law of Ukraine "On Elections of People's Deputies of Ukraine" – Verkhovna Rada of Ukraine Records.
5. Official website of the Central Election Commission of Ukraine – www.cvk.gov.ua.

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Application of European Court of Human Rights Case Law in Ukrainian Courts

The necessity of harmonization of Ukrainian legislation with international law driven by the dynamic processes of European integration makes the study of European legal experience and doctrine relevant for their adaptation to Ukrainian realities. The European Court of Human Rights is one of the key mechanisms for safeguarding human rights in Europe. It was established in 1959 to supervise the compliance of Council of Europe member states (the High Contracting Parties) with the European Convention on Human Rights that was adopted in 1950 and came into force in 1953 [1]. The Verkhovna Rada of Ukraine has ratified The Convention in 1957, thereby commiting itself to execute the judgments of the ECHR issued against Ukraine. Although this obligation is enshrined not only at the international level, it is also enforced nationally, that is reflected in the Law of Ukraine "On the execution of judgements and the application of the European Court of Human Rights case law" [2], and subsequently in procedure codes. Prolonged and systematic non-compliance with judgements of the European Court is a ground for the application of sanctions by the Committee of Ministers of the CoE up to exclusion of the member state from the latter. Whereas the ECHR case law is not mandatory for application by the High Contracting Parties since this process goes beyond standard execution of specific judgements against Ukraine. The procedure involves using principles, standards and legal positions developed by the European Court of Human Rights in its precedent practice (including the judgements concerning other states) in the course of case consideration by national courts and other state organs. The ECHR case law can be considered as the interpretation and concretization of The Convention by the European Court to a particular life situation regarding a specific legal issue arising withing a state. The case law of the Strasbourg Court encourages states to improve their legislation and law enforcement practice to comply with the Convention, regardless of their direct involvement in the cases. Practice reveales that Ukrainian courts are increasingly reffering to the precedents of ECHR in their work, however there are several unresolved issues on this matter. In particular, there is no clear legislative mechanism for the utilization of the ECHR judgements in cases where Ukraine was not a party. This nuance leads to the significant errors in the Ukrainian juridical practice including fragmentary citation and references to the Court's legal positions that are not relevant. Consequently, this hinders the establishment of a consistent practice of application of the ECHR judgments by national courts. As noted by R. Babanly, the application of the Court's case law should be based on a thorough assessment of the circumstances of the case in which such a decision was made, and with particular attention to their correlation with the circumstances of the case being reviewed by the national court [3]. As equally important problem is the lack of official authentic translations of most of the ECHR judgments concerning other countries, which limits access to information for lawyers and increases the risk of misinterpretation and complication of the judicial process.

Thus, the judgments of the European Court of Human Rights are cruicial in both lawmaking and law enforcement activities of the state, yet this area necessitates further legislative regulation and enhancement.

References

1. European Convention on Human Rights, URL: https://www.echr.coe.int/european-convention-on-human-rights
2. Law of Ukraine «On Enforcement of Decisions and Application of the Practice of the European Court of Human Rights», URL: https://zakon.rada.gov.ua/laws/show/3477-15#Text
3. Babanly, Rasim «Criteria for the Relevant Application of the ECHR case law and a consolidated review of the Court judgements», URL: https://advokatpost.com/kryterii-relevantnoho-zastosuvannia-praktyky-iespl-ta-zvedenyj-ohliad-sudovykh-rishen-rasim-babanly/

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Human rights under martial law in Ukraine

It is important to acknowledge that scientists have historically classified humans as mammals [1]. Despite their advanced cognitive abilities, which far surpass those of most other animals, humans are the most perilous species on Earth. The capacity for complex thought, analysis, and problem-solving, extending not only to domestic but also international levels, distinguishes humans from other animals. However, this cognitive ability, while a remarkable trait, also poses a significant threat to human existence, as it has the potential to lead to self-destructive behaviours. It is an irrefutable fact that since the existence of humankind, hundreds of thousands of wars and conflicts have occurred on the global stage, ranging from major to minor in scale. Concurrently, a plethora of conventions, memoranda, and interstate treaties concerning armistice or cessation of armed aggression have been established. This provides a valuable opportunity to reflect on the evolution of human civilisation, particularly with regard to the establishment of sustainable standards for the protection of human rights. These standards have been developed not during periods of peaceful coexistence, but rather in the context of armed conflicts to ensure equitable and essential support for individuals in times of armed conflict.

The relevance of the chosen topic is a fundamental question in academic research. At present, there is a major conflict between Ukraine and Russia, which has been termed a war. The Russian people's conduct and mindset towards the crisis has repeatedly been called into question, particularly with regard to the potential consequences for human life, including that of both Ukrainians and Russians. Their actions, which include targeting residential buildings, businesses vital to the functioning of the state, infrastructure, and hospitals with sick children, demonstrate a blatant disregard for fundamental human rights, including the right to life itself.

The chapter of O.V. Senatorova's [3] book on the protection of human rights substantiates the basic principles and norms of international law that protect human rights in times of war. A particularly interesting question is why only Ukraine was affected by the Budapest Memorandum, while other countries were not obliged to give up their weapons and kept them? Today's conflict began at the very moment when the injustice in protecting the rights and freedoms of Ukrainians became apparent. This is not the first, but unfortunately not the last case.

Talking about protecting rights is good, but acting is much better. When there is overt aggression on the territory where you grew up, concepts such as freedom, security, faith, hope, loyalty, etc. come to mind. It's a logical connection, but many things are ignored. The safety of the military at the front depends largely on the subjective side, i.e. orders from superiors. Our country used to have a lot of weapons before the war, we were ranked 3rd in the world in terms of nuclear arsenal, but it suddenly disappeared, not during the war itself, but even earlier, and not just nuclear weapons [3]. There were questions about assistance from other countries: why did most of them refuse Ukraine, even though they knew that they could be next? Why hasn't Ukraine declared the Russian-Ukrainian war a war at the legislative level, limiting it to martial law? This is a question that needs to be addressed.

It is a matter of interest that, during mobilisation, military organisations have been known to dispatch two dozen individuals to issue military cards to a single recipient [5]. A similar phenomenon pertains to instances where individuals are discharged from military hospitals with severe spinal injuries, yet are declared 'fit' for service. Regrettably, these accounts lack formal corroboration; nevertheless, their veracity is substantiated by their origin within the military itself, rendering them a credible source of information. The following information concerns the captivity of Ukrainian prisoners, which is directly related to the protection of human rights, especially during armed conflicts. According to the journalist Ihor Burdyga, 'Ukrainian prisoners of war are subjected to systematic torture and ill-treatment at all stages of Russian captivity. These abuses include physical violence, such as beatings, strangulation, electric shocks, and simulated bombardment'. [6] Such treatment is known to have a profound impact on the human psyche. It is challenging to comprehend the extent of suffering endured by these individuals in the context of armed conflict, particularly when considering the violations of fundamental rights and freedoms perpetrated by the Russian military.

In addition, captivity is not only about torture, but also about human conditions for existence: the sterility of the premises, food, shower, calls to relatives, etc. This topic does not raise general questions about war and individual people; it explains how important it is to pay attention to the current situation in order to avoid blatant human rights violations under martial law in the future.

References

1. Mammalogy — Encyclopedia of Modern Ukraine. URL: https://esu.com.ua/article-63298 (access date: 06.03.2025). (in Ukrainian)
2. Senatorova O. V. Human Rights and Armed Conflicts. Kyiv: «FOP Golembovska O.O.», 2018. 208 p. URL: https://nlu.edu.ua/wp-content/uploads/2021/05/msc_6_copy.pdf (in Ukrainian).
3. Ukraine had the world's third-largest nuclear potential. *Ukrinform*. 19.10.2024. URL: https://www.ukrinform.ua/rubric-world/3917915-ukraina-mala-tretij-u-sviti-adernij-potencial-ci-realno-jogo-vidnoviti.html (access date:06.03.2025). (in Ukrainian).
4. Bohdanyok O. The Rada extended martial law and mobilization. *Suspil'ne Novyny*.15.01.2025. URL: https://suspilne.media/925599-rada-prodovzila-voennij-stan-i-mobilizaciu/ (date of access: 06.03.2025). (in Ukrainian).
5. Ihor Burdyga. *Deutsche Welle* (DW). UN: Ukrainian prisoners are subjected to brutal torture. 01.10.2024. URL: https://www.dw.com/uk/oon-ukrainski-poloneni-zaznaut-zorstokih-katuvan3-a-70379485/a (in Ukrainian).

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English as a Key Factor in the Globalization of IT Communication and Software Development

In today's world, globalization is a defining force shaping the development of information technology (IT). English, as the lingua franca of our time, has become not only a means of international communication but also the foundation for effective interaction between IT professionals from all corners of the globe. Its role permeates all aspects of the industry, from technical documentation and specifications to daily communication in development teams and the exchange of knowledge in the global IT community.

In the EF EPI 2024 report [1], which is the world's largest English language proficiency ranking based on testing of 2.1 million adults in 116 countries and regions, Ukraine ranks 40th out of 116 countries, while Romania ranks 12th, Poland - 15th, Hungary -17th, Estonia -20th.

In the annual Coursera Global Skill Report 2022 [2], Ukraine was ranked 8th in the Technology category, ranking among the leaders in the number of IT professionals, including computer networking, operating systems, databases, cybersecurity, software development, programming, cloud computing, web and mobile development. The level of English proficiency among IT specialists in Ukraine exhibits significant variation. A significant proportion of companies stipulate a minimum proficiency level of Intermediate, with a higher level of Advanced or Proficiency being mandatory for those engaging with international clients or participating in international projects.

English is the foundation of technical communication in the IT sphere. It dominates the creation of documentation and standards. Technical documentation, specifications, standards, and APIs (Application Programming Interfaces) are predominantly written in English [3]. Organizations that set standards, such as IEEE (Institute of Electrical and Electronics Engineers) and ISO (International Organization for Standardization), publish their documents in English, making it essential for understanding modern technologies.

The syntax of most popular programming languages, such as Python, Java, C++, JavaScript, is based on the English language. This makes knowledge of English necessary for understanding and writing code. Platforms for collaborative work and knowledge sharing, such as GitHub, GitLab, Stack Overflow, Reddit (especially subreddits dedicated to programming), function predominantly in English. This creates conditions for global collaboration and knowledge exchange. Most online courses, tutorials, webinars, and other educational materials on IT are available in English. This makes knowledge of English a key to self-education and professional development.

English is a tool for international collaboration. In today's IT environment, development teams often consist of professionals located in different countries. English provides effective communication and coordination between team members. It is also crucial for successful cooperation between companies that order software development and development teams located in other countries (outsourcing and offshoring). Most international conferences, seminars, and forums on IT use English as their working language. This allows professionals from different countries to exchange knowledge and experience.

At the same time, there are certain challenges and opportunities. For many IT professionals, especially in countries where English is not a native language, the language barrier can be a significant obstacle. This can lead to difficulties in learning, communicating, and participating in international projects. Overcoming the language barrier requires additional efforts to learn English, especially technical terminology. However, knowledge of English opens access to a wide range of opportunities, including international collaboration, career growth, access to the latest technologies and information. The development of machine translation technologies can help facilitate communication between specialists who speak different languages, but so far the quality of translation is not always sufficient for effective technical communication.

English influences innovation and the development of technologies. It promotes the rapid dissemination of information about new technologies, research, and development in the IT sphere. It facilitates collaboration between researchers and scientists from different countries, which contributes to the development of new technologies and innovations. English is a key factor for startups looking to enter the international market and attract investment.

English plays an indispensable role in the globalization of the IT industry. Its importance goes far beyond a simple means of communication. It is a tool for accessing knowledge, a platform for international collaboration, and a key to career growth in IT. Proficiency in English significantly enhances the competitiveness of professionals and opens new perspectives in the global IT environment. In this regard, investing in English language training for IT students and professionals is an important factor for the successful development of the IT industry as a whole.

References:

1. Report on EF English URL: proficiency index 2024 https://www.ef.com/wwru/epi/about-epi/
2. Global Skills Report 2022 URL: https://thetalentplace.s3.us-east-2.amazonaws.com/public/2022-09/Coursera-Global-Skills-Report-2022.pdf
3. Johan Sebastian J. The Importance of English in Technology. Linkedin. 2024. https://www.linkedin.com/pulse/importance-english-technology-johan-sebastian-jimenez-molina-inzqe#:~:text=English%20as%20the%20Universal%20Language, APIs)%2C%20and%20discussion%20forums.

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English as a bridge language in education, cultural diplomacy and economic integration of Ukraine into the European community

With the signing of the Law of Ukraine 'On the Use of English in Ukraine' by the President of Ukraine in June 2024, the Law clearly positions English as a language of international communication, which aims to promote Ukraine's European integration, enhance its international image and competitiveness [1]. Although the focus of the law is on promoting English, some of its provisions may contribute indirectly to a shift away from the dominance of Russian in certain areas of Ukrainian society.

The main problem causing disputes in the linguistic environment of Ukraine is the status of the Russian language, which, although not an official language, has historical roots, influence in society and some support. In late 2010, the Ukrainian language received support from a European institution for the first time. The authors and compilers of the European Charter for Regional or Minority Languages pointed out to the Ukrainian government the need for greater support for the state language [2].

In 2019, the Verkhovna Rada finally adopted the Law of Ukraine 'On Ensuring the Functioning of the Ukrainian Language as the State Language', which officially established the status of Ukrainian as the state language and serves as a language of inter-ethnic communication, is a guarantee of human rights protection for every Ukrainian citizen regardless of their ethnic origin, and is a factor of unity and national security of Ukraine" [3].

The situation changed dramatically in 2022 after Russia's full-scale invasion into Ukraine, when not only state institutions but also the world came to the conclusion that Russia was committing genocide against the Ukrainian people, their language and cultural heritage. Thus, analysts from the Harriman Institute in New York, as well as experts from the Raoul Wellenberg Centre for Human Rights (Montreal, Quebec, Canada) and the New Lines Institute (Washington) are studying Russia's genocidal practices against Ukrainians and recording war crimes of the Russian army in Ukraine. Based on the results of their research, they published an 'Independent Legal Analysis of the Violations of the Genocide Convention in Ukraine by the Russian Federation and the Tasks of Preventing Them', which concluded that Putin intended to destroy Ukrainians. [4].

Since 2022, the Ukrainian government has shown a significant push to raise the status and use of English in the country. This policy direction is largely driven by Ukraine's aspirations for European Union membership and the recognition of English as a key language of international communication and global integration. On the other hand, if a significant part of the population is proficient in English, there will be no need to turn to Russian as a means of international communication. The Baltic States, Poland, the Czech Republic and other post-socialist countries have already gone this way. Ukraine is confidently embarking on this path, fighting for independence and the right to join the international community with the blood of its children.

Based on the analysis of the above documents, we provide key aspects of the Ukrainian government's language policy towards the English language and the scope of potential replacement of Russian with English.

The law provides for obligatory English language proficiency for candidates applying for a number of positions, including: heads of local state administrations and their deputies, civil officers of certain categories, military personnel (certain ranks), prosecutors, tax and customs officers, heads and academic staff of higher education institutions and research institutions, and heads of healthcare institutions.

Areas of potential displacement of Russian from social circulation in public administration and civil service are possible, in particular, in terms of mandatory English language proficiency for various positions in state and local government (Article 3), which means a move towards prioritising English for professional advancement. This could gradually reduce the dependence on Russian, which historically had a strong presence in these sectors, especially among older generations of officials. A salary supplement for English language skills (Article 4) further encourages its use.

International interaction: Articles 5, 6 and 7 require the use of English in communication with foreign stakeholders, emergency services working with foreigners, and border control. This directly replaces the potential use of Russian in these scenarios, bringing Ukraine into line with international norms and reducing the role of Russian as the main language of cross-border communication.

Education: The law's emphasis on compulsory English language instruction from early childhood to higher education (Article 8) aims to produce a generation that is fluent in English. This increased focus on English may over time lead to a decreased emphasis on Russian in the curriculum, potentially reducing its overall prevalence among young Ukrainians. The requirement for university websites to have an English-language version also prioritises English in the international academic sphere.

Culture and tourism: While Article 9 promotes the development of English in the areas of cultural information and tourism, it does not directly aim to displace Russian. However, the availability of information in English alongside Ukrainian appeals to a wider international audience, potentially reducing the relative dominance of Russian in these areas, especially for attracting non-Russian-speaking tourists.

Transport and healthcare: Articles 10 and 11 oblige the use of English in announcements at transport hubs and in communication with foreign patients in the healthcare sector. This again gives priority to English in the provision of services to foreigners, potentially reducing the reliance on Russian in these specific contexts.

We also have examined the mechanisms of indirectly displacing Russian from circulation in Ukrainian society. By making English a prerequisite for certain coveted positions and offering financial incentives, the Law increases the ‘linguistic capital’ associated with English language skills. This may motivate people to invest more in learning English, potentially at the expense of maintaining or improving their Russian language skills.

The increasing official status of English as a language of international communication may quietly change the public perception of the importance of the language. As English is increasingly associated with professional success and international activities, the perceived need for and prestige of Russian may gradually diminish, especially among the younger generation who are focused on global opportunities.

The Law directly links the development of the English language to Ukraine's European aspirations. This positions English as the language of the future and integration, implicitly contrasting it with Russian, which is often associated with the country's Soviet past.

While the Law on the Use of English in Ukraine does not explicitly aim to suppress the Russian language, its strategic promotion of English as the language of international communication in key public spheres has the potential to indirectly contribute to a gradual shift in language use and societal perceptions. By prioritizing English for professional advancement, international interactions, and education, the law could lead to a reduced reliance on Russian in these domains, particularly among younger generations and in contexts involving international engagement. However, the deeply rooted presence of Russian in Ukrainian society and the law's specific focus on international communication suggest that a complete displacement is unlikely in the foreseeable future. Instead, the law may contribute to a more multilingual Ukraine where English plays an increasingly prominent role alongside the state language, Ukrainian, and potentially leading to a gradual rebalancing of the linguistic landscape.

References:

1. Про застосування англійської мови в Україні : Закон України від 04.06.2024 № 3760-IX. URL: https://zakon.rada.gov.ua/laws/show/3760-20#Text
2. Бестерс-Дільґер Ю. Сучасна мовна політика України та її оцінка європейськими установами // Мова і суспільство. - 2012. - Вип. 3. - С. 170–179. - Режим доступу: http://nbuv.gov.ua/UJRN/mis_2012_3_22.. (Language and society. 2012. Issue 3. P. 170–179) – ст 170-179 ISSN 2227-5525.
3. Про забезпечення функціонування української мови як державної : Закон України від 25.04.2019 № 2704-VIII : станом на 15 листоп. 2024 р. URL: https://zakon.rada.gov.ua/laws/show/2704-19#Text
4. An Independent Legal Analysis of the Russian Federation's Breaches of the Genocide Convention in Ukraine and the Duty to Prevent / G. H. Stanton et al. Montreal, Quebec, Canada, Washington, USA, 2022. 48 p. URL: https://newlinesinstitute.org/wp-content/uploads/English-Report-2.pdf (date of access: 10.04.2025).

Section 05 Actual Problems of Economy and Sustainability of Economic Development, Management, Globalization and Eurointegration of Industries

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Die Börse und die Finanzmärkte

Die Finanzmärkte spielen eine zentrale Rolle als Finanzierungsquelle für Unternehmen, Gebietskörperschaften und den Staat. Sie ermöglichen es diesen Akteuren, Kapital für Investitionen zu beschaffen, indem sie sich direkt oder indirekt an Sparer wenden. Die Finanzmärkte tragen zur wirtschaftlichen Entwicklung bei, indem sie Kapital effizient zu den vielversprechendsten Investitionsmöglichkeiten leiten.

Die Anlagemöglichkeiten sind folgende:

- Auf dem Primärmarkt werden neue Wertpapiere emittiert, sei es in Form von Anleihen oder durch Börsengänge neuer Unternehmen.
- Durch Börsengänge neuer Unternehmen. Diese Wertpapiere werden dann auf den Sekundärmärkten gehandelt, auf denen bestehende Wertpapiere zwischen Anlegern gekauft und verkauft werden.
- Neben diesen beiden Hauptmärkten gibt es noch Tertiär- und OTC-Märkte, auf denen Derivate, Anleihen und spezielle Finanzprodukte gehandelt werden.
- Die Finanzmärkte werden von nationalen und internationalen Finanzaufsichtsbehörden wie der AMF (Autorité des marchés financiers) und der BaFin (Bundesanstalt für Finanzdienstleistungsaufsicht) überwacht. Zu ihren Aufgaben gehören - der Schutz der Anleger und ihres Kapitals, - die Bereitstellung von Informationen für Anleger, - die Gewährleistung des reibungslosen Funktionierens der Marktmechanismen, - die Bekämpfung von Marktmissbrauch und Insiderhandel, - die Regulierung neuer Finanzinstrumente und Handelsplattformen.

Beim Kauf oder Verkauf von Wertpapieren an der Börse ist es notwendig, die Art und Menge der Wertpapiere, das gewünschte Geschäft (Kauf oder Verkauf) und die Kursmerkmale genau anzugeben. Es gibt verschiedene Arten von Aufträgen, die je nach Strategie verwendet werden können.

Eine Limit-Order erlaubt es Ihnen, ein Geschäft nur zu einem vorher festgelegten Preis oder besser abzuschließen - dies schützt Sie vor ungünstigen Kursschwankungen. Eine Market Order hingegen wird sofort zum nächstmöglichen Kurs ausgeführt, was unter Umständen zu Abweichungen führen kann. Eine Stop-Loss-Order sorgt dafür, dass ein Wertpapier automatisch verkauft wird, sobald der Kurs unter ein bestimmtes Niveau fällt - ein nützliches Instrument zur Verlustbegrenzung. Eine Trailing-Stop-Order geht noch einen Schritt weiter und passt sich bei steigenden Kursen automatisch an, um Gewinne zu sichern. Orders können auch befristet erteilt werden - zum Beispiel nur für den aktuellen Handelstag oder für einen längeren Zeitraum. Wird die Order nicht innerhalb des festgelegten Zeitraums ausgeführt, muss sie erneut erteilt werden.

Neben der Analyse von Märkten und Zahlen ist auch die psychologische Komponente entscheidend für den Anlageerfolg. Emotionen wie Angst und Gier

beeinflussen oft unbewusst das Anlegerverhalten und können zu unüberlegten Entscheidungen führen. Gerade in turbulenten Zeiten ist es wichtig, Ruhe zu bewahren und an der eigenen Strategie festzuhalten.

Kurzfristige Schwankungen sollten nicht überbewertet werden. Wer sich zu sehr auf die neuesten Nachrichten konzentriert oder Trends hinterherläuft, riskiert, erfolglos zu investieren. Im Gegenteil: Jede Entscheidung sollte gut überlegt sein und auf objektiven Informationen beruhen.

Zu den wichtigsten Produkten auf den Finanzmärkten gehören Aktien, d.h. Anteile an Unternehmen, die den Anlegern nicht nur die Chance auf Kurssteigerungen, sondern auch das Stimmrecht auf Hauptversammlungen und das Recht auf Dividenden bieten. Daneben gibt es Anleihen, die von Unternehmen oder Regierungen ausgegeben werden. Sie gelten oft als sichere Anlage und versprechen regelmäßige Zinszahlungen.

ETFs (Exchange Traded Funds) sind börsengehandelte Fonds, die in der Regel einen Index abbilden und damit eine kostengünstige und transparente Möglichkeit zur Diversifikation bieten. Derivate hingegen sind komplexere Finanzinstrumente, deren Wert von einem Basiswert abhängt - zum Beispiel einer Aktie, einem Rohstoff oder einer Währung. Zunehmend an Bedeutung gewinnen auch Kryptowährungen wie Bitcoin oder Ethereum, die aufgrund ihrer Volatilität vor allem für risikobereite Anleger interessant sind. Schließlich bieten Anlagefonds die Möglichkeit einer professionellen Vermögensverwaltung und die Vorteile einer breiten Diversifikation.

Wer an der Börse investieren will, muss sich der Risiken bewusst sein - schließlich sind Wertverluste nie ganz auszuschließen und die Kursentwicklung der Vergangenheit ist kein verlässlicher Indikator für die Zukunft. Am Anfang einer durchdachten Strategie stehen klare Anlageziele, die sowohl kurz- als auch langfristige Aspekte berücksichtigen. Dabei spielen sowohl der geplante Anlagezeitraum als auch die persönliche Risikobereitschaft eine entscheidende Rolle. Es ist sehr wichtig, das Verhältnis zwischen Risiko und Rendite zu verstehen. Hohe Renditen lassen sich in der Regel nur mit erhöhtem Risiko erzielen - dies gilt insbesondere für spekulative Anlageformen wie Kryptowährungen oder gehebelte Finanzprodukte. Gleichzeitig sollten Anlegerinnen und Anleger darauf achten, nur Kapital zu investieren, auf das sie nicht täglich angewiesen sind. Gerade in Zeiten volatiler Märkte können Verluste sehr schnell eintreten.

Regelmäßige Analysen des eigenen Portfolios und ein solides Grundwissen über die Marktmechanismen helfen, fundierte Entscheidungen zu treffen. Emotionen wie Angst oder Gier sollten dabei möglichst keine Rolle spielen - rationale Überlegungen und sachliche Informationen sollten im Vordergrund stehen. Wer zudem auf eine breite Streuung des Kapitals über Anlageklassen, Regionen und Branchen setzt, kann das Gesamtrisiko deutlich reduzieren. Allerdings sollte auf eine sinnvolle Portfoliostruktur geachtet werden - zu viele unterschiedliche Positionen können schnell unübersichtlich werden. Langfristiges Denken ist ein weiterer Erfolgsfaktor. Wer geduldig investiert und Marktschwankungen aushält, hat gute Chancen, über viele Jahre solide Renditen zu erzielen.

Erfolgreiches Investieren erfordert nicht nur Glück, sondern auch eine klare Strategie, eine vernünftige Risikoeinschätzung und Disziplin. Durch Diversifikation,

ständige Marktbeobachtung und eine langfristige Perspektive können Anleger ihre Chancen auf ein stabiles Einkommen deutlich erhöhen. Gleichzeitig ist es wichtig, flexibel zu bleiben und die Anlagestrategie bei Bedarf an veränderte Marktbedingungen anzupassen.

Quellen:

1. https://transatplan.banquetransatlantique.com/de/die-borse-und-die-finanzmarkte.html
2. https://www.oenb.at/finanzmarkt.html
3. https://wirtschaftslexikon.gabler.de/definition/boerse-29728

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The role of media in shaping political narratives in context of the Russia-Ukraine war

Social media has greatly influenced how people view the Russia-Ukraine war, which is a turning point in modern history. This conflict has resulted in a great deal of information warfare, according to research from ETH Zurich, with factions using social media to spread their opinions. The article from Grani supports this, emphasizing how globalization and the rapid development of internet communications have provided the ability to manipulate public opinion and engage in extensive information warfare. It highlights that media, while not were the primary source of "fake news," now facilitate its mass distribution through bots and individual

users. Molfar, for instance, has demonstrated the dissemination of misleading information on Azovstal's defenders. Even though a lot of research examines the dissemination of fake information, more research is still required to determine the long-term effects of the media stories on people's political beliefs and behavior, particularly with reference to national identity. Examining these changing stories will enable us to comprehend the wider significance of modern conflicts and international relations.

Disinformation Campaigns: Weaponizing Social Media

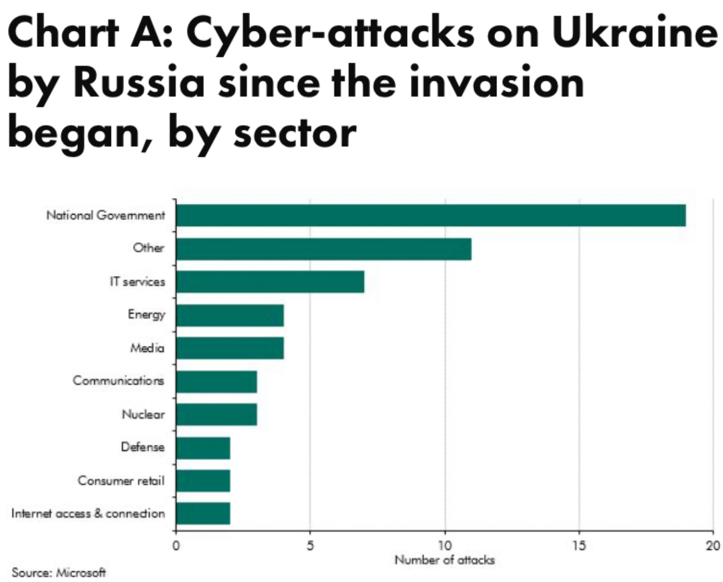
Social media platforms have been central to disinformation campaigns during the Russia-Ukraine war. A notable example is a tweet from RT (Russia Today), a Russian state-affiliated media outlet, claiming that Mariupol residents were allegedly used as human shields by Ukraine. The visual accompanying this tweet includes an interview with a woman in a hallway, with English subtitles reinforcing the propaganda narrative. Below the image, a caption in Ukrainian identifies it as a statement from propagandists on platform X (formerly Twitter).

However, independent investigations and media sources have debunked this claim, confirming that Russian forces committed war crimes in Mariupol by targeting civilian infrastructure and residential areas. This case exemplifies how social media can be weaponized to spread false narratives designed to manipulate public opinion and justify military actions.

Globalization and advancements in communication technologies have enabled large-scale manipulation of public opinion. Fake news, while not new, has reached unprecedented levels of distribution through bots and individual users on social networks. These platforms allow actors to rapidly disseminate deceptive content that exploits psychological vulnerabilities among users, creating an "illusion of independence" where individuals unknowingly propagate biased or false information.

Cyber Warfare: Complementing Disinformation

In addition to disinformation campaigns, cyber-attacks have played a significant role in Russia’s hybrid warfare strategy against Ukraine. A chart sourced



from Microsoft illustrates the distribution of cyber-attacks on Ukraine by Russia since the full-scale invasion began. The national government has been the primary target, followed by

other sectors such as IT services, energy infrastructure, and media. These attacks aim to destabilize Ukraine's critical institutions while disrupting communication channels. Notably, the media and communication sectors have also been targeted, underscoring the strategic importance of controlling information flows.

These cyber operations align with broader disinformation efforts on social media by undermining trust in digital systems and reinforcing manipulative narratives. Such hybrid warfare tactics combine military aggression with digital disruption to achieve political objectives. The increasing role of cyber operations demonstrates how digital platforms have become a crucial battleground for shaping political narratives in modern conflicts.

The use of visuals plays a significant role in amplifying propaganda during the Russia-Ukraine war. The examples demonstrate how visuals are not merely supplementary but integral to shaping perceptions in modern information warfare. They serve as powerful tools for reinforcing propaganda narratives while making disinformation more accessible and believable.

Broader Implications for Political Narratives

The weaponization of social media has profound implications for political narratives and national identity. By framing Ukraine as either a heroic defender of democracy or a corrupt state under external control, these narratives influence both domestic audiences and international perceptions. Information warfare is not solely about controlling facts but also about shaping emotions—a strategy effectively employed by Russia to sway public opinion globally.

Social media platforms must navigate the delicate balance between combating disinformation and preserving free speech. Governments also face challenges in countering state-backed propaganda without infringing on democratic principles.

The Russia-Ukraine war illustrates how social media has become a powerful tool for shaping political narratives and conducting information warfare. Disinformation campaigns like RT's false claims about Mariupol residents demonstrate how state-backed propaganda can manipulate public perception on a massive scale. Cyber-attacks targeting Ukraine's critical sectors further reinforce this hybrid warfare approach by combining digital disruption with narrative control.

To mitigate these challenges, it is essential to strengthen media literacy programs that empower users to critically evaluate online content. Governments must also collaborate with tech companies to implement stricter regulations on digital platforms while safeguarding democratic freedoms. Understanding how social media shapes political narratives is crucial not only for addressing its negative impacts but also for leveraging its potential as a tool for transparency and truth in global crises like the Russia-Ukraine war.

References:

1. Mallick, Pk. 2022. 'Ukraine Is Winning the Information War Against Russia on Social Media: But Experts Say It Is Far From Over !!'

https://www.research-collection.ethz.ch/bitstream/handle/20.500.11850//RAD282.pdf?sequence=3&isAllowed=y
2. "Grani", İsmayılzada Laman Mais, 2023. "Media, manipulation, and information war" https://grani.org.ua/index.php/journal/article/view/1945/1908
3. Molfar media, 2024. "Neozazis," "foreigners", and "pockets full of gold". How is Russian propaganda spreading lies about the defenders of "Azovstal"? https://molfar.com/en/blog/yaki-feiky-poshyryue-rosiiska-propaganda-pro-oboronciv-azovstali
4. Office for budget resronsibility, 2022. "Cyber-attacks during the Russian invasion of Ukraine" https://obr.uk/box/cyber-attacks-during-the-russian-invasion-of-ukraine/

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Financial literacy of the population as a factor of economic stability

Financial literacy is an important element of a country's economic stability. It determines citizens' ability to manage their finances effectively, plan expenses, invest funds, and avoid financial risks. In countries with a high level of financial awareness, there is stable economic development, low household debt, and an efficiently functioning financial sector. In Ukraine, however, insufficient financial literacy leads to debt problems, a low level of savings, and weak investment activity.

The aim of this study is to analyze the level of financial literacy among the population and its impact on economic stability, identify key issues, and justify the need for government initiatives in this area.

Financial literacy affects various aspects of a country's economic life, namely:

- Debt burden levels (financially educated citizens use credit rationally, reducing the number of defaults and financial crises).
- Increase in savings (a high level of financial literacy promotes long-term savings, positively impacting the banking sector).
- Development of small businesses (informed entrepreneurs manage finances more effectively, contributing to economic growth).
- Reduction of the shadow economy (financially literate citizens trust official financial institutions more and use legal financial instruments).

Financial literacy in Ukraine is below the European average. According to the World Bank and the National Bank of Ukraine, only 42% of Ukrainians have savings, and 38% keep a personal budget, while in the EU, these figures are significantly higher.

Indicator	Ukraine	Average level in the EU
Level of financial literacy (on a scale of 1-10)	5.3	7.5

Percentage of population that keeps a budget	38%	65%
Share of citizens with savings	42%	75%
Use of investment instruments	12%	40%

The insufficient level of financial literacy is explained by:

- Limited financial education, as most educational institutions do not include financial literacy fundamentals in their curricula.
- Low trust in financial institutions, since negative past experiences often lead people to avoid banking services.
- Lack of accessible educational programs for adults, because government initiatives in this area are underdeveloped.
- Weak awareness of investment opportunities, as most citizens do not understand the principles of investing and risk management.

To improve financial literacy levels, comprehensive government programs covering various aspects of education, economics, and financial regulation are necessary. The main areas of such programs include:

1. Integration of Financial Literacy into the Education System

- Implementation of mandatory courses in schools – development of curricula for students in grades 7–11, covering the basics of personal financial planning, budgeting, saving, lending, and investing.
- Expansion of financial literacy courses in higher education institutions – inclusion of financial literacy courses for students of non-financial specialties so that future professionals in various fields have basic financial knowledge.
- Training of qualified teachers – development of training programs for educators to effectively teach financial literacy in schools and universities.

2. Increasing the Availability of Educational Materials

- Creation of free online courses on government educational platforms with certification, covering both basic and advanced aspects of financial literacy.
- Development of informational resources in the form of mobile applications, websites, video lessons, and interactive tests for self-study.
- Conducting mass educational campaigns through social media, television, and printed materials to promote financial literacy among the general public.

3. Regulation of the Financial Market and Consumer Protection

- Increasing transparency of banks and financial institutions – requiring financial organizations to provide clients with clear and detailed information on loan terms, deposits, and other financial services.
- Establishing mechanisms for monitoring financial services – strengthening oversight of banks, insurance companies, and microfinance organizations to prevent fraud and unfair lending practices.

- Expanding the functions of state regulators – introducing special programs to protect consumers of financial services and mechanisms for rapid response to violations.

4. Encouraging Entrepreneurship

- Providing free consultations and training for small and medium-sized businesses on financial accounting, tax planning, and risk management.
- Introducing government grants and preferential loans for young entrepreneurs who want to start their own businesses.
- Creating business incubators – special platforms to support startups, where entrepreneurs can receive expert assistance, access educational resources, and obtain financing.

5. Promoting a Culture of Saving and Investing

- Launching state programs to encourage savings, such as tax incentives for citizens who open deposit accounts or invest in pension funds.
- Educational campaigns on investment opportunities – organizing webinars, training sessions, and publishing materials about investment instruments (stocks, bonds, real estate, pension funds).
- Implementing government initiatives to stimulate long-term investments, such as state bonds with attractive conditions for the population.

The implementation of these measures will contribute to reducing financial illiteracy, increasing financial stability among citizens, and fostering the country's economic development.

Financial literacy is a key factor in economic stability. Increasing public awareness of financial matters will contribute to economic growth, reduce debt burdens, and increase savings levels. Government initiatives in this area should become a priority to ensure the country's sustainable economic development.

References

1. On Financial Services and State Regulation of Financial Services Markets. Official web portal of the Parliament of Ukraine. URL: https://zakon.rada.gov.ua/laws/show/2664-14#Text (accessed: 11.03.2025).
2. National Bank of Ukraine. Over the Past Three Years, the Financial Literacy of Ukrainians Has Improved – Research Results. National Bank of Ukraine. URL: https://bank.gov.ua/ua/news/all/za-ostanni-tri-roki-riven-finansovoyi-gramotnist-ukrayintsiv--polipshivsya--rezultati-doslidjennya (accessed: 11.03.2025).
3. DSpace at West Ukrainian National University: Main Page. URL: http://dspace.wunu.edu.ua/bitstream/316497/40778/1/Гриценюк%20В.С..pdf (accessed: 11.03.2025).

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Anti-Crisis Management of Enterprises under Martial Law: Adaptation Strategies and Recovery Mechanisms

The current conditions of martial law in Ukraine have put businesses in the face of unprecedented challenges, such as the destruction of infrastructure, disruption of logistics chains, loss of sales markets, reduced purchasing power, and loss of human resources due to migration or mobilization. These factors lead to deep crises in the operations of enterprises that require the introduction of effective crisis management mechanisms. Therefore, anti-crisis management has become a key tool for ensuring business sustainability in extreme circumstances.

Anti-crisis management in wartime has its own peculiarities that differ from traditional crisis situations. In particular, a wartime crisis is characterized by an acute shortage of response time and limited timeframes for overcoming the crisis. The main purpose of anti-crisis management in such conditions is to make prompt decisions aimed at minimizing the negative economic and social consequences of war for the enterprise [1].

Modern research proves that the effectiveness of business adaptation depends on the flexibility of measures and the use of external assistance. Digital transformations are one of the key drivers for improving the efficiency of anti-crisis management in an environment of instability [2]. At the same time, state programs and international assistance provide additional opportunities for enterprise stabilization and growth [3]. Anti-crisis management under the circumstances of martial law thus consolidates adaptation strategies and recovery mechanisms, which determines its relevance and practical applicability to the current Ukrainian economy.

Anti-crisis management is a system of management measures aimed at revealing, preventing, neutralizing and overcoming crisis phenomena and their causes on all levels of the economy. It is based on the general principles and methods inherent in the management processes. The main mission of such management is to ensure a stable financial condition as a result of prompt response to changes produced by the external environment (economic, political, social, and international changes) by implementing anti-crisis measures that allow removing temporary financial difficulties at the company and overcoming the symptoms of bankruptcy [4].

Anti-crisis management is especially important in times of war, when businesses suffer significant losses. As of November 2024, direct losses of enterprises from the war amounted to $14.4 billion in the industrial, construction, and service sectors, which is the part of the total losses of Ukraine's infrastructure estimated at $170 billion. Since the beginning of the war, the assets of nearly 500 large and medium-sized private and state-owned enterprises, as well as tens of thousands of small ones, have been damaged or destroyed, with the actual number likely to be higher due to a lack of data from the occupied territories. Enterprises are divided into two groups: those destroyed by accident during shelling and those targeted by missile strikes, including dual-use production. Metallurgy (e.g., Azovstal and Ilyich Iron and Steel Works in Mariupol) and Donetsk region, where almost half of the damage was concentrated, suffered the most. In the retail sector, direct losses amounted to $2.43 billion (2.9 thousand damaged outlets), and shopping centers lost $381 million, as 9 facilities were destroyed and 23 damaged [5]. Prompt anti-crisis solutions, such as the relocation of more than 800 companies in 2022-2023 [3], were a response to these challenges. Table 1 below summarizes the estimated losses by type of asset:

Table 1 - Estimated direct losses of the industrial, construction and services sectors [5]

Types of assets	Initial quantity, units.	Destroyed, units.	Damaged, units.	Estimated losses, $ billion
Large and medium-sized private enterprises	5270	92	n/a	7.7
Small private enterprises and sole proprietors	538932	n/a	n/a	4.8
State-owned enterprises	1665	348	n/a	1.9
Total	-	-	-	14.4

Adaptation strategies under martial law are aimed at ensuring business resilience through relocation, diversification, and digital solutions. According to the 2024 study, relocation remains a key tool. As of mid-2024, more than 800 companies had relocated their facilities, in particular to the western regions of Ukraine, which allowed them to save up to 65% of jobs in relocated companies [6]. Diversification of markets has also gained importance: agricultural enterprises have reoriented exports from traditional Black Sea ports to railways through Poland and Romania, increasing supplies to the EU by 25% in 2024 [3]. Digital technologies have accelerated adaptation - companies that have implemented automation and remote work have increased operational efficiency by 15-20%, according to an analysis of the IT sector in 2024 [7]. Recovery mechanisms include the state program “Affordable Loans 5-7-9%”, under which in 2025 companies received 2794 soft loans worth UAH 9.4 billion, of which UAH 2.4 billion was allocated for investment and UAH 2.3 billion for processing, as well as international grants from the EBRD to restore infrastructure [8]. These measures emphasize the flexibility of crisis management in times of war.

Anti-crisis management during the war in Ukraine is becoming increasingly valuable as a tool not only for business survival, but also for preparing the ground for its further growth. The combination of adaptation measures and recovery tools creates the conditions for economic transformation with a focus on sustainability and competitiveness in the post-war period. Thus, further improvement of these approaches will be crucial for ensuring the country's long-term economic recovery.

References:

1. Ватченко, Б., & Шаранов, Р. (2022). Антикризове управління підприємством в умовах війни. Економічний простір, (182), 38–43. https://doi.org/10.32782/2224-6282/182-5

2. Сойма, С., Білоусько, Т., & Вдовічена, О. (2022). Цифровізація антикризового менеджменту підприємства в умовах війни. Економіка та суспільство, (44). https://doi.org/10.32782/2524-0072/2022-44-115

3. Копитко, М., & Грицан, В. (2024). Сутність, значення та особливості антикризового управління підприємством в умовах впливу на нього чинників війни та євроінтеграційних процесів. Науковий вісник Львівського державного університету внутрішніх справ (серія економічна), (1), 36–42. https://doi.org/10.32782/2311-844X/2024-1-5

4. Прохорова, В. В. (2023). Повоєнне відновлення економіки України: проблеми та напрямки вирішення. Рекомендовано рішенням вченої ради Науково-дослідного центру індустріальних проблем розвитку НАН України (Протокол № 13 від 28.12.2023 р.). Рецензенти: Манойленко О. В. – д.е.н., проф., т.в.о. директора навчально-наукового інституту економіки, менеджменту і міжнародного бізнесу Національного технічного університету «Харківський політехнічний інститут». URL: https://www.ndc-ipr.org/media/publications/files/Post-War_Recovery_Mono.pdf

5. Київська школа економіки (KSE). (2024). Прямі збитки, завдані інфраструктурі України внаслідок війни: оцінка станом на листопад 2024 року. URL: https://kse.ua/wp-content/uploads/2025/02/KSE_Damages_Report-November-2024-UA.pdf

6. Цалко, Т., Невмержицька, С., & Птуха, А. (2024). Антикризове управління персоналом під час війни. *Економіка та суспільство*, (60). https://doi.org/10.32782/2524-0072/2024-60-120

7. Свистун, Л. А., & Роман, К. Ю. (2023). Цифрові інструменти антикризового управління підприємством. URL: https://surl.li/mkkckm

8. Міністерство економіки України. (2025). Державні сайти України. URL: https://surl.li/hiewpa

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University-business partnership as a factor in improving of specialist training

In today's digital economy and globalised labour market, the quality of specialist training must not only meet academic standards but also respond to the real needs of business. Education should be flexible, practice-oriented, and aligned with employer expectations. In this context, university-business cooperation (UBC) plays a strategic role in enhancing the competitiveness of higher education and contributing to sustainable regional development [1]. The autonomy of universities provides new opportunities for adapting curricula to labour market demands, making it crucial to harmonise the interests of all participants in the educational process – students, universities, and businesses [2].

Modern education must answer three key questions: what content to teach, how to teach it effectively, and for whom. Education becomes a lifelong process, and graduate competencies should ensure adaptability and competitiveness. UBC should be based on trust, transparency, a shared vision, and long-term commitment. This enables universities to make learning more applied, while businesses benefit from better-trained personnel and expanded innovation opportunities [1].

However, UBC also faces challenges. In Ukraine, cooperation is often superficial and lacks systemic integration. While guest lectures and curriculum support are common, deeper forms like dual education or structured internships remain rare due to organisational limitations, low funding, and differing priorities between academia and business [1; 3].

There are several models of UBC that reflect the depth of interaction. The transactional model implies short-term service provision, such as professional courses. The strategic model involves long-term goal-setting and content development. The transformational model features joint research, startups, and deep cooperation. The integration model represents a fully developed ecosystem where both parties co-create value through ongoing collaboration and resource exchange. These models can be implemented through internships, joint curricula, practitioner-led courses, research funding, and innovation centres [3].

Forms of cooperation vary in intensity – from guest lectures and job fairs to programme development and dual education systems. Each format provides mutual benefits. The cooperation of universities with business affects all stakeholders, which can be divided into four main groups: the university as an institution, students and teachers, business, and the local economy. Universities receive additional resources, including business investment in research institutions, as well as improved curricula that increase their attractiveness to students [4]. Students gain practical skills, scholarships, experience, and employment prospects, while faculty receive research funding, new knowledge, and the opportunity to improve curricula [6]. Businesses improve their recruitment strategies, develop employees, enhance their image and gain access to research resources. The local economy benefits by developing human capital, increasing productivity and stimulating economic growth [6], [4].

Despite the potential, UBC in Ukraine is held back by mismatches in academic and corporate culture. Universities are slow to change, while businesses seek quick results. Legal and institutional frameworks for cooperation are underdeveloped, and tax or investment incentives are lacking. Businesses often undervalue universities as innovation partners, and many educators lack business experience. Students, while offered internships or training, are not yet systematically integrated into business tasks. There is a pressing need for modernised infrastructure, updated teaching methods, and active engagement with external experts [3].

To develop effective partnerships, strategic management is essential. This includes conducting marketing audits of cooperation, evaluating impact using measurable indicators, and creating motivation systems for all participants [2]. Dual education, successfully implemented in Europe, holds promise for Ukraine as well. Internationalisation also offers valuable opportunities: grant programmes like Erasmus+, Horizon, and various academic exchanges help integrate global best practices and foster collaboration with international companies [3].

A survey conducted by Iryna Trunina and Inna Khovrak [1] revealed that only 19.5% of respondents (students, teachers, university administrators, employees (business), top managers/business owners, freelancers and others were interviewed) are fully confident in the quality of Ukrainian university education, while 29.3% believe businesses are interested in staff development. At the same time, 41.5% see real potential in university-business collaboration. Realising this potential requires ethical, transparent cooperation and clear identification of priorities. For universities, this means quality education aligned with labour market needs; for students – a responsible attitude to learning and career goals; for businesses – investment in education and development of future professionals. Problems arise when any party seeks benefits without contribution – students wanting only diplomas, businesses seeking ready-made employees, or universities pursuing profit without improving quality [1].

Among the most effective UBC formats are internships (53.85%), site visits to companies (40.38%), participation in forums, trainings, business lectures, quests, and hackathons. These formats help develop practical competencies and prepare graduates for real-world challenges. Therefore, quality education should be the focus of modern university development. Competencies – a combination of knowledge, skills, values, and motivation – form the foundation of graduate competitiveness and the key to effective entrepreneurial and professional activity [1].

Ultimately, successful UBC leads to an education system built on real societal and economic needs, strengthening the region’s resilience and graduate employability. Real transformation is possible only through equal partnership supported by regulatory, organisational, and financial mechanisms. This approach will not only improve training quality but also reinforce Ukraine’s innovation potential and global competitiveness.

References:

1. Iryna Trunina, Inna Khovrak. Harmonization of the interests of employers and institutions of higher education as a basis for the sustainable regional development / 2019 IEEE International Conference on Modern Electrical and Energy Systems (MEES), sep.2019. URL: http://surl.li/tojdda (accessed: 05.04.2025).
2. Diaconu Mihaela, Pandelică Amalia. The partnership relationship between economic academic and business environment, component of modern university marketing orientation / Procedia - Social and Behavioral Sciences, 62, 722–727. URL: https://v.gd/JLI0EI (accessed: 05.04.2025).
3. How to promote cooperation between universities and business. Analytical note / Centre for Expert Strategies. (2020). URL: http://surl.li/qqmstf (accessed: 05.04.2025).
4. Healy A. et al. Measuring the impact of university-business cooperation. European Commission. Directorate-General for Education and Culture. Lifelong Learning Programme. 2014 (accessed: 05.04.2025).
5. Ranga Marina et al. A study of cooperation between universities and business in the United States. 2013 (accessed: 05.04.2025).
6. Galan-Muros Victoria, Davey Todd. The CBA Ecosystem: A description of an integrated system of cooperation between universities and businesses // Journal of Technology Transfer. № 44. Issue 4. 2019. C. 1311-1346 (accessed: 05.04.2025).

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Inflation et politique monétaire en Ukraine pendant la guerre

Après avoir chuté de 28,8 % en 2022, l’économie s’est redressée de 5,3 % en 2023. Fin 2024, la croissance du PIB n’était que de 2,9 % sur un an, soit moins que prévu. La reprise économique ralentit progressivement. Au cours de chaque trimestre de 2024, la croissance par rapport à 2021 a été inférieure à celle de 2023, et au quatrième trimestre, le PIB global a diminué de 0,1 % par rapport au quatrième trimestre 2023.

La situation sécuritaire difficile, la pénurie de travailleurs qualifiés et les bombardements russes sur les infrastructures énergétiques continuent d’entraver la reprise économique. De plus, en 2023, les meilleurs indicateurs de reprise du PIB ont été facilités par une base de comparaison faible après la baisse de 2022 et une augmentation rapide des dépenses publiques, qui en 2024 ressemblent déjà davantage à une norme de temps de guerre.

L'Ukraine est entrée dans une guerre à grande échelle avec une inflation à la consommation de 10 % en glissement annuel. Par exemple, en février 2022, les prix des biens et services de consommation étaient 10 % plus élevés qu'en février 2021. L'invasion russe a provoqué une accélération significative de l'inflation, dont le taux a atteint son pic en octobre 2022 — 26,6 % en glissement annuel. Les raisons en étaient alors les conséquences directes de la guerre : la destruction des installations de production, la perturbation des chaînes d'approvisionnement et l'augmentation des coûts de production pour les entreprises. Une pression supplémentaire sur l'inflation a également été créée par l'impression de hryvnia par la Banque nationale pour couvrir le déficit budgétaire : en 2022, la NBU a imprimé 400 milliards d'UAH (12,5 milliards de dollars), avec lesquels elle a acheté des obligations militaires du gouvernement.

Fin 2022 et tout au long de 2023, les taux d'inflation ont été maîtrisés grâce à la stabilisation de la situation économique, aux actions compétentes de la NBU et au refus de financer le budget par l'impression de hryvnia. Le ralentissement de l'inflation a également été influencé par les récoltes records de 2023.

Cependant, en 2024, l'inflation a commencé à s'accélérer à nouveau : parmi les principales raisons, la NBU a cité l'épuisement de l'impact des récoltes importantes de l'année dernière, les pénuries d'électricité et de main-d'œuvre, ainsi que la sécheresse de l'été 2024.

L'inflation a atteint 13,2 % en glissement annuel en février, mais le taux de croissance ralentit pour le troisième mois consécutif.

En février, les prix des denrées alimentaires ont continué d'augmenter : les prix ont augmenté pour toutes les catégories, à l'exception du sucre. Le prix des œufs a connu la plus forte hausse ce mois-ci (+3,5% par mois). Les prix de tous les produits restent nettement plus élevés que l'année dernière.

Afin d'influencer l'inflation, la NBU utilise le principal instrument monétaire : le taux d'escompte. Le taux d'escompte affecte indirectement le taux d'intérêt auquel les banques prêtent aux entreprises et au public et le taux d'intérêt auquel elles attirent les dépôts. Lorsque le ministère des Finances envisage de vendre des obligations militaires, il examine le taux de dépôt : les obligations d'État devraient être plus attractives et plus rentables.

Depuis le 7 mars 2025, la NBU a encore augmenté le taux d'escompte à 15,5% afin d'inverser la tendance de l'inflation et d'atteindre son ralentissement en 2025. Selon la NBU, l'accélération de l'inflation s'est poursuivie en février. La NBU s'attend à ce que l'inflation revienne à une trajectoire de ralentissement au cours du second semestre de l'année et baisse à un niveau à un chiffre d'ici la fin de 2025.

Le rendement des obligations d'État reste supérieur en termes réels à l'inflation. Cela signifie que les investisseurs peuvent protéger leur argent de la dépréciation et réaliser de réels bénéfices.

En février 2025, les réserves internationales ont chuté de 6,7 % pour atteindre 40,1 milliards de dollars, couvrant 4,9 mois d'importations — toujours bien au-dessus du minimum requis de 3 mois. Cette dynamique est principalement due à l'absence totale d'aide internationale en février. Pour stabiliser le taux de change de la hryvnia, la NBU a vendu 3,8 milliards de dollars en janvier et 3 milliards de dollars en février.

En février 2025, la demande de devises étrangères a diminué. Cette hausse est due à la stabilité des exportations et à l'amélioration des anticipations de taux de change en raison de la politique plus stricte de la Banque nationale d'Ukraine. En conséquence, les ventes de devises étrangères ont diminué à 3,1 milliards de dollars et la hryvnia s'est renforcée, maintenant l'écart entre les taux au comptant et les taux officiels en dessous de 0,7 %.

Depuis le début de l'invasion à grande échelle, tous les revenus du budget de l'État ukrainien ont été utilisés pour financer la défense. Ces dépenses représentent environ la moitié du budget. L'Ukraine finance toutes les dépenses civiles du budget de l'État grâce à l'aide financière étrangère – en 2025, le besoin d'un tel financement extérieur s'élève à 38,4 milliards de dollars.

L'Ukraine est entrée en 2025 avec une situation budgétaire plus stable qu'en 2024. Le financement extérieur de cette année devrait couvrir entièrement l'ensemble des besoins prévus du budget de l'État.

Références :

1. La finance pour tous. *Centre de stratégie économique.* URL : https://www.lafinancepourtous.com/outils/dictionnaire/centre-danalyse-strategique/ (Dernier accès : 05.04 .2025)

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Prospects of Ukraine's European integration

Ukraine's integration into the EU is a key strategic goal that drives its foreign policy and enhances security amid tensions with Russia. The relevance of this study lies in analyzing the positive impact of Ukraine's European integration, which opens opportunities for economic modernization, foreign investment, and technological advancement. EU integration enhances Ukraine's global competitiveness, creates new jobs, and strengthens democracy and the rule of law. Understanding these benefits helps assess the long-term advantages of alignment with European standards. During the study, scientific works of domestic and foreign authors were used, devoted to European integration, legal and economic aspects of cooperation between Ukraine and the EU. In general, the literature on the prospects of Ukraine's integration into the EU can be considered successful, since due to the relevance of the problem, many scientists try to analyze it from their point of view, which offers us a variety of views and approaches to solving this issue. The presence of scientific articles from both sides gives us the opportunity to assess the prospects of European integration for both Ukraine and the European Union. However nowadays, when the USA changed its policy, the EU needs a more reliable partner, so this change could positively affect Ukraine's integration process, as the EU adjusts its foreign policy and works on becoming more united and independent. In this case, we need more modern and actual literature and research to look at the issue from this point of view.

Ukrainian dimension of membership prospects

The integration of Ukraine into the European Union is undoubtedly a great prospect for Ukrainian society; otherwise, our country would not be striving to join the European community as soon as possible.

The adaptation of Ukrainian legislation to EU standards is an integral part of Ukraine's path to development and progress. Aligning legislation with EU standards opens up new opportunities for cooperation and the exchange of experience with European Union member states. This process creates favorable conditions for developing international partnerships, sharing best practices and technologies, and enhancing the competitiveness of Ukrainian enterprises and products in the European market. Moreover, the adaptation process has already

become a catalyst for internal reforms in Ukraine, prompting Ukrainian society to reconsider its values and practices and align them with European standards [1, p. 20].

The EU is energy security. In today's conditions, no European country is capable of ensuring its energy security alone. On its path toward EU membership, our country seeks support and the protection of its energy interests from the leading European nations. Upon becoming a member of the European community, Ukraine will no longer be perceived merely as a "transit territory" through which pipelines to Europe are laid [2].

It is impossible not to emphasize the economic benefits that Ukraine gains from integration. Joining the European community will provide opportunities for sustainable political and socio-economic development, attracting foreign investments, expanding export markets, and modernizing the economy. Although the reform process and adaptation to European standards pose a challenge, they gradually lay the foundation for stable economic growth, the rule of law, and an improved quality of life for Ukrainian citizens. [3, p. 387] A shared market with European countries will strengthen Ukraine's economy, allowing entrepreneurs to earn significantly higher incomes. There will be no need to search for new markets for goods and services. Thanks to a stable economy, the currency will strengthen, and the overall standard of living will improve significantly.

Ukraine's membership in the EU will provide its citizens with significant opportunities for free movement, education, and employment in European countries. The removal of visa restrictions will ensure seamless access to EU member states, which is especially important for students seeking education in European institutions. They will benefit from scholarship programs, reduced tuition fees, and internships, greatly enhancing their career prospects. For workers, EU membership will open the European labor market, allowing them to work legally, gain experience in international companies, and grow professionally, bringing valuable knowledge and expertise back to Ukraine's economy.

European dimension of membership prospects

Any union creates new opportunities for its members. Some may gain more, some less, but overall, everyone benefits—that's the purpose of integration.

Ukraine's accession to the EU will bring advantages not only to Ukraine but also to all member countries.

We know that the Ukrainian IT industry has great potential: our specialists have a strong foundation, and Ukrainian IT companies are in demand abroad. Even with the start of the full-scale war, Ukraine's IT exports grew by 5.85% in 2022, according to data from the National Bank of Ukraine. [4] Ukrainian programmers and engineers are competitive due to their modern knowledge, creative approach, and ability to work in a multicultural environment. Unique developments created for the front line have significant potential for further commercial application.

Ukraine can become an important source of highly qualified specialists for EU countries facing an IT talent shortage. Cooperation with Ukrainian educational and technological institutions will provide the EU with skilled professionals ready to contribute to joint projects and strengthen the European economy. This partnership will not only enhance economic ties between Ukraine and the EU but also boost Europe's technological potential, increasing its global competitiveness. Ukraine is also making significant progress in digitalizing public and commercial services. The success of the "Diia" platform has gained recognition in Europe, with Ukraine opening its code to developers worldwide [4]. This demonstrates Ukraine's readiness to share its digital transformation experience.

Ukrainian Membership Prospects	**European Membership Prospects**	**Shared Membership Prospects**
Adaptation of Ukrainian legislation to EU standards	Access to highly qualified Ukrainian IT specialists	Strengthening economic ties between Ukraine and the EU
Development of international partnerships and exchange of best practices	Strengthening Europe's technological potential through cooperation with Ukrainian IT	Increasing Europe's global competitiveness
Increased competitiveness of Ukrainian enterprises and products	Access to Ukraine's experience in digital transformation (e.g., "Diia" platform)	Enhancing regional energy security
Energy security support from EU countries	Alternative gas storage site in Ukraine for EU traders	Joint management of energy resources during crises or peak demand
Economic benefits: foreign investments,	Optimization of gas reserves near European	Strengthening the shared energy

export expansion, and modernization	markets	infrastructure
Sustainable political and socio-economic development	Reduced reliance on external gas suppliers	Development of a common digital market
Strengthening of Ukraine's economy through the EU's shared market	Access to innovative military technologies from Ukraine	Mutual development of defense technologies
Free movement, education, and employment for Ukrainian citizens in the EU	Enhanced security and stability in Eastern Europe	Joint participation in the European labor market
Better access to EU scholarship programs and reduced tuition fees	Increased innovation potential through joint projects	Exchange of skilled professionals
Access to the European labor market	Expansion of research and development cooperation	Strengthening rule of law and democratic values in both regions

The table highlights the benefits of Ukraine's EU membership for both sides. Ukraine gains economic growth, market integration, and energy security, while the EU benefits from IT talent, technology, and new energy opportunities. Shared prospects include economic cooperation, strengthened security, and the development of digital and energy initiatives.

Russian aggression has reinforced the urgent need for a European trajectory as the best path for Ukraine's democratic future. The prospects for Ukraine's EU membership remain positive, reaffirming the necessity of moving forward. With strong support from European partners and the unwavering determination of the Ukrainian people, favorable conditions for achieving this goal continue to develop. Ukraine's accession to the EU is a mutually beneficial step that will enhance economic, security, and political cooperation. European integration is not just a strategic choice but an investment in a peaceful, stable, and prosperous future for both Ukraine and Europe.

References:

1 Komakha, L. H., Orliv, M. S., & Ruban, Y. H. (Eds.). (2024). *Ukraine on the path to the EU: Challenges and prospects: Materials of the round table for Europe Day in Ukraine (Kyiv, May 9, 2024)*. Kyiv: Educational and Scientific Institute of Public Administration and Civil Service, Taras Shevchenko National University of Kyiv. Retrieved from ipacs.knu.ua

2 Bukovinian State Medical University. (2018, July 6). *Positive consequences of Ukraine's accession to the EU*. Retrieved from bsmu.edu.ua

3 Asiryan, R. R., Perepelytsia, K. O., & Asiryan, S. R. (2023). *Prospects of Ukraine's access to the EU*. Legal Scientific Electronic Journal, (5), 95. https://doi.org/10.32782/2524-0374/2023-5/95
4 Berdyansk City Territorial Community. (2024, May 9). *Prospects of Ukraine's accession to the European Union.* Retrieved from brd.gov.ua

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The Impact of Inflation Targeting on Economic Stability in Developing Countries

In the contemporary global economic landscape, inflation targeting (IT) has emerged as a dominant monetary policy framework adopted by central banks in both developed and developing economies. Its main objective is to maintain price stability by setting explicit inflation targets and using interest rates as the primary tool to achieve them. However, in developing countries where financial systems are often less mature, the effectiveness of inflation targeting as a mechanism for ensuring macroeconomic stability remains a subject of ongoing research and debate [1].

One of the key advantages of inflation targeting lies in its transparency and predictability. By publicly announcing inflation goals and consistently implementing policies aimed at achieving them, central banks can anchor inflation expectations, reduce uncertainty, and foster investor confidence. For developing countries, which frequently experience high inflation rates due to fiscal imbalances, currency depreciation, or external shocks, this framework offers a structured approach to monetary discipline [2].

Ukraine's experience illustrates both the benefits and limitations of inflation targeting in an unstable economic environment. Since adopting inflation targeting in 2015, the National Bank of Ukraine (NBU) has made significant strides in stabilizing consumer prices. Inflation dropped from over 40% in 2015 to single-digit levels in subsequent years. These improvements were supported by enhanced central bank independence, improved communication strategies, and prudent fiscal policies [3].

Nevertheless, inflation targeting is not a panacea. In developing economies, it often faces structural challenges such as weak institutional capacity, a high degree of dollarization, limited transmission of interest rate changes to the broader economy, and vulnerability to external factors like commodity price shocks and geopolitical risks. For instance, in Ukraine, despite monetary efforts, inflation rose sharply in 2022 due to the full-scale war and supply chain disruptions, underscoring the limits of monetary policy in times of crisis [4].

Moreover, the success of inflation targeting hinges on effective coordination between monetary and fiscal authorities. If fiscal policies are expansionary or unsustainable, they can undermine monetary efforts, leading to policy inconsistency. This is particularly relevant in countries with high public debt or reliance on external financial aid, where fiscal-monetary alignment becomes more difficult to achieve [5].

Another important factor is the credibility of the central bank. Inflation expectations are more likely to be well-anchored when the public trusts the monetary authority. In developing countries, however, this trust is often fragile due to a history of political interference, hyperinflation, or banking crises. Building and maintaining credibility requires not only policy consistency but also legal safeguards and transparent governance structures [1].

In conclusion, while inflation targeting can contribute significantly to macroeconomic stability in developing countries, its implementation must be supported by institutional reforms, strong fiscal discipline, and effective communication. The Ukrainian experience shows that progress is possible even under difficult conditions, but also highlights the need for flexibility and complementary policies to address unexpected shocks.

References:

1. Mishkin, F. S. (2007). I*nflation targeting: A retrospective.* NBER Working Paper No. 13500. URL:https://www.nber.org/papers/w13500
2. Taylor, J. B. (1993). *Discretion versus policy rules in practice.* Carnegie-Rochester Conference Series on Public Policy, 39. URL:https://doi.org/10.1016/0167-2231(93)90009-L
3. National Bank of Ukraine. (2023). *Monetary Policy Report.* URL: https://bank.gov.ua/en/news/all/inflation-report
4. International Monetary Fund. (2022). *Ukraine: Selected Issues*. URL: https://www.imf.org/en/Publications/CR/Issues/2022/03/18/Ukraine-Selected-Issues-515273
5. Svensson, L. E. O. (2010). *Inflation Targeting.* Handbook of Monetary Economics, Volume 3B. URL: https://doi.org/10.1016/B978-0-444-53238-1.00010-4

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Rebranding in Marketing: The Power of Transformation

Rebranding is a fascinating marketing strategy that can make or break a brand's success. This is an important subject because it helps brands stay relevant, engage with new audiences, and differentiate themselves in a competitive market. It's all around us, from the goods we purchase to the public figures we admire, and it shows how change can lead to incredible growth.

Rebranding is when a company or person refreshes their image to stay relevant or reach new audiences. It's crucial because markets and tastes evolve – think about how brands like Apple or Instagram have stayed fresh over decades. Rebranding keeps you competitive, helps you connect with new people, and signals growth. For example, a pop star might shift from a teen idol image to something more mature to match their audience's changing lives.

Companies should consider rebranding for several reasons [1]:

- to differentiate themselves from competitors better;
- to give new life to outdated branding;
- to outgrow their poor reputation;
- to align with the business evolution;
- to target a new customer profile.

Key features of successful rebranding include understanding your mission, vision, and values. Before making any changes, clearly define what makes your brand special, where it's headed, and what it stands for. Ensure that your rebranding actions reflect these elements to maintain authenticity and consistency. A complete rebranding strategy should align with your existing branding. Your new strategy shouldn't contradict an old one. Also don't forget to consider your audience, the market, and your competition. To avoid mistakes that can cost a lost in market share, conduct surveys and test ideas through focus groups. Collaboration with your team is essential to diverse ideas and eliminate bad ones. Rename your business and rebuild your brand identity if necessary. However, remember to manage the rebrand carefully. Once ready, launch your rebrand and tell the world [2].

These four key principles are important to make your rebrand truly effective:

Consistency. Your new image needs to shine through in everything, from visuals to messaging.

Authenticity. It has to feel real, not forced.

Audience focus. You need to clearly understand who you're targeting with this change.

Bold moves. Taking risks can set you apart, whether through a drastic style shift or a standout campaign.

A case study which illustrates a successful rebranding is Sabrina Carpenter's recent transformation. Known from her Disney days on Girl Meets World, but in 2024, she completely transformed her career with her "Short n' Sweet" era. She traded her youthful and playful, featuring lots of bright colours and fun patterns teen style for a "blonde bombshell" persona, retro 1960s-inspired looks, playful yet confident vibe. The campain was well-planned and lasted several months. It was built around three core aspects shaping her brand: ties to Hollywood and acting, witty humor, and romance. This element are well-displayed by storytelling method in the music videos for her songs "Espresso", "Please Please Please", and "Taste" that were crucial in establishing Carpenter's refreshed identity. Song "Espresso" embraced a vintage European summer vibe, "Please Please Please" told a Bonnie and Clyde-inspired story, and "Taste" is refered to timeless horror movies such as Death Becomes Her and Kill Bill: Volume 1. These music videos enhanced the album's themes while reinforcing Sabrina Carpenter's cinematic, sophisticated image [3].

Her fashion choices, particularly the babydoll dresses and swimsuits, weren't just cute – they strategically aligned with her music's tone, striking a perfect balance between innocence and allure. This made her relatable to Gen Z and Gen Alpha, while appealing to millennials and Gen X. By making hearts and kisses her signature symbol, evident in her visuals, products, and outfits, Carpenter leaned into a gentle, feminine style that highlighted romance.

The song "Espresso" itself is a banger - catchy, well-produced and summer-ready, but it's Sabrina's transformation into a blonde bombshell that truly elevated the track. Her look has become as integral to her brand as her music, with both working in perfect harmony.

Sabrina's playful side also shone through in her collaboration with Dunkin', where she starred in a commercial featuring cheeky humor and a play on the phrase "shaking that ess." This campaign, designed to advertise a new shaken espresso drink, showcased her fun-loving personality while adding a clever twist to her brand. The playful commercial charmed fans and highlighted Sabrina's skill at effortlessly combining humor with her elegant style.

Her stage setup also embraces cinematic grandeur, with dramatic spiral staircases and flowing curtains, creating an experience that echoes classic Hollywood glamour. Sabrina's fun onstage chatter and crowd engagement highlight her cheerful nature, often catching fans off guard with her surprising cheeky humor. This lighthearted humor adds a lively touch to her live appearances, ensuring each event remains distinctive and memorable. The stage is also decorated with romantic elements, such as large heart symbols and heart-shaped cut-out dresses in different colors, keeping fans eager to see which one she'll wear next [3].

As a result of a successful rebranding are chart-topping hits, Grammy wins, and sold-out arena tours. By consistently combining fashion, collaborations, live performances, and innovative merchandise, Carpenter shifted from being a former Disney star to a sophisticated pop icon with a distinct, mature identity. Her rebrand worked because it was consistent across her music and visuals, felt authentic to her personality, targeted a broader audience, and wasn't afraid to take risks. These calculated promotional moves have significantly contributed to her thriving career in the music industry.

Rebranding is vital for staying relevant. Key features that make it successful are consistency, authenticity, audience focus, and bold moves, and Sabrina Carpenter used them to skyrocket her career.

In conclusion, rebranding is about adapting to change while staying true to your identity, and Sabrina's story proves it can lead to an amazing success.

References

1. Kimbarovsky R. Rebranding: What it is, Why it's Important, Strategies, and Examples [Internet]. 2025 February 26 [cited 2025 March 25]. Available from: https://www.crowdspring.com/blog/how-to-rebrand/
2. What Is Rebranding? Best Examples & Strategies to Consider [Internet]. 2025 February 26 [cited 2025 March 25]. Available from: https://blog.hubspot.com/marketing/rebranding
3. Sabrina Carpenter Marketing Case Study: Rebranding as a Superstar [Internet]. 2025 February 26 [cited 2025 March 25]. Available from: https://www.venicemusic.co/blog/sabrina-carpenter-marketing-case-study-rebranding-as-a-superstar

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Adaptation Management for Sustainable Development of a Company under Polycrisis Conditions

The issue of adaptation management for sustainable development of a company in polycrisis conditions is important for development of the modern management theory, as it responds to some main challenges of our time. Firstly, the country, and the world, have been enduring the complex crisis (known also as "polycrises") [1], which includes rapid climate changes, worsening the quality of life, social stratification, decline of free trade model, economic recession and financial volatility, preparation to a global military conflict, political turbulence, as well as the absence of global leadership and ignorance of international law. Secondly, the modern world is undergoing global technological and digital transformations. Rapid development of innovations, automation of business processes, implementation of artificial intelligence. These changes require companies to be flexible, adaptable and constantly improve their digital competencies. At the same time, they create risks related to cybersecurity, digital inequality, and the need for significant investments in technological infrastructure. Finally, Ukraine, as the potential member-state of EU, is obliged to implement those EU directives and regulations, which requires the transformation of European economics in circular one, based on the Goals of Sustainable Development. One of the priority tasks for the European Union is the transformation of the national economies of the member states in accordance with the principles of sustainable development and their transformation into circular ones. That involves reducing the carbon footprint, developing reverse logistics and waste recycling, using sustainable supply chains and creating value. In fact, the global value chains are understood as a system of sequential logistic and production relations of organizations and individuals that perform their specific functions in creating a product or service for final consumption and increase the added value of input resources received from previous participants [2]. Gary Gereffi's work describes the characteristics of the global value chain [3; 4], they are the followings: 1) the sequence of relationships between participants in the global production and trade process; 2) a set of certain stages in creating a final product, each of which adds value; 3) cooperation of participants from different countries, each of which has a specific function in creating total value.

Among the current tasks of the UN Sustainable Development Goals [5], the most important for business management are Goal 8 "Decent work and economic growth", Goal 12 "Responsible consumption", and Goal 17 "Partnerships for sustainable development", and the latter considers the requirements for the formation of value chains based on sustainable development. The implementation of such goals at the micro level will ensure the transition to an economic model, which is aimed at energy saving, environmentally friendly production and consumption and known as the "circular economy" or "closed-loop economy". At the same time, responsible consumption involves the reuse of resources, the development of reverse logistics (operations related to the reuse of materials). It is obvious that the use of sustainable supply chains by Ukrainian enterprises creates additional risks for business entities through the complexity of finding partners, additional costs for creating closed-loop systems, as well as the application of managerial approaches to change management and anti-crisis management. At the same time, an important requirement for creating an anti-crisis management system at an enterprise is its adaptability, i.e. the ability to respond and adapt to the emergence of unforeseen circumstances, ensure the identification of potential threats, assessment of their impact and development of management decisions to minimize negative consequences. Such consequences may include changes in the external environment (due to the introduction of protectionist measures and breakthrough innovations, sanctions, economic recession, complications in international logistics and volatility in resource prices), the internal environment (the need to replace technologies, change the business model, reorganise business processes, acquire modern competencies by personnel, and the availability of material and financial resources).

In summary, adaptation management is a key factor in the sustainable development of firms in conditions of polycrisis. Modern challenges, such as global economic instability, technological transformations and Ukraine's integration into the European space, require effective approaches to managing changes and risks. Implementing the principles of a circular economy, which includes responsible consumption, reducing carbon footprints and developing sustainable supply chains, is an important component of sustainable development. However, this process comes with additional challenges, including finding partners, the need for investment in technology and adapting to new economic conditions. The application of adaptation management allows enterprises to identify potential threats, assess their impact and promptly develop management solutions. This contributes to increasing business resilience, improving competitiveness and ensuring long-term development in conditions of uncertainty.

References:

1. Федулова С.О. Багатовимірна поточна світова криза проти концепції полікризи. Наука, економіка, інновації. 2023. №1, С. 3-8.
2. Gereffi, G., Korzeniewicz, M. (1990). Commodity chains and footwear export in the semiperiphery, in Semiperipheral States. World Economy, 45-46.
3. Gereffi, G., Humphrey, J., Sturgeon, T. (2005). The governance of global value chains. Review of International Political Economy, 78-104. URL: http://dx.doi.org/10.1080/09692290500049805
4. Георгіаді Н., Кубант А. Поняття і види адаптаційних систем менеджменту підприємств . Економіка та суспільство. 2024. №62.
5. Sustainable Development Goals | United Nations Development Programme

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Implementation of ESG practices and their impact on financial results

In the context of globalization and growing environmental and social challenges, the issue of sustainable development is becoming increasingly important. Environmental disasters, social inequalities and management crises are forcing businesses to reconsider traditional approaches to operations, while Ukraine's European integration course requires adaptation to European reporting standards, including in the area of non-financial reporting. Growing investor interest in ESG factors is shaping a new paradigm of corporate responsibility [2]. However, despite the popularity of ESG as a responsible business concept, its implementation remains a challenge due to the lack of uniform international standards for assessing ESG indicators and the lack of awareness in the Ukrainian financial sector of the impact of ESG approaches on the financial stability and profitability of companies.

The concept of ESG covers three key areas of company performance assessment: environmental responsibility, social orientation and management efficiency. The institutionalization of ESG in business practices involves the introduction of non-financial reporting standards, transparency policies, and new assessment tools such as ESG ratings or compliance with responsible investment principles.

The importance of ESG lies not only in its ethical dimension, but also in it's direct link to financial performance. Studies confirm that high ESG performance can reduce risks, increase investor confidence and, consequently, have a positive impact on financial metrics such as return on assets, return on capital or investment [1].

In today's business ESG is not longer an optional initiative and is becoming a mandatory element of a sustainable development strategy. Companies that integrate environmental, social and governance standards into their operations have a better chance of ensuring long-term sustainability and adaptability to external challenges. ESG contributes to:

- transparency in internal processes and relations with stakeholders;
- reducing operational, regulatory and reputational risks;
- attracting investors who are increasingly focused on the principles of responsible investment.

In addition, the development of ESG is supported by a wide range of international regulatory initiatives. One of the most prominent is the Global Reporting Initiative, which creates standards for disclosing environmental, social and governance information. The European Corporate Sustainability Reporting Directive requires companies to provide in-depth non-financial reporting, which indicates a transition to a new reality of corporate transparency [3]. Thus, ESG compliance is not longer a choice, but a necessity for those seeking to remain competitive in the global economy.

In international practice, ESG approaches have already become an integral part of the strategies of leading companies. Tesla, for example, has invested more than 1.5 bn. $ in the development of environmental technologies, reducing CO_2 emissions by 40%, which has helped to increase its capitalization to 850 bn. $ [4]. Unilever has switched 80% of its production capacity to renewable energy sources and reduced its use of plastic by 30%, which has led to a 12% increase in operating profit. These examples demonstrate that ESG approaches provide not only reputational but also significant financial benefits, forming a new logic of economic growth.

In the Ukrainian context, it is worth highlighting Metinvest, which has made significant strides in implementing its ESG strategy. By investing in modernizing its production facilities, the company has reduced emissions by 20% and implemented a number of social initiatives, including in education, healthcare and local community development, which has had a positive impact on its financial performance and enhanced its investment attractiveness [4].

In order to highlight the positive impact of the ESG strategy on the company's performance, let us analyze the financial results of the British company Unilever for the period 2014-2024 and compare the results.

Unilever is a global consumer goods company that produces food, beverages, hygiene and household chemicals [4].

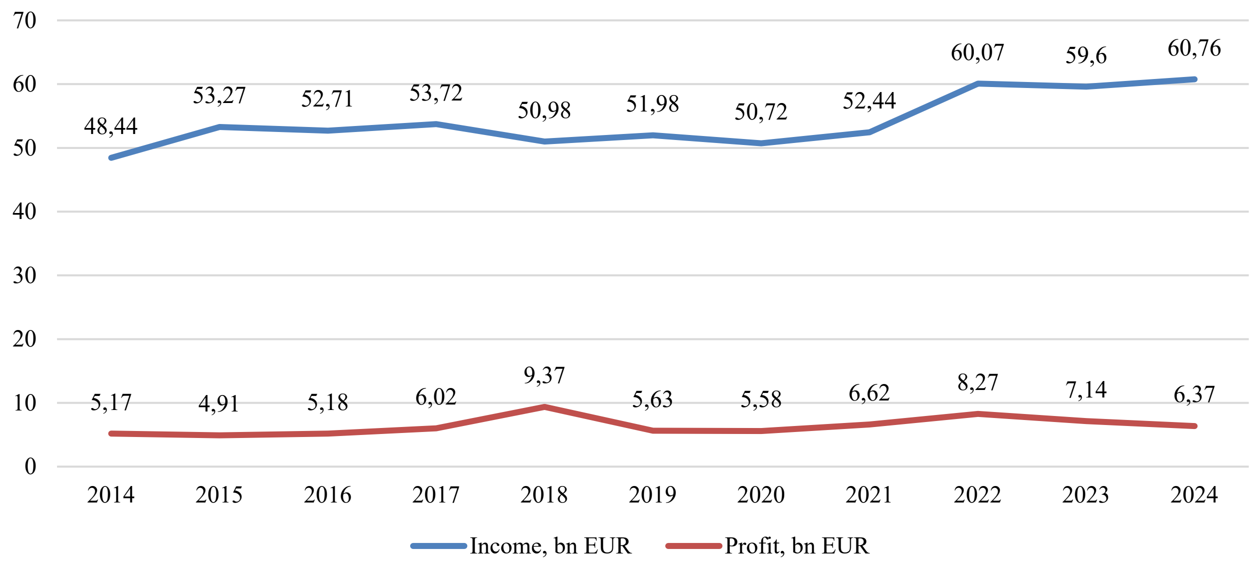

Fig. 1 – Dynamics of Unilever's sales revenue and net profit for the period 2014-2024.

Following the implementation of ESG approaches in 2020 and the launch of the Sustainable Living Plan, Unilever has demonstrated positive changes in its financial performance. In particular, since 2020, revenue growth has accelerated and consistently reached 5% per annum, compared to 3% per annum before. There has also been an increase in return on sales, from 10% to 12%. In 2022, the company recorded a significant increase in revenues to 60,07 bn. EUR, one of the largest achievements in its history. At the same time, net profit showed variability: after peaking in 2018 at 9,37 bn. EUR, it declined, but remained at a consistently high level. This may be the result of numerous investments in sustainability and transformational changes in the company aimed at reducing environmental impact and improving social aspects. Increasing transparency and social responsibility through the implementation of ESG practices has also contributed to the growth of investor confidence and improved the company's investment attractiveness. As a result, the Sustainable Living Plan has become an important part of the company's strategy, which has had a positive impact on its financial performance and long-term sustainability.

Thus, it can be noted that the implementation of ESG approaches significantly improves not only the company's reputation but also its financial performance. Sustainability strategies help companies attract investment, improve their financial performance and strengthen their competitive position in the market. Integration of ESG approaches has become a strategic necessity for modern business, as it ensures long-term sustainability and responds to the challenges of globalization and social responsibility [2]. For Ukrainian companies, it is important to focus on transparency of their operations, constantly improve the level of education on these issues and adapt to global ESG standards to strengthen their position in the international business environment.

References:

1. Bloomberg. (n.d.). Sustainable Finance and ESG Investing. Bloomberg. URL: https://www.bloomberg.com/markets/sustainable-finance
2. Komporek, M. (2024). ESG Indicators, Profit Management, and Financial Indicators. Financial and Credit Activity: Problems of Theory and Practice, 5(58), 185–198. https://doi.org/10.55643/fcaptp.5.58.2024.4540
3. Parfentieva, O. (2023). Institutionalisation of Environmental, Social, and Governance Practices. Economics and Society, (56). https://doi.org/10.32782/2524-0072/2023-56-112
4. Zhytar, M. (2024). ESG Trends in the Financial Activities of Companies: Key Areas and Recommendations. European Scientific Journal of Economic and Financial Innovations, 2(14), 86–94. URL: https://doi.org/10.32750/2024-0209

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Technogenic mineral resources of Kryvbas as a strategic iron ore reserve

In recent decades, increasing attention has been given to technogenic deposits, as they can play a crucial role in ensuring Ukraine’s resource independence. The enterprises of Kryvbas have accumulated vast reserves of iron-containing rock dumps. Previously regarded as waste, these materials are now becoming viable for processing due to advancements in beneficiation technologies.

According to various estimates, over 6 Bn t of technogenic material has been accumulated in Kryvbas dumps, with iron content ranging from 15% to 35%. In some cases, this secondary raw material exhibits higher quality than low-grade primary iron ores. Modern technologies, including magnetic separation, gravity sorting, flotation, and biohydrometallurgy, enable the extraction of up to 60–70% of iron. This creates significant prospects for the rational development of technogenic deposits, particularly in light of increasing environmental restrictions and economic challenges impacting conventional mining.

A review of scientific publications confirms the feasibility of developing technogenic deposits in Kryvbas. Ivanchenko et al. [1] examine the application of combined beneficiation methods that enhance the recovery of iron from secondary resources. Pugin’s research [2] focuses on economic evaluation algorithms for selecting utilization strategies for ferrous metallurgy waste, which can serve as a foundation for modeling optimal exploitation scenarios for technogenic deposits. Kovalchuk [3] analyzes the impact of varying cut-off grades in dump processing on the efficiency of beneficiation plants, which is especially relevant for Kryvbas mining enterprises.

The processing of technogenic deposits offers several significant advantages. Firstly, it reduces the dependence of enterprises on primary ore extraction, allowing cost savings in geological exploration, drilling and blasting operations, transportation, and ore crushing. Since technogenic waste has already undergone partial beneficiation or pre-processing, its reutilization requires fewer resources and less energy than conventional mining. This not only alleviates financial pressure on enterprises but also promotes more rational utilization of natural resources. Secondly, it is an environmentally sustainable measure, as waste dumps occupy vast areas, and their reprocessing facilitates land reclamation for alternative use. Thirdly, the advancement of secondary mining can enhance the structure of the mining industry, making it more adaptable and resilient to market fluctuations.

However, the implementation of such approaches requires a well-founded economic justification for the feasibility of developing technogenic mineral deposits. In practice, estimation of the investment attractiveness of mining projects, including the re-use of industrial waste, involves standard methods of the capital investment efficiency analysis. The main estimation criteria include Net Present Value (NPV), Internal Rate of Return (IRR), Profitability Index (PI), and Payback Period (PP). These indicators enable comparison of technogenic deposits with conventional mineral sources by profitability, investment risk, and project timeframes. Both national and international studies demonstrate that, under current conditions, the secondary processing of beneficiation waste may yield a positive NPV and a payback period of less than five years, making such projects investment-attractive.

Technogenic deposits can be conditionally classified into two main categories: iron-containing rock dumps and beneficiation tailings. Their subtypes arise across different industrial sectors such as mining, metallurgy, thermal energy production, and chemical manufacturing. Each type has specific properties (e.g. particle size distribution, content of valuable components, and processing suitability) and requires an individual technical and economic approach to assessment of the feasibility of secondary proccesing.

In this context, a coordinated approach to utilizing technogenic deposits is necessary. One possible solution is the “pit-technogenic deposit” concept, which envisions an integrated interaction between primary ore extraction from open pits and the reprocessing of accumulated technogenic raw materials. In the long term, considering the interaction of parameters within these technogenic facilities will enable real-time adjustments of iron cut-off grades and the implementation of integrated metal recovery methods.

Prospects for further research in this field include the development of mathematical models for predicting iron content in dumps, the design of technological chains for efficient technogenic deposit processing, and the integration of circular economy principles into the mining industry. Future studies will focus on identifying correlations between parameters within the “pit-technogenic deposit” system.

Thus, technogenic deposits in Kryvbas have the potential to become a strategic resource for Ukraine’s mining industry. Utilizing these deposits is not only an issue of profitability but also a pathway toward more sustainable and responsible development of the mining sector.

At the same time, the efficient exploitation of these deposits should be based on a systematic approach that considers the dependence between the dynamic parameters of open-pit mining and technogenic deposits, during both their formation and subsequent processing. This will enable the optimization of extraction conditions, ensure the stability of technological processes, and create conditions for the comprehensive utilization of the region’s resource potential.

References

1 **V. P. Ivanchenko, S. I. Petrov, and O. V. Kovalenko**, “Study of the Efficiency of Combined Beneficiation Methods for Iron-Bearing Technogenic Resources,” Mining Bulletin, No. 4, pp. 45–52, 2020.

2 **O. S. Pugin**, “Economic Aspects of Using Ferrous Metallurgy Waste in the Context of Sustainable Development,” Metallurgy of Ukraine, No. 2, pp. 30–38, 2011.

3 **M. V. Kovalchuk**, “Impact of Cut-Off Grade Variation on the Efficiency of Beneficiation Plants,” Technologies and Mining, No. 3, pp. 20–28, 2018.

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Gender equality in the Tech Industry

Gender equality represents a fundamental principle where individuals of all genders possess equal rights, responsibilities, and opportunities. It is not merely a social ideal but a critical requirement for building peaceful, sustainable, and thriving societies. Recognized globally, gender equality is one of the United Nations' Sustainable Development Goals (Goal 5), reflecting its significance for economic development, social cohesion, and human rights [4].

Throughout history, women have faced systemic barriers to education, employment and leadership opportunities. Men, too, have often been constrained by rigid societal expectations. Gender equality aims to dismantle these restrictions, enabling each individual to pursue their potential without discrimination or stereotypical limitations. Equal pay, equal participation in decision-making and shared family responsibilities are vital components of a balanced and fair society.

In the context of the technology industry, which is shaping every aspect of modern life, gender equality is especially critical. Despite rapid technological advancements, gender disparities persist across the sector.

Recent research indicates that only 28% of workers in STEM fields (Science, Technology, Engineering and Mathematics) are women, and in technology-specific roles, the figure is around 25%. Leadership representation remains alarmingly low: only 11% of tech executives are women. Moreover, a consistent wage gap persists, with women in technology earning approximately 84 cents for every dollar earned by men in equivalent positions [2].

Multiple factors contribute to this inequality. Traditional gender norms continue to influence education and career choices from an early age. Girls are often subtly discouraged from pursuing technical fields, resulting in lower female enrollment in computer science and engineering programs. Even when women enter the tech industry, they frequently encounter unconscious bias, limited promotion opportunities, workplace cultures that lack inclusivity, and insufficient mentorship.

The consequences of gender inequality in technology extend beyond issues of fairness. Diverse teams consistently demonstrate better problem-solving capabilities, higher levels of creativity and improved financial performance. According to McKinsey & Company, companies with gender-diverse leadership teams are 25% more likely to achieve above-average profitability. Lack of diversity not only narrows the talent pool but also results in technologies that fail to address the needs of broader, more diverse markets [2].

Furthermore, countries that invest in gender equality benefit from stronger innovation ecosystems. For example, Nordic countries where policies supporting gender balance are widespread lead global innovation indices. Conversely, regions where women are excluded from technological sectors face slower growth and limited competitiveness in the global market [6].

Several initiatives have emerged to tackle the gender gap. Programs such as “Girls Who Code”, “Women Who Tech” and “SheCodes” are working globally to inspire and train young women in coding, robotics and data science [1; 3; 5]. Large corporations like Google, Microsoft and IBM have introduced mentorship programs, diversity hiring goals and bias training to improve gender representation. Meanwhile, universities are launching STEM scholarships aimed specifically at women and conducting outreach campaigns to challenge stereotypes.

Governments also play a crucial role by enacting policies that support gender equality in education and employment. Policies such as paid parental leave, equal pay legislation and gender-responsive education programs are instrumental in creating a more level playing field. Despite positive developments, challenges remain. Cultural resistance, deep-seated stereotypes and the underrepresentation of women in decision-making roles require sustained efforts. Achieving gender equality in technology demands a comprehensive strategy that combines education reform, workplace transformation and societal attitude changes.

In conclusion, gender equality in the tech industry is not solely about addressing injustice. It is about harnessing the full potential of the workforce to drive innovation, economic growth and societal progress. The future of technology and society itself will be stronger, more inclusive, and more successful when built by all people, regardless of gender.

References:

1. Girls Who Code. (n.d.). Girls Who Code. URL: https://girlswhocode.com

2. McKinsey & Company. (2020). Diversity Wins: How Inclusion Matters. McKinsey & Company. URL: https://www.mckinsey.com/business-functions/organization/our-insights/diversity-wins-how-inclusion-matters

3. SheCodes. (n.d.). SheCodes. URL: https://www.shecodes.io

4. United Nations. (n.d.). Goal 5: Gender Equality. United Nations Sustainable Development. URL: https://www.un.org/sustainabledevelopment/gender-equality

5. Women Who Tech. (n.d.). Women Who Tech. URL: https://womenwhotech.com

6. World Economic Forum. (2023). Global Gender Gap Report 2023. World Economic Forum. URL: https://www.weforum.org/reports/global-gender-gap-report-2023

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Innovative technologies in marketing: creating virtual environments and using them in management

Modern technologies are evolving at a rapid pace, thereby providing new opportunities in obtaining information, entertainment, and work processes. One such technology is virtual reality (VR) – a type of reality in the form of the identity of the material and the ideal, which is created and exists due to another reality or an illusion of reality generated by computer systems that provide visual, auditory, and other sensations [1]. Simply put, it is an artificial environment that exists in images but not in real life.

Virtual reality belongs to the category of interactive tools, which, through a 360° image, can transport a person into an artificial world where the environment is fully constructed using information technologies, and one can even immerse oneself in this virtual space using special mechanisms: a virtual reality headset or VR glasses, as well as various controllers [4].

Virtual reality has found wide application in the fields of education, entertainment (including computer games), robotics management, economics, production, marketing, management, and others. The use of virtual reality opens up many new opportunities in any of these areas, which are quite complex, time-consuming, or costly under traditional approaches. Therefore, four main advantages of using this technology are highlighted:

1) Visualization.

In a virtual environment, any process or object can be examined in detail without hindrance. This provides a realistic picture that cannot be seen in real life. Additionally, there are no restrictions to delve deeper and examine everything in the smallest detail [2].

2) Safety.

With the help of VR technologies, complex operations can be carried out, experiments can be performed; viewers can be immersed in any real-life situation without the slightest threat; images of economic models can be obtained and their further development planned; personnel management skills can be trained [2].

3) Focus.

The viewer is not distracted by external stimuli, thereby being fully focused on interactive actions in the virtual environment and concentrated on the material [2].

4) Engagement.

This technology offers many opportunities for full control over the scenario and the ability to influence the course of events [2].

Modern technologies bring necessary changes to learning and work processes. With the help of virtual reality tools, it is possible to create an inclusive learning environment, as well as provide jobs for people with physical, social, or cognitive impairments, taking into account the abilities and needs of each individual. Conducting interactive seminars, training sessions, demonstrating all aspects of a real object or process, remotely controlling technical means – all of this is made possible through the use of VR technologies [3].

In marketing and management, they can be used as follows:

1) VR in Management:

- Staff training. For example, large corporations already use these technologies to simulate work situations (crisis situations, logistics processes, customer service), thereby preparing employees without risks and unnecessary costs.
- Meetings and negotiations. Instead of classic video conferences, they allow the creation of a space that provides participants with a sense of "presence," simplifying communication in international companies.

2) VR in Marketing:

- Presentations and VR tours for real estate companies, where they offer 3D tours of buildings, allowing potential buyers to experiment with changing interiors, furniture, or the arrangement of details in the apartment.
- Promotional campaigns, where consumers can easily immerse themselves in the world of the brand (for example, Coca-Cola has created VR scenarios to immerse viewers in the festive atmosphere).
- Virtual fitting applications, which allow users to try on makeup, products, etc., through the camera of any device.

The use of modern technologies such as virtual reality in various spheres of life provides significantly more opportunities for interactive actions, obtaining information, and allows for the transformation of certain work and learning processes, improving efficiency. In marketing and management, they enable reducing training costs, optimizing management processes, increasing company competitiveness, and offering new tools for interaction with the product.

Additionally, the use of VR reveals new aspects previously impossible to see or experience for any viewer, thanks to its functions, which opens up new paths for innovation and the continuous development of information technologies. Therefore, virtual environments and the introduction of similar technologies play a key role in understanding the world through interactive participation and full engagement of participants in the process.

References:

1. Wikipedia: Virtual Reality. (2023). Wikipedia. URL: https://uk.wikipedia.org/wiki/Віртуальна_реальність
2. Trach, Y. (2017). VR technologies as a method and tool of learning. *Osvitolohichnyi Dyskurs*. https://doi.org/10.28925/2312-5829.2017.3-4.3932
3. Osvitoria Editorial. (2021). Virtual and augmented reality: how new technologies inspire learning. URL: https://osvitoria.media/opinions/virtualna-ta-dopovnena-realnist-yakoyu-mozhe-buty-suchasna-osvita/
4. D'Souza, J. (2024). VR headset statistics by unit sales, geography, shipments, and usage. *Coolest-gadgets.com*. URL: https://www.coolest-gadgets.com/vr-headset-statistics

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Harmful driver bias: the impact of gender stereotypes on women's safety and public perception

Despite persistent stereotypes, the evidence overwhelmingly shows that women are better, safer drivers than men. Numerous studies confirm that men cause twice as many fatal crashes per mile driven as women [1], while also performing worse on a wide range of driving skills [2]. Nevertheless, cultural perceptions continue to paint women as inferior drivers. A closer analysis of available data reveals how male overconfidence, psychological biases, outdated cultural narratives, and gendered power structures sustain this false belief, often with dangerous real-world consequences.

Data across various studies paints a clear picture: men are significantly more likely to cause fatal car accidents. They are also more prone to hitting vehicles, potholes, and road objects, braking or accelerating suddenly, and missing parking spots due to speeding [2]. In contrast, independent driving evaluations consistently show women outperforming men. Women park more accurately [3], back into spaces better, and score higher on formal driving tests. Even regarding navigation, men drive 276 more miles a year due to getting lost – 20 miles more than women [4]. Measured objectively, women display stronger driving competence across nearly all key indicators.

Paradoxically, men report far greater confidence behind the wheel. According to surveys, 82% of male drivers describe themselves as "very confident" [5]. However, this self-assurance does not correlate with better outcomes. Instead, it leads to riskier behaviors such as drunk driving, reckless speeding, and greater involvement in fatal accidents [5]. The pattern persists into older age: even among drivers in their seventies, men fail road tests at a higher rate than women. In short, men's confidence far exceeds their actual abilities behind the wheel, and this misplaced confidence is often deadly.

The consequences of male reckless driving also disproportionately harm women. Women are 73% more likely to be injured in crashes caused by men [5]. Furthermore, stereotypes portraying women as poor drivers amplify these risks. Research on stereotype threat – a psychological phenomenon where being aware of a negative stereotype worsens performance – shows that women's driving skills suffer when reminded of the "bad woman driver" narrative [6]. Instead of reflecting natural ability, poorer outcomes under stereotype threat stem from increased anxiety, self-monitoring, and cognitive overload. Thus, stereotypes not only misrepresent reality but actively sabotage women's real-world driving performance.

The persistence of the "bad woman driver" myth cannot be understood without addressing deeper patriarchal structures. Patriarchy, as a system that historically positions women as less capable in public spheres, benefits from reinforcing narratives of female incompetence. Driving, symbolizing autonomy and independence, became a highly gendered domain during the early twentieth century, when mass automobile adoption coincided with women's expanding social freedoms. Cultural historians such as Cotton Seiler have shown that jokes, cartoons, and popular media consistently portrayed women drivers as comically inept – a direct response to growing fears about women's independence [7].

These stereotypes served (and continue to serve) broader societal goals:

- limiting women's autonomy by casting them as unfit for independent mobility;
- justifying male dominance in public and professional spaces;
- undermining women's credibility not just behind the wheel, but across fields requiring judgment, competence, and leadership.

Psychological research also supports this dynamic. The availability heuristic causes people to recall striking or stereotype-confirming events more readily. Thus, a woman's minor driving error becomes "evidence" of her incompetence, while similar mistakes by men are dismissed as individual incidents. Confirmation bias then reinforces these misperceptions over time, selectively noticing what fits existing beliefs and ignoring contrary evidence.

Moreover, viewing women as inferior drivers parallels a broader societal tendency to depict women as less competent across multiple domains – leadership, scientific reasoning, financial management – despite overwhelming data showing women's equal or superior performance in many of such. The stereotype of the bad woman driver fits into a much larger narrative that positions women as emotional, irrational, and prone to error – a narrative that ultimately benefits systems of male privilege by justifying exclusion and diminished opportunities.

The consequences of this bias are not limited to reputational harm. They have tangible, dangerous outcomes. When women internalize stereotypes about their supposed incompetence, they may experience increased driving anxiety, which impairs performance and increases accident risk. Furthermore, underestimating female drivers can lead to dismissive attitudes toward their safety concerns, less rigorous enforcement of protective measures, and even poorer vehicle design standards – as many crash test protocols historically prioritized male body models, resulting in higher injury risks for women [1].

In summary, empirical evidence consistently shows that women are safer, more competent drivers than men. Men's greater overconfidence contributes to higher rates of reckless behavior and fatal accidents, while women, despite better driving records, suffer both physical harm and reputational damage due to persistent stereotypes. The belief in female driving incompetence does not arise from reality, but from cognitive biases, cultural inertia, and patriarchal systems that benefit from undermining women's perceived competence. Challenging these myths is not only a matter of correcting public opinion – it is an urgent issue of safety, fairness, and social equity.

References:

1. R. Aldred, R. Johnson, Ch. Jackson, J. Woodcock. How does mode of travel affect risks posed to other road users? An analysis of English road fatality data, incorporating gender and road type – 2020. Available from: https://injuryprevention.bmj.com/content/27/1/71.abstract

2. N. Kalula. Netstar data shows women are better drivers than men. Carmag – 2022. Available from: https://www.carmag.co.za/news/data-shows-women-are-better-drivers-men/

3. V. Ko. What Stereotype? Women Are Better Than Men at Parking, Study Finds. Time – 2012. Available from: https://newsfeed.time.com/2012/01/30/what-stereotype-women-are-better-than-men-at-parking-study-finds/

4. Male Drivers Lost Longer Than Women. ABC News – 2010. Available from: https://abcnews.go.com/Travel/male-drivers-lost-longer-women-refuse-directions/story?id=11949176

5. Men are more confident drivers, but data shows women are safer. The Zebra – 2024. Available from: https://www.thezebra.com/resources/driving/gender-driving-confidence-survey/

6. A. Moè 1, M. Cadinu, A. Maass. Women drive better if not stereotyped – 2015. Available from: https://pubmed.ncbi.nlm.nih.gov/26457739/

7. C. Seiler. Republic of drivers: A cultural history of automobility in America – 2008. Available from: http://dx.doi.org/10.7208/chicago/9780226745657.001.0001

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Taxation Management in the Times of Social Challenges

Taxation management is, on the one hand, a system of methods and principles of developing and implementing decisions about the tax system selection, tax payments calculation, and continuous execution monitoring, and on the other, a process of managing taxes, regulating financial "business-state" and "workers-state" relations, and forming revenues of the state budget [4, p. 82]. Currently, the global world is facing an economic and geopolitical instability due to the wars in Ukraine and Gaza, and strict US customs policy, not mentioning that it there were already a lot of turbulences in past, the latest of which was the COVID-19 crisis. To understand the scale of the spread of so called "social challenges," the countries that suffer fragility or are conflict affected are populated by approximately one billion people and are at risk of not only sliding beneath their pre-turbulence state, but also failing the Sustainable Development Goals [2]. Every precariousness brings a wide range of problems such as GDP slowdown, inflation, incensement of a public debt and the unemployment rates, and in the process of overcoming these difficulties taxation deserves a special attention, and the measures taken ought to be beneficial for taxpayers as well as governments [3, p. 155, 157]. Therefore, an effective fiscal policy is an essential component of ensuring the sustainability and growth of any state.

1. Basic tax rules for crisis periods. One of the most important steps in any "swampy" challenged agenda it to **assess the risks and plan** different **scenarios** [3, p. 155]. The authorities have to understand what are the most, the least profitable and the midpoint course of events [5, p. 3]. In order to manage taxation processes in the turbulent times, state tax services should **understand the possible impacts of the exact challenge** on the economy (and revenue collection as well), answering such questions as what those potential economic burdens are, how they are presented and when they will appear, who will have to bear them, how the potential revenue loss is estimates and what actions of the authorities can ease the trouble. The interests of not only the society but also those of the business have to be taken into consideration – there it should be assessed what business processes may be affected, how that will influence domestic and foreign markets, who, where and when receives the goods and services produced [5, p. 2].

2. Personal security of tax service employees and taxpayers. That is not an exaggeration to say that nowadays modern digital technologies allow to significantly reduce the costs of certain processes and do not require the recipient and the service provider to be physically in the same space. This benefit must be used in order to provide and maintain the security of the population and the tax service workers. (For instance, in case of a disease spread this measure prevent infection, and if the military conflict is ongoing, such a step helps to preserve people in the secure places.) In other words, **the use of digital channels for interaction with taxpayers** is utterly recommended [3, p. 155]. Most of the non-essential activities must be performed remotely [5, p. 3-4]. In addition, **digitalisation and simplification of the revenue collection process helps to reduce the number of unnecessary delays and level of bureaucracy** [1, p. 45].

3. Easing fiscal requirements. The demands towards collecting the taxes may be softened in different ways. First of all, **the extension of deadlines** is recommended. The deadline for submitting tax returns can be extended according to the wide range of principles (separately for conscientious payers, or installing flexible plans of payment by the means of increasing deadlines for filling out documentation or reducing the number of reports during the year etc.) [3, p. 155; 5, p. 4]. **Obligations payment flexibility** might be another relief for the business and workers [3, p. 155]. **The suspension of certain payments** may be also a good idea [5, p. 4]. Measures aimed at **bringing the "shadow" sector "under the light" of the law** are also advisable as this may help with the economic activity intensification and economic growth boost [3, p. 157].

In addition, **fines, penalties and control measures application may also be cancelled** for some groups or in conditions of extreme harshness. The suspension may be either full or partial, taking into consideration the essence of work, goods and services, the challenge itself, the time, speed and area of its spread. What may also be put aside are the **advance payments** [3, p. 155-156; 5, p. 4-6]. Such compliance and enforcement activities as audits and checks are recommended to be suspended or limited as well [5, p. 5].

Targeted tax revenue indicators must be adequately **revised** as usually there is no possibility of meeting the pre-turbulence requirements during the period of unease [3, p. 156; 6, p. 7]. **Deductions, discounts and other tax incentives** may take place. Taxation objects' social significance will be helpful in defining the spheres that need more soft terms of fiscal policy [3, p. 155, 157; 5, p. 6]. **The speed of the tax return** is also advices to be quickened, prioritising food, essential services and goods [3, p. 155; 1, p. 44]. **Tax rates are preferable to be temporarily reduced** [3, p. 155]. Here the authorities should be careful and precise in defining the period of this relief, its scope and eligibility criteria [5, p. 5-6]. Additionally, economic entities may be also given some **"non-refundable financial support"** in order to preserve the jobs existing. To ensure rapid response capacity in the regions of the state, it is necessary to transfer additional **interbudgetary funds onto the local budgets balance** [3, p. 157]. **Free donations** on the accounts of the enterprises should also be widely supported and less taxed [6, p. 6].

4. Is there really any need to strengthen the imposts. The experience of the war-time taxation of World Wars I and II showed a growing need to finance weapon production and security expenditures and led to **the increasing of taxation among the fighting states**. In particular, in the meantime of the World War II, marginal income tax rates rose to peak levels in the United States, the United Kingdom (90%), and Sweden (70%) [7]. The taxes went upwards during these two military conflicts and some period longer [6, p. 313]. Middle as well as low classes were affected by the income tax expansion, which was caused by inflation as “higher prices reduced the real value of tax thresholds” [6, p. 312]. The burden of taxation, extended onto the mentioned groups, also helped against inflation, reducing their purchasing power [6, p. 314, 318]. After the wars, the revenue collection indicators were never back on the pre-conflict level [6, p. 311, 331].

5. Post-turbulence period. Despite all the recommendations to ease the burden on businesses and households during the crisis periods, **in Ukraine war case** an agreement with the IMF about **the need to boost taxation revenues** was reached in 2022, shaped into the Program Monitoring with Board involvement (PMB). It claimed the necessity to cancel tax audits moratorium, re-establish the **pre-war tax payment regime** instead of 2% tax, and ensure the cash registers use enforcement in shops until January 2023 [1, p. 34]. This point supports the outlook elaborated in the previous section of the paper about the need to increase taxes during the military conflicts to enable the functioning of the economy and cover security expenditures.

Considering the example of Ukraine further, it is widely said that post-war taxation policy of the state should be aimed and increasing of revenues. Such approach is dictated not only by the fact of higher pre-turbulence rates, or low government revenues, or big public debt. As every challenge leaves certain consequences behind, **higher expenditures are required to overcome them** [1, p. 43]. The raising of social security contributions, elimination of the SSC cap, progressive personal income tax and additional top 1-5% earners rate implementation may be expected [1, p. 44]. Moreover, the IMF recommends the states that are undergoing military conflicts to bring the highest possible **transparency to their taxation systems** and introduce **proportional taxes**. As any crisis results into limited tax control, such an approach helps to reduce the wishes for tax legislation violations [7].

In conclusion, taxation management is one of the tools of stabilizing the crisis periods and easing the economic burdens of both households and businesses. In the times of social challenges, it is recommended to perform the risks assessment and scenario planning, and carry out the majority of the processes online in order to maintain safety of both taxpayers and tax service workers. The extension of payment and reporting deadlines, suspension of some taxes and fines, lowering of revenue indicators and tax rates bring the support and relief to those economic active ones, but the necessity of increasing tax requirements to enable state’s capability of dealing with crisis is not rare as well. Anyway, it is worth paying attention at the specific conditions of every problem, the area it covers, and the peculiarities of the society it influences. Best international practices and experiences may play in hand, but all the challenges require a unique approach towards solving them and dealing with the consequences.

References:

1. Bogdan T., Jovanović B. Public expenditure and tax policy for the post-war reconstruction of Ukraine. Policy Notes and Reports. No. 69. 2023. 68 p.

2. IMF Executive Board Supports New Strategy for Fragile and Conflict-Affected States. *International Monetary Fund*. URL: https://www.imf.org/en/News/Articles/2022/03/14/pr2275-imf-executive-board-supports-new-strategy-for-fragile-and-conflict-affected-states (date of access: 17.03.2025).
3. Savitska S., et al. Tax systems of Ukraine and EU countries during the COVID-19 pandemic: current status and prospects. *Independent Journal of Management & Production*. Vol. 13, no. 3. P. 2022.
4. Sokolova L., Sokolov D. Tax Management in the Enterprise Management System in Ukraine at the Current Stage. SJ-Economics Scientific Journal. 2024. Vol. 55, no. 4. P. 82-89.
5. Suggested COVID-19 measures for tax administrations (2020). URL: https://www.ataftax.org/ataf-publishes-measures-to-help-manage-the-impact-of-covid-19-on-tax (date of access: 17.03.2025).
6. Torregrosa-Hetland S., Sabaté O. Income tax progressivity and inflation during the world wars. *European Review of Economic History*. August 2022. Vol. 26, no. 3. P. 311-339.
7. Zolkover, Andrii, et al. Fiscal measures and their consequences: European experience against Ukrainian perspectives. *Archives des Sciences: A Multidisciplinary Journal* (2024).

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Formation of marketing policy of enterprises in the conditions of economic crisis and martial law

Modern Ukrainian businesses operate in an extremely challenging environment caused by a combination of a protracted economic crisis and martial law. This combination of external challenges is radically transforming the market environment, affecting the purchasing power of the population, logistics, demand structure and the competitive field. In these conditions, the marketing policy of enterprises ceases to be just a tool for promoting products – it becomes a means of strategic adaptation to the new reality.

Developing an effective marketing policy in a crisis requires businesses to be flexible, responsive, reoriented to new communication channels, digitalized and focused on customer needs. At the same time, businesses are faced with limited resources, high uncertainty and the need to remain competitive in the face of limited domestic demand and difficult access to international markets.

One of the key requirements for marketing policy in such conditions is its flexibility and ability to quickly adapt to changes. As noted in the studies, such a response by enterprises is necessary to maintain their competitiveness and market leadership [1]. This implies constant monitoring of the market situation, analysis of consumer trends and prompt adjustment of marketing strategies.

Due to the economic crisis, companies are forced to review their pricing policies, as the decline in consumer purchasing power has a significant impact on demand. In such circumstances, businesses can focus on creating budget options or offering discounts to maintain customer loyalty and keep demand for their products high. For example, in 2022-2023, EVA actively promoted its own TMs (private labels) in the lower price segment to meet demand in a situation of overall cheaper consumption.

Due to restrictions on physical interaction and mobility caused by the crisis or military situation, the importance of digital communication and sales channels is growing significantly. Companies are increasingly using online marketing tools, such as social platforms, targeted advertising, email newsletters and other digital tools, to effectively promote their products and services [1]. An important element of digital marketing is the creation of high-quality content that helps companies prove their competence, attract the attention of the audience and strengthen their reputation [3]. At the same time, digitalization opens up new opportunities to optimize marketing costs and increase the effectiveness of communications with the target audience [2]. For example, Rozetka reformatted its social media advertising in the first months of the full-scale invasion with a focus on the availability of essential goods and stability of work, which helped it maintain audience loyalty.

In a crisis, not only economic but also psychological factors affecting consumer behaviour change. People are becoming more anxious, emotional and sensitive to social issues. Therefore, the marketing policy of enterprises should take into account these changes and be based on the principles of empathy, support and social responsibility. In particular, a significant number of consumers emphasise that it is important for them to feel cared for and supported by their favourite brands and trademarks [3]. This means that companies should actively communicate with their audience, express support, participate in social initiatives, and demonstrate their concern for the problems of society. For example, during the war, Nova Poshta launched communication campaigns focusing on customer care, assistance to the Armed Forces, and support for local entrepreneurs, which significantly enhanced its reputation.

In addition, in times of martial law or a deep economic crisis, security and stability issues come to the fore for consumers. Businesses should take this factor into account in their marketing policy, emphasising the safety of their products, the reliability of their services and the stability of the company [3]. It is also important to ensure the safety of staff and customers by taking the necessary protective measures.

In such situations, additional restrictions and challenges arise for the marketing activities of enterprises. Consumers' priorities change, logistics chains are disrupted, and problems arise with the supply and sale of products [1].

Businesses should constantly monitor changes in the market situation and changes in consumer demand, develop approaches to effective risk response, update logistics schemes and supply systems, actively interact with customers, form strong partnerships with key market participants, pay attention to innovation and research, and regularly review marketing costs to optimise them [1,2].

In my opinion, in the context of economic instability and military operations, the adaptation of marketing policy is not just desirable, but a vital condition for business survival and development. Businesses that are able to respond quickly to changes, innovate and build strong customer relationships have a better chance of not only surviving the crisis, but also emerging from it stronger and more competitive. It is important to remember that marketing is not only about promoting products or services, but also about building relationships with people, supporting them and meeting their needs, especially in difficult times.

So, in the current environment of turbulence and uncertainty, marketing policy is becoming a key tool for ensuring the sustainability and further development of enterprises. Its effectiveness is determined by the ability of companies to be flexible, innovative and customer-focused, which allows them not only to adapt to challenges but also to find new opportunities for growth.

References:

1. Savytska N., Bubenets I., Zakovorotnyi I., Ihnatenko O. (2024). Formation of the marketing policy of enterprises under martial law. Herald of Khmelnytskyi National University. Economic Sciences, 328(2), 330-335. URL: https://doi.org/10.31891/2307-5740-2024-328-55

2. Shostak L.V., Lipych L.G., Morokhova V.O. Features of the formation of a marketing strategy for enterprise development in the context of digital transformation, economic and political changes and wartime. Transformational economy. 2023. № 4. C. 86-90. URL: https://transformations.in.ua/index.php/journal/article/view/53/52.

3. Migal, O., & Kvasovskyi, D. (2024). Formation of the marketing complex of enterprises in wartime. Economy and society, (64). URL: https://doi.org/10.32782/2524-0072/2024-64-80

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Leadership as a Key Component of Effective Enterprise Management

In light of global changes in the external environment marked by high levels of dynamism and uncertainty business organizations increasingly recognize the need to adapt and reengineer their business processes. A pivotal role in these transformations belongs to a new generation of managers: leaders capable of making strategic decisions and managing change [1]. Leadership is fundamental to the development of strategy, the implementation of innovation, the achievement of competitiveness, and the execution of effective crisis management.

Nowadays, not every manager who successfully fulfills their functional responsibilities feels equally confident when faced with interpersonal challenges within the team—challenges that can undermine cohesion and collective performance. Managing people remains one of the most complex and demanding aspects of organizational leadership. Moreover, not all managers inherently possess the leadership qualities that are essential for guiding subordinates effectively [2]. Consequently, the issue of leadership continues to attract significant attention and retains its relevance, as leadership, in one form or another, is now a necessary attribute in most professional fields.

Before analyzing the role of a leader within an organization, it is important to understand what leadership truly entails.

The terms *"leader"* and *"leadership"* originate from the Anglo-Saxon root lead (which translates into Ukrainian as "path"). This root is derived from the verb *leaden*, meaning *"to travel"* or *"to go"*. According to the Oxford English Dictionary (1933), the word *"leader"* emerged in the 13th century, while the concept of *"leadership"* began appearing in scholarly texts at the start of the 19th century. This, of course, does not mean that the phenomenon of leadership itself did not exist earlier. Leadership naturally arises in any group of two or more individuals, and is especially prominent in large organizations and social structures. Leadership is best understood as a dynamic relationship between a leader and the group members—one in which both parties influence one another while striving toward meaningful change and shared goals. The leaders of today's generation play a decisive role in this process by utilizing advanced management technologies and guiding others through innovation and vision.

A true leader is someone who inspires others through personal example, guides them along successful paths, and teaches by doing. In various academic and practical sources, a leader is defined as a person within a group or organization who holds recognized authority and influence, plays a central role in coordinating collective efforts, regulates interpersonal dynamics, and makes responsible decisions in critical situations [2]. A leader thinks in broad, strategic terms—anticipating future opportunities, creating a shared vision of success, and demonstrating technical competence. Furthermore, effective leaders delegate authority, foster teamwork, embrace change, value diversity, and cultivate a sense of partnership and constructive dialogue within their teams.

Undoubtedly, the success of any business largely depends on who its leader is. As Alexander the Great once remarked: *"I am not afraid of an army of lions led by a sheep; I am afraid of an army of sheep led by a lion"* [3]. A professional leader motivates and guides the team forward. To achieve optimal results, the leader must build a cohesive, committed, and motivated group. Team members—regardless of their formal power—must trust the leader and work together toward shared accomplishments. In turn, the leaders bear tremendous responsibility. They must manage their time and energy wisely, avoid missteps, and uphold the trust of the team. This is not an easy task. That is why anyone aspiring to lead must possess a range of essential leadership qualities, such as: willingness to take calculated risks; proactive and purpose-driven mindset; honesty, fairness, reliability, and accountability; forward-looking perspective; and the ability to empower others and foster their self-realization [2].

Modern leadership theories highlight a range of leadership styles that managers may adopt, including **transformational**, **transactional**, **situational**, and **servant leadership**. For instance, transformational leaders focus on inspiring individuals to exceed expectations by reshaping their beliefs and values. Transformational leaders, for example, focus on inspiring employees to exceed expectations by changing their views and beliefs, while transactional leaders manage through established procedures, rewards, and punishments. Understanding these styles is vital for leaders seeking to choose the most appropriate approach to different circumstances and individual team members.

Over the past few years, **emotional intelligence (EQ)** has become recognized as a vital trait of a leader. Leaders with high emotional intelligence better understand and manage their own emotions, as well as recognize the emotions of others and influence them. This skill set enables them to resolve conflicts constructively, build trusting relationships, and create a workplace culture in which employees feel valued and engaged. Emotional intelligence significantly enhances a leader's ability to unite, motivate, and elevate a team [4] and plays a vital role in both professional development and the broader competitiveness of the organization.

It should be concluded that leadership is an indispensable component of effective management and a cornerstone of success in the modern professional landscape. The leader holds a central position in driving innovation, introducing new forms of work, and implementing strategies to meet evolving goals and market needs. It is evident that organizations with strong leaders are better positioned to achieve success rapidly and sustainably. A manager equipped with true leadership capabilities is more than a functionary—they are a visionary capable of navigating challenges and elevating the entire organization to new heights. Therefore, the key to effective management lies in the deliberate and thoughtful application of leadership principles and tools.

References:

1. Комарова К.В. Проблеми та необхідні умови розвитку інноваційного лідерства в Україні. *Наукові конференції*. URL: http://www.konferenciaonline.org.ua/ua/article/id-774/ (date of access: 15.04.2025).

2. Поняття лідерства та керівництва. *Освіта.UA*. URL: https://osvita.ua/vnz/reports/psychology/10041/#google_vignette (date of access: 15.04.2025)

3. 10 Famous Leadership Quotes. *QuestionsAnswered.net*. URL: https://www.questionsanswered.net/article/10-famous-leadership-quotes (date of access: 15.04.2025).

4. Важливість емоційного інтелекту в сучасному лідерстві. *Кафедра менеджменту Львівської комерційної академії*. URL: https://surli.cc/bmklbk (date of access: 15.04.2025).

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Green Finance and Innovation: Catalysts for Advancing the Circular Economy

The growing urgency of climate change, biodiversity loss, and unsustainable resource use demands a fundamental transformation in global economic practices. The traditional linear model of production and consumption – defined by a “take-make-dispose” approach is proving increasingly incompatible with ecological limits. As a response, the circular economy (CE) has gained traction as a sustainable alternative, emphasizing strategies such as reuse, recycling, renewable inputs, and long-term value preservation. Yet, for this transformation to move beyond rhetoric and into practice, it must be supported by mechanisms capable of financing and enabling systemic change. Among the most critical of these mechanisms are green finance (GF) and green innovation (GI), both of which play complementary roles in fostering circularity at scale.

Green finance refers to a suite of financial products, services, and policies designed to support environmentally beneficial activities. These include green bonds, climate funds, and ESG-linked investments that direct capital flows toward projects aligned with sustainable development goals. In the context of circular economy implementation, green finance helps fund the development of eco-efficient infrastructure, clean technologies, and sustainable supply chains. More importantly, it helps reduce the perceived financial risk associated with green projects, thus attracting greater participation from both institutional and private investors. However, the credibility and effectiveness of green finance initiatives depend on transparent regulatory frameworks and reliable classification systems. Without standardization and oversight, the risk of greenwashing where environmentally harmful practices are disguised as sustainable could erode public trust and financial impact [1].

In tandem with financial strategies, green innovation acts as the technical driver of circular economy practices. It refers to the development and application of new products, services, processes, and business models that reduce environmental footprints and promote resource efficiency. Examples include industrial symbiosis, modular product design, biodegradable materials, and digital tools that monitor material flows across lifecycles. Recent technological advances such as blockchain, artificial intelligence (AI), and the Internet of Things (IoT) are increasingly being integrated into circular systems to enhance traceability, optimize energy consumption, and enable closed-loop supply chains. These technologies not only improve operational efficiency but also offer new ways to measure and verify environmental outcomes. Despite this promise, many green innovations face adoption barriers such as high initial investment, uncertain economic returns, and lack of technical knowledge particularly in low- and middle-income countries [1; 2].

The synergy between green finance and green innovation forms a critical foundation for circular economic systems. Financial support is indispensable for the research, development, and scaling of green technologies. At the same time, proven innovations can increase investor confidence by demonstrating the viability and profitability of sustainability-driven models. This feedback loop strengthens the business case for circular practices and drives broader economic participation. Government policies can further reinforce this dynamic by offering tax incentives, subsidies, and public-private partnerships that lower entry barriers for firms and entrepreneurs. Importantly, effective integration of finance and innovation must be embedded in coherent policy strategies that are sensitive to regional needs and levels of economic development [2].

Nonetheless, realizing the full potential of this transformation requires overcoming several obstacles. A major challenge is the lack of unified definitions and metrics to assess what qualifies as ‘green’ or ‘circular,’ leading to inconsistencies in policy implementation and financial reporting. Furthermore, many developing countries remain excluded from these advancements due to limited access to finance, weak institutional capacities, and inadequate infrastructure. This disparity threatens to widen the global sustainability gap unless deliberate efforts are made to promote inclusive access to both financial and technological resources. Future research should therefore explore context-specific models for CE adoption, behavioral incentives for sustainable investment, and innovative platforms for democratizing access to green finance and innovation.

In conclusion, the transition to a circular economy is not just a technological or financial issue – it is a systemic shift that requires the integrated mobilization of capital, innovation, and policy support. Green finance and green innovation, when effectively combined, can serve as powerful levers for enabling this transformation. Together, they support the creation of resilient, inclusive, and regenerative economic systems that prioritize long-term environmental health and social well-being. As the world moves toward a more sustainable future, unlocking this synergy will be vital for addressing not only ecological concerns but also fostering economic stability and equity.

References:

1. Usman, M., Wang, X., Iqbal, M., et al. (2023). *Adoption of Green Finance and Green Innovation for Achieving Circularity: An Exploratory Review and Future Directions*. Geoscience Frontiers, 15(4), 101669. https://doi.org/10.1016/j.gsf.2023.101669
2. Tian, F., Irfan, M., Zhang, Z., et al. (2023). *Nexus between Green Finance, Green Innovation and Circular Economy: A Roadmap toward Sustainable Development*. Green Energy and Environment. https://doi.org/10.1016/j.gee.2023.03.005

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Innovative Approaches to Ensuring Sustainable Regional Development in the Context of Digitalization and Environmental Challenges

Sustainable regional development is one of the priority tasks of the modern economy, requiring a comprehensive vision and integration of economic, social, and environmental interests. In the context of global transformations, including climate change, urbanization, and digitalization, innovative management solutions are gaining particular significance. These solutions ensure the efficient use of regional resources and the implementation of new technologies to achieve balanced development.

Today, regional governance is increasingly oriented towards digital technologies, which serve as an effective tool for improving decision-making and enhancing regional management efficiency [2, p. 336]. Digitalization enables the implementation of modern territorial management models, among which the concept of “smart cities” holds a prominent place. This concept integrates environmental standards into all areas of life, promotes rational resource management, and employs intelligent monitoring systems. Digital solutions, such as big data analytics (Big Data), the development of e-government, and intelligent transportation systems, not only streamline administrative processes but also significantly improve interaction between authorities and citizens, enabling rapid responses to challenges and public needs. Another crucial step in this direction is the automation of municipal management systems, which facilitates the rational use of resources and enhances service quality.

At the same time, the modern model of regional development is increasingly oriented towards the principles of the green economy. This approach involves the ecological modernization of industries, the promotion of renewable energy sources, and the support of green entrepreneurship. Innovations in the green economy sector not only reduce the environmental burden of industrial activity but also create additional economic opportunities for regional development. One effective mechanism in this regard is the application of circular economy principles, which focus on waste reduction and material reuse, ensuring closed-loop production cycles [1, p. 157]. European experience demonstrates the feasibility of combining economic growth with environmental security through the financing of innovative projects and the development of green city infrastructure, featuring efficient transportation systems, energy-efficient buildings, and innovative waste management methods.

Social innovations also play a crucial role in ensuring sustainable development, as they open new opportunities for citizen participation in governance processes. The activation of civic engagement through digital platforms, the use of crowdfunding tools to support local environmental and social initiatives, and the expansion of educational programs on environmental awareness help shape a new model of interaction between society and government. This contributes to increasing public trust in state institutions, fostering responsible attitudes towards the environment, and enhancing the effectiveness of regional strategies.

Overall, innovative approaches to regional development management should form the foundation of a new paradigm of regional policy that accounts for modern global challenges and focuses on long-term sustainability. Regional development cannot be limited to economic growth indicators alone; essential conditions for successful development include maintaining environmental balance, ensuring social justice, and using resources rationally.

In this context, close cooperation between governmental institutions, businesses, and civil society is becoming particularly relevant.

Such a tripartite alliance creates conditions for the development and implementation of effective regional strategies capable of simultaneously achieving economic, environmental, and social objectives. An essential component of this process is also the adoption of international experience and innovative technologies, enabling regions not only to adapt to modern conditions but also to act as active participants in the global economy.

Thus, an innovative approach to managing sustainable regional development is not only a contemporary challenge but also an opportunity to create qualitatively new governance mechanisms that ensure economic competitiveness, social well-being, and environmental security. By combining cutting-edge technologies, ecological responsibility, and active citizen participation, it is possible to develop a modern regional development model that addresses both societal needs and contemporary challenges.

References:

1.Anfilov D. Strategies and Prospects for Sustainable Urban Development in Ukraine. *Bulletin of Khmelnytskyi National University*. Series: Economic Sciences. 2025. No. 1. P. 334-342. [In Ukrainian].

2.Pizhuk O. I., Plakhotniuk V. V. Innovative Approaches to Regional Development: The Concept of a "Digital City." *Regional Economy*. 2024. No. 4 (62). P. 154-160. [In Ukrainian].

3.On the Approval of the State Strategy for Regional Development for 2021-2027: Resolution of the Cabinet of Ministers of Ukraine dated August 5, 2020, No. 695. URL: https://zakon.rada.gov.ua/laws/show/695-2020-%D0%BF#Text (Accessed: February 13, 2025). [In Ukrainian].

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Digitalisation of Ukraine's economy as a tool for sustainable development

The current stage of global economic development is characterised by qualitative changes driven by intensive digital transformation. This process involves not only technological modernisation, but also a fundamental change in the approach to business, where digital solutions are becoming a key factor in improving the competitiveness of national economies. This topic is particularly relevant in the context of the formation of a new model of the global economy based on knowledge and innovation.

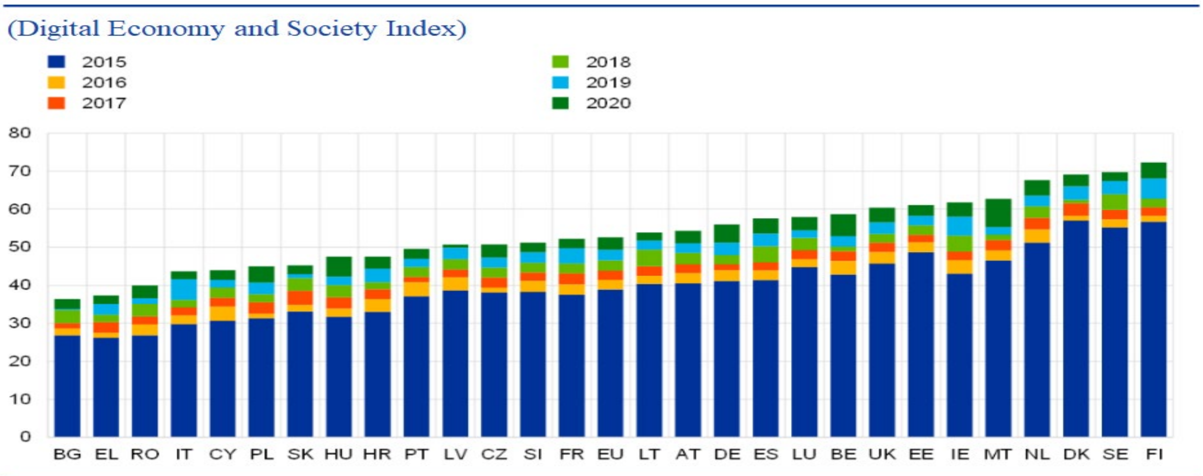

Figure 1. Dynamics of digitalisation in the Eurozone and the EU [1]

An analysis of current economic trends shows that there is a close relationship between the level of digitalisation and economic growth. This dependence is particularly evident in countries with highly developed institutional mechanisms to support innovation. At the same time, digital transformation is accompanied by a number of structural changes, including the transformation of the labour market, the emergence of new forms of employment, and the emergence of technological asymmetries that require comprehensive scientific research (Figure 1).

For Ukraine, digitalisation is a strategic necessity, especially in the context of overcoming the consequences of economic crises and shaping a new development model. The high potential of the IT sector, which accounts for about 4% of the country's GDP, combined with government initiatives such as Diia, creates the preconditions for accelerated digital transformation [2]. However, research shows that the uneven distribution of digital opportunities between regions and social groups can be a serious barrier to inclusive development [3].

The purpose of this study is to systematically analyse the interdependence between digitalisation and sustainable development of the national economy, as well as to develop practical mechanisms for optimising these processes, taking into account international experience and Ukrainian realities.

Modern economic research confirms that digitalisation is a powerful catalyst for economic growth. According to the Moskalyk and Balashova model, technological progress in the digital age transforms traditional factors of production, creating a synergistic effect [4]. The impact of digitalisation on productivity is particularly noteworthy: thanks to automation and data analytics, companies can optimise costs and improve product quality, which directly affects GDP growth. Thus, digitalisation not only changes production processes but also creates new opportunities for the development of economic sectors that determine the future of the global economy.

An important aspect is the transformation of business models under the influence of digital technologies. According to Sirko, e-commerce and digital platforms are fundamentally changing the trade landscape, giving small and medium-sized enterprises access to global markets [5]. This is especially true for Ukraine, where the development of export-oriented SMEs can become a driver of the economy. However, unlike EU countries with targeted support programmes (e.g. Digital Europe), Ukrainian enterprises often face a lack of infrastructure and financial support.

The experience of leading technology companies shows that digitalisation opens up new opportunities for cross-sectoral cooperation [5]. In Ukraine, this potential is only partially realised, mainly in the IT sector, while in Germany or Denmark, technological solutions are actively integrated into industry and agriculture. To bridge this gap, it is necessary to develop innovation centres involving universities, businesses and the government. This will allow Ukraine not only to modernise its traditional industries but also to create new jobs, stimulate economic growth and ensure integration with global markets, which in turn will increase the country's international competitiveness.

The digitalisation process, in addition to its many benefits, poses a number of structural challenges that require careful analysis. One of the most significant problems is the transformation of the labour market, which is manifested in the polarisation of employment - the growing demand for high- and low-skilled personnel while the middle segment is shrinking [1]. This trend is particularly relevant for Ukraine, where the outflow of skilled professionals abroad exacerbates socio-economic disparities. The experience of EU countries, such as Sweden and the Netherlands, shows that overcoming this problem requires comprehensive retraining and professional development programmes aimed at adapting the workforce to the new requirements of the digital economy.In Ukraine, the implementation of such initiatives will be key to maintaining the competitiveness of the labour potential and minimising the social consequences of the labour market transformation.

The problem of the digital divide, which in Ukraine has both territorial and social dimensions, deserves special attention. According to studies, the insufficient level of digital literacy and limited access to infrastructure in rural areas create serious barriers to inclusive development [3]. The experience of EU countries such as Poland, which has implemented the Digital Villages programme, which provides for the creation of local digital centres and training for the elderly, may be useful in addressing this problem. Implementation of similar initiatives in Ukraine will not only reduce the digital divide between urban and rural areas, but will also contribute to a more inclusive development of the country, ensuring equal access to modern technologies for all citizens. This, in turn, will improve social mobility, increase the level of digital literacy among different social groups, and create new opportunities for economic development in the regions.

To further develop digitalisation in Ukraine, it is advisable to strengthen government support for digital initiatives at the regional level by encouraging the creation of technology hubs in small towns and villages. This will help to equalise access to digital opportunities and ensure the development of local business and innovation. It is also necessary to adapt the education system to meet the current challenges of the digital economy, in particular, to expand curricula in digital literacy and STEM disciplines. This will help train qualified specialists who will meet the requirements of the labour market and contribute to the country's technological development. An important area is the development of public-private partnerships in the field of digital innovation, creating conditions for attracting investment in digital infrastructure. The state's cooperation with business and international partners will help accelerate technological transformation and provide financial support for strategic projects. In addition, it is worth using successful European experience in the digitalisation of public services, including the introduction of international standards for electronic document management and electronic identification. This will increase management efficiency, reduce bureaucratic barriers, and make public services more accessible to citizens and businesses.

References:

1. European Central Bank. The digital economy and the euro area. [Electronic resource] – Available at: https://www.ecb.europa.eu/press/economic-bulletin/articles/2021/html/ecb.ebart202008_03~da0f5f792a.en.html

2. **Digitalization in Ukraine** [Electronic resource]. – Available at: https://ukraine.ua/invest-trade/digitalization/#:~:text=Another%20milestone%20for%20Ukraine%20on,of%20Ukrainian%20export%20of%20services.

3. Маркевич, К. Цифровізація: переваги та шляхи подолання викликів [Electronic resource] / К. Маркевич. – 2021. – Available at: https://razumkov.org.ua/statti/tsyfrovizatsiia-perevagy-ta-shliakhy-podolannia-vyklykiv

4. Moskalyk, R. Ya., & Balashova, V. A. (2021). Economic growth model: the role of digitalization [Electronic resource] – Available at: chrome-extension://kdpelmjpfafjppnhbloffcjpeomlnpah/https://acadrev.duan.edu.ua/images/PDF/2024/2/5.pdf

5. Сірко А. В. РЕАЛІЇ ЦИФРОВОЇ ЕКОНОМІКИ: НОВІ МОЖЛИВОСТІ ТА ВИКЛИКИ ДЛЯ СУСПІЛЬСТВА І ДЕРЖАВИ [Electronic resource] – Available at: chrome-extension://kdpelmjpfafjppnhbloffcjpeomlnpah/http: //www.economy.nayka.com.ua/pdf/11_2020/17.pd

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Populism in the Digital Age: How Social Media Transforms Political Discourse

First of all, it is worth starting with a small introduction and understanding of the concept of populism as a phenomenon in the public life of people. Populism is a political approach that seeks to appeal to ordinary people who feel that their concerns are ignored by the elite. It often positions "the people" against "the establishment" or "the elite," portraying the latter as corrupt or out of touch. Populist leaders or movements can exist across the political spectrum, from the left to the right. Left-wing populism usually focuses on economic inequality and advocates for wealth redistribution, while right-wing populism often emphasizes nationalism, anti-immigration policies, and skepticism toward global institutions. A key characteristic of populism is its simplistic and emotional rhetoric, which offers easy solutions to complex problems. While populism can increase political engagement, critics argue that it may undermine democratic institutions by rejecting compromise and weakening checks and balances.

Populism has existed as a political phenomenon for a long time, evolving into various branches and categories that define its different forms. Today, it serves not only as a tool for influencing governmental decision-making but also as a powerful mechanism for shaping public opinion.

1.1. Populism on Twitter

In the digital age, populism has undergone a profound transformation with the rise of social media, fundamentally reshaping political discourse. Traditionally, populist leaders relied on mass rallies, television, and newspapers to convey their messages, positioning themselves as the voice of the 'common people' against the 'elite.' However, social media platforms such as Facebook, Twitter, and YouTube have enabled them to communicate directly with their audience, bypassing traditional media gatekeepers and amplifying their rhetoric without external mediation. The digital landscape further reinforces populist narratives by fostering echo chambers and filter bubbles, where individuals primarily encounter information that confirms their preexisting beliefs. Research from the London School of Economics (LSE) highlights how populist leaders exploit these digital environments to cultivate a strong sense of in-group identity while discrediting political opponents, journalists, and institutions. Moreover, the algorithm-driven nature of social media—optimized for engagement—unintentionally favors emotionally charged and polarizing content, making it an ideal vehicle for populist communication.

As an example of populism on social networks, I would like to consider Elon Musk's tweets, which are a great demonstration of the populist politics of not only this person, but also as an object of imitation for American and other societies. One example is the scandal that began when Elon Musk wrote on social media X on March 9 that his Starlink system is the "backbone of the Ukrainian army" and he "literally challenged Putin to a one-on-one physical fight over Ukraine." "Their entire front line will fall apart if I turn it off. What makes me sick is the years of slaughter in a stalemate that Ukraine inevitably loses. Anyone who really cares, really thinks, and really understands wants this meat grinder to stop," the American entrepreneur said. [2] Having considered one of Elon Musk's scandalous tweets, we can conclude that a social network such as X (Twitter) has become a platform for populists of different ideologies and different social strata, since publications of this type tend to spread very quickly among the public. We can also conclude that, in principle, with the purchase of Twitter by Elon Musk and its re-registration as X, this platform has become the main platform for the dissemination of right-wing ideas and right-wing populism as a social phenomenon.

1.2. Populism in the hands of politicians and leaders

Returning to the definition and identification of such a phenomenon as populism, populism is defined as a stark social and political divide between the common people and the corrupt elite. The author of The Global Rise of Populism, Benjamin Moffit writes that populist leaders aim to represent the unified "will of people," hence arguing that populism "is generally misused especially in a European context" (Moffitt, 2016: 101-102). Accordingly, populism is embraced both by left-wing and right-wing political parties, as well as other extremist groups along the political spectrum. Even though populist leaders seem—at least superficially—to have the well-being of their citizens at heart, with time, idiosyncratic politicians tend to corrupt the popular spirit and seek to realize their own goals by labelling themselves as the natural or sole representative of the true people. [1] This tendency often results in the erosion of democratic institutions, as populist leaders may attempt to bypass established checks and balances, undermine judicial independence, or suppress dissenting voices in the media. Moreover, their rhetoric frequently relies on emotional appeal and crisis narratives, portraying the elite as an existential threat to the common people. As a result, political polarization deepens, making compromise and pluralism increasingly difficult.

Additionally, while populism can sometimes bring neglected issues to the forefront of political discourse, its long-term consequences can be destabilizing. Economic policies driven by populist sentiment may prioritize short-term gains over sustainable development, leading to financial instability or social unrest. Furthermore, the exclusionary tendencies of certain populist movements, particularly those with nationalist or xenophobic elements, can strain international relations and disrupt global cooperation. Ultimately, the success and sustainability of populist movements depend on their ability to balance popular demands with responsible governance. While they may initially thrive on anti-establishment fervor, their long-term viability hinges on whether they can transition from reactionary politics to constructive policymaking.

1.3. Why is populism a threat to democracy?

It is also worth touching on the aspect of the harm of populism in a democratic society, and specifically right-wing populism, which is gaining more and more influence in the media space. Right-wing populism's incompatibility with democracy is clear when one carefully considers who "the people" often are in the populist imagination. They are not all the people. They are the minimum winning coalition of the people, and usually a part of the people that are defined in terms of their ascriptive characteristics (e.g., white). Such an exclusionary view of "the people" cannot be reconciled with democracy's requirement of political equality. The picture for left-wing populism looks rather different, lacking this prima facie contradiction with democracy. As an example, the Workers' Party (PT) in Brazil has built a notably diverse coalition of support, still making the claim that the party represents the interests of "the people" against the elite. However, the claim that a party or politician speaks for the authentic and singular people can become difficult to square with democracy, as the descent of Venezuela into authoritarianism under the left-wing populist Hugo Chavez illustrates.

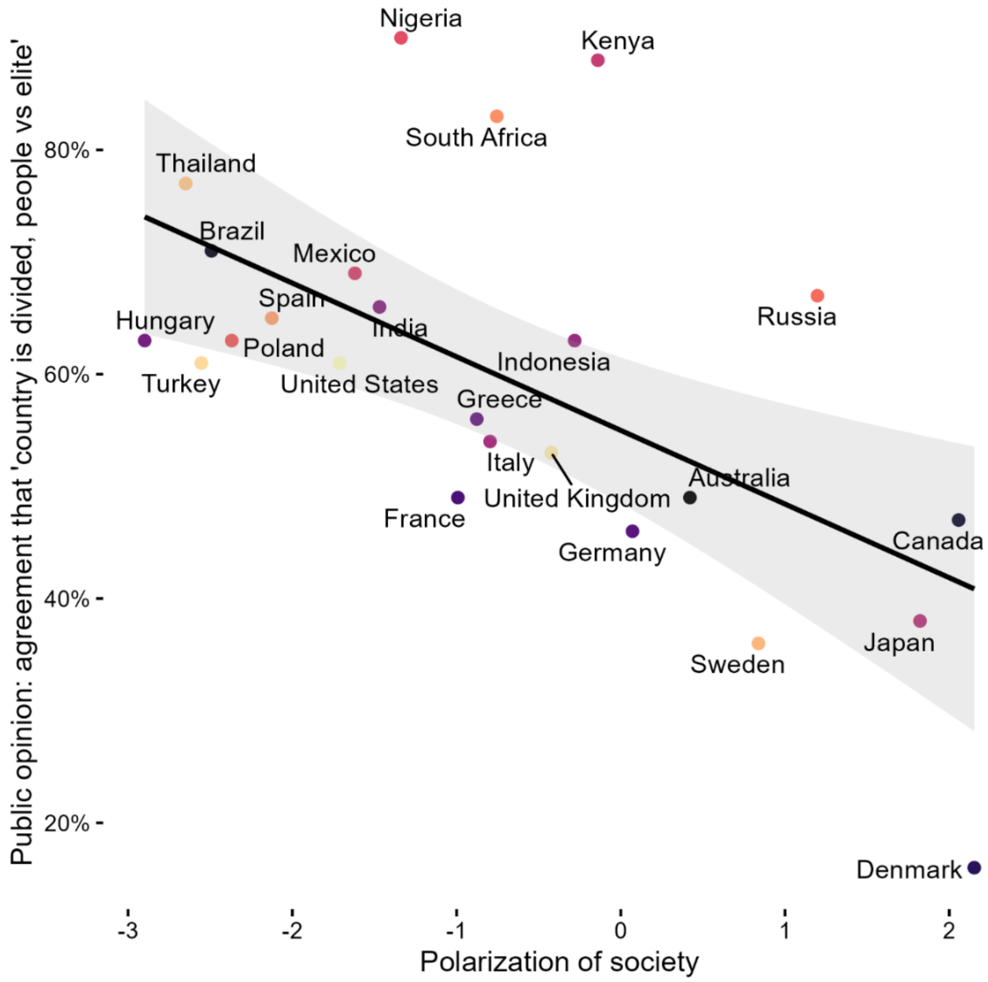
As an ideal, democracy includes all the people, considered as equals, finding a collective path toward the best possible policies to address the challenges that they face.

1.4. The Problem of Left and Right Populism

It is also worth considering the difference in the issues of left and right populism, because this analysis gives us the opportunity to look at populism from different angles. Both left- and right-wing populists oppose elite control in liberal democracies, but the left targets corporations, while the right focuses on external threats. Left-wing populists see socio-economic structures as the enemy, whereas right-wing populists blame "others," such as immigrants. The right also tends to distrust mainstream media and intellectuals, valuing rootedness in a specific place.

Populism is not a new phenomenon and often follows cyclical patterns. As the graph below shows, public opinion on the divide between "ordinary people and corrupt elites" strongly correlates with social polarization (where negative scores indicate higher polarization). [3]

In the digital age, populism has found a powerful ally in social media, which amplifies its reach and impact. By bypassing traditional media, populist leaders can engage directly with the public, fostering echo chambers that reinforce polarized narratives. Platforms like «X» serve as battlegrounds where populist rhetoric spreads rapidly, shaping public opinion and political discourse. While populism can bring attention to overlooked issues, it often challenges democratic principles by promoting simplistic solutions, deepening divisions, and undermining institutional checks and balances. The contrast between left- and right-wing populism highlights the complexity of this phenomenon—while left-wing populism focuses on economic disparities, right-wing populism often exploits nationalist sentiments. However, both forms, when unchecked, can threaten democratic stability. Ultimately, the rise of digital populism calls for a more nuanced approach to media literacy, fact-checking, and policy responses to ensure that democratic institutions remain resilient in an era of rapid information dissemination.



Sources: YouGov Cambridge, The Globalism Project, 2021.
<https://yougov.co.uk/topics/yougov-cambridge/globalism-project>
Coppedge, Michael et al. V-Dem [Country-Year] Dataset v12, Varieties of Democracy Project.
<https://doi.org/10.23696/vdemds22>

References

1. Sena Eksi, «Digital Populism: The Internet and the Rise of Right-wing Populism», European Center for Populism Studies (ECPS), December 26, 2021, https://www.populismstudies.org/digital-populism-the-internet-and-the-rise-of-right-wing-populism/
2. Анна Березіна, «Конфлікт навколо Starlink та атака на X. Як Ілон Маск потрапляє в скандали через заяви про Україну», РБК-Україна, March 11, 2025, https://www.rbc.ua/rus/news/konflikt-navkolo-starlink-ta-ataka-h-k-ilon-1741714746.html
3. Alexander Hudson, Seema Shah, «Populism - Left and Right, Progressive and Regressive», International IDEA, November 21, 2022, https://www.idea.int/blog/explainer-populism-left-and-right-progressive-and-regressive

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Positive and negative effects of economic globalization on exchange rates

In 1985, Roland Robertson defined globalization as a series of objectively created changes that have as their key objective the oneness of the world into an integrated whole [3]. With this focus of globalization, states are being asked to come increasingly closer to each other into a single economic space through trade, investment, money flows and uniform regulatory standards. For the effective functioning of this space, one of the important factors is the coordination of financial mechanisms, such as exchange rates. Thus, currency is a form of “language” of the global economic space that allows countries to communicate with each other.

This issue is especially relevant to transition economies, exporting nations, dollarized nations, weak monetary policy nations, and economies attracting FDI. For such countries, a fixed exchange rate or exchange rate fluctuations directly affect their economic growth, investment climate, and well-being because they determine foreign product prices, prices, and foreign trade opportunities. It is very common to observe that exchange rates under globalization can have local and global implications.

Economic integration is the process of convergence of national economies by creating a single economic space for free movement of goods, services, capital, and labour across national borders [2]. This is why it is important to understand how exchange rates are affected by globalization because it is vital for all nations regardless of their economic development level. In order to have a clear picture of this, it is advisable to observe how economic globalization influences exchange rates under various circumstances.

Positive and negative effects of economic globalization on exchange rates.

1. Currency strengthening due to higher exports, and currency weakening due to higher imports. Export growth increases demand for the domestic currency since foreign buyers need to buy the domestic currency to pay for exported goods and services. While imports increase demand for foreign exchange because the country must trade currency in exchange for goods and services. This leads to depreciation of the national currency, first and foremost when imports significantly outnumber exports.

2. Foreign investments can strengthen the currency. However, excessive dependence makes the economy vulnerable to fluctuations of global economy. Foreign companies making direct investments must purchase local currency in order to finance their transactions. Foreign purchasers of the country's shares and bonds also contribute to strengthening the currency. On the contrary, excessive dependence of the state on foreign funds can lead to the situation that the government is forced to adapt its domestic politics to the requirements of foreign investors.

3. Trust in the national economy guarantees stability in foreign exchange market, but speculative transactions can temporarily disturb this stability, as well as contribute to a positive impact. For example, frequent transactions ensure high market liquidity, thus allowing investors to sell or buy the asset in question at any given moment [1]. Having the high exchange rate volatility, even stable economies cannot avoid short-term fluctuations caused by speculators in financial markets.

It should be noted that positive impacts can arise only under certain internal conditions: macroeconomic stability, clear institutional environment, sound banking system, and effective regulation of financial flows.

Consequently, the impact of economic globalization on exchange rates is multifaceted and depends on a combination of internal and external economic factors. The extent to which globalization affects the exchange rate depends on the integration of the domestic economy into the global economic system, i.e., on the ability of the country to coordinate its economic policy with global trends. Under globalization, when economies are linked to each other through trade, investment, and the flow of capital, domestic concerns instantly become global in nature. This is particularly true with exchange rates, reflecting both national economic climate and external influences.

References

1. Andrieieva, H. I. (2011). The role and place of speculative operations in the derivatives market. *Scientific Notes of the National University "Ostroh Academy". Series: Economics*, (17), 449–453. URL: http://nbuv.gov.ua/UJRN/Nznuoa_2011_17_60

2. Kozak, Y. H. (2017). *International Economics: Questions and Answers*. Kyiv: Center for Educational Literature. 228 p.

3. Robbins, T., Shepherd, W., & McBride J. (Eds.) The Relativization of Societies: Modem Religion and Globalization. Cults, Culture, and the Law. Chicago. 1985

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Ukraine's participation in the international division of labor

The modern development of the economy has been influenced by globalization and informatization processes, which create prerequisites for the integration of the state into an open economy. The greater a country's role in global economic processes, the more competitive its economy becomes. [1]

Participation in the international division of labor provides Ukraine with new prospects for social and economic development. However, a key prerequisite for international labor division is the use of competitive advantages, leading to increased efficiency, scientific and technological progress, and an improved standard of living, i.e., factors that are crucial for Ukraine's economy. The relevance of this research stems from the complexity of Ukraine's current economic situation.

Therefore, the introduction of innovations, the development of industrial clusters and technology parks, as well as the optimization of natural resource utilization, are key aspects of the country's economic transformation. Each macroregion of Ukraine has unique characteristics and potential for implementing these tasks.

To begin with, investment attractiveness of Kyiv and its role in technological development should be mentioned in this study. Kyiv and its suburbs should become a hub for comprehensive activities that incorporate various technologies and directions, as well as applied and fundamental research within existing and newly established technology parks, laboratories, and intellectual practices.

In addition, potential partners include higher education institutions and research organizations from countries such as the USA, the UK, Germany, and others. In the process of attracting investments, local governments must:

- shape the image of the territorial community to attract investors;
- create favorable conditions for investment inflows and successful implementation;
- maintain relationships and cooperation between local businesses and potential investors.

Secondly, the potential of the central macroregion for industrial development and international cooperation should be studied. [2]

The central macroregion, which includes Kyiv, Chernihiv, Poltava, Cherkasy, Zhytomyr, and Vinnytsia regions, has significant potential for developing capacities for primary processing of minerals and targeted development of certain sectors, including mechanical engineering, chemical, and food industries. These industries can be integrated into international production networks.

Ukrainian resources have gained particular importance in the global economy due to the rejection of Russian resources and the search for substitutes with minimal logistical losses. Potential partners may include companies from Lithuania, Poland, Sweden, Germany, and Japan. Furthermore, establishing relevant production facilities in the central macroregion can compensate for the shutdown of many food and chemical enterprises.

Thirdly, the western macroregion and its environmental potential and high-tech development should be in focus. [2]

The western macroregion – Lviv, Volyn, Ternopil, Zakarpattia, Khmelnytskyi, Ivano-Frankivsk, and Chernivtsi regions – is characterized by the lowest level of industrialization but boasts strong environmental indicators. This allows for the development of diverse ecological food products and integrated agriculture, including livestock farming for export.

An additional perspective involves the creation of industrial clusters that could later be integrated into European mechanical engineering corporations. [2]

So, it is obvious that without establishing a new economic model in Ukraine supported by capital investments, the country's reconstruction will merely restore destroyed material assets. [2]

Moreover, meeting a country's production and other needs solely through its own workforce is economically unfeasible under modern conditions, as it requires advanced productive forces. Ukraine possesses significant potential for manufacturing goods and services on the global stage. [1]

To sum up, sustainable technological development depends on addressing complex issues related to improving technological specialization, creating a scientifically grounded national technology strategy, and implementing it into economic activities.

References

1. Antofii, N.M. (2012). Features of Ukraine's participation in the international division of labour. Business-navigator, 3 (29), 79-83.

2. Yemets, V.V. (2024). Economic recovery strategy of Ukraine: the new role of macroregions in the international division of labour. International economic cooperation: current state analysis, realities and problems (279-282). DOI: https://doi.org/10.36059/978-966-397-363-0-76

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ESG Strategy in Post-War Ukraine: Path to Sustainable Reconstruction and Investment Confidence

The post-war reconstruction of Ukraine significantly transforms the approaches to economic development, infrastructure recovery, and the building of investor trust. In this context, the ESG strategy – encompassing Environmental (E), Social (S), and Governance (G) principles– has become increasingly relevant. The implementation of

ESG approaches is not only essential for attracting international financing but also for establishing a long-term and resilient model of economic recovery.

ESG management is the process of integrating sustainability principles into national reconstruction strategies, allowing the incorporation of environmental standards, social responsibility, and efficient governance across all economic sectors. The primary goal is to ensure transparency, accountability, and ethical practices, thereby reinforcing trust among citizens and international partners [1].

This includes the development of national ESG indicators, monitoring of sustainable investment, the introduction of green energy innovations, eco-construction, and support for socially responsible businesses. It is essential for these strategies to align with Ukraine's overarching recovery policies and reflect the specific needs of regional development [2].

Amid current challenges, the creation of regional and sectoral ESG profiles not only helps prioritize investment areas but also allows for transparent risk assessment. As Dyakovskyi [3] emphasizes, ESG investing is a key factor in enhancing financial stability and deterring speculative capital.

One of the most critical areas is the development of the green economy, including energy transition, industrial modernization, and the implementation of "green" standards in public administration [4]. These initiatives not only reduce carbon emissions but also make the economy more adaptable to global changes.

Alongside ESG adoption, it is crucial to ensure effective engagement with communities, businesses, and international stakeholders. Feedback mechanisms, public oversight, and transparency of processes help build a sustainable ecosystem of trust, which serves as the foundation for a new economic model [5].

Institutional transformation also plays a critical role in the success of ESG strategy implementation. Strengthening public institutions, improving regulatory frameworks, and increasing the capacity of local governments are essential to ensure transparency and accountability in ESG-related decision-making [6]. The integration of ESG principles into public procurement processes, environmental assessments, and social programs can significantly enhance the legitimacy and effectiveness of reconstruction efforts. Moreover, the promotion of public-private partnerships based on ESG standards may serve as a catalyst for innovation and sustainable economic growth [1].

International cooperation remains a cornerstone for advancing ESG practices in Ukraine. Support from the European Union, international financial institutions, and global development agencies has already laid the groundwork for integrating sustainability into national recovery plans [7]. Continued collaboration through technical assistance, funding, and knowledge exchange will help Ukraine adopt global best practices and localize them effectively. Building on this momentum, Ukraine has the opportunity to emerge as a regional leader in ESG implementation, offering a model for other post-conflict and transitioning economies.

The ESG strategy in Ukraine is not merely a set of recommendations but a comprehensive mechanism for national modernization. Its implementation will help

Ukraine emerge as a transparent, responsible, and investment-attractive country capable of sustainable development in the post-war period.

References

1. Reznik, O., Treus, A., & Kozmenko, S. (2023). Priority impact investing in environmental protection projects. *Business: Theory and Practice*, *24*(2), 459–472. URL: https://doi.org/10.3846/btp.2023.18020
2. Zolotova, O. (2023). Post-war recovery strategy for the Ukrainian light industry: Regional ESG rating application. *Review of Economics and Finance*, *21*, 1370–1379. URL: https://doi.org/10.55365/1923.x2023.21.150
3. Dyakovskyi, D. A. (2024). ESG-investing in Ukraine's economic recovery: Perspectives, benefits and weaknesses. *Naukovi zapysky NaUKMA. Ekonomichni nauky*, *9*(1), 40–45. URL: https://doi.org/10.18523/2519-4739.2024.9.1.40-45
4. Tokarchuk, D., Pryshliak, N., Bereziuk, S., & Tokarchuk, O. (2024). Supporting sustainable recovery in Ukraine. *Polityka Energetyczna – Energy Policy Journal*, *27*(2), 71–88. URL: https://doi.org/10.33223/epj/185209
5. Bondarenko, L., & Blavt, A. (2024). Focuses of ESG-based sustainable investment under martial law in Ukraine. *Ekonomika ta suspilstvo*, *59*, 48. URL: https://doi.org/10.32782/2524-0072/2024-59-48
6. World Bank. (2023). *Green Resilient Reconstruction in Ukraine: Building Back Better*. URL: https://www.worldbank.org/en/news/feature/2023/03/31/green-resilient-reconstruction-in-ukraine
7. European Commission. (2023). *Ukraine Facility and Sustainable Recovery Package* URL: https://ec.europa.eu/commission/presscorner/detail/en/ip_23_3529

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Benefits and Risks of Globalization

Few forces have shaped the modern world as profoundly as globalization. From economic interdependence to cultural exchange, globalization has transformed how societies interact, creating both opportunities and challenges in its wake. Globalization is defined as the increasing interconnectedness of economies, societies, and cultures through trade, technology, and communication. It has shaped the modern world, enabling economic growth, technological progress, and international cooperation. Over decades, due to its relevance, globalization has been extensively studied, with a strong scientific foundation supporting the idea that it primarily benefits the world by contributing to development and integration.

Despite most research depicting globalization as a rather positive phenomenon, yet, its impact on cultural identity and diversity remains a topic of ongoing debate. While some argue that it promotes mutual understanding and enriches local cultures [Arjun Appadurai, Roland Robertson], others claim it leads to cultural homogenization and the dominance of Western values [Edward Said, George Ritzer]. This debate raises an important question: Does globalization blur national and cultural boundaries, or does it create a framework where regional identities adapt and evolve? The following article targets this debate with an attempt to resolve it or at least lay the foundation for a further framework.

Globalization has contributed to cultural exchange on an unmatched scale, allowing societies to interact, share ideas, and adopt new cultural elements. This exchange has led to cultural hybridization, where local traditions integrate global influences, creating unique cultural forms rather than erasing them. One of the most prominent examples is K-pop, which blends Western pop music elements with Korean language and aesthetics, gaining global popularity while reinforcing South Korea's cultural identity. Similarly, Bollywood has absorbed Western cinematic techniques while maintaining its distinct storytelling traditions, illustrating how global interactions enrich rather than replace local cultures.

Technology has played a crucial role in this process by preserving and spreading local cultures to a wider audience. Digital platforms, streaming services, and social media allow cultural products from diverse regions to gain international recognition. Indigenous music, traditional crafts, and minority languages find new audiences online, countering fears of cultural extinction. Globalization, in this sense, does not necessarily impose a dominant culture but creates opportunities for cross-cultural engagement and appreciation.

Despite these benefits, critics argue that globalization reduces cultural diversity, making the world more uniform and dominated by Western values. Instead of true cultural exchange, globalization often spreads the traditions and lifestyles of the most powerful economies, particularly those of the Global North. This is evident in the global popularity of Hollywood movies, American fast-food chains, and English as a common language, which can overshadow local traditions and customs.

Another major concern is the decline of indigenous traditions and languages. Global economic and media influences promote dominant cultural norms, making it harder for local heritage to survive. Many indigenous languages are disappearing, as younger generations adopt more widely spoken ones for better opportunities. This trend, often called McDonaldization, describes how consumer culture makes lifestyles more standardized, replacing unique cultural identities with global mainstream trends.

As globalization raises concerns about cultural loss, regionalization has emerged as a counterforce, aiming to protect and strengthen local identities.

This trend of regionalization is evident in trade, as the graph illustrates a rise in intra-continental trade alongside a decline in intercontinental trade from 1950 to 2020. This indicates a shift toward regionalization, where countries trade more within their own regions rather than globally. Trade agreements like the EU, *NAFTA/USMCA, and ASEAN likely contribute to this trend. Lower transportation costs and economic interdependence also make regional trade more attractive. While globalization remains strong, regional ties are becoming increasingly dominant. This suggests that regionalization is reshaping global trade patterns, balancing global integration with stronger local connections.*

Governments and cultural institutions implement policies that prioritize local languages, media, and traditions, ensuring they remain relevant in a globalized world. For example, France enforces language laws to limit the dominance of English in media and public life, while China's internet regulations restrict foreign influence in digital spaces to promote domestic content. The growth of regional media industries is another response to cultural homogenization. Countries increasingly invest in their own entertainment industries, offering culturally specific alternatives to Hollywood-dominated media. The success of Latin American cinema, Nollywood (Nigeria's film industry), and Turkish television dramas demonstrates how regional cultures can thrive even in a globalized media landscape. These movements suggest that globalization does not necessarily erase cultural identity but instead reshapes it, allowing regional identities to adapt while maintaining their distinctiveness.

Globalization undoubtedly influences the culture of every society, but this impact is not necessarily negative. It allows cultures to interact, exchange elements, and evolve. While it may sometimes seem that one culture dominates while another fades, this is not the fault of globalization itself. Rather, it is the responsibility of people to preserve and adapt their cultural heritage.

Globalization does not erase cultures; it simply exposes them to a wider audience, creating opportunities for cultural exchange and learning. If a culture is valued by its people, it will not disappear—it will adapt to modern realities while maintaining its core identity. In this sense, globalization does not weaken cultural boundaries but expands them, enabling societies to enrich their traditions through interaction with others. While some argue that globalization threatens cultural uniqueness, it can also be seen as a catalyst for cultural evolution, allowing traditions to grow, transform, and remain relevant in a changing world.

References

1. BBC Bitesize. *What is globalization?* Available at: https://www.bbc.co.uk/bitesize/articles/zp8jwnb#zdyb3j6

2. International Monetary Fund (IMF). *Globalization: A Brief Overview.* (2008). Available at: https://www.imf.org/external/np/exr/ib/2008/053008.htm

3. Peterson Institute for International Economics (PIIE). *What is globalization?* Available at: https://www.piie.com/microsites/globalization/what-is-globalization#:~:text=Globalization%20describes%20the%20growing%20interdependence,investment%2C%20people%2C%20and%20information

4. World Economic Forum (WEF). *Is globalization shifting toward regionalization?* (2021). Available at: https://www.weforum.org/stories/2021/07/regionalization-globalization-future-direction-trade/

5. ThoughtCo. *The McDonaldization of Society.* Available at: https://www.thoughtco.com/mcdonaldization-of-society-3026751

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Current Challenges in Ukraine's Economy and Sustainable Development Management

Ukraine is currently facing numerous complex challenges that hinder its path to sustainable development. These include the ongoing military conflict, economic instability, infrastructure damage, and environmental degradation. Despite these obstacles, Ukraine continues to pursue strategic reforms and engage international support to rebuild its economy and ensure long-term resilience.

The war has caused unprecedented destruction to Ukraine's infrastructure, especially the energy sector. The European Bank for Reconstruction and Development (EBRD) plans to invest around €1 billion in 2025 to help restore the war-ravaged power system. These efforts focus on decentralization and increasing energy resilience, particularly through renewable energy solutions [1]

Furthermore, the destruction of transport routes, bridges, and railways has hindered domestic and international trade, making it difficult for Ukrainian producers to access markets. Restoring this infrastructure will be essential for reactivating industrial and export potential, especially in the metallurgical and agricultural sectors.

Ukraine's economic growth has been significantly affected. The World Bank forecasts a slowdown to 3.2% in 2024 and 2% in 2025 due to infrastructure losses and electricity shortages. The EBRD similarly lowered its 2025 forecast to 3.5%, citing prolonged damage to energy infrastructure [2] [3].

Agriculture, a core part of Ukraine's economy, is experiencing serious disruptions. Recent policy changes regarding minimum export pricing have alarmed grain traders, potentially risking export contracts and damaging Ukraine's role in global food supply [2].

One of the key factors in achieving sustainable economic recovery is the development of small and medium-sized enterprises (SMEs). These businesses represent a significant portion of Ukraine's economy and are often more flexible in adapting to crisis conditions. Governmental support programs aimed at providing grants, access to credit, and simplified taxation are essential for stimulating entrepreneurship and creating jobs at the local level. Supporting SMEs can also help reduce regional disparities by encouraging economic activity in both urban and rural communities. In post-war recovery, the role of SMEs in rebuilding infrastructure and local supply chains becomes even more prominent.

Rebuilding the energy sector is a top priority. The focus is on decentralization, renewable energy adoption, and long-term sustainability. War-induced destruction has revealed the vulnerability of centralized energy systems, prompting investments in local energy generation [2].

Environmental degradation caused by war, including pollution of water and soil, destruction of ecosystems, and increased emissions, poses long-term risks. Ukraine's future environmental policies must incorporate restoration programs, supported by international organizations, to ensure a return to safe and productive land use practices. There is also great potential in green hydrogen and ammonia production [5] [6]

Ukraine's international partners have pledged long-term support to aid reconstruction. For instance, the EU, IMF, and World Bank are not only providing financial assistance but also technical guidance to align Ukraine's development with European standards. This partnership creates an opportunity for Ukraine to integrate more fully into global supply chains and economic systems.

Eastern and southern regions, more heavily affected by military actions, lag behind in economic recovery and investment. A strategy for balanced regional development is necessary to avoid long-term socio-economic disparity and to integrate these areas back into the national economy.

Another challenge that influences the long-term development prospects of Ukraine is the loss of human capital due to migration. Since the beginning of the full-scale invasion, millions of Ukrainians have been forced to leave the country, including highly qualified specialists in IT, engineering, education, and healthcare. This brain drain can weaken the national economy if not addressed through effective repatriation policies and incentives for return. At the same time, the Ukrainian diaspora abroad can become a powerful source of investment, knowledge transfer, and international advocacy if properly engaged in development strategies.

The education system and scientific community will also play a vital role in shaping a sustainable future. Investments in modern education, vocational training, and research can help prepare a new generation of specialists equipped with the skills needed for rebuilding and modernizing the country. Strengthening partnerships between universities, businesses, and international organizations will be important for promoting innovation and technological development. Additionally, education reform should ensure equal access to quality learning for children affected by the war and displacement.

Ukraine's tech sector remains a key asset. The country has a highly skilled IT workforce and strong digital potential. Digital transformation in government services, education, and business can accelerate recovery. However, equal access to digital tools, especially in war-torn rural areas, remains a challenge.

Modernization of industrial facilities and the implementation of digital technologies in production processes are necessary steps toward creating a competitive and green economy. Enterprises that adopt energy-efficient equipment and automation not only reduce costs and emissions but also improve product quality and market competitiveness. Support from international donors and private investors can help accelerate this transformation, especially in sectors such as metallurgy, machinery, and food processing. The integration of Industry 4.0 principles will allow Ukraine to rebuild with a focus on innovation and sustainability.

The destruction of tax-generating sectors and rising defense costs have created pressure on public finances. Ukraine now depends heavily on international aid and loans. Transparency and efficient allocation of resources are vital to maintain macroeconomic stability and public trust.

Decentralization reforms aim to empower municipalities with financial and administrative authority. While promising, they require institutional capacity-building to ensure effective governance and public service delivery at the local level.

In conclusion, sustainable development in Ukraine must address a wide array of interconnected issues: post-war recovery, economic stability, social cohesion, environmental restoration, digital inclusion, and transparent governance. With coordinated support from international partners and effective domestic reforms, Ukraine has the potential to build a resilient, inclusive, and sustainable future.

References:

1. Reuters. (2025). EBRD to provide €1 billion for Ukraine's energy sector.
2. Reuters. (2025). Grain traders ask Ukraine to suspend price changes.
3. World Bank. (2025). Ukraine Economic Update.
4. EBRD. (2025). Economic Forecast for Ukraine.
5. Social Change Ukraine. (2025). Development of Green Economy in Ukraine.
6. Arxiv. (2025). Green Innovations in Ukraine.
7. UNDP. (2024). Social Cohesion in Ukraine.

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Modern Economic Problems And Ways To Solve Them

Economics is a complex and fascinating field that deals with how people, businesses, and societies allocate scarce resources, make choices, and face trade-offs. As an economist, you need to apply rigorous analytical tools and methods to solve various problems, such as how to design policies, evaluate impacts, forecast trends, or optimize decisions. In this article, you will learn about some of the most effective problem-solving strategies for economists that can help you tackle any challenge with confidence and creativity. [1]. It's a difficult and challenging time for people around the world with the tempest of global crises they face today; post-pandemic life, the war in Ukraine, inflation and the cost-of-living crisis and other local and social issues.

In the modern world, economies are facing a range of interconnected problems that impact not only businesses and markets but also public administration and governance. As the global landscape continues to evolve, understanding these economic challenges and exploring practical solutions is crucial for policymakers, public servants, and citizens alike.

One of the most pressing issues in today's economy is inequality. Despite significant advances in technology and globalization, the gap between the rich and the poor continues to grow. Income inequality leads to social instability, reduces access to essential services, and hampers overall economic growth. In many countries, poverty remains widespread, with millions lacking access to basic needs like healthcare, education, and decent housing. Public administration can play a key role in addressing inequality by implementing progressive taxation, improving access to social services, and ensuring that government policies prioritize the needs of disadvantaged groups. Effective governance means creating an inclusive environment where economic opportunities are available to everyone, not just a select few.

Programs that promote job creation, vocational training, and education can empower individuals and reduce poverty in the long term. With technological advancement and the rise of automation, many traditional jobs are being replaced by machines, leading to significant job losses in some sectors. At the same time, the gig economy is growing, but it often comes with insecure working conditions and lack of benefits for workers. The gig economy is a market system where temporary positions are common, and organizations contract with independent workers for short-term tasks. Although the concept of the gig economy has existed for a long time, it has gained increased attention in recent years due to the growing number of people able to access it through the Internet [2]. The shift in labor market dynamics creates challenges for governments in terms of social welfare, tax systems, and job creation strategies. Governments need to adapt to these changes by focusing on education and skills development, preparing the workforce for new industries and professions. Public administration can facilitate the transition from traditional to modern jobs through retraining programs, support for entrepreneurship, and the creation of flexible labor market policies. Additionally, investing in research and development (R&D) can drive innovation and create new job opportunities in emerging sectors like green energy and technology.

Economic growth often comes at the cost of environmental degradation. Climate change, pollution, and resource depletion pose significant risks to economies, particularly in countries reliant on industries that exploit natural resources. The costs associated with climate change—such as natural disasters, health issues, and damage to infrastructure—are not only environmental but economic, as they drain resources and hinder development. Governments can address these issues through strong public policy and governance. Transitioning to a green economy, which focuses on renewable energy, sustainable agriculture, and circular economic models, is essential for long-term prosperity. The green economy is a system of economic activities related to the production, distribution, exchange, and consumption of goods and services that contribute to the long-term well-being of people, while ensuring that future generations are not exposed to significant environmental risks or resource depletion. [3]

Public administration plays a vital role in enforcing environmental regulations, promoting green innovation, and supporting industries that prioritize sustainability.

At the same time, encouraging global cooperation on climate change initiatives, such as the Paris Agreement, will help to tackle these challenges on a broader scale.

Globalization has created interconnected economies, but it has also led to some significant challenges. On the one hand, it has opened up new markets and opportunities for growth; on the other hand, it has increased the vulnerability of economies to external shocks, such as financial crises, pandemics, and supply chain disruptions. Many nations face difficulties balancing global trade with the need to protect domestic industries and jobs. Governments must strike a balance between promoting open markets and protecting the interests of their own citizens. Public administrators can encourage policies that foster economic resilience, such as diversifying trade partners, supporting local industries, and ensuring social protections for those impacted by economic changes. International collaboration is also essential to address global challenges like financial instability or pandemics, requiring strong leadership and effective public governance.

Public debt has reached unprecedented levels in many countries, exacerbated by the COVID-19 pandemic and ongoing economic challenges. High levels of debt can lead to fiscal crises, inflation, and reduced public spending on vital services such as healthcare, education, and infrastructure. Managing public finances and ensuring long-term fiscal sustainability is one of the most critical tasks for governments today. To address public debt, governments must implement fiscal policies that prioritize efficiency and transparency in public spending. Public administration can help by improving financial management systems, reducing corruption, and ensuring that government funds are used effectively.

Moreover, it is important to create a balanced approach to tax collection and public expenditure, as well as exploring innovative funding methods like public-private partnerships to reduce the burden on the state.

Economic challenges are complex, but they are not insurmountable. Public administration and governance play a critical role in designing policies that can address inequality, unemployment, climate change, and other economic problems. By focusing on inclusive growth, sustainability, and innovation, governments can guide economies toward a more prosperous and equitable future. With strong leadership, collaboration, and a focus on public well-being, we can solve today's economic problems and build a better world for future generations.

References:

1. URL:https://www.linkedin.com/advice/0/what-most-effective-problem-solving-strategies-economists-5eqqc (date of access: 18.03.2024).
2. D. R. S. Gig Economy. International Journal For Multidisciplinary Research, 2023, Vol. 5, No. 1. URL:https://doi.org/10.36948/ijfmr.2023.v05i01.1638 (date of access: 18.03.2024).
3. Боровик Ю. Т., Єлагін Ю. В., Полякова О. М. «ЗЕЛЕНА ЕКОНОМІКА»: СУТНІСТЬ, ПРИНЦИПИ, ПЕРСПЕКТИВИ ДЛЯ УКРАЇНИ. Вісник економіки транспорту і промисловості. 2020, No. 69. URL: https://doi.org/10.18664/338.47:338.45.v0i69.200551 (date of access: 18.03.2024).

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Development of the Food Industry in Ukraine

Ukraine's food industry is an important component of the country's economic landscape, acting not only as a key factor in providing the population with food but also as a significant player in the global food market. In response to modern challenges and the growing global demand for high-quality and environmentally friendly products, the Ukrainian food industry is actively transforming, providing new opportunities for development and international influence.

Structure of Ukraine's agricultural exports in 2023 [1]:

Sunflower, safflower, or cottonseed oils	Ranks first with a share of 23% and a value of $5 billion. However, compared to 2022, there is a 16% decrease
Corn	Ranks second, accounting for 23% of the structure of agricultural exports with a value of $4.9 billion. However, there is a drop of 9%.
Wheat	Ranked third, representing 13% and a value of $2.9 billion, which indicates an increase of 10%.
Soybeans	The share is 6% and exports amount for $1.3 billion, showing a decline of 17%.
Rapeseed or rapeseed	Occupies 5% of the structure of agricultural exports, bringing in $1.2 billion, but is marked by a 7% decrease.
Oilcake, solid waste from the extraction of vegetable fats and oil	Occupies 4% with an amount of $1 billion but shows an increase of 12%.
Meat and edible offal of poultry	Accounts for 4% of the structure of agricultural exports, representing $0.8 billion, but is experiencing a 7% decline.
Sugar from sugar cane or sugar beet in solid form	Holds a 2% share with a value of $0.4 billion, showing a significant decline of 50%.
Barley	Holds 2% of the agro-export structure with a volume of $0.4 billion but is marked by a 19% decrease.
Sunflower seeds	Ranks last with a 1% share and $0.3 billion, showing the most significant increase of 98%.

As for the top buyers of Ukrainian agricultural products in 2023, the picture is as follows:

1.**Romania**: The leader in terms of agro-exports worth $2.9 billion, with a 12% increase based on transit growth through the port of Constanta.

2.**China**: Ranked second with $2.2 billion, showing an annual growth of 17%, becoming in fact the largest importer of Ukrainian agricultural products.

3.**Turkey**: The volume of agricultural exports is $2 billion, with a decrease of 10%.

5.**Poland**: It amounts up to $1.7 billion with a decrease of 35%.

In 2023, Ukraine's agricultural exports recorded a decrease of $1.5 billion, according to the annual agro-export summary data presented by the Ministry of Agrarian Policy. Overall, exports reached $21.9 billion in 2023, a decrease from the $23.4 billion recorded in 2022. It should be noted that the volume of agricultural exports in 2023 increased by 9.5 million tons.

The decline in exports in monetary terms is determined by two main factors. Firstly, there is a decrease in export prices for agricultural products. Secondly, an important determinant of the decline is Russia's military aggression, which has significantly complicated export routes for the export of agricultural products from Ukraine [2].

This can be attributed to a number of factors, such as fluctuations in global markets, changes in consumer demand, and other economic influences. This context creates significant pressure on producers and exporters of the Ukrainian agricultural sector [3]. New realities taking place at foreign markets require such urgent measures as adaptation, active exploration and use of alternative export routes as well as continuous improvement of existing strategies to maintain and improve positions in the global markets.

It should be concluded that effective addressing and adapting to the challenges of the Ukrainian agricultural sector will require not only close monitoring of global trends, but also active cooperation between government agencies, business structures, and agricultural associations. Changes in logistics schemes, the external trade environment, and the legal framework require systemic solutions and effective strategies.

At the same time, there is a need to focus on the development of internal agricultural processes, such as increasing the production of raw materials, improving product quality, and optimizing the supply chain. Investments in new technologies, research and development of new varieties, and increased competitiveness in the domestic market could be key strategies to ensure the sustainable development of Ukraine's agricultural sector.

Resources:

[1] How did Ukraine's agricultural exports and its structure change in 2023? agropolit.com URL: https://agropolit.com/blog/536-yak-zminivsya-agroeksport-ukrayini-i-yogo-struktura-za-2023-rik

[2] The agricultural sector of Ukraine during the war - an infographic guide for 2023, agropolit.com URL: https://agropolit.com/spetsproekty/1003-agrosektor-ukrayini-pid-chas-viyni--infografichiy-dovidnik-za-2023-rik

[3] Grain exports from Ukraine fell by almost 30% to 11 million tons over the year, Forbes URL: https://forbes.ua/news/eksport-zernovikh-z-ukraini-za-rik-vpav-mayzhe-na-30-do-11-mln-t-16112023-17299

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Restriction Of Hazardous Zones Of Crane Load Movement Using Automated Systems

Every year, lifting machinery moves billions of tons of cargo, playing a key role in constructing millions of buildings and structures, including potentially hazardous facilities. At the same time, occupational safety when using cranes and other lifting machines remains a serious concern, as the accident rate involving lifting equipment continues to rise [1].

During the construction or reconstruction of buildings and structures, crane load movement zones may intersect with buildings, roads, pedestrian paths, or other areas where workers or unrelated individuals may be present. This typically occurs when the hazardous crane operation zone extends beyond the construction site or when the site contains premises with potential human presence.

Builders face the challenge of ensuring crane safety in dense urban environments, or when hazardous operation zones extend beyond construction or worksite boundaries, or involve areas of permanent or temporary human presence.

According to Clause 6.1.8 of DBN A.3.2-2, if crane load movement zones include roads, pedestrian paths, sanitary, domestic, or production buildings and structures, or other areas with human presence during construction and installation work, safety must be ensured through artificial restriction of the tower crane's operating zone and the use of protective devices such as screens [2].

To restrict the crane's operating zone, it is necessary to limit the crane's movement path, trolley travel, boom outreach and sector, as well as load lifting height. As artificial restriction means, sensors and limit switches are used to automatically disable crane mechanisms in case of collision risks, and emit warning signals when the boom or load approaches a set boundary.

Several automated systems have been developed to restrict crane load movement within predetermined vertical and horizontal boundaries [3–6]. Based on sensor commands, the system determines the crane's location, boom position, load outreach, and hoist height, comparing these with data programmed into the construction site parameter block (CSPB). Based on the comparison, it sends relay control signals to crane drives: rail movement (CRM), boom rotation (BRD), load outreach movement (LOM), and hook suspension lift (HSL).

As a result, boundaries can be set beyond which the crane boom or load should not pass, and load lifting height can be limited.

Restricted crane operation zones must be marked on the construction site plan. The forced restriction angle is tied to the crane rail axis or tower axis depending on crane type.

In work execution projects (WEP), the boom rotation restriction angle is specified in coordinates and degrees. Along the rays of this angle (and forced restriction lines), WEP includes prohibition signs, and ahead of them—warning signs. The distance between restriction and warning lines must be at least 7.0 meters.

The crane operator must reduce the load movement speed to a minimum at least 1 meter before the warning sign, and then move the load using short, repeated control inputs.

Signs are placed so the crane operator can see the service zone boundary, with at least two signs of each type per angle ray or restriction line.

To reduce hazardous zone size on tower cranes, a lifting height limiter can be installed at positions other than just the top, and adjusted during the construction process.

In constrained conditions, load lift height restrictions may apply during loading-unloading operations, underground utility installation, or construction of underground building parts, following organizational and technical measures.

If the load lift height is limited to 4–6 meters per these measures, lifting above the height set in the WEP is prohibited. Such zones are marked with special signs around the perimeter with explanatory notes. A designated, experienced signalman visually monitors lift height, with their position shown in diagrams. Reliable communication must be maintained between the tower crane operator and the slinger.

Work in restricted crane zones must be conducted under a work permit. The execution time for any restrictions must be recorded in the crane operator's shift log and confirmed prior to any change in the service zone. Safety signs must be relocated accordingly. Therefore, in areas where cranes are essential to production, automated systems can protect people from hazards during load movement by limiting crane operation within dangerous zones.

References

1. Ali Hassan Ali, Tarek Zayed, Roy Dong Wang, Matthew Yau Shun Kit, *Tower crane safety technologies: A synthesis of academic research and industry insights*, Automation in Construction, Volume 163, 2024, 105429, ISSN 0926-5805, https://doi.org/10.1016/j.autcon.2024.105429
2. DBN A.3.2-2-2009 *Occupational Safety and Industrial Safety in Construction*. https://e-construction.gov.ua/laws_detail/3074220455066862610?doc_type=2
3. *AUTOMATION*. https://www.magnetekdrives.com/wp-content/uploads/sites/7/automation-brochure.pdf
4. *MacGregor highly automated crane system*. https://www.macgregor.com/news-insights/news-articles/2024/macgregor-highly-automated-crane-system-proves-optimal-for-esl-shipping
5. Noh, S.-H. et al. (2020). *Economical Auto Moment Limiter for Preventing Mobile Cargo Crane Overload*, Sensors, 20(21), 6355. https://doi.org/10.3390/s20216355
6. Shapovalov V.A. (2017). *Ensuring Occupational Safety in Construction Site Organization*. Kryvyi Rih: KNU Publishing.

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The State As A Guarantor Of Sustainable Development Of National Economic System

The countries of the world strive for development, stability and security, but sustainable development is often associated with the preservation of the existing state. The problem is that most people are dissatisfied with their standard of living – only 1 in 8 billion feel satisfied. During the global economic crisis, the principles of the "green" economy were defined, which can become a mechanism for achieving sustainable development for the countries with different political systems and levels of economic development. A comparative analysis of indices assessing economic, social and environmental indicators (Table 1) shows that countries like Switzerland, Sweden and Norway have almost reached sustainable development [1].

Table 1 – Comparative characteristics of indices of economic, social and environmental indicators

Index	Country								
	Switzerland	Sweden	Norway	Japan	Germany	France	USA	Ukraine	China
Environmental Performance index	8,91	8,6	8,11	7,25	7,32	7,82	6,35	5,82	4,9
Global Competitiveness Index	5,63	5,56	5,14	5,37	5,39	5,13	5,43	3,9	4,84
Economic freedom	3,05	3,1	2,7	2,5	2,9	2,45	3,2	1,35	1,45
Human Development Index	0,947	0,949	0,963	0,943	0,93	0,938	0,944	0,766	0,755
GDP growth, %	2	2,7	1,5	3	3,6	1,6	2,7	4,3	10,3
GDP per capita/1 thousand US	4,29	3,9	5,91	3,42	3,59	3,33	4,74	0,67	0,74

dollars									
GDP, billion US dollars	0,326	0,354	0,276	4,338	2,96	2,16	14,72	0,306	9,872
Population growth	0,21	0,16	0,33	-0,28	-0,21	0,5	0,96	-0,62	0,49

Today, the role of the state is becoming increasingly important due to changes in the world economy. The state has its pros and cons, which depend on the circumstances. In a stable economy, its intervention may be inappropriate, but in the face of strategic threats that undermine Ukraine's development, it may be necessary. In such cases, the state activates state property – the enterprises that help to get out of the economic recession and rebuild the direction of development. The state has more opportunities to finance events, attract participants and control changes [2].

Sustainable development of the region can be defined as its ability to withstand negative external and internal influences, while maintaining economic growth and reproduction of productive forces. It is important to take into account social and environmental aspects. State regulation of sustainable development aims to ensure economic efficiency, environmental safety and social justice. Whereas environmental safety is the basis for the protection of the individual, society and the state [4].

The main directions of the innovation policy of sustainable economic development are:

– creation of conditions for growth of market demand for innovations;
– promoting the development of a competitive environment;
– providing priority support for the development of science and education;
– ensuring intellectual property protection;
– ensuring the improvement of workforce quality and the outstripping growth of its value;
– ensuring the basic economic security of the entire set of economic agents;
– support for the use of renewable resources [3].

Economically developed countries such as Japan, Germany, France and the United States have made significant progress in sustainable development, while others, including Ukraine, are lagging behind. This raises the issue of implementing a sustainable development strategy in countries with low income, serious resource and environmental problems. For effective implementation, it is important to combine economic efficiency, social stability and environmental safety. The green economy is becoming important for sustainable development. UN experts emphasize the need for equal treatment of environmental and social aspects together with economic ones [1].

The principal US government body responsible for coordinating technological progress is the Department of Commerce, specifically the Office of Technical Policy. This department explores the technical needs of industries and implements programs for the development of innovation in the private sector. The post-war US administrations actively supported the innovative development of the economy at financial level. In Ukraine, the emphasis was on indirect regulation through price freedom and privatization. The sale of state-owned enterprises for a pittance led to low economic efficiency of new owners and a decrease in investment in innovations [2].

The institutional basis for sustainable development is a developed innovative economy. Ukraine has already taken the first steps in this direction, focusing on intelligence and innovation as new factors of production, i.e., intellectual capital and property. In addition, sustainable development of the region requires the formation of a sustainable society at the global level, which provides for the strengthening of integration processes and the expansion of economic ties outside the region and the state [4].

To ensure the state policy of sustainable development in accordance with international obligations, Ukraine should, due to available scientific and methodological developments of both domestic researchers and international experts, the representatives of the UN, prepare and approve the Strategy of the state policy of sustainable development at the legislative level. This strategy should be based on the principles of a "green" economy, providing for the effective use of natural resources; reducing the negative impact on the environment and creating favorable conditions for social development. It is also important to include mechanisms for monitoring and evaluating the results of this strategy implementation to ensure its adaptability to changing conditions and challenges [1].

Thus, the state plays a key role in ensuring the sustainable development of the national economy, especially in the face of modern challenges. The analysis of international indicators shows a significant gap between economically developed countries and Ukraine, which requires an effective state policy. Important areas are supporting innovation; promoting a competitive environment; using renewable resources and creating favorable conditions for investment. Sustainable development depends on an integrated approach that includes economic efficiency, environmental safety and social stability. To achieve these goals, it is necessary to adopt a state strategy for sustainable development, based on the principles of the 'green' economy, international experience and effective mechanisms of state regulation.

References

1. State policy of sustainable development on the basis of "green" economy. (2013). URL: **https://www.niss.gov.ua/doslidzhennya/nacionalna-bezpeka/derzhavna-politika-stalogo-rozvitku-na-zasadakh-zelenoi-ekonomiki**

2. The state as an institution for ensuring the sustainable development of the national economy. (2011). URL: http://www.evd-journal.org/download/2011/2011-1/Ek_visnyk_1_2011-211-217.pdf

3. Yereshko, J. (2021). THE STATE IN THE MECHANISM OF SUSTAINABLE DEVELOPMENT. Economy and Society, (25). https://doi.org/10.32782/2524-0072/2021-25-86

4. State regional policy and its role in ensuring sustainable economic development of the regions. (2016). URL: http://www.economy.in.ua/pdf/3_2016/11.pdf

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Digital Marketing And Its Role In The Sustainable Development Of The Country

Sustainable development is one of the key priorities of the modern world, combining economic growth, social progress and environmental responsibility. In the 21st century, digital marketing has become an important tool for achieving these goals. It allows more efficient use of resources, provides transparency in business and contributes to the formation of environmentally responsible consumption.

Thanks to the rapid development of digital technologies, marketing has reached a new level. The use of artificial intelligence, Big Data, social networks, content marketing and mobile applications opens up new opportunities for enterprises and government agencies. But what is more important – these technologies contribute to sustainable development, helping to optimize the use of resources, to raise awareness of citizens and to develop the economy.

The use of digital technologies in marketing allows enterprises to effectively reach the target audience, reducing the cost of traditional advertising channels. This increases business competitiveness and stimulates economic growth. Digital marketing 4.0 uses advanced computer networking technology to develop new markets and find new consumers in the most efficient and cost-effective way [1].

Furthermore, the use of digital marketing tools, such as mobile applications, contributes to business development. Mobile applications allow businesses to provide ongoing communication with consumers, provide personalized offers and improve customer service [4].

Thanks to digital marketing, companies can enter international markets without significant investment, which contributes to the development of e-commerce and the creation of new jobs [9].

Besides, digital marketing contributes to raising public awareness of social and environmental initiatives, attracting the public to actively participate in solving socially important issues. This contributes to the formation of a responsible society and improves the quality of life. Therefore, the development of digital technologies is transforming the modern world and the interconnections in it, contributing to the creation of a digital society and a global digital economy [10].

In addition, digital marketing contributes to the development of social entrepreneurship by enabling small and medium-sized enterprises to promote their goods and services in a global market. This contributes to the creation of new jobs and improves living standards.

Modern data analysis algorithms allow experts to create personalized marketing campaigns focused on the needs of a particular consumer. This not only increases business efficiency, but also contributes to a better understanding of the needs of different groups of the population [2].

Through digital marketing, companies can promote environmentally friendly products and practices, informing consumers about the importance of sustainable consumption. This helps to reduce the negative impact on the environment and supports environmental sustainability. Digital marketing technologies can play a leading role in increasing transparency, accountability and engagement by aligning investment practices with sustainability goals.

Thanks to digital marketing, the use of print advertising and paper catalogs is reduced, which contributes to the preservation of natural resources. For example, the transition of companies to electronic mailings instead of printed brochures can reduce deforestation [12].

Brands that support sustainability actively use digital marketing to spread awareness about their environmental initiatives. For example, companies producing eco-friendly goods can inform consumers about the importance of environmental responsibility through social networks and blogs [5].

Digital marketing plays an important role in supporting sustainable development using modern technology. In particular, artificial intelligence (AI) helps to analyze consumer behavior, personalize content and automate marketing processes [7]. Big Data allows companies to process large amounts of information, which contributes to optimizing business processes and reducing the negative impact on the environment [6]. Augmented (AR) and virtual reality (VR) are used to create interactive marketing content that increases the level of consumer engagement. Furthermore, blockchain technologies provide transparency and security of financial transactions, which is a key factor for environmentally responsible business [11].

There are many examples of successful digital marketing implementation to support sustainable development. In the European Union, sustainable development marketing contributes to the satisfaction of human needs and the simultaneous development of local communities and society as a whole. This includes the economical use of resources and the promotion of economic exchanges at the level of the macroeconomic system [3].

So, for example, Tesla uses social media and online marketing to promote electric vehicles, contributing to lower fossil fuel use. Patagonia actively conducts environmental campaigns through digital channels, calling for responsible consumption.

In Ukraine, digital marketing plays an important role in the development of the banking business, providing effective interaction with customers and increasing the competitiveness of financial institutions [8]. In addition, digital marketing contributes to the activation of international activities of enterprises, providing an opportunity to use modern online platforms to promote goods and services in foreign markets.

Therefore, digital marketing is a powerful tool that contributes to the sustainable development of the country. Its use allows business to reduce costs; the state to increase the level of transparency of management, and society to gain access to important information about environmental and social responsibility.

In the future, the role of digital marketing in sustainable development will obviously grow, as new technologies open up even more opportunities to optimize resources and increase the efficiency of economic processes.

References

1. Azhazha, M.A., Fursin, O.O., Wenger, O.M. Concept of digital marketing 4.0: evolution, characteristics, typology. *Humanities studies: Collection of Scientific Papers / Ed. V. Voronkova. Zaporizhzhia: Publishing house "Helvetica"*, 2023, № 14(91). C. 135-147.
2. Bozhok, A. Trends in digital marketing: tools for attracting consumers. Sectoral aspect of the development of the national economy. 2020. №4(24). P. 27-32.
3. Dovhan, Y., Serednytska, L. (2023). Sustainable development marketing: EU experience. Economics and Society, (49). URL: https://doi.org/10.32782/2524-0072/2023-49-49.
4. Hrabovych, I. V. Global trends in the application of digital marketing tools. Scientific Bulletin of Uzhgorod National University, (42), P. 34-41.
5. Kasian, S.Y. Promotion of environmental, energy-saving innovations of high-tech enterprises in the holistic digital marketing system. Economic Bulletin of the National Technical University of Ukraine. Kyiv Polytechnic Institute. 2021. № 19. P. 107-114.
6. Lupak, R. Directions of realization of the potential of the sector of information and communication technologies in the context of ensuring the qualitative characteristics of the functioning of the internal market and the development of the information society in Ukraine. Galician Economic Bulletin of Ternopil National Technical University. 2019. № 60 (5).
7. Ostrovska, G.Y., Ostrovsky, A.T. Artificial intelligence in the conditions of modern enterprises and marketing campaigns: effective tools and development prospects. Marketing and digital technologies. 2023. № 7 (3). P. 66-82.
8. Pass Me. AND. Digital marketing as the main tool for ensuring the development of Ukrainian banking business. Modern Economics. 2023. № 42(2023). P. 91-97.
9. Solntsev, S. O., Zhyhalkevych, Z. M., Zalutskyi, R. O. Trends in the development of digital marketing. Journal of Strategic Economic Research. 2022. № 6 (11). S. 131-141.
10. Sychova, O., Osypenko, N., Petrishyna, T. (2023). Digital marketing as a tool for sustainable business development. Economics and Society, (50). URL: https://doi.org/10.32782/2524-0072/2023-50-32.
11. Volkova, N.V., Harkava, V.F., Skorokhod, I.P. The role of digital processes in the innovative development of Ukrainian business: the economic aspect. Academic visions. 2023. № 19. P. 1-9.
12. Zabarna, E. Integration of digital marketing technologies into the investment strategy of sustainable development of Ukraine. Scientific notes of TNU named after V.I. Vernadsky. Series: Economics and Management. Volume 35 (74). № 2, 2024. P. 60-66.

Section 03 Computer Science and Solutions in IT

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Automated Security Testing of Software Using Artificial Intelligence

In today's fast-paced software development environment, ensuring the security of applications has become crucial. As cyber threats grow more sophisticated, traditional testing methods, such as manual code reviews and static analysis, often fail to detect all vulnerabilities. The introduction of Artificial Intelligence (AI) and Machine Learning (ML) has greatly enhanced and automated security testing, providing faster and more accurate detection of potential threats. According to a report by Capgemini, 87% of organizations are using AI for security testing, reducing vulnerabilities during development by 40% [1].

The Importance of Automating Security Testing

Vulnerability testing is critical to ensuring software security, particularly as applications become more complex. With AI and ML, automated testing methods can effectively identify potential weaknesses in the code. According to a 2023 survey by the SANS Institute, 63% of developers believe AI-driven security testing reduces the risk of vulnerabilities slipping through manual processes. These technologies enable early detection of vulnerabilities, reducing risks and cutting the costs of fixing issues in later stages. By integrating AI into security testing, companies can transition from reactive to proactive security practices, leading to faster time-to-market and lower security risks [2].

The Role of AI in Enhancing Security Testing Automation

AI significantly enhances security testing by enabling faster and more detailed analysis of large datasets. Using machine learning models, AI systems can detect known vulnerabilities, recognize patterns, and predict potential threats based on historical data. For instance, IBM discovered that AI-powered testing tools could reduce security vulnerabilities by up to 70% compared to manual static code analysis. These AI-powered tools streamline security testing, improving the speed and accuracy of vulnerability detection. As software development cycles become shorter, integrating AI into Continuous Integration/Continuous Deployment (CI/CD) pipelines is increasingly essential. Studies show that integrating AI into CI/CD processes has resulted in up to 50% faster detection and remediation of security issues [3].

AI in Penetration Testing Automation

Penetration testing (pen testing) plays a vital role in evaluating the security of a software system. AI can automate penetration testing by simulating cyberattacks and identifying exploitable vulnerabilities. A 2023 report by Cybersecurity Insiders revealed that 54% of organizations using AI in penetration testing reported an increase in the number of vulnerabilities detected. AI-based tools employ techniques such as reinforcement learning to optimize testing processes, allowing for more efficient and thorough penetration testing. With AI, proactive testing becomes possible, continuously monitoring the system for security risks [4].

Using AI to Detect Vulnerabilities in Source Code

One of AI's key applications is the automatic analysis of source code to uncover potential vulnerabilities. Traditional static analysis techniques often fail to detect intricate flaws in complex code. AI-driven systems using deep learning methods can thoroughly examine code to identify weaknesses such as logical errors, memory management issues, and security flaws that might otherwise go unnoticed. A recent study found that AI-based systems identified 40% more security vulnerabilities in source code compared to traditional static analysis methods. This significantly improves software quality and reduces the likelihood of introducing vulnerabilities.

To practically demonstrate the potential of AI in security testing, we can refer to real-world cases such as the use of IBM Watson for automatic vulnerability detection in code or the application of DeepCode for in-depth code analysis to identify critical errors. These technologies help reduce risks associated with human error and significantly improve the accuracy of vulnerability detection. Additionally, platforms like Google's AutoML and Darktrace showcase how AI can be integrated into broader systems to provide proactive monitoring and real-time threat response [5].

Challenges in Implementing AI-Based Security Testing

Despite the significant advantages of AI in security testing, it also presents certain challenges. One primary issue is the integration of AI tools into existing development workflows. AI models require large datasets to function optimally, and obtaining such data can be time-consuming. Additionally, a 2022 report by Forrester Research indicated that 46% of security professionals are concerned about AI generating false positives, which could lead to unnecessary remediation efforts. Ethical concerns related to the use of AI in security, such as privacy and fairness, also need to be addressed. Despite these challenges, the growing capabilities of AI systems continue to drive the shift towards automation in security testing.

The Future of AI in Security Testing

The future of AI in security testing looks promising, with continuous advancements in machine learning algorithms. According to Gartner, the market for AI-driven security tools is projected to grow by 30% annually over the next five years. As AI becomes more adept at detecting new vulnerabilities and adapting to evolving attack methods, it will play an increasingly vital role in securing applications. Incorporating AI into CI/CD workflows will make security testing faster and more reliable. Moreover, as AI models become more transparent and interpretable, security professionals will gain more confidence in AI-driven assessments, making it a central component of modern cybersecurity strategies.

In conclusion, automating security testing through AI offers great potential to enhance software security. By automating vulnerability detection, penetration testing, and overall security assessment, AI helps developers identify weaknesses earlier in the development lifecycle. While there are challenges related to AI tool integration, data quality, and ethical issues, the growing capabilities of AI systems will continue to improve the security and quality of software, providing greater protection against emerging threats. The statistics and studies discussed here highlight AI's growing impact on security testing, demonstrating its significant contribution to creating a safer digital environment.

References:

1. 87% of UK organisations are vulnerable to cyberattacks in the age of AI, research reveals. URL: https://ukstories.microsoft.com/features/87-of-uk-organisations-are-vulnerable-to-cyberattacks-in-the-age-of-ai-research-reveals/ (accessed: 21.02.2025)
2. Cybersecurity Snapshot: How AI Can Boost Your Cybersecurity Program. URL: https://www.tenable.com/blog/cybersecurity-snapshot-how-ai-can-boost-your-cybersecurity-program?utm_source=chatgpt.com (accessed: 21.02.2025)
3. AI in Cybersecurity: Exploring the Top 6 Use Cases. URL: https://www.techmagic.co/blog/ai-in cybersecurity?utm_source=chatgpt.com (accessed: 21.02.2025)
4. New Report Reveals Fears, Hopes and Plans for Artificial Intelligence in Cybersecurity URL: https://www.cybersecurity-insiders.com/artificial-intelligence-in-cybersecurity-2023-report/?utm_source=chatgpt.com (accessed: 21.02.2025)
5. Code smarter, not harder: watsonx Code Assistant. URL: https://www.ibm.com/products/watsonx-code-assistant?utm_source=chatgpt.com (accessed: 21.02.2025)
6. Transforming Security Testing With AI: Benefits and Challenges. URL: https://www.cyberdefensemagazine.com/transforming-security-testing-with-ai-benefits-and-challenges/?utm_source=chatgpt.com (accessed: 21.02.2025)
7. An AI-Based Approach for Automating Penetration Testing. URL: https://www.ijraset.com/research-paper/an-ai-based-approach-for-automating-penetration-testing?utm_source=chatgpt.com (accessed: 21.02.2025)
8. A Preliminary Study on Using Large Language Models in Software Pentesting. URL: https://arxiv.org/abs/2401.17459?utm_source=chatgpt.com (accessed: 21.02.2025)
9. A New Era in Software Security: Towards Self-Healing Software via Large Language Models and Formal Verification. URL: https://arxiv.org/abs/2305.14752?utm_source=chatgpt.com (accessed: 21.02.2025)
10. DeVAIC: A Tool for Security Assessment of AI-Generated Code. URL: https://arxiv.org/abs/2404.07548?utm_source=chatgpt.com (accessed: 21.02.2025)

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The Evolution of Web Development

Web development is the process of transforming static web designs into fully functional, interactive websites. It brings designs to life, enabling users to access and interact with them through web browsers. This is achieved by translating designs into coding languages that browsers can interpret and display.

With the advancement of modern information technologies, computing power, and the growing accessibility and performance of information and telecommunication software-hardware systems, the requirements for web resources have significantly increased. This, in turn, has expanded their capabilities. For example, while early web resources consisted only of plain text in a command-line interface, today users expect interactive, multimedia, and functional websites that support video, music, animation, and complex interaction logic.

From simple HTML pages to sophisticated ecosystems of tools, languages, and frameworks, web development has evolved rapidly over the past few decades. The journey began in the early 1990s with the creation of the first website and has since progressed to mobile-first designs, cloud computing, and emerging technologies like artificial intelligence, blockchain, and augmented reality. As we stand on the brink of another technological shift, understanding the history and trends of web development is more relevant than ever.

In 1989, Tim Berners-Lee, a researcher at CERN, proposed a global information-sharing system that would become the World Wide Web. He created the first web server and website, which consisted of simple text and hyperlinks—laying the foundation for the modern internet.

To facilitate web page creation, Berners-Lee introduced Hypertext Markup Language (HTML), a simple yet powerful language for structuring web content. Alongside this, he developed the first web browser, World Wide Web, which allowed users to read and navigate web pages, marking the beginning of an interconnected digital era.

As web development progressed, scripting languages emerged to enhance interactivity. A key distinction arose between client-side and server-side scripting.

- Client-side scripting runs on the user's browser, enabling dynamic content updates without requiring a server request. Technologies like JavaScript revolutionized this space, allowing developers to create interactive elements.
- Server-side scripting runs on web servers, processing requests and delivering customized content. Languages like PHP, Python, and Node.js handle complex backend operations such as database management and user authentication.

Balancing these two approaches is crucial for optimizing website performance, security, and scalability.

It is important to maintain a balance between minimal and excessive content on a website. A site that is too simple may not meet user expectations, while an overloaded one with too many elements can hinder navigation, slow down loading times, and create unnecessary cognitive load.

The need for efficiency led to the development of web frameworks such as Ruby on Rails and Django, which standardized web application development. These frameworks provided built-in tools and libraries, allowing developers to build robust applications more quickly while maintaining consistency across projects.

More recently, frontend frameworks and libraries like React, Angular, and Vue.js have streamlined the creation of dynamic, responsive user interfaces. By following structured development practices, these tools enhance maintainability and efficiency, enabling developers to build complex applications with ease.

One of the greatest challenges in web development has been ensuring that websites function seamlessly across a variety of devices, from desktops to smartphones. Responsive design emerged as the solution, allowing web pages to automatically adjust to different screen sizes without compromising usability.

With the increasing dominance of mobile browsing, responsive design has become a fundamental principle in modern web development, ensuring a consistent user experience across platforms.

The performance, security, informativeness, and usability of a website directly depend on web design choices. For instance, a well-structured layout and logical navigation improve user interaction, while the use of secure protocols and optimized code ensures safety and stable operation of the site.

The evolution of web development reflects the continuous push for more interactive, efficient, and user-friendly online experiences. From static HTML pages to cutting-edge frameworks, the field has been shaped by innovation and adaptation.

As emerging technologies like AI-driven automation, blockchain-powered applications, and immersive augmented reality experiences gain traction, the future of web development promises even greater transformations. For both seasoned developers and newcomers, this is an exciting time to be part of an ever-evolving industry.

References:

1. 6.4: Веб-розробка. URL: https://ukrayinska.libretexts.org/%D0%91%D1%96%D0%B7%D0%BD%D0%B5%D1%81/%D0%9C%D0%B0%D1%80%D0%BA%D0%B5%D1%82%D0%B8%D0%BD%D0%B3/%D0%9A%D0%BD%D0%B8%D0%B3%D0%B0%3A_%D0%95%D0%BB%D0%B5%D0%BA%D1%82%D1%80%D0%BE%D0%BD%D0%BD%D0%B8%D0%B9_%D0%BC%D0%B0%D1%80%D0%BA%D0%B5%D1%82%D0%B8%D0%BD%D0%B3_-_%D0%9E%D1%81%D0%BD%D0%BE%D0%B2%D0%BD%D0%B8%D0%B9_%D0%BF%D0%BE%D1%81%D1%96%D0%B1%D0%BD%D0

%B8%D0%BA_%D0%B7_%D0%BC%D0%B0%D1%80%D0%BA%D0%B5%D1%82%D0%B8%D0%BD%D0%B3%D1%83_%D0%B2_%D1%86%D0%B8%D1%84%D1%80%D0%BE%D0%B2%D0%BE%D0%BC%D1%83_%D1%81%D0%B2%D1%96%D1%82%D1%96_(Stokes)/06%3A_Create_-_%D0%92%D0%B5%D0%B1-%D1%80%D0%BE%D0%B7%D1%80%D0%BE%D0%B1%D0%BA%D0%B0_%D1%82%D0%B0_%D0%B4%D0%B8%D0%B7%D0%B0%D0%B9%D0%BD/6.04%3A_%D0%92%D0%B5%D0%B1-%D1%80%D0%BE%D0%B7%D1%80%D0%BE%D0%B1%D0%BA%D0%B0

2. Marija C. The Evolution of Web Development: A Look Back and a Look Ahead. URL: **https://codevix.com/blog/the-evolution-of-web-development-a-look-back-and-a-look-ahead**
3. Ray Parker. The Evolution of Web Development: A Historical Perspective. URL: https://dev.to/ray_parker01/the-evolution-of-web-development-a-historical-perspective-4f2j

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The Present and Future of Robotic Surgeries

Robotic surgeries are transforming the medical field by enhancing the precision of minimally invasive procedures, improving surgical outcomes, and reducing patient recovery time. The development of artificial intelligence (AI) has further contributed to technological advancements, making robots more autonomous and expanding their functionality.

According to the Asia Pacific Medical Technology Association, medical technologies are very important in diagnosis, treatment, and the improvement of human health and well-being. No modern hospital can function without specialized equipment that assists doctors in performing their work [1].

An example of AI-driven advancements is its application in image processing to enhance diagnostic accuracy, analysis of physiological signals for better health monitoring, and for treatment planning, particularly for neurological disorders.

However, despite AI's potential, trust remains a significant hindrance to its widespread adoption in healthcare. Both medical professionals and patients often approach AI-based systems with skepticism, as they may seem complex and lack transparency in their working principles. To build trust, such tools must undergo rigorous validation, be smoothly integrated into existing medical systems, and have access to reliable health data. Managing misinformation and increasing public awareness are also important steps in their implementation.

One of the most fascinating examples of AI integration in medicine is the use of robotic surgical systems, which vary in capabilities and levels of autonomy. Not all surgical robots operate with the same degree of independence. Their autonomy is classified into several levels [2]:

- Level 0 (No Autonomy): Robots at this level are entirely controlled by the surgeon. Modern commercial surgical robots, such as the da Vinci Surgical System, function at this level, where every movement is dictated by the surgeon without any decision-making.
- Level 1 (Assistive Autonomy): These robots provide physical or cognitive support to the surgeon. Examples include systems that automatically suture or control the camera, but still require direct human supervision.
- Level 2 (Task Autonomy): Robots can perform specific surgical tasks independently but under the supervision of a human.
- Level 3 (Conditional Autonomy): These robots can adjust their actions based on real-time data and changing conditions during surgery. They can plan tasks and make certain decisions but still require surgeon approval before implementation.
- Level 4 (High Autonomy): Robots can autonomously perform a significant portion of a procedure but still need human confirmation at critical stages.
- Level 5 (Full Autonomy): Robots are capable of performing surgical procedures without human intervention. They can independently plan and execute task sequences, responding to intraoperative changes in real-time. However, this level remains in the research phase due to significant ethical, legal, and safety concerns.

The da Vinci Surgical System exemplifies significant progress in medical technology, providing enhanced precision, efficiency, and minimally invasive capabilities. Developed by Intuitive Surgical, this advanced system allows surgeons to perform complex operations with high accuracy, resulting in improved patient outcomes and shorter recovery times.

The system consists of a surgical console, a patient cart, and a vision cart. It translates the surgeon’s hand movements into precise movements, reducing tremors and improving dexterity. Da Vinci is widely used in general surgery, urology, gynecology, and cardiothoracic procedures, offering benefits such as smaller incisions and improved visualization. Despite challenges like high costs and the need for specialized training, ongoing advancements continue to enhance its accessibility and effectiveness, making robotic-assisted surgery a key component in the future of healthcare [3].

In summary, robotic surgery has revolutionized medicine by making procedures more precise and less invasive, leading to faster patient recovery. As AI and automation advance, surgical robots will become more autonomous, though challenges like trust, regulation, and training remain. Balancing innovation with safety and ethics is key to ensuring wider adoption and continued improvements in patient care.

References:
1. Bitkina O. V., Hyun K. K., Park J. Application of artificial intelligence in medical technologies: A systematic review of main trends. SageJournals. 18.07.2023. URL: https://journals.sagepub.com/doi/10.1177/20552076231189331?
2. Attanasio A., Scaglioni B., De Momi E., Fiorini P., Valdastri P. Autonomy in Surgical Robotics. AnnualReviews. 10.10.2020. URL: https://www.annualreviews.org/content/journals/10.1146/annurev-control-062420-090543.
3. The Da Vinci Technology: Pioneering a New Era in Medical Imaging and Patient Care. Open Medscience. 28.04.2023. URL: https://openmedscience.com/the-da-vinci-technology-pioneering-a-new-era-in-medical-imaging-and-patient-care/.

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Security of crypto wallets

Crypto wallet is an application that functions as a wallet for your cryptocurrency. It is called a wallet because it is used similarly to a wallet you put cash and cards in. Instead of holding these physical items, it stores the passkeys you use to sign for your cryptocurrency transactions and provides the interface that lets you access your crypto.

There are two main types of wallets: custodial and noncustodial. Custodial wallets (also called online wallets) are hosted by a third party that stores your keys for you. This could be a company that provides enterprise-level data security systems businesses use to preserve and secure data. Noncustodial wallets are wallets in which you take responsibility for securing your keys. There are two subcategories of wallets: hot and cold. A hot wallet has a connection to the internet or to a device that has a connection, and a cold wallet has no connection.

Keeping your wallet secure is crucial since cryptocurrencies are often targeted by hackers. To enhance protection, consider encrypting your wallet with a strong password, enabling two-factor authentication on exchanges, and storing significant funds offline.

Modern cryptocurrency wallets typically generate a twelve-word mnemonic seed phrase. For example, a phrase like "valley window suggestion sample snap protection cucumber road..." may appear random but is securely linked to your wallet keys. This phrase allows you to recover your wallet if your device is lost or damaged. It’s essential to store these words securely, as anyone who gains access to them can control your funds.

Some cryptocurrency exchanges now provide custodial key storage for users, but it's important to approach this option with caution. These exchanges are prime targets for cybercriminals making stored assets vulnerable to attacks.

Moreover, if an exchange shuts down, there is no certainty that you will recover your funds. For instance, Coinbase, a well-known exchange, revealed in its quarterly report to the Securities and Exchange Commission in May 2022 that: "*...because custodially held crypto assets may be considered to be the property of a bankruptcy estate, in the event of a bankruptcy, the crypto assets we hold in custody on behalf of our customers could be subject to bankruptcy proceedings and such customers could be treated as our general unsecured creditors*" [3].

How Users Can Keep Their Wallets Safe:

- Secure your passwords by using a password manager to create and store complex, unique passwords. With a strong password generated this way, frequent changes may not be necessary. However, if you suspect a security breach, update your passwords and enable two-factor authentication (2FA) immediately. Avoid reusing passwords across multiple accounts, especially for critical services like banking, cryptocurrency, or email.
- Enable 2FA on all accounts.
- Utilize a sensitive account only email address (or multiple) for sensitive accounts related to banking, crypto, or similar. This will widen your attack surface for a bad actor.
- Protect your seed/recovery phrase offline and make more than one copy. Split the phrase in half and store it in two separate locations such as in safety deposit boxes.
- Use a secure hardware wallet and keep it in a secure location.
- Keep browsers/devices/OS up to date.
- Verify sender email addresses before replying or sharing any information.
- Enable allowlisting on all wallets and accounts.
- Keep your seed phrase to yourself and keep it off devices.
- Do not share or expose your private key to anyone.
- Only buy hardware wallets from trusted vendors and directly from the vendor.
- When buying hardware wallets online, have them shipped to an Amazon locker location (or similar). In the event that a vendor has a data breach, your home address won't be compromised.
- Avoid SMS authentication and use app based 2FA.
- When connecting your wallets to dApps or other third-party sites only leave your wallet connected for the duration that you are using the dApp. - Disconnect your wallet from the site as soon as you're finished using it.
- Balance is important. One wallet should not hold all your crypto or NFTs.
- Utilize burner wallets to connect to sites you aren't familiar with or for minting/airdrops. You can transfer assets to a safer and more long-term storage wallet post collection.

References:

1. Cryptocurrency Wallet: What It Is, How It Works, Types, And Security https://www.investopedia.com/terms/b/bitcoin-wallet.asp
2. An Introduction to Crypto Wallets and How to Keep Them Secure https://www.quicknode.com/guides/web3-fundamentals-security/security/an-introduction-to-crypto-wallets-and-how-to-keep-them-secure
3. SEC Filings Details, Coinbase https://investor.coinbase.com/financials/sec-filings/sec-filings-details/default.aspx?FilingId=15804000

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Cybersecurity challenges in 2025

In the time of fast digital advancement, cybersecurity has become a big concern not only for bureaucratic institutions and large corporations but also for ordinary people who are not even connected to the IT or business world. As more and more parts of our life are connected to digital platforms, cybercriminals rapidly develop new, more precise schemes to profit from people's vulnerabilities. Cyber threats are advancing with such speed and amount that improving our awareness about them has become crucial. Right now, we can see a very wide range of different cyber-attack methods. But I will point out the most common ones:

Fake parcel delivery messages: In the centre of this scheme there are notifications about parcel delivery. User is asked to click on a malicious link that redirects to a phishing website created to gather personal data or install unknown dangerous software.

Social media marketplace scams: Deceivers use platforms like Facebook and Instagram to promote imaginary products. They utilize stolen photos and fake profiles, in the end the victims either pay for a non-existent product or the one they didn't order.

Artificial Intelligence voice cloning: By replicating the voice of trusted individuals through AI technologies, cybercriminals deceive victims into authorizing transactions or disclosing confidential information.

Impersonation scams: Usually it happens after other users' phone was hacked and their acquaintances start to receive financial requests via texts, emails or even calls.

Deepfake celebrity endorsements: AI is used to create fake videos of celebrities to promote products. Because of trust for public figures many people can be easily led to buy something without checking facts.

Also, the complexity and automation of attacks are making the process of blocking them more complicated. Multilayered tactics like zero-day exploits, ransomware as a service and advanced persistent threat that can be undetected while extracting data are much more complex than older threats that are more known and easier prevented. Human factors of these methods shouldn't be ignored too, as many of them depend on curiosity, urgency and fear. Which requires basic knowledge of psychology to be able to manipulate the victim's emotions.

AI and machine learning are used to further advance these cyber-attacks tactics. They are even used for defence but these technologies can create realistic deepfakes, automate phishing and data analytics tools can provide information for personalization and credibility of scams. Additionally, rising popularity of Internet of Things devices adds risk because of less developed security systems and outdated software.

All those developments lead us to an important problem – the gap in cybersecurity across different social groups. Smaller businesses lack the resources for stronger security systems and more vulnerable groups with limited digital literacy are more approachable for cyber thieves. Studies show that 86% of adults in the UK express concern about misuse of AI and 66% worry about their less aware family members. Nonetheless, confidence in avoiding scams has increased by 29%.

Global legal cooperation is still not fully established which leads to hindering international investigations of cybercrimes. Which is alarming because nowadays data is a very important asset and this becomes a question of trust for big international organizations.

So, it is everyone's need to work on basic individual cybersecurity measures. There are commonly known ones, such as regular software update, antivirus software and firewalls, strong password and multifactor-authentication and avoiding public networks. But there are some not often talked about actions that can help. For example, the 3-2-1 backup rule, when you save three data copies on two types of storage and one off-site. After that even in case of serious ransomware or hardware failure you will be able to recover data without many obstacles.

In conclusion I can say that the problem of creating and regulating more cybersecurity laws on every legal level will inevitably appear in the future. The most important action we can take is to encourage everyone to learn about cybersecurity and educate them making it easier even for more vulnerable groups.

References:

1. Fastest growing scams of 2024 revealed. NatWest Group [07 November 20224] URL: https://www.natwestgroup.com/news-and-insights/news-room/press-releases/ai-and-data/2024/nov/fastest-growing-scams-of-2024-revealed.html
2. Top 10 Personal Cybersecurity Tips.Dustin Smith, Information Security Analyst [20 December , 2017] URL:
https://waverly-advisors.com/insights/top-10-personal-cybersecurity-tips/
3. Maintain Good Cybersecurity Habits. Morgan Stanley [23 September,2024] URL: https://www.morganstanley.com/articles/personal-cybersecurity

4. Top cybersecurity threats in 2025.Michelle Moore.University of SanDiego [25 February,2025] URL: https://onlinedegrees.sandiego.edu/top-cyber-security-threats/
5. 8 Ways Governments Can Improve Their Cybersecurity by Michael Chertoff and Jeremy Grant in Harward business review URL: https://hbr.org/2017/04/8-ways-governments-can-improve-their-cybersecurity

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Detecting Malware C&C Communication Traffic Using Artificial Intelligence Techniques

With the rapid advancement of digital technologies, cyber threats have become more sophisticated, making traditional security methods less effective. One of the critical elements of modern malware is the command-and-control (C&C) infrastructure, which allows attackers to manage infected systems remotely. Detecting this type of traffic is essential for mitigating threats such as data breaches, ransomware attacks, and botnet activities. This paper explores the application of artificial intelligence (AI) techniques for identifying C&C traffic, enhancing network security measures.

Conventional malware detection techniques primarily rely on signature-based and rule-based methodologies. However, these approaches have significant limitations, as they fail to detect novel threats or modified attack patterns that do not match known signatures. AI-driven solutions, particularly those based on machine learning (ML), offer a more adaptive approach. By analyzing patterns in network traffic and identifying anomalies, ML-based methods can achieve higher detection accuracy than traditional systems.

1. Data Collection and Processing

The research leverages real-world network traffic datasets containing both legitimate and malicious communications. To enhance the effectiveness of classification, data preprocessing techniques were applied, extracting key network parameters such as packet transmission rates, session duration, entropy levels, and protocol usage. A feature selection process was conducted to optimize the dataset and improve the efficiency of the machine learning models.

2. Development of AI Models

Several machine learning algorithms, including Random Forest, Gradient Boosting, and Deep Neural Networks (DNNs), were employed for classification. The models were trained on labeled datasets to distinguish between normal and C&C-related traffic patterns. The selection of relevant features played a crucial role in improving model accuracy and reducing false positives.

3. Evaluation of Performance

To assess the efficiency of the proposed approach, multiple performance metrics were considered, such as accuracy, precision, recall, and F1-score. The findings revealed that AI-based detection methods outperform conventional approaches, particularly in identifying previously unknown threats. The system was also evaluated for its real-time applicability, demonstrating its potential for deployment in live network environments.

One of the key benefits of AI-driven malware detection is its adaptability to emerging cyber threats. Unlike static, rule-based systems, machine learning models continuously refine their detection capabilities through new data. However, the implementation of AI-based security solutions comes with challenges. One significant issue is the lack of interpretability in complex models, often referred to as the "black box" problem, which makes it difficult to understand how specific decisions are made. Additionally, adversarial attacks, where malicious actors manipulate input data to deceive AI models, remain a serious concern.

Integrating AI-powered threat detection into existing security frameworks could further enhance cybersecurity resilience. By combining AI-driven approaches with traditional security tools such as Intrusion Detection Systems (IDS) and Security Information and Event Management (SIEM) platforms, organizations can strengthen their defense mechanisms while reducing false alarms. Future research should focus on developing hybrid models that incorporate AI, behavioral analytics, and rule-based methodologies to achieve greater accuracy and robustness.
The application of AI techniques for detecting C&C traffic presents significant potential for enhancing cybersecurity defenses. Machine learning models offer improved accuracy and adaptability, making them more effective in combating evolving cyber threats. However, challenges such as model transparency and resistance to adversarial manipulation must be addressed to ensure practical implementation. Future studies should focus on integrating AI-based detection with existing security architectures, optimizing feature engineering processes, and enhancing model resilience against adversarial attacks.

References:

1. Abbaspour Asadollah, S.; Imtiaz, S.; Dehlaghi-Ghadim, A.; Sjödin, M.; Sirjani, M. Enhancing Cybersecurity through Comprehensive Investigation of Data Flow-Based Attack Scenarios. *Journal of Cybersecurity and Privacy* 2024, *4*, 823-852. https://doi.org/10.3390/jcp4040039

2. Redino, C.; Nandakumar, D.; Schiller, R.; Choi, K.; Rahman, A.; Bowen, E.; Weeks, M.; Shaha, A.; Nehila, J. Zero Day Threat Detection Using Graph and Flow Based Security Telemetry. *arXiv* 2022. https://arxiv.org/abs/2205.02298

3. Kim, J.; Lee, J.; Lee, S.; Kim, Y. A Study on a Scenario-Based Security Incident Prediction System for Industrial Control Systems Using the MITRE ATT&CK Framework. *Applied Sciences* 2024, *14*, 11836. https://doi.org/10.3390/app142411836

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The Need for Cybersecurity in War

In the context of a modern military conflict, cybersecurity is becoming critical. Traditional military operations are now accompanied by attacks in the digital space, which requires states, organizations and individuals to pay increased attention to the protection of information systems.

Increase in cyber-attacks during war

Since the beginning of the armed conflict in Ukraine, there has been a significant increase in cyber-attacks. In 2024, the number of such incidents increased by almost 70%, reaching 4,315 cases compared to 2,541 in 2023 The main targets of hackers were government agencies, the energy sector and critical infrastructure [1].

Examples of significant cyberattacks:

Cyberattacks became an important tool in the conflict in eastern Ukraine (2014–2022). In December 2015, large-scale cyberattacks targeted Ukraine's energy infrastructure, causing power outages in several regions. The US National Security Agency considered these attacks to be part of the fighting in the east of the country. The conflict also saw the active use of electronic warfare systems and drones to adjust artillery strikes.

Attack on Ukrainian state registries (December 2024): On December the 19th, 2024, Ukraine faced a large-scale cyberattack targeting state registries. As a result, key registries of the Ministry of Justice were disabled, which led to the suspension of their work and the need to switch to paper media for registering state acts.

Cyberattack on Kyivstar (December 2023): In December 2023, the largest Ukrainian telecom operator Kyivstar was subjected to a serious hacker attack. Russian hackers allegedly penetrated the company's systems back in May of that year, gaining full access to critical infrastructure. The attack led to large-scale network failures and the loss of a significant amount of data [2].

Types of cyber-attacks and their consequences

Cyber-attacks during war are varied and include:

- DDoS attacks: overloading servers in order to disable them.
- Malware: spreading viruses and worms to destroy or steal data.
- Phishing: fraudulent attempts to obtain confidential information by deception.

For example, in February 2022, before the start of a full-scale invasion of Ukraine, an attack using the HermeticWiper malware was recorded, aimed at destroying data in Ukrainian organizations.

The cyber troops of Ukraine play a key role in ensuring national security in the digital space, especially in the face of modern threats. Their main task is to protect critical infrastructure, conduct offensive and defensive operations in cyberspace, and counter information attacks.

Creation and development of cyber troops

The idea of forming cyber troops in Ukraine was officially confirmed in August 2021, when President Volodymyr Zelensky signed a decree implementing the decision of the National Security and Defense Council (NSDC) to create cyber troops within the Ministry of Defense. According to this decision, the government was obliged to promptly determine the necessary material and technical resources and financial resources to form and ensure the functioning of these units, as well as develop a corresponding bill for consideration by the Verkhovna Rada.

In October 2024, the General Staff of the Armed Forces of Ukraine announced plans to create cyber forces as a separate branch of the armed forces. This decision highlights the growing importance of cyberspace in modern military operations and the need to strengthen national cyber defense [3].

Main tasks of the cyber troops

The cyber troops of Ukraine perform a wide range of tasks, including:

- Protection of information systems: ensuring the security of state and military information resources from unauthorized access and cyber-attacks.
- Conducting cyber operations: carrying out offensive and defensive operations in cyberspace to neutralize threats and ensure Ukraine's freedom of action in the digital sphere.
- Cyber intelligence: monitoring and analysis of cyber threats, identifying potential attacks and their sources.
- Information counteraction: combating disinformation and propaganda, protecting the country's information space.

Cyber warfare has become an integral part of modern armed conflicts, and its role will only grow in the future. Ukrainian experience shows that cyber-attacks can be as destructive as traditional military actions, affecting critical infrastructure, information space, and public opinion.

Ukraine's experience in the field of cyber warfare has become valuable for the international community, as it has demonstrated new methods of protection and warfare in the digital sphere. This underscores the need for all countries to strengthen their cyber defense, develop new counteraction strategies, and actively cooperate with international partners in the field of cyber security.

In the face of constant threats, cyberspace is becoming a new battlefield where the winners are not only those with a powerful army, but also those with advanced technologies and the ability to effectively defend against cyber-attacks.

References:

1. Артемчук.О. Кількість кібератак на Україну зросла на 70% за рік: головні мішені хакерів. URL: https://epravda.com.ua/tehnologiji/kilkist-kiberatak-na-ukrajinu-zrosla-na-70-za-rik-golovni-misheni-hakeriv-801807/

2. Війна на Донбасі. URL: https://en.wikipedia.org/wiki/War_in_Donbas
3. Левицький.Д В Україні створять кібервійська. Президент підписав рішення РНБО URL: https://www.rbc.ua/ukr/news/ukraine-sozdadut-kibervoyska-prezident-podpisal-1629999298.html

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Neural Interfaces: Between Human Potential and Ethical Responsibility

In the age of rapid technological transformation, the line between science fiction and scientific reality is steadily dissolving. One of the most fascinating – and controversial – breakthroughs of recent years is the emergence of neural interfaces, which establish a direct connection between the human brain and digital devices. These brain-computer interfaces (BCIs) offer unprecedented opportunities to restore lost functions and even expand human capabilities. However, the ethical and social consequences of such progress remain the subject of intense debate.

Let us begin with a real-life example that captured the attention of the world. In early 2025, Elon Musk's Neuralink project successfully implanted a brain chip into a man named Noland Arbaugh, who was paralyzed from the shoulders down. After the surgery, he was able to move a computer cursor on the screen using only his thoughts. He described the experience as "life-changing" – a moment when his mind could bypass his body and interact directly with the digital world [1]. This event is not only a medical achievement but a turning point in the history of human-machine interaction.

BCIs work by detecting neural signals through tiny electrodes and translating them into commands that a computer can understand. The ultimate goal is seamless two-way communication between brain and machine – and this goal is becoming more achievable. As Harvard researcher C. Schmidt notes, designing such interfaces involves solving a variety of problems, including biocompatibility, data interpretation, and long-term neural safety. Engineers and neuroscientists are working together to create systems that are not only effective but also safe and sustainable for long-term use [2].

Yet as we stand on the threshold of a new frontier, we must ask: What are the risks of merging mind and machine? Among the most serious concerns are:
Privacy of thought: BCIs collect data directly from the brain – potentially the most intimate source of personal information. Who owns this data? Could it be misused by corporations or governments?

1. Loss of autonomy: If machines can not only read but also potentially influence brain activity, does this threaten the concept of free will?
2. Social inequality: Advanced neural technologies may be expensive and accessible only to the wealthy, creating a new technological divide.
3. Ethical dilemmas in enhancement: Should BCIs be used only for healing and rehabilitation, or also for enhancement – giving healthy people cognitive or physical advantages?

The publication Toxigon emphasizes that while neural interfaces may eventually allow people to control devices, communicate telepathically, or even store memories externally, society must consider how these capabilities redefine what it means to be human [3]. Will we become more powerful – or more vulnerable?

Despite the risks, it would be short-sighted to reject such innovations outright. Neural interfaces have the potential to restore dignity and agency to millions of people with disabilities. They could also revolutionize education, mental health treatment, and even creative expression. The challenge lies not in stopping progress, but in guiding it ethically. This means:

- Developing transparent regulations and guidelines for BCI use.
- Ensuring informed consent and long-term monitoring for participants.
- Establishing strict data protection laws.
- Involving ethicists, psychologists, and sociologists in the development process.
- Promoting public dialogue to include diverse voices in shaping this future.

In conclusion, neural interfaces are not just a technical innovation – they are a philosophical turning point. They force us to re-evaluate our understanding of the mind, identity, and the relationship between human beings and machines. As Elon Musk himself once said, “The future is going to be weird.” But whether that future will be inspiring or terrifying depends not only on scientists and engineers – but on all of us.

References:

1. Kleeman J. Elon Musk put a chip in this paralysed man's brain. Now he can move things with his mind. Should we be amazed – or terrified? The Guardian. 2025.
URL: https://www.theguardian.com/science/2025/feb/08/elon-musk-chip-paralysed-man-noland-arbaugh-chip-brain-neuralink
2. Schmidt C. Designing Brain-Computer Interfaces That Connect Neurons to the Digital World. Harvard Medical School Magazine. 2025.
URL: https://magazine.hms.harvard.edu/articles/designing-brain-computer-interfaces-connect-neurons-digital-world
3. Anonim. Neural Interfaces: The Future of Human-Computer Interaction. Toxigon. 2025.
URL: https://toxigon.com/neural-interfaces-future-of-human-computer-interaction

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Context-Aware Help Systems in Enterprise Software: Leveraging User Behaviour and System Events to Offer Real-Time Guidance

In the current day and age, no consumer is stranger to the concept of having to deal with clunky, unhelpful enterprise software. With the lazily thrown together menus, the lost and purposeless buttons, as well as the ever so unhelpful "AI" assistants plaguing the modern periphery, it is no wonder to hear of people quickly losing hope long before reaching their goals. Such experiences are a strain not only on the users themselves, but also on the tech departments of the corresponding companies as well as the branches offering on-site assistance. As automation becomes the norm, there is an overwhelming need for assistance that adapts dynamically to user needs, including the nuanced, ever-changing context of daily life; the goal being the application of user behaviour and system events for timeliness and the personalisation of help that is truly helpful. With the information I have gathered through research as well as first-hand encounter, I shall advocate for context-aware help systems as an emerging standard in enterprise UX design.

Systems such as these that are aware of the context are developed in a way that enables them to respond and make decisions based on the user's surroundings, which may include location, time, state of the device, as well as user activity.[3] Context aware adaptability is becoming a necessity especially in enterprise software where users suffer from multifaceted interfaces and rudimentary help tools. Unlike traditional support systems that work with manual input, context-aware help systems offer real-time role assistance that is based on user actions and system events. A number of studies suggest this technique is effective, Herzog and Wörndl (2017)[1] showed the added contextual cues improve mobile event suggestions, and Bortlik et al. (2018)[2] suggested heuristics for multi-user focused service selection.

To context-aware help systems, there are three core components:

1. Trigger mechanisms
2. Contextual data dimensions
3. Delivery methods

One may describe the trigger mechanisms as the actions completed by the users in non-deliberate fashion – hesitation, repeated or incomplete interactions, for example – clues, which would ideally signal the consumer to be in need of immediate assistance. The contextual data dimensions are the temporal, geographic or social clues that would describe the user as well as make ground for educated assumption on what future action should be taken, and when. Meanwhile, the delivery methods range from subtle tooltips and highlights to proactive modals or conversational agents. Drawing from recommender system logic, such help systems can combine collaborative and content-based filtering to personalize guidance. Crucially, they must balance helpfulness with non-intrusiveness, allowing users to maintain control while benefiting from adaptive support. [1]

I would like to use the Telekom app, which is widely used in Germany to manage internet and mobile services offered by the country's second most-popular provider, as an example of the aspects of the current context-aware help system applications that would greatly benefit from further development and feedback. From the user's standpoint, the app has unclear navigation and a dependence on static frequently asked questions that are not updated in real-time or catered for specific situations. For instance, trying to view contract agreements or inquire for help with personal data frequently results in redundant menus, the AI Assistant repeating itself like a broken clock or dead ends; no helpful prompts or assistance are provided during these moments of significant user friction. By applying the principles mentioned above, a context-aware help system could greatly enhance the user experience. This, in turn, demonstrates the practical consequences of inadequate user assistance and emphasises the importance of flexible systems that can react to user requirements as they arise. Context-aware help systems bring major advantages to businesses, such as better onboarding for users, quicker task completion, and less user frustration. A well-implemented virtual assistant could provide help to the consumer exactly when it's needed, making it feel natural and tailored to the individual. Still, putting these systems in place has its fair share of difficulties. Privacy concerns arise when monitoring user behaviour, and if not handled carefully, too many prompts might overwhelm or irritate users. From a technical angle, integrating behavioural data, event tracking, and contextual triggers requires strong infrastructure and teamwork across different departments – greatly impacting future scalability and potential for further development.[2] Despite these obstacles, the possibility of having more intelligent, responsive enterprise software makes context-aware help a highly appealing path for future growth.

In conclusion, it's not an unrealistic guess to say that the potential is tremendous. With the intention of making the user experience as smooth as applicably possible, the future shines bright: perhaps, in a few decades' time, the technological advancements may have the apps shifting their interfaces and accomplishing complex tasks using just the user's thoughts and whims as guidance, all the while keeping the wheel in the human's hands. Although, we are yet to see an implementation as magical as that, and it, still, is a long road before we see science-fiction-esque virtual assistants in application.

References

1. Herzog, D., & Wörndl, W. (2017). Mobile and Context-Aware Event Recommender Systems. In WEBIST 2016, pp. 142–163. Springer. URL: https://doi.org/10.1007/978-3-319-66468-2_8

2. Bortlik, M., Heinrich, B., & Mayer, M. (2018). Multi User Context-Aware Service Selection for Mobile Environments. Business & Information Systems Engineering, 60(5), 415–430. URL: https://doi.org/10.1007/s12599-018-0552-2

3. Dey, A.K. (2001). Understanding and Using Context. Personal and Ubiquitous Computing, 5(1), 4–7. URL: https://doi.org/10.1007/s007790170019

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From networks to the Internet: how computers communicate

A computer network is a system of linked devices that use standardised protocols to exchange information and share resources. Computers, servers, and other hardware can share data thanks to these networks. Networks form the backbone of modern digital infrastructure.

The logical and physical components of a network are where its functionality starts. End devices, including computers and cell phones, are like the originators or final destinations of data. To route traffic, these devices rely on intermediary hardware such as switches and routers [1]. Routers act as gatekeepers between networks, they use IP addresses to forward data packets toward their destinations. MAC addresses are used by switches to link devices within a local network, guaranteeing that data reaches the correct recipient. Data travels via the physical medium of transmission, which might be wired (fibre optics, Ethernet connections) or wireless (Wi-Fi, cellular signals). Finally, protocols, the established guidelines that specify how devices format, transmit, and analyse data, are the foundation of all that interactions [3].

The idea of layered architectures, which decompose the complexity of data transmission into manageable tasks, is fundamental to network communication [8]. Two models dominate this framework: the Open Systems Interconnection (OSI) model and the Transmission Control Protocol/Internet Protocol (TCP/IP) suite. The OSI model, a seven-layer theoretical framework, begins at the Physical Layer, where raw bits are transmitted as electrical or optical signals [5]. Moving upward, the Data Link Layer organises these bits into structured frames and manages access to the physical medium. The Network Layer introduces logical addressing (e.g., IP addresses) to route packets across interconnected networks, while the Transport Layer ensures reliable delivery through protocols like TCP or prioritises speed with UDP. The upper layers – Session, Presentation, and Application – handle connection management, data translation (encryption, compression), and user-facing services like web browsing (HTTP) or email (SMTP). In contrast, the TCP/IP model, a practical implementation powering the internet, condenses these layers into four: Network Interface, Internet, Transport, and Application. This model emphasises end-to-end communication, with IP handling addressing and routing, and TCP or UDP managing data integrity or speed [6].

Data transmission itself is a process of segmentation and reassembly. Data is separated into smaller parts called packets when a user sends a message, whether an email or a video stream. Each packet contains a header with metadata (source and destination addresses, sequencing information) and a payload carrying the actual data. Routers analyse packet headers to identify the best routes across networks, using routing tables that map network topologies as a guide. Upon arrival, the recipient device reconstructs the original message by reassembling packets in the correct order. In contrast to traditional circuit-switching systems, this packet-switching technology maximises fault tolerance and bandwidth efficiency.

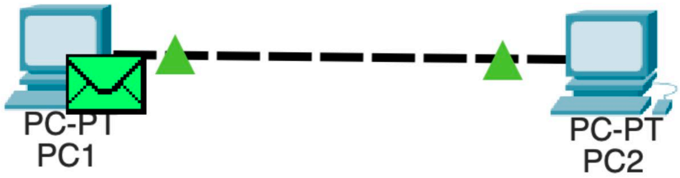

Fig. 1. Data transmission

In order to guarantee that data reaches its intended destination, addressing mechanisms are essential. Every network interface possesses a Media Access Control (MAC) address, a unique hardware identifier used for local network communication. At a broader scale, IP addresses – logical identifiers such as IPv4 (e.g., 192.168.1.2) or IPv6 (e.g., 2001:0db8:85a3::8a2e:0370:7334) – enable routers to direct traffic across the Internet. Similar to a digital phonebook, the Domain Name System (DNS) converts easily navigable domain names (e.g., "nmu.org.ua") into numerical IP addresses, bridging the gap between human convenience and machine efficiency [9].

Networks vary in scale and structure. Local Area Networks (LANs), such as a home Wi-Fi system, connect devices within a confined geographic area, while Wide Area Networks (WANs), like the Internet, span global distances [1]. Network topologies – the physical or logical layouts – also influence performance. A star topology centralises traffic through a single switch (common in LANs), whereas a mesh topology provides redundant pathways to enhance reliability, crucial for mission-critical systems.

Security remains a paramount concern in network design. Threats such as eavesdropping, data breaches, and malware necessitate robust safeguards. Firewalls filter unauthorised traffic, while encryption protocols like HTTPS and VPNs scramble data to protect confidentiality. Passwords and biometric verification are examples of authentication techniques that guarantee that only authorised users can access sensitive data.

The foundation of contemporary connectedness, computer networks allow for anything from cloud computing to instant messaging. Their functionality depends on addressing systems that transport data over long distances, security mechanisms that preserve integrity, and layered protocols that break down communication into specialised tasks. Reliability, efficiency, and scalability will continue to define the future of networked communication as technology advances, including 5G, quantum networking, and AI-driven security. Comprehending these foundational concepts not only clarifies the digital realm but also highlights the creativity that went into creating the Internet, humanity's most revolutionary creation.

References:

1. Andrew S. Tanebaum Computer networks. Pearson Inc. 2010. URL: https://csc-knu.github.io/sys-prog/books/Andrew S. Tanenbaum - Computer Networks.pdf (Date of access 16.03.25)
2. Computer Networks. Elsevier B.V. 2023. Vol. 233 URL: https://www.sciencedirect.com/journal/computer-networks (Date of access 28.03.25)
3. Mohanakrishnan R. What Is a Computer Network? Definition, Objectives, Components, Types, and Best Practices. Spiceworks Inc. 2025. URL: https://www.spiceworks.com/tech/networking/articles/what-is-a-computer-network/ (Date of access 28.03.25)
4. Nabilah Aisyah Siregar COMPUTER NETWORK. ResearchGate GmbH. 2023 URL: https://www.researchgate.net/publication/367021503_Computer_Network (Date of access 29.03.25)
5. Shengli Zhang Hot topic: physical-layer network coding. ACM. 2006. P. 358-365.
URL: https://www.researchgate.net/publication/220926184_Hot_topic_Physical-layer_network_coding (Date of access 28.03.25)
6. QUIC vs. TCP — Development and Monitoring Guide. Catchpoint Company. 2024. Chapter: 7. URL: https://www.catchpoint.com/http2-vs-http3/quic-vs-tcp (Date of access 9.03.25)
7. Heena Rathore Computer Networks. Springer. 2016. P. 11-25. URL: https://www.researchgate.net/publication/314631420_Computer_Networks (Date of access 7.03.25)
8. Guan-Qun Gu Some Issues on Computer Networks: Architecture and Key Technologies. Springer. 2006. Vol. 21 P. 708-722. URL: https://link.springer.com/article/10.1007/s11390-006-0708-2 (Date of access 28.03.25)
9. How DNS works. DNSimple Corporation. 2024. Ep. 1. URL: https://howdns.works/ep1/ (Date of access 29.03.25)

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Operating Systems: Invisible Architects of the Digital World

Inspired by the format of "Neural Interfaces: Between Human Potential and Ethical Responsibility"

In a world increasingly reliant on digital technology, we often overlook the invisible systems that make everything work. One such unsung hero is the operating system (OS) – the essential bridge between hardware and software, user and machine. From your smartphone to the most powerful supercomputer, every digital device relies on an OS to function efficiently and securely.

Let us begin with a familiar example. When you open an app on your phone or boot up your laptop, the seamless experience you enjoy is powered by an operating system like Windows, macOS, Linux, or Android. Each OS has been designed to meet specific needs, yet they all serve the same core purpose: managing hardware resources and enabling software to function correctly [1].

Behind this simplicity lies a complex orchestration. Operating systems are responsible for:

1. **Process Management**: Scheduling tasks so that multiple applications can run simultaneously without conflicts. Algorithms like First Come, First Served, Shortest Job Next, and Round Robin ensure tasks are prioritized effectively [2].

2. **Memory Management**: Allocating memory dynamically using techniques like paging, segmentation, and virtual memory to prevent crashes and keep applications running smoothly [3].

3. **File System Management**: Organizing data on storage devices using file systems like NTFS, ext4, and HFS+. Disk scheduling methods such as SSTF and SCAN improve access times and storage efficiency [4].

4. **Device and I/O Management**: Coordinating with peripherals – from printers to USB drives – ensuring data flows correctly between the user and the machine.

5. **Security and Protection**: Implementing firewalls, authentication systems, encryption, and access control to defend against rising cybersecurity threats like malware and ransomware [5].

These functions aren't just technical – they are essential for digital society. As devices become smarter and more interconnected, operating systems evolve. Real-time OS now power life-critical systems in medical devices and automated manufacturing, where delays can be catastrophic. Cloud-based OS and AI-driven platforms are redefining how businesses and consumers access services, making systems more adaptive and scalable [6].

Process scheduling determines how the OS assigns CPU time to various tasks. Scheduling algorithms like First Come, First Served (FCFS), Shortest Job Next (SJN), and Round Robin (RR) help prioritize tasks effectively [7; 8]. Modern OS designs support multitasking, where multiple processes run simultaneously, enhancing productivity and system responsiveness. Efficient scheduling ensures minimal delays and maximizes CPU utilization, making the system faster and more efficient for users [9].

Memory management is essential for optimal performance, ensuring applications have enough RAM to execute tasks. Techniques like paging and segmentation allocate memory dynamically [10]. When RAM is insufficient, the OS utilizes virtual memory, which extends available memory by using a portion of the hard drive. This prevents crashes and allows large applications to run smoothly. Proper memory management enhances system efficiency and prevents memory leaks or fragmentation [11].

The file system is responsible for organizing and storing data efficiently. OS platforms use various file systems like NTFS (Windows), ext4 (Linux), and HFS+ (macOS) [12]. Storage management also involves disk scheduling algorithms such as First Come, First Served (FCFS), Shortest Seek Time First (SSTF), and SCAN, optimizing data retrieval speeds. Without an effective file system, data organization and access would be slow and unreliable [13].

In conclusion, while often invisible, operating systems shape our digital experiences from behind the scenes. Like the brain to the body, they manage the flow of information, balance competing demands, and protect critical functions. As we step into a more connected and intelligent world, the operating system remains a vital foundation — not just for computing, but for the future itself.

References:

1. GeeksforGeeks. *Introduction of Operating System - Set 1*. 2025.
URL: https://www.geeksforgeeks.org/introduction-of-operating-system-set-1/
2. StudyTonight. *CPU Scheduling Algorithms.*
URL: https://www.studytonight.com/operating-system/cpu-scheduling-algorithms
3. TutorialsPoint. *Memory Management in Operating System.*
URL:
https://www.tutorialspoint.com/operating_system/os_memory_management.htm
4. JavaTpoint. *Disk Scheduling Algorithms.*
URL: https://www.javatpoint.com/disk-scheduling-algorithms
5. IBM. *What is an Operating System?*
URL: https://www.ibm.com/topics/operating-systems
6. Analytics Insight. *10 Future Trends of Operating Systems in 2025.*
URL: https://www.analyticsinsight.net/10-future-trends-of-operating-systems-in-2025/
7. Techzzers.
URL: https://techzzers.wordpress.com/process-scheduling-algorithms-fcfssjfpriority-round-robin/

8. University of Illinois at Chicago (UIC) - Department of Computer Science
URL:
https://www.cs.uic.edu/~jbell/CourseNotes/OperatingSystems/5_CPU_Scheduling.html
9. Enterprise Storage Forum
URL: https://www.enterprisestorageforum.com/hardware/paging-and-segmentation/
10. Wikipedia - Virtual Memory
URL: https://en.wikipedia.org/wiki/Virtual_memory
11. Kingston Technology Blog
URL: https://www.kingston.com/en/blog/personal-storage/understanding-file-systems
12. Workat.tech
URL: https://workat.tech/core-cs/tutorial/disk-scheduling-algorithms-in-operating-system-os-ope5ahnn6mhh

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Securing the VPN Tunnel on Social Media

As digital technologies evolve, cybersecurity threats continue to grow. One widely used method of securing online communications is virtual private networks (VPNs). By encrypting traffic, VPNs ensure privacy and protect data from unauthorized access. However, no technology is completely stupid. Cybercriminals can exploit VPN vulnerabilities to intercept or manipulate sensitive information. This article discusses the potential risks associated with VPN tunnels, effective security measures, and expected advances in VPN technology.

Understanding VPN Tunnels

The VPN tunnel creates a secure encrypted connection between the two devices, protecting the transmitted data from interception. This is achieved using protocols such as OpenVPN, IPSec, and WireGuard. Each protocol has different advantages: OpenVPN is known for its adaptability and support for various encryption standards, IPSec is widely used in corporate networks, and WireGuard contributes to its speed and optimized configuration.

VPN tunnel security relies heavily on cryptographic methods. Encryption ensures data privacy and authentication mechanisms check the legality of communication between devices. However, incorrect configuration or use of outdated encryption algorithms can weaken security.

Top VPN Security Threats Despite their protective capabilities, VPNs run several risks:

Man-in-the-Middle (MitM) attacks: Hackers can intercept communications between the user and the VPN server, potentially gaining access to sensitive data. If encryption is poorly implemented, attackers can exploit vulnerabilities.

• Disadvantages of the protocol: Outdated protocols such as PPTP are known for weak encryption, making them easy targets for cyber threats.

• DNS Leaks: Misconfigured VPN services may not send DNS requests securely, inadvertently detecting browsing activity.

• Using the software: Bugs or vulnerabilities in VPN applications can provide attackers with an entry point to bypass security measures or access sensitive information. Best Practices for Strengthening VPN Security To improve VPN security, organizations and individuals must implement the following strategies:

• Regular software updates: Updating VPN applications helps to fix security vulnerabilities.

• Strong encryption standards: The use of strong encryption algorithms such as AES-256 or ChaCha20 provides a high level of data protection.

•Multifactor authentication (MFA): Adding a layer of authentication significantly reduces the risk of unauthorized access.

Firewalls and intrusion detection systems (IDS): These tools help detect and mitigate suspicious network activities. The Future of VPN Technology Expected Some key events include:

•Quantum-Safe Encryption: With the development of quantum computing, new encryption standards will be needed to counter potential decryption threats.

•Decentralized VPNs: Unlike traditional VPNs that rely on central servers, decentralized models distribute control, increasing user anonymity and security.

•Integration with zero-trust security models: This approach assumes that no device or user should be trusted by default, which requires constant verification to maintain security.

VPN tunnels play a crucial role in providing internet traffic, but their effectiveness depends on the correct configuration and implementation of modern security practices. Threats such as MitM attacks, DNS leaks, and protocol vulnerabilities can be mitigated by implementing modern encryption methods, multifactor authentication, and continuous software updates. Looking ahead, VPN technology will continue to evolve to counter new cybersecurity threats, making it an important tool for protecting digital communications.

References:

1.Top 5 VPN Security Threats: What They Are And How To Protect Yourself
URL: https://www.nairaland.com/8255616/top-5-vpn-security-threats
2. VPNs Demystified: Why Everyone's Talking About Online Privacy
URL: https://www.lifewire.com/vpn-and-online-privacy-8741271

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The Metaverse: A New Reality or a Tech Illusion?

The concept of the metaverse has sparked much debate among tech experts and everyday users. Some see it as the next phase of the internet, offering immersive digital experiences that could reshape how we work, communicate, and spend time. Others view it as exaggerated hype, limited by current technology and infrastructure.

The term *"metaverse"* was introduced in Neal Stephenson's 1992 novel *Snow Crash*, describing a virtual world where people interact as avatars. Today, companies like Google, Microsoft, and Meta are investing heavily in developing metaverse platforms. But the key question remains: is it a revolutionary step forward, or just a passing trend?

At its core, the metaverse is a network of virtual spaces where users can interact using VR and AR. Key technologies include:

- **VR and AR devices** like Oculus and HoloLens for immersive experiences
- **Blockchain and NFTs** for secure digital ownership
- **AI** for creating interactive environments and virtual assistants
- **5G and cloud computing** for smooth, real-time interactions

Together, these tools aim to build user-driven digital worlds that merge with reality.

Supporters believe the metaverse could transform many areas:

- **Remote Work:** Platforms like Microsoft Mesh let users collaborate using avatars, enhancing virtual meetings.
- **Education:** Virtual classrooms can offer 3D experiments and AI tutors, making learning more interactive.
- **Social Interaction:** Instead of texts or video calls, people could meet in 3D spaces using avatars.
- **Digital Economy:** Platforms like Decentraland let users buy, sell, and trade virtual land and items, including fashion NFTs.
- **Gaming & Entertainment:** Games like Roblox and Fortnite already offer shared virtual worlds, along with concerts and events.

However, there are several limitations:

- **Cost and Access:** VR headsets and fast internet remain expensive.
- **Privacy and Data Security:** Large-scale data collection poses risks of breaches and surveillance.
- **Legal and Ethical Issues:** Taxation, regulation, and digital rights need clear frameworks.
- **Mental Health:** Extended use may cause addiction or social isolation.

Environmental Impact: Running metaverse platforms demands a lot of energy.

Several real-world projects demonstrate the growing implementation of metaverse technologies:

- **Meta's Horizon Worlds** is a social platform for exploring and creating virtual spaces. It allows users to attend events, play games, and collaborate in shared 3D environments using VR headsets.
- **The Sandbox** and **Decentraland** are blockchain-based virtual worlds where users can purchase digital land, build structures, trade virtual goods, and even host social or business events.
- **Microsoft Mesh** is a mixed-reality platform designed for enterprise collaboration, enabling teams to meet as holograms or avatars in virtual workspaces.
- Luxury brands like **Gucci** and **Nike** are exploring virtual fashion by creating digital collections and selling NFT-based sneakers and accessories within the metaverse.

These examples highlight how the metaverse is becoming both a cultural trend and a commercial strategy. However, its long-term sustainability and mass adoption are still uncertain.

Looking forward, the development of the metaverse could follow several key directions:

- **Increased realism and interactivity** through advanced AI and more sophisticated VR/AR technology, enabling lifelike avatars, emotional expressions, and realistic digital environments.
- **Regulatory frameworks** may be established by governments and institutions to ensure safe, ethical development. These could address issues such as user privacy, digital property rights, and online conduct.
- **Hybrid experiences**, where augmented reality blends with the physical world, may reshape areas such as tourism, education, retail, and smart city infrastructure.
- **Broader industry adoption** could extend beyond gaming, with applications in healthcare (like surgical simulations), real estate (virtual tours), training, and the arts.

The success of these developments will depend on how effectively the industry addresses current limitations and gains public trust and interest.

The metaverse is an ambitious and controversial concept. While some see it as the future of digital life, others remain sceptical. The truth likely lies in between. Its success depends on overcoming current limits while ensuring ethical, inclusive, and sustainable development. Whether it becomes a true digital revolution or fades as a tech illusion, it is already shaping how we think about virtual interaction.

References:

1. Marak L. A. The Metaverse is the Real World and all else is the illusion, 2021 URL: https://www.unlock-bc.com/82328/the-metaverse-is-the-real-world-and-all-else-is-the-illusion/

2. Anderson J., Rainie L., Atske S. The Metaverse in 2040, 2022 URL: https://www.pewresearch.org/internet/2022/06/30/the-metaverse-in-2040/?gad_source=1&gclid=Cj0KCQjw16O_BhDNARIsAC3i2GDCpyWB7fnaT5TqXLv4DUHjudxMGX14goSaGkE4J3NxYuBF9DwZz9QaAsrGEALw_wcB
3. Lee P. The Metaverse illusion, 2023 URL: https://waccglobal.org/the-metaverse-illusion/
4. Ezenwa E. Beyond the hype: Is the Metaverse a future reality or just a tech mirage? 2024 URL: https://www.yahoo.com/news/beyond-hype-metaverse-future-reality-105001297.html?guccounter=1&guce_referrer=aHR0cHM6Ly93d3cuZ29vZ2xlLmNvbS8&guce_referrer_sig=AQAAABxAKrPTXdxMG8QOE1JDz7BaV8Q_CVycRIloOtJ0t07ezaUMFcaWFbA8wbcvTOcZA0lkKabZNEPq1EKKm2pltOfay9NDl0IrgwG90W994UsFw77z0h9SOeQGHKscTljGLIjdbBmKd-IkTpUnun5vNOPlR977xfKR0aSOVrn1w-9o
5. Tucci L. What is the metaverse? An explanation and in-depth guide 2024 URL: https://www.techtarget.com/whatis/feature/The-metaverse-explained-Everything-you-need-to-know
6. Duan H. et al Metaverse for social good: A university campus prototype 2021, pp.153-161 URL: https://dl.acm.org/doi/10.1145/3474085.3479238

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Video games as a form of art

The question of whether video games are art has fallen out of fashion in recent years, mainly because people think the matter is settled. Statements like, “Art is subjective”, “Look at this game!”, and “Video games are still young” are thought to have solved the problem. But, for a supposedly “solved” debate, things are pretty much just as they were − video games are still not recognized as an art form, co-equal with others [1].

The medium of video games is potentially post-modern art and should be viewed through the same critical lens as any other form of art. Even if there is not a game yet that could be considered an epic, the medium is changing faster than all other forms of art and will only continue to do so as technology advances and cultural perception shifts − look at how much games have changed since their conception 60 years ago. Not all games deserve the title of art or high art. But to be fair, we also sell terrible paintings and *tasteless* books [3].

One of the most obvious aspects of video games as art is their visual component. Modern game worlds astonish players with their detail, scale, and innovative design. Some projects have become so aesthetically refined that players compare them to actual paintings [2].

The narrative depth of video games has evolved significantly over the past few decades. While early stories often revolved around simple motifs like rescuing princesses or finding artefacts, today's video games offer emotionally rich plots that delve into complex philosophical and social issues [2].

Unlike cinema, where the audience remains passive observers, video games allow players to influence the storyline. Choices made by the player can alter the ending, character relationships, and even the overall tone of the story. This makes video games a unique medium where every playthrough can become a personal experience [2].

Creating music for video games requires not only talent but also a deep understanding of the gameplay experience. Composers work closely with developers to craft an atmosphere that not only matches the on-screen action but also enhances the player's emotions. Often, music becomes such an integral part of the game that without it, the experience loses much of its magic [2].

Furthermore, sound design in video games plays a critical role. Realistic environmental sounds, the emphasis on dramatic moments, and the creation of a sense of presence enhance the player's immersion in the virtual world. In this regard, video games even surpass cinema in terms of personalizing the experience [2].

Video games are a medium of mediums. Composers create soundtracks and effects, artists create 2D images and 3D models, writers draft story arcs and dialogue, and programmers choreograph all the moving pieces into a seamless world. The art is a hodgepodge of art. The players/audience experience the games in a first-person sort of way. They act and react in the game. Quite a few of today's games are rich enough in all of these to send chills down spines, adrenaline through veins, and tears in our eyes. There is no other medium where the audience or person experiencing it empathizes with it so heavily that they use personal pronouns when describing what they experienced. They are not merely reactionary. No one reads a book or watches a movie and claims that they themselves harpooned Moby Dick or defeated the soviet boxer in Rocky IV. But when a player talks, they might say something like, "I unlocked the chest and found the treasure," or "I beat the boss, but the princess was in another castle, so I had to keep going" [3].

Each art form has − if you will − its own expression vectors − music uses audio, movies use audio and visuals, etc. Video games share the same expression vectors as movies but add one of their own: interactivity [1].

I can't agree with this opinion of Henry July: "However, "interactivity" is not comparable to the other expression vectors. While the usual expression vector transmits aesthetic content, interaction can only change the content being transmitted by another vector. By itself, interactivity does not convey anything. Interactivity is always a gimmick or a way for the user to move from content to content. It is never the content itself. Pressing on a button might show a work of art, but the interactivity only serves as a doorway for the real artwork to proceed" [1].

Players not only observe what is happening but actively participate in creating their own stories. This unique characteristic of video games opens entirely new horizons for self-expression [2].

In role-playing games like The Witcher 3: Wild Hunt, players can make decisions that directly affect the development of the plot, relationships between characters, and even the story's ending. For example, choices made by the player can determine the fate of key characters, alter the political landscape of the game world, or unlock new storylines. This creates a unique sense of responsibility for one's actions, deepening emotional engagement. Players feel their decisions matter, leading to a much more immersive experience than traditional art forms like film or literature [2].

Additionally, video games offer platforms for creativity that extend beyond gameplay itself. Modifications (mods) and user-generated content allow players to reinterpret existing games or create something entirely new. For instance, Minecraft provides tools for creating entire worlds, from fantasy castles to complex mechanisms, while LittleBigPlanet lets users design custom levels and scenarios, turning the game into a true playground for creativity [2].

But simply being immersed in a nice − looking digital field of virtual flowers, or getting a rush from exchanging gunfire between online players does not in itself qualify a game as art. There are plenty of games that never intend to be art. In fact, most games are made with the sole purpose of creating income. While this is not evil by itself, it is not art − just as most dinnerware in Walmart is not artistic pottery, but a piece crafted to be sold. It's not that making money conflicts with art, but if the basic purpose in creation is financial, it is a widget for your bottom line, not a work of art. There are video games that intend to suck the player in, chew on their mind, and spit it back out with new experiences. There are video games that intend to be art and imbue their players with experiences that rival any gained from Monet or Mozart [3].

Again, the gaming industry has grown and transformed more rapidly over the past 60 years than any other medium. Compare the first game, Tennis for Two (think Pong) to any game on the market today. The exponential difference between the two dwarfs any difference in cinema, literature, music, textiles, or 2D art. Or compare the state of games to 70 years ago, before games were invented. The medium is still in the cave painting stage of its lifetime. Perhaps it is just now beginning to exit. One thing is certain, the medium contains the potential to become high art and contains some examples of postmodern art [3].

In my opinion, and according to the research, games can be considered as a form of art. We do not say anything about some specific game, but the concept of games as art. Of course, not every game can be a masterpiece. Like every type of art, it expresses feelings but in a way which there was not before. It is an opportunity for consumers to become a part of a piece of art and to "feel" the game by bringing other forms of art like visuals, music or literature (the plot) into it. Yes, as the author of the article said, there are also games which have not so interesting gameplay (interactivity) like rhythm games where you should move your character to a musical beat. Without music it would just be a moving character. But also, it would not be so interesting if the character moved without you but moved to good music. So, in some games there can be less interactivity in some more, but interactivity is the basis of any game which distinguishes it from other forms of art and can play a bigger role than other forms of art which games also include.

References:

1.Henry July, Video Games Are Art; They're Just Bad at It; Medium; Feb 20, 2024. URL: https://medium.com/@henryjuly/video-games-are-art-theyre-just-bad-at-it-22d9415c04a0

2.Video Games as Art: Can Game Worlds Compete with Painting and Cinema?; See Great Art; December 5, 2024. URL: https://www.seegreatart.art/video-games-as-art-can-game-worlds-compete-with-painting-and-cinema/

3.Nathan Deardorff; An Argument That Video Games Are, Indeed, High Art; Forbes Oct 13, 2015.URL:https://www.forbes.com/sites/berlinschoolofcreativeleadership/2015/10/13/an-argument-that-video-games-are-indeed-high-art/

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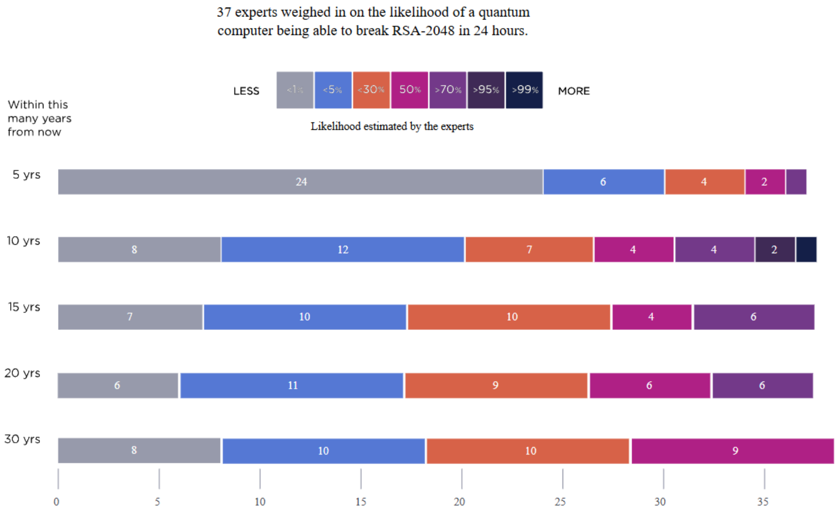
The role of quantum technologies in the future of educating information security

The time has come when most encryption methods can easily cease to be secure and relevant due to quantum computers, which are rapidly approaching the moment when they will be able to seriously affect current encryption and hashing technologies. Modern quantum processors, containing up to 60 qubits, perform tasks in less than 3 minutes. By comparison, the most powerful supercomputer we have today would take 10,000 years to perform the same tasks. This calls into question the future of modern cybersecurity systems and requires a rethinking of approaches to training future specialists. [1]

As quantum computing becomes more and more real in the modern world, universities must adapt their curricula to train cybersecurity specialists who can work in conditions of new technological threats and have a clear understanding of the threat from quantum computers. Inclusion in the curricula of disciplines related to quantum computers, quantum cryptography, and quantum-resistant algorithms is a necessity in the modern world.

According to a study conducted by "The Global Risk Institute", which recently surveyed leaders and experts in quantum science and technology to find out their opinion on the probability and timing of the emergence of a quantum threat to public-key cybersecurity. The time when quantum technologies will become a real threat to data protection is still unknown, but some models emerge from their answers, as shown in the illustration below.

Are quantum technologies a threat to public-key cybersecurity?



Pic. 1. – Number of respondents who indicated a certain probability [2]

The main problem in this area is the lack of cybersecurity specialists capable of working with quantum technologies. Universities that train cybersecurity professionals should expand their curricula. The availability of practical works for simulating quantum algorithms, as well as the use of quantum computers in cloud services such as IBM Quantum Experience (or similar), can significantly accelerate the training process in this field.

Unfortunately, at present, in most universities in Ukraine, there are not so many classes and practical research that would consider in detail all the capabilities of quantum computers and show the real danger from them. So, to start faster development in this direction, we need to understand who we need to cooperate with. At the moment, there is no quantum computer in Ukraine, no laboratories that have been studying it, no ordinary quantum computers that could be rented. Because of this, it is worth considering the possibility of cooperation with international giant companies in this direction.

Top Quantum Computing Companies

- IBM;
- Google;
- Amazon;
- Microsoft;
- Intel;
- NVIDIA.

Fortunately, it is now possible to rent quantum computers, or even use them for free, but unfortunately there are limitations. For example:

- IBM provides the ability to use a quantum computer remotely for 10 minutes, or for about $50 per minute;
- Google, in turn, does not provide the ability to use quantum computers, but it has simulators and free courses. For example, the qubit simulator “qsim” is a full wave function simulator written in C++. It uses gate fusion, AVX/FMA vectorized instructions, and multi-threading using OpenMP to achieve state of the art simulations of quantum circuits;
- AWS (Amazon Web Services) Free Tier gives you one free hour of quantum circuit simulation time per month. And also, they provide the ability to use the quantum processor itself, which also comes out to about $50 per minute, or even more. It depends on the type of rented processor.

Considering all of the above, it is necessary to implement new curricula now that will prepare future experts to work in conditions of quantum threats now. The inclusion of relevant disciplines and programs in the educational process will not only increase the level of knowledge of students, but also ensure the stability of information systems in the future.

References:

1. Quantum computing: present and future. URL: https://www.dataart.team/ua/articles/kvantovye-vychisleniya-nastoyashee-i-budushee. (accessed: 21.02.2025)
2. Understanding Post-Quantum. URL: https://www.entrust.com/resources/learn/post-quantum-cryptography. (accessed: 21.02.2025)

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Vibecoding: Climbing Or Falling Down The Stairs Of Progress

The field of software development is undergoing a profound transformation. The emergence of large language models and conversational artificial intelligence (AI) systems has introduced a new paradigm for software creation, referred to as "vibecoding." This method allows users to describe desired functionality in natural language, and AI generates the corresponding code. While this unlocks significant potential for productivity and accessibility, it also presents serious challenges – particularly regarding cognitive dependency, skill acquisition, and long-term developer autonomy.

Vibecoding is the process of building software through natural language interaction with AI. The user expresses intent in plain language; the system delivers executable code. This eliminates the traditional requirement of understanding logic, syntax, and architecture. As a result, individuals without formal technical backgrounds can create applications. For example, a 2025 study documented the use of vibecoding in clinical education, where educators with no programming experience created diagnostic simulators and learning tools using AI. These tools were subsequently used by students, illustrating a shift in authorship from engineers to domain experts [1].

Despite promising use cases, the widespread adoption of vibecoding raises concerns about cognitive offloading and skill erosion. If users bypass understanding and rely entirely on AI, they lose the ability to diagnose, scale, or modify their code. A similar phenomenon is observed in other academic fields. A 2025 paper on legal scholarship found that while language models increased productivity, they also introduced blind spots in reasoning and argumentation [3]. In software, the implications are similar: when AI takes over the construction process, users fail to build the mental models necessary for development.

Significant consequences are also evident in professional engineering. In the VEA-VEO framework introduced in 2025, researchers demonstrated the application of AI to automate structural design, electrical load calculations, and spatial planning in EPC projects. This AI usage produced concrete benefits: design cycles were reduced by 30 – 50%, and rework decreased by 70%. However, all outputs remained subject to human validation. This represents the correct boundary: AI accelerates, but humans maintain control [2]. The dual nature of vibecoding – as both an enabler and a cognitive crutch – requires a critical evaluation of its long-term effects. Tools shape not only output but thinking. The issue is not merely code quality, but the development of engineering judgment. If AI substitutes for human reasoning, the result is diminished technical insight. This shift presents a fork in the road. Vibecoding can serve as a ladder – a way to climb faster, higher, and more deliberately. Or it can become a crutch – a way to proceed without foundational understanding. AI is not magic. It mirrors the clarity of your input. If your thinking is structured, AI assists. If it is not, AI conceals the confusion.

Vibecoding is a major step forward in software methodology. Its ability to democratize creation and reduce friction is undeniable. But its cognitive implications demand a deliberate response – from education systems, professional standards, and individual developers. The human must remain the primary agent of thought, design, and responsibility. AI must augment, not replace, human capacity. Only under that condition can the benefits of vibecoding avoid eroding the depth of technical thinking.

References:

1. Clinical Education Paper (2025). Application of Conversational AI in the Development of Diagnostic and Learning Tools for Medical Training.
2. VEA-VEO Framework (2025). AI-Oriented Automation in EPC Project Design: A Framework for Structural, Electrical, and Spatial Optimization.
3. Large Language Scholarship Paper (2025). Impacts of Generative AI on Legal Reasoning and Academic Integrity in the Legal Field.

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The role of artificial intelligence in construction: transforming the industry

The construction industry is rapidly adopting artificial intelligence (AI), revolutionizing traditional processes, optimizing efficiency, improving safety, and enhancing project management. This presentation explores AI's impact on the industry and the challenges it faces.

AI in project planning and design. AI-driven software employs generative and parametric design techniques to analyze geodetic data, climate conditions, and material availability, generating optimal building designs [1]. Tools like Autodesk's generative design allow engineers to input project specifications and receive cost-efficient solutions [2]. Additionally, AI helps identify design flaws before construction begins. Machine learning algorithms detect inconsistencies in blueprints, reducing costly errors. Integrating AI with Building Information Modeling (BIM) further improves precision and data-driven decision-making [3].

AI in risk assessment and safety monitoring. AI-powered predictive analytics forecast potential risks, allowing managers to implement preventive measures. Algorithms predict material shortages and weather conditions that could impact project timelines [2]. Computer vision technology and IoT (Internet of Things) sensors detect safety violations, such as missing protective gear or hazardous environments, providing real-time alerts to managers. AI-driven safety monitoring has reduced workplace injuries by 25% [2].

AI-Driven automation and robotics. AI-powered robotics handle repetitive and hazardous tasks, such as bricklaying and excavation, improving efficiency. Drones conduct site surveys and inspections, generating progress reports without human intervention [3]. Autonomous construction equipment, such as robotic arms and automated cranes, enhances productivity while minimizing risks associated with physically demanding tasks [5].

AI in construction management and cost optimization. AI optimizes logistics, scheduling, and cost estimation by analyzing past projects and real-time data to create accurate timelines [4]. Cost optimization benefits include AI algorithms tracking material prices, predicting fluctuations. AI also aids in financial auditing by detecting discrepancies and preventing mismanagement [1].

Challenges of AI adoption in construction. Despite its benefits, AI adoption faces obstacles. Resistance to change remains a significant challenge, particularly for smaller firms lacking technical expertise or financial resources [2]. Data security is another concern, as AI relies on vast amounts of information, increasing risks of cyber threats. Robust cybersecurity measures are essential [3]. Workforce adaptation is crucial. AI requires skilled workers who can operate and manage AI-powered systems. Companies must invest in training and upskilling programs [4].

The future of AI in construction. AI's role in construction will continue expanding. Future advancements include autonomous construction machinery, AI-driven predictive maintenance, and sustainability solutions to minimize environmental impact [5]. Smart construction techniques will integrate AI-driven systems for energy-efficient buildings and infrastructure [3]. The industry is moving toward a data-driven, automated future, enhancing safety, cost-efficiency, and sustainability.

Conclusion. AI is transforming construction, improving efficiency, safety, and innovation. From AI-driven design tools and risk management solutions to automation and cost optimization, its benefits are extensive. However, overcoming challenges such as resistance to change, data security concerns, and workforce adaptation is crucial for unlocking AI's full potential. As AI advances, firms that embrace these innovations will gain a competitive edge.

References:

1. Izdebsky V. AI in everyday life: contribution to the transformation of everyday life. Wezom. 2024. URL: https://wezom.com.ua/ua/blog/shi-v-budivnitstvi-vpliv-na-transformatsiyu-budivelnoyi-galuzi (accessed: 22.03.2025).
2. Rudge S. The Rise of Artificial Intelligence in Construction. Construction today. 2024. URL: https://construction-today.com/news/the-rise-of-artificial-intelligence-in-construction/ (accessed: 22.03.2025).
3. Lialiuk O. & Osypenko R. Features of implementing artificial intelligence in construction. VNTU. 2023. URL: https://ir.lib.vntu.edu.ua/bitstream/handle/123456789/42648/%D0%9E%D0%A1%D0%9E%D0%91%D0%9B%D0%98%D0%92%D0%9E%D0%A1%D0%A2%D0%86%D0%87%20%D0%86%D0%9C%D0%9F%D0%9B%D0%95%D0%9C%D0%95%D0%9D%D0%A2%D0%90%D0%A6%D0%86%D0%87.pdf (accessed: 22.03.2025).
4. Bang S. & Nils O.E. Olsson. Artificial Intelligence in Construction Projects: A Systematic Scoping Review. NTNU. 2022. URL: https://www.researchgate.net/publication/365675233_Artificial_Intelligence_in_Construction_Projects_A_Systematic_Scoping_Review (accessed: 22.03.2025).
5. How artificial intelligence is used in construction. LLC CAC ATLANT. 2023. URL: https://blog.poltava.to/atlant/17139/ (accessed: 22.03.2025).

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Quantum Internet – Connection of Future

Internet connection has become such a usual thing in our life; it is a fast network that connects billions of devices in our world. You probably heard about super-fast NASA internet or Starlink owned by SpaceX, but did you know that scientists making innovations in creating a completely new type of internet, that will enable services unmatched by the classical internet?

The quantum internet, which design has moved beyond theory is a much sought-after network of interconnected quantum computers that will one day allow people to send, compute, and receive information using quantum technology. Quantum internet refers to a network that uses quantum signals instead of traditional radio or optical signals for communication. It leverages the principles of quantum entanglement and superposition to transmit data, offering a level of security and efficiency far beyond current capabilities.

Nevertheless, how does quantum internet work? Mostly it is based on laws of quantum physics and works similar to quantum computers. They use fundamental units of information similar to the bits used in classical computing. These are called "qubits." However, unlike conventional computer bits – which convey information as a 0 or 1 – qubits convey information through a combination of quantum states, which are unique conditions found only on the subatomic scale. For example, one quantum state that could be used to encode information is a property called "spin," which is the intrinsic angular momentum of an electron. Spin can be thought of like a tiny compass needle that points either up or down. Researchers can manipulate that needle to encode information into the electrons themselves, much like they would with conventional bits – but in this case, the information is encoded in a combination of possible states. Qubits are not either 0 or 1, but rather both and neither, in a quantum phenomenon called superposition.

This allows quantum computers to process information in a wholly different way than their conventional counterparts, and therefore they can solve certain types of problems that would take even the largest supercomputers decades to complete. These are problems like factoring large numbers or solving complex logistics calculations. Quantum computers would be especially useful for cryptography as well as discovering new types of pharmaceutical drugs or new materials for solar cells, batteries, or other technologies. But to unlock that potential, a quantum computer must be able to process a large number of qubits – more than any single machine can manage at the moment. That is, unless several quantum computers could be joined through the quantum internet and their computational power pooled, creating a far more capable system. That is how quantum internet improves already breakthrough technologies, which unfortunately have their borders. Also one of the most significant advantages of the quantum internet is its potential to create virtually unbreakable encryption. Quantum encryption, or quantum key distribution (QKD), ensures that any attempt to eavesdrop on a quantum communication automatically alters the quantum state of the data, alerting the sender and receiver to the breach. It provides much higher level of security in connection and exchanging information, since with development of internet it became such a dangerous place for unprotected users. Their key distinction though lies in the nature of the information being transmitted: the quantum internet is concerned with distributing quantum information, which has unique properties like superposition and entanglement, setting it apart from classical information. This salient characteristic makes the quantum internet a disruptive technology to underpin many non-classical services including quantum computing, sensing, and security. Also due to such properties of quantum information, the design of quantum internet faces many unique challenges that the classical internet never has to deal with.

While the concept of a quantum internet is promising, it is still in its infancy. First of all researchers doubt that individuals will own personal quantum computers in near future. Instead, they will be housed at academic institutions and private companies where they can be accessed through a cloud service. Maybe in far future we will switch to quantum technologies, but for now, scientists cannot rely on that theory. However, one of the problems before the quantum internet can become a reality is the realization of a quantum repeater, an essential component in the long-distance transmission of quantum information. As the analog of a classical repeater, extender, or booster, the quantum repeater works to overcome loss and noise in the quantum channels comprising a quantum network.

Talking about problem of the distance, recently Chinese scientists discovered a solution in that field. They have successfully demonstrated quantum entanglement over several kilometers of existing optical fibers in urban environments. This significant milestone, achieved by connecting parts of a network using infrared photons, brings us one step closer to the realization of a future quantum internet.

As we see quantum internet in pair with quantum computers and computing allows humanity to step on a whole new stage in internet technologies helping improve different fields of our life. No matter how many difficulties or challenges scientists meet, they do everything to bring quantum internet to reality.

References:

1. Liu J., Le T., Ji T., Yu R., Farfurnik D., Byrd G., Stancil D. The road to quantum internet: Progress in quantum network testbeds and major demonstrations. https://www.sciencedirect.com/science/article/abs/pii/S0079672724000545

2. Azuma K., Economou S.E., Elkouss D., Hilaire P., Jiang L., Lo H.K., Tzitrin I. Quantum repeaters: From quantum networks to the quantum internet. (2022) https://arxiv.org/abs/2212.10820
3. Shah A. Quantum Internet - The Future of Secure Online Communication. (2024) https://www.linkedin.com/pulse/quantum-internet-future-secure-online-communication-ahsan-shah-agcqf#:~:text=Quantum%20internet%20refers%20to%20a,efficiency%20far%20beyond%20current%20capabilities.
4. Nellis A. The quantum internet, explained https://news.uchicago.edu/explainer/quantum-internet-explained#what
5. Linwen China Builds the World's First Quantum Internet in Urban Area (2024) https://thechinaacademy.org/china-builds-the-worlds-first-quantum-internet-in-urban-area/

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