ДИАЛОГ КУЛЬТУР

МАТЕРИАЛЫ XIX МЕЖДУНАРОДНОЙ НАУЧНО-ПРАКТИЧЕСКОЙ КОНФЕРЕНЦИИ НА АНГЛИЙСКОМ ЯЗЫКЕ

Научное издание

Часть II

Санкт-Петербург
2026

Министерство науки и высшего образования Российской Федерации
ФЕДЕРАЛЬНОЕ ГОСУДАРСТВЕННОЕ БЮДЖЕТНОЕ ОБРАЗОВАТЕЛЬНОЕ УЧРЕЖДЕНИЕ ВЫСШЕГО ОБРАЗОВАНИЯ
«Санкт-Петербургский государственный университет промышленных технологий и дизайна»
Высшая школа технологии и энергетики

МАТЕРИАЛЫ

XIX Международной научно-практической конференции на английском языке «ДИАЛОГ КУЛЬТУР»

20–21 мая 2026 года

Научное издание
2026 ● Часть II

Под общей редакцией заведующего кафедрой иностранных языков, кандидата филологических наук, доцента
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Санкт-Петербург
2026

УДК 62+54+502.001
ББК 31+35+20.1
Д 44

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Д 44 Материалы XIX Международной научно-практической конференции на английском языке «Диалог культур» (20–21 мая 2026 г.). В 2 ч. / Минобрнауки РФ; ФГБОУ ВО «С.-Петерб. гос. ун-т промышленных технологий и дизайна»; ответ. ред. и сост. Т. С. Шарапа, М. С. Липатов; под общ. ред. В. В. Кирилловой. — СПб.: ВШТЭ СПбГУПТД, 2026. — Ч. II. — 383 с.

ISBN 978-5-91646-487-0

В настоящем сборнике представлены материалы XIX Международной научно-практической конференции на английском языке «Диалог культур», состоявшейся 20-21 мая 2026 года в Санкт-Петербурге.

Сборник адресован широкому кругу читателей, заинтересованных в научных открытиях и исследованиях, написанных учеными, докторами наук, профессорами, доцентами, преподавателями, аспирантами, магистрантами и студентами различных высших учебных заведений, а также всем, кто интересуется данной тематикой с целью применения в научной деятельности и образовательном процессе.

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Материалы конференции размещены в научной электронной библиотеке elibrary.ru и зарегистрированы в наукометрической базе РИНЦ (Российский индекс научного цитирования).

УДК 62+54+502.001
ББК 31+35+20.1

ISBN 978-5-91646-487-0

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Ministry of Science and Higher Education of the Russian Federation

FEDERAL STATE BUDGETARY EDUCATIONAL INSTITUTION OF HIGHER EDUCATION

“Saint Petersburg State University of Industrial Technologies and Design”
Higher School of Technology and Energy

PROCEEDINGS

of the XIX International Scientific and Practical Conference in English “DIALOGUE OF CULTURES”

Scientific publication
2026 ● Part II

Under the general editorship of Head of the Department of Foreign Languages, PhD in Philology, Associate Professor
V. V. Kirillova

Saint Petersburg
2026

UDC 62+54+502.001
BBK 31+35+20.1
D 44

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D 44 Proceedings of the XIX International Scientific and Practical Conference in English “Dialogue of cultures” (20–21 May 2026). In 2 parts / Ministry of Education and Science of the Russian Federation; FSBEI HE “Saint Petersburg State University of Industrial Technologies and Design”; responsible editors and compilers T. S. Sharapa, M. S. Lipatov; under the general editorship of V. V. Kirillova. SPb.: HSTE SPbGUITD, 2026. Part II, 383 p.

ISBN 978-5-91646-487-0

This collection presents the materials of the XIX International Scientific and Practical Conference in English "Dialogue of Cultures", held on 20-21 May 2026 in St. Petersburg.

The collection is addressed to a wide range of readers interested in scientific discoveries and research written by scientists, doctors of sciences, professors, associate professors, teachers, postgraduates, master's students and students of various higher educational institutions, as well as to all those who are interested in this subject in order to apply it in scientific activities and educational process.

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The proceesings of the conference are posted in the Scientific Electronic Library elibrary.ru and are registered in the Scientometric Database of the RSCI (Russian Science Citation Index).

UDC 62+54+502.001
BBK 31+35+20.1

ISBN 978-5-91646-487-0

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SECTION 1. ECONOMICS AND SOCIAL DEVELOPMENT TRENDS

УДК 001.891:338.1(597)

RESEARCH TRENDS IN VIETNAM-RELATED BUSINESS AND ECONOMIC STUDIES

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Abstract. Vietnam's rapidly changing business environment requires a systematic understanding of how it is represented in international research. The dataset includes 1,378 English-language publications retrieved from Scopus. The study applies a scoping review design and uses BERTopic topic modelling of titles, abstracts and keywords. The model identified 28 topics, which were grouped into 7 clusters. The findings reveal the main research areas shaping Vietnamese studies and provide a basis for further analysis of the country's business environment.

Keywords: Vietnam, business environment, economy, topic modelling, international management.

ИССЛЕДОВАТЕЛЬСКИЕ ТЕНДЕНЦИИ В ИЗУЧЕНИИ БИЗНЕСА И ЭКОНОМИКИ ВЬЕТНАМА

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Аннотация. Быстро меняющаяся бизнес-среда Вьетнама требует системного понимания того, как она представлена в международных исследованиях. Материалом послужили 1 378 англоязычных публикаций, отобранных из Scopus. В работе используется обзор предметного поля и тематическое моделирование BERTopic по названиям, аннотациям и ключевым словам. Модель выявила 28 тем, которые были объединены в 7 кластеров. Полученные результаты раскрывают основные исследовательские направления в изучении Вьетнама и создают основу для дальнейшего анализа бизнес-среды страны.

Ключевые слова: Вьетнам, бизнес-среда, экономика, тематическое моделирование, международный менеджмент.

Vietnam is one of the fastest-growing economies in Southeast Asia. Its strategic position in the Asia-Pacific region makes the country important for regional trade and global supply chains. Traditionally, Vietnam's economy has been closely connected with agriculture, manufacturing and export-oriented industries. In recent decades, rapid industrialization, economic modernization and foreign direct investment have strengthened its role as a dynamic business environment.

One of the most visible areas of change is digital commerce. Vietnam is considered one of Southeast Asia's fastest-growing e-commerce economies, and its e-commerce market is projected to reach 60 billion U.S. dollars by 2030 [1]. This creates research interest in online retail, logistics, fintech, digital marketing and consumer behaviour.

Vietnam also has a large and growing consumer market. With a population of nearly 100 million people, rising income levels, urbanization and the expansion of modern retail channels, the country offers significant opportunities for local and international companies. The rapid growth of the FMCG sector further confirms the relevance of Vietnam for studies of consumer markets and business development [2].

Investment activity provides another reason for academic interest. Vietnam's stock market capitalization is projected to reach about 305.04 billion U.S. dollars in 2026 [3], while the private equity market is expected to reach 6.01 billion U.S. dollars in deal value by the same year [4]. These indicators point to growing investor confidence and the development of the country's startup, technology and financial ecosystem.

The labour market also supports Vietnam's economic transformation. Employment trends are shaped by infrastructure development, education reform and digital transformation initiatives [5]. These processes strengthen labour productivity and increase the country's competitiveness in global supply chains.

Therefore, Vietnam is worth studying as a business environment shaped by digital commerce, consumer demand, investment activity, labour-market change and sustainable transformation. Before analysing these areas in detail, it is necessary to understand how they have already been represented in international academic literature. A scoping review helps identify the main research directions, dominant themes and underexplored areas. For this reason, the present article aims at mapping Vietnam-related business and economic studies.

The study applies a scoping review design combined with topic modelling. The scoping review design is used to map the selected publication corpus and identify the main directions of academic interest [6]. Topic modelling is used as an analytical tool that helps reveal the internal thematic structure of the corpus. The empirical basis of the study consists of publications indexed in Scopus. The search was conducted using the keyword "VIETNAM". The dataset was limited to English-language publications relevant to business and economic research. After screening and preprocessing, the final corpus included 1,378 publications. The analytical corpus included publication titles, abstracts and author keywords. These text fields were selected because they contain concentrated information about the object, subject and thematic focus of each publication. The data were exported from Scopus and prepared for automated text

analysis.

The dataset was further processed in Google Colab using Python. Topic modelling was performed with BERTopic. This method combines text embeddings and clustering algorithms to group semantically similar publications into thematic topics. The model was used to identify recurring semantic patterns in the corpus.

BERTopic was first used to identify 28 topics in the selected corpus. These topics were then interpreted on the basis of their keywords, frequency and semantic proximity. At the next stage, related topics were grouped into 7 broader analytical clusters. Topic and cluster labels were formulated through the analysis of frequent words and the thematic content of publications within each group.

The dynamics of publications related to Vietnam are presented in Figure 1. The data show a noticeable increase in research activity after 2015. The most intensive growth is associated with consumer behaviour, banking and finance, tourism, sustainability, digital transformation, agriculture and innovation. This indicates that Vietnam-related business and economic studies have become more visible in international research and increasingly reflect the country's economic modernization, technological development and sustainable transformation.

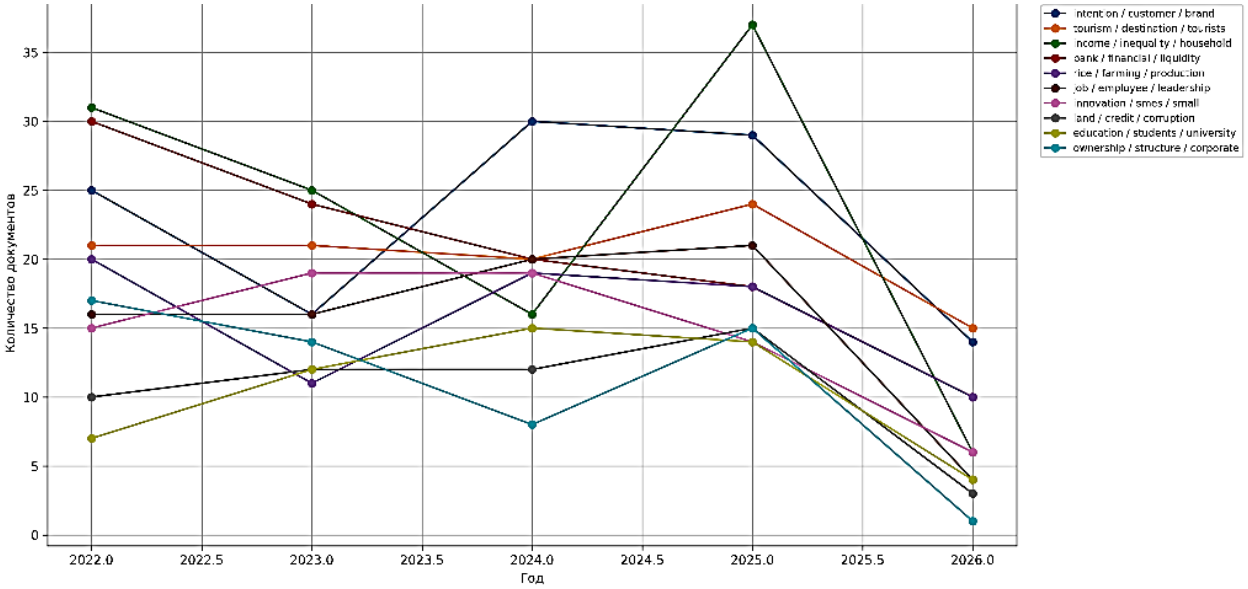


Figure 1. Dynamics of research topics related to Vietnam

The distribution of publications across the 28 identified topics is shown in Figure 2. The largest topics are associated with income inequality, consumer behaviour, banking and finance, tourism, agricultural development, innovation and sustainability. At the same time, the distribution is uneven, because several topics form the visible core of the field, while more specialized areas are represented by smaller groups of publications.

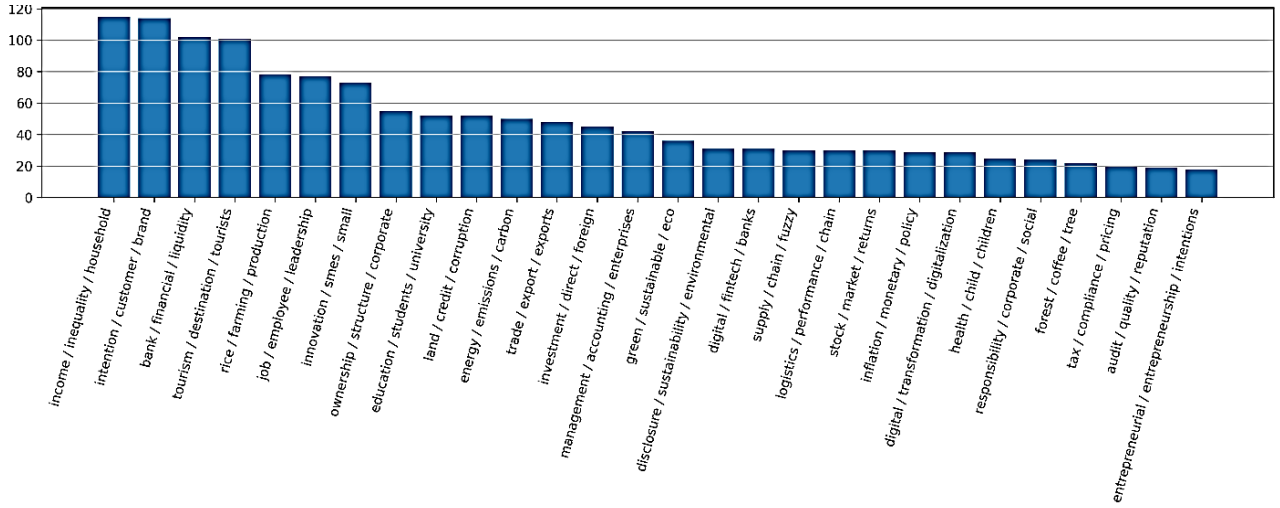


Figure 2. Distribution of publications across research topics

To clarify the topic structure, Table 1 presents the results of BERTopic modelling. The table includes all 28 topics, their frequency in the corpus and the key lexical patterns used for interpretation.

Table 1. Results of BERTopic modelling

Topic	Theme	Documents	Keywords
1	Consumer behavior and brand intention	114	intention, customer, brand, purchase
2	Destination tourism and recreational development	101	tourism, destination, tourists, sustainable
3	Income inequality and household development	115	income, inequality, household, poverty
4	Banking systems and financial liquidity	102	bank, financial, liquidity, commercial
5	Farming, rice production and agriculture	78	rice, farming, production, agricultural
6	Employment, leadership and job satisfaction	77	job, employee, leadership, organizational
7	Innovation and small enterprises	73	innovation, SMEs, small, medium
8	Emissions, carbon transition and energy	50	energy, emissions, carbon, renewable
9	Land management and corruption	52	land, credit, corruption, residential
10	Education, students and university development	52	education, students, university, learning
11	Corporate foreign investment and trade	55	ownership, structure, corporate governance
12	Export trade and competitiveness	48	trade, export, free agreement

13	Green sustainability and environmental development	36	green, sustainable, eco, consumption
14	Digital transformation and technology	29	digital transformation, digitalization
15	Green sustainability and environmental policy	45	foreign direct investment, FDI
16	Logistics and supply-chain management	30	logistics, performance, chain, service
17	Digital banking and financial technologies	31	digital, fintech, banks, banking
18	Monetary policy and inflation	29	inflation, monetary, fiscal policy
19	Market stock and investment development	30	stock market, returns, volatility
20	Accounting and enterprise management	42	management accounting, enterprises
21	Corporate responsibility and social governance	24	corporate social responsibility, CSR
22	Free trade, forestry and coffee production	22	forest, coffee, environmental
23	Entrepreneurship intention and business development	18	entrepreneurship, entrepreneurial intentions
24	Supply-chain systems and fuzzy modelling	30	supply chain, industry, resilience
25	Tax compliance and regulation	20	tax, compliance, transfer pricing
26	Audit quality and corporate reputation	19	audit, quality, reputation
27	Healthcare and children welfare	25	health, child, expenditure
28	Sustainability disclosure and environmental policy	31	sustainability, environmental reporting

The table above shows that the topic model produced a detailed but highly fragmented thematic structure. Several topics are closely related in content. For example, banking, fintech, monetary policy and investment form a financial block; export trade, logistics and supply chains are connected with international business infrastructure; sustainability-related topics appear in several parts of the model. Therefore, at the second stage of the analysis, the 28 BERTopic topics were grouped into 7 broader clusters.

Table 2. Aggregation of BERTopic topics into 7 clusters

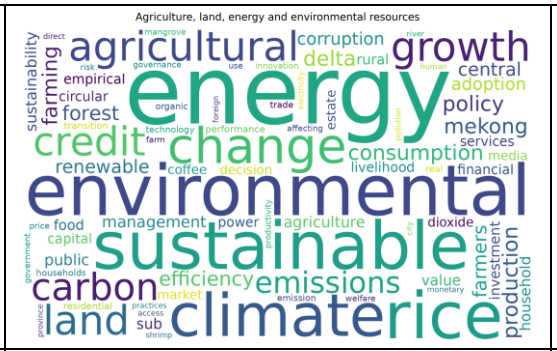
Clusters	Included topics	Share
1. Market behaviour, tourism and sustainable consumption	1, 2, 13	251
2. Enterprise development, innovation and work	6, 7, 14, 20, 23	239
3. Agriculture, land, energy and environmental resources	5, 8, 9, 22	202
4. Human capital, inequality and social welfare	3, 10, 27	192
5. Financial sector, fintech and macro-finance	4, 17, 18, 19	192
6. Trade, investment, logistics and supply chains	12, 15, 16, 24	153
7. Corporate governance, reporting, tax and audit	11, 21, 25, 26, 28	149

Table 2 shows that the largest cluster combines market behaviour, tourism and sustainable consumption. It brings together studies of consumer practices, destination development and sustainability-oriented demand. The second largest cluster is related to enterprise development, innovation and work, which points to the role of business modernization, digital transformation and entrepreneurship in Vietnam-related research. Other clusters show the importance of agriculture, environmental resources, finance, trade, logistics and corporate governance.

After the 28 topics were aggregated into 7 clusters, the analysis focused on the internal content of each cluster. Table 3 presents the keywords and the most cited publications associated with every cluster. The publications were selected from the Scopus export according to citation count and thematic relevance.

Table 3. Clusters and research trends

Cluster	Keywords	Most cited publications
1. Market behaviour, tourism and sustainable consumption		Law et al. [7], Nguyen Thi et al. [8]
2. Enterprise development, innovation and work		Nguyen et al. [9], Sadiq et al. [10]

3. Agriculture, land, energy and environmental resources		Raihan [11], Hoa et al. [12]
4. Human capital, inequality and social welfare		Maheshwari [13], Bui et al. [14]
5. Financial sector, fintech and macro-finance		Nathan et al. [15], Phuoc et al. [16]
6. Trade, investment, logistics and supply chains		Akbari et al. [17], Tseng et al. [18]
7. Corporate governance, reporting, tax and audit		Anh et al. [19], Nguyen et al. [20]

The most cited publications help clarify which research problems have received the strongest academic attention in Vietnam-related business and economic studies. Law et al. analyse Cambodia, Laos, Myanmar and Vietnam and show a long-term relationship between air transport, economic growth and inbound tourism [7]. Nguyen

Thi et al. examine online shopping among Generation Y and Z in Vietnam during the "new normal" period and identify factors that support the intention to continue online purchases [8]. The studies show the importance of mobility, tourism and digital consumer behaviour for understanding Vietnam's changing business environment.

Nguyen et al. apply an extended Technology-Organization-Environment framework and identify factors that influence the adoption of online retailing by Vietnamese firms [9]. Sadiq et al. examine the transportation industry and show that the sharing economy can contribute to sustainable development goals, especially when supported by an innovative culture [10]. These findings connect business modernization with digital tools, innovation and sustainability-oriented practices.

Raihan evaluates the effects of economic growth, energy use and agricultural value added on carbon dioxide emissions in Vietnam [11]. Hoa et al. analyse the relationship between innovation, renewable energy consumption, foreign direct investment, economic growth and CO_2 emissions [12]. The publications demonstrate that Vietnam's economic development is closely connected with energy demand, environmental pressure, agricultural transformation and foreign investment.

Maheshwari studies entrepreneurial intentions among university students in Vietnam and combines social learning theory, human motivation theory and the theory of planned behaviour [13]. Bui et al. examine the effects of fiscal policy on households during the COVID-19 pandemic in Thailand and Vietnam, showing how public support is related to consumer sentiment and household spending [14]. These works highlight the role of human capital, entrepreneurship and public policy in economic development.

Nathan et al. analyse fintech adoption, financial literacy and financial health among consumers in Vietnam during the COVID-19 pandemic [15]. Phuoc et al. use machine learning algorithms to predict stock price trends in the Vietnamese stock market [16]. These studies show that financial research on Vietnam increasingly involves fintech, consumer financial behaviour, data analytics and investment decision-making.

Akbari et al. examine the influence of Industry 4.0 on digital transformation in Vietnamese supply chains [17]. Tseng et al. study sustainable supply chain management in the healthcare industry and identify criteria related to sustainable supply and process management [18]. These publications indicate that logistics and supply chains are studied not only as operational systems, but also as areas of digital and sustainable transformation.

Anh et al. analyse the adoption of artificial intelligence in accounting and auditing in Vietnam and show the importance of technology readiness for AI adoption [19]. Nguyen et al. examine the relationship between corporate social responsibility and financial performance in Vietnamese listed companies [20]. These studies show that corporate governance research increasingly addresses digital technologies, transparency, responsibility and financial outcomes.

The analysis shows that Vietnam-related business and economic studies form a broad field. The most cited publications indicate that Vietnam is studied as a dynamic business environment shaped by digital transformation. Traditional research areas, including agriculture and tourism, remain important, while newer topics such as fintech, online retailing, artificial intelligence are becoming increasingly visible.

The study is limited to English-language publications indexed in Scopus. Therefore, the results should be interpreted as a structured map of this corpus rather than a review of all research on Vietnam.

For further research on Russia and Vietnam cooperation, the most relevant entry point is the cluster “Trade, investment, logistics and supply chains”. This cluster directly connects Vietnam-related business studies with cross-border trade, investment flows, logistics infrastructure and international supply chains. It therefore provides the clearest basis for a focused systematic review of bilateral business cooperation. Other clusters, especially “Enterprise development, innovation and work” and “Financial sector, fintech and macro-finance”, may be considered as supporting directions.

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УДК 658.1:658.5:338.2:334.012

STRATEGIC BUSINESS PLANNING AT MILITARY-INDUSTRIAL COMPLEX ENTERPRISES IN A MARKET ECONOMY

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Abstract. This article examines theoretical and practical aspects of business planning in enterprises within a market economy, with a focus on the military-industrial complex in the context of production diversification and state defense orders. It analyses key theoretical approaches, including the strategic management theories of I. Ansoff and M. Porter, and E. Goldratt's theory of constraints. Case studies illustrate business plan development and adaptability for defense enterprises. Challenges in the Russian market and improvement directions aligned with national defense objectives are also addressed.

Keywords: market economy, military-industrial complex, production diversification, state defense order, business planning, strategic management.

СТРАТЕГИЧЕСКОЕ БИЗНЕС-ПЛАНИРОВАНИЕ НА ПРЕДПРИЯТИЯХ ВОЕННО-ПРОМЫШЛЕННОГО КОМПЛЕКСА В УСЛОВИЯХ РЫНОЧНОЙ ЭКОНОМИКИ

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Аннотация. В статье рассматриваются теоретические и практические аспекты бизнес-планирования на предприятиях в условиях рыночной экономики с акцентом на военно-промышленный комплекс (ВПК) в контексте диверсификации производства и выполнения гособоронзаказа. Анализируются ключевые теоретические подходы, в том числе теории стратегического управления И. Ансоффа и М. Портера, а также теория ограничений Э. Голдратта. На примере кейсов (кофейня, салон фотоуслуг) демонстрируется разработка бизнес-плана и его адаптивность для оборонных предприятий.

Также затрагиваются проблемы российского рынка и направления совершенствования бизнес-планирования с учетом задач обеспечения обороноспособности страны.

Ключевые слова: рыночная экономика, военно-промышленный комплекс, диверсификация производства, гособоронзаказ, бизнес-планирование, стратегическое управление.

The experience of many successful companies in developed countries has shown that in a competitive market environment, planning of economic and production activities is an essential condition for their survival, economic growth, and prosperity. In a market economy, business planning constitutes an integral part of any company's operations. Planning enables enterprises to anticipate development trends, avoid the risk of bankruptcy, identify potential cost-saving opportunities, and more.

For enterprises of the military-industrial complex (MIC), which operate under strict government regulation and face heightened requirements for product quality and delivery timelines, business planning takes on special significance. It ensures the fulfilment of state defense orders and the efficient use of budgetary funds allocated for army rearmament.

Relevance of the Research Topic. In the theory and practice of modern management, one of its key functional components – business planning – is gaining increasing relevance. For example, during a crisis, the role of motivation and incentive systems undergoes noticeable changes.

It is important for an organization to identify motivation and incentive methods that preserve its budget as much as possible. Conversely, for employees, it is more critical to receive the highest possible monetary (and non-monetary) rewards for fulfilling their job duties.

Understanding the fundamentals of motivation and incentives helps improve the effectiveness of managing organizational development and systems. In defense industry enterprises, where highly qualified specialists work on complex military products, building an effective motivation system is a key factor in retaining human capital and ensuring the continuity of production cycles.

Objective of the Study. The aim of this work is to develop an effective business plan for expanding the product range in ornamental plant enterprises. Within the context of the military-industrial complex, this objective can be interpreted as developing a business plan for production diversification. Such a plan would enable defense enterprises to utilize their capacities for civilian production while maintaining mobilization readiness and the technological core required for arms production. To achieve this goal, the following tasks must be addressed: to elucidate the theoretical foundations of business planning, its classification, and the economic essence of efficiency, to provide an example of business planning, to analyze a business plan in the manufacturing sector, to develop business planning measures within a market economy and to forecast their socio-economic effectiveness.

Theoretical Foundations of Business Planning in a Market Economy. Business planning is the process of developing a company's strategy and tactics within

a market economy. It involves analyzing the external and internal environment, setting goals, selecting methods to achieve them, and assessing potential risks [1, p. 355].

For enterprises of the military-industrial complex, business planning must take into account not only market factors but also the specifics of government regulation, the confidentiality of certain production aspects, and the strategic importance of the products for the country's defense capability. In a market economy, a business plan serves several fundamental functions:

Market adaptation helps the enterprise respond to changes in demand, competition, and technology. This is particularly relevant for MIC enterprises entering foreign arms markets.

Resource optimization minimizes costs and maximizes profit. This is critically important when fulfilling state defense orders with fixed profitability.

Risk management identifies potential threats and proposes methods for mitigating them, including geopolitical risks.

Investment attractiveness serves as a tool for attracting capital, including for technological modernization projects.

The theoretical foundations of business planning include:

I. Ansoff's strategic management theory (Fig. 1), which encompasses the concept of strategic management and a matrix describing possible strategies for company growth in the market (the Ansoff Matrix). For defense enterprises, this matrix can be used to choose between deepening specialization in military production and diversifying into civilian production.



Figure 1. The Ansoff Matrix

M. Porter's strategic management theory is based on the "Five Forces" model (Fig. 2), which helps to systematically analyze the competitive forces shaping any industry. These forces are:

Rivalry among existing competitors – the intensity of competition between companies already operating in the market.

Threat of new entrants – the potential for new players to enter the industry.

Bargaining power of suppliers – the ability of suppliers to influence prices and terms.

Bargaining power of buyers – the influence that customers have on pricing and product offerings.

Threat of substitute products or services – the risk posed by alternatives that can replace the existing offering.

In the defense industry, the analysis of these forces has its own specific features, related to the state acting as the main customer and a limited number of enterprises having access to critical technologies.



Figure 2. Porter's Five Forces Model

E. Goldratt's Theory of Constraints is a management methodology that proposes identifying and eliminating "bottlenecks" in systems that limit their effectiveness. Key principles include a focus on the constraint, the application of systems thinking, managing flow rather than capacity, and subordinating the entire system to the constraint. In the production of complex weapons systems, identifying bottlenecks is critical for meeting the deadlines of state defense orders [2, p. 358].

Modelling of economic processes is a method that allows forecasting the future development of the economy and identifying the factors that influence it. It is based on mathematical and statistical models that describe economic processes and their interrelationships. Types include macroeconomic models, microeconomic models, financial models, and econometric models. For military-industrial complex (MIC)

enterprises, modelling can be applied to forecast the demand for various types of weapons depending on geopolitical scenarios.

Analysis of the Business Planning System in a Market Economy. Setting specific, measurable, achievable, realistic, and time-bound goals helps employees clearly see the prospect of their professional growth and gain satisfaction from achieving set tasks. Clearly formulated goals contribute to a better understanding of priorities and directing efforts towards completing the most important tasks. In defense enterprises, where tasks often have a strategic nature, clear goal-setting is especially important.

Business Plan for Diversification of a Defense Enterprise: A Case Study of a Photo Services Salon

Executive Summary. Project name: Diversification of production at a defense enterprise through the establishment of a photo services salon. Location: City center, with possible use of part of the enterprise's existing premises. Format: A modern photo salon providing a full range of services to the public. Target audience: city residents, visitors, corporate clients. Unique selling proposition: use of high-precision equipment originally designed for defense purposes, high quality standards inherent in military production. Initial investment: 3 500 000 rubles (can be partially funded from the enterprise's development fund). Expected monthly profit: 150 000–250 000 rubles. Payback period: 14–20 months.

Business Description. The concept assumes using the production capacities of a defense enterprise, its experience in precision machining and quality control to provide photo services to the public. Emphasis is placed on high quality and precision, which is a competitive advantage of defense enterprises. The range of services includes printing photographs, image restoration and editing, production of business cards and invitations, photography in a studio, sale of related goods, and provision of photographer services for events.

Market Analysis. The target audience consists of city residents, corporate clients, and participants in celebratory events. Competitors include specialized photo salons and freelance photographers. Advantages of a defense enterprise include high quality standards, availability of precision equipment, and the ability to utilize experienced engineering personnel during downtime periods.

Marketing Strategy. Promotion will be carried out through social media, collaborations with event agencies, targeted advertising, and emphasizing the high quality inherent in military production. The loyalty program will include discounts for regular customers and for employees of the parent enterprise.

Operational Plan. The personnel include photographers, a retouching engineer (possibly from among the enterprise's engineers), and an administrator. The equipment includes high-precision photographic equipment, professional printers, and processing stations, partially converted from existing capacities.

The organization of photo services production falls under the small-batch type, as the volume of output directly depends on the projected sales level. This format is optimal for testing diversification mechanisms at defense industry enterprises, as it involves moderate risks. The list of planned services includes: printing photographs, image restoration and editing, production of business cards and invitations, conducting

photo shoots in a studio, selling related goods, and providing photographer services for on-site events.

The most preferable location is the city center; the use of part of the defense enterprise's premises is allowed, provided a separate entrance is equipped. It is planned to conclude a lease agreement for a space of 100 sq. m for a period of 3 years, with a monthly payment of 50 000 rubles. To simplify the calculation of consumable material costs, all company products are условно divided into four groups: photographs, digital cameras, related goods, and other services.

Financial Plan. Initial expenses (3 500 000 rubles) cover equipment, premises renovation, licenses, and marketing. Monthly expenses (465 000 rubles) include rent, salaries, materials, utilities, and advertising. With an average check of 500 rubles and 80–120 visitors per day, the expected monthly revenue is 1 200 000–1 800 000 rubles, yielding a net profit of 150 000–250 000 rubles.

Risks and Solutions. Risks include insufficient demand (solution: active marketing, offering unique services), price competition (emphasis on quality), and underutilization of capacities (using engineers for core work during peak loads).

Problematic Situation. The nature of the enterprise's activities is highly diverse. The problem lies in ensuring staff loyalty given the heterogeneous nature of the enterprise's operations and in defining an effective labor incentive system that improves the quality of production task execution. At defense enterprises, this problem can be addressed by combining a guaranteed salary for fulfilling state defense orders with a bonus system for additional civilian production workload.

Thus, diversification through the creation of civilian production allows defense enterprises to utilize their capacities, retain personnel, and generate additional profit. With a well-thought-out concept and a focus on quality, the project has every chance of becoming profitable.

Improving Business Planning in a Market Economy. Currently, the instability of environmental factors requires enterprises to conduct detailed forecasting of their strategic and current activities, accounting for threats and opportunities for further development and achieving set goals. The modern economic environment demands that management of any organization be capable of making adequate managerial decisions under uncertainty.

Business planning is an important element of strategic planning that can crucially anticipate an enterprise's response to external environment requirements and maintain its appropriate market behavior. For MIC enterprises, business planning must take into account both market factors and the specifics of fulfilling state defense orders, including possible changes in the geopolitical situation.

Many businesspeople who have studied numerous foreign publications on business planning and try to follow the recommendations therein face challenges unknown in the West. Unlike Western countries, business planning in the Russian Federation has several specific features, particularly in the defense industry.

Russian legislation today does not mandate business planning for all enterprises, but for organizations receiving budgetary funds under state defense orders, planning is mandatory [3, p. 47]. Such a document is new for many defense enterprises transitioning to market principles in the post-Soviet era.

The non-competitiveness of Russian business plans stems from a number of misconceptions, primarily on the part of their clients. The most common issue lies in the scope of work that clients expect from developers. In practice, the business environment faces the problem of insufficient awareness among executives regarding business planning and where the figures come from. For defense enterprises, this issue is exacerbated by the confidentiality of many input data and the difficulty of forecasting under geopolitical instability.

Let us consider another problematic aspect of a business plan: risk analysis. Most often, this section is approached without due responsibility, with a template entry inserted into the document without even adjusting it to the specifics of the business project. The developer must identify all possible risks and then develop measures for each risk aimed at preventing it or compensating for its negative impact. For MIC enterprises, the list of risks must include geopolitical risks, risks of changes in state defense orders, export restriction risks, etc.

It should also be noted that one of the main and, in most cases, decisive aspects of business planning specifics in Russia is cost. A high-quality, reliable business plan is created by highly qualified specialists for a specific project, taking into account a range of individual features [4]. Consequently, the cost of a quality business plan prepared by highly qualified specialists, considering the project's individual features, is substantial. This is why clients often opt for only parts of the document that are most complex and important for their analysis. This situation is the cause of all the listed errors. For defense enterprises, which often have limited budgets for consulting services, this problem is especially acute.

Despite the absence of legislative acts that directly mandate business planning for all enterprises, a significant number of decrees have been adopted in the Russian Federation that shape the business environment. Operating within it implies the need to develop a business plan to secure project funding. For defense enterprises, a business plan is necessary both to obtain funding for modernization and to justify product costs under state defense orders. Increasing awareness among entrepreneurs and managers, as well as adopting foreign business planning experience, can lead Russian business, including the defense industry, to a new, higher level of development.

Conclusion. A business plan is a system of methodically formulated measures (economic, technical, organizational, and social) aimed at achieving a planned goal, balanced by objectives and resources, interconnected in time and space. It is a compact document that includes prerequisites, conditions, a specific action program, and defines the financial and economic conditions and outcomes of a business project. For military-industrial complex enterprises, a business plan becomes a tool not only for commercial activities but also for ensuring strategic planning of the defense industry's development.

The business planning process itself provides the opportunity to determine the optimal management decision based on the enterprise's own potential and the opportunities of the external environment. In most cases, business planning is necessary for small and medium-sized enterprises, as they operate under uncertainty and have less tolerance for errors [5]. For defense enterprises, many of which are large industrial complexes, business planning helps them adapt to market conditions while

preserving key competencies required for fulfilling state defense orders.

Currently, increasing competitiveness requires continuous enterprise development, production expansion, introduction of innovations, and improvement of work processes. For effective enterprise operation, it is important to remember that sound planning plays a crucial role and helps achieve enterprise goals. For defense enterprises, this is especially important due to their strategic significance for the country's security.

The choice of a specific business plan development methodology, the depth and time horizon of its elaboration, the variability of solutions included, the scope, and the presence of attached documents and certificates depend on many factors, such as the amount of anticipated investment, the purpose of the plan (e.g., obtaining a bank loan or state support), and whether own funds are to be invested. For MIC enterprises, an additional factor is the need to align the business plan with defense industry development programs and the state armament program.

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УДК 336.71:330.13

CURRENT RESEARCH TRENDS IN THE ECONOMIC EVALUATION OF COMMERCIAL BANK PERFORMANCE

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Abstract. The paper examines current research trends in the economic evaluation of commercial bank performance in the international context. The study is based on 976 Scopus-indexed publications on banking, international finance and related fields. A scoping review is combined with thematic modelling of titles, abstracts and keywords. The results identify key research areas, including bank efficiency, financial crises, lending, capital regulation, risk management, Islamic finance and sustainability-related studies. The findings may be useful for specialists in international business.

Keywords: bank performance, efficiency, international business, scoping review, Scopus.

СОВРЕМЕННЫЕ ТЕНДЕНЦИИ ИССЛЕДОВАНИЙ В ОБЛАСТИ ОЦЕНКИ ЭКОНОМИЧЕСКОЙ ЭФФЕКТИВНОСТИ КОММЕРЧЕСКИХ БАНКОВ

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Аннотация. В статье рассматриваются современные тенденции исследований, посвященных экономической оценке эффективности деятельности коммерческих банков в международном контексте. Материалом исследования послужили 976 публикаций, индексируемых в Scopus и связанных с банковским делом, международными финансами и смежными областями. Методология включает обзор предметного поля и тематическое моделирование названий, аннотаций и ключевых слов. В результате выделены ключевые направления исследований: эффективность банков, финансовые кризисы, кредитование, регулирование капитала, управление рисками, исламские финансы и устойчивое развитие. Результаты могут быть полезны специалистам в области международного бизнеса.

Ключевые слова: эффективность банков, банковская деятельность, международный бизнес, обзор предметного поля, Scopus.

Commercial banks occupy a central position in the modern financial system. They provide access to credit, maintain liquidity, support payment mechanisms and redistribute financial risks. Their stability is closely associated with investment activity, entrepreneurship, economic growth and the resilience of national financial systems. For this reason, the assessment of banking performance remains a significant area of international finance research [1].

In recent decades, the evaluation of banking activity has become increasingly complex. Traditional indicators, including profitability, liquidity, capital adequacy, asset quality and cost efficiency, are no longer sufficient for explaining the factors that shape the performance of financial institutions [1]. Contemporary banks operate under the influence of financial shocks, regulatory changes, digital transformation, global capital flows, environmental risks and intensified competition. As a result, academic interest has shifted from separate financial ratios to broader studies of efficiency, risk management, lending behaviour, reporting standards, corporate governance and sustainable finance.

The importance of this study is determined by major changes in the global banking sector after a series of financial and economic shocks [2]. Financial instability, sanctions, credit market volatility, changes in international regulation and the growing importance of environmental, social and governance factors have influenced approaches to bank assessment. In this context, it is necessary to examine not only individual financial indicators, but also the way academic literature reflects current trends in the evaluation of banking activity.

Before developing new approaches to bank performance analysis, it is important to identify the main research areas already represented in the international academic landscape. A scoping review makes it possible to reveal dominant themes, trace links between related areas and determine directions requiring further study. This is particularly relevant for international finance, where banking performance is often discussed in relation to financial crises, credit markets, capital regulation, risk-taking, accounting standards, Islamic banking and sustainable development.

The aim of this study is to identify current research trends in the economic evaluation of commercial bank performance. The empirical basis consists of 976 scientific publications devoted to international finance, banking and global economic development. The Scopus search was conducted in May 2026. The study combines a scoping review with BERTopic thematic modelling. For analytical clarity, automatically generated topic labels were renamed on the basis of the most representative words and the semantic content of the corresponding documents [3].

The article contributes to the systematization of academic knowledge on bank performance assessment. It presents a thematic map of current research trends and highlights the interdisciplinary character of banking studies in the context of international finance. The findings may be useful for further research on financial stability, risk management and methods for evaluating commercial banks [3]. The general distribution of publications across the identified BERTopic clusters is presented in Figure 1.

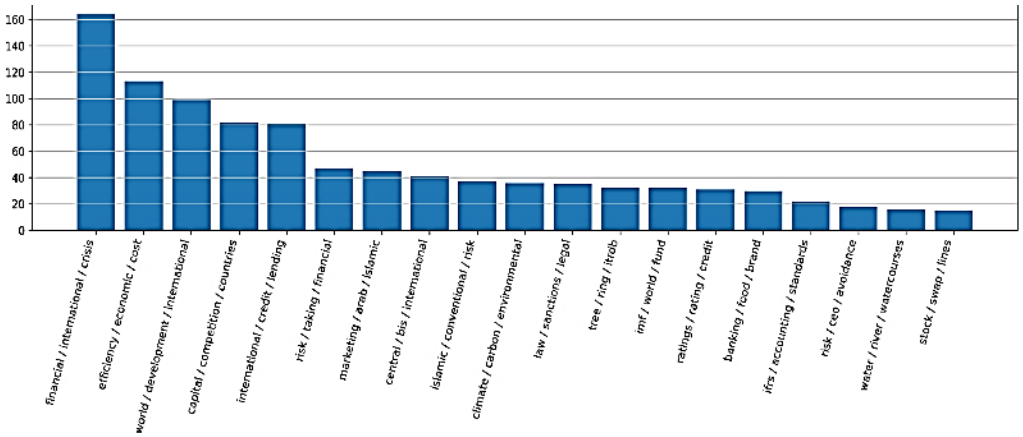


Figure 1. Distribution of documents by research topics

The distribution of documents is uneven. The largest cluster includes more than 160 publications and is associated with financial instability, international monetary processes and crisis-related studies. Two other major groups focus on efficiency indicators and global development. This structure indicates that bank performance is usually examined through both internal financial characteristics and wider macroeconomic conditions. The remaining clusters broaden the scope of the corpus and connect bank assessment with capital, lending, risk-taking, Islamic banking, regulation, climate issues, accounting standards and international liquidity mechanisms [4].

To clarify the semantic content of the main clusters, the most representative words within each group were analysed. These lexical markers help reveal the internal structure of the topics and support the interpretation of the modelling results. The topic word scores are presented in Figure 2.

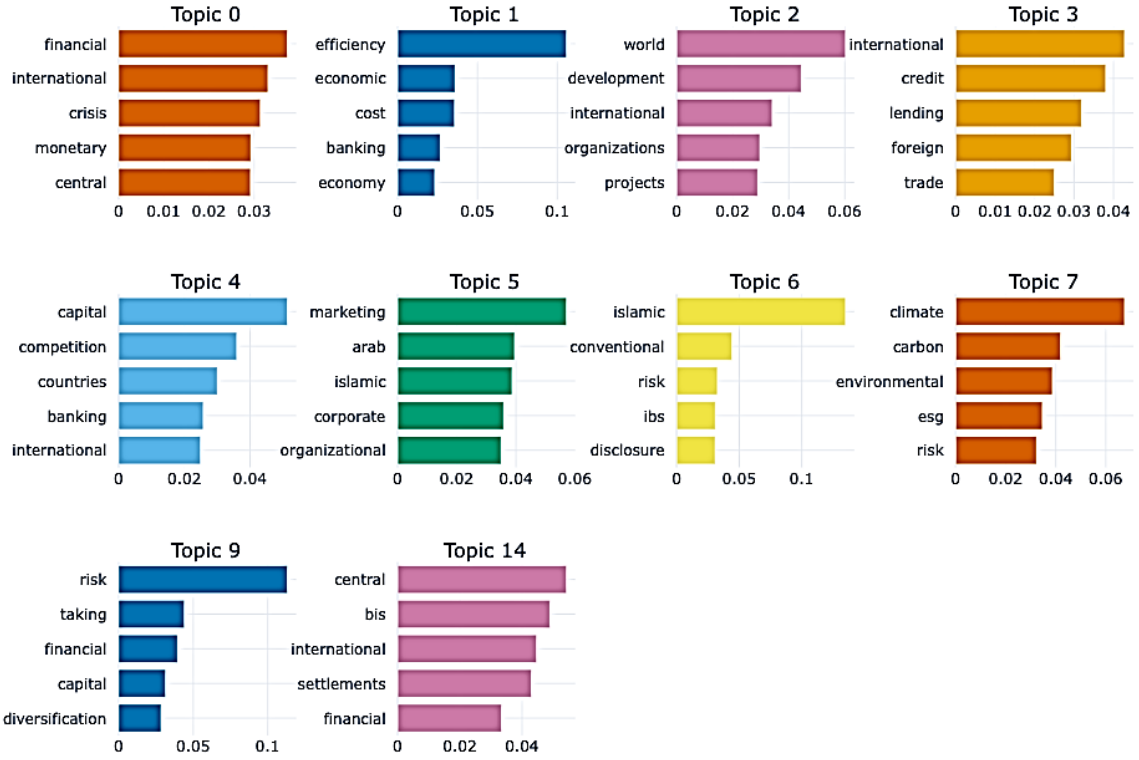


Figure 2. Topic word scores

The topic word scores specify the semantic boundaries of the clusters. They confirm that the corpus covers both traditional and emerging aspects of banking research. The central part of the field is associated with crisis studies, efficiency assessment, international development, credit relations and capital structure. More specialized lexical patterns point to Islamic finance, corporate disclosure, ESG-related issues, central banking and international financial institutions.

The relationships between the identified topics were analysed with an intertopic distance map. This visualization shows the degree of semantic proximity between thematic groups and helps assess whether the field is fragmented or internally connected. The results are presented in Figure 3.

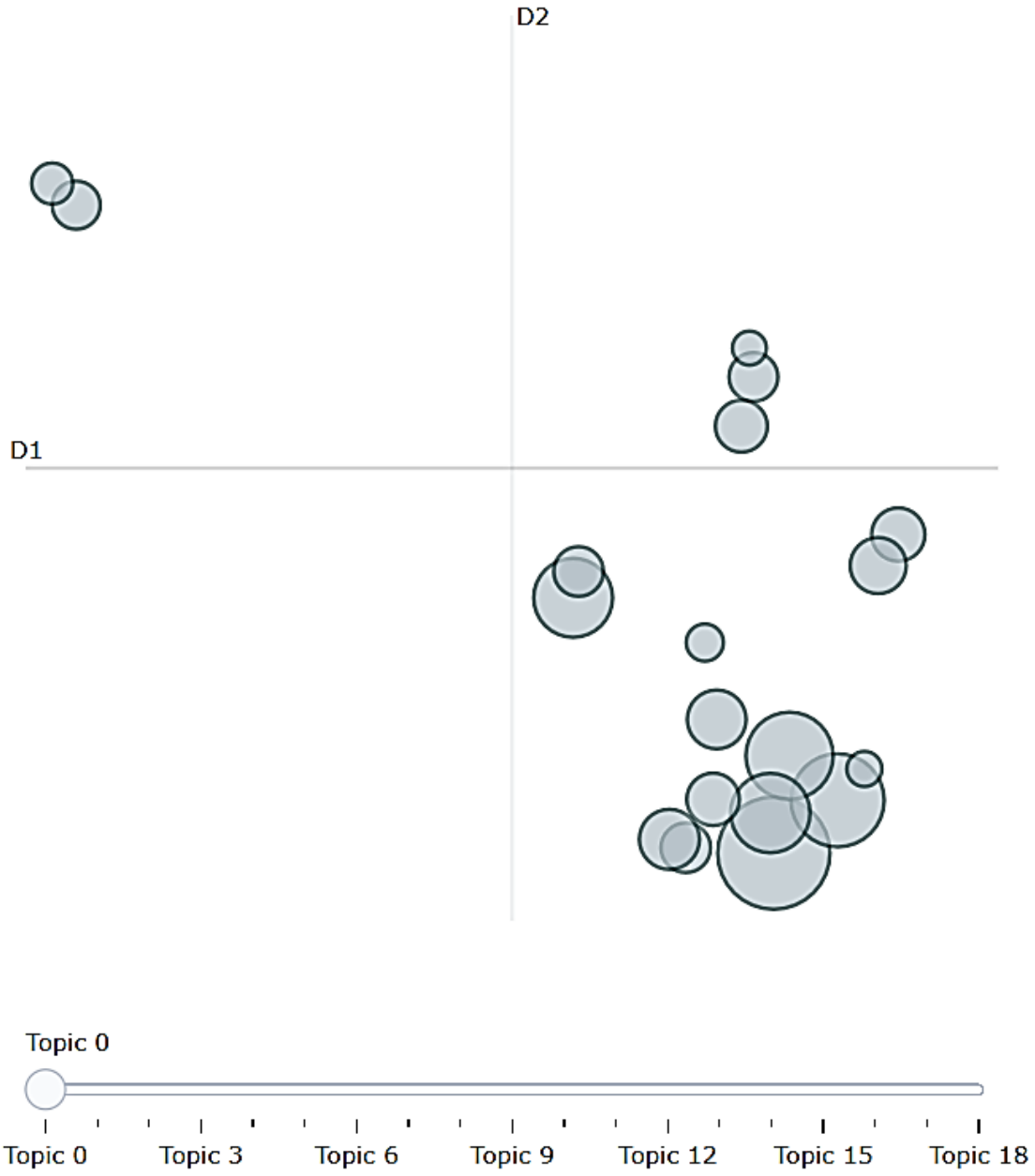


Figure 3. Intertopic distance map

The intertopic distance map reveals semantic proximity between the identified thematic groups. The size of each circle reflects the relative importance of the topic,

while the distance between circles indicates how closely the topics are related. Most topics are located close to one another, which suggests that the core areas of the corpus are semantically interconnected. Studies of efficiency, lending, capital, regulation and risk are usually discussed within a shared financial and institutional context. Several topics are positioned at a greater distance from the main cluster and represent more specialized institutional, environmental or sector-specific issues [5].

To systematize the results of thematic modelling, the identified clusters were summarized in Table. The table presents the number of documents within each topic, the interpreted thematic direction and the most representative keywords generated by BERTopic.

Table. Results of the thematic modelling

Theme	Keywords	Documents
Financial crises and international monetary studies	financial, international, crisis, monetary, central	164
Bank efficiency and economic performance	efficiency, economic, cost, banking, economy	112
Global development and international organizations	world, development, international, organizations, projects	99
International credit, lending and trade finance	international, credit, lending, foreign, trade	91
Bank capital, competition and cross-country analysis	capital, competition, countries, banking, international	82
Financial risk-taking and diversification	risk, taking, financial, capital, diversification	47
Islamic banking and corporate practices	marketing, Arab, Islamic, corporate, organizational	45
Central banks and international settlements	central, BIS, international, settlements, financial	41
Islamic and conventional finance risk studies	Islamic, conventional, risk, disclosure, financial	37
Climate, carbon and ESG-related banking studies	climate, carbon, environmental, ESG, risk	36
Legal regulation, sanctions and international law	law, sanctions, legal, international, corruption	35
IMF, monetary institutions and global finance	IMF, world, fund, monetary, international	32
Environmental data and interdisciplinary sustainability studies	tree, ring, ITRDB, diversity, environmental	32
Credit ratings and lending regulation	ratings, rating, credit, risk, lending	31
Banking, brands and corporate relations	banking, food, brand, international, corporate	30

IFRS, accounting standards and audit	IFRS, accounting, standards, audit, financial	22
CEO risk avoidance and corporate behaviour	risk, CEO, avoidance, taking, behaviour	18
Water resources and international environmental regulation	water, watercourses, resources, international	16
Stock markets, swap lines and volatility	stock, swap, lines, volatility, market	15

The identified topics show that academic discussion is concentrated around a core group of themes related to financial instability, efficiency, international development, lending and capital. Alongside this core, the corpus includes specialized areas concerning Islamic finance, ESG-related studies, accounting standards, legal regulation, risk-taking behaviour and international settlements. Peripheral clusters associated with environmental data and water resources indicate that the search strategy also captured studies linked to sustainability and broader international economic development.

For a clearer representation of the topic modelling results, a mind map was developed (Figure 4). It provides a consolidated view of the analysed corpus.

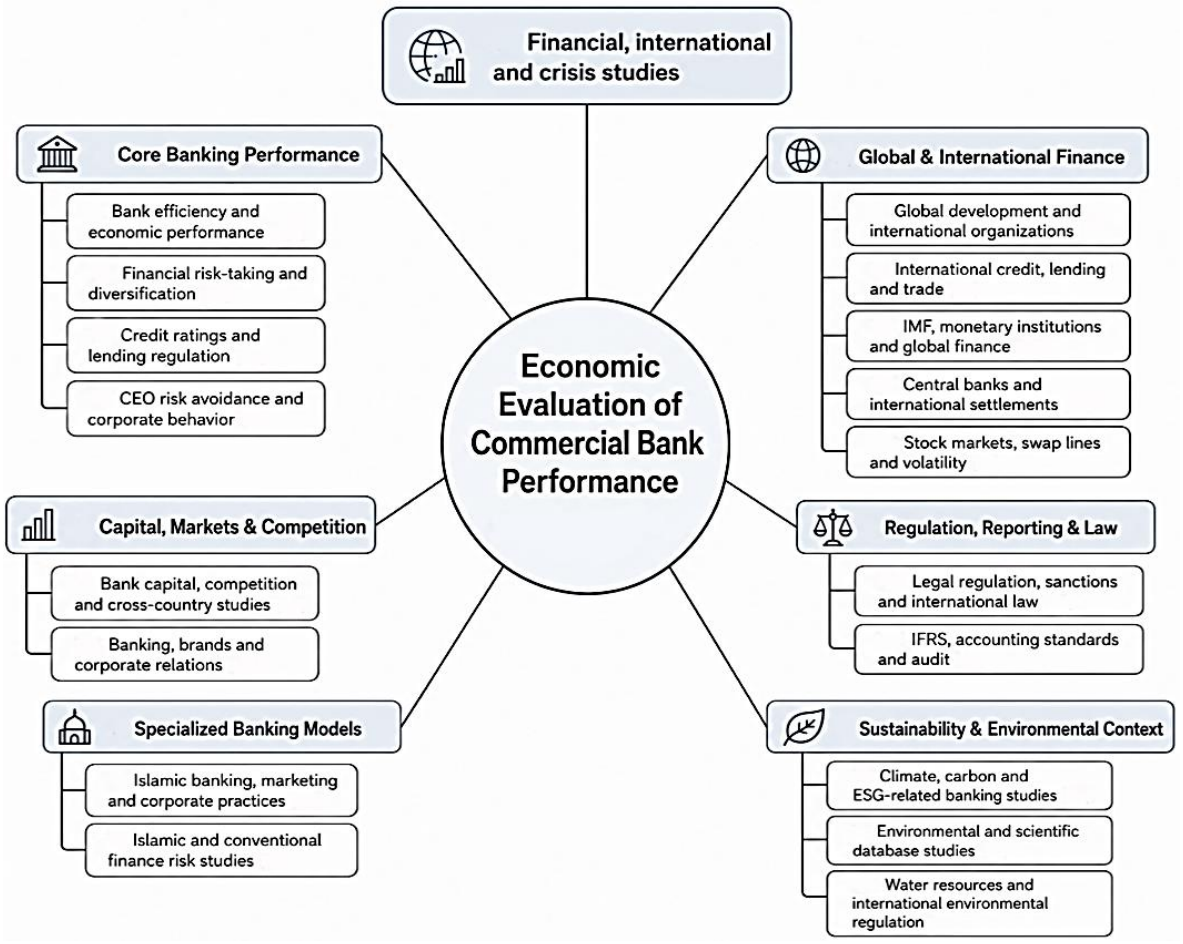


Figure 4. Thematic map of research areas in the economic evaluation of commercial bank performance

The conducted study systematized current academic trends in this area. The results show that the evaluation of commercial banks is a broad interdisciplinary field that goes beyond traditional financial indicators. The modelling results suggest two interconnected tendencies. The first is the continuation of classical financial analysis focused on efficiency, capital, lending and risk. The second is the expansion of the field toward broader institutional, regulatory and sustainability-related factors. This means that bank performance assessment should be understood not only as a quantitative financial procedure, but also as a multidimensional analytical framework.

The study is limited to Scopus-indexed publications and to the analysis of titles, abstracts and keywords. Further research may focus on integrated models that combine financial indicators with regulatory, institutional and ESG-related factors in assessing bank performance.

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УДК 336.71

THE IMPACT OF CENTRAL BANK DIGITAL CURRENCIES ON THE LIQUIDITY OF THE COMMERCIAL BANKING SECTOR

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Abstract. This article examines the impact of the implementation of Central Bank Digital Currencies (CBDCs), using the digital ruble as an example, on the liquidity of the commercial banking sector. The author analyzes the risks of bank disintermediation, the potential outflow of customer funds from deposits, and the transformation of the liability structure of credit institutions. The article considers the adaptation mechanisms of the banking system to the new form of money and the role of the Central Bank of the Russian Federation in maintaining financial stability through refinancing instruments. Special attention is paid to the regulatory framework governing the circulation of the digital ruble in the Russian Federation.

Keywords: digital ruble, CBDC, liquidity, commercial banks, monetary policy, Bank of Russia, financial stability.

ВЛИЯНИЕ ЦИФРОВЫХ ВАЛЮТ ЦЕНТРАЛЬНЫХ БАНКОВ НА ЛИКВИДНОСТЬ КОММЕРЧЕСКОГО БАНКОВСКОГО СЕКТОРА

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Аннотация. В данной статье на примере цифрового рубля исследуется влияние внедрения цифровых валют центральных банков (CBDC) на ликвидность коммерческого банковского сектора. Автор анализирует риски дезинтермедиации банков, возможный отток клиентских средств с депозитов и трансформацию структуры пассивов кредитных организаций. Рассматриваются механизмы адаптации банковской системы к новой форме денег и роль Центрального банка РФ в поддержании финансовой стабильности через инструменты рефинансирования. Особое внимание уделено нормативно-правовой базе, регулирующей оборот цифрового рубля в Российской Федерации.

Ключевые слова: цифровой рубль, CBDC, ликвидность, коммерческие банки, денежно-кредитная политика, Банк России, финансовая стабильность.

The global financial landscape is undergoing a fundamental transformation driven by the digitalization of payment systems and the emergence of distributed ledger technologies (DLT). Central Bank Digital Currencies (CBDCs) have become a focal point for monetary authorities worldwide. In the Russian Federation, the transition to the “Digital Ruble” represents not merely a technological update but a structural shift

in the architecture of the national payment system.

The introduction of a retail CBDC, as a third form of money alongside cash and non-cash funds, creates a unique set of challenges for the commercial banking sector. The primary concern among academic circles and practitioners is the “liquidity drain” – the potential migration of funds from commercial bank accounts to the digital wallets of the Central Bank. This paper aims to evaluate the transmission mechanisms of this impact and the regulatory response required to mitigate systemic risks.

The implementation of the digital ruble is grounded in a robust legal foundation. The key regulatory act is the Federal Law of July 24, 2023, No. 340-FZ “On Amendments to Certain Legislative Acts of the Russian Federation” [1], which established the legal status of the digital ruble and defined the rules for the operation of the digital ruble platform.

According to the Bank of Russia's “Concept of the Digital Ruble” (2021) [2], the digital ruble is a digital code stored in an electronic wallet on a specialized platform managed directly by the regulator. Unlike non-cash funds in commercial banks, which are liabilities of private credit institutions, the digital ruble is a direct liability of the Central Bank. This distinction is crucial for understanding liquidity risks: in times of financial stress, a “flight to quality” could trigger a rapid conversion of bank deposits into digital rubles, bypassing the traditional banking intermediary.

The principal mechanism through which the digital ruble affects the liquidity of the commercial banking sector is the process of disintermediation. This phenomenon represents a fundamental shift in the traditional relationship between depositors and commercial banks, whereby the latter risk being bypassed as the central repository for public savings. When individuals and legal entities elect to transfer their funds from conventional current accounts or fixed-term deposits into digital ruble wallets, which are direct liabilities of the central bank, it triggers a direct and often irreversible outflow of resources from the commercial banking system.

This migration of capital has profound implications for the stability and operational capacity of commercial banks. The funds held in bank deposits constitute a stable, low-cost, and predictable funding base, which is the lifeblood of a bank's lending activities. By converting these deposits into central bank digital currency, customers effectively remove this capital from the bank's balance sheet. As a result, commercial banks lose a significant portion of their core funding, which is typically less volatile than wholesale market borrowings.

The consequence of this funding drain is a contraction in the pool of lendable resources. With a diminished deposit base, a bank's ability to originate new loans to households and businesses is directly curtailed. To maintain their lending volumes and meet regulatory liquidity requirements in this new environment, banks may be compelled to seek alternative, and often more expensive, sources of funding in the interbank or capital markets. This shift can lead to an increase in the cost of funds for the banks, which is then likely to be passed on to end-borrowers in the form of higher interest rates on loans.

Furthermore, the loss of stable funding can impair a bank's asset-liability management, making it more challenging to match the maturities of assets and liabilities. This mismatch can elevate a bank's exposure to interest rate risk and liquidity

risk, potentially destabilizing its financial position and contributing to broader systemic vulnerabilities within the financial system.

A substantial and sustained outflow of liquidity from the commercial banking sector into digital ruble wallets has the potential to trigger a reduction in the money multiplier, thereby dampening the overall capacity of the banking system to create credit and expand the money supply. The money multiplier is a fundamental concept in monetary economics that reflects the relationship between the monetary base (high-powered money) and the broader money supply. It is a function of the public's preference for holding cash versus deposits, banks' reserve requirements, and, most critically, the volume of excess reserves that banks hold for lending. When a significant volume of funds is transferred from commercial bank deposits to the central bank's digital currency, the base for fractional-reserve lending contracts.

This contraction occurs within the operational framework of the two-tier model for the digital ruble. In this architecture, the Central Bank is the sole issuer and custodian of the digital currency, owning the core ledger and infrastructure. However, it delegates the customer-facing interface, the onboarding and user support, to commercial banks and other authorized financial institutions. This design is intended to leverage the existing banking network and avoid a disruptive overhaul of the financial system.

The mechanics of a fund transfer in this model are crucial to understanding the liquidity impact. When a customer decides to convert their commercial bank deposit into digital rubles, a two-step accounting process is initiated. First, the funds are debited from the customer's deposit account at the commercial bank. Second, and most importantly for system-wide liquidity, an equivalent amount is debited from the commercial bank’s correspondent account, which it holds at the Central Bank. This correspondent account is the bank's gateway to the central interbank payment system and the repository for its reserves.

This direct debit from the correspondent account has an immediate and mechanical effect: it reduces the commercial bank's reserves held at the central bank. Since these reserves are the raw material for creating new loans through the fractional-reserve system (a new loan creates a new deposit, which can be partially lent out again), their depletion directly limits a bank's ability to extend credit. As this process occurs on a large scale across many banks, the aggregate level of reserves in the banking system falls. With a smaller pool of reserves available for lending, and assuming reserve requirements remain constant, the effective money multiplier declines, leading to a slower growth rate of the total money supply than would otherwise be possible.

In his comprehensive study, S. A. Andryushin also emphasizes: “The central bank’s digital currency also has a number of significant shortcomings that reduce the efficiency of a monetary system based on the circulation of digital sovereign money” [3, p. 60].

Key risks for commercial banks include:

Reduction in Net Interest Margin (NIM). To retain depositors, banks may be forced to increase interest rates on traditional deposits, thereby increasing the cost of funding.

Structural Liquidity Deficit. A permanent shift of balances to the CBDC platform

reduces the volume of “cheap” overnight liquidity available for interbank lending.

Compliance with Basel III Ratios. The outflow of retail deposits directly affects the Liquidity Coverage Ratio (LCR) and the Net Stable Funding Ratio (NSFR), potentially limiting the bank's ability to issue long-term loans.

The Bank of Russia emphasizes that the digital ruble will be non-interest bearing (0% remuneration) to minimize direct competition with interest-bearing bank deposits. However, as noted in the “Guidelines for the Advance of State Monetary Policy for 2024–2026” [4], the regulator anticipates a redistribution of liquidity within the banking system.

The introduction of CBDC changes the operational target of monetary policy. If the commercial sector faces a persistent liquidity shortage due to the digital ruble, the Central Bank will be required to expand its refinancing operations (e.g., Repo operations and Lombard loans). This increases the banking sector's dependence on the regulator's facilities, effectively shifting the system from a liquidity surplus to a structural liquidity deficit.

This transition requires exceptional accuracy from the regulator in forecasting the autonomous factors driving liquidity, driven by the increasingly complex structure of the money market and the increasing importance of short-term interest rates as the primary instrument of the monetary policy transmission mechanism. In today's environment, with the interest rate operating corridor narrowing and the demand for liquidity becoming more volatile under the influence of both internal and external shocks, even minor deviations in the assessment of factors such as changes in required reserve levels, currency dynamics, budget balances, and government account flows can lead to significant imbalances in the interbank market. In particular, underestimating or overestimating the banking sector's need for reserves leads to either an excess or deficit in liquidity supply, which directly impacts the level and stability of short-term interbank rates, such as RUONIA.

If autonomous liquidity factors are underestimated and, as a result, reserves are insufficiently supplied, banks are forced to compete more vigorously for limited resources, which drives up interbank lending rates and increases their volatility. Conversely, an excess liquidity supply caused by miscalibration of monetary policy instruments can lead to a downward deviation of interest rates from the target level, reducing the effectiveness of the transmission mechanism and complicating the achievement of inflation targets. Therefore, high forecasting accuracy and timely adjustments to the volume of provided reserves become critical for ensuring money market stability, minimizing financial system risks, and maintaining confidence in central bank policy. In this context, improving liquidity forecasting models and introducing more flexible reserve management tools are essential for the successful functioning of the interest rate corridor and achieving macroeconomic stability.

To ensure a smooth transition, the Bank of Russia has implemented several “safeguard” mechanisms:

Holding Limits. Currently, there are restrictions on the monthly amount that can be transferred into a digital ruble wallet (initially set at 300,000 rubles for individuals).

The “Lighthouse” Model. Commercial banks continue to play a role as intermediaries for KYC (Know Your Customer) and AML/CFT procedures, preserving

their relationship with the client.

Adaptive Refinancing. The regulator has committed to providing the necessary volume of liquidity to credit institutions to compensate for the outflow into digital rubles, ensuring that credit supply to the real economy remains uninterrupted.

The discourse within Russian academia regarding the introduction of the digital ruble is characterized by a pronounced duality, encompassing both pessimistic and optimistic perspectives. On one hand, proponents of the digital currency emphasize its potential to modernize the national payment infrastructure, enhance transactional efficiency, reduce settlement costs, and foster financial inclusion by providing access to digital money for unbanked or underbanked segments of the population. Furthermore, it is argued that a state-backed digital currency could strengthen the central bank's ability to implement monetary policy in real-time and improve the traceability of financial flows, thereby mitigating risks associated with illicit activities.

Conversely, a significant body of scholarly opinion expresses considerable concern regarding the systemic implications for the stability and competitive landscape of the domestic banking sector. A central point of this pessimistic view is the potential for disintermediation, where individuals and corporations might preferentially hold their funds in digital ruble wallets directly with the Central Bank, rather than in traditional commercial bank deposits. This shift in preference could precipitate a structural decline in the deposit base of commercial banks.

This risk is perceived to be especially acute and potentially painful for small and medium-sized banks (SME banks). Unlike their larger counterparts, these institutions do not possess the robust and diversified funding profiles that are typical of “Systemically Important Financial Institutions” (SIFIs). Their business models are often more heavily reliant on retail and small-business deposits as a primary and relatively low-cost source of funding for their lending operations. Consequently, a rapid and significant outflow of deposits to the central bank's digital currency platform could severely impair their liquidity positions, compress their net interest margins, and ultimately threaten their viability and independence in an increasingly concentrated financial market.

However, the positive effects of the introduction of the digital ruble are that the digital ruble can increase the transparency of targeted budget expenditures, which in the long term improves the overall quality of assets in the banking system, indirectly supporting liquidity by reducing the share of problem loans.

S. A. Cherenkova emphasizes that “the launch of a digital national currency in such a large-scale economy as Russia's will indicate the country's advanced level of digitalization and its competitiveness in the international arena. It will also help maintain productive and uninterrupted trade with friendly countries, reducing dependence on potential sanctions and improving the country's financial stability” [5, p. 62].

The influence of the digital ruble on the liquidity of commercial banks is multifaceted. While the risk of deposit outflow and disintermediation is real, it is manageable through a combination of administrative limits on wallet balances and active liquidity management by the Central Bank.

The success of the digital ruble integration depends on the ability of commercial

banks to transform their business models from “deposit-collectors” to “service-providers”, offering value-added products that the CBDC cannot provide (such as credit products and complex investment tools). For the Russian banking sector, the digital ruble serves as a catalyst for further technological optimization, though it requires a careful recalibration of liquidity risk management frameworks in accordance with the evolving regulatory landscape of the Bank of Russia.

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УДК 338.22.021.1

GREENWASHING AS A REPUTATIONAL THREAT: IDENTIFYING UNFAIR ESG PRACTICES AND IMPLICATIONS FOR INVESTMENT ATTRACTIVENESS

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Abstract. The article analyzes the phenomenon of greenwashing as a reputational risk for Russian companies. The scope of unfair environmental practices in various industries, methods for their detection, as well as the impact on investment attractiveness of business in the context of tightening regulatory requirements are considered.

Keywords: greenwashing, greenhashing, ESG, sustainable development, reputational risks, investment attractiveness.

ГРИНВОШИНГ КАК РЕПУТАЦИОННАЯ УГРОЗА: ДИАГНОСТИКА НЕДОБРОСОВЕСТНЫХ ESG-ПРАКТИК И ПОСЛЕДСТВИЯ ДЛЯ ИНВЕСТИЦИОННОЙ ПРИВЛЕКАТЕЛЬНОСТИ

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Аннотация. В статье анализируется феномен гринвошинга как репутационного риска для российских компаний. Рассматриваются масштабы распространения недобросовестных экологических практик в различных отраслях, методы их выявления, а также влияние на инвестиционную привлекательность бизнеса в условиях ужесточения регуляторных требований.

Ключевые слова: гринвошинг, гринхашинг, ESG, устойчивое развитие, репутационные риски, инвестиционная привлекательность.

In the context of the global transformation of the economic paradigm towards sustainable development, the environmental responsibility of business is becoming not merely an ethical requirement but also a significant factor of competitiveness. For Russian companies seeking to maintain investment attractiveness in both domestic and international markets, the formation of a credible ESG profile is acquiring strategic importance.

However, in the pursuit of a «green» image, many companies resort to the practice of “greenwashing” – the deliberate misleading of consumers and investors regarding the actual environmental friendliness of a product or activity. Simultaneously, Russia is also witnessing the opposite phenomenon – “greenhashing” – where companies deliberately conceal their environmental initiatives, fearing excessive attention from regulatory authorities or criticism [3].

Greenwashing is a form of unfair competition in which a company disseminates disinformation to create a false image of an environmentally responsible business. In contemporary scientific literature, greenwashing is viewed as a systemic problem capable of misleading not only consumers but also experts and regulators.

In contrast, greenhashing is the deliberate concealment of a company's environmental initiatives and achievements due to fears of excessive control, criticism from activists, or the additional burden associated with public acknowledgment of environmental responsibility. While greenwashing is often linked to a desire to profit from the “green” agenda without real investment, greenhashing may be a consequence of excessive regulatory burden or a lack of trust in institutions assessing environmental performance.

A distinctive feature of Russian practice is the coexistence of both phenomena. Environmental dishonesty has turned into a direct reputational threat, leading to an irreversible loss of audience loyalty. Current research demonstrates a significant prevalence of greenwashing in the Russian market. According to data from the ARIR Committee for Sustainable Development, in 2025, 33 % of advertising market participants encountered instances of greenwashing in their practice, which is 6 percentage points higher than in 2024 and 25 points higher than in 2023 [2].

Of particular concern is the situation in the food and beverage (FMCG) segment, where 81 % of respondents encountered greenwashing. The increase in this indicator over the year was 25 percentage points, indicating that the “green” agenda has become a key battleground for competitive rivalry. In second place is the cosmetics and beauty sector. A study conducted by the Union ONE together with Roskachestvo showed that one-third of cosmetic products on the Russian market contain environmental claims, with 42 % of these showing signs of greenwashing [5].

A study of communication channels shows that the main battlefield for consumer attention remains product packaging – 64 % of respondents identified it as a source of greenwashing. The most dynamic growth is observed in the segment of product cards on marketplaces; over the year, the share of mentions of this channel increased from 25 % to 44 % [4].

PR campaigns maintain a consistently high position (30 %), which is explained by the increased trust audiences place in messages presented as editorial materials. The three main markers of dishonest environmental practices:

– Use of pseudo-“ECO” certificates – the creation of signs that mimic official certification but are not confirmed by independent expert assessment.

– Vague, unsubstantiated wording – such as “environmentally friendly”, “eco-friendly”, or “harmless to nature”.

– Visual mimicry of well-known ecolabels (45 %) – packaging design deliberately resembling the logos of trusted environmental standards.

An illustrative example of positive dynamics is the agricultural sector. While in 2024, 25 % of respondents noted greenwashing in this industry, in 2025, this figure dropped to 12 %. Experts attribute this to stricter industry regulations and the growing share of large, transparent agricultural holdings shifting focus from declarations to actual environmental practices [1].

Large companies with high public visibility and access to international markets are more inclined to form formal ESG strategies. However, they are also more often at risk of greenwashing, as their environmental claims are under close scrutiny from investors and regulators.

Small and medium-sized businesses, in contrast, may exhibit signs of greenhashing, fearing that public acknowledgment of environmental responsibility will lead to additional inspections and burdens.

According to ARIR data, 64 % of respondents anticipate a deterioration in their relationship with a brand if greenwashing is exposed, with 19 % expecting a significant deterioration. The total share of skeptics reaches 83 %. This indicates that environmental dishonesty is turning into a direct reputational threat, leading to an irreversible loss of audience loyalty [6].

The Council for the Prevention of Greenwashing has developed recommendations for verifying communications for the presence of a «pseudo-green» agenda. Key detection methods include:

– Verification of independent certification. Credible environmental claims must be confirmed by certificates from recognized systems.

– Analysis of the specificity of wording. A credible claim contains precise data, for example: “the bottle, excluding the cap, is made of 50 % recycled plastic.”

– Verification of references to standards. If the packaging indicates a percentage of natural origin, the manufacturer must explain the calculation methodology with reference to a standard (e.g., GOST ISO 16128).

– Checking compliance with mandatory requirements. Claims about properties whose provision is mandated by law (e. g., “contains no ozone-depleting substances”) cannot be considered environmental advantages.

The Federal Antimonopoly Service is actively developing a system for monitoring environmental claims. Recommendations have been developed to prevent greenwashing, with which 53% of market participants are familiar. The introduction of a system of “green” public procurement and the legislative formalization of requirements for environmental claims is planned.

For investors, risks associated with potential sanctions from regulators are becoming a significant factor in assessing investment attractiveness. The exposure of dishonest environmental practices entails significant reputational losses, regulatory sanctions, and a loss of trust from institutional investors. In the context of tightening legislation and growing requirements for non-financial disclosure, companies that bet on genuine environmental responsibility gain a sustainable competitive advantage. The key direction for further development should be the formation of unified and transparent criteria for environmental friendliness, widespread consumer education about these criteria, and the introduction of a system of state labeling for environmentally responsible products.

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УДК 001.891:338.1(574)

RESEARCH TRENDS IN STUDIES OF BUSINESS AND ECONOMIC DEVELOPMENT OF KAZAKHSTAN

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Abstract. The paper provides a structured overview of academic interest in Kazakhstan as an object of business and economic research. The dataset includes 965 English-language publications retrieved from Scopus. The study uses a scoping review design with BERTopic topic modeling applied to titles, abstracts and keywords. The results reveal 20 thematic areas, with the largest clusters related to innovation and management, tourism, digital economy, finance, regional development and sustainability. The findings outline directions for further Kazakhstan-related business studies.

Keywords: Kazakhstan, business development, economic development, Scopus, topic modeling, BERTopic, digital economy, innovation.

ИССЛЕДОВАТЕЛЬСКИЕ ТЕНДЕНЦИИ В ИЗУЧЕНИИ БИЗНЕСА И ЭКОНОМИЧЕСКОГО РАЗВИТИЯ КАЗАХСТАНА

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Аннотация. В статье представлен структурированный обзор научного интереса к Казахстану как объекту исследований в области бизнеса и экономики. Материалом послужили 965 англоязычных публикаций, отобранных из Scopus. В работе используется обзор предметного поля с тематическим моделированием BERTopic по названиям, аннотациям и ключевым словам. Выявлено 20 тематических областей. Крупнейшие кластеры связаны с инновациями и менеджментом, туризмом, цифровой экономикой, финансами, региональным и устойчивым развитием. Полученные результаты позволяют выделить направления дальнейших исследований бизнеса и экономического развития Казахстана.

Ключевые слова: Казахстан, развитие бизнеса, экономическое развитие, Scopus, тематическое моделирование, BERTopic, цифровая экономика, инновации.

Kazakhstan is one of the largest and most important countries in Central Asia. It has a strategic geographic position between Europe and Asia, which makes it an

important economic and transport hub. Kazakhstan is the ninth-largest country in the world by land area and has a population of approximately 20 million people. It also ranks first by gross domestic product in Central Asia and second after Russia in the Commonwealth of Independent States and the Eurasian Economic Union [1].

For many years, the economy of Kazakhstan has been strongly connected to the extraction and export of natural resources. The oil and energy sectors remain important for the country's economic development and foreign trade. According to Statista, Kazakhstan is one of the major uranium producers, with uranium mine production exceeding 21,000 metric tons. The country also produced nearly 1.9 million barrels of oil per day in 2023 and remains one of the leading exporters of grains, including wheat and barley [1].

At the same time, Kazakhstan is not only a resource-based economy. The services sector represents the largest part of GDP, with a share of around 56 percent in 2023, while manufacturing accounts for 26.5 percent of GDP and agriculture, forestry and fishery account for over four percent. These figures show that Kazakhstan is a relevant case for studying economic diversification, industrial development and structural change. Kazakhstan's geopolitical and economic connectivity also increases its research relevance. The country is well connected to Europe, Asia and the Middle East, participates in the Belt and Road Initiative and attracts foreign direct investment, including in green energy and digital sectors [1]. Therefore, business and export interest in Kazakhstan is understandable as the country combines a large resource base, developing infrastructure, regional market access and growing diversification efforts.

Before studying Kazakhstan's business and economic development in detail, it is necessary to understand how this topic has already been represented in academic literature. A scoping review helps identify the main research directions, dominant themes and underexplored areas [2]. For this reason, the present article focuses on mapping the existing research field. The aim of this paper is to provide a review of academic interest in Kazakhstan as an object of business and economic research and to identify the main thematic directions.

In order to achieve this aim, the study applies a scoping review design combined with topic modelling. The scoping review design is used to map the selected publication corpus, while topic modelling makes it possible to reveal the internal thematic structure of the field. The empirical basis of the study consists of publications indexed in Scopus. The search was conducted using the keyword "KAZAKHSTAN" in the title field.

The initial search results were screened by language and relevance to the aim of the study. The final dataset included 965 English-language publications. The data were then exported from Scopus and prepared for analysis. The analytical corpus included publication titles, abstracts and author keywords, as these elements reflect the main focus of each study.

The dataset was processed in Google Colab using Python. Topic modelling was performed with BERTopic, which combines text embeddings and clustering algorithms to group semantically similar publications into thematic clusters. At the final stage, the clusters were interpreted as research directions. Topic labels were formulated on the basis of frequent words, representative publications and the most cited works within

each group. The main parameters of the dataset and analytical procedure are summarized in Table 1.

Table 1. Dataset and topic modelling parameters

Parameter	Description	Indicator	Value
Database	Scopus	**Text fields analysed**	Titles, abstracts, keywords
Search field	Publication title	**Review design**	Scoping review
Search keyword	"Kazakhstan"	**Topic modelling method**	BERTopic
Language	English	**Programming environment**	Google Colab
Final dataset	965 publications	**Number of identified topics**	20

The results of BERTopic modelling are presented through five visualizations: topic dynamics over time (Fig. 1), distribution of publications across topics (Fig. 2), topic word scores (Fig. 3), similarity between topics (Fig. 4) and the hierarchical structure of topics (Fig. 5). Together, these figures make it possible to interpret the main research directions in Kazakhstan-related business and economic studies.

Figure 1 presents a noticeable increase in publication activity after 2007, with the most intensive growth in recent years. This growth is mainly associated with innovation and management, digital economy, tourism, sustainability and regional development.

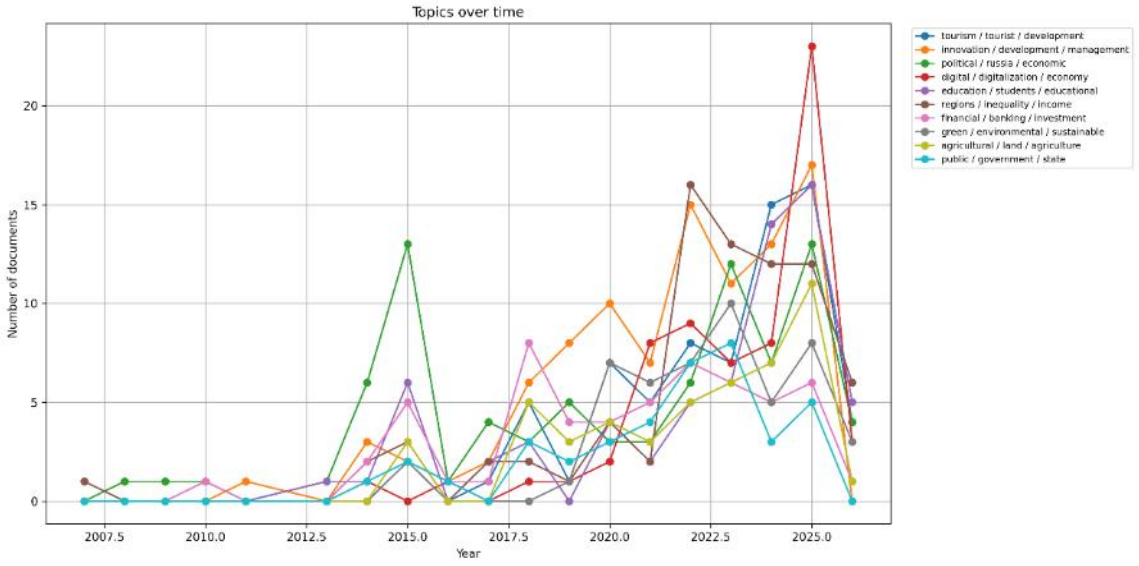


Figure 1. Dynamics of research topics related to Kazakhstan over time

Figure 2 shows the the largest clusters related to innovation and management, political and economic studies, tourism and digital economy. This distribution indicates that the field is centred on economic modernization, institutional development, digital transformation and service-sector growth.

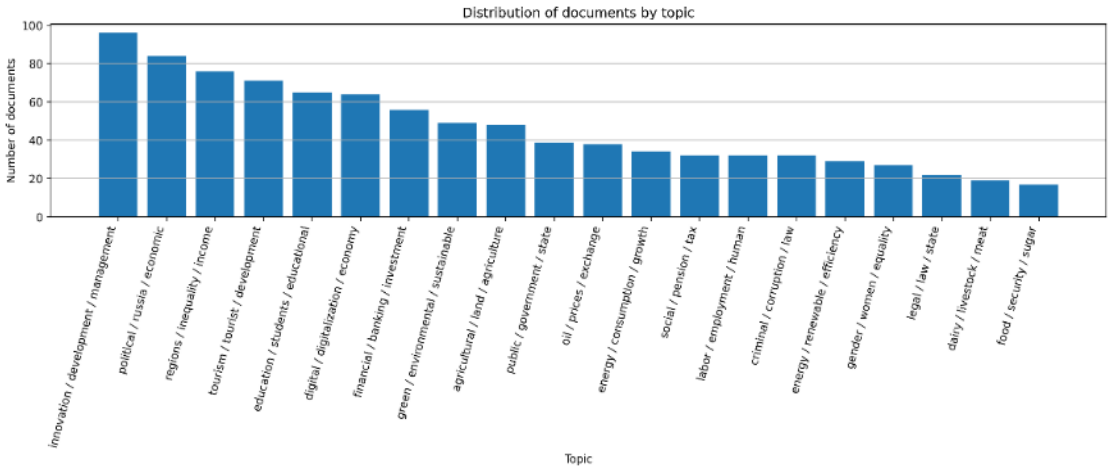


Figure 2. Distribution of publications across research topics

Figure 3 presents topic word scores generated by BERTopic. The most significant words indicate the lexical patterns that define each cluster and support the interpretation of automatically generated topics as research directions. BERTopic uses zero-based numbering, therefore, Topic 0 in the figure corresponds to Theme 1 in Table 2, where the topics are renumbered from 1 to 20 for readability.

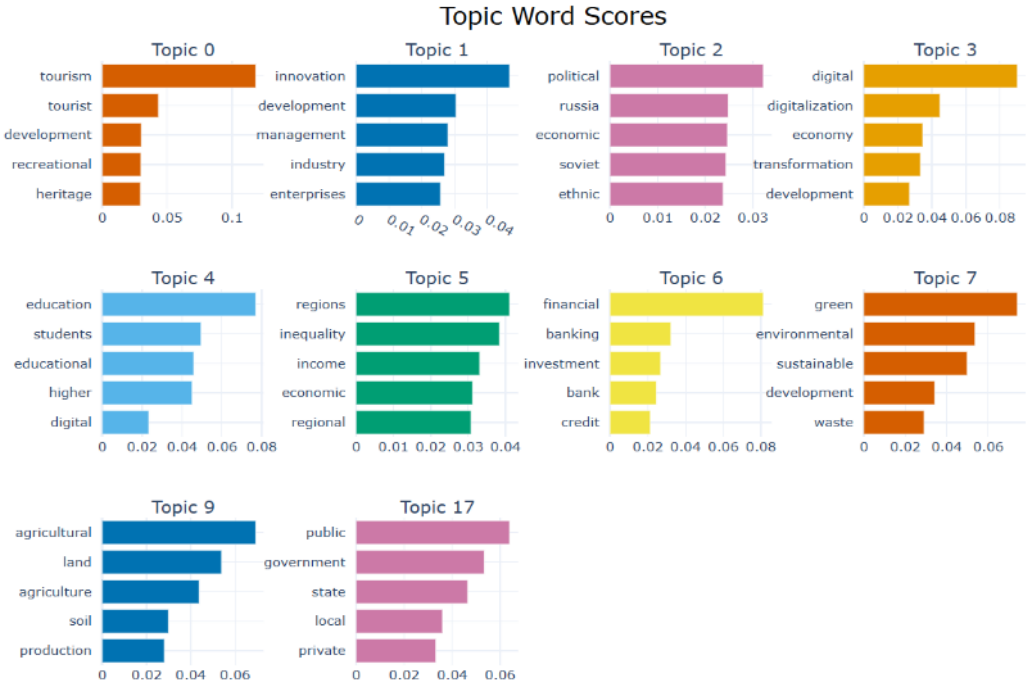


Figure 3. Topic word scores

Figure 4 shows the similarity between topics. It demonstrates that economic, technological and regional directions are interconnected, especially in areas related to innovation, digitalization, regional development and sustainability.

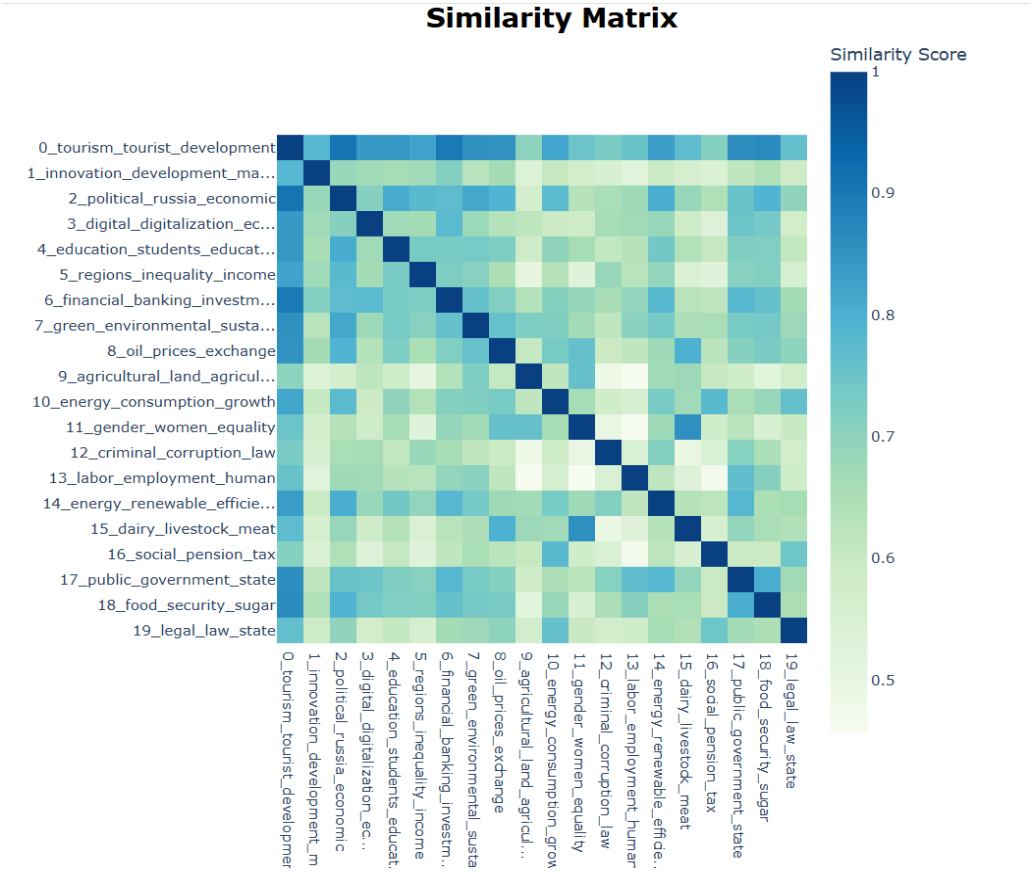


Figure 4. Similarity between research topics

Figure 5 presents the hierarchical structure of the topics. It shows how the 20 clusters can be grouped into broader thematic blocks, including economic development, digital transformation, sustainability, tourism, regional studies and public governance.

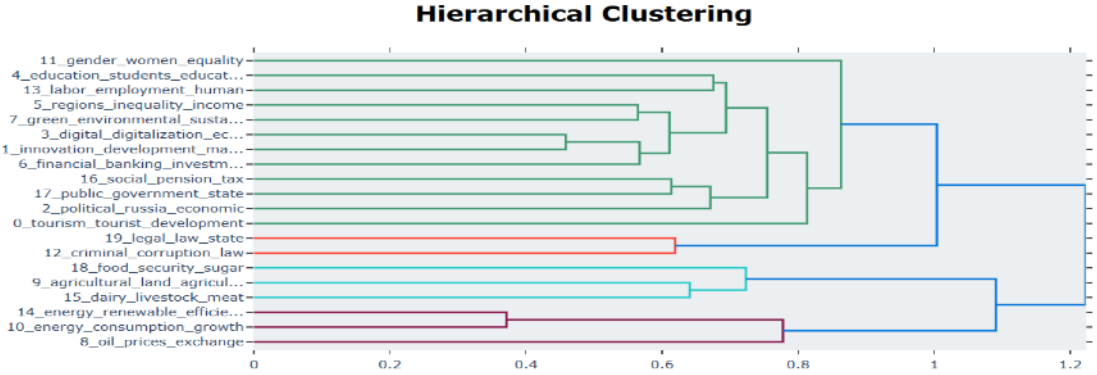
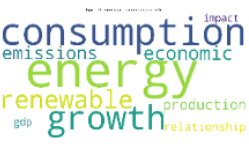


Figure 5. Hierarchical structure of research topics

Figures 1-5 provide a general picture of the research field, showing the dynamics, distribution and relations between the identified topics. Table 2 presents all 20 thematic groups as interpreted research directions and indicates the most cited authors associated with each group.

Table 2. Results of the thematic modelling

Theme	Keywords	Most cited authors
1. Tourism and recreational development		Tiberghien [3], Tleuberdinova [4], Daye [5]
2. Innovation, management and entrepreneurship		Sadyrova [6], Seitzhanov [7], Heim [8]
3. Regional cooperation, economic growth and institutional transformation		Konopelko [9], Agrawal [10]
4. Digital economy and digital transformation		Zhanibek [11], Alibekova [12]
5. Education and human capital		Del Sordi [13], Yakavets [14], Seilkhan [15]
6. Regional development and inequality		Howie [16], Agrawal [10]
7. Financial systems, investment and energy consumption		Mukhtarov [17], Heim [8]
8. Sustainability and green economy		Poberezhskaya [18], Mazina [19], Akbota [20]
9. Oil prices and energy markets		Mukhtarov [17], Heim [8]
10. Agriculture, land use and rural development		Löw [21], Kvartiuk [22], Azat [23]
11. Energy consumption and economic growth		Mukhtarov [17], Akbota [20]
12. Gender, leadership and equality		Kakabadse [24], Kuzhabekova [25], Ryskaliyev [26]
13. Entrepreneurship, trust and institutional risks		Petrenko [27]

14. Labour, employment and supply chain management		Kot, Onyusheva and Grondys [28], Ryskaliyev [26]
15. Renewable energy and electricity-sector modernization		Kerimray [29], Mazina [19]
16. Rural production and agribusiness transformation		Kvartiuk [22], Azat [23]
17. Social protection and pension reforms		Mukhamadiyeva [30], Buribayev [31]
18. Public administration and government modernization		Janenova [32], Buribayev [31]
19. Food production and agricultural sustainability		Azat [23], Löw [21]
20. State policy and legal regulation		Mukhamadiyeva [30], Buribayev [31]

Theme 1, Tourism and recreational development, brings together studies on eco-cultural tourism, entrepreneurship and international connectivity. Tiberghien discusses the planning of authentic eco-cultural tourism [3]. Tleuberdinova and co-authors consider macroeconomic factors influencing tourism entrepreneurship [4], while Daye and co-authors address local stakeholders' views on the Belt and Road Initiative and its possible effects on the sector [5]. This direction links tourism with regional growth, cultural resources and cross-border cooperation.

Theme 2, Innovation, management and entrepreneurship, reflects the role of innovation in economic modernization. Sadyrova and co-authors identify factors shaping innovation processes [6], Seitzhanov and co-authors focus on entrepreneurial innovation activity [7], and Heim and co-authors study value co-creation between foreign firms and local SMEs in the oil and gas industry [8]. The cluster connects business renewal with institutional change and cooperation between domestic and international actors.

Theme 3, Regional cooperation, economic growth and institutional transformation, places Kazakhstan within broader Eurasian and post-Soviet processes. Konopelko considers the country in the context of the Eurasian Economic Union and EU policy [9], whereas Agrawal studies growth and poverty reduction [10]. Together, these works reveal links between integration, economic policy and institutional change.

Theme 4, Digital economy and digital transformation, covers the technological dimension of modernization. Zhanibek and co-authors discuss the digital

transformation of Kazakhstan's national image through the Astana International Finance Centre [11]. Alibekova and co-authors identify enablers and barriers of digital transformation in the national economy [12]. This direction is important for understanding innovation policy and international positioning.

Theme 5, Education and human capital, includes publications on student mobility, school leadership and distance learning. Del Sordi studies the Bolashak programme as an instrument of mobility, development and political stability [13]. Yakavets and co-authors focus on school leadership and capacity building [14], while Seilkhan and co-authors consider distance education during the COVID-19 pandemic [15]. These studies show how education policy contributes to human capital formation.

Theme 6, Regional development and inequality, focuses on uneven effects of growth. Howie and Atakhanova discuss the relationship between the resource boom and inequality [16]. Agrawal's work on growth and poverty reduction also contributes to this direction [10]. The cluster is significant for understanding regional disparities and social differentiation in a resource-based economy.

Theme 7, Financial systems, investment and energy consumption, connects finance with energy and business interaction. Mukhtarov and co-authors study the effect of financial development on energy consumption [17]. Heim and co-authors add a firm-level perspective through their work on foreign companies and local SMEs in the oil and gas sector [8]. This direction links investment processes with energy demand and industrial cooperation.

Theme 8, Sustainability and green economy, addresses environmental policy and green transformation. Poberezhskaya and Bychkova discuss climate policy in relation to national priorities and the international agenda [18]. Mazina and co-authors focus on green fiscal policy and investment efficiency in renewable energy enterprises [19]. Akbota and Baek consider the environmental consequences of economic growth [20]. Together, these studies show the increasing importance of sustainability in economic research.

Theme 9, Oil prices and energy markets, is closely related to the resource-based structure of the economy. Mukhtarov and co-authors connect energy consumption with financial development [17], while Heim and co-authors consider the oil and gas sector through technology spillovers and value co-creation [8]. The cluster confirms the centrality of energy markets for Kazakhstan-related economic studies.

Theme 10, Agriculture, land use and rural development, combines research on agricultural land, rural markets and resource efficiency. Löw and co-authors study abandoned agricultural land in Kyzyl-Orda using satellite remote sensing [21]. Kvartiuk and Petrick focus on land reform and its effects on rental and credit markets [22]. Azat and co-authors discuss sustainable silica production from rice husk waste [23]. This direction connects rural transformation with land use and circular-economy practices.

Theme 11, Energy consumption and economic growth, highlights links between development, energy demand and environmental pressure. Mukhtarov and co-authors study financial development and energy consumption [17], while Akbota and Baek consider the environmental consequences of growth [20]. This direction shows that

economic expansion is often discussed together with energy and sustainability challenges.

Theme 12, Gender, leadership and equality, represents the social and organizational side of economic participation. Kakabadse and co-authors focus on female entrepreneurial leadership [24]. Kuzhabekova and co-authors study the experience of female leaders in civil service [25], while Ryskaliyev and co-authors address workplace equality [26]. The cluster links gender issues with leadership, employment and institutional change.

Theme 13, Entrepreneurship, trust and institutional risks, concerns the conditions of entrepreneurial activity. Petrenko and co-authors discuss the entrepreneurship ecosystem and risks related to loss of trust in economic stability [27]. This direction is relevant for understanding how institutional confidence shapes business activity.

Theme 14, Labour, employment and supply chain management, combines workplace issues with SME practices. Kot, Onyusheva and Grondys study supply chain management in SMEs using evidence from Poland and Kazakhstan [28]. Ryskaliyev and co-authors contribute through their work on workplace equality [26]. This direction links employment, organizational routines and small-business development.

Theme 15, Renewable energy and electricity-sector modernization, focuses on energy transition. Kerimray and co-authors investigate the transition to a coal-free residential sector using a regionally disaggregated energy systems model [29]. Mazina and co-authors discuss green fiscal policy and renewable energy investment [19]. This cluster reflects the importance of electricity-sector modernization and renewable energy policy.

Theme 16, Rural production and agribusiness transformation, should be interpreted broadly rather than as a narrow livestock topic. Kvartiuk and Petrick focus on land reform and its effects on land rental and credit markets [22]. Azat and co-authors discuss the sustainable use of rice husk waste for silica production [23]. The cluster connects agribusiness, rural markets and resource-efficient production.

Theme 17, Social protection and pension reforms, concerns the institutional side of social policy. Mukhamadiyeva and co-authors discuss the modernization of social security regulation with reference to OECD standards [30]. Buribayev and co-authors focus on reform efficiency in public social sector management [31]. This direction links welfare institutions with legal modernization and public-sector reform.

Theme 18, Public administration and government modernization, addresses administrative reform and public service delivery. Janenova and Kim study one-stop shops as an example of innovation in public services [32]. Buribayev and co-authors provide a broader view of reform efficiency in the public social sector [31]. The cluster shows the role of governance capacity in the national development model.

Theme 19, Food production and agricultural sustainability, is connected with agricultural resources and sustainable production. Azat and co-authors discuss silica production from rice husk waste [23], while Löw and co-authors study agricultural land use through remote sensing [21]. This direction is more accurately understood through resource efficiency and agricultural sustainability than through a narrow focus on the sugar industry.

Theme 20, State policy and legal regulation, brings together studies on legal and institutional aspects of public policy. Mukhamadiyeva and co-authors focus on social security regulation [30], while Buribayev and co-authors address public-sector reform [31]. This direction demonstrates how legal governance and state regulation contribute to the broader understanding of economic and social transformation.

The analysis shows that Kazakhstan-related business and economic studies form a broad multidisciplinary field. The main directions include economic development, energy markets, agriculture, regional policy, digitalization, sustainability, education, entrepreneurship and public administration. The identified clusters reflect several key perspectives on Kazakhstan's development: resource dependence, modernization, institutional change, digital transformation, regional inequality and social policy. This confirms that the country's business environment should be studied through an interdisciplinary approach.

For further research in international business, the most relevant directions are innovation and management, digital economy, entrepreneurship, tourism, financial systems and regional development. These areas may serve as a basis for the systematic review on business and economic development of Kazakhstan.

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УДК 658.152:657.471:338.242:623.4

THEORETICAL FOUNDATIONS OF WEAR AND DEPRECIATION OF FIXED ASSETS IN THE CONTEXT OF ENSURING THE COUNTRY'S DEFENCE CAPABILITY

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Abstract. This article examines wear and depreciation of fixed assets in enterprises, focusing on the military-industrial complex (MIC). It analyses the main forms of asset deterioration – physical wear and functional/economic obsolescence – and methods for calculating depreciation in accordance with Russian Accounting Standard (FSBU) 6/2020. The study also addresses approaches to optimizing depreciation policies. Particular attention is paid to the strategic importance of timely renewal of fixed assets to ensure technological sovereignty and the country's defense capacity.

Keywords: fixed assets, depreciation, military-industrial complex, depreciation policy, asset deterioration, technological sovereignty.

ТЕОРЕТИЧЕСКИЕ ОСНОВЫ ИЗНОСА И АМОРТИЗАЦИИ ОСНОВНЫХ СРЕДСТВ В КОНТЕКСТЕ ОБЕСПЕЧЕНИЯ ОБОРОНОСПОСОБНОСТИ СТРАНЫ

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Аннотация. В статье исследуются износ и амортизация основных средств на предприятиях с акцентом на военно-промышленный комплекс (ВПК). Анализируются основные формы износа активов – физический износ и функциональное/экономическое устаревание – а также методы расчета амортизации в соответствии с российским стандартом бухгалтерского учета (ФСБУ) 6/2020. В исследовании рассматриваются подходы к оптимизации амортизационной политики. Особое внимание уделяется стратегической

значимости своевременного обновления основных средств для обеспечения технологического суверенитета и обороноспособности страны.

Ключевые слова: основные средства, амортизация, военно-промышленный комплекс, амортизационная политика, износ активов, технологический суверенитет.

In a market economy, control over the use of fixed assets – material assets involved in production for more than a year and transferring their value to finished products in parts – is of particular importance. Fixed assets include buildings, equipment, transport, inventory and other objects used in production activities and generating economic benefits. During operation, fixed assets gradually lose their original qualities, wear out and lose value, which makes their timely replacement necessary through the mechanism of depreciation. For enterprises of the military-industrial complex (MIC), issues of accounting for and compensating the value of fixed assets acquire special significance, since the specifics of defense production impose increased requirements on equipment accuracy, reliability and timely renewal in accordance with technological requirements for creating modern military equipment.

Theoretical aspects of wear and depreciation of fixed assets. *Fixed assets* are means of labor that function in the production process for a long time, retaining their material form and transferring their value to finished products in parts as they wear out [1, p. 138]. During repeated use, they gradually lose their characteristics under the influence of operation and natural factors, which is called wear of fixed assets (Fig. 1).

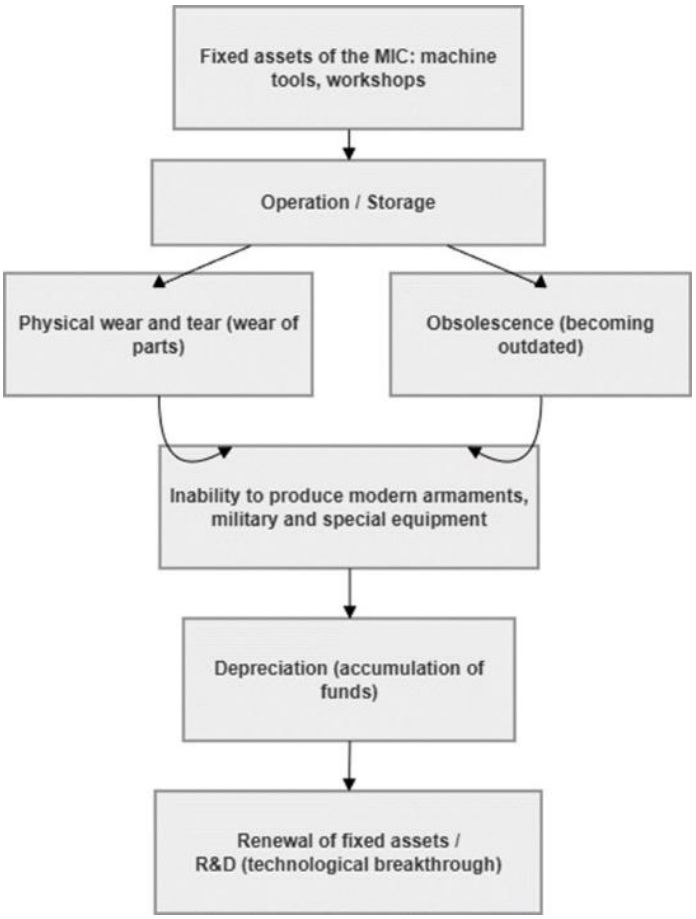


Figure 1. Fixed assets of the MIC

There are two main forms of wear: *physical* and *obsolescence*. In defense industry enterprises, obsolescence plays a critical role, since weapons production technologies develop rapidly, and equipment that is still physically suitable for operation can quickly become outdated compared to new models that allow producing more advanced products.

Physical wear is the loss of the consumer value of fixed assets under the influence of physical forces, technical and economic factors, including storage conditions [2, p. 109]. For different groups of fixed assets, physical wear manifests itself differently: equipment loses accuracy and productivity, buildings wear out more slowly, transmission devices lose their characteristics over time, and inventory wears out most quickly. Physical wear can be partial, when it can be eliminated by repair, or complete, requiring replacement of the object. In military production, where requirements for the accuracy of processing parts and components of military equipment are extremely high, timely identification and elimination of physical wear is a condition for ensuring the quality of output.

Obsolescence is expressed in the loss of value of fixed assets that are still physically suitable for operation but have become less profitable due to the emergence of more efficient analogues. It arises as a result of scientific and technological progress, when new equipment becomes cheaper or more productive, as well as due to stricter social requirements for safety and environmental friendliness [3, p. 344]. Table presents the regulatory framework for obsolescence. For defense enterprises, obsolescence has strategic importance, since a lag in technological equipment can lead to the inability to produce modern types of weapons that meet the requirements of the Ministry of Defense and export standards.

Table. Regulatory framework for obsolescence

Area of regulation	**Regulatory document**	**Description**
Accounting (Standards)	FSBU 6/2020 “Fixed Assets”	Fundamental document. Mentions “obsolescence” (clauses 31, 35, 37) as a key criterion for checking and changing the useful life (UL) of an object. If equipment becomes outdated before the deadline, its UL is revised.
Write-off of state property	Decree of the Government of the Russian Federation No. 834 “On peculiarities of writing off federal property”	Provides a direct basis for write-off: an object is subject to write-off due to its “obsolescence” if restoration is impossible or economically unfeasible.
Budget accounting	Instruction No. 157n of the Ministry of Finance of the Russian Federation	It establishes that non-financial assets are written off when they are deemed "unfit for further use," including due to obsolescence.

Depreciation is a method of transferring the cost of acquired property to the cost of production. It is necessary for accumulating funds to replace worn-out fixed assets and is an important component of an organization’s costs, affecting the formation of financial results. When calculating depreciation, the initial cost, useful life, residual value and chosen accrual method are taken into account. In MIC enterprises,

depreciation policy must take into account not only economic but also strategic aspects related to ensuring the country's defense capability.

Main methods for calculating depreciation of fixed assets. The amount of depreciation charges is a crucial indicator for every organization. Overstating depreciation rates leads to an increase in production costs and a decrease in profit, while understating can result in an object becoming out of service before its value is fully transferred to finished products. Depreciation is calculated by the organization independently based on the expected useful life of the object. For defense industry enterprises, correct depreciation calculation is of particular importance, as it affects the cost of military products, which are funded from the state budget and must be economically justified.

The main rules for depreciation accrual are enshrined in the Federal Accounting Standard 6/2020 "Fixed Assets". Depreciation is accrued on all fixed assets, except for property below the limit set by the organization, as well as investment real estate, land plots and natural resource objects [4, p. 133]. The start of depreciation accrual is determined by the organization independently: either from the date of recognition of the object or from the first day of the month following the month of recognition. Depreciation accrual does not stop during periods of downtime or conservation and ceases only when the residual value of the object becomes equal to or exceeds its book value. For MIC enterprises, where temporary reduction of production programs or switching to the production of another range of products is possible, this aspect is especially important.

Useful life is the period during which the company will receive economic benefits from using the object. It is established by a commission for accepting fixed assets, taking into account the expected period of use, physical wear, obsolescence and modernization plans. Residual value is the amount that a company can receive when selling an object at the end of its service life, minus disposal costs. It can be zero and is subject to annual review. In defense enterprises, when determining the useful life of unique technological equipment, it is necessary to take into account not only standard factors but also prospects for the development of military equipment and possible changes in production technologies. FSBU 6/2020 provides for three methods of calculating depreciation (Fig. 2).

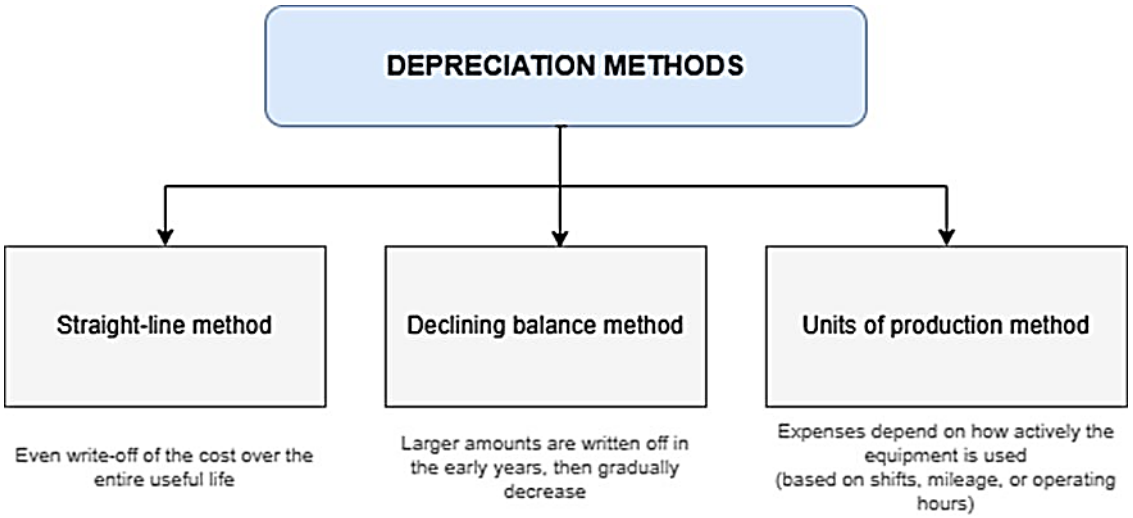


Figure 2. Methods of calculating depreciation according to FSBU 6/2020

Options for improving the efficiency of depreciation policy. Depreciation policy is an important component of an organization's accounting policy, as it directly affects financial performance. It determines the speed of transferring the value of fixed assets to production costs and accumulating funds for their replacement. The main directions for preventing excessive wear include the introduction of new technology, outpacing the commissioning of assets over their decommissioning, improving maintenance services and differentiating useful life periods depending on the degree of susceptibility to obsolescence [5, p. 81]. For MIC enterprises fulfilling the state defense order, an effective depreciation policy is a condition for maintaining technological sovereignty and the country's defense capability.

In modern conditions, depreciation becomes the only component of production costs that can be managed, since pricing largely depends on market conditions. Let us consider this statement with two examples.

Example 1. A factory produces machine tools. The market price of a similar machine tool is 5 million rubles (set by competitors). The production cost is 4 million rubles, including: materials and components – 2.5 million rubles (market price, not manageable), wages – 0.8 million rubles (limited by the labor market), overheads – 0.5 million rubles, equipment depreciation – 0.2 million rubles per machine tool. Thus, the profit per machine tool is 1 million rubles. *What can the factory do in this situation?* The factory decides to increase the useful life of machines in the workshop from 5 to 8 years (straight-line method), which reduces the annual depreciation rate from 0.2 to 0.13 million rubles.

Example 2. A defense factory produces components for missiles under a state order. The product price is fixed by contract at 10 million rubles. The actual production cost is 9 million rubles, including depreciation of a unique test bench – 0.5 million rubles per product. Thus, the profit is 1 million rubles. *What can the factory do in this situation?* The factory applies accelerated depreciation (declining balance method) with a factor of 2. In the first two years, depreciation per product increases to 0.9 million rubles. The production cost rises to 9.4 million rubles. In this case, profit decreases to 0.6 million rubles.

Consequently, the choice of an appropriate depreciation method can significantly affect the profitability of an enterprise. It is necessary to strike a balance between increasing expenses for production development and creating a source of funds for asset renewal. In the defense industry, this balance must take into account not only the commercial interests of the enterprise but also the strategic objectives of providing the army with modern armament.

Slow depreciation is chosen when it is necessary to reduce the production cost to increase profit. It involves increasing the useful life of assets, reducing depreciation rates and infrequent renewal of fixed assets. For MIC enterprises producing goods at fixed state prices, this approach can be justified when production technology is stable and there is no need for frequent equipment replacement.

Accelerated depreciation, by contrast, is applied when frequent renewal of fixed assets is required, especially in areas where obsolescence occurs rapidly. It is implemented through increasing coefficients applied to depreciation rates or through non-linear methods that ensure rapid formation of a depreciation fund. In the defense

industry, where technological re-equipment is a condition for creating competitive armament models, accelerated depreciation allows faster accumulation of funds for purchasing new high-tech equipment.

The *effectiveness of depreciation policy* is assessed based on the financial condition of the organization. The main indicators are: the *fixed asset wear coefficient*, which shows the proportion of transferred value, *capital intensity*, reflecting the value of assets per unit of revenue and *return on fixed assets* [6, p. 40]. For MIC enterprises, these indicators must be analyzed in the context of fulfilling the state defense order and ensuring the mobilization readiness of production capacities.

Directions for improving depreciation policy include applying increasing coefficients in the first year of operation for assets acquired as replacements, determining wear costs for a group based on the cost of the last acquired object and adjusting depreciation rates in proportion to revenue growth. In the defense industry, it is also advisable to take into account industry specifics when developing a depreciation policy, aligning it with technical re-equipment plans approved within the framework of the state armament program.

Conclusion. Fixed assets remain in operation for a long time, but under the influence of external factors, they gradually lose their properties and require replacement. Their value is compensated through depreciation, which is the process of transferring the cost of fixed assets to finished products in order to accumulate funds for renewal. For enterprises of the military-industrial complex, timely renewal of fixed assets is not only an economic but also a strategic task that ensures technological independence and the country's defense capability. Three methods are used for calculating depreciation: straight-line method, declining balance method and units-of-production method.

Each organization selects a method independently, fixing it in its accounting policy. In a market economy, depreciation becomes a controllable element of production cost, and the correct choice of method allows increasing profitability. In MIC enterprises, this choice must take into account production specifics and requirements for the quality of military products.

The effectiveness of depreciation policy is evidenced by the wear coefficient, capital intensity and return on fixed assets. Its improvement involves applying increasing coefficients, linking depreciation to revenue and using the replacement method based on the cost of the last acquired object.

For defense enterprises, it is especially important to align depreciation policy with long-term development programs and production modernization plans. This ensures not only economic efficiency but also fulfilment of strategic objectives for ensuring the country's defense capability. A sound depreciation policy contributes to increased investment attractiveness and profit growth, which in the MIC context creates the foundation for further technological development and strengthening the country's defense potential.

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УДК 338.2

NARRATIVE REVIEW OF STUDIES ON ENTERPRISE ECONOMIC SUSTAINABILITY

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Abstract. The article reviews studies on enterprise economic sustainability and is based on Scopus records. After screening, 12 publications directly related to firm-level economic sustainability were selected for the thematic analysis. The review identifies four main areas: conceptual approaches to firm economic sustainability, indicators and assessment methods, managerial and organizational determinants, and crisis resilience of enterprises. The findings may be useful for students and researchers studying economic sustainability at the enterprise level.

Keywords: enterprise, sustainable growth rate, ESG, cost control, organizational resilience, narrative review.

ОПИСАТЕЛЬНЫЙ ОБЗОР ИССЛЕДОВАНИЙ ПО ЭКОНОМИЧЕСКОЙ УСТОЙЧИВОСТИ ПРЕДПРИЯТИЯ

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Аннотация. В статье представлен описательный обзор исследований, посвященных экономической устойчивости предприятия на материале статей из Scopus. После отбора были выделены 12 публикаций и четыре направления научной мысли: теоретические подходы к определению экономической устойчивости предприятия, показатели и подходы к оценке, управленческие и организационные факторы, кризисная устойчивость предприятий. Результаты могут быть полезны студентам и исследователям, изучающим устойчивость предприятия.

Ключевые слова: предприятие, устойчивый темп роста, ESG, контроль затрат, организационная устойчивость, описательный обзор.

Economic sustainability has become an important topic in business and management studies because enterprises operate in conditions of market uncertainty, technological change, social pressure and periodic crises. For a firm, sustainability is not limited to environmental responsibility. It also concerns the ability to remain

financially viable, maintain stable development, control costs, use resources effectively and adapt to external shocks. In this sense, enterprise economic sustainability connects financial performance with management quality and long-term competitiveness.

The relevance of the topic is also connected with the fact that different studies use different indicators and explanations of sustainability. Some authors assess it through sustainable growth rate, income level or financial stability. Other authors focus on organizational resilience, strategic orientation, human resources, enterprise resource planning systems or buyer-supplier relationships. As a result, the concept is broad and requires a review that brings these approaches together at the enterprise level.

The aim of this article is to conduct a narrative review of studies on enterprise economic sustainability. The study is based on the Scopus export provided for the search query TITLE("economic sustainability" OR "economic resilience" OR "financial sustainability" OR "economic viability") with limits by subject area, English language, open access, selected keywords and article document type. The initial export contained 109 records as Table 1 shows. The titles, abstracts and keywords were screened in order to select publications directly related to enterprises, firms, SMEs, banks, industrial companies or other business organizations. Studies focused mainly on national economies, regions, cities, infrastructure, construction materials, roads, energy systems, tourism territories and macroeconomic policy were excluded from the main corpus because they did not directly answer the research question of firm-level sustainability.

Table 1. Screening results of the Scopus export

Stage	Documents	Description
Initial Scopus export	109	Records retrieved by the author’s search query on economic sustainability, economic resilience, financial sustainability and economic viability
Excluded records	97	Publications outside the firm-level focus, including regional, national, urban, infrastructure, tourism, energy and material-focused studies
Core sources for thematic review	12	Publications directly connected with enterprise, firm, SME, banking, industrial or organizational economic sustainability

A narrative review design was chosen because the purpose of the article is not to calculate a single effect size, but to describe and compare several research lines. This approach makes it possible to group the sources thematically and to show how different authors explain the same general concept from financial, managerial and resilience perspectives as Table 2 shows.

Table 2. Thematic structure of selected sources

Theme	Focus	Sources
Conceptualising firm economic sustainability	Definitions and theoretical explanations of sustainability as firm viability, structural balance and resilience	Mora Ortega et al. [1], Dergachova et al. [2], Rai et al. [3]
Indicators and assessment approaches	Sustainable growth rate, sustainable income, financial stress and enterprise survival rate	Lin [4], Bayramoglu et al. [5], Masi et al. [6], Kuzmin et al. [7]
Managerial and organizational determinants	Strategic orientation, ERP use, cost control, HRM and supplier relationships	Yang et al. [8], Jaradat et al. [9], Taha and Taha [10], Munyimi and Chari [11]
Crisis resilience of enterprises	Ability to anticipate, withstand and recover from shocks	Rai et al. [3], Birbirenko et al. [12]

The reviewed studies indicate that enterprise economic sustainability may be interpreted as a multidimensional capacity of a firm to generate stable income, remain solvent, maintain growth, preserve internal balance and adapt to market or crisis-related changes. Mora Ortega, de la O Cordero and Briones Peñalver examine the relationship between corporate social responsibility and the economic sustainability of small and medium-sized enterprises. Their systematic literature review covers scientific activity for 2000-2023 and groups the field around corporate social responsibility, strategy, perceptions, leadership and financial performance [1].

Dergachova, Kravchenko, Kuznietsova, Dergachova and Melnykova develop a systemic-structural view of economic sustainability. Their study of machine-building enterprises treats the firm as an economic system consisting of several interrelated subsystems. According to this approach, enterprise sustainability depends on the balance between these subsystems and on the ability of the system to preserve stability in space and time [2].

Rai, Rai and Singh connect economic sustainability with organizational resilience during COVID-19. They describe resilience through crisis anticipation, organizational robustness and recoverability [3]. This perspective is significant because sustainability is not limited to periods of stable development. A firm may appear sustainable under normal market conditions, whereas the actual strength of its economic model becomes visible when demand, supply chains, labour mobility or access to finance are disrupted.

The first group of indicators is connected with growth and financial capacity. Lin uses the sustainable growth rate as the main measure of corporate economic sustainability. Based on Chinese listed companies from 2009 to 2021, the study finds that ESG performance has a positive effect on the sustainable growth rate. The mechanism analysis suggests that ESG may support sustainable growth through patent applications, lower agency costs and lower firm risk [4]. This article is central to the present review because it provides a measurable indicator and links sustainability with financial performance, innovation and risk control.

The sustainable growth rate reflects whether a firm can expand without damaging its financial balance. It is not only a growth indicator, but also a constraint. When a

company expands faster than its internal financial capacity allows, growth may become a source of instability. In this sense, Lin's approach connects economic sustainability with responsible growth rather than expansion at any cost [4].

Bayramoglu, Oguz, Karakayaci and Arisoy use a different assessment logic. Their study identifies the income level required for agricultural enterprises to achieve economic sustainability. The authors divide economic sustainability into components related to the cost of living, depreciation and interest costs. Enterprises that reach this income level are considered economically sustainable. In their survey of 181 agricultural enterprises in Konya, more than 150 enterprises were found to be unsustainable [5].

Masi, Marrocco, Fusco, Adinolfi and Vecchio assess economic sustainability through financial performance and financial stress. Their study of Italian aquaculture farms uses Altman's Z-score and balance sheet data for 2017-2021. The authors show that 80 percent of the analysed companies were under financial stress, which limited their ability to invest in new practices and technologies [6].

Kuzmin, Vinogradova and Guseva analyse enterprise survival rate in the dynamics of regional economic sustainability. Although their article includes a regional comparison of Russia and the European Union, the indicator itself is directly related to firms. The authors focus on business demography and show that enterprise survival may be used as a universal characteristic of sustainable economic activity [7].

The next group of studies explains why some enterprises are more economically sustainable than others. Yang, Jaafar, Al Mamun, Salameh and Nawi examine the significance of strategic orientation for competitive advantage and economic sustainability. Their study of 284 halal SMEs in Indonesia uses PLS-SEM and artificial neural network analysis. The results show a positive effect of strategic orientation on economic sustainability, while competitive advantage strengthens this relationship. The authors particularly emphasize innovation, network and technological orientation [8].

Jaradat, AL-Hawamleh, Altarawneh, Al-Tahat and Akram Nazzal study the effect of effective ERP system utilization on enterprise economic sustainability through product life cycle cost control. Their research is based on data from Jordanian industrial firms and shows that ERP use positively affects product life cycle costing control, which in turn positively influences economic sustainability [9].

Taha and Taha focus on human resource management in Jordanian banks. They examine the role of HRM in enhancing economic sustainability using data from 23 banks for 2014-2019. Their variables include management of the human resources environment, acquisition and preparation of human resources, assessment and development, and compensation. The results show a positive relationship between these HRM dimensions and economic sustainability [10].

Munyimi and Chari examine buyer-supplier relationships in the private telecommunication sector in Zimbabwe. Their study shows that strategic alliances with suppliers of strategic items and transactional relationships with suppliers of routine materials play an important role in achieving economic sustainability [11].

The crisis dimension is essential for understanding enterprise economic sustainability. Rai, Rai and Singh argue that organizational resilience supports social

and economic sustainability during COVID-19. Their model includes crisis anticipation, organizational robustness and recoverability [3]. Applied to enterprises, this model describes three key abilities. The first is the ability to identify risks before they cause serious damage. The second is the ability to maintain core operations under pressure. The third is the ability to restore performance after disruption.

Birbirenko, Zhadanova and Banket directly study the influence of the COVID-19 pandemic on the economic resilience of enterprises [12]. The study concludes that enterprises need risk assessment, a clear business plan, adaptability to threats, continuity of business processes and constant renewal. Crisis resilience differs from ordinary efficiency. In stable conditions, a firm may improve efficiency by minimizing reserves, reducing costs and simplifying operations. During a crisis, the same approach may increase vulnerability if the firm has no financial buffer, flexible suppliers or alternative processes. For this reason, economic sustainability should be understood as a balance between efficiency and resilience. An enterprise needs cost discipline, but it also needs the capacity to respond when the environment changes suddenly.

The reviewed literature offers several approaches to assessment. Lin's study uses sustainable growth rate as the key indicator of corporate economic sustainability [4]. Bayramoglu et al. apply sustainable income as a threshold for agricultural enterprises [5]. Masi et al. assess financial stability and stress through Altman's Z-score [6]. Kuzmin et al. use enterprise survival rate as an indicator of continuity [7]. These approaches differ by sector and data type, but they all measure whether the firm has sufficient economic capacity to continue operating and developing.

The review also shows that economic sustainability depends on managerial and organizational factors. Strategic orientation, innovation, technology orientation, ERP systems, product life cycle cost control, HRM and buyer-supplier relationships can strengthen the economic position of an enterprise. At the same time, crisis studies demonstrate that firms need resilience capabilities, including risk anticipation, robustness, recovery and adaptability. Without these capabilities, financial indicators may worsen quickly during external shocks.

The study has several limitations. It is based on one Scopus export and uses a narrative review design. Some selected publications belong to specific sectors, such as agriculture, aquaculture, banking, telecommunications or machine building. Further research may compare industries separately, add Russian-language sources and develop a more formal system of indicators for assessing enterprise economic sustainability.

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УДК 339.138

CUSTOMER ORIENTATION OF STAFF AS A RESULT OF A COMPANY'S INTERNAL MARKETING

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Abstract. This article examines the impact of employees' internal customer experience on the quality of service to external customers. Based on an analysis of theoretical approaches, in particular L. Berry's concept of internal marketing, it is demonstrated that treating employees as internal customers and meeting their needs contributes to the development of service-oriented employee behavior. It is shown that positive employee engagement directly improves the quality of service to external customers, which ultimately ensures competitive advantages and long-term profitability for the company.

Keywords: internal marketing, employee customer experience, service quality, external customers, employee engagement, ergonomics.

КЛИЕНТООРИЕНТИРОВАННОСТЬ ПЕРСОНАЛА КАК РЕЗУЛЬТАТ ВНУТРЕННЕГО МАРКЕТИНГА КОМПАНИИ

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Аннотация. В статье рассматривается влияние внутреннего клиентского опыта сотрудников на качество обслуживания внешних клиентов. На основе анализа теоретических подходов, в частности концепции внутреннего маркетинга Л. Берри, обосновывается, что отношение к персоналу как к внутренним клиентам и удовлетворение их потребностей способствуют формированию сервисно-ориентированного поведения сотрудников. Показано, что позитивная вовлеченность работников напрямую повышает качество обслуживания внешних клиентов, что в итоге обеспечивает конкурентные преимущества и долгосрочную прибыльность компании.

Ключевые слова: внутренний маркетинг, клиентский опыт сотрудников, качество обслуживания, внешние клиенты, вовлеченность персонала, эргономика.

Sustainable long-term profitability and growth in a company's market value are achieved through systematically creating value for customers, enhancing competitiveness, effectively managing resources, and building trust with key stakeholders.

Organizations typically collect marketing intelligence that can give them a market advantage. Competitive positioning improvement techniques, such as market orientation, are achieved primarily by the organization taking an external, customer-focused, and coordinated perspective, collecting data on the needs of those outside the business. These include (1) external shareholders, (2) external customers, and (3) external competitors. Despite the widespread acceptance of such techniques, there have been repeated calls for greater attention to internal processes as part of this strategic objective [5].

Employees are typically viewed as passive recipients of sustainability strategies. However, employees can play a more active role in organizations' sustainability efforts by engaging and delivering benefits to the organization and its stakeholders [6]. The Impact of Employees' Internal Customer Experience on External Customer Service Quality

Positive employee engagement supports positive relationships with external customers, partners, and stakeholders [5].

In the context of market orientation, marketing plays a special role as a key tool for building competitive advantage. More broadly, marketing is a system for managing a company's market activities and creating value for the consumer. The term "marketing" itself derives from the English word "market," emphasizing its focus on analyzing the market environment, consumer behavior, and the mechanisms of interaction between supply and demand.

It's important to consider that employees constitute a company's "first" market and should be served as efficiently as customers. According to L. Berry's model, treating company personnel as customers will change employees' attitudes toward their work and the organization as a whole. Employees will become service-oriented, which will lead to improved service quality for external customers and, consequently, to a competitive advantage and company success [2].

Effective marketing involves not only working with external audiences but also building internal processes aimed at aligning company goals with the needs of its employees. L. Berry is considered the founder of the concept of internal marketing. In his research, he argues that a company's highest performance is achieved when employees are perceived as clients and meeting their needs through marketing tools is a priority [1].

One common definition of internal marketing is based precisely on employee needs.

Internal marketing is a strategy for shaping a product offering (jobs) so that it satisfies human needs" [2].

Internal marketing develops workplaces as internal products to satisfy the needs and desires of these internal clients and to align employees with the organization's goals [5].

Such internal products include:

A reward and motivation system, including wages, bonuses, and non-material incentives, that create a sense of fairness and value for the employee's contribution;

Training and development programs aimed at improving skills, career growth, and professional self-realization;

Organizational culture and communication environment that ensure support, trust, and employee engagement;

Working conditions and social guarantees that influence comfort, safety, and stability;

Ergonomic corporate digital environments and internal services, where high-quality user experience (UX) plays a key role. The more users like a system, the more likely they are to maintain good performance over the long term [4].

Ergonomics (human factors) is a scientific discipline that understands the interactions between human and other system elements [3].

Employee well-being increases their commitment and satisfaction, which are early indicators of improved company performance [5].

“Investing in the performer contributes to performance... Investing in the success of a company's employees guarantees the success of the company itself” [2].

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УДК 659.4

THE IMPACT OF CORPORATE MEDIA ON THE UNIVERSITY'S IMAGE AND THEIR INDIRECT ECONOMIC BENEFITS: A CASE STUDY OF SPbSUITD CORPORATE RESOURCES

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Abstract. The article examines corporate media as a tool of the university's marketing policy, which shapes its institutional image and generates brings indirect economic benefits. The present study analyses the case of SPbSUITD and describes the specific findings of an investigation into the university's corporate media resources. The article focuses on saving advertising budgets due to high citation frequency in third-party media outlets, enhanced institutional visibility owing to high standings in media ratings and establishing and cultivating the commercial partnerships through corporate media resources.

Keywords: university corporate media, institutional image, SPbSUITD, citation frequency, media visibility, commercial partnership, media rating.

ВЛИЯНИЕ КОРПОРАТИВНЫХ МЕДИА НА ИМИДЖ УНИВЕРСИТЕТА И ИХ КОСВЕННЫЕ ЭКОНОМИЧЕСКИЕ ВЫГОДЫ (НА ПРИМЕРЕ КОРПОРАТИВНЫХ РЕСУРСОВ СПбГУПТД)

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Аннотация. В статье рассматриваются корпоративные медиа как инструмент маркетинговой политики университета, формирующий его имидж и приносящий косвенные экономические выгоды. В представленной работе анализируется кейс СПбГУПТД и описываются конкретные результаты исследования корпоративных медиаресурсов вуза. Наибольшее внимание уделяется экономии рекламного бюджета за счет высокой упоминаемости в сторонних СМИ, повышению узнаваемости вуза в связи с высокими позициями в медиарейтингах, а также формированию коммерческих партнерств через корпоративные медиаресурсы.

Ключевые слова: корпоративные медиа вуза, имидж образовательной организации, СПбГУПТД, частота цитирования, медийная узнаваемость, коммерческое партнерство, медиарейтинг.

In the context of high competition between higher education institutions in Russia corporate media is an important part of the marketing policy of modern universities. This tool is used by universities to create an organization's image, reputation and a positive perception of the brand among the audience. Moreover, corporate resources provide indirect economic benefits to universities. While they may not generate direct revenue, they attract public attention and serve as a tool for attracting new students, partners and sponsors. In this paper we will examine the impact of corporate media on the image of the Saint Petersburg State University of Industrial Technologies and Design, determine the indirect economic benefits that this marketing tool brings to the university.

In the scientific community, the issue of studying the image of universities became widespread in 1990s. It was then that the process of commercialization of higher education took place: "In April 1991, the law on entrepreneurial activity was adopted, allowing the registration of universities and schools on a common basis with commercial enterprises" [1, p. 75]. At that time, paid educational programs and the first private universities appeared – the state's monopoly on the educational sphere ended, the struggle for applicants began between universities, and universities needed to explore ways to attract students and shape the organization's image.

The image of an educational institution is understood as a specially constructed image of a university in the minds of its stakeholders (primarily students and applicants), which should meet these expectations and needs [2, p. 538]. The researches note that formation of a positive image allows the university to achieve competitiveness "based on achieving a high level of trust from members of the internal and external target audience" [3, p. 660]. Corporate media is one of the main marketing tools capable of influencing the designated audience segments. According to V. I. Yarnykh, this tool is one of the most important mechanisms of brand journalism and implies "the formation of company's positive image in the eyes of various stakeholders, such as shareholders, staff, management, customers, suppliers, investors, society, etc." [4, p. 77].

There is no consensus on the definition of "corporate media". Some scholars adhere to the old approach of considering corporate media as soviet mass-circulation publications or exclusively officially registered media affiliated with organizations. For example, Yu. V. Chemyakin defines corporate media as "officially registered media that reflect the interests of specific founding corporations, are published on their initiative and contribute to their development and the resolution of their tasks by establishing and maintaining contact with public groups that are significant to these corporations" [5, p. 100]. However, in this work this approach will be considered to be outdated because of appearing of new information resources, tools and ways of presenting information means. The concept of corporate media should not be limited to media typology, genre or formal conditions: "…traditional media platforms with stable roles… are becoming a thing of the past, the system of content distribution is becoming more complicated, the number of communication channels, the nature of interaction and the direction of initiative within them increases" [6, p. 67].

So, based on the definition proposed by Yu. V. Chemyakin, corporate media should be understood as means and channels of communication and presentation of information that reflect the interests of the company that initiated them, contribute to its

development and meet its needs.

Earlier, we found out that corporate media is a tool aimed at shaping the image of an educational organization. The degree of audience loyalty and its reputation depends on the university's positioning in the corporate media. However, researchers have to face a methodological problem. Corporate resources rarely bring a direct economic effect (in cases of publishing advertising or partner content), and indirect benefits are incalculable. In modern practice there are no metrics to record the exact percentage of growth in the number of applications for admission after applicants view a post on social networks and other benefits received by an organization through the dissemination of corporate content. However, corporate media can bring significant economic benefits. In this paper we are trying to examine the case of SPbSUITD and identify non-financial indicators of the effectiveness of corporate media.

Saint Petersburg State University of Industrial Technologies and Design is the only state university in the North-Western Federal District that trains specialists in the textile and light industry, the printing industry, thermal power engineering, and the pulp and paper industry [7]. The diversity of educational programs and fields of study, combined with the institution's mission to train not only secondary-level specialists, bachelor's and master's degree students, but also postgraduate students and specialists who wish to continue their education, necessitates the implementation of a wide range of communicative tools. As a result, SPbSUITD has a large number of corporate media aimed at various segments of the target audience. Thus, several groups of corporate information resources based on their goals, functions, and target audiences can be identified:

1. Corporate media of the admissions committee (website, unified official community, admissions committee communities based on individual university departments, and applicant chats on the VKontakte social network).
2. Corporate media of student associations (communities of the trade union committee, student council, student squads, sports club "GUTID" on VKontakte, etc.)
3. Corporate media of university departments (communities on VKontakte of individual institutes, departments, centers, etc.)
4. Corporate media of the university (internet magazine "Sarafan" on social networks and in the form of a printed magazine for first-year students, magazine "Kontakt" on VKontakte and in the form of a printed magazine, printed magazine "GUTID. Sport lives here", the urban student media centre "STUDPRESSA").

Within the framework of the given media resources, media projects of different genres and types are implemented at the university: corporate podcasts, series, reality shows, documentaries, special projects, etc. As it has been mentioned earlier, the active communication policy of the university allows it to receive indirect economic benefits from corporate media, and also contributes to the formation of the image. Let's list the main ways of profit generation on the example of the activities of corporate media of SPbSUITD.

First, the active use of corporate media to disseminate news about the educational organization’s activities contributes to the university’s increased visibility in third-party media. The dissemination of internal news stories can serve as a substitute for paid advertising for the university.

So, the cost of placing an advertising post for 24 hours on the social networks of the St. Petersburg edition of Fontanka in May 2026 is 20 thousand rubles (in the MAX messenger), 40 thousand rubles (in the VKontakte social network for 1 year), 60 thousand rubles (in the Telegram messenger for 24 hours) [8]. In this case, if the SPbSUITD media generates 30 mentions per year, the advertising budget savings can range from 600,000 rubles to 1,800,000 rubles.

As of May 10, 2026, University of Industrial Technologies and Design was mentioned once in non-advertising posts by the Fontanka.ru VKontakte community, and six times on the publication's website. Notably, the publication cites the university's corporate media, specifically the official VKontakte community of SPbSUITD, as a source in its materials [9].

As a result, the mention of the university and its corporate media as a source of information in the third-party media allows you to save on advertising publications and increase the university's brand awareness by increasing its citation rate.

Secondly, the active use of corporate media resources allows the university to participate in media rankings, which also contributes to increasing its citation rate, mentioning, strengthening its authority, increasing its recognition among the target audience and shaping the university's image as a university that meets the current market requirements.

Thus, in the media activity rating of the Russian Ministry of Education and Science (M-RATE) for March 2026, SPbSUITD ranks 24th in the consolidated ranking of 233 universities in the country, the university's channel on Rutube ranks 6th, and the university is in the fifth position in terms of media coverage [10]. The results highlight the activity of SPbSUITD's communication channels.

M-RATE takes into account the effectiveness of universities in the media space in three main areas: working with the media, with their own audience in groups and channels on major social networks and with their own websites [11]. This rating contributes to raising public awareness about university activities and allows regional universities to compete with the large ones. Participation in other rankings may involve receiving prizes from partners, which can also lead to budget benefits.

Thus, universities' participation in media rankings brings them indirect economic benefits by increasing the universities' visibility, increasing the trust of applicants and partners. The mention of an educational institution in a media ranking is an external signal of quantity. Increasing the place in such lists enhances the visibility of the university for applicants and partners, which directly affects the interest in the university's activities.

Thirdly, commercial partnerships can be formed through the use of external corporate media. The university's active presence in the media field demonstrates its expertise to potential companies and its ability to achieve real results in areas of their interests.

The specific assessments of the effectiveness of corporate media in this context are the number of incoming requests and commercial offers from companies in the media of universities. During the preparation of the article the author made an attempt to analyse the work of the corporate media of SPbSUITD from within, namely, the author was given access to personal messages from the community of the GUTID sports club

on the VKontakte social network.

In the period from 01/12/2025 to 01/05/2026, the community received 10 proposals for sports related partnerships from other universities, sports organizations, frequent companies and organizers of sport events in the region. Among the offers there are special prices for accommodation of athletes in country camps, discounted sports uniforms and invitations for students to participate in sports events (see fig.).

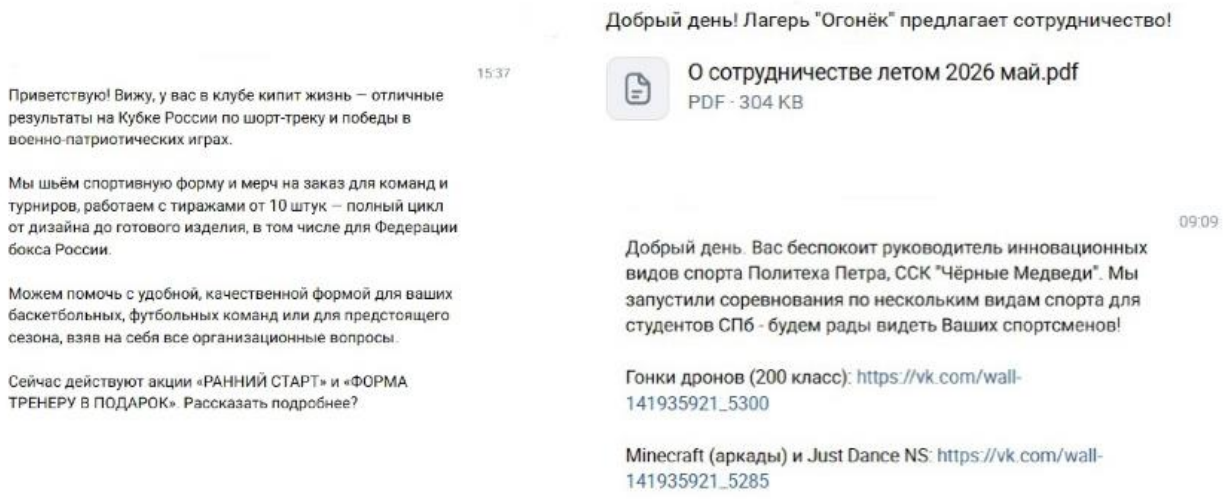


Figure. Offers from potential partners in the GUTID Sport club community on the VKontakte social network

It may therefore be concluded that maintaining corporate media dedicated to the institution's core areas of activity cultivates an expert image of the university and may facilitate collaboration across a range of fields. Corporate media resources attract new partners, some of whom may evolve into commercial stakeholders, thereby enabling the expansion of the university's agreement portfolio and the optimization of its budget.

To summarize, the present study has established that corporate media can position a university as a dynamic, professionally oriented institution that is open to partnership and engagement. In the case of SPbSUITD, this manifest in increased citation rates, enhanced institutional recognition and greater trust among prospective students, partners and external media outlets. Corporate media content serves as an instrument of both reputational and economic development, enabling the university to reduce expenditure on paid advertising, strengthen its standing in institutional rankings and broaden its network of professional contacts.

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УДК 336.7

AI-ASSISTED REGULATION OF DIGITAL CURRENCIES AND CRYPTO-ASSETS BETWEEN FINANCIAL CONTROL AND DECENTRALISATION

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Abstract. The article examines how artificial intelligence can support risk-based regulation of digital currencies without turning supervision into total financial control. It distinguishes crypto-assets, stablecoins, CBDCs and tokenised assets, and argues that AI-assisted monitoring may improve AML/CFT, provided that human review, audit, transparency, privacy safeguards and appeal mechanisms are preserved.

Keywords: digital currencies, crypto-assets, artificial intelligence, AML/CFT, blockchain analytics, risk-based supervision, decentralisation.

РЕГУЛИРОВАНИЕ ЦИФРОВЫХ ВАЛЮТ И КРИПТОАКТИВОВ С ИСПОЛЬЗОВАНИЕМ ИСКУССТВЕННОГО ИНТЕЛЛЕКТА МЕЖДУ ФИНАНСОВЫМ КОНТРОЛЕМ И ДЕЦЕНТРАЛИЗАЦИЕЙ

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Аннотация. В статье рассматривается, как искусственный интеллект может поддерживать риск-ориентированное регулирование цифровых валют без превращения надзора в тотальный финансовый контроль. Разграничиваются криптоактивы, стейблкоины, цифровые валюты центральных банков и токенизированные активы. Сделан вывод, что AI-мониторинг может повысить эффективность AML/CFT при сохранении человеческой проверки, аудита, прозрачности, защиты приватности и механизмов апелляции.

Ключевые слова: цифровые валюты, криптоактивы, искусственный интеллект, AML/CFT, блокчейн-аналитика, риск-ориентированный надзор, децентрализация.

Digital currencies and crypto-assets are no longer only a technological experiment. They are connected with payments, investments, international transfers, decentralised finance, stablecoins and tokenised assets. In this article, the term digital currencies is used as a broad category that includes different forms of digital value.

Crypto-assets, such as Bitcoin, Ethereum and other tokens, are one part of this category. Stablecoins are a specific type of crypto-asset whose value is usually linked to a fiat currency, such as the US dollar or the euro. Central bank digital currencies (CBDCs), by contrast, are sovereign digital money issued or developed by central banks. Consequently, these concepts should not be treated as identical [1].

This terminological distinction is essential for regulation. A decentralised crypto-asset, an e-money token, a stablecoin and a CBDC may create different legal, financial and technological risks. The European regulatory approach, for example, distinguishes several categories of crypto-assets and connects them with different obligations for issuers and service providers [2]. Therefore, the article focuses not on digital currencies in a narrow monetary sense, but on digital currencies and crypto-assets as a wider regulatory field.

The regulatory landscape remains fragmented. In different jurisdictions, crypto-assets may be treated as property, commodities, securities, virtual assets, e-money tokens or digital rights. This legal status affects taxation, inheritance, bankruptcy, custody, investor protection and enforcement. Comparative studies show that states have developed different approaches to licensing, consumer protection, market integrity and supervision [3]. In light of this, regulation cannot be based on one universal definition or on a simple transfer of banking rules to all digital assets.

Traditional financial regulation works most effectively when there is a clear intermediary. A bank, broker, payment institution or exchange can be licensed, audited and supervised. In the crypto-asset sector, this logic is applied to Virtual Asset Service Providers (VASPs) and Crypto-Asset Service Providers (CASPs). Such an approach is reasonable because exchanges, custodians and brokers are closer to users and transactions. International recommendations also emphasise market integrity, custody, conflicts of interest and operational resilience in crypto-asset markets [4].

Nevertheless, intermediary-based regulation has significant limitations. Open blockchain networks allow users to transfer value directly, and decentralised finance (DeFi) protocols do not always have a traditional legal operator. Financial stability authorities also note that global crypto-asset activity requires cross-border cooperation, consistent supervision and attention to gaps between jurisdictions [5]. As a result, regulation through intermediaries alone cannot fully address self-hosted wallets, peer-to-peer transactions and decentralised protocols.

At the same time, the purpose of regulation is not to remove innovation from the market. The International Monetary Fund stresses that crypto-asset policies should protect monetary sovereignty, financial stability, market integrity and consumers, while avoiding regulatory gaps and excessive fragmentation [6]. This means that a balanced approach should reduce real risks without transforming all decentralised exchange into a copy of the traditional banking sector.

Stablecoins demonstrate this problem particularly clearly. They are designed to maintain a relatively stable value, but they may still create risks connected with reserve assets, redemption rights, governance, liquidity and cross-border use. International payment authorities note that stablecoin arrangements can affect cross-border payments and financial stability if they are widely adopted without sufficient safeguards [7]. Therefore, stablecoins require stricter attention than ordinary decentralised tokens, although they should still not be confused with CBDCs.

DeFi creates a different challenge. It may provide lending, exchange, derivatives, collateral management and other financial functions through protocols rather than through ordinary financial institutions. Mapping projects conducted by central bank innovation units show that DeFi activity can be observed and analysed on public blockchains, but its legal and organisational structure remains difficult to identify in many cases [8]. This creates a gap between technical transparency and legal accountability.

Artificial intelligence and machine learning may support regulation by changing how risks are detected. Earlier supervision depended mainly on manual checks, reports from intermediaries and formal anti-money laundering and countering the financing of terrorism (AML/CFT) procedures. New technologies are increasingly discussed as tools that may improve AML/CFT effectiveness by supporting data analysis, anomaly detection and more targeted monitoring [9]. However, AI should be understood as a support instrument, not as a substitute for legal judgement.

AI-assisted systems may examine the timing, frequency, routing and clustering of transactions, as well as behavioural patterns of wallets and links between addresses. Research based on blockchain datasets shows that graph-based and subgraph-based machine learning methods can be used to identify suspicious structures and transaction patterns [10]. It should be emphasised that AI does not provide legal interpretation; rather, it functions as a tool for pattern recognition and risk identification. The resulting signals should then be reviewed by competent specialists.

Blockchain analytics also has a practical role in detecting crime typologies. Industry reports identify patterns connected with scams, ransomware, darknet markets, sanctions evasion, illicit services and other forms of crypto-related crime [11]. Typology reports similarly describe methods used to obscure funds, including complex transaction chains, high-risk services and attempts to move assets across platforms or networks [12]. Such materials do not remove the need for legal evidence, but they help define risk indicators for further analysis.

Table 1 is included to clarify why AI-assisted supervision differs from traditional intermediary-based regulation. It shows that the main advantage of AI is not stricter control in itself, but the ability to focus regulatory attention on higher-risk cases.

Table 1. Comparison of traditional and AI-assisted regulation

Criterion	Traditional regulation	AI-assisted risk regulation
Main method	Formal checks, reports, licensing and manual review	Data analysis, pattern detection and risk scoring
Speed	Often slow, especially when control is manual	Faster processing of large transaction flows
Bureaucratic load	May be high for many participants, including low-risk users	May redistribute attention towards higher-risk cases
Risk detection	Depends mainly on known rules and documents	May reveal unusual behaviour and hidden patterns
Human involvement	Many routine checks are performed by people	People review serious, disputed or high-risk cases

Criterion	Traditional regulation	AI-assisted risk regulation
Main limitation	Excessive formal control and paperwork	False positives, opacity and possible misuse

As shown in Table 1, AI-assisted regulation changes the logic of supervision. Instead of applying the same formal procedures to every participant, it may help identify transactions, wallets or platforms that require closer human review. Nevertheless, this advantage is meaningful only if risk scoring remains transparent, auditable and legally limited.

A risk-based approach is especially relevant because digital currencies are used in very different situations. A low-risk retail payment, a licensed platform, a stablecoin issuer and a suspicious network of wallets should not receive the same level of scrutiny. Ordinary low-risk operations should not be overloaded with unnecessary procedures, whereas unusual patterns, high-risk intermediaries and suspicious routes should receive greater attention. This is not a rejection of supervision; rather, it is a more proportionate form of supervision.

The risk-based approach is already part of modern financial regulation. Therefore, the novelty is not the abstract idea of risk orientation itself, but the possible use of AI to make such supervision more accurate, faster and less bureaucratic. At the same time, AI does not automatically reduce bureaucracy. If it is added without transparency, clear responsibility and audit, it may simply create another opaque layer of control.

Table 2 presents possible indicators that may be used in AI-assisted risk analysis. These indicators should not be understood as proof of illegal activity. They are analytical signals that may justify additional review, especially when several indicators appear together.

Table 2. Possible AI indicators of transaction risk

Indicator	What it may show	Why it matters
Unusual timing	Activity that differs from the normal pattern of a wallet	May indicate automated, hidden or atypical activity
Unusually long transfer chain	Movement through many addresses or services for a specific transaction type	May make tracing more difficult and require context analysis
Links with high-risk wallets	Contact with addresses associated with fraud, sanctions or earlier suspicious activity	Helps identify higher-risk connections
Use of mixers or tumblers	Possible attempt to obscure the transaction history of crypto-assets	Requires additional analysis, but is not proof of guilt
Change in wallet behaviour	Sudden change in usual amounts, timing or counterparties	May indicate account compromise or new risky activity
High transfer frequency	Many transfers in a short period	May suggest laundering, bot activity or market manipulation
Unusual routing	Movement through several platforms, networks or services	May indicate an attempt to avoid ordinary compliance checks

As shown in Table 2, transaction risk usually appears not from one isolated factor, but from a combination of signals. A long transaction chain, interaction with high-risk addresses and sudden changes in wallet behaviour may together create a stronger reason for further analysis than any single feature alone. Consequently, risk assessment should be contextual and should include human review before restrictive action is taken.

Privacy-enhancing tools also require precise terminology. Mixers and tumblers are especially relevant for AML/CFT because they may obscure the transaction history of crypto-assets by mixing or routing funds through multiple addresses and users. Tor, VPNs and similar network-level privacy tools perform a different function: they may hide network metadata, such as an IP address or location, but they do not directly hide the movement of funds on a blockchain. Therefore, mixers are primarily connected with transaction tracing, whereas Tor and VPNs are more closely related to privacy and cybersecurity.

The use of privacy tools should not automatically be interpreted as evidence of illegal conduct. There are legitimate reasons why users may wish to protect privacy. However, when privacy tools are combined with suspicious transaction patterns, they may become one element of a broader risk assessment. In this context, AI output should be treated as an early warning mechanism. It may indicate that a transaction or wallet pattern requires closer examination, but further action should depend on legal procedures, evidence and competent review.

AI-assisted supervision may also support taxation and reporting. The Crypto-Asset Reporting Framework developed by the Organisation for Economic Co-operation and Development shows that crypto-asset markets increasingly require standardised information exchange between jurisdictions [13]. AI tools cannot replace legal reporting duties, but they may help identify inconsistencies, unusual flows and cases that require additional verification.

Banks and other regulated financial institutions face additional prudential concerns when they are exposed to crypto-assets. The Basel Committee has developed rules for the prudential treatment of crypto-asset exposures, reflecting risks related to capital, liquidity and risk management [14]. AI-assisted monitoring may support these institutions by improving the identification of exposure patterns, but supervisory responsibility must remain clearly defined.

DeFi and self-hosted wallets should be treated carefully. The fact that a system is decentralised does not remove all risks, but formal regulation should not destroy decentralised architecture. IOSCO recommendations on DeFi focus on functions and risks rather than labels, which is useful because decentralised projects may perform activities similar to those of financial intermediaries [15]. Therefore, AI-based supervision should focus on concrete risk indicators rather than on the mere existence of decentralisation.

CBDCs raise a separate set of questions. The digital euro project, for example, is connected with public money, payment efficiency, privacy and the possible design of central bank digital payments [16]. In Russia, digital ruble materials also show that state digital currency projects are linked with AML rules and the organisation of payment infrastructure [17]. CBDCs should therefore not be merged conceptually with private crypto-assets: they may use digital technologies, but their issuer, legal nature and governance model are different.

Cross-border transfers are another practical context in which digital currencies are often discussed. Remittance data show that international transfers remain economically significant and may involve costs for users [18]. Digital assets may potentially reduce friction in some payment scenarios, but this potential must be balanced against risks of fraud, sanctions evasion, weak consumer protection and fragmented supervision.

The risk of centralised AI control is one of the central issues in this article. Digital currencies were created partly as an alternative to highly centralised financial systems. If all AI control tools are operated by one state, one private provider or a small group of regulators, decentralisation may become only formal. Such a system could decide which transactions are risky, which wallets are suspicious and which users should be blocked. Without independent audit and appeal, it may become a digital form of total financial supervision.

This problem is not only technical, but also political and economic. AI infrastructure may become a new centralised authority governing decentralised finance. To avoid this, AI-based supervision should be limited by law, subject to independent audit and protected from political or commercial pressure. Distributed governance, open standards, external audits and participation from technical communities may reduce the risk that one centre of power controls the entire system.

A balanced system should therefore be multi-stakeholder. Regulators, licensed platforms, independent auditors, academic institutions, international organisations, civil society and the crypto community should have different responsibilities. Table 3 summarises these roles.

Table 3. Participants in a balanced framework of AI-assisted regulation

Participant	Role	Why it is necessary
Public regulators	Set legal rules, supervise systemic risks and protect public interests	They are responsible for AML/CFT, market integrity and financial stability
Licensed platforms	Apply compliance tools and provide data within legal limits	They are close to users, transactions and operational risks
Independent auditors	Check AI models, data quality, bias and error rates	They reduce the risk of hidden or unfair decisions
Academic institutions	Study model quality, social effects and legal risks	They add independent expertise and methodological review
Crypto community	Represent users, developers and decentralised projects; support code review and technical feedback	They help protect decentralisation and digital autonomy
International organisations	Support common standards and cross-border cooperation	Digital currencies and crypto-assets are global by nature
Civil society experts	Monitor privacy, rights and proportionality	They help prevent excessive surveillance

As shown in Table 3, the legitimacy of AI-assisted regulation depends on the distribution of roles. Regulators define legal duties, platforms apply compliance tools, auditors check the fairness and accuracy of AI models, and civil society and the crypto

community help protect privacy and decentralisation. The role of the crypto community should not be purely symbolic: it may include technical feedback, code review, identification of protocol-specific risks and discussion of governance standards.

The proposed framework is based on the principle that AI should support risk-based supervision without replacing human legal judgement. It combines public control with the protection of decentralisation, privacy and digital autonomy. The framework should not function as a system of total surveillance. Instead, it should operate as a staged process in which AI identifies risk signals, human specialists review high-risk cases, and affected users or companies have access to appeal mechanisms (Figure).

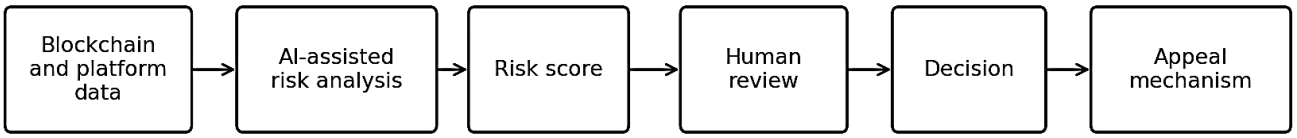


Figure. Staged framework for AI-assisted regulation of digital currencies and crypto-assets

In this framework, blockchain and platform data are first collected within legal limits. AI-assisted tools then analyse transaction patterns and produce a risk score. Low-risk activity may proceed without additional intervention, whereas high-risk activity is transferred to human review. A decision may then be made by a compliance specialist or competent authority, and the affected user or company should have access to an appeal mechanism. This staged structure is necessary because analytical risk indicators should not be transformed into automatic punishment.

The framework also shows where decentralisation may be preserved. Public authorities should not become the only operators of the system. Independent auditors should check models, technical experts should evaluate the reliability of indicators, and the crypto community should contribute knowledge about decentralised protocols. Where full transparency of risk criteria is impossible for security reasons, external audit and clear responsibility for errors become especially significant.

The study has several limitations. AI-assisted supervision depends on data quality, model transparency, reliable labelling of suspicious activity and cooperation between jurisdictions. AI models may also suffer from bias, insufficient training data, excessive false positives and vulnerability to manipulation. These limitations show that future research should examine not only technical accuracy, but also legal accountability, privacy protection and the institutional design of independent audit.

In conclusion, digital currencies and crypto-assets require a regulatory approach that differs from ordinary banking supervision. They are fast, cross-border and partly decentralised; therefore, old regulatory models cannot be applied without adaptation. Intermediary-based regulation remains necessary for exchanges, custodians, stablecoin issuers and other service providers, but it cannot fully address peer-to-peer transfers, DeFi protocols and self-hosted wallets.

AI-assisted systems may improve risk-based supervision by analysing transaction timing, frequency, routing, clustering, wallet behaviour and links between addresses. Nevertheless, AI does not solve AML/CFT, tax or sanctions problems by itself. It can identify risk signals, but final legal assessment should remain with humans, regulators,

courts or other competent authorities. For this reason, human review, audit and appeal mechanisms are essential.

The core risk is that AI-based supervision may become a system of excessive centralised control. If all control nodes are operated by one state, one private company or a small group of actors, the decentralised nature of crypto-asset markets may be weakened. Consequently, the most promising approach is a multi-stakeholder, transparent, auditable and legally limited framework. Its goal should be to reduce real risks, protect users and financial stability, and preserve innovation, privacy and digital autonomy.

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При подготовке статьи были применены технологии искусственного интеллекта.

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УДК 005.95/.96

ANALYTICAL REVIEW OF HR BUSINESS PARTNERSHIP IN THE AGE OF REMOTE AND HYBRID WORK

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Abstract. The paper investigates into the role of HR business partners changes in distributed organisational environments. The study combines Google Scholar search dynamics for 2022-2025 with an analytical review of 34 Scopus records. After screening the corpus, relevant personnel management publications were analysed thematically. The results identify key capability areas: strategic role navigation, line manager collaboration, digital literacy, HR analytics, flexible work coordination and employee support. The findings may be useful for HR managers and further research on HR business partners.

Keywords: strategic HRM, distributed teams, digital literacy, HR analytics, line manager support, employee wellbeing, analytical review.

АНАЛИТИЧЕСКИЙ ОБЗОР HR-БИЗНЕС-ПАРТНЕРСТВА В ЭПОХУ УДАЛЕННОЙ И ГИБРИДНОЙ РАБОТЫ

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Аннотация. В статье рассматривается трансформация роли HR-бизнес-партнеров в условиях распределенной организационной среды. Исследование объединяет анализ динамики поисковых результатов Google Scholar за 2022-2025 гг. и аналитический обзор 34 записей из базы Scopus. Релевантные публикации в области управления персоналом были проанализированы тематически. В результате выделены ключевые группы компетенций HR-бизнес-партнеров: стратегическая ориентация в профессиональной роли, взаимодействие с линейными руководителями, цифровая грамотность, HR-аналитика, координация гибких форм работы и поддержка сотрудников. Результаты могут быть полезны HR-менеджерам и исследователям в сфере управления персоналом.

Ключевые слова: стратегическое управление персоналом, распределенные команды, цифровая грамотность, HR-аналитика, поддержка линейных руководителей, благополучие сотрудников, аналитический обзор.

Remote and hybrid work have become stable forms of organisational practice after the COVID-19 pandemic. They have changed not only the place where employees perform their tasks, but also the way organisations coordinate teams, support line managers, maintain employee engagement and use digital tools in personnel management. In this context, the role of HR business partners becomes more complex, because they are expected to connect people management with business objectives in distributed organisational environments.

The relevance of the topic is confirmed by the growing research interest in remote and hybrid work. According to the Google Scholar search, the approximate number of results for the query "remote work" OR "hybrid work" OR "virtual teams" OR "distributed work" increased from 38,300 in 2022 to 41,200 in 2025. This indicates a growth of approximately 7.6 % over the analysed period. Google Scholar results are approximate and were used only as an indicator of research interest. To illustrate this trend, the Google Scholar search results are presented in Table 1.

Table 1. Google Scholar search results on remote and hybrid work

Year	**Approximate number of Google Scholar results**
2022	38,300
2025	41,200

The HR business partner model is traditionally associated with the strategic role of HR in organisations. HR business partners support line managers, participate in organisational change and help align HR practices with business goals. However, recent studies show that this role is internally complex. Strategic HR partnering may generate tensions between strategic, operational and employee-oriented expectations [1, p. 942]. The HRBP model may also be interpreted differently across institutional and cultural contexts, which means that it cannot be understood as a universal role transferred unchanged from one organisational environment to another [2, p. 49].

The transformation of work has intensified these tensions. Remote and hybrid arrangements require new forms of coordination, feedback, trust-building and employee support. In such conditions, HR business partners need to work not only with formal HR policies, but also with digital communication routines, flexible work practices, line manager support, people analytics and employee wellbeing.

Digitalisation is another important factor. Studies on artificial intelligence in HR ecosystems and HR analytics show that HR professionals increasingly work with data, digital platforms and technology-mediated decision-making [3, article 1339782; 4, p. 2077]. For HR business partners, this means that digital literacy and analytical thinking are no longer optional skills. They become necessary for interpreting people data, supporting distributed teams and contributing to strategic decisions.

The existing literature does not yet provide a fully developed model of the HR business partner in remote and hybrid work settings. Many studies focus on virtual teams, digital collaboration, flexible work or HR transformation in general, while the specific capabilities of HR business partners in distributed environments remain

insufficiently systematised. This creates a need for an analytical review of available publications and for the identification of key capability areas relevant to this role.

The aim of this article is to identify and systematise the key capability areas required for HR business partners in remote and hybrid work settings.

The study follows an analytical review design. The main empirical material consists of a Scopus export containing 34 records retrieved by the author's search query: ("HR business partner" OR "strategic HR" OR "people partner") AND ("remote work" OR "hybrid work" OR "virtual teams" OR "distributed work") AND ("capabilities" OR "competencies" OR "skills")

At the first stage, titles, abstracts and keywords were screened for relevance to human resource management and HR business partnering. The screening showed that the export included both relevant HRM publications and false-positive records caused by the ambiguity of the abbreviation HR. In several records, HR referred not to human resources, but to harm reduction, homologous recombination, high-risk groups, human papillomavirus, retinol-binding protein, Hevea rubber or high-resolution bioassay profiling. These records were excluded from further analysis.

After screening, 20 records were identified as potentially relevant to HRM. From this set, 13 core sources were selected for thematic synthesis because they directly addressed HR business partnering, HR transformation, line manager relations, flexible work, HR analytics, artificial intelligence in HR ecosystems or IT competencies for strategic HR roles. The procedure used to screen the Scopus export is summarized in Table 2.

Table 2. Screening results of the Scopus export

Stage	Documents	Description
Initial Scopus export	34	Records retrieved by the author’s search query
Excluded records	14	False-positive or irrelevant records where “HR” had a non-HRM meaning or the topic was outside human resource management
Potentially relevant HRM records	20	Publications related to HR business partnering, HR transformation, HR analytics, line managers, flexible work or HR competencies
Core sources for thematic synthesis	13	Publications directly connected with HRBP roles, strategic HR, line manager relations and digital HR capabilities

Thematic analysis was used to group the core sources into broader research areas. The analysis focused on two questions: what aspects of HR business partnership are discussed in the literature, and what capabilities become important when HR business partners operate in remote or hybrid work settings. The Scopus screening showed that the topic does not yet form a narrow and fully developed body of literature on the "hybrid HRBP". Instead, the relevant publications are distributed across several related areas: HRBP role tensions, HR transformation, line manager relations, flexible work,

digital HR, HR analytics and technology-mediated people management. The thematic structure of the relevant Scopus publications is presented in Table 3.

Table 3. Thematic Areas Identified in the Scopus Corpus

Theme	Focus	Source
HRBP role and tensions	Role ambiguity, paradoxes, conflicts and contextual adaptation of the HRBP model	[1], [2], [7], [8]
HR transformation	Development of strategic and transformational HR roles, HR function redesign and HR department ecosystems	[9], [10], [11]
Line manager relations and flexible work	Cooperation between HR professionals and line managers, supervisor support and flexible work implementation	[4], [12], [13]
Digital HR and analytics	Artificial intelligence in HR ecosystems, HR analytics, IT competencies and data-informed HR work	[5], [6], [14]

The first thematic area concerns the complexity of the HR business partner role. Bennett et al. show that strategic HR partnering is associated with paradoxes and tensions surrounding the HRBP role [1, p. 942]. Häll demonstrates that the model may be interpreted differently across contexts and may lose part of its original meaning when transferred to another institutional environment [2, p. 49]. McCracken et al. examine the relationship between HRBPs and line manager partners as a developing lifecycle, which is important because HRBP work depends on the quality of cooperation with managers [5, p. 58]. Winch also shows that the HRBP model may become a source of conflicts in organisations, especially when expectations toward this role are not clearly defined [6, p. 198]. These studies suggest that HRBP work is not a fixed set of tasks, but a flexible role shaped by organisational context, expectations and relationships.

The second thematic area is HR transformation. Azam's systematic review shows that HR professionals are expected to move from traditional administrative functions toward roles that deliver strategic value [7, p. 81]. Ginting et al. analyse the HR department as an ecosystem in which different actors contribute to the development of HR roles [8, article e0295544]. Cuel et al. examine the changing role of HR professionals in the context of new forms of work [9, p. 722]. These sources support the idea that HR business partnership should be analysed as part of broader HR transformation rather than as an isolated position.

The third thematic area concerns line managers and flexible work. Maxwell and Watson show that line managers are important actors in HRM implementation [10, p. 1152]. Williams argues that flexible work depends on supervisor support and that HR has an enabling role in helping supervisors manage flexible arrangements 11, p. 914]. Jonsson et al. also highlight the importance of cooperation between line managers and HR partners in organisational interventions [12, p. 177]. This is directly relevant to remote and hybrid work because line managers become key actors in daily communication, workload coordination, feedback and employee support.

The fourth thematic area concerns digital HR, artificial intelligence and analytics. Singh and Pandey show that the adoption of artificial intelligence in HR ecosystems depends on both technological and organisational conditions [3, article 1339782]. Wirges and Neyer demonstrate that HR analytics requires a process-oriented approach because organisations often struggle to transform HR data into strategic value [4, p. 2077]. Joseph et al. identify information technology competencies as important for entry-level HR strategic partners [13, article a1327]. These studies provide the basis for including digital literacy and analytical thinking in the capability profile of the HR business partner. Based on the thematic synthesis, five capability areas can be identified. They are summarized in Table 4.

Table 4. Capabilities of HR business partners in remote and hybrid settings

Capability	Description	Sources
Strategic role navigation	Ability to balance strategic, operational and employee-oriented expectations	Bennett et al. [1]; Häll [2]; McCracken et al. [3]; Winch [4]
Line manager collaboration	Ability to support managers in implementing HR practices and managing distributed teams	Maxwell and Watson [8]; Williams [9]; Jonsson et al. [10]
Digital literacy and HR analytics	Ability to use digital tools, people data and HR analytics for decision-making	Singh and Pandey [11]; Wirges and Neyer [12]; Joseph et al. [13]
Flexible work coordination	Ability to support remote and hybrid work policies, communication routines and adaptation	Cuel et al. [7]; Williams [9]
Employee support and trust-building	Ability to maintain engagement, wellbeing and trust in technology-mediated work environments	Bennett et al. [1]; Williams [9]; Jonsson et al. [10]

The analysis supports a cautious interpretation of the "hybrid HRBP" idea. The reviewed publications do not yet provide a fully developed theory of a hybrid HR business partner. However, they show that strategic HR partnership is increasingly shaped by digital tools, HR analytics, flexible work arrangements, distributed communication and the changing role of line managers. Therefore, the hybrid HRBP should be understood not as a new HR position, but as a preliminary capability profile of an HR business partner working in remote and hybrid organisational environments. The Scopus screening showed that the relevant literature is distributed across several related areas: HRBP role tensions, HR transformation, line manager relations, flexible work, digital HR and HR analytics.

Based on the thematic synthesis, five capability areas were identified: strategic role navigation, line manager collaboration, digital literacy and HR analytics, flexible work coordination, and employee support and trust-building. These capabilities describe the preliminary profile of an HR business partner who works in distributed, technology-mediated and data-informed organisational contexts.

The study is limited by the size of the Scopus export and by the fact that some relevant publications address HR transformation or flexible work in general rather than HR business partnership directly. Further research may include a systematic review in

Scopus and Web of Science, interviews with HR business partners working in hybrid organisations and empirical validation of the proposed capability profile.

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УДК 364.044.26

DIGITALISATION OF INTERNATIONAL COOPERATION IN THE CONTEXT OF WORKING WITH YOUTH

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Abstract. This article examines the role of digital technologies in the development of international youth cooperation. The study investigates how digitalisation shapes cross-border experience exchange in youth work and facilitates intercultural dialogue. The following dimensions are addressed: the development of digital platforms and management systems, the expansion of online education, the integration of digital formats in international events, legislative consolidation of digital youth initiatives, and the enhancement of specialist competencies. The findings suggest that digitalisation constitutes a strategic instrument for strengthening international relations and creating conditions for the self-realisation of young people in a global context.

Keywords: digitalisation, international youth cooperation, digital platforms, intercultural dialogue, online education, youth policy, digital competencies.

ЦИФРОВИЗАЦИЯ МЕЖДУНАРОДНОГО СОТРУДНИЧЕСТВА В КОНТЕКСТЕ РАБОТЫ С МОЛОДЕЖЬЮ

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Аннотация. Статья исследует роль цифровых технологий в развитии международного молодежного сотрудничества. Цель данного исследования – изучить, как цифровизация влияет на международный обмен опытом в работе с молодежью и диалог культур. В статье освещены следующие аспекты: развитие цифровых платформ, онлайн-образование, цифровые мероприятия, совершенствование законодательства, повышение компетенций специалистов. Это исследование способствует пониманию того, что цифровизация – ключевой инструмент укрепления международных связей и поддержки молодежи.

Ключевые слова: цифровизация, международное молодежное сотрудничество, цифровые платформы, диалог культур, онлайн-образование, молодежная политика, цифровые компетенции.

Despite the growing body of literature on digital transformation, the specific implications of digitalisation for international youth cooperation remain insufficiently explored. Over recent decades, digital technologies have become firmly embedded in various fields of activity. For Russia, as for most countries, the implementation of digital solutions represents a significant stage in improving public administration and enhancing the quality of life for the population [1, p. 1].

The process of implementing digital technologies and tools is advancing at an increasingly rapid pace. In international relations this trend significantly helps overcome geographical distances and build relationships, fosters the strengthening of cultural dialogue between countries, facilitates the exchange of experience, supports youth initiatives, and creates conditions for the self-realisation of young people in a global context.

International cooperation in the youth affairs is one of the key spheres of the Russian Federation's state policy. It is aimed at strengthening international bonds, promoting cultural dialogue, exchanging experience, and developing joint youth projects with other countries. The legal foundation for such cooperation comprises the Constitution of the Russian Federation, universally recognised principles and norms of international law, international treaties of the Russian Federation, as well as Federal Law No. 489-FZ of 30 December 2020 "On Youth Policy in the Russian Federation" [2].

Several forms of international cooperation in this sphere are distinguished. Of paramount importance is multilateral cooperation, for example within the framework of international organisations and associations such as the United Nations, the Commonwealth of Independent States, the Shanghai Cooperation Organisation, BRICS, the Eurasian Economic Union, and others. The SCO and BRICS have youth councils, and regular forums are held to strengthen humanitarian connections. Another form of interaction is bilateral cooperation based on intergovernmental treaties with individual countries, under which exchange projects and joint initiatives are implemented [3, p. 1492].

International youth cooperation in Russia is coordinated by a number of responsible bodies, each playing an important role. Several government agencies are in charge of international youth cooperation. The Federal Agency for Youth Affairs (Rosmolodyozh) organises large-scale international events, including the World Youth Festival, and oversees projects under such initiatives as "Russia – BRICS" and "Russia-Arctic Council", among others [4]. The next government agency involved in international youth cooperation is the Ministry of Science and Higher Education. It promotes academic mobility and student exchange programmes between countries, organises international youth forums, and develops specialised scientific and educational programmes. This Agency organises major international events – such as the World Youth Festival – and oversees the work of project offices in strategically important areas, such as "Russia – BRICS" and "Russia-Arctic Council", thereby contributing to the strengthening of bonds with youth communities within these

associations. The National Council of Youth and Children's Associations of Russia acts as the representative of the Russian youth non-governmental sector at the international level. The organisation actively participates in relevant projects and programmes, including the International Youth Camp "Dialogue" [5].

Having examined the institutional framework, it is now pertinent to address the main directions of digitalisation in the field of international youth cooperation. Chief among these is the development of digital platforms and management systems. This development simplifies interaction between youth organisations from different countries, ensures information exchange, project coordination, and monitoring of their implementation. For example, unified platforms are used that consolidate data on government programmes, projects, and events aimed at supporting the younger generation. The creation and launch of educational programmes and online courses present new opportunities for the professional development of young people. By means of distance learning – in the format of master classes, training sessions, and interactive activities – young individuals gain the opportunity to develop their competencies regardless of their place of residence. Concurrently, online platforms offering courses for specialised professionals are being developed: they help enhance the qualifications of those working with youth projects and initiatives, broadening access to knowledge and extending its reach.

Modern international events and forums are actively integrating digital technologies: online conferences, webinars, and specialised initiatives in the field of digital diplomacy are becoming an integral part of international engagement. A notable example is the V Forum on Digital Diplomacy, organised within the framework of the International Exhibition-Forum "Russia". The event brought together young professionals from numerous countries and enabled a substantive dialogue on digitalisation trends, digital diplomacy tools, and the prospects for their further development.

The development of digital youth initiatives requires reliable legal support. Legislative consolidation of their status makes it possible to streamline key aspects: ensure transparent funding, establish reporting requirements, and guarantee the protection of participants' rights. Through such legal mechanisms digital forms of youth engagement are seamlessly integrated into the system of international youth policy, enhancing its effectiveness and accessibility [6].

The following section considers the role of digital competencies. The training of specialists capable of working with digital technologies in an international environment is becoming an integral part of state policy. This includes the development of professional standards and qualification requirements for employees in the field of youth policy [7]. The modern development of digital competencies is not merely a trend, but a strategic objective of state policy. The training of specialists who can confidently use digital technologies in international engagement is becoming particularly relevant. To achieve this goal, a systematic approach is required: developing professional standards, clearly defining qualification requirements for personnel in the field of youth policy, and creating conditions for their continuous learning and development in a digital environment. International "Digital Lessons" ("Uroki Tsifry") is a large-scale educational initiative implemented within the framework of international cooperation. The initiative aims to raise awareness of

modern digital technologies among young people, help them better understand the principles of IT solutions, get acquainted with emerging fields of digital innovation, and develop basic digital competencies.

The development of international educational cooperation is actively advancing through the implementation of comprehensive professional development programmes and internships. A notable example is the work of MIREA – the Russian Technological University, which organises educational programmes for specialists from Russia and CIS countries. The learning format systematically combines distance-learning modules – designed to master the theoretical foundation – with practical internships that allow participants to consolidate their knowledge and gain applied professional experience.

Projects are also being implemented within the framework of cooperation with the CIS. For example, in 2024, experts agreed on a plan of activities for 2025 – 2026 to implement the Strategy for International Youth Cooperation of the CIS countries for 2021 – 2030. The plan includes such initiatives as the International Project "100 Ideas for the CIS", the International Beauty and Talent Contest "Queen of Studentship", the Youth Delphic Games, and others.

BRICS Youth Programmes represent a set of international initiatives, events, and projects aimed at strengthening cooperation, mutual understanding, and friendship among young people from the BRICS member states (Brazil, Russia, India, China, South Africa, as well as new members since 2024). The youth dimension is one of the keys and most dynamically developing fields of engagement within the BRICS framework, playing an important role in shaping the future of the association and strengthening humanitarian bonds. For Russia, advancing this area is a priority, as enshrined in the Strategy for the Implementation of Youth Policy in the Russian Federation for the Period up to 2030. Youth cooperation covers a wide range of fields: from education, science, and technology to entrepreneurship, culture, sports, and volunteering. With the expansion of BRICS, the youth agenda acquires greater strategic relevance, opening opportunities for implementing joint projects involving representatives from an even greater number of countries. Key events demonstrating the growing importance of this area include the establishment of the BRICS Youth Council in 2023 and the regular holding of BRICS Youth Summits, which serve as the main platform for dialogue and the development of joint initiatives [8].

A concrete institutional example of this trend is the Russian State University for the Humanities (RSUH) has launched an international mentoring programme for youth from BRICS and CIS countries. Students and young professionals will have the opportunity to learn from experts representing various nations in order to implement their own projects [9].

Building on the above, the present analysis turns to the domain of cultural exchange. Cultural exchange in the field of youth work represents a set of activities and programmes aimed at familiarising young people from various countries with each other's traditions, value systems and lifestyles. This activity contributes to the formation of a tolerant attitude towards other cultures, the development of intercultural competencies, and the strengthening of international connections. One of the key objectives of cultural exchange is to strengthen international understanding and friendship. It helps foster tolerance and counter extremism, expands the cognitive and cultural horizons of young people, and contributes to their personal development.

Furthermore, such exchange builds important intercultural communication skills, promotes the cultures and languages of different peoples, and creates conditions for establishing an international network of contacts necessary for future cooperation.

International cultural exchange today is represented by a wide variety of formats, enabling participants to select the optimal option based on their goals and time availability. Short-term formats provide an opportunity to immerse oneself in a new culture through participation in thematic sessions, seminars, and camps, as well as within the framework of exchange programmes. Medium-term formats include academic internships and volunteer projects – these allow for a deeper exploration of the environment and enable participants to make a personal contribution to joint initiatives. Long-term formats encompass academic exchanges and professional work under international programmes, ensuring the most comprehensive immersion in the cultural and professional context of another country.

International cultural exchange represents a comprehensive system of interaction that integrates various formats of socio-cultural communication: cultural mass events, educational practices, virtual platforms, socially oriented volunteer initiatives, and contest-based and creative engagement formats. This system facilitates the transmission of cultural heritage, the formation of intercultural competence, the development of global civic consciousness, and the strengthening of non-hierarchical international networks among youth.

Participation in international programmes contributes to the development of intercultural communication skills among youth, including the ability to perceive and respect cultural differences, as well as to overcome established stereotypes. This creates conditions for the development of adaptability – the capacity to quickly adjust to changing conditions and new social norms – and resilience, i. e., overcoming the challenges of cross-cultural adjustment.

Acquiring new cultural experience contributes to the formation of global thinking, which implies a conscious perception of the interconnections between different countries and cultures. Participation in international activities through overseas trips fosters the development of independence among young people, as it involves independently solving a wide range of everyday, academic, and social tasks in unfamiliar conditions. In the context of digitalisation of international cooperation, competencies for remote professional networking are being actively cultivated. This creates opportunities for building and maintaining professional connections at the international level without the need for physical presence.

The digitalisation of international cooperation in the field of youth work faces a number of challenges, the key one being the shortage of digital competencies among relevant specialists. Cybersecurity and data protection issues gain particular importance in an international context. When exchanging information and implementing joint projects, strict compliance with data confidentiality requirements is essentialfor ensuring the confidentiality of personal information and reliable protection of data against cyber threats [7].

Thus, the digitalisation of international cooperation in youth work contributes to strengthening dialogue, exchanging experience, developing digital competencies, and creating conditions for the self-realisation of young people in a global context. Cultural exchange is an effective instrument for educating youth oriented towards the principles

of mutual understanding and cooperation. Such programmes not only enrich participants' personal experience but also promotes stability and peace at the international level. Well-organised programmes establishing the basis for long-term dialogue between countries and generations.

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УДК 339.92, 811.11-112

THE ROLE OF FOREIGN LANGUAGE PROFICIENCY IN INTERNATIONAL BUSINESS AND ECONOMICS: PROFESSIONAL REQUIREMENTS

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Abstract. This study examines how corporate language policies and global English proficiency trends intersect with emerging workforce demands during the green and digital transition. Analysing multinational operational data and international skills reports, we identify significant gaps between current linguistic capabilities and future professional requirements. Findings reveal that productive speaking skills consistently lag behind receptive competencies, hindering cross-border collaboration. The paper recommends integrating plurilingual training, prioritising oral fluency and aligning language education with sustainable economic strategies.

Keywords: language competencies, multinational corporations, green transition, digital skills, English proficiency, workforce development.

РОЛЬ СТЕПЕНИ ВЛАДЕНИЯ ИНОСТРАННЫМИ ЯЗЫКАМИ В МЕЖДУНАРОДНОМ БИЗНЕСЕ И ЭКОНОМИКЕ: НОРМЫ И СТАНДАРТЫ

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Аннотация. В исследовании анализируется взаимосвязь корпоративной языковой политики и глобальных тенденций владения английским языком с новыми требованиями рынка труда в условиях зеленого и цифрового перехода. На основе данных транснациональных компаний и международных отчетов выявлены существенные разрывы между текущими лингвистическими навыками и будущими профессиональными запросами. Установлено, что продуктивные навыки говорения стабильно уступают рецептивным, ограничивая международную коллаборацию. Предложены рекомендации по интеграции полилингвального обучения и развитию устной речи.

Ключевые слова: языковые компетенции, транснациональные корпорации, зеленый переход, цифровые навыки, владение английским языком, развитие рабочей силы.

The ongoing decarbonization of global industries, coupled with accelerated digital transformation, is fundamentally reshaping professional labour structures. As enterprises recalibrate operational frameworks to meet net-zero objectives and embed algorithmic decision-making, the requisite professional competency profiles shift in tandem. Within this reconfigured landscape, linguistic competence – particularly command of English as the established medium for transnational commerce – constitutes a structural prerequisite of talent mobility, cross-cultural knowledge transfer, and distributed problem-solving across geographically dispersed networks [1]. Proceeding from this premise, the present analysis consolidates empirical findings from five authoritative scholarly and institutional sources to investigate how corporate communication protocols, standardized proficiency benchmarks, and emerging skill demands intersect during the ongoing ecological and technological transformation. The investigation addresses three primary questions:

1. How do linguistic policies and routine communication practices differ across multinational headquarters regions?
2. Which discrepancies persist between existing language readiness and projected labor market needs?
3. What institutional modifications should academic institutions corporate training divisions and regulatory authorities implement to promote equitable workforce adaptation?

Empirical mapping of internal communication flows reveals pronounced geographical determinism in how global enterprises navigate multilingual operations. Large-scale quantitative surveys encompassing over 800 subsidiary locations demonstrate that linguistic preferences correlate primarily with headquarters geography rather than industrial classification [2, p. 8]. Organizations based in native English-speaking regions systematically institutionalize English across all managerial tiers, with virtually all headquarters-branch correspondence conducted in English (99.3 %), thereby consolidating structural advantages associated with linguistic dominance [2, p. 10]. Firms operating from continental Europe and the Nordic region exhibit comparable English integration rates (89 % and 88 % respectively), motivated by a pragmatic acknowledgment that their native tongues possess restricted global circulation, irrespective of historical influence [2, p. 14]. Notably, Scandinavian and Western European corporations occasionally encounter inverted linguistic power dynamics, wherein subsidiary staff demonstrate superior English fluency compared to headquarters executives, subtly recalibrating conventional authority structures [2, p. 14]. Conversely, Asian multinationals adopt markedly different strategies: approximately half refrain from formalizing any corporate language, while 70 % of those that do designate their headquarters tongue instead of English [2, p. 13]. Consequently, more than 61 % of internal exchanges within Asian enterprises depend on regional languages, indicating a strong preference for localized linguistic practices

that corresponds with both the expanding economic prominence of Asian markets and comparatively limited English fluency among regional management [2, p. 13].

Worldwide patterns in English acquisition and application further contextualize these corporate strategies, highlighting an enduring structural disparity between receptive comprehension and active production. Contemporary multinational evaluations show that aggregate language progress has stagnated since 2020, with reading and listening consistently outperforming speaking in approximately 80 % of assessed nations [3, p. 4]. Just three countries, all recognizing English as an official tongue, reached advanced oral standards, and none attained the highest proficiency tier [3, p. 6]. This gap between comprehension and expression generates concrete professional obstacles: employees may readily absorb technical documentation yet struggle to negotiate, deliver presentations, or collaboratively design solutions in international contexts, thereby restricting their impact on knowledge-driven projects. Geographic differences further intensify these constraints, as European test-takers attain high aggregate results but exhibit significant internal skill imbalances, Asian participants demonstrate the most uniform competency distributions, Latin American groups display pronounced age-related discrepancies, and African regions show considerable diversity with women consistently outscoring men [3, p. 6]. These linguistic realities closely correspond with labor market projections that emphasize analytical reasoning, digital fluency, and adaptive innovation as essential competencies for the next five-year horizon [4, p. 22]. Still, the capacity to clearly articulate sophisticated concepts within a shared linguistic framework remains indispensable for effectively deploying these cognitive and technical capabilities across globally dispersed teams.

A frequently overlooked bottleneck emerges at the intersection of linguistic readiness and emerging green-tech competencies. While technical training initiatives routinely prioritize hard skills such as carbon accounting, circular supply chain management, and AI-assisted diagnostics, they seldom integrate communicative agility into core curricula. This oversight creates a less-acknowledged obstacle: professionals equipped with cutting-edge sustainability expertise often struggle to translate technical insights into actionable strategies for cross-functional or international teams. The receptive-productive divide documented in recent language assessments directly amplifies this challenge, as workers capable of decoding complex regulatory frameworks in English frequently lack the spontaneous oral fluency required to advocate for environmentally oriented innovations in international executive settings. Consequently, language proficiency ceases to function merely as an auxiliary skill and instead operates as a threshold competency that determines whether technical knowledge translates into measurable organizational impact. Bridging this gap requires instructional paradigms that treat linguistic and technical upskilling as mutually reinforcing processes, rather than sequential milestones.

Cultivating these communicative and cognitive capacities should therefore be examined through the lens of sustainability-oriented competency architectures. Modern professional development frameworks stress that successfully navigating ecological and technological disruption demands targeted investment across several skill categories [5, p. 15]. Core information-processing abilities, encompassing advanced

reading comprehension, mathematical reasoning, and digital navigation, enable workers to evaluate, integrate, and transmit data within increasingly intricate business environments. As renewable energy sectors expand, organizations will increasingly require specialists who can convert technical specifications into practical, cross-culturally applicable strategies. Concurrently, interpersonal and emotional competencies, including dispute resolution, intercultural empathy, and cooperative problem-solving, represent distinctly human traits that cannot be automated and are vital for managing large-scale environmental initiatives [5, p. 28]. Self-regulated learning skills, which involve tracking personal development and modifying study strategies, are becoming increasingly critical in unpredictable work settings where continuous training is standard. Crucially, research demonstrates that individual values and ecological mindsets strongly influence how skills are applied; young professionals who prioritize environmental protection are 16 percentage points more likely to implement sustainable practices [5, p. 28]. However, motivational gaps often reflect broader educational inequalities, preventing economically disadvantaged groups from acquiring both the necessary expertise and the drive needed to succeed in emerging eco-friendly industries.

Addressing these interconnected challenges demands synchronized policy adjustments within business, academic, and governmental domains. Corporate communication guidelines ought to evolve from rigid single-language requirements toward adaptable, situation-specific linguistic approaches that maintain workflow efficiency while promoting broader inclusion. While English streamlines inter-departmental coordination, overdependence on one language can suppress local expertise and hinder innovation originating at operational levels; in contrast, carefully designed multilingual frameworks that match languages to specific audiences, objectives, and locations significantly improve information sharing and employee satisfaction [2, p. 19]. At the same time, educational institutions must redesign evaluation and teaching methods to prioritize active language use, especially speaking, which remains globally underdeveloped. Implementing this transformation requires abandoning traditional rule-based instruction in favor of realistic, scenario-based simulations and collaborative dialogue, supported by intelligent software that offers customized speech correction while maintaining vital interpersonal communication practice [3, p. 12]. Career retraining initiatives for workers transitioning from fossil-fuel-dependent roles to green technology or digital infrastructure fields should explicitly combine language coaching with technical training, guaranteeing that newly acquired skills can be properly utilized in cross-cultural teams and global networks [4, p. 45]. Lastly, fairness-driven policies must ensure affordable language courses, flexible online training, and community mentoring for at-risk groups, such as low-income individuals, remote workers, and employees in shrinking sectors, ensuring that communication obstacles do not widen existing economic inequalities throughout the ecological and technological shift [4, p. 35].

In conclusion, linguistic proficiency, organizational communication policies and holistic training programmes function as interdependent factors that jointly determine employee readiness for sustainability led economic transformation. Research data verify that global enterprises' language habits continue to be heavily influenced by

headquarters location, directly affecting power dynamics, information flow, and institutional flexibility [2, p. 20]. Concurrently, international testing results demonstrate that although basic English understanding is now widespread, active expression abilities, especially impromptu conversation, remain severely lacking, creating ongoing barriers in research-intensive, internationally connected workplaces [3, p. 8]. As manufacturing and service industries increasingly adopt carbon-neutral practices and smart technologies, the demand for analytical, digital, and collaborative competencies will grow at a corresponding pace. Language mastery serves not merely as a foundational requirement for learning these abilities, but as the primary conduit through which they are negotiated, transferred, and implemented across diverse cultural settings. Targeted investment in flexible multilingual programmes, practical speaking exercises, and equal training opportunities will be crucial for guaranteeing that the economic and social advantages of the green and digital revolution are equitably distributed. Future studies ought to examine how artificial intelligence translation systems and customized learning applications alter corporate interaction patterns, while also assessing how policy structures can formalize flexible, inclusive skill-building in rapidly transforming labour markets.

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УДК 304.9

FORMATION OF ENVIRONMENTAL CULTURE OF THE POPULATION AND ENTERPRISE PERSONNEL IN THE INTERESTS OF OCCUPATIONAL SAFETY

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Abstract. This article substantiates the transformation of environmental education from an academic discipline into a strategic factor of national security. It analyzes contemporary macro-trends: total urbanization, the economic model of overconsumption, global disparities in resource utilization, and greenwashing, which determine the relevance of continuous environmental awareness-raising. Particular attention is paid to the training of enterprise personnel as a component of occupational safety.

Keywords: environmental education, environmental culture, sustainable development, greenwashing, occupational safety.

ФОРМИРОВАНИЕ ЭКОЛОГИЧЕСКОЙ КУЛЬТУРЫ НАСЕЛЕНИЯ И ПЕРСОНАЛА ПРЕДПРИЯТИЙ В ИНТЕРЕСАХ БЕЗОПАСНОСТИ ТРУДА

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Аннотация. В статье обосновывается трансформация экологического образования из академической дисциплины в стратегический фактор национальной безопасности. Анализируются макротренды современности: тотальная урбанизация, экономическая модель сверхпотребления, глобальные диспропорции в использовании ресурсов, гринвошинг, которые обусловливают актуальность непрерывного экологического просвещения. Особое внимание уделено подготовке персонала предприятий как составляющей безопасности труда.

Ключевые слова: экологическое образование, экологическая культура, устойчивое развитие, гринвошинг, безопасность труда.

The current stage of human development is characterized by unprecedented anthropogenic impact on the environment. Under these conditions, environmental education and upbringing become a strategic factor of national security and a necessary condition for the realization of the constitutional right of every individual to a favorable environment. The organization of environmental education possesses a distinct specificity in terms of its normative entrenchment, since the formation of citizens' environmental culture represents not merely a pedagogical task but a comprehensive legal objective that ensures the implementation of environmental protection legislation [1]. The role of environmental education in the observance of legal norms is multifaceted: it extends from the formation of individual legal consciousness to the minimization of environmental risks at industrial enterprises, where the competence of personnel becomes a guarantee of occupational safety for workers, the prevention of local emergencies, and compliance with the law.

The relevance of the widespread implementation of environmental awareness-raising is dictated by a number of macro-trends unprecedented in human history. First, the world has encountered the phenomenon of total urbanization; never before has the number of large urban agglomerations been so significant. The concentration of population in megacities creates a colossal burden on local ecosystems and necessitates highly complex logistical solutions for water supply, energy provision, and waste management. The urban resident often loses direct contact with the natural environment, leading to the formation of a “consumer gap” in which the consequences of resource use become non-obvious and abstract.

Second, the current economic model stimulates an unprecedented level of consumption of goods, services, and natural resources. This model, known as “fast fashion” – that is, rapidly changing trends and a culture of disposable goods – has led to an exponential increase in the volume of waste [2]. The production of low-quality, quickly deteriorating items fosters a “consumer society” in which recycling represents, at best, the final stage of a short product life cycle, while landfilling represents, at worst. Responsible consumption directly depends on the awareness of each individual – on the understanding that behind every commodity lies a resource-intensive and energy-intensive production process, inextricably linked to the generation of waste, atmospheric emissions, and the discharge of wastewater.

Third, incommensurable disparities in the level of resource consumption persist and are being exacerbated between so-called “civilized countries” and “Third World” countries. This disproportion generates not only social injustice but also geopolitical tension in matters pertaining to climate change and carbon footprint reduction.

Environmental awareness-raising and education constitute a complex, multi-level system encompassing all stages of human life (Figure). In the Russian Federation and abroad, a practice of continuous environmental education has been established, comprising several key types. Preschool and school education lay the foundations of environmental ethics, forming an emotional and value-based attitude toward nature through play-based methodologies and direct contact with the surrounding world [3]. At this stage, it is important not merely to impart knowledge about natural phenomena but also to cultivate the habit of environmentally competent behavior in daily life. University education is divided into general education – the study of ecological

fundamentals by students of any specialization – and specialized education – the training of professional ecologists. Within the system of supplementary education and awareness-raising, libraries, museums, and civil society organizations play a key role, acting as hubs for environmental initiatives and implementing interactive projects for all age groups.

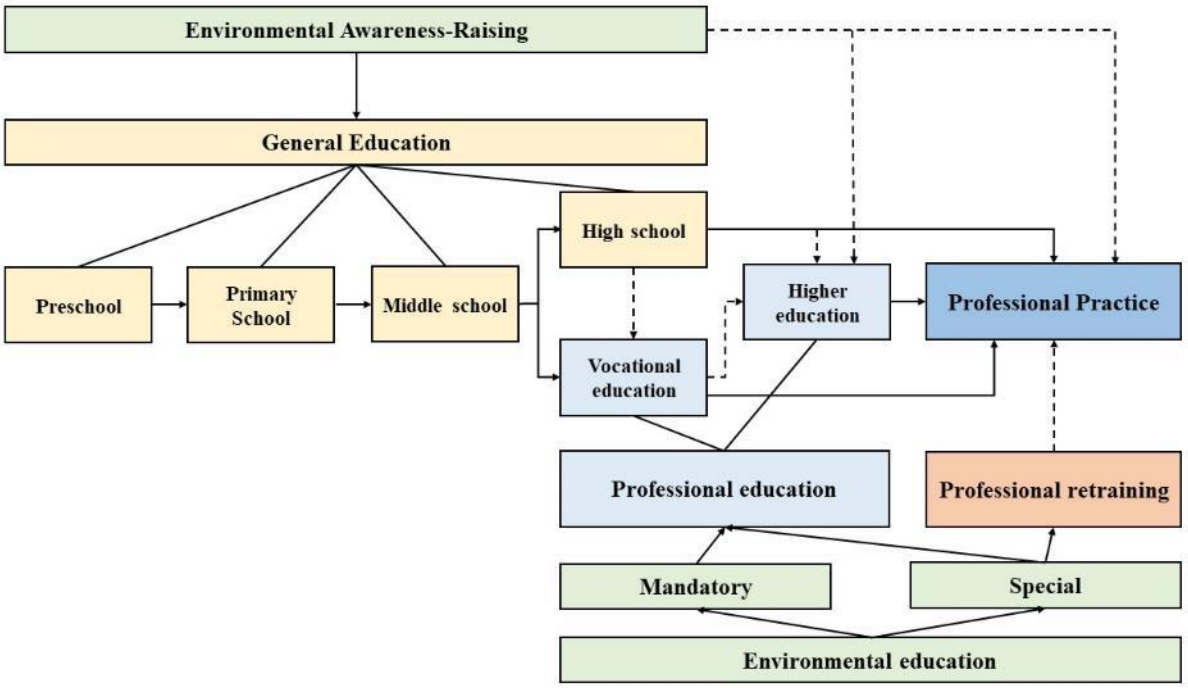


Figure. Environmental Awareness-Raising and Education at Different Stages of Learning in the Russian Federation

In the context of the information society, environmental advertising and advocacy serve as conduits for disseminating environmental values to the masses. However, an excess of "green" rhetoric, combined with insufficient public education, has given rise to a paradoxical and dangerous phenomenon – greenwashing. This term, introduced in the 1980s, denotes a marketing strategy whereby a company creates the illusion of its environmental responsibility without implementing any genuine changes to its production processes [4-6].

This constitutes a deliberate misleading of the consumer, exploiting the fashion for environmental friendliness. The techniques of greenwashing are diverse: the use of "natural" packaging design while retaining the same production technology; vague formulations such as "natural" or "eco-friendly" without documentary substantiation; the creation of false eco-labels; and an emphasis on minor improvements [4, 7].

The level of environmental literacy among the population serves as a key factor limiting the opportunities for misleading consumers. A consumer capable of identifying genuine eco-labels and distinguishing them from marketing ploys makes an informed decision and refuses to purchase products from pseudo-ecological companies.

Consequently, the economic and environmental consequences of an inadequate level of environmental training among personnel of economic entities manifest

themselves in the form of administrative sanctions, civil liability for harm caused to the environment, as well as a tangible deterioration in the state of natural environment components resulting from emergency and routine emissions. Ignorance or disregard of environmental legal requirements does not exempt one from liability; however, the cost of such ignorance is particularly high: oil product spills, batch releases of pollutants, multimillion-dollar fines, suspension of enterprise operations, and, in the most severe cases, criminal prosecution of managers and specialists. In this regard, environmental education of personnel serves not merely as a recommendatory measure but as a necessary condition for minimizing the environmental risks of an enterprise and ensuring its compliance with legislative requirements.

The normative basis for the organization of training is established by documents of cross-sectoral significance. The “Decree on the Procedure for Occupational Safety Training and Testing of Occupational Safety Knowledge” is primarily oriented toward occupational safety, yet its provisions also extend to the environmental component of industrial safety [8]. This is supplemented by the “Occupational Safety Standards System. Organization of Occupational Safety Training”, which elaborates on the requirements for the content of training programs, the forms of knowledge assessment, and the frequency of refresher training for employees [9]. Collectively, these regulatory acts form a legal framework obligating the employer to ensure personnel training in the area of interaction with the environment.

However, the formation of an employee's environmental culture extends far beyond formal instruction and the rote memorization of regulatory requirements [5]. Genuine environmental culture represents a multifaceted phenomenon that encompasses the cultivation of personal responsibility for the state of the environment, a profound understanding of technological processes and their potential impact on ecosystems, as well as the psychological readiness to act competently and decisively in emergency situations. Environmental training must be continuous, practice-oriented, and integrated into the overall system of professional personnel development. Only then is it capable of fostering in the employee not merely a body of knowledge but lasting skills of environmentally safe behavior.

The practical significance of this approach lies in the transition of an enterprise from a reactive model of environmental risk management to a preventive one. An employee possessing a sufficient level of environmental education and a developed environmental culture acquires the ability to address several key tasks:

- Conscious compliance with technological discipline, thereby minimizing waste generation and preventing excess emissions;
- Competent operation of treatment equipment and environmental protection facilities, promptly identifying malfunctions and preventing emergency situations;
- The ability to identify potential threats at an early stage;
- In the event of an accident, trained personnel take adequate and prompt measures to contain and mitigate the consequences, thereby significantly reducing the scale of environmental damage and the financial losses of the enterprise.

From an economic perspective, investments in environmental training of personnel represent a rational allocation of funds, ensuring the reduction of legal and

reputational risks. The cost of a high-quality educational program for employees is incomparable to the amounts of fines that may be imposed on an enterprise for an environmental violation, not to mention the expenses associated with emergency response and compensation for environmental damage. Moreover, a high level of environmental culture among personnel becomes a competitive advantage in the context of increasingly stringent environmental requirements and growing demands from consumers and investors regarding the environmental responsibility of businesses.

Environmental culture constitutes an important component of the moral upbringing of the younger generation. The formation of environmental culture includes awareness of contemporary environmental problems, critical reflection on information regarding the state of the environment and the rational use of natural resources, as well as knowledge of environmental safety and a healthy lifestyle. Professionally oriented foreign language teaching plays a significant role in the "ecologization of education" and in the formation of environmental competence and culture among the younger generation. Proficiency in a foreign language and the ability to engage in cross-linguistic communication in professional activities enable future specialists to perceive themselves as an integral part of the global community. Within the framework of language education, faculty members of the Higher School of Technology and Energy employ various project-based methodologies, case studies, and teamwork, and encourage students to participate in scientific conferences in English, thereby fostering their environmental awareness and behavior [10].

Thus, education and law enforcement form an indissoluble unity. The law establishes a norm and provides for sanctions for its violation, thereby shaping the external boundaries of permissible behavior. Environmental education, in turn, ensures the voluntary, competent, and responsible fulfillment of these norms, transforming the requirements of the law from an external constraint into an internal imperative. The formation of environmental culture among employees becomes a key factor determining the real effectiveness of legal regulation in the field of environmental protection.

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УДК 339.138

RESEARCH TRENDS IN DIGITAL MARKETING

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Abstract. The paper examines current research trends in digital marketing in the international academic context. The material for the study consisted of 900 Scopus-indexed publications. The methodology includes a scoping review based on the thematic modelling. The results identify key research areas: consumer engagement, online trust, purchase intention, customer journey, social media marketing, electronic word-of-mouth, customer satisfaction and customer loyalty. The findings may be useful for specialists in marketing and international business.

Keywords: scoping review, consumer engagement, social media marketing, customer journey, customer loyalty.

ТЕНДЕНЦИИ ИССЛЕДОВАНИЙ В ОБЛАСТИ ЦИФРОВОГО МАРКЕТИНГА

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Аннотация. В статье рассматриваются современные исследовательские тенденции в области цифрового маркетинга в международном академическом контексте. Материалом исследования послужили 900 публикаций, индексируемых в базе данных Scopus. Методология включает обзор объема литературы на основе тематического моделирования. В результате определены ключевые исследовательские направления: вовлеченность потребителей, доверие в онлайн-среде, покупательское намерение, путь клиента, маркетинг в социальных сетях, электронное сарафанное радио, удовлетворенность клиентов и лояльность потребителей. Результаты могут быть полезны специалистам в области маркетинга и международного бизнеса.

Ключевые слова: обзор предметного поля, вовлеченность потребителей, маркетинг в социальных сетях, путь клиента, лояльность потребителей.

Digital marketing has become an important part of modern business and communication. Today, companies use digital channels to promote products, communicate with customers and influence their buying decisions [1]. According to international reports, the number of internet and social media users continues to grow

every year. This shows that digital platforms play an important role in consumer behaviour and business development. Within this context, digital marketing is not limited only to online advertising. It also includes social media marketing, e-commerce, electronic word-of-mouth, personalized communication, customer engagement, online trust, purchase intention, satisfaction and loyalty [2]. These factors show how consumers react to digital communication and how companies can build stronger relationships with them. For this reason, digital marketing has become an interdisciplinary research field connected with marketing, consumer behaviour, information technologies and business strategy.

The topic has a relatively recent but rapidly developing research tradition. In the analysed Scopus dataset, publications related to digital marketing have been represented since 2009. However, the most intensive growth has taken place after 2020. This trend can be explained by the rapid development of social media, e-commerce, mobile technologies and the growing role of online communication after the COVID-19 pandemic [3]. The dynamics of the main research topics by year are presented in Figure 1.

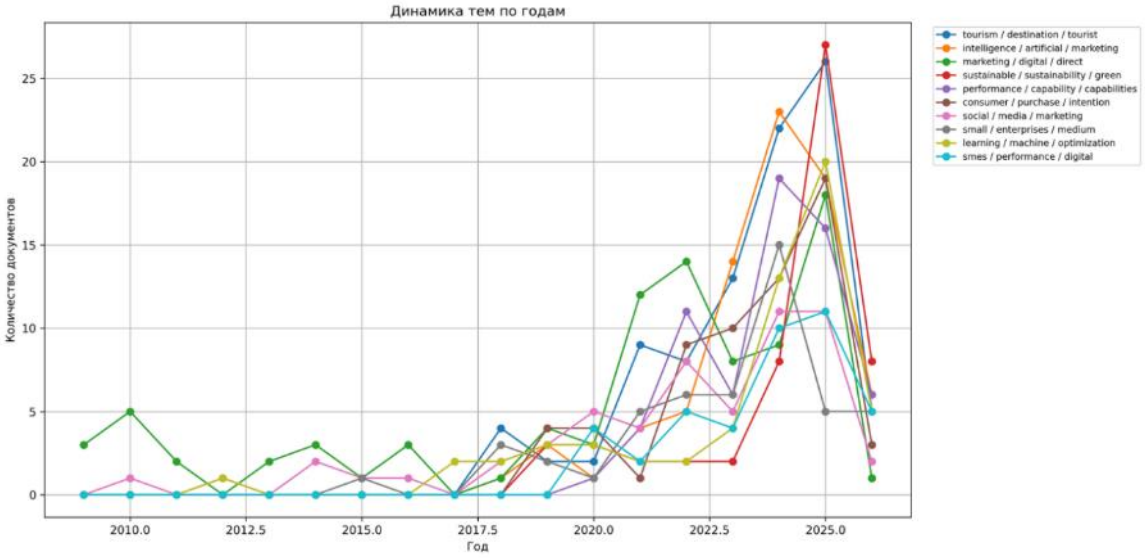


Figure 1. Dynamics of digital marketing research topics in Scopus for the years 2009-2026.

Note: The number of publications recorded for 2026 is incomplete, since recently published articles require time to be indexed in Scopus

Despite the growing number of studies on digital marketing, there is still a need to systematize this research field. Digital marketing is a broad topic, as it includes social media marketing, e-commerce, artificial intelligence, mobile technologies, online advertising and consumer behaviour. For this reason, the present paper focuses on one important direction within digital marketing research, namely consumer engagement, online trust and purchase intention [4]. Although the article pays special attention to consumer-oriented studies, the thematic modelling covers the broader field of digital marketing research.

The study is guided by the following research question: What are the main research trends in digital marketing, especially in relation to consumer engagement, online trust and purchase intention?

To answer this research question, the study uses a scoping review and thematic analysis. The material for the study includes Scopus-indexed publications devoted to digital marketing and consumer behaviour. Special attention is paid to studies that examine consumer engagement, online trust, electronic word-of-mouth, purchase intention, customer satisfaction and loyalty [5]. The selected publications were analysed in order to identify the main research directions and explain how digital marketing is studied in relation to consumer behaviour [6]. The empirical material consisted of 900 Scopus-indexed publications retrieved in May 2026. The analysis was based on titles, abstracts and keywords. The dataset was processed using thematic modelling. Automatically generated topics were interpreted on the basis of representative words and then manually renamed according to their semantic content.

The thematic analysis helped to group the publications into several key areas. These areas include social media marketing, digital marketing tools, online trust, purchase intention, customer journey, customer engagement, satisfaction and loyalty [7]. This approach makes it possible to show the structure of the research field without focusing on citation indicators or author networks.

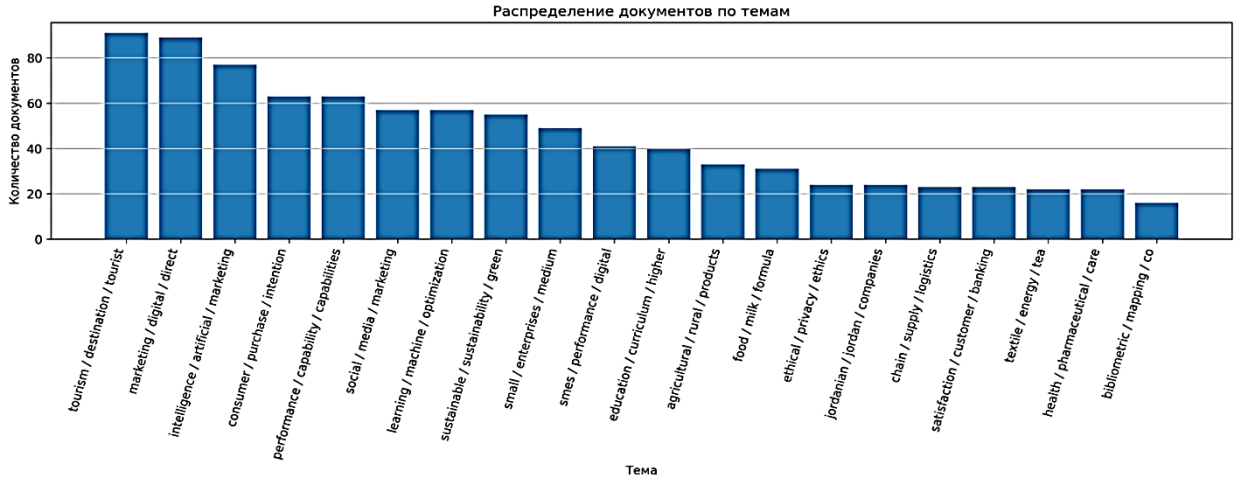


Figure 2. Distribution of documents by research topics

The distribution of documents is uneven. The largest topic includes more than 90 publications and is associated with tourism, destination marketing and tourists. Two other major groups focus on direct digital marketing and artificial intelligence in marketing. This structure indicates that digital marketing is often examined through both applied sectoral contexts and technology-based marketing tools. Another important group is connected with consumer purchase intention, which supports the consumer-oriented focus of the present article. The remaining topics broaden the scope of the corpus and connect digital marketing with business performance, digital capabilities, social media, machine learning, sustainability, small and medium-sized enterprises, education, privacy, customer satisfaction, supply chains, banking and healthcare.

To clarify the semantic content of the main topics, the most representative words within each group were analysed. These lexical markers help reveal the internal structure of the topics and support the interpretation of the thematic analysis. The topic word scores are presented in Figure 3.

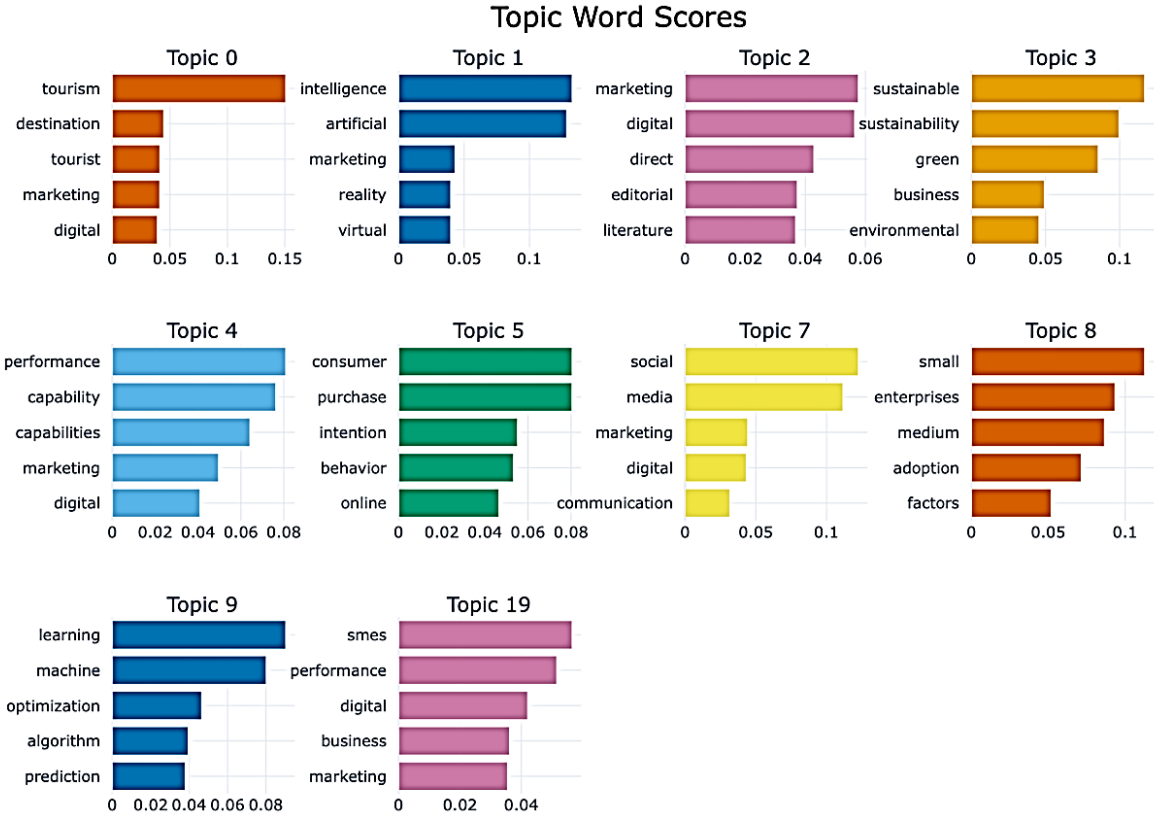


Figure 3. Topic word scores

The topic word scores specify the semantic boundaries of the clusters. They show that the corpus covers both general and more specific aspects of digital marketing research. The central part of the field is connected with digital marketing, social media, consumer behaviour, purchase intention and business performance. More specialized topics are related to tourism, artificial intelligence, machine learning, sustainability, small and medium-sized enterprises and different sectoral applications of digital marketing.

The relationships between the identified topics were analysed with an intertopic distance map. This visualization shows the degree of semantic proximity between thematic groups and helps to determine whether the field is fragmented or internally connected. The results are presented in Figure 4.

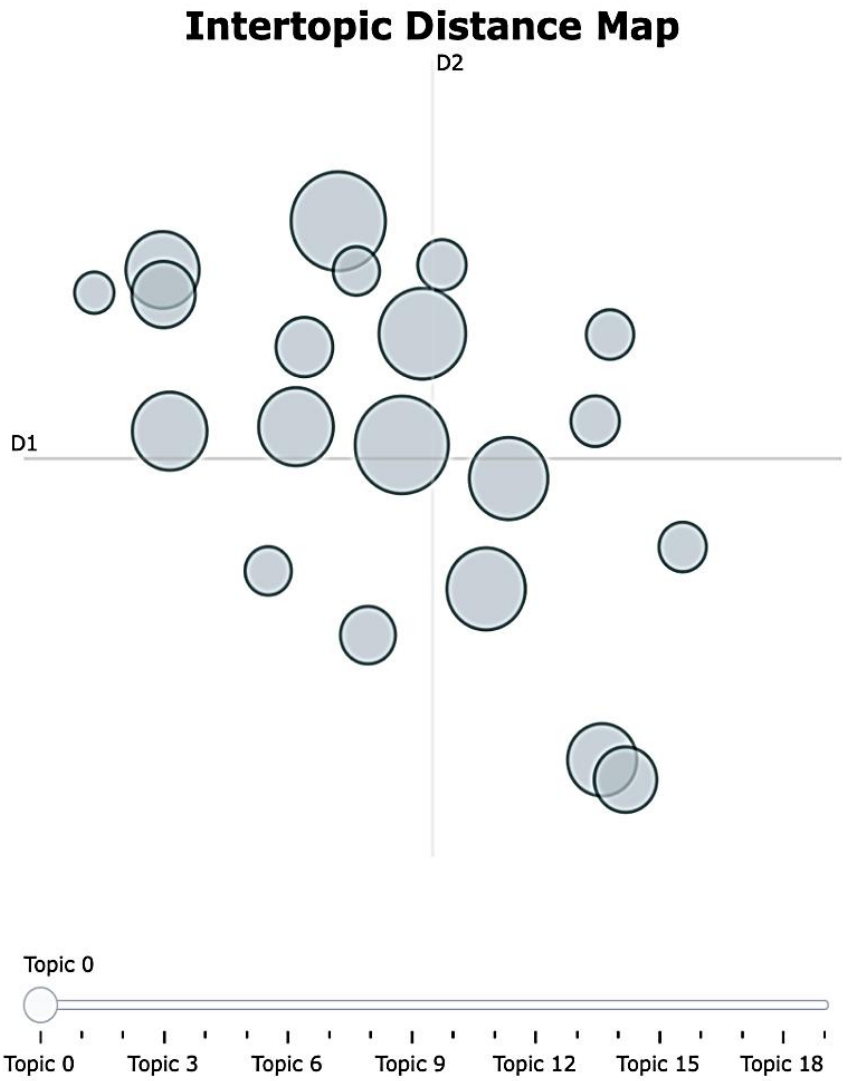


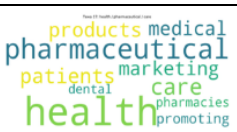
Figure 4. Intertopic distance map

The intertopic distance map reveals semantic proximity between the identified thematic groups. The size of each circle reflects the relative importance of the topic, while the distance between circles indicates how closely the topics are related. Most topics are located relatively close to one another, which suggests that the core areas of the corpus are semantically connected. Studies of digital marketing, consumer behaviour, purchase intention, social media communication, artificial intelligence and business performance are usually discussed within a shared marketing and technological context. Several topics are positioned at a greater distance from the main cluster and represent more specialized sectoral or applied research areas, such as tourism, sustainability, education, small and medium-sized enterprises, healthcare and supply chains.

To systematize the results of thematic analysis, the identified topics were summarized in Table. The table presents the number of documents within each topic, the interpreted thematic direction and the most representative keywords.

Table. Results of the thematic modelling

Theme	Keywords	Documents
1. Agricultural and rural product marketing		33
2. SME performance and digital business		41
3. Ethical, privacy and legal issues in digital marketing		24
4. Digital marketing in Jordanian companies		24
5. Machine learning and marketing optimization		57
6. Consumer behaviour and purchase intention		63
7. Sustainability and green digital marketing		55
8. Tourism and destination marketing		91
9. Bibliometric mapping and research reviews		16
10. Artificial intelligence in marketing		77
11. Digital marketing capabilities and business performance		63
12. Social media marketing and digital communication		57

13. Health and pharmaceutical digital marketing		22
14. Food products and consumer markets		31
15. Textile, energy and sectoral studies		22
16. Direct digital marketing and research reviews		89
17. Customer satisfaction and banking services		23
18. Digital marketing in small and medium-sized enterprises		49
19. Education and digital marketing curriculum		40
20. Supply chains and logistics		23

The identified topics show that academic discussion is concentrated around a core group of themes related to consumer behaviour, purchase intention, social media communication, artificial intelligence in marketing, digital marketing capabilities and business performance. Alongside this core, the corpus includes specialized areas concerning sustainability, machine learning, SMEs, sector-specific applications, ethical and privacy issues, health and pharmaceutical marketing, food products, education, supply chains, and regional studies such as Jordanian companies. Peripheral clusters associated with bibliometric mapping and research reviews indicate that the search strategy also captured studies linked to methodological and systematization approaches in digital marketing research.

For a clearer representation of the topic modelling results, a mind map was developed (Figure 5). It provides a consolidated view of the analysed corpus and visually demonstrates how the core and peripheral topics relate to each other.

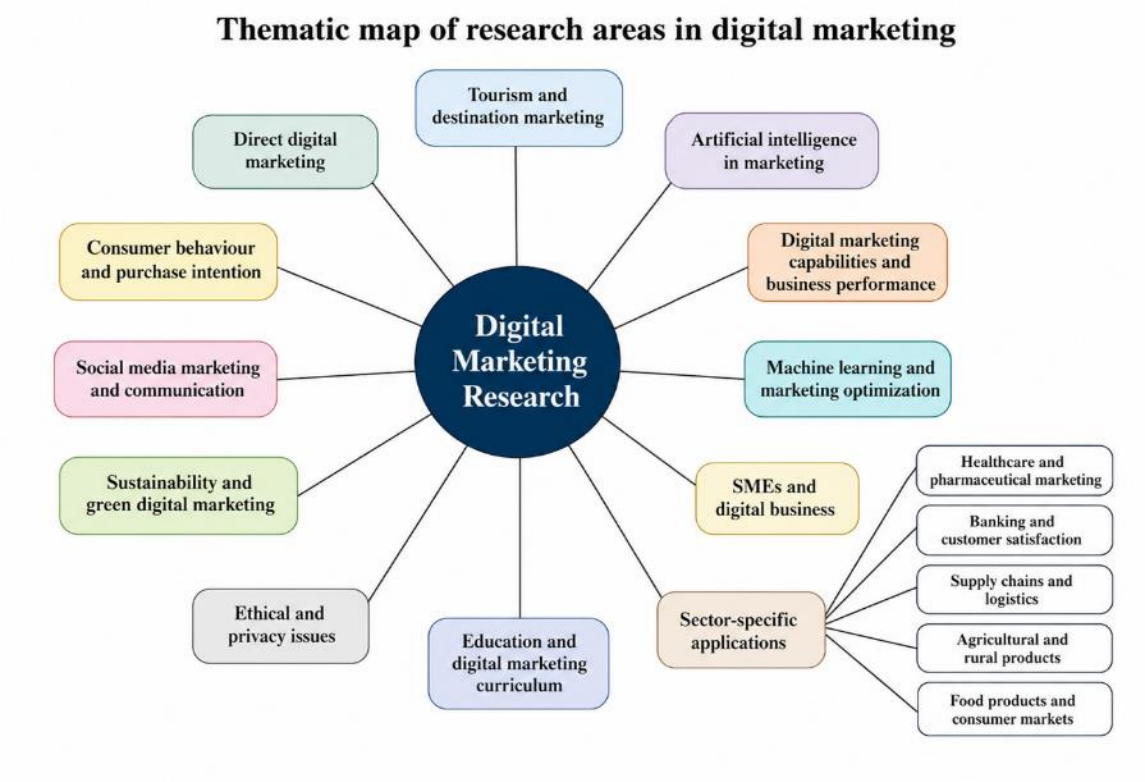


Figure 5. Thematic map of research areas in digital marketing research

The conducted study systematized current academic trends in digital marketing research. The results show that digital marketing is a broad interdisciplinary field that goes beyond simple advertising or promotional activities. The thematic modelling suggests two interconnected tendencies. The first is the continuation of classical research focused on consumer engagement, purchase intention, social media and digital marketing capabilities. The second is the expansion of the field toward technological applications, sector-specific studies, sustainability and methodological innovations. This means that digital marketing research should be understood not only as a set of marketing tools, but also as a multidimensional field combining consumer, technological, ethical, and organizational perspectives.

The study is limited to Scopus-indexed publications and to the analysis of titles, abstracts and keywords. Further research may focus on deeper integration of emerging technologies, cross-industry applications, and advanced analytics for evaluating digital marketing effectiveness.

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УДК 658.7

TRANSFORMATION OF SUPPLY CHAINS IN THE FMCG SECTOR: TRANSITION FROM 3PL TO 4PL AS A DRIVER FOR REDUCING TRANSACTION COSTS

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Abstract. The transition of the Russian FMCG sector from the third-level logistics outsourcing model (3PL) to the integrated logistics management model (4PL). The relevance of the topic is driven by fundamental changes in consumer behaviour – the rapid growth of online food sales – as well as by the aggravation of systemic industry constraints: the growing shortage of truck drivers, the fragmentation of logistics infrastructure, and the consistently high share of last-mile costs in the delivery cost structure.

Keywords: supply chain management, FMCG, 3PL operator, 4PL provider, logistics outsourcing, transaction costs, last mile, digital logistics.

ТРАНСФОРМАЦИЯ ЦЕПЕЙ ПОСТАВОК В FMCG-СЕКТОРЕ: ПЕРЕХОД ОТ 3PL К 4PL КАК ДРАЙВЕР СОКРАЩЕНИЯ ТРАНЗАКЦИОННЫХ ИЗДЕРЖЕК

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Аннотация. Переход российского FMCG-сектора от модели логистического аутсорсинга третьего уровня (3PL) к модели интегрированного логистического управления (4PL). Актуальность темы обусловлена фундаментальными изменениями потребительского поведения – стремительным ростом онлайн-продаж продуктов питания, а также обострением системных ограничений отрасли: нарастающим дефицитом водителей грузового транспорта, фрагментацией логистической инфраструктуры и устойчиво высокой долей затрат на последнюю милю в структуре себестоимости доставки. Совокупность этих факторов ставит под вопрос способность традиционной

мультивендорной модели 3PL обеспечивать требуемый уровень эффективности цепей поставок.

Ключевые слова: управления цепями поставок, FMCG, 3PL-оператор, 4PL-провайдер, логистический аутсорсинг, транзакционные издержки, последняя миля, цифровая логистика.

During the study, the role of a digital integration platform as a dividing barrier between the models was identified. A 4PL provider fundamentally differs from a set of 3PL operators not so much in the range of operations performed, but in the presence of a unified IT architecture – a "control tower" – that ensures end-to-end traceability of the supply chain and real-time coordination of multiple subcontractors' resources.

The practical significance of the study lies in the development of a phased roadmap for transitioning to the 4PL model, tailored to the industry specifics of food producers and distributors. The roadmap includes:

1) an audit of the total cost of ownership of the logistics function (TCLO);
2) a pilot implementation of the 4PL model in a limited geographic area;
3) mechanisms for minimising lock-in risk through open-book accounting and regular benchmarking of tariffs;
4) recommendations for retaining strategic logistics competencies within the client company.

The Russian FMCG sector in 2025 is demonstrating a structural transformation of logistics models, driven by the simultaneous action of several factors. Online food sales in the first quarter of 2025 grew by 26,8 % year-on-year, reaching 388 billion rubles, and the total annual volume may exceed 1.7 trillion rubles [1]. At the same time, systemic constraints are intensifying: a shortage of truck drivers (demand has grown by 58 %, with supply increasing by only 6 %), city bans on heavy-duty vehicle traffic, and the share of last-mile costs reaching 17 % of the delivery cost [2].

Under these conditions, the traditional model of outsourcing individual logistics functions (3PL) demonstrates its limited efficiency. The fragmentation of performers, the lack of a unified supply chain management centre, and the duplication of transaction costs are forcing FMCG manufacturers to seek fundamentally different approaches. The 4PL model, which involves transferring not individual operations but the entire set of supply chain design and management processes to an external provider, is considered one of the most promising vectors for solving the accumulated problems.

Despite the fact that the 4PL concept is theoretically well-developed in foreign literature, its adaptation to the Russian FMCG market remains insufficiently researched. Existing publications either focus on general principles without taking into account the industry specifics of the food segment, or are limited to describing individual cases without proposing a methodologically sound model for assessing the effectiveness of the transition.

3PL and 4PL as evolutionary stages of logistics outsourcing

The evolution of logistics outsourcing models is commonly described through the five-level 1PL–5PL classification. Fundamental changes occur between 3PL and 4PL, which is due to a qualitative change in the provider's role in the supply chain (Table 1).

Table 1. Comparative characteristics of the 3PL and 4PL models

Parameter	3PL	4PL
Management object	Individual logistics functions	End-to-end supply chain
Responsibility	Execution of operations	Overall supply chain performance
Assets	Own fleet, warehouses	Minimal assets; management of partners' assets
IT component	TMS, WMS	Integration platform, control tower
Payment	Per operation/trip	Per result/percentage of savings
Expertise	Transportation, warehousing	Supply chain engineering, analytics, consulting

Thus, the conceptual transition from 3PL to 4PL is not just about adding another intermediary to the chain, but a qualitative change in the management architecture. A 3PL operator performs individual operations (transportation, warehousing, processing) better than the client could do on their own, thanks to economies of scale and specialisation. A 4PL provider addresses a higher-order task – it designs and administers its own analytical competencies and IT solutions [3].

Transaction costs as an analytical framework

Methodologically, the most sound tool for comparing the efficiency of 3PL and 4PL is Oliver Williamson's theory of transaction costs. When applied to FMCG logistics, transaction costs can be classified into four types:

Information search costs: expenses for monitoring the carrier market, tender procedures, and counterparty verification. In a 3PL model, any change in the supply geography or seasonal expansion requires repeating this cycle. In a 4PL model, these costs are borne by the provider, who maintains a database of qualified subcontractors.

Bargaining costs: negotiating terms with each carrier, resolving disputes over quality and deadlines. In a 3PL model, the number of counterparties can reach dozens, each with their own SLA and penalty system. The 4PL model reduces this diversity to a single contract with unified KPIs.

Opportunistic behaviour costs: associated with the risks of non-fulfilment of obligations, inflated volumes, or collusion between the driver and the recipient. In 3PL, control is dispersed, while in 4PL a unified monitoring system with independent dispatching is created.

Measurement costs: expenses for monitoring delivery quality, temperature regime compliance, and packaging integrity. A fragmented 3PL model forces the duplication of control functions, whereas a 4PL provider ensures end-to-end traceability via a unified IT platform [4].

The FMCG sector imposes logistics requirements that qualitatively distinguish it from other industries.

First, it involves high-frequency distribution with a short order lifecycle. According to a Relog study, the busiest days of the week for deliveries are Tuesday to Thursday, while weekends are characterised by a decline in volumes [1]. This unevenness creates peak loads on the logistics infrastructure, which 3PL operators – working under fixed rates per trip – handle by raising rates during peak periods.

Second, the criticality of meeting SLA delivery time requirements. Industry studies show that 67 % of online retailers face challenges at the last-mile stage, and up to 65 % of consumers abandon a retailer after 2–3 late deliveries [2]. Retail chains include strict time windows in supply contracts, and a delay of even one hour results in fines or rejection of acceptance.

Third, the cost structure of FMCG delivery is dominated by personnel costs (39,14 %) and fuel costs (25,3 %), over which a 3PL operator has limited leverage without systemic route and load optimisation [2].

The margin of most FMCG categories does not allow for endlessly passing growing logistics costs onto the consumer, making supply chain optimisation a matter of survival, not just efficiency improvement.

The structure of the FMCG logistics market in Russia

The total volume of online food sales by the end of 2025 may exceed 1.7 trillion rubles, and the load on the logistics infrastructure will grow proportionally. The organisation of delivery in the sector remains predominantly hybrid:

1) 59 % of companies combine their own transport with outsourced services;
2) 23 % rely entirely on outsourcing;
3) only 18 % use exclusively their own vehicle fleet [1].

About 90 % of FMCG distributors operate within one or several neighbouring regions, and only 10% of companies provide nationwide delivery, which is explained by the high cost of long-distance transportation and the need for a developed warehouse network [1]. The geographical fragmentation of logistics creates prerequisites for implementing the 4PL model as an integrator of regional 3PL operators into a unified federal supply chain.

To quantitatively compare the two models, it is necessary to move from general reasoning to a factor-based cost structure. The cost of owning a logistics function (Total Cost of Logistics Ownership, TCLO) is the sum of direct operational costs and indirect transaction costs.

Table 2. Comparative TCLO structure for 3PL and 4PL (a hypothetical FMCG manufacturer with an annual logistics budget of 100 million rubles)

Cost item	3PL	4PL	Source of estimation
Direct transportation costs	65 million rubles	58 million rubles	Reduction due to consolidation and route optimisation
Warehousing processing	15 million rubles	14 million rubles	Benefits from centralised inventory management
Transaction costs (tenders, monitoring, arbitration)	8 million rubles	2 million rubles	Reduction in the number of counterparties from dozens to one
IT infrastructure (TMS, WMS, integration)	5 million rubles	3 million rubles	Cost transfer to the provider, shared services
Losses due to SLA breaches and suboptimal routes	7 million rubles	3 million rubles	Unified responsibility centre, predictive analytics
Total TCLO	100 million rubles	80 million rubles	Savings potential ~20 %

The key source of savings when transitioning to 4PL is not the reduction of direct operational costs (they decrease by 10–12 %), but a radical decrease in transaction costs and losses from suboptimal coordination (in total – more than threefold). This confirms the hypothesis that the advantages of 4PL lie primarily in the area of integration and management, rather than in the operational efficiency of individual links [5].

The fundamental difference between 3PL and 4PL in 2025 is increasingly shifting towards the IT domain. About 27 % of companies have already implemented automated route planning systems (TMS), and deploying a modern router can reduce transportation costs by up to 27 % [2]. However, 3PL operators implement such systems to optimise their own fleet, whereas a 4PL provider uses an integration platform for end-to-end optimisation of the entire chain, including the resources of multiple subcontractors.

In the 2025 e-commerce ecosystem map, the "Logistics" block showed the largest increase in the number of services, and within it a new direction emerged – "Warehouse solutions" [1]. The growing complexity of the IT landscape creates an additional barrier for FMCG manufacturers to independently manage their supply chain and strengthens the argument in favour of comprehensive 4PL outsourcing.

Table 3. Comparison of the IT component in the 3PL and 4PL models.

IT function	**3PL**	**4PL**
Transportation management (TMS)	Operator's own system	Integration platform combining subcontractors' TMS
Delivery monitoring	Batch tracking	Unified real-time "control tower"
Predictive analytics	Absent or basic	Demand forecasting, dynamic routing
Integration with client's ERP	Order-level API	Deep integration with production planning and inventory management

The IT architecture acts not just as an auxiliary tool, but as a dividing barrier between the models – the 4PL provider fundamentally differs by having an integration platform that unites data from multiple executors and ensures end-to-end optimisation.

The transition to 4PL brings not only economic benefits but also specific risks that must be compared with the risks of the traditional 3PL model.

Under the 3PL model, the main risk is the fragmentation of responsibility. When a supply chain failure occurs, each operator tends to shift responsibility to the adjacent link. For example, a delivery delay may be attributed to untimely vehicle provision (one 3PL's area of responsibility) or incorrect preparation of shipping documents (another's area), and the FMCG manufacturer, as the final customer, ends up having to independently investigate the causes and negotiate compensations with each participant.

Under the 4PL model, the main risk is dependence on a single provider (lock-in effect) and loss of direct contact with the carrier market, which could potentially lead to inflated service costs in the absence of competition. This risk is mitigated by including mechanisms for regular tariff benchmarking and cost structure disclosure obligations in the 4PL contract [5].

Table 4. Risk matrix of 3PL and 4PL models

Risk category	3PL	4PL
Fragmentation of responsibility	High	Low
Dependence on the provider	Low	High (requires open-book accounting)
Loss of in-house expertise	Low	Medium
SLA breach risk	Medium (diffused responsibility)	Low (unified SLA contract)
Personnel risk	High (driver shortage)	Shared with the provider

Russian FMCG retailer Befree demonstrates an evolutionary approach to logistics outsourcing, which can be seen as a transitional stage from fragmented 3PL to more mature models.

The company has fundamentally rejected the idea of creating its own courier service given its current volumes. According to Dmitry Tilicheev, head of Befree's e-commerce division, the company achieves savings through favourable contracts with contractors and direct deliveries of some goods to stores via cross-dock warehouses, bypassing the central warehouse [6].

The key result is that the transition from outsourcing warehousing to operating its own warehouse has allowed the company to reduce the cost of processing one product unit and overall expenses by 15 %. Commenting on this decision, D. Tilicheev noted: "We used to invest in the same process, but with our partner's margin. Now we control the costs ourselves" [6].

This example shows that 4PL does not mean abandoning all in-house assets. On the contrary, Befree maintains its own warehouse and logistics staff, while also establishing external contracts with carriers – moving towards a model where the company manages the supply chain as a single entity, even if operational execution remains with external partners. The company sees its further development in process automation, "including through the use of artificial intelligence" [6].

Based on the analysis, a roadmap for transitioning to the 4PL model can be formulated for FMCG manufacturers and distributors [7]:

1. Audit of the current supply chain and transaction costs. Before deciding to transition, it is necessary to inventory current logistics processes and quantitatively assess the TCLO structure. At this stage, it is important to separate direct operational costs from indirect transaction costs and identify nodes with the highest concentration of the latter. As Befree's experience shows, a detailed analysis of the cost of processing a product unit was what justified the decision to move the warehouse from outsourcing to in-house management.

2. Selection of a 4PL provider and contract model. The key selection criterion is that the provider has an integration IT platform capable of uniting data from various 3PL operators. The contract must include open-book mechanisms, regular tariff benchmarking, and target TCLO reduction indicators.

3. Pilot project in a limited geography. It is recommended to start the transition to 4PL with a single region or product category. This allows assessing real savings, refining interaction procedures, and minimising risks.

4. Scaling while retaining key competencies in-house. Even with full 4PL outsourcing, it is advisable for an FMCG manufacturer to retain strategic competencies

in-house – demand planning, assortment management, and service quality control. A model where the client completely disengages from logistics carries the risk of losing market expertise and becoming overly dependent on the provider.

The transition from 3PL to 4PL in the Russian FMCG sector is not a matter of following a trend, but an economically justified response to the industry's systemic challenges. With online food sales growing by more than 26 % year-on-year and the driver shortage problem simultaneously worsening, the traditional fragmented outsourcing model is exhausting its efficiency potential.

The main economic benefit of the 4PL model is achieved not through reducing direct operational costs (savings of 10–12 %) but through a radical reduction of transaction costs (by more than threefold), as confirmed by the factor model of the total cost of ownership of the logistics function developed in the study.

Russian practice (the Befree case) demonstrates that an effective transition to 4PL is not a binary choice but an evolutionary construction of a hybrid architecture, where in-house capacities and competencies are combined with external resources under unified management.

The IT component acts as a key dividing barrier between the models: a 4PL provider fundamentally differs from a set of 3PL operators by having an integration platform that ensures end-to-end optimisation of the supply chain.

The proposed 4PL transition roadmap provides a practical basis for decision-making by FMCG company management, allowing them to minimise risks and progressively realise the economic potential of the model.

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УДК 314.174

DEMOGRAPHIC CHANGES AND THEIR IMPACT ON NATIONAL ECONOMIES

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Abstract. The article analyzes the impact of demographic processes on the global economy and state social policy during the period 2020-2025. It examines key trends such as population ageing, declining birth rates, and increasing migration mobility. Using the examples of Japan, Germany, India, Russia, the United States, and France, the author demonstrates how demographic challenges are transforming labor markets, pension systems, and mechanisms of state regulation. Special attention is paid to the dual nature of the demographic problem: for businesses, the key issue is labor shortages, while for governments, it is the long-term sustainability of social systems. The article concludes that demographic changes are becoming one of the most important factors of economic security and the future development of nations.

Keywords: demography, population ageing, birth rate, migration, labor market, economic growth, pension system, workforce, demographic dividend.

ДЕМОГРАФИЧЕСКИЕ ИЗМЕНЕНИЯ И ИХ ВЛИЯНИЕ НА ЭКОНОМИКУ СТРАНЫ

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Аннотация. Статья посвящена анализу влияния демографических процессов на мировую экономику и социальную политику государств в период 2020–2025 гг. Рассматриваются такие ключевые тренды, как старение населения, снижение рождаемости и рост миграционной мобильности. На примере Японии, Германии, Индии, России, США и Франции авторы показывают, как демографические вызовы трансформируют рынки труда, пенсионные системы и механизмы государственного регулирования. Особое внимание уделяется двойственному характеру демографической проблемы: для бизнеса ключевым является дефицит рабочей силы, тогда как для правительств – долгосрочная устойчивость социальных систем. Делается вывод, что демографические

изменения становятся одним из главных факторов экономической безопасности и будущего развития стран.

Ключевые слова: демография, старение населения, рождаемость, миграция, рынок труда, экономический рост, пенсионная система, рабочая сила, демографический дивиденд.

Demography and the demographic crisis have remained important topics for researhers, economists, and goverments for many decades. In the 21st century, demographic processes became one of the key factors that influence economic development and social policy in different countries.

In the 21st century, demographic processes became one of the key factors that influence economic development and social policy in different countries. Population ageing, lower birth rates, and active migration strongly affect labor markets, economic growth, and state policy. These issues became especially noticeable between 2020 and 2025, when the consequences of the COVID-19 pandemic, economic instability, and geopolitical conflicts accelerated many demographic changes that had already existed before.

The relevance of this topic is connected with the fact that demography today affects not only society, but also econmy. Goverment today have a tricky balancing act. On one hand, they need people to keep working so the economy can grow. On the other hand, the have to keep society stable by offering good pensions, healthcare, and weafcare support. But different countries face very different problems. Some have lots of order people and not enough young workers, which can slow down the economy. Other countries have huge numbers of young people, which puts presure on things like schools, hospitals, and jobs.

To understand the influence of demography on the economy, it is necessary to define the meaning of demography itself. Demography is the science that studies population size, population structure, population distribution, and changes connected with birth rates, mortality, and migration. Specialists in demography analyze how populations change over time and how these changes affect society and the economy. The main demographic indicators usually include fertility rate, death rate, migration level, and the age composition of the population.

The demographic situation between 2020 and 2025 experienced significant transformations in many regions of the world. One of the main trends was the ageing of the population. In developed countries, the share of elderly people continued to increase, while the number of young citizens gradually declined. This process is connected with longer life expectancy and lower birth rates. Even states that traditionally had high levels of natural population growth have recently experienced a reduction in the number of births.

Several factors can explain these demographic changes. First of all, urbanization continues to influence people’s way of life and their attitude toward family. In large cities, living expenses are constantly growing. Housing, medical services, and education have become much more expensive in many countries. Because of this, many young people are not ready to start families at an early age. They prefer to finish education, find stable jobs, and improve their financial situation before having children. Today

marriage and parenthood are often seen as decisions that require careful planning and confidence in the future.

The COVID-19 pandemic also had a strong influence on demographic processes. During this period, many families faced financial instability, unemployment, and psychological stress. Uncertainty about health and the future made people less willing to have children. As a result, birth rates decreased in many parts of the world during and after the pandemic.

Another important demographic tendency is the growth of migration. For many developed countries, migration has become an important way to solve the problem of labor shortages. Countries such as the United States, Germany, France, and Canada attract migrants in order to support economic development and fill vacancies in different sectors of the economy. Migrants often work in healthcare, construction, transport, agriculture, and other areas where there are not enough local workers.

At the same time, active migration also creates new social and political difficulties. Governments must spend additional money on housing, education, healthcare, and language programs for newcomers. In many countries, migration policy has become a topic of serious political discussion. Questions connected with integration, cultural differences, and public security are discussed more actively in society than before.

Another serious problem for developed countries is the reduction of the working-age population. In many states, the number of people who work and pay taxes is gradually decreasing, while the number of elderly citizens continues to grow. This situation creates pressure on pension systems and healthcare services. Governments are forced to introduce pension reforms, raise the retirement age, and search for additional workers. However, such measures are often unpopular and can cause negative reactions among the population.

The modern world also shows strong demographic differences between regions. While many developed countries face ageing populations and low birth rates, several countries in Africa and South Asia continue to experience rapid population growth. These differences increase economic inequality between regions and stimulate migration from poorer countries to richer ones.

Overall, the period from 2020 to 2025 can be described through three major demographic tendencies: population ageing, declining birth rates, and the growth of migration. Today these processes strongly affect economic development and social policy in different parts of the world.

One of the most noticeable examples of demographic ageing is Japan. The country’s population has been decreasing for many years. The main reason for this trend is the extremely low birth rate. According to data from the World Bank Group, in 2024 the fertility rate in Japan remained close to 1.1 children per woman. This level is much lower than the rate needed for stable population replacement. At the same time, life expectancy in Japan remains among the highest in the world and is close to 85 years. Because of this, the share of elderly people in society continues to grow.

Population ageing creates serious economic problems for Japan. Many companies experience shortages of workers in healthcare, industry, transportation, and the service sector. In addition, the government has to spend increasing amounts of money on pensions and medical care for older citizens. To reduce the effects of labor shortages,

Japan has become more open to foreign workers in recent years. The country also активно develops robotics and automation technologies. Today Japan is considered one of the world leaders in the use of robots both in industry and in social care.

Germany faces similar demographic challenges. Although the birth rate there is slightly higher than in Japan, the country still experiences population ageing and natural population decline. The number of pensioners continues to rise, while the number of young workers becomes smaller. Unlike Japan, Germany actively uses migration to compensate for demographic losses. After the migration crisis of 2015, the country accepted many migrants and refugees. Later, a significant part of them joined the labor market, which helped reduce labor shortages and support the economy.

However, migration also created additional social and political tensions in Germany. The integration of migrants requires serious government spending on housing, education, and social support programs. Public debates about migration policy, security, and national identity have become much more active in German society during recent years.

Germany faces similar demographic difficulties. Although Germany's birth rate is slightly higher than Japan's, the country still experiences natural population decline and population ageing. The number of pensioners continues to grow, while the number of young workers becomes smaller. Unlike Japan, Germany actively uses migration to compensate for demographic losses. After the migration crisis of 2015, Germany accepted a large number of migrants and refugees, many of whom later entered the labor market. This helped reduce labor shortages and supported economic growth.

However, migration also created social and political challenges. Migrant integration requires large government investments in housing, language education, and social programs. Public discussions about migration, security, and cultural identity became more active in German society.

Both Japan and Germany experience growing pressure on pension systems. Pension systems depend on taxes paid by workers, but the number of working citizens is decreasing. Because of this, governments are forced to raise the retirement age and encourage older people to remain economically active for longer periods of time.

A different demographic situation can be observed in India. Unlike Japan and Germany, India continues to experience population growth and has a very large share of young people. According to the World Bank Group, India became the most populated country in the world in 2023 and moved ahead of China in total population size. A large part of India's population consists of young people, especially teenagers and adults under 30 years old. Every year millions of them enter the labor market and search for employment.

Economists often describe this situation as a "demographic dividend." If the state can create enough jobs and improve education, transport, and infrastructure, a large working-age population may become an important advantage for economic growth. In recent years, India has strengthened its position in information technology, digital services, and industrial production. Many international companies are expanding their business activities there because of the large labor force and growing domestic market.

However, a young population does not automatically guarantee stable economic development. India still faces serious internal difficulties. In some regions,

unemployment remains high, while poverty and social inequality continue to affect millions of people. Infrastructure also develops unevenly across the country. Because of this, the main demographic problem for India is connected not with population ageing, but with the need to provide jobs, housing, education, and acceptable living standards for a rapidly growing population.

The demographic situation in Russia between 2020 and 2025 is marked by natural population decline and low birth rates. According to data from Rosstat, the fertility rate decreased from around 1.5 to 1.4 children per woman. This level remains much lower than what is necessary for stable population replacement. Although mortality rates became lower after the COVID-19 pandemic, the number of births continues to fall.

One of the main demographic problems in Russia is the reduction of the working-age population. This situation is connected with several factors, including the ageing of generations born during the Soviet period, the smaller number of women of reproductive age, and relatively high mortality rates among men. As a result, labor shortages are becoming more visible in healthcare, industry, transportation, and other sectors of the economy.

Migration is also viewed as an important instrument for compensating demographic losses. Migrants play a major role in construction, logistics, and services. However, migration alone cannot completely solve the problem of natural population decline.

Another important measure was the pension reform that gradually increased the retirement age. The government hopes that this reform will reduce pressure on the pension system and help preserve the labor force. In addition, the state continues to introduce programs supporting families and birth rates, including maternity capital, льготные mortgages, and tax support for families with children. Despite these efforts, birth rates remain low in most regions of the country.

An important feature of the Russian demographic situation is regional inequality. Some regions continue to lose population because of economic problems and migration to larger cities. In addition, Russia experiences a gender imbalance, since the number of women is significantly higher than the number of men.

Compared to many developed countries, the demographic situation in the United States and France looks relatively stable. Although birth rates in both states are gradually declining, migration helps maintain population growth and supports the labor market.

The United States remains one of the world’s main destinations for international migrants. The country needs both highly qualified specialists and workers in areas such as agriculture, construction, healthcare, and services. Migrants contribute to economic activity, increase tax revenues, and help compensate for lower birth rates.

France also demonstrates a more stable demographic situation than many European countries. The country has one of the highest fertility rates in Europe. One of the reasons is the developed social support system for families. The French government provides financial assistance, childcare programs, tax benefits, and more flexible family policies. Migration also plays an important role in supporting the size of the population and the labor force.

At the same time, migration creates political and social debates in both countries.

Discussions connected with national identity, security, and migrant integration remain very active. Despite these difficulties, the experience of the United States and France shows that a combination of moderate birth rates and controlled migration can partly reduce the economic consequences of population ageing.

Demographic processes strongly influence labor markets. Every economy requires enough workers to support industrial production, services, and technological progress. When the number of working-age citizens declines, businesses and governments experience labor shortages. This problem is especially visible in developed countries such as Japan and Germany, where employers increasingly struggle to find employees. Labor shortages reduce economic growth, increase pressure on existing workers, and raise production costs for companies.

Because of this, governments pay more attention to migration as an additional source of labor. Migrants help support production levels and reduce shortages in many sectors of the economy. However, demographic issues are important not only because of labor supply, but also because of taxation and social systems.

This problem becomes especially serious for pension systems. In most modern countries, pension systems are based on the principle that working citizens finance pensions through taxes and insurance payments. When the number of pensioners grows faster than the number of workers, pension systems experience financial difficulties. Governments are then forced to increase taxes, reduce social spending, or raise the retirement age. Such measures often become unpopular and may lead to protests and public dissatisfaction.

At the same time, governments continue attempts to stimulate birth rates because future generations are expected to become future workers and taxpayers. However, demographic policy usually produces results only after many years, while labor shortages already exist today.

Some countries also attempt to solve demographic problems through technological development and automation. Robots and automated systems are increasingly used in industry, logistics, healthcare, and services. Automation allows companies to reduce dependence on human labor. However, technologies cannot completely replace people, especially in professions connected with healthcare, education, and social support.

In addition, automation requires large financial investments and highly qualified specialists. For this reason, such solutions are mainly available to economically developed countries.

Demographic changes influence not only labor markets, but also the structure of the economy itself. Ageing societies increase demand for healthcare services, medicine, pharmaceutical production, and elderly care. At the same time, a smaller number of young people may reduce demand in sectors connected with entertainment, tourism, restaurants, and consumer goods.

For this reason, demography has become one of the central factors of long-term economic development. Governments must consider population structure when planning economic policy, state budgets, healthcare systems, and social support programs.

Therefore, demographic problems have a dual character. For businesses, the main

issue is the availability of enough workers who can support production and economic activity. For governments, the key task is maintaining stable pension systems, healthcare, and social programs in conditions of changing population structure.

Demographic changes between 2020 and 2025 became one of the main factors influencing the global economy. Population ageing, natural population decline, falling birth rates, and migration flows continue to transform modern societies and force governments to reconsider economic and social policy.

The comparison of different countries demonstrates that demographic problems differ depending on economic conditions and the level of development. Developed countries mainly face ageing populations and labor shortages, while developing countries often struggle with rapid population growth and the need to create enough jobs for young citizens.

Although demographic changes influence both the economy and society, governments and businesses often view these problems differently. Companies focus mainly on finding enough workers and maintaining economic growth. Governments are more concerned with the long-term stability of budgets, pensions, and social systems. To balance these interests, states use different instruments, including migration policy, support for families, pension reforms, and automation. However, none of these measures can solve demographic problems quickly, and the results usually become visible only after many years.

Therefore, demographic processes should not be viewed only as statistical changes. Today they are becoming one of the main factors that determine economic stability, social security, and the future development of modern states

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При подготовке статьи были применены технологии искусственного интеллекта.

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УДК 004.7+656.073

INFLUENCE OF CLOUD TECHNOLOGIES ON OPTIMIZATION OF LOGISTICS PROCESSES IN THE SPHERE OF FREIGHT TRANSPORT

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Abstract. The article examines the use of cloud technologies in logistics to optimize loading, route management, real-time cargo tracking and document automation. It also covers their application for monitoring fuel consumption, vehicle maintenance, navigation system integration and data analytics. Special attention is given to the challenges and risks of implementing cloud solutions, as well as their future prospects in commercial transport.

Keywords: cloud technologies, cloud computing, transport, optimization of loading of transport units, optimization of transportation routes.

ВЛИЯНИЕ ОБЛАЧНЫХ ТЕХНОЛОГИЙ НА ОПТИМИЗАЦИЮ ЛОГИСТИЧЕСКИХ ПРОЦЕССОВ В СФЕРЕ ГРУЗОПЕРЕВОЗОК

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Аннотация. В статье описаны возможности применения облачных технологий для оптимизации загрузки транспортных единиц, управления маршрутами перевозок, отслеживания грузов в реальном времени и автоматизации процессов хранения документации. Также рассматривается применение облачных технологий для мониторинга топливопотребления, обслуживания транспорта, взаимодействия с системами навигации и маршрутизации, аналитики данных по эксплуатации транспортных средств. Особое внимание уделяется вызовам и рискам, связанным с внедрением облачных решений, а также перспективам их применения в коммерческом транспорте.

Ключевые слова: облачные технологии, облачные вычисления, транспорт, оптимизация загрузки транспортных единиц, оптимизация маршрутов перевозки.

The logistics industry has long faced a number of systemic challenges hindering its development. Inefficient route planning led to delays and fuel overconsumption, manual document exchange slowed down request processing and introduced errors, while the lack of transparency in the supply chain reduced customer trust. High costs of maintaining proprietary IT infrastructure and the risks of data breaches associated with local storage systems further exacerbated the situation. Under these conditions, cloud technologies have become not merely an innovation, but a necessary tool for transformation, capable of addressing the key challenges of the industry.

Cloud solutions offer a fundamentally different approach to managing logistics processes. Instead of investing in expensive hardware, companies gain access to computing resources via the Internet, paying only for the actual capacity used. This enables flexible scaling of infrastructure according to current needs and significantly reduces capital expenditures. At the same time, mobility is enhanced: employees can access data from anywhere in the world using smartphones or tablets, which is particularly important for dispatchers, drivers, and customer service managers. A prominent example of this approach's effectiveness is the experience of the logistics company DHL (Bonn, Germany). By implementing a cloud-based platform for cargo tracking in 2019, the company automated document workflows and ensured instant access to shipment status data. As a result, customer request processing time was reduced by 30 %, significantly improving service levels and customer satisfaction [1, p. 63]. A key success factor was the integration of the cloud platform with the company's internal systems and mobile applications for drivers.

Another illustrative case is the implementation of the CargoWise system (WiseTech Global, Sydney, Australia) by Onboard Logistics in 2020. Through data centralization and integration with dimensioning machines, the company effectively managed operations in the complex regulatory environment of Latin America. Warehouse productivity increased by 300 %, clearly demonstrating the potential of cloud solutions for optimizing warehouse processes [2; p. 207]. The system enabled automated cargo tracking, reduced order picking time, and minimized inventory errors.

The transportation company Maersk (Copenhagen, Denmark) took this further by starting in 2021 to use cloud technologies for real-time tracking of 13 million containers. This step reduced administrative costs by 15 % and improved delivery accuracy by 25 %. A similar approach was adopted by Amazon (Seattle, USA), which in 2018 implemented cloud-based trackers for package monitoring. The Amazon Map Tracker feature, allowing real-time visibility of delivery locations, enhanced transportation reliability and security and enabled prompt responses to delays or route changes [3].

Inventory optimization is another area where cloud technologies demonstrate impressive results. The retailer Walmart (Bentonville, Arkansas, USA), by establishing a hybrid cloud infrastructure in 2022, gained tools for accurate demand forecasting. This allowed optimizing inventory levels and reducing stockouts by 30 % [4]. Consequently, companies can avoid both overstocking and stock shortages, directly impacting business profitability.

Equally significant are achievements in transport monitoring. The Wialon service (an international company specializing in cloud-based transport monitoring), launched

in 2007, enables real-time fuel consumption tracking, helping companies reduce fuel costs by 10–15 %. The automaker Volvo (Gothenburg, Sweden) has used cloud-based algorithms for predictive maintenance of trucks since 2020, reducing unplanned repairs by 20 % [5]. The integration of cloud systems with GPS technologies ensures precise vehicle tracking, optimizes routes, and enhances overall operational efficiency. An important but often overlooked benefit of cloud technologies in logistics is their positive impact on environmental sustainability. By optimizing routes and reducing fuel consumption, cloud-based systems contribute to lowering greenhouse gas emissions. For instance, route optimization algorithms can reduce vehicle mileage by up to 15 %, directly decreasing CO_2 output.

Predictive maintenance, enabled by cloud analytics, extends the lifespan of transport equipment, reducing the need for manufacturing new units and associated resource consumption. Furthermore, the shift from paper-based to digital document workflows eliminates significant volumes of paper waste. A study by the International Transport Forum (2023) estimates that widespread adoption of cloud logistics could reduce the industry's carbon footprint by 8–12 % by 2030 [6]. This aligns with global ESG (Environmental, Social, and Governance) goals and enhances corporate social responsibility profiles of logistics companies. For clarity, key case studies of cloud technology implementation in logistics are summarized in the table below:

Table. Case Studies of Cloud Technology Implementation in Logistics

Company	**Year of Implementation**	**Technology**	**Effect**
DHL (Germany)	2019	Cloud-based cargo tracking platform	30 % reduction in request processing time through automated document workflows
Onboard Logistics (Latin America)	2020	CargoWise system with dimensioning machine integration	300 % increase in warehouse productivity
Maersk (Denmark)	2021	Cloud tracking of 13 million containers	15 % reduction in administrative costs, 25 % improvement in delivery accuracy
Amazon (USA)	2018	Cloud trackers (Amazon Map Tracker)	Enhanced transportation reliability and safety, prompt resolution of delay issues
Walmart (USA)	2022	Hybrid cloud infrastructure	30 % reduction in stockouts through accurate demand forecasting
Wialon (International)	2007	Cloud-based fuel consumption monitoring	10–15 % reduction in fuel costs
Volvo (Sweden)	2020	Cloud-based predictive maintenance algorithms	20 % reduction in unplanned repairs

However, the adoption of cloud solutions entails certain challenges. One of the main concerns is data security. Migrating sensitive information to the cloud requires robust protection against cyberattacks and data breaches. FedEx (Memphis, USA), which implemented a multi-layered authentication system in its cloud platform in 2023, managed to reduce leakage risks by 40 % [7, p. 478]. Ensuring business continuity is equally important: disruptions in cloud service operation or internet connectivity issues may lead to downtime. To minimize such risks, companies must develop disaster recovery plans and utilize backup communication channels.

The adoption of cloud technologies in logistics is also shaped by evolving regulatory frameworks and international standards. Key developments include:

GDPR (EU) and similar data protection regulations, which mandate strict controls over personal and operational data stored in the cloud;

ISO 27001 for information security management, providing a baseline for cloud provider certification;

UNECE standards for electronic data interchange in international logistics, promoting interoperability between cloud platforms;

national regulations on data localization (e. g., in Russia, China, Brazil), which influence where cloud infrastructure must be deployed.

Compliance with these frameworks is not merely a legal requirement but also a competitive advantage. Companies that align with international standards gain trust from global partners and can more easily expand into new markets. For example, logistics providers certified under ISO 27001 experience 25 % faster onboarding of international clients, according to a 2024 survey by the Global Logistics Association. This regulatory landscape underscores the need for logistics firms to consider compliance as a strategic component of their cloud adoption strategy.

The prospects for cloud technology development in logistics appear promising. According to a Research Nester report, the cloud logistics market is projected to grow from $22,13 billion *in* 2025 *to* $77,14 billion by 2035, with an average annual growth rate of approximately 13,3 %. By 2035, about 40 % of the market will be concentrated in North America, and 25 % in the Asia-Pacific region [8, p. 135]. Key growth drivers will include the adoption of the Internet of Things (IoT) and artificial intelligence (AI), as well as the increasing demand for scalable logistics solutions.

In the future, deeper integration of cloud platforms with transportation management systems is expected, along with higher levels of AI-driven automation and standardization of data exchange protocols among companies. Cloud ecosystems will enable the creation of unified logistics spaces where participants can interact efficiently, exchange data, and optimize processes in real time. For instance, services like Yandex Routing (launched in 2017) already help companies reduce delivery times by 15–20 %, while Uber Freight uses cloud-based machine learning (ML) models for demand forecasting, increasing vehicle utilization by 18 %.

Conclusion. For successful cloud solution adoption, companies should follow a phased approach. First, they need to conduct an audit of current processes and identify bottlenecks where technology can deliver maximum impact. Next, they should assess information security risks and develop a data protection plan. Selecting a reliable provider tailored to the specifics of logistics operations is another critical step. After pilot testing in a specific segment of the supply chain, companies can proceed to

full-scale implementation, accompanied by staff training and regular performance evaluation.

Thus, cloud technologies do not merely modernize logistics – they create a new paradigm for supply chain management. Increased transparency, faster information exchange, and more accurate forecasting enable companies to achieve significant economic benefits and competitive advantages. In the context of digital transformation, cloud solutions become a strategic asset capable of fundamentally changing freight transportation efficiency and strengthening business positions in the global market.

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SECTION 2. SCIENCE AND TECHNOLOGY SYNERGY

УДК 621.1

INCREASING THE OPERATIONAL FLEXIBILITY AND HEAT OUTPUT OF COMBINED CYCLE POWER PLANTS (CCPPS) BY INTEGRATING ADDITIONAL COMBUSTION SYSTEMS INTO WASTE HEAT BOILERS

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Abstract. The problem of structural misalignment between the electrical and thermal loads of combined heat and power plants equipped with combined-cycle gas turbines (CCGTs) under the uneven heat demand patterns of large cities is investigated. A technical solution for increasing the thermal capacity of CCGT-450s without reducing electrical output by installing a modular afterburner (MBA) in the waste heat boiler's gas path is proposed. An optimal BBA placement scheme (downstream of the high-pressure superheater and before the high-pressure evaporator) is substantiated, minimizing thermal stresses and expanding the control range.

Keywords: combined cycle gas turbine unit, waste heat boiler, block afterburner, cogeneration, specific fuel consumption, power unit maneuverability, feasibility study, off-season load.

ПОВЫШЕНИЕ ЭКСПЛУАТАЦИОННОЙ МАНЕВРЕННОСТИ И ТЕПЛОВОЙ ОТДАЧИ ПАРОГАЗОВЫХ УСТАНОВОК ТЭЦ ЗА СЧЕТ ИНТЕГРАЦИИ СИСТЕМ ДОПОЛНИТЕЛЬНОГО СЖИГАНИЯ В КОТЛЫ-УТИЛИЗАТОРЫ

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Аннотация. В статье рассматривается проблема структурного рассогласования электрической и тепловой нагрузок теплоэлектроцентралей, оснащенных парогазовыми установками (ПГУ), в условиях неравномерного графика теплопотребления крупных городов. Предложено техническое решение по повышению тепловой мощности ПГУ-450 без снижения электрической выработки за счет установки блочного дожигающего устройства (БДУ) в газовый

тракт котла-утилизатора. Обоснована оптимальная схема размещения БДУ (после пароперегревателя высокого давления перед испарителем высокого давления), обеспечивающая минимизацию термических напряжений и расширение диапазона регулирования.

Ключевые слова: парогазовая установка, котел-утилизатор, блочное дожигающее устройство, теплофикация, удельный расход топлива, маневренность энергоблока, технико-экономическое обоснование, межсезонная нагрузка.

The reform of the Russian electric power industry and the introduction of the capacity supply agreement (CSA) mechanism have stimulated the widespread construction of combined-cycle gas turbines (CCGTs), which demonstrate high fuel efficiency (specific fuel consumption for electricity of 180–230 g/kWh). However, the specific nature of heat supply in large Russian cities, where the share of heating in the annual balance exceeds 60–70 %, creates a systemic imbalance between electric and thermal generation. During periods of minimal and transient heat loads (off-season), CCGTs are unable to independently meet consumer demand without reducing electrical capacity on the wholesale electricity and capacity market (WECM). The traditional solution – switching on steam turbines of the P, T, PT type or peak hot water boilers (PHB) – leads to an increase in specific fuel consumption to 340–380 g/kW h, which exceeds the profitability threshold (280–300 g/kW h) and reduces the competitiveness of the station [1, 2].

In this regard, the search for technical solutions that allow for flexible increases in the thermal capacity of combined cycle gas turbines (CCGTs) without reducing electrical output or involving external boiler equipment has become a pressing issue. One of the most promising approaches is the integration of modular afterburning units (BDUs) into waste heat boilers (WHS) utilizing residual oxygen (13–16 %) from the exhaust gases of gas turbine units [3, 4].

The objective of this study is to provide a thermodynamic, design, and economic justification for upgrading the thermal circuit of a 450-CCGT unit by installing BDUs with optimized placement within the gas path. The object of the study is the combined cycle power unit PGU-450T of the Yuzhnaya CHPP-22 (St. Petersburg), consisting of two GTE-160 gas turbine units (155 MW each), two double-circuit drum waste heat boilers Pr-228/47-7.86/0.62-515/230 and a T-125/150-7.4 cogeneration steam turbine (151.4 MW). The base thermal capacity of the unit is 237 Gcal/h, and the electric capacity is 450 MW. The gas turbine unit includes the following main components (Figure1).

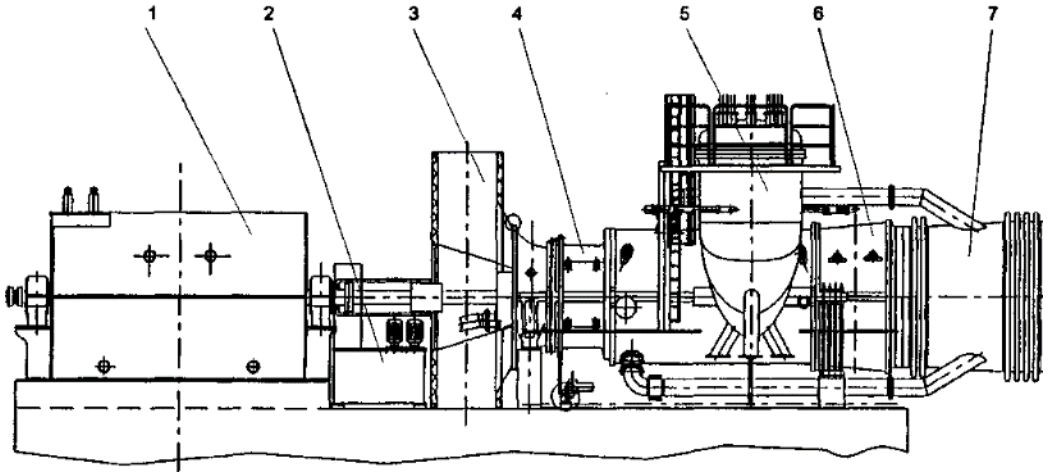


Figure 1. Gas turbine unit with electric generator:
1 – electric generator; 2 – oil tank; 3 – suction pipe; 4 – compressor; 5 – combustion chamber; 6 – turbine; 7 – exhaust diffuser

A key aspect of the methodology is the selection of the installation location for the exhaust gas control system (BDU). Two options were considered: at the inlet of the CU (upstream of the HPHP) and downstream of the HPHP, before the high-pressure evaporator (HPE). The second option was chosen as technically and economically optimal, as it reduces the heat-resistance requirements for the HPHP pipes, reduces thermal insulation costs, and ensures smoother steam pressure regulation before the steam turbine [5, 6].

When the BDU is included in the CU gas path, the exhaust gas temperature before the HPP increases from ~540 °C to 680–720 °C. This ensures a 15–20 % increase in the high-pressure circuit's steam capacity (up to 260–270 t/h), an increase in the HP steam pressure to 11.16 MPa, and a temperature of 530 °C (within the permissible limit of 545 °C). The thermal capacity of the power unit increases from 237 to 320–350 Gcal/h. At the same time, the combined cycle power unit's electrical capacity remains at 450 MW, as the additional steam generation is compensated by closing the STU's rotary diaphragm in cogeneration mode without reducing the declared capacity on the wholesale electricity and capacity market.

The specific fuel consumption for electricity increases slightly: from 184 to 190 g/kWh (+3 %), which remains significantly below the break-even point (280–300 g/kWh). The unit's electrical efficiency decreases by approximately 5 % (to 36.3 %), but this is fully offset by eliminating the need to run the T-250 steam turbines in a mode close to condensing (specific fuel consumption > 350 g/kWh). In thermal circuits of combined cycle plants with waste heat boilers, the operation of burner devices in afterburning chambers is possible at an oxygen concentration of more than 12-14 % and an excess air coefficient of more than 2 [7].

Figure 2 shows an example of the design of a diffusion-stabilizer burner in an afterburner chamber, often used in practice. These burners are installed in the transition flue gas duct connecting the gas turbine diffuser to the heat exchanger (waste heat boiler).

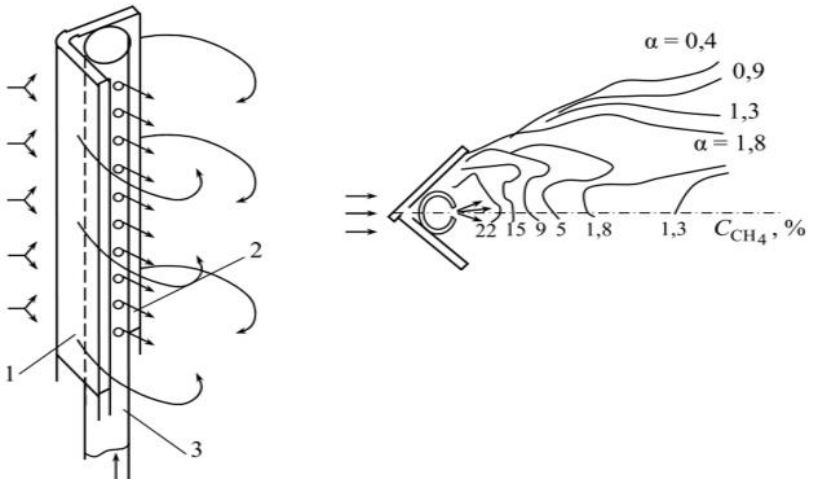


Figure 2. Diffusion-stabilizer burner of the afterburning chamber:
1 – Stabilizer; 2 – gas jet axis; 3 – gas manifold – nozzle

The modernization of the boiler unit is localized and does not require replacement of the main body. To ensure reliable operation at elevated temperatures, the following solutions were implemented:

1. Installation of a 1.2-1.5 m long mixing chamber with a heat-resistant lining made of high-alumina concrete (80-100 mm thick).

2. Upgrading the steel grade of the first row of HPS pipes from P265GH to 12Kh1MF with an increase in wall thickness from 2.9 to 3.6 mm.

3. Installation of adjustable hangers with thermal expansion compensators in the BDU area.

4. Installation of 6-8 additional thermocouples for temperature field monitoring.

5. Integration of 4-6 microflare diffusion-stabilizer burners with individual valve-controlled gas supply. A verification calculation confirms the safety of the modification: the specific heat flux to the first row of HPS pipes is ~22.5 kW/m² (35–40 kW/m² is acceptable), and the calculated pipe wall temperature is ~299 °C (the limit for 12Kh1MF is 580 °C). The hydraulic resistance of the gas path does not exceed 3300 Pa [8].

An analysis of the actual heat output of CHPP-22 during transition periods (April, May, September, and October) reveals a persistent thermal capacity deficit in the basic CCGT configuration: in April and October, the imbalance reaches –110.6 and –119 Gcal/h, respectively. At average monthly temperatures of +3 to +9 °C, the consumer load is 240–315 Gcal/h, exceeding the basic thermal capacity of the CCGT. The introduction of the BDU makes it possible to cover this deficit without turning on the T-250 or KVG, ensuring smooth regulation of thermal power in the range of 237–350 Gcal/h.

Capital expenditures for the modernization of one power unit are estimated at 451.85 million rubles (including equipment, construction and installation work, transportation, and VAT). Annual savings from reduced fuel consumption due to the

elimination of inefficient operation of the T-250 are approximately 1,542 million rubles. Estimated payback period:

- 0.3 years from the start of operation;
- 1.3 years, taking into account the design and construction period (12 months) [9].

High commercial efficiency is due to the elimination of the need to expand generating capacity, minimal reconstruction costs, and a significant reduction in operating costs during the off-season.

CONCLUSION

Integration of modular afterburners into the waste heat boilers of combined cycle CHP units represents a technically sound and cost-effective solution for eliminating the structural imbalance between electric and thermal generation in the context of uneven heat consumption in large cities. Placing the BDU after the high-pressure superheater and before the evaporator allows for a safe increase in the thermal capacity of the 450 CCGT unit to 320–350 Gcal/h without reducing electrical output, eliminating the need for inefficient steam power equipment during the off-season, and ensuring a project payback period of less than 1.5 years [10].

The proposed modernization scheme is minimally invasive, maintains the operational reliability of the CU, and meets modern requirements for the flexibility of generating facilities. Further research should be focused on developing adaptive control algorithms for the BDU in dynamic modes, assessing the long-term service life of materials during cyclic afterburning, and integrating afterburning systems with hybrid heat supply systems incorporating renewable energy sources.

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УДК 676.038.2

MODERNIZATION OF THE OLD CORRUGATED CARDBOARD PROCESSING LINE TO IMPROVE THE OPTICAL PROPERTIES OF TESTLINER

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Abstract. The Russian corrugated cardboard market in 2024–2026 is analyzed, the main trends of corrugated cardboard production are identified, the relevance of improving the optical and printing properties of testliner without a significant increase in cost are substantiated. A solution is proposed – bleaching secondary fiber from old corrugated cardboard for the top layer of testliner. The aim of the work is to modernize the technological processing line for old corrugated cardboard.

Keywords: corrugated cardboard, testliner, old corrugated cardboard, secondary fiber, bleaching, optical properties, kraftliner.

МОДЕРНИЗАЦИЯ ТЕХНОЛОГИЧЕСКОЙ ЛИНИИ ПЕРЕРАБОТКИ МАКУЛАТУРЫ МАРКИ МС-5Б ДЛЯ ПОВЫШЕНИЯ ОПТИЧЕСКИХ СВОЙСТВ ТЕСТ-ЛАЙНЕРА

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Аннотация. В работе проведен анализ российского рынка гофрокартона в 2024–2026 гг., выявлены основные тренды и обоснована актуальность повышения оптических и печатных свойств тест-лайнера без существенного увеличения стоимости. Предложено решение: отбелка вторичного волокна из макулатуры марки МС-5Б для верхнего слоя тест-лайнера. Целью работы

является модернизация технологической линии переработки макулатуры марки МС-5Б.

Ключевые слова: гофрокартон, тест-лайнер, макулатура марки МС-5Б, вторичное волокно, отбелка, оптические свойства, крафт-лайнер.

Introduction

The production of packaging products continuous to develop and remains a key direction in the technology of cellulose and composite materials. Analytical data shows that by 2025 the Russian cardboard and corrugated cardboard packaging market was characterized by high competition and excess production capacity at subdued demand [1]. In 2025, the production of corrugated cardboard boxes reached 7.11 billion units. It was 9 % higher than in 2023. The total market volume in monetary terms exceeded 360 billion rubles.

Between 2019 and 2024, the average annual growth rate was 5.78 %. Given the production growth trends observed between 2019 and 2025, it can be projected that corrugated cardboard production in Russia will reach at least 4 567 022 000 square meters by 2029.

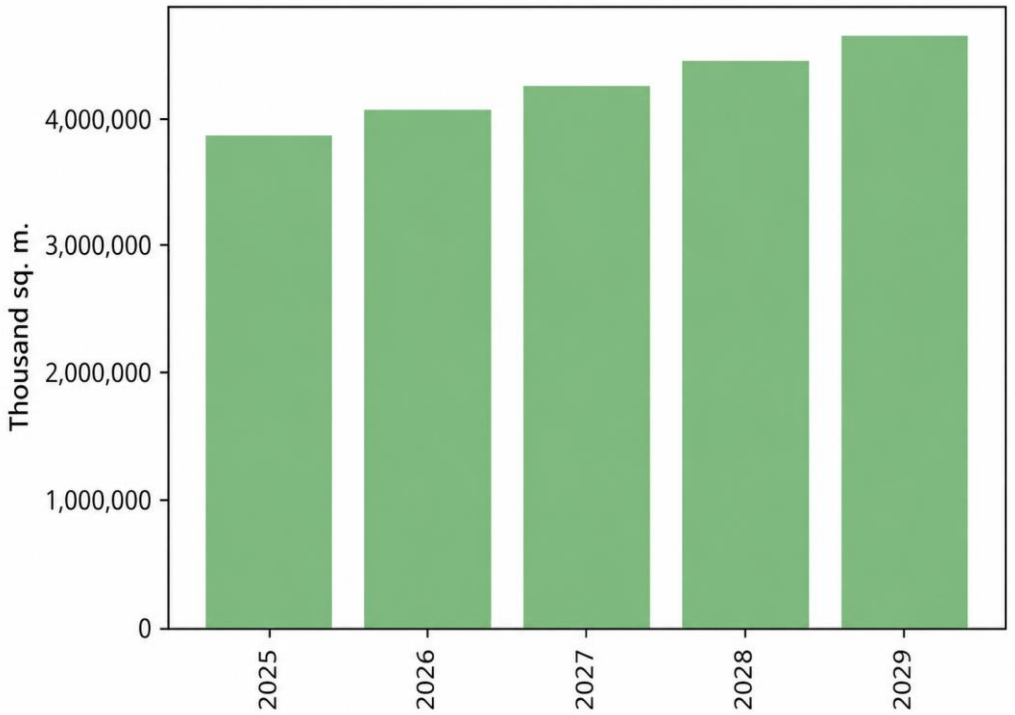


Figure 1. Forecast of trends in the Russian corrugated cardboard market

The main drivers of old corrugated cardboard (OCC) utilization

It is common knowledge that innovative technological trends include the use of lightweight materials, environmental-safety optimization, increasing the share of recycled raw materials up to 70–80 %, digitalization, and regional expansion. Therefore, we point out the main drivers of OCC utilization:

1. The rise of e-commerce. In 2024–2025, online sales increased by 36–42 %, which directly boosted demand for corrugated cardboard shipping boxes.

2. Import substitution in the food and pharmaceutical industries → Food, beverage, and pharmaceutical manufacturers increased production, driving up demand for transport packaging [2].
3. Government environmental policy → According to the Russian Government's Order No. 2827-r dated October 14, 2024, effective from September 1, 2025 adopted banning certain types of plastic packaging production [3]. Pursuant to Federal Law No. 451-FZ (came into force January 1, 2024), which amends the Law on Production and Consumption Waste, the Extended Producer Responsibility (EPR) framework has seen significant qualitative improvements. In 2026, companies transitioned to mandatory recycling of 75 % of their packaging, and from 2027, this responsibility will extend to the entire volume of packaging produced [4].

This encourages an increase in the proportion of recycled materials used in corrugated cardboard production.

In this context, the key challenge for manufacturers is to give their products unique features without significantly increasing their cost. This increases product competitiveness on an oversupply market.

The liner and its significance in the corrugated cardboard structure

Corrugated cardboard is one of the most widely used material due to its combination of low cost, high physical and mechanical properties, the possibility of use at various stages of logistics and retail.

Liner is used for outer and inner flat layers of corrugated cardboard. It determines strength and appearance of the packaging. It is important to improve the properties of the liner – the “face” of the packaging: its technological characteristics and properties affect print quality, brand perception and the consumer's assessment of product quality.

The following requirements apply to the liner:

- Strength properties (bursting strength, edgewise crash resistance)
- Consumer properties (surface smoothness, surface water absorptiveness at one-sided wetting)

Based on the type of fibrous raw material, liners are classified into several groups, which differ in terms of strength, appearance, cost, and application.

Kraftliner is produced from virgin fiber – a mixture of semi-cellulose or mechanical pulp with sulphate pulp. This ensures high strength (breaking length up to 4500 m, bursting strength up to 190 kPa). Bleached cellulose is used to improve quality. This ensures good ISO whiteness (70–85 %), a smooth surface, and high printing properties. However, the use of virgin raw materials makes this material more expensive. Cost expenditures for production are 2-4 times higher than those at paper recycling enterprises.

In Russia, testliners for corrugated cardboard are often produced from OCC (production and consumption waste from corrugated cardboard and its components). Fiber from OCC provides high strength properties, as it consists of waste from unbleached fibrous semi-finished products. However, this cardboard has poor optical properties (ISO whiteness of 25–35 %, a color closer to gray or light brown) and a less smooth surface. This limits the possibility of high-quality printing and, consequently, the visual appeal of the packaging. The use of such a testliner is appropriate for mass-

market packaging, where strength and cost are the priorities rather than design [5, p. 6-9].

Thus, there is a need for a material that offers higher optical and print properties without significantly increasing costs, bridging the gap between a standard testliner and a testliner with a top layer made of bleached pulp. The Department of cellulose and composite materials technology (CCMT) of the Higher School of Technology and Energy investigates the use of bleached recycled fiber from OCC for the top layer of the testliner as a potential solution, and is also conducting research to identify the optimal bleaching method.

The purpose of this paper is to present the results of the assembly unit of OCC bleaching development.

Processing line modernization

At most Russian plants, the OCC processing line includes the following main stages: pulping of waste paper in a hydropulper, sorting, removal of heavy and light impurities, fractionation, thickening, thermal dispersion, and refining. The fiber bleaching stage is absent in a conventional line, which accounts for the low optical properties of the finished testliner.

To achieve the ISO whiteness targets (50 %), it is proposed to design a section for bleaching recycled fiber and integrate it into the existing OCC processing line.

It is proposed to use the bleached recycled fiber for the top layer of the testliner, which would provide higher optical and print properties without a significant increase in cost.

The integrated assembly unit for the testliner top layer bleaching will include the following stages:

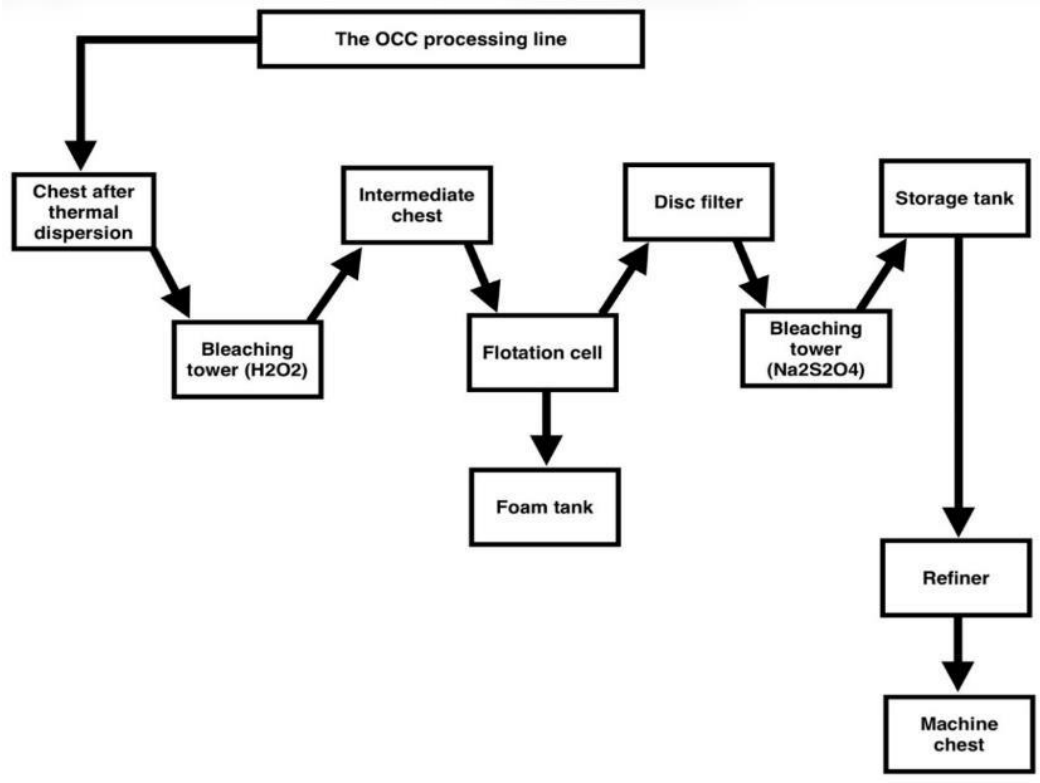


Figure 2. Flow diagram of the integrated assembly unit

After the thermal dispersion stage, during which residual light impurities and printing ink particles are ground down to sizes invisible to the naked eye, the slurry is supplied to the chest, where chemicals - hydrogen peroxide, sodium hydroxide, sodium silicate – are added, and then to the first bleaching stage (oxidative), which takes place in the bleaching tower. Bleaching is carried out at a high slurry concentration (30 %) and a peroxide concentration of ~35 %. The bleaching time is ~60 minutes. Conducting bleaching at a high concentration ensures:

- reduced chemical consumption;
- shorter bleaching time.

At the bottom of the tower, the slurry is diluted with recirculating water (clear filtrate) to a concentration of 1 % and pumped into a chest.

From the chest, the slurry is supplied to the flotation. Liquid soap is added to the slurry prior to flotation. Air is introduced into the suspension, forming bubbles. Hydrophobic particles – residues of paint, coating colors, and stickies – adhere to the bubbles, which rise to the surface as foam. The foam layer with impurities is removed.

The slurry is then supplied to a disc filter. The main objective is to separate the water from the slurry while simultaneously removing fine impurities. The slurry is concentrated to a 12 % concentration. The process is based on filtration through a screen under the action of a pressure difference: the filtrate passes through it, while the fibers are retained and form a layer on the surface.

After thickening, the slurry proceeds to the second bleaching stage. The second bleaching stage (reductive) is carried out with sodium hydrosulfite in the bleaching tower. Two-stage bleaching using oxidative and reductive reagents ensures a high degree of whiteness.

The finished slurry is supplied to a storage tank and then, to refining.

Types and purposes of chemicals:

- Sodium hydroxide – creation of an alkaline condition, improvement of fiber swelling-up, removal of printing inks;
- Hydrogen peroxide – bleaching agent;
- Sodium silicate – stabilizes hydrogen peroxide;
- Soap – increases the hydrophobicity of ink particles;
- Sodium hydrosulfite – bleaching agent.

Conclusion

The corrugated cardboard market analysis conducted and scientific literature review performed proved the fact of the necessity to improve the optical properties of the testliner. The use of a traditional testliner made from old corrugated cardboard is limited by its low ISO whiteness (25–35 %), while the use of a kraftliner with bleached virgin pulp significantly increases production costs. A promising solution is the bleaching of OCC recycled fiber for the top layer, which would yield a product with improved optical properties while maintaining an acceptable cost.

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УДК 004.738.5

HOW DO SOCIAL NETWORKS KNOW WHAT TO SHOW US?

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Abstract. The article discusses the basic principles of recommendation algorithms in social networks. It shows how user behavior affects the formation of a news feed. The article explains the mechanisms of content personalization, including user activity analysis, collaborative filtering, and attention-grabbing strategies. Special attention is given to the limitations of algorithms and their inability to interpret complex behavioral contexts.

Keywords: social networks, recommendation algorithms, personalization, user behavior, collaborative filtering, and attention retention.

КАК СОЦИАЛЬНЫЕ СЕТИ УЗНАЮТ, ЧТО НАМ ПОКАЗЫВАТЬ?

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Аннотация. В статье рассматриваются базовые принципы работы алгоритмов рекомендаций в социальных сетях. Показано, каким образом пользовательское поведение влияет на формирование новостной ленты. Объясняются механизмы персонализации контента, включая анализ действий пользователя, коллаборативную фильтрацию и стратегии удержания внимания. Особое внимание уделяется ограничениям алгоритмов и их неспособности интерпретировать сложный контекст поведения.

Ключевые слова: социальные сети, алгоритмы рекомендаций, персонализация, пользовательское поведение, коллаборативная фильтрация, удержание внимания.

Social networks have become the primary channel for news, entertainment, and interpersonal communication for a significant portion of the world's population. According to DataReportal for 2024, the average user spends approximately 2 hours and 23 minutes per day on social media [1, с. 45]. At the heart of shaping user

experience are recommendation algorithms – machine learning systems that select and rank content in real-time within the feed.

Among users, both optimistic and concerning views about how these algorithms work are widespread. On one hand, many appreciate the convenience of a personalized feed. On the other, concerns are regularly voiced that social networks "read minds," "eavesdrop on conversations," or deliberately trap a person in an ideological bubble [2, p. 12].

The purpose of this paper is to provide a systematic yet accessible explanation for non-specialists of how social networks actually determine relevant content. This article addresses the following tasks: 1) describe the main types of signals used by algorithms; 2) analyze the collaborative filtering method; 3) demonstrate the role of user retention as the primary objective function; 4) discuss social consequences and popular myths.

We will examine this using the social network VKontakte as an example.

1. You get what you do

The algorithm can be compared to an attentive assistant that tracks your every action on VKontakte.

At the core of any recommendation system lies the collection and processing of behavioral data, typically divided into two categories [3, p. 294].

Explicit signals are actions that users consciously perform, directly expressing their attitude toward content:

- Likes: if you like a rock music post, the system records your interest in rock.
- Subscriptions: the pages and bloggers you follow largely define your feed.
- Comments: even a negative comment signals engagement.
- Viewing time: finishing a long article suggests strong interest; skipping quickly suggests the opposite.
- Shares and bookmarks: these act as “super-likes,” increasing similar content.

Implicit signals are recorded automatically, often without deliberate intent:

- video watch time (whether content is watched fully or skipped);
- scrolling speed;
- repeated views;
- commenting behavior (length, emotional tone);
- clicks on links within posts.

Implicit signals are considered more reliable [4, p. 14]. Explicit actions can be random or manipulated, whereas implicit behavior is harder to fake. For example, watching content that вызывает negative emotions (anger, anxiety) still signals high engagement. As a result, “hated content” may be promoted just as much as enjoyable content.

2. Collaborative Filtering: The “Similar Users” Principle

Collaborative filtering is one of the key methods for building recommendation systems, used in virtually all major social networks [3, p. 293]. Its essence is as follows: the system finds a group of users whose behavioral patterns (history of likes, views, pauses) are maximally similar to those of the given user. The user is then offered content that has already generated high engagement among these "digital twins" but has not yet been viewed by the user themselves.

For social networks, the advantage of this approach is obvious: the system does not need to deeply analyze the content of each post or video (e.g., recognizing objects in an image or the semantics of text). It is enough to know that "User A behaves like User B."

But there is a dark side to this – the information bubble [2, p. 25]. If you always like the same thing (e.g., only memes), the algorithm will start showing you only memes. The longer a user remains in the system, the less frequently they are shown content that falls outside already established interests. Escaping the bubble becomes a random event with low probability.

3. User Retention as the Main Objective

Although users may feel that the social network's algorithm selflessly aims to satisfy their interests, the economic logic must be understood. The business model of most social networks is based on advertising. The platform's revenue is directly proportional to the time users spend in the application. Accordingly, the algorithm's objective function maximizes not "objective benefit" to the user, but retention and engagement [1, p. 78].

To achieve this goal, algorithms exploit known mechanisms from behavioral psychology. In particular, the variable reward schedule – the same principle used in slot machines [5, p. 23]. A user scrolling through their feed does not know what content will appear next. Each new post is a "spin" of the reels. The unpredictability of the outcome triggers a dopamine response, reinforcing the habit of returning to the app again and again

A 2018 Stanford study directly showed that pull-to-refresh mechanisms and infinite scrolling activate the same neural circuits as gambling. This is not accidental — such behavioral architecture was intentionally designed.

Furthermore, algorithms quickly learn that emotionally charged content (fear, anger, surprise, joy) generates higher retention rates than neutral or calm content [6, p. 1148]. So the feed often looks as if the world is falling apart. In reality, the algorithm is simply feeding you what grabs your attention most strongly.

4. What Social Networks Do NOT Understand

It seems like the algorithm knows everything about us. But that's not true [4, p. 205]. There are things it does not see or understand:

- Accidental clicks. You accidentally liked an ex's post? The algorithm decides you're interested in their life and will start showing them to you more often.
- The difference between "like" and "annoys me, but I read it." For the algorithm, prolonged viewing is always a signal that "this is interesting."
- Context. You searched for a cake recipe for your sick grandmother, but the algorithm decided you've become a sweet tooth and flooded you with cooking posts.
- Your actual mood. Today you're feeling down, and you're scrolling through silly videos. The algorithm will remember this forever, even when you're happy again.

Consequently, the algorithm relies exclusively on recorded actions and is incapable of distinguishing their underlying reasons [6, p. 15].

5. What About “Listening”?

Many of us have experienced an eerie feeling: you speak out loud about a new vacuum cleaner, and half an hour later you see an ad for vacuum cleaners on your phone. It seems like social networks turn on the microphone and eavesdrop on conversations.

Research suggests otherwise [7, p. 16]. In 2017–2019, scientists from Northeastern University (USA), in collaboration with Google, conducted a large-scale experiment. Volunteers installed a special application for a week that recorded everything said around them, and these recordings were compared with the ads participants later saw. No systematic coincidences were found.

So where does the illusion of eavesdropping come from? Several explanations exist:

1. The Baader-Meinhof Phenomenon (or frequency illusion). As soon as you think about or mention something, your brain starts noticing that topic everywhere. The vacuum cleaner ads were there before, but you simply ignored them. Now – you notice them.

2. Geolocation. You entered an appliance store, and the social network detected this. Vacuum cleaner ads will reach you the same day.

3. Friend behavior. Your partner googled vacuum cleaners from your home IP address or was simply sitting next to you – and the targeting "transferred" to you as well.

4. The predictive power of algorithms [4, p. 210]. Social networks know your habits and seasonal patterns so well that they can predict an interest in a vacuum cleaner (spring cleaning, and your old model statistically broke 2 years ago) faster than you can utter the word out loud.

Thus, “listening” is unnecessary – algorithms already have sufficient data.

6. Conclusion

Recommendation algorithms in social networks are based on analyzing user behavior and applying machine learning methods. They do not read minds or eavesdrop on conversations, but they do predict user behavior with high accuracy based on their past actions (explicit and implicit signals) and the actions of their "digital twins [8, p. 30]." The primary objective function of algorithms is not "benefit" to the user, but maximizing time spent in the application, which leads to the amplification of emotionally charged content and the formation of information bubbles [2, p. 30].

Understanding these principles allows users to develop a more conscious strategy for behaving in the digital environment: avoid engaging with unwanted content, deliberately "break up" the information bubble by searching for alternative topics, and think critically about the illusion of total eavesdropping.

What does this mean for the average user?

- If you don't want the algorithm to show something – don't like it, don't watch it, don't comment on it, don't save it. Even if you're doing it out of negativity.
- Occasionally, intentionally search for and view content that falls outside your usual interests. This "untangles" the bubble.

– Don't believe the eavesdropping myth – but remember that geolocation, browser history, and your friends' behavior reveal far more about you than a microphone ever could.

And most importantly – understand: your feed is a mirror of your digital habits. A distorted, stubborn, but nonetheless a mirror. And only you can change it.

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УДК 621.9.048+621.3.013.6

DEVELOPMENT OF A LOW-VOLTAGE CAPACITOR FOR THE SPACE INDUSTRY: WORKING PRINCIPLE, WAYS TO IMPROVE EFFICIENCY

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Abstract. The article presents an analysis of the electrohydraulic effect (Yutkin's effect) and the design of a low-voltage cavitation based on the evaporation of conductive wire during discharge of condenser battery. The author describes methods to increase the efficiency of the installation, advantages of the technology for space production, areas of application and the prospects of electro-hydraulic converters as an element of technological sovereignty in the space industry.

Keywords: electro-hydraulic effect, Yutkin effect, space industry, low voltage cavitation.

РАЗРАБОТКА НИЗКОВОЛЬТНОГО КАВИТАТОРА ДЛЯ КОСМИЧЕСКОЙ ОТРАСЛИ: ПРИНЦИП РАБОТЫ И СПОСОБЫ ПОВЫШЕНИЯ ЭФФЕКТИВНОСТИ

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Аннотация. В статье представлен анализ электрогидравлического эффекта (эффекта Юткина) и потенциала его применения в космической отрасли. Автор описывает конструкцию низковольтного кавитатора, работающего на основе испарения проводящей проволоки при разряде конденсаторной батареи. Рассматриваются методы повышения эффективности установки, показаны преимущества технологии для космического производства, возможность замены традиционного пресса с двойной формой на гибкую систему с одной активной формой. Делается вывод о перспективности электрогидравлических преобразователей как элемента технологического суверенитета в космической отрасли.

Ключевые слова: электрогидравлический эффект, эффект Юткина, космическая отрасль, низковольтная кавитация.

The electro-hydraulic effect and its potential for the space industry. The electro-hydraulic effect (Yutkin's effect) is a physical phenomenon in which high pressure occurs in a liquid environment due to high voltage electrical discharge between the electrodes immersed therein. At the heart of the process is the release of energy in the form of a pulsed shock wave spreading from the discharge channel. This wave creates a superstrong pressure that can be specifically used to perform mechanical work: deformation of materials, destruction of contaminants, dispersion of substances**.**

Technology is of particular value to the space industry for several reasons. It consumes little energy and requires no connection to a powerful external power source, which is critical for orbital stations and interplanetary missions. In addition, the method is universal - it can be applied to solve diverse tasks: from stamping metal parts to cleaning and shredding materials. Substantially also that the process takes place in a liquid environment, excluding dust formation dangerous in closed spaces of spacecraft. [1, p. 26].

Low-voltage cavity operating principle. The design of the low-voltage cavity is shown in Fig. 1. The electrohydraulic effect is realized by controlled evaporation of the conductive element - copper wire - during discharge of the condenser battery. The process proceeds in several sequential steps. First, capacitors are charged from grid to 320V voltage. After the control signal is delivered, the power supply is switched off to protect the network from overload. Then the charged capacitors are switched to the load (wire) and a powerful current pulse passes through it.



Figure 1. Appearance of the capacitor

As a result, the wire evaporates instantly, forming a plasma channel. This leads to explosive expansion of the fluid around the channel, generating a shock wave and cavitation bubbles. The shock wave spreads in the work environment, creating local super-high pressure zones. This is the pressure and performs useful mechanical work: it deforms metal, destroys pollution, disperses solid particles.

The low-voltage solution has a number of crucial advantages over high-voltage counterparts. First, it is significantly safer to operate: lower voltage reduces the risk of leaky isolation and injury for staff. Secondly, the design is more compact – no need for bulky high-voltage units and reinforced protection. Thirdly, the cost of components and operating costs are lower, which is important when technology is widely adopted in space production [2, p. 134].

Structural features of the capacitor. The installation includes several key functional elements that ensure its operability and efficiency. The base is a condensing battery with a capacity of about 600 μF and a working voltage of 320-630 V. It accumulates energy, which is then released abruptly in the work area. Power relays are used to switch the load and are controlled by logic keys. The work chamber is filled with liquid (usually water or a special process environment) and equipped with electrodes or wire holders.

When designing a plant, the electrical diagram of which is shown in figure 2. Special attentions are paid to critical parameters that directly affect its performance. The diameter and material of the wire determine the amount of energy released during discharge, as well as the hydrodynamic parameters of the shock wave: the greater the thickness of the wire, the more energy is released, but also the higher the cost of its evaporation. The speed of switching devices (relays) is critical: if switching is not fast enough, the wire does not evaporate completely and some energy dissipates. Capacitance of the capacitors provides a total energy reserve that can be converted into mechanical work; its increase leads directly to an increase in pulse power.

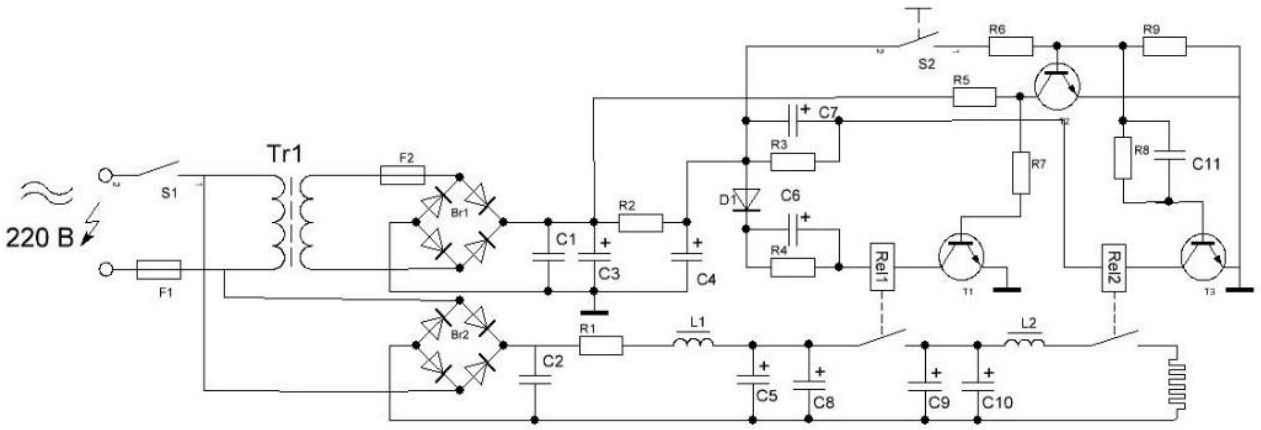


Figure 2. The cavitation diagram

Moreover, the properties of a working fluid such as density, viscosity, and electrical conductivity play an important role. For example, adding salts can improve conductivity and intensify discharge but also increase the corrosive activity of the environment. Therefore, the choice of liquid is a compromise between discharge efficiency and equipment durability [3, p. 40].

Ways to increase efficiency and power of the instrument. During the experimental testing of the installation, limitations in the original construction of the cavity were identified as reducing its efficiency. The results of the experimental launches are shown in Figure 3 and Figure 4. First of all, there was a “sticking” of the contacts i.e. the relay contacts did not completely open, creating parasitic currents and overheating. This shortcoming required a systemic solution aimed at increasing the plant’s efficiency and capacity.





Figures 3-4. Jar of water before the explosion and during the explosion

The first step was to modernize the commutation system. Thus, through the use of faster relay it was possible to reduce switching time to milliseconds. This ensured that the wire received its full current instantly and evaporated completely in a minimum amount of time. This solution significantly increased the efficiency of converting electric energy into mechanical.

The second area of optimization was to reduce transition resistance in contact groups. For this purpose, the relay contacts were covered with a silver layer, which reduced the ohmic resistance and minimized current loss on side loads. As a result, much of the spare energy was directed directly to the work area and not dissipated as heat in contacts.

The third way to increase capacity was to increase capacitance of the capacitors, although this led to an increase in mass and dimensions of the installation, the gain in energy momentum proved significant. The more capacitive capacitors accumulated more charge, allowing for stronger shock waves and larger parts to be processed [4, p. 58].

The fourth solution was to use multipliers of tension. Thus, by including a voltage multiplier in the circuit, it was possible to raise the operating voltage from 320 V to 630 V without drastic change of the instrument design. This nearly doubled the reserve current while maintaining safe operating conditions and no critical insulation loads. [5, p. 327].

Application of low-voltage capacitor in the space industry. The developed technology offers a wide range of opportunities to address key challenges in the space industry, where traditional methods are often either too energy-intensive or inapplicable due to mass, volume, and safety constraints.

In the field of metal stamping, the capacitor allows abandoning classic presses that require the use of paired forms (positive and negative). Instead, a universal system with a single active form can be applied in which the workpiece is placed. Under the impact of the shock wave, metal is deformed to take on the desired configuration. This approach simplifies the manufacturing process, reduces tooling weight and allows you to quickly re-engineer production for different parts. This is especially true for orbital assembly complexes, where every kilogram of cargo is critical.

When cleaning parts, the instrument is highly effective at removing alkali, rust,

mold earth and other contaminants. The process takes place in a water environment, which completely rules out dust formation - a factor dangerous to electronics and the crew's respiratory system. In addition, the shock waves penetrate into hard-to-reach cavities and cracks, ensuring even cleaning of complex parts. This is important when preparing the units for reuse or when carrying out regulatory work on board the station. The design of the installation chamber is shown in Figure 5, it has three varieties.

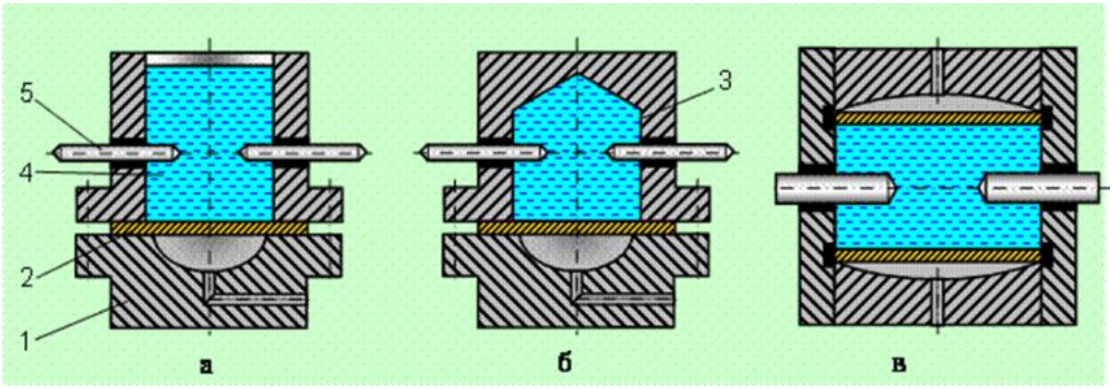


Figure 5. General view of press based on the capacitor:
1 – Lower aisle, press form; 2 – Processing the part; 3 – Working fluid; 4 – Upper half chamber; 5 – Electrodes

In the field of shredding, a low-voltage cavitation allows for efficient crushing of minerals, fragile alloys and rock. Compared to traditional explosive methods, this solution is cheaper, safer and more precise: the energy of the pulse can be adjusted by obtaining the desired particle size. Such a technology is promising for the processing of lunar regolite or Martian soil to produce building materials or raw material for 3D printing.

The technology is also applicable for overload testing of articles. By simulating impact, it is possible to check the strength of structures by simulating launch, landing or docking conditions. This is necessary for the certification of components before their use in spacecraft. Thus, the method allows to detect hidden defects - micro fractures, stratifications - which can only occur under extreme loads [6, p. 165].

In addition, the plant is suitable for surface treatment: formation of emulsions, sterilization of wastewater, modification of soil properties. In particular, shock waves can destroy the cell walls of microorganisms, disinfecting water without chemical reagents. This is important for closed life support systems where consumption of consumables must be minimized. In the long run, technology can be used to improve soil fertility in space greenhouse labs by destroying dense aggregates and improving aeration.

The author has developed a low-voltage capacitor, the operation of which is based on the electrohydraulic effect in the form of wire evaporation during the discharge of capacitors with an operating voltage of 320-630 V. The installation combines compactness, safety and relatively low cost of components, which makes it a promising entry point for space production. The proposed methods of increasing efficiency – retrofitting the relay, silver-plating contacts, increasing capacitance and voltage of the capacitors, optimization of the geometry of the work area – have significantly improved the device's performance. In particular, it was possible to reduce the switching time to units of milliseconds; reduce the contact transition resistance;

increase the reserve energy of the pulse; increase the speed of the buildup of the impact wave front.

The practical applicability of the technology has been confirmed for a number of key processes in the space industry: stamping, cleaning, shredding and testing. Its main advantages (autonomy, versatility, lower production costs and environmental friendliness) meet the requirements of equipment for orbital and interplanetary missions. In the future, the author plans to further scale up the plant's capacity, integrate it into production lines of space enterprises and adapt it for use in bioregenerative systems. This will open up new opportunities for the space industry, including the creation of closed production cycles at orbital stations; processing of local raw materials (regalite, ice) on the Moon and Mars; production of spare parts and tools, etc.

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УДК 62-52

PROBLEMS OF MISMATCH BETWEEN DESIGN ASSUMPTIONS AND REAL OPERATING CONDITIONS OF AUTONOMOUS TECHNICAL SYSTEMS

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Abstract. The paper examines how mismatches between design assumptions and real operating conditions gradually reduce the reliability of autonomous technical systems. It shows that timing drift, degraded data quality, environmental stress, power constraints, maintenance actions, and transitional operating modes can weaken control coherence without producing immediate failures. The study emphasizes adaptation, monitoring, modularity, and recalibration as practical ways to maintain controllability in changing environments.

Keywords: autonomous technical systems, design assumptions, operating conditions, reliability, timing drift, adaptation, system stability.

ПРОБЛЕМЫ НЕСООТВЕТСТВИЯ ПРОЕКТНЫХ ПРЕДПОЛОЖЕНИЙ И РЕАЛЬНЫХ УСЛОВИЙ ЭКСПЛУАТАЦИИ АВТОНОМНЫХ ТЕХНИЧЕСКИХ СИСТЕМ

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Аннотация. В статье рассматривается влияние несоответствия проектных предположений реальным условиям эксплуатации на надежность автономных технических систем. Показано, что дрейф времени, ухудшение качества данных, внешние воздействия, ограничения по энергии, обслуживание и переходные режимы постепенно снижают согласованность управления без явных отказов. Обоснованы мониторинг, адаптация, модульность и перекалибровка как практические способы сохранения управляемости.

Ключевые слова: автономные технические системы, проектные предположения, условия эксплуатации, надежность, временной дрейф, адаптация, устойчивость системы.

Autonomous systems are usually designed using simplified models of their environment and operation. Engineers assume a limited set of conditions – for example, fixed ranges for temperature, vibration, mechanical load, communication delay, sensor accuracy, and available energy – to keep the design manageable. These assumptions

underpin the system's architecture, control algorithms, and performance guarantees [1, 4]. In practice, this effectively locks in many system parameters, allowing engineers to predict and verify behavior under known conditions.

But when reality deviates from those assumptions, the guarantees can break down. Autonomous systems – especially in safety-critical domains – often face large uncertainties that can erode reliability. Real-world failures highlight this danger. For instance, investigators concluded that flawed assumptions about pilot reaction times were a key factor in the Boeing 737 MAX crashes. Likewise, a 2018 fatal crash of an autonomous car in Tempe, Arizona was traced to software that misclassified a real pedestrian as a false alarm. Such incidents show that ensuring each component works correctly isn't enough if the system's higher-level logic or environmental assumptions fail.

During development, designers typically treat key assumptions as fixed parameters. For example, they might set sensor update rates to fixed intervals, budget CPU time for a given processor load, and assume communication links have bounded latency and no packet loss. Each subsystem expects the others to behave within those predefined limits. Under these idealized conditions, the system functions in a tightly coordinated way: data arrives on time, control actions execute in a steady sequence, and feedback loops operate with known delays. This makes the system's behavior analyzable and optimizable under the original model.

However, these coordination assumptions are rarely rechecked once the system is deployed. The system's internal "model" stays valid only as long as reality conforms to it. Modern safety standards even acknowledge this risk: they explicitly note that even if every component works correctly, unexpected system behaviors can still arise when assumptions fail [1]. For example, recent aerospace guidelines define an "unexpected operation of integrated systems" as a hazard even if no individual component has a fault. In other words, it's the interactions between parts – not just the parts themselves – that determine overall behavior. Hidden assumptions about timing, data quality, or environment can drift unnoticed, slowly creating a gap between the theoretical design model and the running system [5].

For instance, formal verification might prove a controller safe under idealized parameters. But if those parameters shift, the proof no longer holds. Imagine a robot controller verified with a fixed friction coefficient. If an unexpected oil spill suddenly reduces the floor friction, the controller's previously "safe" state space can expand into unsafe regions. The controller may then drive too aggressively on the slick surface and collide. In short, the very conditions that enabled the design to be validated can change in the field, invalidating its guarantees.

The first signs of this mismatch usually appear in timing and data handling. What was assumed to be stable timing becomes variable under real workloads. Execution cycles may slow or speed up due to processor load spikes, multitasking, or operating-system jitter. Communication delays can vary with interference or network traffic. These factors weaken the assumed synchronization between sensing, computation, and actuation [4, 5].

Even tiny timing mismatches can have big effects in tightly coupled systems. If a control loop expects a fresh sensor reading but gets data a few milliseconds late, the

controller is acting on outdated information. It might overshoot or oscillate while trying to correct a stale error. Over many cycles, these tiny delays add up, reducing tracking precision. In practice, the robot may still follow its intended path roughly, but with lower accuracy and stability. Timing drift doesn't usually cause an immediate crash, but it quietly degrades performance over time [4].

Similarly, assumptions about data delivery break down. A design might assume data arrives reliably, but in reality, sensor measurements can come irregularly or even be dropped. As delays become unpredictable, subsystems that once marched in lockstep start to fall out of sync. One controller might act on a delayed input while another moves ahead. The result is that the logical consistency between components deteriorates. The system keeps running, but not with the rigid coordination the original design presumed [5].

Information quality degrades too. Sensors still output data, but the relationship between those readings and the actual state becomes less certain. Changes in lighting or temperature, component aging, or mechanical disturbances introduce biases and noise that were not in the model. Even if the data look valid, their reliability can drop. The estimator or controller will keep using these values, unaware the data's meaning has shifted. Gradual sensor drift often goes unnoticed because simple diagnostics only flag obvious faults [2, 3]. So the system might continue trusting inputs that are technically within bounds but increasingly inaccurate.

In effect, mismatches in timing and data create scattered errors throughout the system, rather than one clear failure. The machine stays "up" overall, but it becomes more sensitive to disturbances and loses precision. Small inconsistencies compound: a late sensor here, an out-of-sync command there. On the surface the system seems healthy, but internally its model no longer matches reality. Over time, it becomes more brittle when faced with new challenges [1].

Mismatch grows even bigger when the system interacts with the physical world. During design, factors like temperature, vibration, and load are given simplified bounds. In reality, those conditions fluctuate and combine in complex ways. Surfaces wear out, tolerances shift, and unexpected stresses occur. Each subtle physical change can alter how control commands translate into motion [2].

A concrete example is friction and wear. A controller tuned for a specific friction coefficient will behave predictably in that context. But as parts wear or conditions change, the robot's response diverges from the model. The controller may keep sending the same commands it "thinks" are correct, but the resulting motion no longer matches the plan. Over many cycles, these small physical discrepancies – loose bolts, tiny scratches, uneven terrain – add up, pulling the system further from its original behavior [2, 4].

Temperature is another factor. Components expand or contract, and material properties shift with heat. Electronic sensors and circuits can drift when operating outside their nominal temperature range. Even if the system runs within its rated limits, repeated heating and cooling can gradually alter performance. For instance, a motor that runs hot on one day might deliver a slightly different torque the next day. These thermal drifts typically lie outside the simple models used in design [3].

Vibration and long-term stress cause similar problems. Continuous vibration can

loosen joints or fasteners. Over time, a camera mount might shift by millimeters, or a gearbox might develop play. Such mechanical degradation may never be labeled as a "fault", yet it subtly changes the system's dynamics [2]. The original calibration becomes inaccurate as the machine ages. Eventually, the assumption that "the machine we designed" still exists ceases to hold – the running system is effectively a different machine than the one that was tested.

These physical factors often combine nonlinearly. For example, temperature swings can worsen mechanical stress, or moisture can alter both friction and corrosion rates. Such interactions make the operating conditions far more complex than any single parameter suggests [1, 2]. Over time, many small deviations reinforce each other, so the system's behavior reflects a landscape of conditions far from the original assumption. At that point, the machine may still run, but it is operating on an evolved model of reality rather than the one used in design.

Energy and maintenance issues deepen the mismatch further. Power budgets and battery life are usually calculated for ideal workloads. But in real-world use, workloads vary, the environment demands different power, and batteries age. When actual power use drifts from predictions, the system might automatically reduce performance to save energy. These measures keep the system alive but also change its timing and resource availability. Tasks that once ran in parallel may now run sequentially, breaking the timing assumptions of the original design.

Maintenance, software updates, and repairs introduce more change. Autonomous systems in the field are rarely static. Sensors get replaced, software is patched, and settings are recalibrated. Each intervention, even a small one, shifts the system's profile. A new sensor might have slightly different noise characteristics; a recalibrated joint might behave with a different offset. Over time, these small changes accumulate. The machine operating months or years after deployment is not identical to the one originally tested. Its internal coherence now depends on a history of updates rather than a single fixed design [1].

Altogether, these lifecycle effects mean design assumptions should be treated as hypotheses to revalidate, not immutable truths [1]. In practice, they rarely stay valid without recalibration. Unfortunately, many systems lack automated ways to realign them. As a result, an autonomous system gradually "drifts" away from its design model through normal wear, updates, and environmental variation. This drift consumes the system's design margins: its tolerance for disturbance shrinks over time, even if no explicit failure occurs.

Certain operating modes expose mismatches most clearly. Startup and shutdown sequences, or switching between major modes, require precise sequencing and timing. In design, these transitions are often treated as brief and predictable. In reality, startups may occur under non-ideal conditions. Components might activate in the wrong order or lag behind others. The result is that a system which runs smoothly in steady state may behave unpredictably during transitions. Mismatch becomes most visible exactly at these moments of change.

When multiple autonomous units work together, the problem scales up. Coordinated operation depends on shared assumptions about time, data consistency, and behavior [4, 5]. If one unit drifts, it can disrupt the whole group. A fleet of drones

might rely on synchronized positioning; if one drone's updates lag, formation flying degrades. Similarly, networked robots often assume reliable messaging; a network glitch on one robot can break a group task. In effect, even if a single machine still "functions," it can introduce errors in the team's behavior if its internal state no longer matches the group's expectations.

The human element ties into these assumptions too. Autonomous systems typically provide diagnostics or require operator oversight. These interfaces are designed with the same fixed assumptions. If the machine's behavior drifts, the information shown to a human can be misleading. An operator might trust a normal voltage reading even if the battery is failing in reality. Conversely, unexpected system behavior can confuse operators who expect the machine to follow its design model. Thus, mismatches also affect how people perceive, control, and fix autonomous systems [2].

In summary, mismatch is a multi-layered phenomenon. It affects timing, data consistency, physical behavior, power management, software, and even human interfaces. There isn't a single failed part to point at; rather, many small deviations add up across the system. Over time, the system remains "operational" but increasingly diverges from its original design model. Recognizing this requires a shift in how we define reliability for autonomous systems.

Because mismatch is inevitable, we can't rely on traditional reliability alone. Instead, reliability must be viewed dynamically: the system's ability to stay safe and controllable even as conditions change. In other words, a system could appear to work fine by conventional checks yet be drifting toward trouble under the surface.

To handle this, autonomous systems need built-in validation and adaptation. One strategy is continuous health monitoring [2, 5]. For example, the system might track execution delays, communication latencies, or data consistency measures. If timing jitter or packet loss exceeds expected bounds, it could raise an alert. Health checks or cross-checks between redundant sensors can spot slow degradation. Even simple threshold monitors can give early warning that an assumption is breaking.

Once changes are detected, the system should adapt. This might involve retuning control parameters, rescheduling tasks, or shifting the performance/safety balance. For example, if sensor noise grows, the controller might slow down or switch to more conservative filtering. If battery is low, it might enter a power-saving mode and postpone non-critical tasks. These adaptive responses amount to graceful degradation: willingly trading off peak performance to stay safe under new constraints [4].

However, adaptation must be done carefully. Overreacting to brief fluctuations can destabilize the system. That's why adaptive algorithms often include smoothing or hysteresis: they only make adjustments after a sustained trend. For instance, a robot might require several consecutive degraded sensor readings before switching strategy. Balancing responsiveness with stability is a key design challenge.

Transparency and human oversight also help. The system should expose its current health and uncertainty. Clear dashboards or alerts can show when assumptions are no longer valid. Without this transparency, both automation and people might keep relying on outdated models. In critical applications, reporting confidence levels, exception counts, or risk indicators can support better decisions and timely

interventions.

From an engineering standpoint, handling mismatch means evolving how we design and test systems [1, 2]. Instead of only checking performance under fixed conditions, we should test long-term trends. For example, run endurance tests where friction or power gradually changes, or cycle through temperature extremes, to observe how performance drifts. Stress tests that push beyond original limits can reveal how the system behaves as it moves away from the model.

Architecturally, systems should favor loose coupling and modularity. Tightly integrated designs can let mismatches cascade quickly. Modular designs with clear interfaces and timeouts can contain anomalies. We should build systems to allow recalibration and updates in the field, so assumptions can be realigned. For example, including self-calibration routines or over-the-air updates can reset drifting parameters. Redundancy – having multiple sensors or fallback algorithms – provides extra resilience: if one part mismatches, others can keep the system safe.

Importantly, we should accept that we cannot eliminate mismatch entirely – the real world is simply too complex. The goal is accommodation and resilience. We should design systems that continue to function acceptably even when assumptions are violated. Practically, this means keeping a safety envelope: as long as the system stays within a safe margin, we call it reliable. Embracing this mindset – prioritizing adaptability and robustness alongside performance – is crucial for modern autonomous engineering.

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УДК 621.184.5

MECHANISMS OF DAMAGE TO AIR HEATERS

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Abstract. The article discusses the main mechanisms of damage to the air heaters of steam boilers during the combustion of gas-oil fuel: low-temperature sulfuric acid corrosion, adhesive ash deposit, combustion of deposits, and air leakage. A comparative analysis of regenerative and recuperative air heaters, their design features, and operational characteristics is conducted. Traditional and modern methods of protecting the tail surfaces of heaters are summarized: preheating of air, use of additives, enameling of surfaces, and automated cleaning systems.

Keywords: low-temperature corrosion, dew point, ash drift, recuperative air heater, regenerative air heater.

МЕХАНИЗМЫ ПОВРЕЖДЕНИЙ ВОЗДУХОПОДОГРЕВАТЕЛЕЙ

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Аннотация. В статье рассматриваются основные механизмы повреждений воздухоподогревателей паровых котлов при сжигании газомазутного топлива: низкотемпературная сернокислотная коррозия, адгезионный золовой занос, возгорание отложений и перетечки воздуха. Проведен сравнительный анализ регенеративных и рекуперативных воздухоподогревателей, их конструктивных особенностей и эксплуатационных характеристик. Обобщены традиционные и современные методы защиты хвостовых поверхностей нагрева: предварительный подогрев воздуха, применение присадок, эмалирование поверхностей, автоматизированные системы очистки.

Ключевые слова: низкотемпературная коррозия, точка росы, золовой занос, рекуперативный воздухоподогреватель, регенеративный воздухоподогреватель.

Air heaters are an integral part of modern steam boilers, improving their efficiency by utilizing the heat of the exhaust gases. The air heater is the final heat exchange

surface of the boiler and determines the degree of utilization of the combustion products' heat. On the other hand, the completeness of combustion of many fuels depends on the level of air heating. Air heaters consume up to 30-40 % of the total metal used in boiler heat exchange surfaces. Low-temperature corrosion in air heaters causes significant damage [1].

When burning gas-oil fuel, especially high-sulfur oil with a sulfur content of more than 1-1.1 %, the temperature of the inlet sections of the air heater often drops below the thermodynamic dew point of sulfuric acid (110-145 °C), which creates conditions for intense low-temperature corrosion, the accumulation of unburned hydrocarbons, and the formation of dense adhesive deposits. The purpose of this work is to systematize the mechanisms of damage to air heaters during the combustion of gas-oil fuel, to analyze the limitations of traditional protection methods, and to summarize modern approaches to improving the reliability of tail heaters [2]. Steam boilers use two main types of devices for heating blast air: regenerative rotary-rotor air heaters (RAPH) and steel tubular air heaters (TAPH). Over the decades, their designs have evolved in parallel. The development of two types of devices, differing in their technical characteristics and operational limitations, provides sufficient design flexibility and the ability to take into account changing economic factors: the ratio between labor and material resources, cost, equipment reliability requirements, and environmental protection. The main differences between regenerative and tubular air heaters can be considered in four characteristics: compactness of the heating surface, tightness of the gas and air tracts, scheme of the heat carriers movement, complexity of the device.

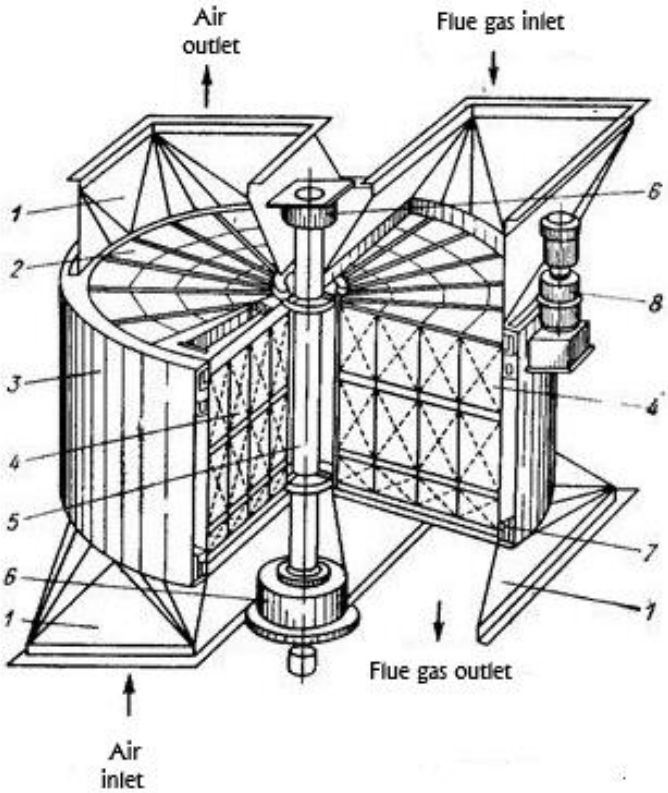


Figure 1. Schematic of the RAPH-54 regenerative air preheater:
1 – box; 2 – drum; 3 – housing; 4 – packing; 5 – shaft; 6 – bearing; 7 – seal;
8 – electric motor

Regenerative air heaters, due to their compactness, have become widespread in high-power power units (Fig. 1). Significant advantages of regenerative air heaters are relatively low metal costs and dimensions, as well as lower aerodynamic drag through gases and air.

The high compactness of the packing in combination with the countercurrent movement of the media provides existing regenerative air heaters with some advantage over the TAPH in terms of weight and size. However, with the advent of high-ash fuels at a number of RAPH power plants, the passage sections began to be clogged with ash due to small gaskets. The aerodynamic resistance of the gas and air tracts increases dramatically (by 2-3 times) when the RAPH is clogged, and the costs for own needs increase, and the exhaust gases are undercooled [3]. The weight and dimensions of tubular air heaters are larger than those of regenerative air heaters, but there is a trend towards convergence of these parameters for tubular and regenerative air heaters. The development and implementation of Z-cross air heaters has significantly contributed to reducing the size and metal consumption of tubular air heaters (Fig. 2). Despite active efforts to create gaskets, the weight reduction of regenerative air heaters is slower, as less than half of the total metal weight of the device is used for the heating surface.

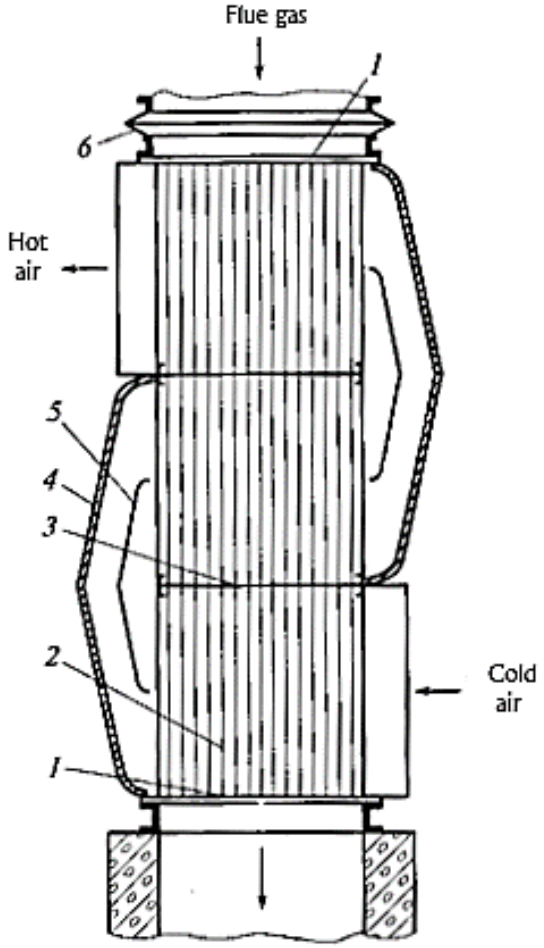


Figure 2. Schematic of a tubular air preheater:
1 – tube sheets; 2 – pipes; 3 – baffle; 4 – shell; 5 – guide vane; 6 – lens-type compensator

The labor intensity of manufacturing and installation is still significantly higher for RAHs than for TAPHs. As a result, the cost of regenerative air heaters is also slightly higher. One of the most important advantages of RAPHs is their greater reliability when operating on sulfurous and abrasive fuels compared to TAPHs. Regenerative air heaters offer lower labor intensity and operating costs compared to older TAPHs, which are prone to ash wear and low-temperature corrosion, leading to significant air leakage into the gas path and requiring frequent repairs. However, the reduced tightness of the air preheater is a significant drawback. As a result, more than 10% of the air flows into the gas path inside the air preheater, increasing the load on the blowers and smoke exhausts without performing any useful work. Another example is the cross-flow of heat carriers in the air preheater, which leads to a decrease in the average temperature difference (Table). However, recent research has revealed some positive aspects of cross-flow, such as the ability to extract air at different temperatures from a single outlet duct [4].

Table. Temperature conditions and corrosion rate

Dew point temperature, °C	Wall temperature, °C	Corrosion rate, mm/year	Note
120-140	70-105	Up to 0,15	Acceptable operation
110-145	65-70	Up to 1,0	Unacceptable (maximum speed)
110-145	Less than 65	0,5-0,8	High rate of corrosion
110-145	More than 105	Less than 0,1	Minimal corrosion

Low-temperature sulfuric acid corrosion affects the tail surfaces of steam boilers in cases where fuel oil and solid fuels with a high sulfur content (usually more than 1-1.1 %) are burned. During the combustion of sulfur fuels, sulfur dioxide so_2 and sulfur anhydride so_3 are formed due to the oxidation of organic compounds containing sulfur and the decomposition of the mineral part of the ash. A relatively small fraction of SO_2 in the temperature range of 1400–400 °C is oxidized to SO_3. In addition, by increasing the exhaust gas temperature, corrosion of metal flues, smoke pumps, and chimneys is eliminated, and the conditions for cleaning the air preheater and dispersing emissions into the environment are improved. and high-sulfur solid fuels, which contain SO_3 and H_2O water vapor, travel through the boiler's gas path and cool down. As a result, at a certain temperature, called the flue gas dew point (110–145 °C), sulfuric acid precipitates, condenses, and settles on surfaces, causing severe corrosion [5].

To avoid corrosion and large deposits of ash on the surfaces of the air preheater, the required inlet air temperature is ensured. The proper temperature regime of the metal of the air preheaters can be achieved by preheating the cold air. The most common method of preventing ash buildup and corrosion of air preheaters abroad and in our country is to preheat the cold air in steam and water heaters. This method is more cost-effective than recirculating hot air or reducing the temperature of the boiler's exhaust gases by increasing the surface area of the air preheater. In addition, by increasing the exhaust gas temperature, corrosion of metal flues, smoke pumps, and

chimneys is eliminated, and the conditions for cleaning the air preheater and dispersing emissions into the environment are improved [6].

Cleaning the heat exchange surfaces of the air preheater and controlling low-temperature corrosion are among the most important factors affecting the reliability of the entire installation. The air preheater is primarily contaminated in the area where water vapor condenses from the flue gases on the heating surface, and this contamination can be reduced by preheating the air before it enters the air preheater. In tubular air preheaters, only the gas path, which is the inner part of the heating surface tubes, is cleaned. They are usually shot-blasted while simultaneously removing contaminants from the horizontal tube bundles located in the downward flue gas duct. The contamination of the tubular air preheater depends on the properties of the ash or soot of the fuel being burned, as well as on the operating conditions, including how regularly the heating surfaces are cleaned. Shot-blasting cannot be used when there is a small distance between the heating surfaces of the regenerative air preheaters. Systematic blowing of the plates during boiler operation and washing off of deposits with a water jet during stops of boiler units or their housings are provided. The blowing devices are installed on the top and bottom of the rotor. The horizontal pipe of such a device with a nozzle facing the heating surface at the end is rotated in the gas channel, and a steam jet with a temperature of up to 450°C and a pressure of up to 4 MPa moves from the peripheral to the central part of the rotor and in the opposite direction. When the rotor rotates, its upper and lower surfaces are blown.

It is considered more effective to wash the plates with heated water from a multi-slot pipe installed in the air channel of the apparatus. In some power plants, both cleaning methods were insufficient, and the aerodynamic resistance of the regenerative air heaters gradually increased. Thermal cleaning of the heating surfaces is considered a more advanced method of cleaning. When the boiler is operating at a reduced load, the air dampers in front of the cleaning unit are closed to increase the temperature of the gases to a predetermined value. The operation of the other air heaters remains unchanged, and the temperature of the flue gases passing through the smoke pumps does not reach dangerous levels or only slightly exceeds them.

Further research can be focused on developing new composite materials with increased corrosion resistance, improving automatic temperature control algorithms for the cold end, and creating more efficient cleaning systems without stopping the boiler.ity of the furnace and convective gas ducts to minimize air leakage, which is not always possible in practice. The implementation of this measure is also complicated by the lack of adaptability of existing burner devices and control systems to ensure efficient combustion with low air excess ratios. It should be noted that reducing the excess air in some cases increases the loss due to mechanical incomplete combustion of fuel, resulting in the formation of soot particles that can accumulate on surfaces and cause self-ignition. According to Laubitz, maintaining an excess air ratio of less than 1% when operating a boiler on fuel oil with a sulfur content of 2.1 % effectively prevented corrosion and ash buildup on the heating surfaces during a period of 40,000 hours of operation.

For effective cleaning, the RAPH is regularly blown with superheated steam at a pressure of 1.4-1.8 MPa and a temperature of at least 350 °C. It is essential to thoroughly drain the steam lines before blowing the RAPH. If necessary, the air heaters are washed with low-pressure technical water. To reduce the corrosion effect on the packing, the washing water is alkalized to pH = 11 and heated to 60-70 °C. The washing water jet is supplied at a pressure of 0.5-1 MPa. Abroad, for cleaning the packing of regenerative air heaters, periodic steam blasting is used at a pressure of 1.4-1.8 MPa and a temperature of 360-380 °C. In this case, the period between water washes is increased to one year. With effective steam blasting, the corrosion losses of the packing are reduced.

Analysis of the mechanisms of damage to air heaters during the combustion of gas-oil fuel demonstrates that low-temperature sulfuric acid corrosion, ash drift, ignition of deposits, and air leakage remain the main factors limiting the reliability and efficiency of boilers. Traditional protection methods based on air heating, recirculation, chemical additives, surface enameling, and periodic flushing reduce risks, but require significant operational costs and skilled maintenance. Modern approaches to improving the reliability of air heaters include: maintaining minimal air excesses (1.01-1.02) while ensuring complete combustion; using corrosion-resistant materials and enamel coatings, automated systems for cleaning with superheated steam, predictive monitoring of temperature conditions and aerodynamic resistance, and the use of modern fuel additives. The combined use of these measures allows for an increase in the overhaul interval, reduction of corrosion losses, and stable operation of air heaters under conditions of burning high-sulfur gas-oil fuels. Further research can be focused on developing new composite materials with increased corrosion resistance, improving automatic temperature control algorithms for the cold end, and creating more efficient cleaning systems without stopping the boiler.

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УДК 681.5.09

PROTECTION AND INTERLOCKS IN PLCS: HOW TO STOP THE CONVEYOR IN CASE OF AN ACCIDENT

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Abstract. The article uses a two-motor conveyor as an example to discuss the principles of functional safety in PLC programming. It analyzes the difference between conventional and safe control logic. The article describes a method for instantly stopping mechanisms when an emergency sensor is triggered. It explains the principle of fail-safe and the rules for connecting emergency sensors. The article is intended for students who are starting to study industrial automation.

Keywords: programmable logic controller, protection, interlocking, emergency sensor, industrial equipment safety.

ЗАЩИТА И БЛОКИРОВКИ В ПЛК: КАК ОСТАНОВИТЬ КОНВЕЙЕР ПРИ АВАРИИ

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Аннотация. В статье на примере двухдвигательного конвейера рассматриваются принципы функциональной безопасности при программировании ПЛК. Анализируется различие между обычной и безопасной логикой управления. Описывается способ организации мгновенной остановки механизмов при срабатывании датчика аварии. Объясняется принцип fail-safe и правила подключения аварийных датчиков. Статья предназначена для студентов, начинающих изучать промышленную автоматизацию.

Ключевые слова: программируемый логический контроллер, защита, блокировка, датчик аварии, безопасность промышленного оборудования.

When students become familiar with industrial controller programming, their thinking is often influenced by their experience working with conventional computers. his first program might look like this: They pressed “START” and the engine turned on. They pressed “STOP" and it turned off. In universities, programming is usually studied using office applications and web services, where a crash only results in a

program reboot. However, an industrial controller operates in a completely different environment: its code controls real-world mechanisms such as motors, valves, and conveyors. In this context, a bug does not result in a "window closing" but rather in a halted production line, broken equipment, or, in the worst-case scenario, an operator injury. Therefore, before writing the first PLC program, a novice engineer must understand the fundamental principle: safety always takes precedence over functionality.

In an industrial enterprise, PLC programmer errors (programmable logic controller) It can lead to physical destruction of equipment, shutdown of the technical line for several days, material damage and, worst of all, injury and death of people [1, p. 332]. The PLC processes the information and sends it to an automated workplace. The operator only plays the role of an observer, monitors the correct operation of control algorithms and the condition of the equipment [2, pp. 10-11]. Therefore, an automation engineer must make the code not just work but ensure security under any circumstances.

Each control algorithm is complemented by protection and locking mechanisms. Protection is the instantaneous shutdown of equipment in case of an accident. Blocking – prohibits starting until safe conditions are met. In a real industrial system, they work together.

Let's imagine the technological process: there are two engines – M1 (loading belt) and M2 (main belt). At startup, M1 turns on first, after a while – M2. When stopping, the opposite is true. Also, according to safety requirements, there is an emergency overflow sensor S1, which is triggered if the material has gone into a lump and presses on the tape. In this case, both engines should stop instantly [3, pp. 64-65]. If the program continues to turn the conveyor, waiting for a regular stop, the belt will break, the shaft will bend, and a spark from an overheated engine can cause a fire.

It is important to remember that the system must fail in a safe way. This is the essence of the fail-safe approach [4, p. 284]. In any unclear situation, the equipment must stop [5, p. 4] In practice, the approach is implemented through two rules:

1.The emergency and normal stop buttons are connected as normally closed (NC) contacts. This means that in the normal state, when the button is not pressed, current flows through it, and the PLC input receives a “1” signal. When the STOP button is pressed, the contact opens and the signal changes to ”0". Why is it safe? Imagine that the wire coming from the logic controller is broken (the signal is always “0"), regardless of the button position.

2. Emergency sensors are also connected as normally closed if their task is to cause a stop. In this case, the signals at the PLC input also change, and the system stops safely.

Table. Comparison of Normally Open (NO) and Normally Closed (NC) contacts for emergency circuits

Parameter	**Normally Open (NO)**	**Normally Closed (NC)**
No emergency	Contact open => PLC input = 0	Contact closed => PLC input = 1
Emergency state (button pressed, sensor triggered)	Contact closed => PLC input = 1	Contact open → PLC input = 0
Response to wire break	PLC input = 0 (as in normal state) => **dangerous!** Equipment will not stop	PLC input = 0 => **safe!** Equipment will stop
Recommendation	For “START” commands, signaling	For “STOP”, E-Stop buttons, thermal relays, emergency sensors

Based on these two rights, we can conclude that all devices that stop the mechanism in case of danger or failure are connected as normally closed. This applies to the STOP buttons, emergency latching buttons, thermal relays, overflow and overpressure sensors.

However, it is not enough to connect the sensors correctly. Even if all the alarm devices are connected to the PLC via NC contacts, the programmer may make a mistake in the logic of processing these signals. The most common mistake made by beginners is using the alarm signals only at the beginning of the program or in only one branch of the algorithm. For example, a student may only check the S1 overflow sensor when the conveyor is starting, if an accident occurs during operation, the program will "react somehow." In practice, this leads to the fact that when S1 is triggered, the PLC continues to execute the main loop because the check condition has already been met.

Another vulnerable element is timers. In the process under consideration, there are delays during start-up and shutdown. If an accident occurs while the timer is already running, the program must not only reset the commands to the motors, but also forcefully reset the timer itself.

In global practice, the requirements for such systems are set out in functional safety standards, primarily IEC 61508 (for electrical, electronic, and programmable electronic systems). This standard introduces the concept of Safety Integrity Level (SIL) and requires that all safety and interlock devices have a quantitative assessment of the probability of a hazardous failure. For a student, this means that PLC logic design is not a "on the fly" endeavor, but a discipline where every step is documented and every emergency condition is tested individually.

Experienced engineers use a single work authorization flag to check the sensors, which is often called Safety_OK or Permit_Run. A boolean variable is created, the value of which is “True” when the security conditions are met. If at least one is violated, then the flag changes to “False”, and the engines instantly shut down.

There are some simple and understandable tips for novice engineers in industrial

programming:

1. Always start designing with emergency situations. Ask yourself the following questions: What could possibly go wrong? What sensors can detect a malfunction? What must necessarily happen when each of them is triggered?

2.Do not throw accident checks throughout the program. Use the Safety_OK flag wherever there are dangerous mechanisms.

3. Remember the fail-safe principle. All emergency and normal stop buttons, as well as sensors, must be connected as normally closed.

4.Test not only the normal modes, but also the emergency ones. Simulate a wire break in the simulator or on real equipment. Only after you are sure that the hardware stops working in all scenarios, the program can be considered ready.

For a student taking their first steps in the automated process control, this means that a good code is not the one that works when you press "Start", but the one that stops predictably and guaranteed in any emergency situation. The habit of first analyzing "what can go wrong" and only then writing algorithms distinguishes a professional engineer from an amateur.

And lastly, never neglect testing and modeling. Modern development environments (such as CodeSys) allow you to debug logic and simulate wire breaks, stuck contacts, and false sensor readings without a real controller. Test your program on all possible emergency scenarios before it goes into a real machine. Remember: your responsibility as a PLC programmer is not just to make the equipment work, but to make sure it never causes harm to a person. This is the main goal of automation.

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УДК 629.78:621.311.24

DEVELOPMENT OF THE "MAKEDON" SPACE SOLAR POWER STATION: FROM CONCEPT TO PROTOTYPE

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Abstract. The article describes the "Makedon" project – an innovative solution in space-based solar power (SSP). The authors developed a solar power plant model with dual-directional panel deployment and a positioning mechanism for optimal solar energy capture in space and on Earth. The universal model can power orbital stations and spacecraft, deploy stationary plants in high-irradiance regions (e.g., southern Russia), and serve as a mobile emergency complex in remote areas (including the Arctic during the polar day). SSP offers long-term benefits: environmental friendliness, stable generation, global accessibility, and scalability.

Keywords: space-based solar power, renewable energy sources, solar panels, photovoltaic effect, wireless power transfer, space infrastructure.

РАЗРАБОТКА КОСМИЧЕСКОЙ СОЛНЕЧНОЙ ЭЛЕКТРОСТАНЦИИ «МАКЕДОН»: ОТ КОНЦЕПЦИИ К ПРОТОТИПУ

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Аннотация. В статье описывается проект «Македон» – инновационное решение в области космической солнечной энергетики (КСЭ). Разработана модель солнечной электростанции с двусторонним развертыванием панелей и механизмом позиционирования для оптимального улавливания солнечной энергии в космосе и на Земле. Модель может: обеспечивать энергоснабжение орбитальных станций и космических аппаратов, развертывать стационарные электростанции в регионах с высоким уровнем солнечной радиации (на юге России), служить мобильным аварийным комплексом в труднодоступных

районах (в т. ч. в Арктике в период полярного дня). КСЭ отличается экологичностью, стабильностью генерации, глобальной доступностью и масштабируемостью.

Ключевые слова: космическая солнечная энергетика, возобновляемые источники энергии, солнечные панели, фотоэлектрический эффект, беспроводная передача энергии, космическая инфраструктура.

Rising global energy consumption, the depletion of fossil resources, and the escalation of climate issues pose a challenge for humanity: we must find ways to transition to sustainable and environmentally friendly energy sources. Traditional renewable energy sources (RES) on Earth, despite their environmental friendliness, have significant limitations: their operation depends on weather conditions, time of day, and seasonality. This leads to generation instability, requires the creation of costly energy storage systems, and reduces the overall efficiency of energy systems.

As a breakthrough solution capable of overcoming these limitations, space-based solar power (SSP) emerges [1, p. 84]. According to the "Makedon" project, solar power plants can be deployed in Earth's orbit to continuously convert solar energy and supply satellites, spacecraft, probes, and other systems. Deploying solar power stations in space will ensure round-the-clock energy generation without the impact of atmospheric losses, cloud cover, or day-night cycles.

Objective of the "Makedon" project. The goal of the "Makedon" project is to develop and substantiate the technical and economic feasibility of an SSP system model that includes dual-directional solar panel deployment and rotation capability. The model is intended to demonstrate the technical feasibility of SSP and expand the range of applications for solar power plants – both in space and on Earth (as stationary solar power stations or mobile emergency units for use in emergency situations).

Scientific novelty of the research. The scientific novelty of the study lies, firstly, in the technical solution for creating a model with dual-directional deployment of solar panels and a positioning mechanism. This approach will ensure optimal capture of solar energy both in orbit and in terrestrial conditions when changing orientation relative to the Sun. Secondly, as the size and capacity increase, the model demonstrates versatility of application: it can operate in space as part of an orbital station, on Earth as a module of stationary solar power plants, or as a mobile emergency complex in case of emergency situations. An important aspect is the developed seasonal operation scheme for ground-based installations: active use in spring and summer, with a transition to backup sources (e.g., modern diesel generators) in the autumn-winter period. This allows accounting for regional irradiance characteristics and minimising dependence on weather conditions.

Practical significance of the "Makedon" project. The practical significance of the "Makedon" project lies in its applied potential for the development of environmentally friendly energy. Implementing the installation will: to ensure stable power supply for spacecraft and orbital stations and to enable creation of mobile energy complexes for rapid deployment in remote and hard-to-reach areas. On Earth, applying the model's deployment principle will increase the efficiency of stationary

solar power plants through the rotation mechanism and multi-directional arrangement of panels – this is especially relevant in regions with high solar irradiance. Moreover, the project promotes the development of related technologies – from robotics and orientation control systems to materials with enhanced resistance to external impacts.

History of space-based solar power development. Abroad, technologies for space and terrestrial solar power are actively developing. In the USA, including through the efforts of *the National Aeronautics and Space Administration* (NASA) and private companies, work is underway within the Space Solar Power project (translated from English as SSP) – aimed at energy transmission from orbit and including experiments on wireless energy transfer. *The Japan Aerospace Exploration Agency* (JAXA) is implementing programs to create orbital solar power plants and conducting tests of energy transmission systems via microwave radiation. *China* has announced plans to deploy space solar power plants by 2035 and is already conducting tests on long-distance energy transmission. In the European Union, research in the field of solar energy is carried out within the *Horizon Europe program*, which places special emphasis on integrating renewable energy sources and developing mobile solar systems for use in emergency situations.

In Russia, solar energy development proceeds within the framework of state support programs for renewable energy sources and includes large solar power plants (SPPs) with a total capacity exceeding 1 GW [2, p. 156]. An example of an SPP is presented in Figure 1. Concurrently, research and development (R&D) work on wireless energy transmission and space energy systems is ongoing – in particular, such research is conducted by specialists from the Bauman Moscow State Technical University and the Space Research Institute of the Russian Academy of Sciences (IKI RAS) [3, p. 20].



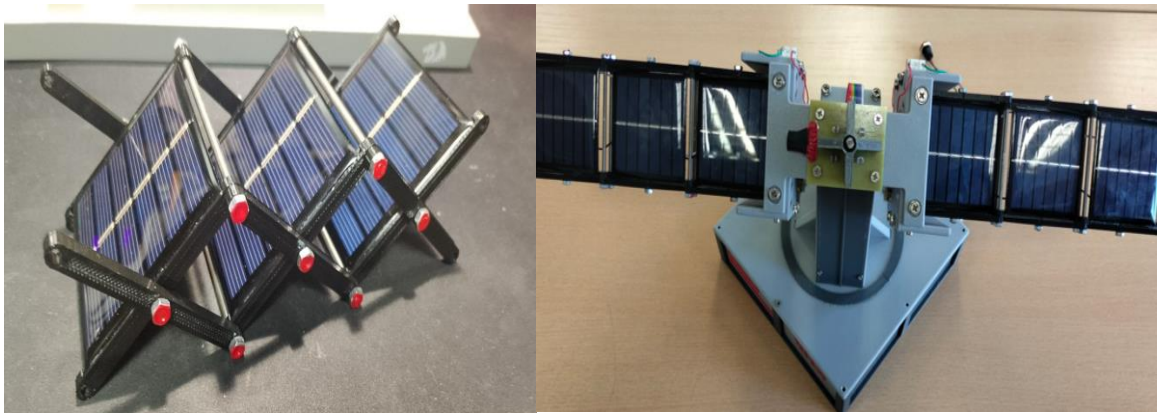
Figure 1. Topirskaya SPP (Buryatia, Russia)

Practical implementation of the project. We have developed a model of a solar power plant system designed to convert solar light energy into electricity (Fig. 2). The design consists of several key components, each performing a specific function.



Figure 2. Model of the SSP system in the folded state

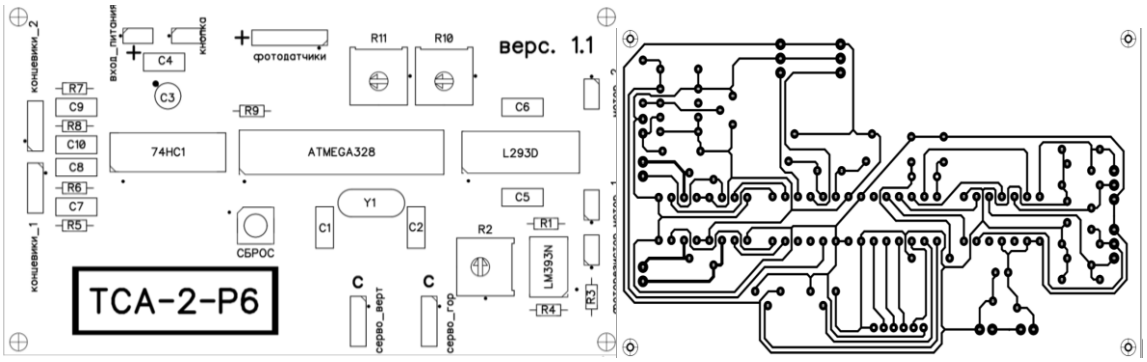
In the folded state, the system is a compact structure where solar panels are folded onto load-bearing frames and share a single base platform, while angle adjustment mechanisms are hidden or minimized. In the operational position, the panels are deployed in two directions (Figures 3–4) and can be oriented towards the Sun through special mechanisms for adjusting the panel tilt angle. This ensures maximum illumination and increases the system's efficiency.


Figures 3–4. Solar panels of the SSP model in the deployed state

The main visual elements of the system are:

- *Solar panels* coated with special protective layers to increase durability (flat rectangular modules manufactured using the silk-screen printing method, which helps improve the efficiency of solar-to-electrical energy conversion);
- *Frames and bases* (metal structures made of aluminium/steel that provide rigidity and stability to the system);
- *Angle adjustment mechanisms* (hinges, actuators, or other devices that allow changing the position of the panels);
- *Battery cabinets or containers* (separate units for housing batteries);
- *Inverters and controllers* (electronic devices housed in protected enclosures).

Control board schematics for the model are presented in Figures 5–6.



Figures 5–6. Integrated circuits of the SSP model

Operating principle of the SSP system. The system's operation is based on the photovoltaic effect. When sunlight hits the photovoltaic cells (typically made of silicon), the energy of photons ejects electrons from atoms, generating an electric current. The process can be described step by step as follows: Photovoltaic cells capture the energy of sunlight and an electric field forms at the boundary between the positively and negatively charged silicon layers, directing the movement of electrons. The movement of electrons generates direct current (DC), which flows to the inverter. The inverter converts DC into alternating current (AC), suitable for use in household grids or for feeding into the main power grid. Excess electricity is stored in batteries for use at night, on cloudy days, or during periods of low generation. Current is directed to consumers via distribution units and power transmission lines. The system also includes additional components: *charge controllers* that regulate the battery charging process, preventing overcharging or deep discharge and *a monitoring system* that tracks the operation of all system components, including generation parameters, battery status, and overall system efficiency.

Technical features and applied methods. The solar power plant design incorporates various technological solutions to improve efficiency, maintainability, and system adaptability. Let us examine in more detail the silk-screen printing method, the modular circuit board structure, and the mechanically driven adjustment mechanism.

Silk-screen printing method (screen printing) is widely used in the production of silicon solar cells to create a contact pattern that ensures collection of the current generated by light radiation. This method allows creating thin and precise contact structures, minimising shading of the cell's active area, reducing the resistance of metal contacts, which improves solar energy conversion efficiency, enabling mass production with high throughput.

Modern developments focus on reducing the width of contact fingers (down to 19 μm or less), which can cut silver consumption (a key component of pastes) by 30–40 % compared to the industry standard. This not only reduces costs but also improves the aesthetic characteristics of panels, making the contact grid virtually invisible.

The modular board structure in solar panel design implies dividing the system into separate interchangeable units or modules. This solution is particularly relevant for printed circuit boards used in solar systems, including controllers, inverters, and other electronic components. A key feature of this technology is that each module

performs a specific function and can be easily replaced if it fails. Consequently, the system is scalable – i.e., modules can be added or removed depending on the required power output and functionality. Moreover, this approach simplifies maintenance and repair, as fault localization is faster, and it enables system upgrades by integrating new technologies or additional features (such as sensors and monitoring systems).

Angle adjustment mechanisms for solar panels are used to optimize the panels' position relative to the Sun throughout the day. This increases electricity generation efficiency, as maximum efficiency (КПД) is achieved when sunlight hits the panel surface perpendicularly [4, p. 55]. The design includes load-bearing frames, bases, and actuators (mechanical ones, such as electric motors, or hydraulic systems) that adjust the panels' tilt angle. The solution can be implemented using adjustable stands, hinges, or telescopic structures. In our SSP system model, actuator control can be either manual or automated (using sensors and controllers that track the Sun's position). The advantages of angle adjustment include: increased electricity production through continuous tracking of sunlight; the ability to adapt to seasonal changes in the angle of incidence of solar rays; and extended panel lifespan due to reduced overheating when the panels are in an optimal position.

Thus, these technologies complement each other, enhancing the overall efficiency and reliability of solar power plants. Silk-screen printing improves the performance of individual components, the modular structure simplifies system maintenance, and angle adjustment mechanisms optimize system performance dynamically.

Application of SSP systems in the space industry. The conceptual space-based energy supply system involves using compact power plants on individual space objects. This approach allows creating an environmentally friendly system of continuous power supply for the needs of space infrastructure. Local installations are advisable for use on satellites, research probes, the International Space Station (ISS), and other spacecraft (SC).

The operating principle of power plants is based on collecting solar energy using high-efficiency solar panels integrated directly into the design of spacecraft. The specifics of panel application depend on the type of SC. For instance, on satellites, panels are placed on external surfaces. Thanks to the satellite's constant presence outside Earth's shadow, a continuous energy flow is ensured for onboard systems: navigation, data transmission, and scientific instruments. On research probes, compact solar modules power orientation systems, communications, and scientific sensors. This is especially important for long-duration missions beyond Earth's orbit – for example, for probes studying Jupiter or Saturn. On the ISS, a combined panel system supplies the station with energy for crew life support, laboratory operations, and maintaining spatial orientation [5, p. 21]. Excess energy is used to charge batteries that ensure station operation during shading periods, such as when passing through Earth's shadow. On small SCs (CubeSats, microsatellites), miniature solar batteries provide power for telemetry transmission, photo and video recording, and environmental sensor operation.

Energy conversion and distribution. Collected energy is converted and distributed as follows. For powering onboard systems, energy is supplied directly

and is used for electronics, motors, and thermal control systems. For transferring energy to other vehicles, wireless energy transmission technology is applied, such as microwave radiation or laser beams, over short distances. This can be useful, for example, for recharging relay satellites or research drones. For storing excess energy, onboard batteries or supercapacitors are used. This ensures system operation under adverse conditions, such as during eclipses or if solar panels fail.

A key factor in system reliability is the precision of solar panel orientation relative to the Sun. For this purpose, automatic guidance systems with gyroscopes and solar sensors are used, along with real-time position correction algorithms accounting for orbital mechanics and stabilizers and flywheels to maintain panel orientation during SC maneuvers.

Examples of successful SSP application. Successful SSP applications include communication and navigation satellites (GLONASS, GPS), where continuous power supply guarantees stable operation of data transmission and positioning systems. They also include scientific SCs, where solar panels provide power for spectrometers, cameras, and space radiation sensors – this is critical for long-term missions, such as asteroid exploration. Another example is the ISS, where the combined solar panel and battery system ensures the station's energy independence and reduces reliance on ground launches of supply ships carrying fuel. In the future, local power plants could supply energy to habitation modules, laboratories, and surface vehicles on lunar and Mars bases.

The economic and technical advantages of local solar power plants are presented in Table.

Table. Economic and technical advantages of solar power plants

Advantages	Description
Reduced launch costs	Compact panels are lighter and cheaper to deploy into orbit
Modularity	The possibility of phased system deployment (adding panels as the station's or satellite's needs grow)
Resilience	Failure of one unit does not lead to a complete system shutdown (energy is redistributed among operational modules)
Reduced technical risks	Elimination of the need for complex mechanisms to transmit energy to Earth

Thus, solar power plants based on solar panels represent a realistic and economically viable path to creating a system of continuous environmentally friendly power supply in space. Despite limitations in the capacity of individual modules, their combination and optimization make it possible to address key challenges of modern astronautics – from maintaining satellite operation to supporting future interplanetary expeditions. This technology has every chance of becoming a cornerstone of space energy development in the coming decades.

Application of solar installations across Russian regions. The "Makedon" installation will be most effective in regions with high solar irradiance, as well as in areas where it is critical to have the ability to quickly deploy mobile energy sources. *In southern Russia* – in Krasnodar Krai, Rostov Oblast, Kalmykia, and Stavropol

Krai – solar irradiance levels are high, so the installation is ideally suited here for creating new-type stationary solar power plants. *In Siberia and the Far East* (for example, in the Republic of Buryatia, Zabaykalsky Krai, and Amur Oblast), it is rational to combine solar generation during the spring-summer period with other energy sources in winter. *In the Arctic zone,* mobile versions of the installation can be used to supply power to temporary bases, expeditions, facilities, and infrastructure – their use is especially effective during the polar day. Finally, mobile "Makedon" installations are advisable for deployment in emergency areas and hard-to-reach territories: they will enable rapid deployment of power systems in case of infrastructure damage due to terrorist attacks or accidents, as well as provide electricity to remote settlements without centralized power supply.

In conclusion, the "Makedon" project opens up new opportunities for using solar energy both in the space industry and on Earth. Further research could focus on optimizing the design, reducing the cost of deploying SSP systems, and integrating the system with other energy sources to improve its efficiency and reliability under various operating conditions.

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УДК 621.182

PROJECT FOR A 15 MW HEATING BOILER HOUSE

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Abstract. The article presents a project development of a block-modular boiler house with a thermal capacity of 15 MW to provide heat energy to the micro district in the urban settlement of Novoselye, Leningrad Region, Lomonosovsky Municipal District, Anninsky Urban Settlement. As a result of the analysis and calculations, the main and auxiliary equipment are selected.

Keywords: boiler house project, operating mode, equipment, thermal scheme, natural gas, chemical water treatment, emissions, gas supply.

ПРОЕКТ ОТОПИТЕЛЬНОЙ КОТЕЛЬНОЙ МОЩНОСТЬЮ 15 МВт

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Аннотация. В данной работе приводится разработка проекта блочно-модульной котельной тепловой мощностью 15 МВт для обеспечения тепловой энергией микрорайона в городском поселении Новоселье, Ленинградская область, Ломоносовский муниципальный район, Аннинское городское поселение. В результате анализа и расчетов подбираются основное и вспомогательное оборудование.

Ключевые слова: проект котельной, режим работы, оборудование, тепловая схема, природный газ, химводоподготовка, выбросы, газоснабжение.

Currently, the problem of rational use of thermal energy is of particular importance due to both economic and environmental factors. Centralized heat sources are the traditional basis for supplying heat to consumers. However, their operation is associated with several drawbacks, including significant losses of thermal energy caused by the imperfections of local distribution and control systems, as well as the

long length and high degree of wear and tear of thermal networks. These factors lead to a decrease in the efficiency of both central heat sources and the entire distribution system.

One solution to this problem is to switch from large centralized sources to small and medium-sized local boiler houses. The use of modern decentralized heating systems allows to combine the modes of heat generation and supply to meet the individual requirements of a specific facility, minimizing transportation losses and increasing the system's flexibility.

The purpose of this work is to develop a project for a block-modular boiler house with a thermal capacity of 15 MW to provide heat energy to a microdistrict in the urban settlement of Novoselye, Leningrad Region, Lomonosovsky Municipal District, Anninsky Urban Settlement. When designing such an object, it is necessary to take into account the functional purpose of the boiler house, as this determines the requirements for the equipment, heat carrier parameters, and operating modes.

As part of this work, a heating-type boiler house is being developed, which fully meets the needs of a residential microdistrict without large industrial consumers. The block-modular design has been chosen as the most rational solution, as it allows for quick commissioning, minimizes construction and installation work on the site, and provides for the possibility of subsequent scaling when the microdistrict is expanded.

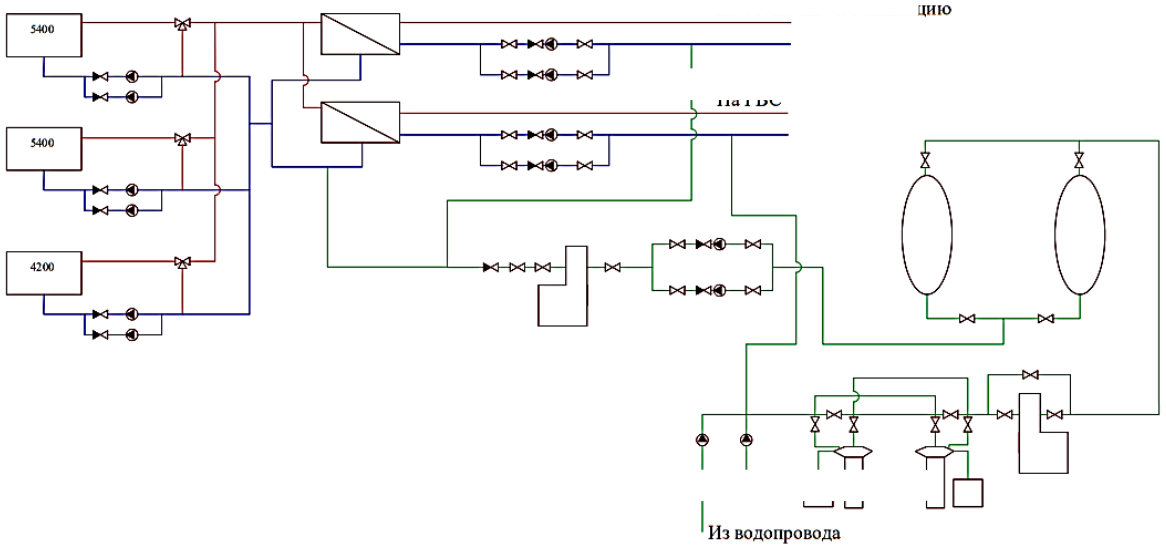


Figure 1. Thermal diagram of a 15 MW boiler house

Parameters of the heating system (Fig.1): four-pipe, closed [1]. By purpose, the boiler house is classified as a heating boiler house, by location – freestanding. The main fuel is natural gas, the reserve – diesel.

First, the boiler house's fuel requirements were calculated, resulting in the annual consumption of conventional fuel and natural gas [2].

Annual consumption of conventional fuel:

$$B_{cond}^{year} = \frac{Q_{prod}^{year}}{Q_{cond}^{r} \cdot \eta_к} = \frac{20{,}88 \cdot 10^7}{29330 \cdot 0{,}944} = 7541{,}3 \ {}^{tons}/_{year};$$

$Q_{cond}^{r} = 29330\ {}^{kJ}/_{kg}$.

Annual gas consumption:

$B_{\text{g}}^{year} = \frac{Q_{prod}^{year}}{Q_i^d \cdot \eta_{\text{к}}} = \frac{20{,}88 \cdot 10^7}{33500 \cdot 0{,}944} = 6602{,}6$ thousand ${}^{m^3}/_{year}$.

Then, the thermal scheme of the boiler house was calculated, where the boiler house operating modes are calculated: the maximum winter, the coldest month, the average heating and summer. The obtained values are entered in Table 1.

Table 1. Final Heat Calculation Table

	Maximum–winter mode t = -23°C	The coldest month t = -5,6°C	Medium heating mode t = -0,8°C	Summer mode
Heating and ventilation thermal loads, MW	11,3	6,5	5,2	0
Thermal loads for hot water supply, MW	3,7	3,7	3,7	2,46
Heat loss in heating networks for own needs, MW	1,5	1,02	0,89	0,246
Total thermal load of the boiler house, MW	16,5	11,22	9,79	2,71
Estimated flow rate of network water for heating and ventilation needs, kg/s	118,7	55	51,1	0
Estimated water consumption for DHW needs, kg/s	16,2	16,2	16,2	12,9
Estimated water flow rate for heating system, kg/s	0,085	0,0488	0,039	0
Boiler water flow rate for hot water heat exchanger, kg/s	28,34	28,34	28,34	18,8
Boiler water flow rate to the network water heat exchanger, kg/s	86,49	49,75	39,8	0
Water flow through boilers, kg/s	114,83	78,1	68,14	18,8

The selection of the main and auxiliary equipment is based on the calculation of the thermal scheme [2, 7]. The following boiler units was selected for installation: two THERMOTECHNIK TT100 boilers with a nominal heat output of 5400 kW, manufactured by Entroros (Russia), and one THERMOTECHNIK TT100 boiler with a nominal heat output of 4200 kW, manufactured by Entroros (Russia), with the following thermal specifications (Table 2).

Table 2. Thermal characteristics of boilers

Name of the parameter	Meaning	
Rated heating capacity, kW	5400	4200
Maximum temperature at the boiler outlet, °C	115	115
Minimum temperature at the boiler inlet, °C	60	60
Maximum operating overpressure, MPa	0,6	0,6
Minimum water consumption, m^3/h	Not regulated	Not regulated
Минимальная мощность первой ступени горелки, %	10	10
Design service life, years, at least	25	25
Designated resource, h, at least	200000	200000
Nominal water consumption depending on Δt = 35 °C, m^3/h	140	105
Hydraulic resistance of the water circuit at a heat carrier flow rate depending on Δt = 35 °C, Pa	800	1100
Operational efficiency, %	At least 94	At least 94
Efficiency at maximum load, %	94,4	95,2
Exhaust gas temperature, °C	144	126
Exhaust gas consumption, кг/с	2,29	1,77
Aerodynamic resistance of the gas path for maximum power, Pa	921	966
Furnace volume, m^3	4,19	3,29
Boiler water volume, m^3	6,17	5,26
Dry boiler weight, kg	11128	8559

When selecting a burner device, it is necessary to follow the "Selection and Installation of the Burner" section of the THERMOTECHNIK TT100 boiler manual. According to this section, burner devices must ensure reliable ignition and stable combustion of fuel without flame separation or breakthrough in the specified range of operating modes, and must prevent fuel droplets from falling onto the furnace surface.

TT100 boilers are operated with overpressure in the combustion chamber. When selecting burners, the following should be taken into account:

- the length and diameter of the firebox;
- the aerodynamic resistance of the boiler.

Based on the analysis of technical documentation and the catalog of burner equipment, the THERMINATOR monoblock combined burners manufactured by Tula Burners LLC (Russia) were selected as the optimal solution. A single model, the THERMINATOR T-5.630 GL, was chosen for all three boiler units.

Six CNP TD 150-25/4 circulation pumps were selected for circulating water in the boiler circuit, two CNP TD 250-29/4 network pumps were selected for circulating network water, two CNP NESO 80-65-320-11/4 hot water pumps were selected for circulating water in the hot water circuit, and two CNSG 1.5-15K5-AM feed pumps were selected for replenishing water in the heating system [6].

Based on the performed thermal calculations and the selected boiler equipment, the required parameters of the coolant for heating and hot water supply systems were determined. The selection of heat exchangers that ensure the required water treatment conditions is based on the flow rate of network water and the required heating surface [3].

Heating surface of one heat exchanger for heating needs:

$$F = \frac{Q}{К_р \cdot \Delta t_{av}} = \frac{12{,}5 \cdot 10^6}{4367 \cdot 14{,}2} = 201{,}6\ м^2.$$

Heating surface of one heat exchanger for hot water supply:

$$F = \frac{Q}{К_р \cdot \Delta t_{av}} = \frac{7{,}1 \cdot 10^6}{4573{,}8 \cdot 61{,}7} = 25{,}2\ м^2.$$

Based on the results of the data obtained, 3 heat exchangers were selected for the Teploteks 100-A heating system and 3 heat exchangers were selected for the Teploteks 50-A heating system.

For a heating boiler house, water preparation is required in three main areas [8]. Firstly, an automatic continuous softening unit, the SF-21RXD, is used to remove hardness salts, which operates without stopping production. Secondly, to adjust the pH adjustment and oxygen binding O2, a set of dosing reagents "Aminat KO-5" and "Aminat KO-2" is required, respectively, to protect the equipment from corrosion. Thirdly, the prepared softened and deaerated water should be accumulated in the tanks of the reserve of chemical water treatment, to ensure stable operation of the system during peak loads or during temporary shutdown of the water treatment plant.

One of the key stages of the work is the calculation of atmospheric pollution by harmful emissions, which proves the correctness of the choice of the preliminary height and diameter of the chimney stack mouth [5, 9]. However, before this stage of the calculation, it is necessary to calculate the composition of the fuel (natural gas) to determine the actual volume of combustion products and the theoretical volume of air required for the combustion process.

Since the obtained value of the dimensionless concentration of harmful substances q = 0.365 is less than one, this means that the preliminary selection of the pipe H = 20 m and the diameter of the chimney mouth Dy = 0.65 m is correct.

A gas supply scheme for a 15 MW boiler house designed for the heating needs of administrative and residential buildings was developed for the design and construction of a gas flow measurement unit (Fig. 2).

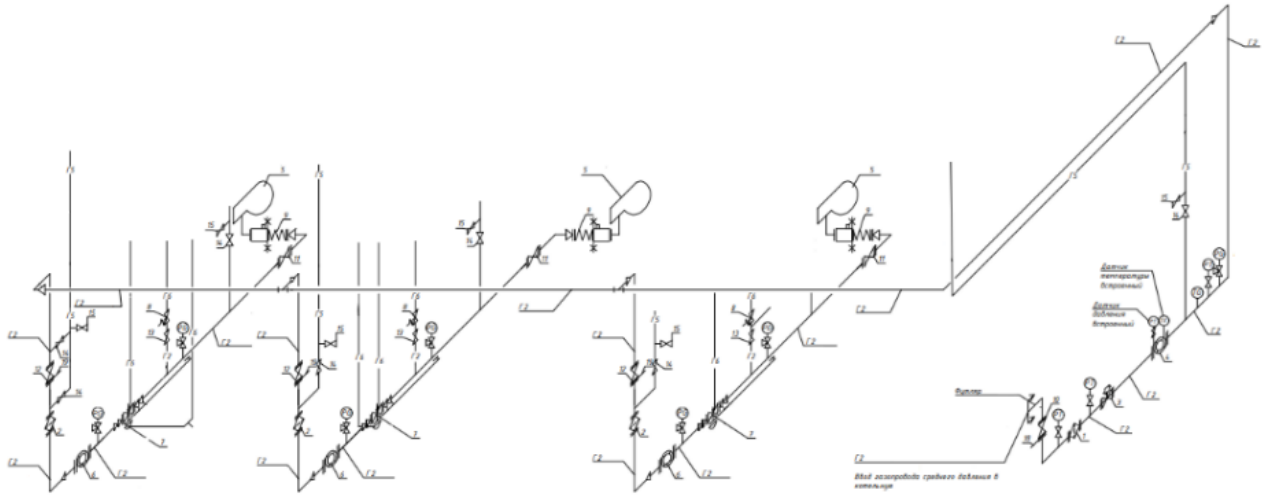


Figure 2. Gas supply scheme for a 15 MW boiler house

The selected equipment used for the gas supply system is presented below (Table 3).

Table 3. Gas supply system equipment

Position	Designation	Name	Quantity
1	FN4-6 flanged	Gas flange filter with contamination indicator	1
2	FN 2 1/2-6	Gas flange filter with contamination indicator	3
3	MADAS EVPS100067 608	Electromagnetic aluminum flange valve with slow opening	1
4	ULTRAMAG PRO BA-M-1A-PTZ-DN100-G250-A1	Ultrasonic Gas Meter	1
5	«THERMINATOR T-5.630 GL»	Gas burner	3
6	CG16MT-160-P-2	Turbine gas meter	3
7	MADAS RB32Z R160 (the flange)	Gas pressure regulator	3
8	MADAS MVS/1 DN25	Safety relief valve	3
9	KCOF 65-16-60	Bellows axial compensator	3
10	GAS.100.016.P/P.02	Ball valve flanged full-bore	1
11	GAS.100.016.N/P.02	Flanged ball valve	3
12	GAS.065.016.N/P.02	Flanged ball valve	3
13	GAS.025.040.N/P.02	Threaded ball valve	3
14	GAS.020.040.N/P.02	Threaded ball valve	8
15	GAS.015.040.N/P.02	Threaded ball valve	7

As a result of the work, a thermal diagram of the boiler house was developed, four characteristic modes of its operation were calculated, and the fuel requirements were determined. Based on the obtained data, the main and auxiliary equipment was selected, including TT100 boilers with a capacity of 4200 and 5400 kW, burner devices, pumping equipment, and heat exchangers for heating and hot water supply systems.

To ensure the regulatory parameters of the coolant, the calculation of water heating units and chemical water treatment was performed. A gas supply scheme for a 15 MW boiler house was developed, with the selection of equipment for measuring gas flow.

The assessment of environmental impact showed that emissions of harmful substances do not exceed the established standards under the adopted parameters of the chimney stack. The obtained results confirm the efficiency and environmental safety of the proposed solutions.

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УДК 621.315.616.97

EFFECT OF THERMAL AGING ON THE ELECTRIC STRENGTH OF ELECTRICAL INSULATING MATERIALS AND PREDICTION OF THE SERVICE LIFE OF DRY TRANSFORMERS

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Abstract. The paper examines the effect of thermal aging of epoxy, silicone and polyimide composites on electric strength. As a result of the analysis, the service life of dry transformer insulation was predicted and an economic comparison is given.

Keywords: thermal aging, electric strength, service life, epoxy resin, silicone rubber, polyimide, dry transformer.

ВЛИЯНИЕ ТЕРМОСТАРЕНИЯ НА ЭЛЕКТРИЧЕСКУЮ ПРОЧНОСТЬ ЭЛЕКТРОИЗОЛЯЦИОННЫХ МАТЕРИАЛОВ И ПРОГНОЗИРОВАНИЕ РЕСУРСА СУХИХ ТРАНСФОРМАТОРОВ

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Аннотация. В работе рассматривается влияние термостарения эпоксидного, силиконового и полиимидного композитов на электрическую прочность. В результате анализа был спрогнозирован срок службы изоляции сухих трансформаторов и приведено экономическое сравнение.

Ключевые слова: термостарение, электрическая прочность, ресурс, эпоксидная смола, силиконовая резина, полиимид, сухой трансформатор.

Introduction

Electric strength is the minimum electric field intensity at which electrical breakdown of a dielectric occurs.

Electrical insulation is the most vulnerable element of any high-voltage device. Its condition determines the service life of power transformers, cable lines, and rotating machines. Among the many operational factors causing insulation degradation, thermal aging occupies a special place: temperature exposure is an inevitable companion of electric power transmission and conversion.

Thermal aging is understood as the totality of irreversible changes in the structure and chemical composition of a dielectric occurring under prolonged exposure to elevated temperature. During thermal aging, chemical processes come to the fore, such as: oxidation, depolymerization, rupture of molecular bonds, and formation of new chemical groups.

Further on, using specific experimental data, it is shown how these molecular changes affect electric strength, and how, based on this knowledge, the service life of insulation can be predicted.

Mechanism of thermal aging and its effect on electric strength

The object for studying thermal aging in this work is polymer composites. These are materials consisting of a polymer matrix and a reinforcing filler. Epoxy-glass fiber composites are most widely used in the insulation of dry transformers.

In work [1], the degradation mechanism of such a composite was investigated in detail at the molecular level. The samples were subjected to accelerated thermal aging at a temperature of 180 °C for 360 hours. Such an approach allows one to simulate, in a short period, processes that would take years under real conditions.

The authors established that during the aging process in the epoxy matrix, three types of processes occur simultaneously: oxidation, chain scission, and recombination. The consequence of these processes is a change in the mobility of molecular chains. Quantitatively, this mobility is characterized by the activation energy E_a, which is understood as the minimum energy that must be imparted to a molecular fragment so that it can undergo movement. Measurements showed that over 360 hours of aging, the activation energy decreased from 0.78 eV to 0.67 eV [1, p. 6-7]. The lower the activation energy, the easier it is to set the molecular chain in motion, and the more microvoids, called free volume, are formed in the material.

The increase in free volume creates favorable conditions for the development of electrical breakdown. In microscopic voids, free electrons obtain a longer path for acceleration under the action of the external electric field, and the longer the free path, the more kinetic energy the electron acquires before colliding with a molecule. Along with this, the probability of rupture of molecular bonds upon impact and the frequency of formation of new free electrons increase. The process acquires an avalanche-like character – this is electrical breakdown.

The results of measuring dielectric strength under direct current showed: before aging, the dielectric strength of the samples was 169.5 kV/mm, and after 360 hours of accelerated thermal aging, it decreased to 141.1 kV/mm [1, p. 9]. The drop amounted to almost 15 %.

The authors established a linear dependence between the activation energy and the electric strength. This result helps, knowing the activation energy, to determine how much the strength will drop.

Prediction of service life and comparison of materials

The main tool for recalculating laboratory data into a real service life forecast is the Arrhenius equation, which was proposed by the Swedish chemist Svante Arrhenius in 1889 and describes the dependence of the rate of a chemical reaction on temperature.

$k = A \cdot \exp\left(-\frac{E_a}{R \cdot T_1}\right)$ – Arrhenius equation.

From which it is not difficult to obtain:

$$\frac{k_1}{k_2} = \exp\left(-\frac{E_a}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)\right).$$

The physical meaning of the equation is that not all molecules can enter into a reaction, but only those whose energy exceeds a certain threshold called the activation energy Ea. The higher the temperature, the larger the proportion of molecules that overcome this barrier, and the faster the process proceeds.

For practical calculations, we use the ratio $\frac{k_1}{k_2}$, which shows how many times faster degradation proceeds at the elevated temperature T_2 compared to the operating temperature T_1. Knowing $\frac{k_1}{k_2}$ and the time to failure under laboratory conditions, one can calculate the predicted service life under real conditions.

It directly follows from the equation that even a small reduction in operating temperature gives a significant gain in service life. Reducing the temperature by just 10 °C approximately doubles the insulation resource. This explains why the simplest measures – installation of cross-flow fans, proper ventilation of the room, and regular cleaning of windings from dust – turn out to be some of the most effective ways to extend the life of a transformer.

Let us perform predictive calculations using the Arrhenius model for three insulating materials. In all cases, the operating temperature is taken equal to 110 ºC, the accelerated laboratory aging temperature – 180 °C, and the time to a critical drop in strength in the laboratory – 680 hours.

For epoxy resin, the degradation activation energy is 64.6 kJ/mol [1, p. 7]. The acceleration factor $\frac{k_1}{k_2}$ is obtained as equal to 23.1, which corresponds to a predicted service life of about 1.8 years of continuous operation at 110 °C. This period is obtained under the condition that the transformer operates without stops at a constant temperature. In reality, however, the load changes cyclically, and the actual service life turns out to be significantly longer, therefore it should be understood that this calculation shows not an absolute figure, but a method of prediction and the degree of influence of temperature on the aging rate.

For silicone rubber, according to data from work [2, p. 1], the activation energy lies in the range from 70 to 101 kJ/mol. Taking the average value of 85 kJ/mol, we obtain an acceleration factor of 62.2 and a predicted service life of about 4.8 years.

For Kapton polyimide film, the activation energy at the initial stage of decomposition is 189.6 kJ/mol [3, p. 5-6]. The acceleration factor reaches 10,000, and the predicted service life is about 776 years. This result shows that at 110 °C, thermal degradation of polyimide insulation ceases to limit the resource, and the insulation retains its properties throughout the entire life cycle of the equipment.

Summary table of results:

Table 1. Calculation of service life

Material	Ea, kJ/mol	$\frac{k_1}{k_2}$	Calculated service life
Epoxy resin	64.6	23	1.8
Silicone rubber	85.0	62	4.8
Kapton Polyimide	189.6	10000	776.0

At the same operating temperature of 110 °C, silicone insulation lasts almost 2.7 times longer than epoxy insulation, while polyimide insulation practically does not age. The difference in service lives is a direct consequence of the exponential dependence of the degradation rate on the activation energy.

It is also necessary to make an economic comparison; for this, let us compare the life cycle cost for dry transformers with a capacity of 250 kVA, voltage of 10/0.4 kV, with aluminum windings. For class F epoxy insulation and class H silicone insulation, real average market prices have been used. For Kapton polyimide insulation, however, it is an exclusive product, and prices for such transformers must be requested from the manufacturer for a specific task.

The price of a 250 kVA epoxy transformer is about 824,000 rubles [4, p. 1]. The price of a silicone transformer of the same capacity is 947,100 rubles [5, p. 1].

For epoxy insulation, the calculated service life until a critical drop in strength of 20 % is assumed – approximately 10 years according to the Arrhenius model. For silicone insulation – about 27 years, which is proportional to the ratio of service lives of 4.8 years versus 1.8 years in the accelerated test.

Cost of one year of service:

Table 2. Cost of one year of service

Material	Cost	Service life	Cost per year of service
Epoxy resin	824000	10	82400
Silicone insulation	947100	27	35077

Despite the higher initial price, the silicone option, when recalculated per year of service, turns out to be approximately 2.35 times more economical. This is a consequence of the higher activation energy of degradation, which slows down thermal aging.

Thermal aging is a complex set of physicochemical processes, the result of which is a steady decrease in the electric strength of a dielectric. Experimental data showed that the drop in dielectric strength is directly related to the decrease in activation energy.

The Arrhenius equation makes it possible to convert laboratory hours into real years of operation. Calculations show that the transition to materials with a higher

degradation activation energy – silicone rubber with 85 kJ/mol or Kapton polyimide with 189.6 kJ/mol – exponentially increases the equipment resource, and the economic analysis confirms that even with a higher initial price, a silicone transformer is more advantageous than an epoxy one when recalculated per year of service, and polyimide insulation, at typical operating temperatures of a dry transformer, is practically not subject to thermal degradation on the scale of the equipment's life cycle.

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УДК 661.728.7

EFFECT OF WATER-ALKALINE TREATMENT ON THE QUALITY OF CELLULOSE MATERIAL

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Abstract. In this work, we conducted a study of the effect of water-alkaline treatment – varying time (30-60 minutes), concentrations (5-17.5 %), and temperatures (20-40 °C) – on the α-cellulose content in commercial sulfate softwood pulp. This process yields high-purity material from bleached pulp without disrupting its structure. Treatment with 17.5 % NaOH solution at 20 °C for 1 hour increases α-cellulose content by 10 %, serving as effective pre-preparation for industrial use.

Keywords: commercial sulfate softwood pulp, α-cellulose, alkaline treatment.

ВЛИЯНИЕ ВОДНО-ЩЕЛОЧНОЙ ОБРАБОТКИ НА КАЧЕСТВО ЦЕЛЛЮЛОЗНОГО МАТЕРИАЛА

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Аннотация. В работе провели исследование влияния водно-щелочной обработки в диапазоне времени (30-60 минут), концентрации (5-17,5 %) и температуры (20-40 °C) на содержание α-целлюлозы в товарной сульфатной хвойной целлюлозе. В результате этого процесса из отбеленной целлюлозы получается материал высокой чистоты без нарушения ее структуры. Установлено, что при обработке 17,5 % раствором NaOH при 20 °C в течение 1 часа увеличивает содержание α-целлюлозы на 10 %, что является эффективной предварительной подготовкой к промышленному использованию.

Ключевые слова: товарная сульфатная хвойная целлюлоза, α-целлюлоза, щелочная обработка.

Introduction

The production of high-purity cellulose includes several important technological stages, such as raw material preparation, pre-hydrolysis, cooking for lignin removal, bleaching, and, when necessary, additional cold or hot purification [1]. Each of these stages plays a specific role in improving the chemical composition and structural quality of the final cellulose product. During processing, the main task is to remove non-cellulosic components, including lignin, hemicelluloses, low-molecular-weight degradation products, resins, waxes, and mineral substances, while preserving the high-molecular cellulose fraction as much as possible. The resulting material is widely used in the production of paper and paper-based products, as well as in a variety of chemical applications. In particular, high-purity cellulose serves as an important raw material for the manufacture of nitrocellulose, hydratcellulose, carbon fibers, membranes, powders, sorbents, and other functional materials. The overall objective of the process is to obtain a cellulose product with maximum α-cellulose retention, minimal impurity content, and properties that meet the requirements of subsequent industrial or chemical conversion.

Materials and methods

Purification enhances cellulose properties to meet end-use needs; for chemical processing like nitration, it requires at least 97 % α-cellulose [2]. α-Cellulose, the high-molecular-weight fraction insoluble in 17.5 % NaOH at 20 °C followed by washing, has a polymerization degree above 200 but includes mannans, xylans, and residual lignin [3]. This research evaluates water-alkaline treatment's effect on α-cellulose content in fibrous semi-finished products from any bleached commercial pulp [4].

Bleached sulfate softwood pulp was selected as the initial cellulose material for the study. The α-cellulose content and degree of polymerization were determined according to standard analytical procedures, which made it possible to assess both the chemical purity of the pulp and the preservation of its macromolecular structure after treatment [5]. Before the alkaline stage, the samples were subjected to preliminary water treatment for 45 minutes in order to remove water-soluble impurities and to ensure more uniform penetration of the reagent into the fibrous material. After this pretreatment, the samples were treated with sodium hydroxide solutions of different concentrations ranging from 5 to 17.5 %, at temperatures of 20 to 40 °C, for 30 to 60 minutes. Such a treatment scheme allowed the effect of alkaline conditions on the cellulose material to be evaluated under controlled experimental parameters.

Changes in degree of polymerization and α-cellulose content pre- and post-treatment are shown in Figures 1 and 2. Degree of polymerization reached 1325, and α-cellulose increased by nearly 10 % with 17.5 % NaOH at 20°C for 1 hour.

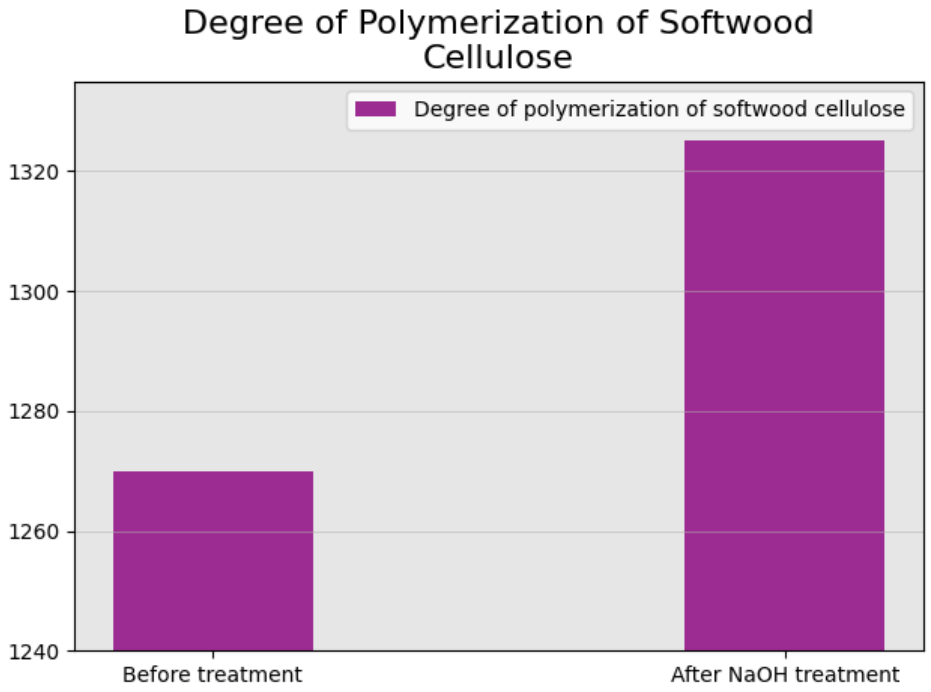


Figure 1. Change in degree of polymerization of bleached sulfate softwood pulp after NaOH treatment

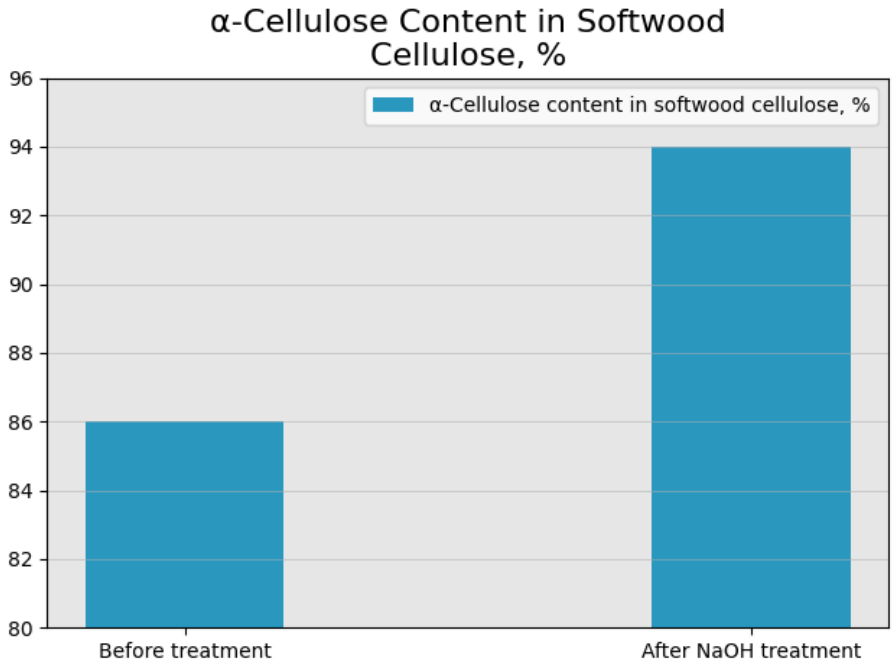


Figure 2. Change in α-cellulose content in bleached sulfate softwood pulp after NaOH treatment

Results

The results obtained indicate that water-base treatment allows for the selective removal of low molecular weight fractions and impurities, practically without destroying the high molecular weight fraction of cellulose. An increase in the content of α-cellulose while maintaining or increasing the degree of polymerization indicates

an increase in the chemical purity of the material and an improvement in its characteristics for subsequent chemical modification.

Discussio

It can be assumed that the optimal processing conditions promote the selective dissolution and leaching of unstable fractions associated with hemicelluloses, residual lignin, and other low-molecular-weight impurities, while having only a minimal effect on the high-molecular-weight cellulose framework. In this case, the treatment acts primarily as a purification step rather than a destructive one, allowing undesirable accompanying substances to be removed while preserving the structural integrity of the cellulose fibers. Such behavior suggests that the proposed treatment regime is particularly promising as a standard stage in the pre-preparation of cellulose raw materials for subsequent chemical conversion. This is especially important for applications requiring highly purified and structurally stable cellulose, including the production of nitrocellulose, cellulose derivatives, and other functional materials in which both chemical purity and preservation of polymer chain length are critical factors.

Conclusion

This treatment facilitates the removal of low-molecular-weight compounds, thereby increasing the overall purity of the cellulose material and improving its suitability for the synthesis of functional cellulose derivatives. By eliminating a significant portion of the non-cellulosic and low-polymer fractions, the process helps preserve the desired high-molecular cellulose component and creates more favorable conditions for subsequent chemical modification. As a result, the treated material becomes a more reliable and higher-quality feedstock for the production of cellulose-based products with controlled properties and improved performance.

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УДК 629.3:504.05

A COMPARATIVE ANALYSIS OF ELECTRIC AND INTERNAL COMBUSTION ENGINE VEHICLES IN TERMS OF THEIR ENVIRONMENTAL IMPACT

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Abstract. This article presents a comparative analysis of electric vehicles and internal combustion engine (ICE) cars concerning their environmental impact. The author examines factors such as the increased mass of vehicles, energy consumption, and the characteristics of electricity production. Additionally, the analysis includes the volume of emissions of harmful substances and greenhouse gases under various operational scenarios. The statistical data provided indicates that, under current conditions, the transition to electric vehicles could potentially worsen the global ecological situation.

Keywords: electric vehicle, internal combustion engine car, emissions of harmful substances.

СРАВНИТЕЛЬНЫЙ АНАЛИЗ ВОЗДЕЙСТВИЯ НА ЭКОЛОГИЮ ТРАНСПОРТНЫХ СРЕДСТВ С ЭЛЕКТРИЧЕСКИМИ ДВИГАТЕЛЯМИ И ДВИГАТЕЛЯМИ ВНУТРЕННЕГО СГОРАНИЯ

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Аннотация. В статье представлен сравнительный анализ электромобилей и транспортных средств, оснащенных двигателями внутреннего сгорания, с точки зрения их воздействия на окружающую среду. Автор рассматривает ключевые факторы, в том числе возросшую массу электромобилей, структуру их энергопотребления и характеристики производства электроэнергии. Кроме того, анализ охватывает объемы выбросов вредных веществ и парниковых газов в различных сценариях эксплуатации. Представленные статистические данные указывают на то, что в нынешних условиях повсеместный переход на

электромобили потенциально может усугубить глобальную экологическую ситуацию.

Ключевые слова: электромобиль, автомобиль с двигателем внутреннего сгорания, выбросы вредных веществ.

In the modern era, internal combustion engine vehicles are among the primary means of transporting goods and passengers, and the fuel they use (oil) is considered a non-renewable natural resource. Consequently, recent years have seen a trend toward shifting from ICE vehicles to electric vehicles (EVs) and hybrid-powered cars. In support of this, the European Union has developed several programs aimed at reducing harmful emissions. One such initiative involves the transition to electric transport. According to the European community, such transport is regarded as a promising solution for decreasing air pollution levels and reducing greenhouse gas emissions.

Therefore, electric vehicles are often viewed as the main alternative to traditional ICE cars—vehicles powered by one or multiple electric motors, supplied by independent energy sources such as batteries, fuel cells, capacitors, etc. Many scientists argue that their primary advantage lies in the absence of exhaust emissions, which contribute to air pollution.

However, from the perspective of the greenhouse effect, electric vehicles are not necessarily more environmentally friendly. Scientific studies conducted by the Munich Institute of Economic Research (IFO) have shown that the carbon footprint, including CO_2 emissions during the extraction of lithium, manganese, cobalt, and the manufacture of batteries, is 1.5 times higher for the Tesla electric vehicle than for the Mercedes-Benz gasoline car [1, 2].

Moreover, an emerging trend in the modern world is the pursuit of ecological sustainability, which stimulates the development of EV infrastructure and the adoption of alternative technologies. However, a more in-depth analysis reveals questions regarding the actual environmental benefits of electric vehicles, given that both their operation and manufacturing entail certain ecological costs. This article will examine three arguments that support the conclusion of a low level of ecological efficiency of electric vehicles.

High Energy Consumption. According to data from the analytical agency "Autostat," the average annual mileage of a passenger car in Russia is 16,700 kilometers. The data used for the environmental analysis are provided in Table 1. It should be noted that, according to statistical estimates, the amount of electricity required at power plants for charging an electric vehicle was calculated taking into account a 24.6 % loss during charging and transmission [3, p. 61].

Table 1. Environmental Analysis of the Energy Consumption of an Electric Vehicle

	Tesla Model S Long Range	**Audi A6 45 TDI Quattro**
Distance travelled per annum	16700 km/year	16700 km/year
Specific consumption	280 W*h/km	8л/100km
Annual consumption	4676 kW*h/year	1360 L/year
Required power generation	7159 kW*h/year	-

Of significant importance to the overall environmental footprint of electric vehicles is the production of battery packs. According to a 2023 study by the International Council on Clean Transportation (ICCT), the manufacture of a lithium-ion battery with a capacity of 60 kWh results in emissions of 35 to 65 metric tons of CO_2 equivalent. The primary sources of these emissions include the extraction of raw materials such as lithium, cobalt, and nickel, energy-intensive processes involved in cathode material synthesis and cell assembly operations.

Moreover, the carbon footprint of battery production varies considerably by region. As highlighted in the ICCT report, manufacturing facilities relying on coal-based electricity generation – such as those in China – produce 50–70 % more emissions compared to plants located in countries with low-carbon energy grids (e.g., Norway and France).

Consequently, the so-called "zero-tailpipe-emission" advantage of EVs is offset by substantial upstream emissions during the production phase, particularly when the supply chain for both raw materials and energy is not optimized from an environmental perspective.

Air pollution from harmful substances. Vehicles are one of the main sources of air pollution in urban areas, resulting not only from exhaust emissions but also from the release of solid particles caused by the wear of brake components, tires, and road surfaces. It has been proven that an increase in vehicle mass leads to a corresponding rise in the intensity of solid particle emissions [4, p. 137]. Additionally, the emissions of solid particles caused by tire wear from passenger cars exceed Euro-6 standards by approximately 26 times, while for freight vehicles, this figure is about 150 times higher. The wear intensity of tires for different types of transport is presented in Table 2.

Table 2. Tire Wear Intensity for Different Types of Transport

Tire type	**Wear rate, g/km**
Car	0,13
Light truck (до 3.5 т)	0,32
Truck	1,5

Moreover, it is necessary to consider that the curb weight of an electric vehicle is 23 % higher than that of a comparable internal combustion engine (ICE) vehicle of the same class (see Table 3).

Table 3. Comparison of Technical Characteristics of Vehicles Within the Same Class

	Tesla Model S Long Range	**Audi A6 45 TDI quattro**
Fuel type	Electric	Diesel
Dimensions (L x W x H), mm	4970 x 1965 x 1435	4939 x 1886 x 1457
Equipped weight, kg	2215	1787
Power, hp/(kW)	562 (413)	249 (183)
Maximum range, km	653	1280
Tire dimension	245/45 R19	225/60 R17

Moreover, due to their higher mass, electric vehicles often use wider tires to distribute the load on road surfaces. However, this leads to increased tire wear

emissions and a reduced driving range, as wider tires generally have higher rolling resistance and lower energy efficiency.

The carbon footprint of electric vehicles (EVs) is critically dependent on the electricity generation mix in the region of operation. According to a 2024 study by the University of Toronto, in Canadian provinces where 95 % of electricity is generated by hydropower (e.g., British Columbia), EVs reduce CO_2 emissions by 70 % compared to internal combustion engine (ICE) vehicles.

However, this advantage diminishes significantly in regions dominated by coal-based power generation. In Alberta, for instance, the emission reduction benefit of EVs drops to 10–15 %. In extreme cases − particularly where coal accounts for a high share of the energy mix and power plants rely on outdated equipment – EVs may even result in higher overall emissions than diesel vehicles.

A similar pattern emerges across the European Union. In Germany, with its diversified energy mix, EVs achieve a 40–50 % reduction in CO_2 emissions relative to ICE vehicles. In contrast, in Poland – where coal provides over 70 % of electricity generation − the environmental benefit of EV adoption is minimal.

Consequently, the large-scale transition to electric mobility is only environmentally justified when coupled with the decarbonization of the power grid. Without a shift towards low-carbon electricity sources, the potential emission savings from EVs remain limited and highly location-dependent.

Greenhouse gas emissions. Tables 4 and 5 present the annual greenhouse gas emissions for electric vehicles and vehicles with internal combustion engines (ICE), respectively.

Table 4. Greenhouse Gas Emissions of an Electric Vehicle per Year

Power consumption kW*h	**Emission factor kg of CO2 / kW*h**	**Emissions of CO2, t**
7159	0,449	3,214

Table 5. Greenhouse Gas Emissions of an ICE Vehicle per Year

Fuel consumption, L	**Emission factor kg of CO2 / L**	**Emissions of CO2, t**
1360	0,211	2,869

Battery recycling poses another significant challenge to the environmental sustainability of electric vehicles (EVs). According to a 2022 report by the U.S. Environmental Protection Agency (EPA) [5, p. 228], less than 5 % of lithium-ion batteries worldwide are fully recycled; the majority are either stored or subjected to incomplete recycling processes that release toxic substances.

Even advanced recycling technologies entail substantial energy consumption and may be accompanied by emissions of fluorides and heavy metals. An alternative approach is the so-called “second-life” concept, in which end-of-life EV batteries are repurposed for stationary energy storage systems. However, scaling up this practice is limited: the service life of such systems rarely exceeds 5–7 years, and subsequent safe disposal remains necessary.

Consequently, without establishing a closed-loop battery economy – where materials are continuously recovered and reused – the environmental benefits of EVs remain uncertain. This underscores the need for comprehensive lifecycle management strategies that address not only vehicle operation but also end-of-life battery treatment.

A comparative analysis of these data indicates that electric vehicles emit approximately 15 % more harmful substances into the atmosphere than comparable vehicles with internal combustion engines within the same class. This increase is primarily due to the higher mass of electric vehicles, their technical characteristics, and the specifics of electricity production at power plants, all of which contribute to greater emissions of harmful substances and greenhouse gases. Furthermore, these emissions exceed permissible limits established by Euro-6 and Euro-5 standards. Additionally, tire wear in electric vehicles – especially those equipped with wider tires – intensifies the release of solid particles. Consequently, it can be concluded that, despite their popularity and potential advantages, the shift to electric vehicles, under current conditions, is more likely to exacerbate the global environmental situation rather than alleviate it.

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УДК 697.1

METHODS OF REDUCING HEAT LOSS IN BUILDINGS AND THEIR APPLICABILITY IN DISTRICT HEATING SYSTEMS

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Abstract. The paper systematizes modern technical methods for reducing heat losses in buildings and evaluates their practical applicability in district heating systems. The study analyzes wall insulation with dew point control, energy-efficient window systems, and ventilation with heat recovery. Special attention is paid to the elimination of thermal bridges and the optimization of the placement of heating devices inside buildings.

Keywords: heat losses, energy efficiency, district heating, thermal insulation, heat recovery, heating networks.

МЕТОДЫ СНИЖЕНИЯ ТЕПЛОПОТЕРЬ В ЗДАНИЯХ И ИХ ПРИМЕНИМОСТЬ В СИСТЕМАХ ЦЕНТРАЛИЗОВАННОГО ТЕПЛОСНАБЖЕНИЯ

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Аннотация. В работе систематизированы современные технические методы снижения тепловых потерь в зданиях и оценена их практическая применимость в системах централизованного теплоснабжения. Произведен анализ утепления стен с контролем точки росы, энергоэффективных оконных систем и вентиляции с рекуперацией тепла. Особое внимание уделяется ликвидации мостиков холода и оптимизации размещения отопительных приборов внутри помещений.

Ключевые слова: тепловые потери, энергетическая эффективность, централизованное теплоснабжение, тепловая изоляция, рекуперация тепла, тепловые сети.

Introduction

This article attempts to develop a classification of engineering solutions aimed at reducing heat losses in buildings and to evaluate the feasibility of their application at different stages of thermal energy transportation, from the heat source (boiler house) to the end consumer.

The relevance of the study is determined by the fact that, in the thermal balance structure of residential and public buildings, heat losses through building envelopes and ventilation systems account for 40–60 % of the supplied thermal energy. At the same time, during the transportation of the heat carrier from the boiler house to heating substations and internal building distribution networks, additional losses occur due to insufficient pipeline insulation, hydraulic imbalance, and improper placement of heating devices [1, p. 23-25].

Part 1. Methods for Reducing Heat Losses in Buildings

1. Thermal Insulation of External Walls with Dew Point Control

The primary method for reducing transmission heat losses is the additional thermal insulation of walls. The decisive factor determining the effectiveness of the insulation system is the placement of the insulation layer on the external side of the building envelope. This ensures the displacement of the "dew point" (the temperature at which moisture from the air condenses) into the insulation layer rather than into the wall structure itself. Internal insulation leads to moisture accumulation, deterioration of the wall material, and mold formation.

Recommended materials include mineral wool boards with a density of 80–125 kg/m³ (vapour-permeable and allowing the wall to "breathe") and extruded polystyrene foam (hydrophobic but less vapour-permeable). Vapour permeability is important not only for removing excess moisture from building envelopes but also for ensuring the durability of the thermal insulation layer.

The insulation thickness is determined through thermal engineering calculations based on the required heat transfer resistance (R_0). For the climatic conditions of central Russia (for example, the Moscow region), the standardized value of (R_0) is at least 3.2 m²·°C/W, which corresponds to 150–200 mm of mineral wool insulation.

2. Energy-Efficient Window Systems

Modern windows consist of multi-chamber insulating glass units with low-emissivity coatings and inert gas filling. Heat losses through windows are composed of three components: thermal conductivity of the frame and glazing, air convection between the panes, and infrared radiation from internal surfaces.

- Multi-chamber design (at least a double-chamber insulating glass unit with three panes) disrupts convective air flows inside the glazing unit, thereby reducing heat transfer caused by moving air.
- Low-emissivity coating (low-E glass, silver coating) is a thin layer of metal oxides that reflects long-wave infrared (IR) radiation. The emissivity coefficient

decreases from 0.84 (ordinary glass) to 0.04–0.1, which reduces radiative heat losses by 3–4 times.

- Filling the chambers with argon (or krypton) – the inert gas is heavier than air and therefore less mobile, resulting in weaker convection. The thermal conductivity of argon is also slightly lower than that of air.
- Thermal break in the frame profile – an insert made of polyamide or another material with low thermal conductivity placed between the external and internal parts of an aluminum or polyvinyl chloride (PVC) profile, preventing the formation of a direct thermal bridge.

The reduced heat transfer resistance of such window systems reaches 0.8–1.0 $m^2 \cdot °C/W$, compared to 0.3–0.4 $m^2 \cdot °C/W$ for old wooden window frames.

3. Thermal Insulation of Attic Floors and Flat Roofs

Warm air rises due to convection, creating increased heat losses through the upper part of a building. For attic floor structures, an effective layered assembly includes (from bottom to top):

- a vapour barrier membrane (preventing water vapour penetration from indoor spaces into the insulation layer);
- a structural insulation layer (mineral wool or basalt wool boards) with a thickness of 200–300 mm;
- a windproof diffusion membrane (allowing vapour to escape from the insulation while preventing heat loss caused by wind);
- a ventilated air gap (for removing accidental moisture accumulation).

For flat roofs, whether accessible or non-accessible, extruded polystyrene foam is used as a more rigid and moisture-resistant material. Ground floor insulation is performed using a polystyrene foam layer at least 100 mm thick across the entire slab area, together with additional perimeter insulation to prevent freezing in the plinth zone.

4. Elimination of Thermal Bridges

Thermal bridges are localized sections of building envelopes with significantly reduced heat transfer resistance. Typical locations include junctions between balcony slabs and walls, lintels above window and door openings, building corners, and panel joints. Through such areas, the heat flux increases by 2–5 times compared to the main wall surface. The total additional heat losses may account for 5–15 % of the overall losses.

Methods of elimination include:

- structural methods – the use of thermal inserts made of polymer materials or stainless steel with low thermal conductivity in junction assemblies;
- technological methods – ensuring a continuous insulation contour without interruptions, as well as covering balcony slabs with insulation both from the façade side and from the slab surface itself;
- inspection methods – thermal imaging surveys make it possible to identify thermal bridges by detecting surface temperature differences of 3–5 °C or greater.

5. Ventilation with Heat Recovery

Ventilation heat losses in systems with natural exhaust ventilation or supply ventilation without heat recovery account for 20–30 % of the total heat losses. With a standardized air exchange rate of 0.5 h^{-1} and a room volume of 150 m^3, heat losses amount to approximately 1000 W at a temperature difference of 30 °C.

A heat recovery unit (recuperator) is a heat exchanger in which thermal energy from exhaust air is transferred to incoming fresh air without mixing the air streams. The main types include:

- plate heat exchangers (cross-flow type) – efficiency of 70–85 %; simple in design but requiring frost protection;
- rotary heat exchangers (rotating heat exchange wheel) – efficiency up to 90 %; capable of transferring moisture but requiring an electric drive;
- systems with an intermediate heat transfer fluid (water or glycol circuit) – less efficient but allowing supply and exhaust systems to be separated over large distances.

A mandatory operating condition in cold climates is preliminary air preheating or bypass operation to prevent condensate freezing on the heat exchanger plates [2, p. 55-58].

6. Reduction of Heat Losses in Heating System Pipelines Inside Buildings

Transportation of the heat carrier from the riser to the heating appliance is accompanied by heat losses caused by:

- the absence or insufficient thickness of thermal insulation on pipelines located in unheated areas (basements, attics, and chases within external walls);
- installation of supply pipelines inside external walls, where the pipe effectively acts as a cooling fin;
- hydraulic imbalance leading to excessive circulation and elevated return water temperature.

Methods for reducing such losses include the insulation of pipelines using foamed rubber or polyethylene foam insulation (for DN20 pipes, the insulation thickness should be 20–30 mm), prohibition of pipeline installation inside external walls without enhanced insulation, and installation of balancing valves and thermostatic control valves.

7. Optimal Placement of Radiators

The thermally efficient placement of heating devices includes the following principles:

- the radiator must be installed beneath the window, since the upward airflow from the radiator blocks the cold air descending from the glazing surface and reduces infiltration;
- the radiator length should be at least 70–80 % of the window width; otherwise, cold air penetrates along the edges;
- radiators should not be covered with decorative screens lacking convection openings, as this reduces heat output by 20–30 %, leading to an increase in the required heat carrier temperature and, consequently, to higher heat losses through pipelines and walls;

– installation of thermostatic valves allows the maintenance of a constant indoor temperature; each additional degree Celsius in the room increases heat losses by approximately 5 %.

8. Underfloor Heating Systems

Underfloor heating systems operate at a lower heat carrier temperature (30–40 °C) compared to radiator systems (60–70 °C). This low-temperature operating mode provides several advantages:

– heat losses through supply pipelines are reduced due to a smaller temperature difference;

– the efficiency of heat pumps and condensing boilers, which are designed for low return water temperatures, is increased;

– uniform temperature distribution throughout the room eliminates overheating zones near the ceiling, thereby reducing overall transmission heat losses through the upper part of the building.

A mandatory requirement is the installation of a thermal insulation layer beneath the underfloor heating pipes (extruded polystyrene foam with a thickness of at least 50 mm); otherwise, downward heat losses into the floor structure or ground may negate the entire effect [3, p. 198-201].

Part 2. Applicability of Methods for Boiler Houses and District Heating Networks

Methods Suitable for Reducing Heat Losses During Heat Transportation from the Boiler House to the Building

1. Thermal Insulation of Pipelines

This method is a direct analogue of wall insulation in buildings, but applied to heating networks. The following materials are commonly used:

– mineral wool cylinders and mats with a protective galvanized steel or foil covering;

– polyurethane foam (PU foam) insulation in a rigid casing, which is the most effective solution for both underground and above-ground pipeline installation.

– The requirements for insulation thickness are regulated by set of rules 124.13330 for two-pipe water-based district heating networks. A properly insulated pipeline reduces heat losses along the “boiler house – heating substation” section to 2–5 %, compared to 15–20 % in the absence of insulation.

– Such a solution is highly effective for preventing unnecessary heat release in areas where it is not required.

2. Optimization of the Hydraulic Operating Mode (Balancing)

Similarly to balancing valves used inside buildings, district heating networks employ differential pressure controllers and flow meters. The elimination of excessive flow redistribution and overcirculation reduces heat losses in the return pipeline and decreases the operating load of network pumps.

3. Control and Elimination of Thermal Bridges in Heating Chambers and Connection Nodes

At locations where pipelines pass through the walls of heating chambers, as well as in stuffing-box expansion joints and pipe supports, local uninsulated zones are

formed. The use of thermal inserts, extended insulated branch pipes, and pre-insulated expansion joints reduces these heat losses.

4. Low-Temperature Operating Modes

If an underfloor heating system is implemented in the building and the required heat carrier temperature is reduced, the boiler house can operate at a lower return water temperature. This increases the efficiency of a condensing boiler by 10–15 % and reduces heat losses in the network proportionally to the square of the temperature ratio.

Methods That Are Not Suitable for Boiler Houses and District Heating Networks

1. Multi-Chamber Insulating Glass Units and Low-Emissivity Coatings

These methods are not applicable because they relate exclusively to transparent building envelope structures. A boiler house either has no windows in the conventional sense or the window area constitutes a negligible fraction of the total surface area. The physics of infrared reflection does not apply to steel pipelines or brick walls of boiler houses.

2. Heat Recovery from Boiler House Ventilation

Although theoretically possible, in practice boiler houses are usually designed with either natural ventilation or mechanical ventilation without heat recovery. The reason is the relatively small volume of ventilated air and the lack of necessity for preheating supply air through a heat recovery unit, since the boiler house already contains excess heat released from equipment surfaces. Furthermore, safety regulations for gas equipment facilities prohibit air recirculation. Therefore, the implementation of heat recovery systems in boiler houses represents an economically unjustified complication.

3. Placement of Radiators Beneath Windows and Underfloor Heating Systems

These are internal building methods that are unrelated to district heating networks. Along the section from the boiler house to the building, there are no windows, floors, or radiators. The relocation of a heating device inside a room does not affect heat losses in the main pipeline.

4. External Wall Insulation

Although the walls of a boiler house can and should be insulated (which reduces heat losses through the building envelope of the boiler house itself), this method is not directly related to the transportation of heat to the consumer. If the objective is specifically to reduce losses within the “boiler house – heating network – building” system, insulation of the boiler house walls has only an indirect effect: it decreases the boiler house’s own heat consumption but does not influence the delivery of heat to apartments. Therefore, within the context of reducing heat transmission losses, this method is generally not considered.

5. Elimination of Thermal Bridges in Building Walls

This method is applicable only to the building envelopes of heated premises. In district heating networks, thermal bridges have a different nature (supports, heating chambers, insulation discontinuities) and are eliminated using other methods, such as pre-insulated branch pipes and trenchless pipeline installation. Solutions developed for

the corner joints of residential buildings cannot be directly transferred to heating mains [4, p. 45-47].

General Conclusion

The integrated application of heat loss reduction methods in buildings – including wall insulation, energy-efficient windows, heat recovery ventilation, elimination of thermal bridges, optimal arrangement of pipelines and radiators, and underfloor heating systems – makes it possible to reduce heating energy demand by 2–3 times.

Additional reduction of heat losses during heat transportation from the boiler house to the building is achieved through pipeline insulation (to prevent unnecessary heat dissipation), hydraulic balancing, and elimination of thermal bridges in heating network components.

At the same time, methods effective within buildings cannot always be applied to heating networks, and vice versa. Consideration of these differences makes it possible to design energy-efficient heat supply systems at all stages, from the heat source to the final heating appliance [5, p. 91-93].

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УДК 004.415

CI/CD PIPELINES: AUTOMATION OF SOFTWARE DELIVERY IN MODERN DEVELOPMENT TEAMS

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Abstract. This article examines the principles and architecture of Continuous Integration and Continuous Delivery (CI/CD) pipelines as a core methodology for automating software delivery in modern development teams. The anatomy of a typical pipeline is analyzed, covering build, test, and deployment stages. Key challenges – including slow pipelines, flaky tests, and secrets management – are identified, and best practices are discussed in the context of DevOps culture.

Keywords: continuous integration, continuous delivery, CI/CD pipeline, DevOps, software automation, deployment, GitHub Actions, Jenkins, trunk-based development, software engineering.

CI/CD ПАЙПЛАЙНЫ: АВТОМАТИЗАЦИЯ ПОСТАВКИ ПРОГРАММНОГО ОБЕСПЕЧЕНИЯ В СОВРЕМЕННЫХ КОМАНДАХ РАЗРАБОТЧИКОВ

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Аннотация. В статье рассматриваются принципы и архитектура конвейеров непрерывной интеграции и непрерывной доставки (CI/CD) в качестве основной методологии автоматизации поставки программного обеспечения в современных командах разработчиков. Анализируется структура типового пайплайна, включая стадии сборки, тестирования и развертывания. Выявлены ключевые проблемы: медленные пайплайны, нестабильные тесты и управление секретами. Рассмотрены лучшие практики в контексте культуры DevOps.

Ключевые слова: непрерывная интеграция, непрерывная поставка, конвейер CI/CD, DevOps, автоматизация программного обеспечения, развертывание, действия на GitHub, Jenkins, магистральная разработка, разработка программного обеспечения.

The landscape of software development has undergone a fundamental transformation over the past two decades. In the early 2000s, software releases were infrequent events – often monthly or quarterly – that required extensive manual coordination, lengthy testing phases, and significant deployment risk. Today, leading

technology companies deploy code to production hundreds or even thousands of times per day. This shift has been made possible by Continuous Integration and Continuous Delivery (CI/CD) pipelines, which automate the process of building, testing, and delivering software changes. Understanding the principles and architecture of CI/CD systems is essential for any software engineering team seeking to compete in an environment where development velocity and reliability have become critical business advantages.

The origins of CI/CD practices trace back to Extreme Programming (XP), proposed by Kent Beck in the late 1990s, which included continuous integration as one of its core practices. The broader DevOps movement, which emerged around 2008–2009, extended these ideas into a comprehensive cultural and organizational framework that brought development and operations teams together under shared responsibility for the entire software lifecycle. CI/CD pipelines became the technical backbone of this cultural shift, providing the automation infrastructure that makes rapid and reliable delivery possible [1].

Continuous Integration (CI) is the practice of merging all developers' working copies to a shared mainline frequently – ideally multiple times per day. Each integration is automatically verified by running a suite of tests to detect errors as quickly as possible. The fundamental insight behind CI is that the longer branches diverge from the main codebase, the more expensive integration becomes: merge conflicts multiply, undiscovered bugs accumulate, and the "big bang" integration at the end of a development cycle becomes a source of significant delay and unpredictability. By integrating continuously, teams keep their changes small and their feedback loops short [1, 2].

A CI pipeline typically consists of several sequential stages. The source stage monitors version control repositories for new commits or pull requests. The build stage compiles source code, resolves dependencies, and produces deployable artifacts. The test stage executes automated tests at multiple levels: unit tests verify individual functions and classes in isolation, integration tests verify interactions between components, and end-to-end tests verify complete user workflows. A code quality stage may additionally run static analysis tools, linters, and security vulnerability scanners. The most widely used CI platforms include GitHub Actions, GitLab CI/CD, Jenkins, CircleCI, and TeamCity, each offering different trade-offs between flexibility, integration, and operational overhead [2, 3].

Continuous Delivery (CD) extends CI by ensuring that software can be reliably released at any time. In a Continuous Delivery pipeline, every change that passes the automated test suite is automatically deployed to a staging environment that closely mirrors production. The actual release to production requires a manual approval step – a deliberate human decision that the change is ready for users. Continuous Deployment goes one step further, eliminating the manual gate entirely: every change that passes all automated checks is automatically deployed to production without human intervention. The choice between these two approaches depends on the organization's risk tolerance, regulatory requirements, and operational maturity [3].

A complete CD pipeline extends the CI pipeline with deployment-specific stages. The staging deployment stage delivers the artifact to a pre-production environment for

further validation. Smoke tests verify that the deployed application starts correctly and that its most critical paths are functional. The production deployment stage executes the release to live infrastructure, often using strategies such as blue-green deployment – running old and new versions simultaneously and switching traffic atomically – canary deployment, which routes a small percentage of traffic to the new version before full rollout, or rolling deployment, which gradually replaces old instances with new ones. Post-deployment monitoring tracks error rates and performance metrics to enable rapid rollback if necessary [3, 4].

The ecosystem of CI/CD tooling has grown substantially over the past decade. GitHub Actions, introduced in 2018, integrates CI/CD directly into the most widely used code hosting platform, allowing pipelines to be defined in YAML files within the repository itself – an approach known as pipeline as code. GitLab CI/CD offers similar repository-integrated pipelines with built-in container registry and deployment management. Jenkins, the oldest and most widely deployed CI server, provides maximum flexibility through an extensive plugin ecosystem at the cost of significant operational effort to maintain. For containerized applications, Kubernetes-native tools such as Argo CD and Flux provide GitOps-based continuous deployment capabilities, where the desired cluster state is declared in a Git repository and automatically reconciled with the running infrastructure [3].

The integration of security practices into CI/CD pipelines – a discipline commonly referred to as DevSecOps, or "shifting security left" – has become an organizational imperative as software supply chain attacks have grown in frequency and sophistication. A security-aware pipeline incorporates Static Application Security Testing (SAST), which analyzes source code for known vulnerability patterns without executing it, alongside Software Composition Analysis (SCA), which scans third-party dependencies for published CVEs. Dynamic Application Security Testing (DAST) tools probe running application instances in staging environments, simulating external attack vectors. Container image scanning verifies that base images and installed packages contain no known vulnerabilities before deployment. High-profile incidents – including the SolarWinds supply chain compromise of 2020 and the Log4Shell vulnerability of 2021 – demonstrated that inadequately secured build pipelines can serve as a vector for introducing malicious code at the dependency or build level, making pipeline security a first-class engineering concern rather than an afterthought [2, 3].

Measuring CI/CD effectiveness requires a principled approach to performance indicators. The DORA (DevOps Research and Assessment) framework, developed through longitudinal research across thousands of organizations, identifies four key metrics that reliably differentiate high-performing software delivery teams. Deployment frequency captures how often an organization successfully releases to production. Lead time for changes measures elapsed time from a developer committing code to that code running in production. Mean time to restore (MTTR) quantifies how quickly a team recovers service following an incident. Change failure rate captures the percentage of deployments that require remediation. Elite performers achieve deployment frequencies of multiple times per day, lead times measured in hours, MTTR under one hour, and change failure rates below 5 %. These metrics provide

objective benchmarks against which organizations can evaluate the maturity and return on investment of their CI/CD initiatives [1, 5].

The widespread adoption of containerization – principally Docker and Kubernetes – has profoundly shaped modern CI/CD architectures. Containers package application code together with its complete runtime environment, guaranteeing behavioral consistency across development, staging, and production. In a container-native pipeline, the build stage produces a Docker image tagged with the commit hash, pushes it to a container registry, and subsequently deploys it through Kubernetes manifests or Helm charts. Microservices architectures – where a system is decomposed into independently deployable services – multiply the number of pipelines an organization must maintain but also enable independent release cadences per service. The GitOps paradigm, embodied by tools such as Argo CD, extends this model by treating the Git repository as the single source of truth for cluster state: changes to manifests trigger automated synchronization, making deployments fully auditable, reproducible, and reversible through standard version control operations [3, 4].

Effective CI/CD pipelines implement a coherent testing strategy organized according to the test pyramid principle. At the base sit unit tests: fast, isolated, and numerous – typically several thousand in a mature codebase – verifiable in under a minute. The middle layer comprises integration tests that verify interactions between components such as databases, message queues, and external APIs; these tests run against real or containerized dependencies and are more expensive to execute. At the apex sit end-to-end tests exercising complete user workflows; these are the most expensive to write and maintain, and should cover only the most critical business paths. Quality gates enforced by the CI server prevent a change from advancing to the next pipeline stage if any tier fails a defined threshold for coverage, pass rate, or code quality score. Contract testing – validating that the API contracts between microservices are honoured – provides a valuable complement to integration testing in distributed systems, where full end-to-end test suites would otherwise be prohibitively expensive to run on every commit [2, 4].

The scope of modern CI/CD pipelines extends beyond application code to encompass infrastructure itself through the practice of Infrastructure as Code (IaC). Tools such as Terraform, Pulumi, and AWS CloudFormation allow cloud resources – virtual machines, network configurations, database instances, and access policies – to be declared in version-controlled configuration files and provisioned or updated automatically as part of the deployment pipeline. IaC replaces manually configured "snowflake" servers with immutable infrastructure: when a configuration change is required, new infrastructure is provisioned from the updated specification and old infrastructure is decommissioned, rather than modified in place. Configuration management tools such as Ansible complement IaC by managing the software state of provisioned servers. Integrating IaC into CI/CD pipelines means that infrastructure changes receive the same automated validation, review, and deployment discipline as application changes, dramatically reducing the risk of environment drift and configuration-related incidents [3, 5].

Despite the benefits of CI/CD, teams commonly encounter several challenges in practice. Pipeline performance is a critical concern: as test suites grow, execution time

increases, and a pipeline requiring 45 minutes to complete significantly degrades developer productivity by delaying feedback. Techniques to address this include test parallelization, test impact analysis – running only tests affected by changed code – and aggressive caching of dependencies and build artifacts. Flaky tests, which intermittently fail without any code changes, undermine trust in the pipeline and must be identified, quarantined, and fixed promptly to prevent alert fatigue [4, 5].

Secrets management represents another significant challenge. API keys, database credentials, and certificates must be injected into pipelines without being exposed in logs or committed to source code repositories. Modern CI/CD platforms address this through dedicated secrets stores – GitHub Encrypted Secrets, HashiCorp Vault, or cloud-native services such as AWS Secrets Manager. Environment parity is also a recurring difficulty: differences between development, staging, and production environments cause bugs that pass all pipeline checks yet manifest only in production. Containerization with Docker and Kubernetes significantly reduces environment parity issues by encapsulating application dependencies and runtime configuration [4].

Research and industry experience have converged on several best practices for effective CI/CD implementation. Trunk-based development – keeping all developers working against a single long-lived branch rather than isolated feature branches – minimizes integration complexity and is strongly associated with high software delivery performance. Feature flags, also known as feature toggles, allow new functionality to be merged and deployed without being activated, decoupling code deployment from feature release and enabling gradual rollout to subsets of users. The "fail fast" principle prioritizes running the fastest and most informative checks early in the pipeline, ensuring developers receive actionable feedback within minutes of committing code [5].

CI/CD pipelines represent both a technical practice and a cultural transformation in how software teams conceptualize quality and delivery. The automation of build, test, and deployment processes eliminates entire categories of manual error, compresses feedback loops from days to minutes, and transforms releases from high-risk events into routine operations. The annual State of DevOps research, conducted since 2014, consistently demonstrates that organizations with mature CI/CD practices significantly outperform their peers across all key delivery metrics: deployment frequency, lead time for changes, time to restore service, and change failure rate. Achieving this maturity requires sustained investment in test automation, pipeline infrastructure, and, most critically, the organizational culture that treats the delivery process itself as a first-class engineering concern subject to continuous measurement and improvement [1, 2].

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При подготовке статьи были применены технологии искусственного интеллекта.

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УДК 621.315.6+621.316.37

COMPARISON OF THE EFFICIENCY OF SOLID AND GASEOUS DIELECTRICS IN COMPACT SWITCHGEAR

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Abstract. In today's context, the appropriate selection of dielectric polymer materials for compact switchgear represents a pressing issue. This paper presents calculations of key physical and operational parameters of polymers, as well as an assessment of their cost-effectiveness. Multi-criteria optimisation criteria have been formulated, including electrical strength, heat resistance, manufacturability and cost. The results obtained enable informed decisions to be made regarding the replacement of traditional insulating materials with polymeric alternatives.

Keywords: polymers, dielectric constant, compact switchgear, capacitor, cost.

СРАВНЕНИЕ ЭФФЕКТИВНОСТИ ТВЕРДЫХ И ГАЗООБРАЗНЫХ ДИЭЛЕКТРИКОВ В КОМПАКТНЫХ РАСПРЕДЕЛИТЕЛЬНЫХ УСТРОЙСТВАХ

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Аннотация. В современных условиях острой проблемой является обоснованный выбор диэлектрических полимерных материалов для компактных распределительных устройств. В работе выполнены расчеты ключевых физических и эксплуатационных параметров полимеров, а также оценена их экономическая эффективность. Сформулированы критерии многокритериальной оптимизации, включающие электрическую прочность, теплостойкость, технологичность и стоимость. Полученные результаты позволяют принимать аргументированные решения о замене традиционных изоляционных материалов полимерными аналогами.

Ключевые слова: полимеры, диэлектрическая проницаемость, компактное распределительное устройство, конденсатор, стоимость.

Compact switchgear is widely used in today's world. The choice of dielectric material is a key factor in ensuring the device’s performance, minimizing losses, and causing minimal environmental harm [1, p. 7]. Polymer dielectrics have become the most widely used due to the ease of manufacturing and installation, low dielectric constant, environmental friendliness, and low cost resulting from mass production.

Dielectrics are materials that do not conduct electricity well. In electrical engineering, they are used to insulate live parts in order to prevent short circuits and breakdowns between live components [2, p. 130-133]. A key characteristic of a dielectric material is its dielectric constant, which determines the material’s ability to store electrical energy and influences the distribution of the electric field within the insulating structure [3, p. 122-127]. In compact switchgear (CSG), dielectrics perform a critical function: they create an insulating barrier between current-carrying busbars and the grounded enclosure, as well as between phases of opposite polarity. The quality of the CSG depends precisely on the properties of the dielectric.

A compact switchgear unit (CSGU) is a metal enclosure containing current-carrying busbars, circuit breakers, disconnectors, and other switching equipment. The main feature of a CSGU is the minimal distances between the current-carrying parts of different phases, as well as between the busbars and the grounded enclosure. In terms of its design, the “current-carrying busbar – dielectric – grounded enclosure” system constitutes a classic capacitor: the busbar (live) and the metal enclosure (grounded) act as plates, while the insulating material filling the space between them acts as the dielectric. It is precisely the capacitive nature of switchgear that explains why dielectric constant, capacitance, leakage currents, and capacitive reactance become key characteristics [4, p. 4-5].

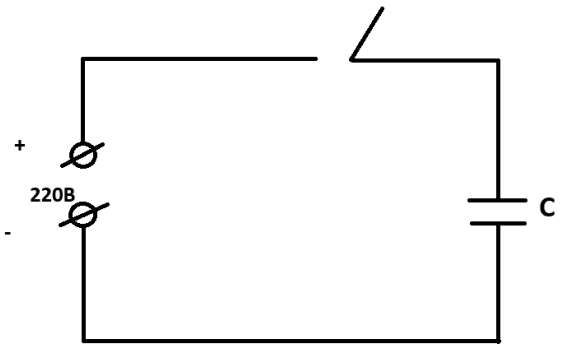


Figure. Electrical circuit diagram with a capacitor

An understanding of capacitor physics is essential for explaining the role of leakage current and capacitive reactance in power distribution equipment. Capacitive reactance is the resistance that a capacitor structure offers to alternating current. It decreases as the dielectric constant (ε) of the material increases. This means that in solid-insulated switchgear, parasitic capacitive currents will be higher–a factor that must be taken into account during design.

Leakage current is the current flowing through a dielectric that is not associated with the charging and discharging of a capacitor. In an ideal capacitor, the leakage

current is zero; in a real capacitor, it is always present due to imperfections in the insulation. For switchgear, leakage current is dangerous because it causes the material to heat up (dielectric losses) and can lead to thermal breakdown. Thus, analysis of capacitive reactance and leakage current is necessary to assess the reliability and durability of switchgear.

This paper examines a capacitor in which various polymers have been selected as the dielectric between the plates. A vacuum was used as the reference dielectric.

The capacitance of a parallel-plate capacitor is determined by the shape and dimensions of the plates, the distance between them, and the dielectric properties of the medium filling the space between the plates [5, p. 89-91].

The capacitance of a parallel-plate capacitor is calculated using the following formula:

$$C = \frac{\varepsilon \varepsilon_0 S}{d} \quad (1)$$

Capacitive reactance:

$$x_c = \frac{1}{2\pi f c} \quad (2)$$

Leakage current:

$$I = \frac{U}{x_c} \quad (3)$$

Table 1. Specifications of the specified capacitor

Voltage, V	220
Frequency, Hz	50
Distance between the capacitor plates, m	0,001
Capacitor plate area, m²	0,01
Electrical constant, F/m	$8{,}85*10^{-12}$

Table 2. Dielectric Permeability of Polymers

Dielectric	**Dielectric constant**
Vacuum	1
Low-density polyethylene (high-pressure)	2,28
Polycarbonate	3,05
IRP Silicone Rubber - 1338	3,6
Getinax	6,5
Polymethyl methacrylate	3,5
FR-4 fiberglass-reinforced laminate	4,7

The results of the calculations are presented in a table for comparison (Table 3):

Table 3. Results of calculations for the main parameters of the capacitor

Dielectric	**Dielectric constant**	**Capacity, Pf**	**Capacitive reactance, MΩ**	**Leakage current, μA**
vacuum	1	8,85	35,9	6,1
Low-density polyethylene (high-pressure)	2,28	201,78	15,8	13,9
Polycarbonate	3,05	269,9	11,8	18,6
IRP Silicone Rubber – 1338	3,6	318,6	10	22
Getinax	6,5	575,25	5,53	39,7
Polymethyl methacrylate	3,5	309,75	10,28	21,4
FR-4 fiberglass-reinforced laminate	4,7	416	7,65	28,7

After calculating the dielectric constant, leakage current, capacitive resistance, and capacitance for each polymer dielectric under study, a natural question arises regarding the practical applicability of a given material. However, even the best combination of these electrophysical characteristics cannot serve as a definitive argument in favor of a choice without considering the cost of the polymer. The price of the material becomes a critical factor, since it is precisely this, in conjunction with the calculated capacitance, that determines such a crucial technical and economic indicator as the cost per unit of capacitance. A polymer that exhibits high dielectric constant and low leakage current but is significantly more expensive than its counterparts may prove economically unfeasible for the industrial production of capacitors. Thus, the cost of the dielectric is not merely an additional parameter, but an integral and significant part of the final comparison, capable of outweighing the individual electrophysical advantages of a given material.

The costs of the dielectrics are presented in a table for comparison (Table 4):

Table 4. Cost of Dielectric Materials

Dielectric	**Price, RUB/m³**
Vacuum	-
Low-density polyethylene (high-pressure)	0,00014
Polycarbonate	0,00067
IRP Silicone Rubber – 1338	0,00145
Getinax	0,00026
Polymethyl methacrylate	0,002
FR-4 fiberglass-reinforced laminate	0,024

For mass production of compact switchgear, low-density polyethylene is recommended as the most cost-effective material. It is distinguished by its low cost and electrophysical parameters sufficient for most applications: a leakage current of about

13.9 μA and a capacitance of about 202 pF, with the leakage current slightly more than double the vacuum reference value. The huge advantage in cost and ease of installation makes polyethylene the preferred choice for budget devices that do not require extremely low leakage currents. For high-voltage systems, however, where insulation reliability is paramount, polycarbonate is the optimal choice. While it trails more expensive materials (silicone rubber and polymethyl methacrylate) by only 10–15% in terms of leakage current and capacitance, it costs two to three times less than they do. In particular, compared to silicone rubber, the cost savings exceed half the price, making polycarbonate indispensable in critical components where every microampere counts.

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УДК 004.312.2

A COMPARISON OF THE COMPLEXITY OF COMBINATIONAL CIRCUITS FOR BINARY AND TERNARY SWITCHING FUNCTIONS

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Abstract. This paper examines how the complexity of implementing logic circuits differs when using binary (Boolean) and ternary (three-valued) logic. It describes the main metrics of circuit complexity (number of gates, transistors, and interconnections) and presents known results of comparative analysis. Using the examples of adders and multipliers, it is shown that ternary circuits often require far more components, although they offer advantages in terms of information density. Conclusions are drawn regarding scenarios in which each approach is best suited for use.

Keywords: Boolean functions, ternary logic, circuit complexity, transistor count, number of wires.

СРАВНЕНИЕ СЛОЖНОСТИ КОМБИНАЦИОННЫХ СХЕМ ДВОИЧНЫХ И ТРОИЧНЫХ ПЕРЕКЛЮЧАТЕЛЬНЫХ ФУНКЦИЙ

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Аннотация. В обзоре рассматривается, как отличается сложность реализации логических схем при использовании двоичной (булевой) и троичной (трехзначной) логики. Описываются основные метрики сложности схем (число вентилей, транзисторов, межсоединений) и приводятся известные результаты сравнительного анализа. На примерах сумматоров и умножителей показано, что троичные схемы часто требуют гораздо больше элементов, хотя имеют преимущества в плотности информации. Сделаны выводы о сценариях целесообразного применения каждого подхода.

Ключевые слова: булевы функции, троичная логика, сложность схемы, транзисторный счет, количество проводов.

A combinational circuit is defined as a logic circuit in which the output signals are determined solely by the current combination of inputs. Conventionally, all digital

computations are performed using binary logic elements (states 0/1). Concurrently, research is being conducted on systems with a more extensive logic base, including ternary systems (states −1, 0, +1 or 0, 1, 2). In principle, ternary logic allows for an increase in the information transmission capacity per channel. The transmission of a single bit requires $log_2 3 \approx 1.585$ bits, meaning that fewer conductors are required for an equivalent volume of data. In addition, symmetric ternary encoding provides arithmetic advantages. When digits are encoded as +1, 0, −1, changing the sign of a number results in all digits being inverted, while truncating excess bits corresponds to rounding without additional logic [1]. However, the implementation of ternary elements is significantly more complex than that of binary ones. The present article analyses how these factors affect circuit complexity.

It is a well-established fact that the vast majority of Boolean functions of n variables necessitate circuits of exponential size $\left(\Theta(2^n/n)\right)$ [2]. As is evident from the extant literature, analogous estimates are in existence for multi-valued (k-valued) functions. Nevertheless, in practice, the focus is generally on the comparison of specific circuits. The complexity of a circuit is typically quantified by the number of gates or transistors, the density of the interconnections, and the circuit's depth. When comparing binary and ternary logic, transistor count and the number of wires are frequently used as key indicators. The selection of these metrics is substantiated by the observation that an increase in the number of transistors typically results in elevated costs with respect to area, energy, and wire density [3]. The ensuing discourse shall be informed by the findings of prominent comparisons and theoretical contemplations.

It is hypothesized that N-ary logic has the potential to reduce the number of connections. It has been demonstrated that increasing the logic base reduces “wiring complexity” – that is, the number of wires required for connections within the network [4]. In practice, it has been observed that ternary multipliers use less than two-thirds of the interconnections of equivalent binary devices [5]. This has the potential to streamline the design process for circuit layouts. Nevertheless, the financial benefits derived from the reduction in wiring are frequently counterbalanced by the increased complexity of the gates themselves. The incorporation of ternary logic elements necessitates larger dimensions and specialized transistor structures, which can impose additional costs.

It is an established fact that binary circuits are generally less complex when the objective is to implement a given function. Empirical evidence demonstrates that a standard 1-bit adder is typically considerably more complex than a binary one. For instance, the implementation of a ternary full adder using a CNTFET required approximately 124 transistors, whereas a comparable 1-bit adder utilizing conventional components required only around 28 [3, 6]. In other words, the number of transistors in ternary circuits can exceed that of binary circuits by a factor of 4–5 or more. Consequently, circuit depth (due to additional multiplexers or encoders) and power consumption increase. In summary, an increase in the number of transistors in a ternary circuit by a factor of 2-3 directly implies higher costs in terms of wiring, area, and energy [3].

The studies in question make comparisons between the sizes of binary and ternary arithmetic units, with the same volume of information being processed. In this context,

equivalent information capacity is taken to be, for example, N-bit and M-trit arrays, where $N \approx M \log_2 3 \approx 1.585M$. It has been demonstrated through rigorous analysis that ternary adders and multipliers exhibit a marked disadvantage in terms of complexity. It has been determined that, in the context of large-scale binary and ternary adders, ternary circuits necessitate a substantially greater number of logic elements and transistors. The authors observe that "ternary adders and multipliers are unable to compete" with equivalent binary ones in terms of transistor complexity [6, 7]. This phenomenon can be attributed to two primary factors. Firstly, the presence of a substantial number of ternary partial products and carry operations contributes to the complexity of the circuitry. Secondly, the advanced design of the code converters involves more intricate circuitry, which further exacerbates the complexity.

Notwithstanding the intricacy of the hardware, ternary logic proffers certain conceptual advantages. As previously stated, in a symmetric ternary system, sign change is achieved simply by inverting all the trits, and there is no requirement for separate logic for rounding: the automatic performance of correct rounding is achieved by the discarding of the least significant trits [1]. Such properties serve to simplify the calculation of signed numbers and ensure that truncation operations are performed with precision, obviating the necessity for additional compensation. This property is advantageous in the context of specialized computational tasks and the design of arithmetic coprocessors.

In the field of engineering, there was experience of constructing ternary devices. For instance, the first Soviet computer, the "Setun" (1958), utilized magnetic trigger cells with three stable states [7]. This demonstrated the viability of the ternary approach, as evidenced by the implementation of arithmetic in base-3 in "Setun". However, the subsequent superiority of binary circuits was due to their ease of manufacture and the widespread availability of components. To date, the implementation of ternary ideas has been limited to experimental or niche developments. For instance, multi-valued logics have been investigated in the context of memory cells or neural networks. The prevailing consensus is that binary logic continues to be the prevailing standard due to its technological maturity. However, multi-valued logic exhibits theoretical potential for reducing wiring and potentially facilitating more compact information encoding [4].

A significant factor that is frequently disregarded when comparing binary and ternary circuits is the cost of converting codes between different number bases. In mixed systems, a ternary computing unit rarely operates in isolation; its inputs and outputs typically require encoders, decoders and multiplexers to convert signals into and from the working representation. Recent research into balanced ternary systems has demonstrated that auxiliary components such as TMIN/TMAX, inverters, encoders and decoders already account for a significant portion of the overall hardware complexity. Furthermore, an increase in complexity is particularly noticeable for functional blocks such as half-adders, multipliers and comparators [8].

A further rationale for the preference of binary logic over ternary logic in mass-market circuit design pertains to the domains of voltage and noise immunity. It is imperative to distinguish not two but three stable voltage ranges, given the three signal levels. Consequently, the recognition windows are narrower and more sensitive to

manufacturing variations, noise and power supply fluctuations. This is precisely why reviews of ternary circuits emphasize that the advantages of multi-level logic in terms of density and the number of connections are often offset by increased delays and power consumption, particularly when based on conventional CMOS technology; better results are only achieved through special optimization and the use of CNTFET structures [9].

In the context of arithmetic units, the significance of three values is not the sole determining factor; the manner in which carry operations are organized is also of paramount importance. In the context of binary arithmetic, the utilization of partial sum roll-up schemes has been a long-standing practice, encompassing approaches such as carry-save and Wallace-tree methods. These schemes facilitate the reduction of the critical path by enabling the concurrent processing of multiple bits. In ternary arithmetic, this concept is maintained; however, the cost of each basic unit increases due to the necessity of supporting additional carry levels and more complex partial products. Consequently, the benefit of reducing the number of trits does not always compensate for the increased complexity of the internal hardware structure [10].

Research focusing not on “full” but on partial ternary adders provides an important clarification. It has been demonstrated that, for a number of arithmetic units, a full ternary adder is not a prerequisite; a partial version, in which the carry does not take on all three possible values, is sufficient. This does indeed simplify implementation and reduce the number of transistors; however, even in this optimized form, ternary solutions generally remain more complex than comparable binary blocks when the volume of information being computed is equal. Consequently, when analyzing complexity, it is important to distinguish between “abstract” functional completeness and the actual cost of the circuit at the transistor level [11].

Ternary logic is particularly advantageous in scenarios where it is necessary to process multiple signal states without reducing them to a strict binary choice. In balanced ternary and related circuits, signed representations and interfaces between arithmetic and logic units are of particular utility. However, it should be noted that this comes at the cost of additional conversions when exchanging data with conventional binary components. Consequently, within a real-world project, the cost of a ternary system is determined not solely by the gate itself, but by the entirety of the chain, encompassing the binary interface, encoding, computation, and decoding. At this level, the theoretical advantages in terms of the number of external wires can diminish significantly [11].

This comparison thus reveals a fundamental duality in the situation. Ternary combinational circuits have been shown to transmit greater information per signal and require fewer wires [4]. However, due to the more complex nature of their circuit elements, they frequently result in circuits that are “heavier” in terms of the number of gates and transistors. The experimental estimates confirm that practical implementations of ternary functions require a significantly higher number of components, resulting in increased area and energy consumption [3, 5]. Consequently, disregarding the historical and logical dimensions of the issue, the binary approach predominates in conventional digital systems. Concurrently, the study of ternary logic has the potential to enhance our comprehension of circuit theory and may offer

practical benefits in specialized applications. Multi-valued logic is of particular interest in scenarios where the minimum size of connections is of critical importance, or where integrated processing of multiple signal levels is required. Therefore, the selection of binary or ternary circuitry should be made according to the particular task and technological conditions. Binary circuits are characterized by simplicity and reliability; however, ternary circuits have the potential to be more compact in terms of wiring. Nevertheless, in practice, ternary circuits necessitate compromises in hardware [4].

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УДК 330.34

RISK MITIGATION IN RESPONSIBILITY DELEGATION VIA QUALIFIED ELECTRONIC SIGNATURE

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Abstract. The article examines the role of a qualified electronic signature (QES) in ensuring information security and optimizing business processes. The author analyses the historical development of electronic digital signatures (EDS), technical foundations and QES algorithms, and the regulatory framework for its application. Particular attention is given to risk mitigation examples in banking, medical documentation, and e-commerce. The benefits of QES implementation for enterprises and technology development prospects are also discussed.

Keywords: qualified electronic signature, information security, electronic document management, cryptographic protection, digitalization.

КВАЛИФИЦИРОВАННАЯ ЭЛЕКТРОННАЯ ПОДПИСЬ ДЛЯ УМЕНЬШЕНИЯ РИСКОВ ПРИ ПЕРЕДАЧЕ ОТВЕТСТВЕННОСТИ ТРЕТЬИМ ЛИЦАМ

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Аннотация. В статье рассматривается роль квалифицированной электронной подписи (КЭП) в обеспечении информационной безопасности и оптимизации бизнес-процессов. Автором анализируется история развития ЭЦП, технические основы и алгоритмы создания КЭП, нормативно-правовая база ее применения. Особое внимание уделяется практическим примерам снижения рисков в разных сферах (банковские транзакции, медицинская документация, электронная торговля и др.). В статье описаны преимущества внедрения КЭП для предприятий и перспективы развития технологии.

Ключевые слова: квалифицированная электронная подпись, информационная безопасность, электронный документооборот, криптографическая защита, цифровизация.

In the contemporary world, information security plays a crucial role in protecting confidential data and ensuring the uninterrupted operation of organizations. The growing number of cyberattacks and threats to the security of information and telecommunication systems necessitates the implementation of robust mechanisms for protecting electronic documents, one of which is the qualified electronic signature (QES).

The aim of this study is to analyze the role of QES in ensuring information security and mitigating business risks. To achieve this goal, the following objectives have been set: to study the historical development of electronic signatures and the evolution of their standards, to examine the technical foundations and algorithms for creating QES, to analyze the regulatory and legal framework governing the use of QES, to identify the advantages and limitations of the technology, to provide practical examples of risk reduction through the implementation of QES, to assess the prospects for the development of QES in the context of digitalization.

The qualified electronic signature offers numerous opportunities and significantly streamlines electronic document management (Fig.). QES plays a vital role in the modern digital environment by ensuring the legal validity and protection of electronic documents [1, p. 28].

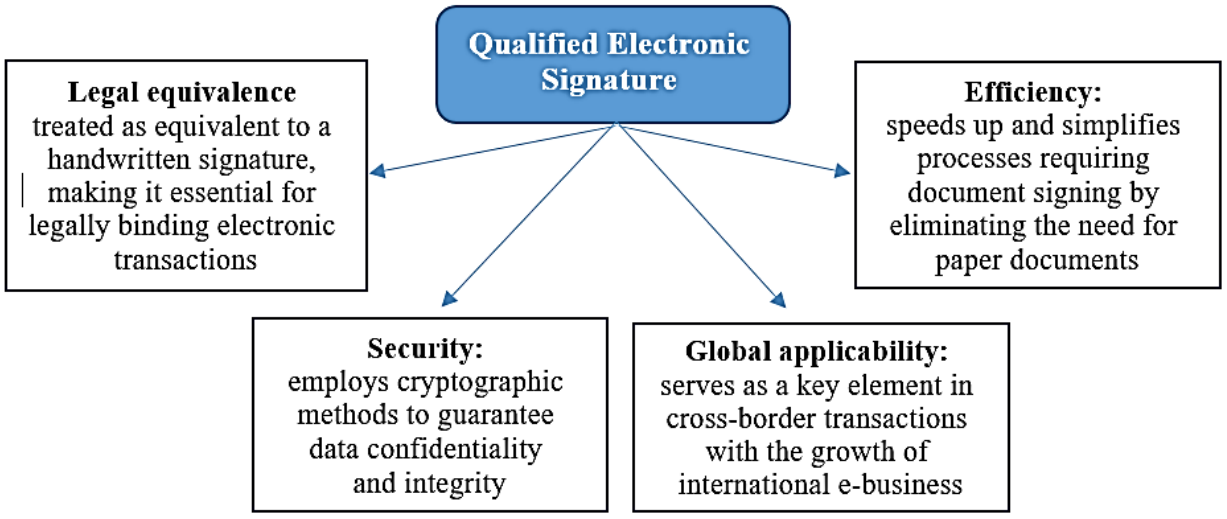


Figure. Key Advantages of the Qualified Electronic Signature

The growing relevance of the qualified electronic signature (QES) is closely tied to fundamental shifts in the global economy and public administration. As digital transformation accelerates across industries, traditional paper-based workflows are being replaced by electronic document management systems. This transition is driven by several key factors: the need for remote collaboration in a post-pandemic world, the rise of cross-border e-commerce, and government initiatives promoting «digital-first» public services. For instance, the European Commission's Digital Decade policy aims to ensure that 80 % of citizens have access to online public services by 2030, with QES playing a central role in this strategy. Similarly, national programs like India's Aadhaar and Estonia's e-Residency demonstrate how QES enables secure digital identity

frameworks. These trends underscore that QES is no longer a niche tool but a critical infrastructure component for modern economies.

Regulatory Framework for QES. The use of QES is regulated by legislation in various countries. In Russia, the primary regulatory act is the Federal Law "On Electronic Signatures" No. 63-FZ, which defines the types of electronic signatures and the conditions for their use [2]. In the European Union, the eIDAS Regulation establishes standards for electronic identification and trust services. These documents закрепляют (affirm) the legal validity of QES and set out security requirements for it.

History of the Development of QES. In 1976, Whitfield Diffie and Martin Hellman first proposed the concept of an "electronic digital signature", although at that time they merely hypothesized that electronic digital signature (EDS) schemes could exist [3, p. 48].

In 1977, Ronald Rivest, Adi Shamir, and Leonard Adleman developed the RSA cryptographic algorithm, which can be used without additional modifications to create primitive digital signatures. Shortly after the development of RSA, other EDS schemes were introduced, including the Rabin and Merkle digital signature algorithms.

In 1984, Shafi Goldwasser, Silvio Micali, and Ronald Rivest were the first to rigorously define security requirements for digital signature algorithms. They described attack models targeting EDS algorithms and proposed the GMR scheme, which meets the specified security requirements.

In 1994, the first Russian standard for EDS – GOST R 34.10-94 – was developed by the Main Directorate for Security Communications of the Federal Agency for Government Communications and Information under the President of the Russian Federation. This standard is based on computations in the group of elliptic curve points and on the hash function described in GOST R 34.11-94.

In 2002, to ensure greater cryptographic strength of the algorithm, GOST R 34.10-2001 was introduced as a replacement for GOST R 34.10-94. According to this standard, the terms "electronic digital signature" and "digital signature" are synonymous.

The evolution of standards and technologies has led to the emergence of the qualified electronic signature, which today meets the most stringent security requirements and ensures the highest level of legal validity.

Technical Foundations of QES. Modern digital signature schemes are built on diverse cryptographic principles, each tailored to specific security and operational requirements. The choice of scheme depends on factors such as computational efficiency, resistance to quantum attacks, and the need for anonymity or delegation. While early approaches relied on symmetric encryption, contemporary systems predominantly use asymmetric algorithms due to their ability to eliminate the need for trusted third parties. Emerging research also explores post-quantum cryptography (e.g., lattice-based signatures) to future-proof QES against advances in computing power. There are several schemes for constructing digital signatures:

Based on symmetric encryption algorithms. This scheme requires the presence of a third party in the system – an *arbiter* trusted by both sides. The authorization of

a document is the very fact of encrypting it with a secret key and transmitting it to the arbiter.

Based on asymmetric encryption algorithms. Currently, such EDS schemes are the most widespread and widely used. The operating principle is based on a key pair: a *private key* (used to create a signature) and a *public key* (used to verify a signature). This enables confirmation of the authorship and integrity of a document without the involvement of a third party [4, p. 37].

In addition, there are other types of digital signatures (group signature, undeniable signature, proxy signature), which are modifications of the schemes described above. Their emergence is driven by the diversity of tasks solved using EDS:

Group signature is used when a document is signed on behalf of a group of individuals, but the identity of the specific signatory remains anonymous to external observers.

Undeniable signature requires the explicit consent of the signatory to verify the signature, thereby preventing unauthorized verification.

Proxy signature involves the participation of a trusted party or system that confirms the legitimacy of the signature in special cases.

A digital electronic signature (DES) is a cryptographic mechanism used to authenticate a message or document in digital form. It serves as the equivalent of a traditional handwritten signature in the electronic environment [5].

Advantages and Risks of Electronic Signatures. The qualified electronic signature plays a key role in mitigating risks in the sphere of electronic transactions and information exchange. The implementation of QES delivers multifaceted benefits that extend beyond basic authentication. From a risk management perspective, QES acts as a preventive control in cybersecurity frameworks, reducing vulnerabilities associated with document tampering and identity fraud. Economically, it aligns with lean management principles by eliminating redundant processes. Legally, it bridges the gap between digital and physical workflows, ensuring compliance without sacrificing agility. However, these advantages are not without trade-offs. Organizations must balance the upfront investment in infrastructure with long-term savings, address human factors like user adoption, and mitigate technical risks such as key compromise or certification authority failures. A holistic view of these dynamics is essential for effective deployment. The advantages of QES are presented in Table 1 [6, p. 80].

Table 1. Advantages of Using QES

Name	Description
Authenticity verification	QES ensures confirmation of the sender's identity and the integrity of the signed data, thereby reducing the risks of falsification and increasing trust in electronic documents and transactions
Legal validity	In most countries, laws recognize qualified electronic signatures as equivalent to traditional handwritten signatures. Consequently, documents signed with QES have legal force
Digital security	The use of QES enhances the security of electronic data and documents, which are protected against unauthorized access and unauthorized modifications.

Time and resource savings	QES enables online transactions and contract execution without the need for physical presence, thus accelerating business processes and reducing costs associated with paper-based documentation.
Tamper resistance	Electronic signatures, especially qualified ones, are more difficult to forge or compromise compared to traditional handwritten signatures on paper
Compliance with regulations and requirements	Many industries have mandatory requirements for the use of qualified electronic signatures to meet regulatory and legal obligations.

At the same time, the implementation of QES is associated with certain limitations, such as high initial costs (acquisition of certificates and infrastructure setup), the need to train personnel to work with new tools, dependence on the reliability of certification authorities issuing QES certificates, and the risk of private key compromise, which may lead to unauthorized use of the signature [7].

Practical Examples of Risk Mitigation through Electronic Signatures. Electronic signatures offer numerous advantages and can significantly reduce risks in various domains. Practical examples are presented in Table 2:

Table 2. Examples of Risk Reduction through Electronic Signatures

Application Area	Problem	Solution
Electronic contracts	Risks associated with the falsification of paper-based contracts	Use of electronic signatures to confirm the authenticity and integrity of contracts. This reduces the risk of forgery and ensures the reliability of legal documents.
Electronic banking transactions	Risk of unauthorized transactions and fraud	Electronic signatures in the authorization of banking operations ensure security and identification of parties, thereby reducing the risk of financial fraud.
Electronic medical documentation	Confidentiality and integrity of medical data	Electronic signatures are used to confirm authorship and integrity of medical records, which reduces the risk of unauthorized access and data tampering.
Electronic correspondence	Risk of email spoofing and message forgery	Electronic signatures ensure the authenticity of the sender and the integrity of message content, thereby reducing the risk of phishing and other types of fraud.
E-commerce on marketplaces	Unfair trading practices and repudiation of obligations	Electronic signatures are used to confirm the consent of parties and provide evidence in case of disputes, thus reducing risks in e-commerce.
Access to classified information	Unauthorized access to digital platforms and sensitive data	Use of electronic signatures for user authentication and secure access to digital resources.
Intellectual property	Forgery and copyright infringement	Electronic signatures can be used to confirm authorship and the integrity of digital creative works, thereby reducing the risks of intellectual property infringement.

Beyond the listed examples, QES demonstrates transformative potential in emerging use cases. In supply chain management, it enables end-to-end traceability of

goods by linking digital signatures to IoT sensor data, reducing disputes over shipment conditions. In academic publishing, QES verifies authorship and prevents plagiarism by timestamping research submissions. Smart contracts on blockchain platforms use QES to authorize transactions, combining legal validity with automated execution. These applications highlight how QES evolves from a compliance tool to an enabler of innovation. For instance, a 2024 pilot in the UAE's real estate sector reduced property transfer times from 14 days to 48 hours by integrating QES with a government blockchain registry.

An analysis of the table shows that the maximum benefit from implementing a qualified electronic signature is achieved in areas with a high cost of errors (finance, healthcare, law) and in sectors with intensive document flow (publicestic public services, business). For example, the introduction of QES in the public services system of the Russian Federation has reduced the processing time for applications by 40 % and lowered costs associated with paper-based document management by 30 % [8, p. 115].

Prospects for QES Development. Technological development opens up new opportunities for improving QES. These include integration with blockchain technology to create immutable logs of signatures and enhance transparency, the use of biometric data (fingerprints, facial recognition) as an additional authentication factor, automation of processes using artificial intelligence to simplify signature management and reduce human error, and the expansion of international recognition of QES through harmonization of standards – for instance, mutual recognition of certificates among EAEU countries.

Conclusion. In light of the above analysis, the qualified electronic signature emerges as a cornerstone of secure digital transformation. Its value lies not only in technical robustness but in its ability to harmonize legal, operational, and economic priorities. By providing cryptographically verifiable proof of authorship and integrity, QES rebuilds trust in remote interactions – a critical factor in an era of rising cyber threats. The technology also reflects broader trends in information security: the shift from perimeter-based defenses to identity-centric models, the convergence of physical and digital authentication methods, and the growing importance of interoperability across national borders.

However, realizing these benefits requires a strategic approach. Organizations should prioritize phased implementation, starting with high-risk processes (e.g., financial approvals), user education to overcome resistance to change, regular audits of certificate authorities and key management practices and investment in hybrid solutions that support legacy systems during transition. These measures ensure that QES delivers on its promise of enhanced security without disrupting business continuity.

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УДК 004.89

MECHANISM OF SELF-ATTENTION IN TRANSFORMERS AND ITS APPLICATION IN ARTIFICIAL INTELLIGENCE TASKS

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Abstract. The article examines the mechanism of self-attention in transformers. The main principles of transformer operation, as well as the advantages of this architecture compared to recurrent neural networks, are described. Methods of applying transformers in artificial intelligence tasks are considered, including natural language processing, computer vision, time series analysis, bioinformatics, and audio synthesis. A conclusion is made about the significant influence of the self-attention mechanism on the current development of modern artificial intelligence.

Keywords: transformers, artificial intelligence, neural networks, machine learning, self-attention mechanism, computer vision.

МЕХАНИЗМ САМОВНИМАНИЯ В ТРАНСФОРМЕРАХ И ЕГО ПРИМЕНЕНИЕ В ЗАДАЧАХ ИСКУССТВЕННОГО ИНТЕЛЛЕКТА

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Аннотация. В статье рассматривается механизм самовнимания в трансформерах. Представлены основные принципы работы трансформеров, а также преимущества данной архитектуры по сравнению с рекуррентными нейронными сетями. Рассмотрены методы применения трансформеров в задачах искусственного интеллекта, включая обработку естественного языка, компьютерное зрение, анализ временных рядов, биоинформатику и синтез аудио. Сделан вывод о значительном влиянии механизма самовнимания на текущее развитие искусственного интеллекта.

Ключевые слова: трансформеры, искусственный интеллект, нейронные сети, машинное обучение, механизм самовнимания, компьютерное зрение.

In 2017, researchers presented the Transformer architecture in the paper Attention Is All You Need [1]. This model introduced a new approach to processing sequential

information through the self-attention mechanism. Unlike earlier neural architectures that handled data step by step, transformers were designed to identify the most relevant parts of an input sequence and analyze relationships between elements simultaneously. The appearance of transformers marked an important stage in the evolution of artificial intelligence and became a major breakthrough in natural language processing (NLP) [2].

Prior to the development of transformers, recurrent neural networks were considered the dominant solution for NLP tasks. RNN-based systems were capable of retaining information from previous sequence elements by maintaining an internal hidden state. This property allowed such networks to process textual and sequential data with contextual dependencies. However, recurrent models also demonstrated several serious weaknesses. Since information passed through the network sequentially, computations could not easily be parallelized, which increased training time. In addition, long input sequences frequently caused vanishing or exploding gradient problems [3], reducing training stability and making optimization more difficult.

The Transformer architecture addressed these limitations by removing recurrent processing and replacing it with self-attention. Instead of analyzing tokens one after another, the model evaluates all sequence elements at the same time and determines how strongly they are connected to each other. This mechanism calculates attention weights that indicate the importance of one token relative to another. Because transformers do not rely on hidden recurrent states, they can process information more efficiently and preserve long-distance contextual relationships within data.

Modern artificial intelligence systems operate mainly with mathematical representations such as vectors, tensors, and matrices. In transformers, the attention mechanism is implemented through three separate matrices known as Query (Q), Key (K), and Value (V) [4]. These matrices interact with word embeddings, which encode semantic information about words based on their statistical occurrence and contextual relationships in large datasets. During the learning process, the parameters of these matrices are continuously adjusted to improve model performance.

The Query matrix represents the token for which contextual relevance is being calculated. The Key matrix describes tokens that are compared against the query, while the Value matrix contains information used to build the final representation. Attention scores are obtained by comparing Query and Key vectors. A larger score indicates a stronger semantic connection between words, whereas smaller values correspond to weaker associations. The resulting scores are then applied to the Value vectors, allowing the network to generate context-sensitive representations. Through iterative optimization and backpropagation, the model gradually minimizes prediction errors and improves accuracy.

During output generation, transformers dynamically redistribute attention depending on context. This allows the network to emphasize the most informative parts of the sequence while ignoring less relevant details. Such an approach significantly improves the processing of sequences with varying lengths and complex contextual structures. After the publication of the original Transformer paper [1], this architecture rapidly became the basis for a new generation of artificial intelligence systems.

Today, transformers are used across numerous technological and scientific domains. Their flexibility allows them to process text, visual information, audio signals, biological data, and other complex structures. The most common applications remain connected with natural language processing [2], including machine translation, conversational systems, search technologies, automated summarization, and sentiment analysis. The rapid progress of transformer architectures directly contributed to the emergence of large language models capable of performing a wide range of linguistic tasks with high precision.

One of the best-known transformer-based systems is BERT, which significantly improved contextual understanding in NLP applications. Another important development was the GPT series created by OpenAI. These models demonstrated advanced capabilities in text generation and human-computer communication. They are currently applied in intelligent assistants, automated support systems, dialogue agents, and content generation platforms. Transformer networks have effectively changed modern approaches to text analysis and information retrieval.

One of the key reasons for the success of transformers in NLP is their ability to preserve contextual relationships between words regardless of distance within a sentence. Earlier recurrent architectures often struggled with maintaining information over long sequences, whereas self-attention mechanisms allow transformers to evaluate semantic relationships more directly. This significantly improved tasks involving contextual interpretation, ambiguity resolution, and coherent text generation. The emergence of large language models additionally accelerated the development of generative artificial intelligence. Modern transformer-based systems are capable of answering questions, generating articles, summarizing documents, translating languages, and supporting interactive dialogue with users.

Transformer architectures are also widely applied in computer vision. A major milestone in this direction was the introduction of the Vision Transformer model [5]. Instead of processing entire images directly, Vision Transformers divide images into smaller patches that are treated similarly to tokens in language models. The self-attention mechanism then evaluates relationships between these image fragments. This method proved effective for image recognition, segmentation, and object detection tasks. Over time, Vision Transformers became competitive with traditional convolutional neural networks in many computer vision applications.

Unlike convolutional neural networks, which mainly focus on local spatial features, Vision Transformers are capable of modeling global relationships between distant image regions. This property improves the understanding of complex visual structures and contextual information within images. As a result, transformer-based vision systems have demonstrated strong performance in medical image analysis, autonomous driving technologies, satellite image interpretation, and industrial quality control.

Another important advantage of Vision Transformers is their scalability. With sufficiently large training datasets, transformer-based image models can achieve competitive or even superior results compared to conventional convolutional architectures. The flexibility of self-attention mechanisms additionally allows

researchers to adapt transformer models to multimodal systems combining visual and textual information.

Text-to-image generation systems represent another important area where transformers are actively used. Models such as DALL·E developed by OpenAI are capable of generating visual content from textual prompts. These systems combine language understanding with image synthesis through transformer-based architectures and attention mechanisms.

Modern artificial intelligence increasingly relies on multimodal transformer systems capable of processing several types of information simultaneously. Such models combine textual, visual, and audio data within a unified architecture. Multimodal transformers are currently used in intelligent assistants, content generation platforms, recommendation systems, and interactive digital environments. The integration of multiple data modalities allows artificial intelligence systems to achieve a more comprehensive understanding of complex tasks and user interactions.

The role of artificial intelligence in education [6] has also expanded considerably. AI technologies are increasingly used to create adaptive educational platforms, automate assessment procedures, analyze student performance, and generate teaching materials. Personalized learning systems built on AI can adjust educational content according to the individual needs and progress of learners.

In scientific research, transformers have shown particularly strong results in bioinformatics. Protein sequences can be represented as vectorized data and processed similarly to language structures [7]. A notable example is AlphaFold, developed by DeepMind. This project combined attention mechanisms with deep learning methods to predict protein structures with unprecedented accuracy, which significantly influenced biological and medical research. Transformer-based models are additionally applied in genomic analysis and disease-related studies.

Self-attention mechanisms have also demonstrated high efficiency in tasks involving temporal and sequential data [8]. Unlike recurrent models that process data sequentially, transformers evaluate all time steps simultaneously, which improves computational efficiency and forecasting quality. Such properties are especially valuable in fields including economics, meteorology, energy management, and financial analytics, where accurate time series prediction is essential.

Transformer-based forecasting systems are especially effective when working with large volumes of sequential information containing long-term temporal dependencies. Self-attention mechanisms allow models to identify hidden patterns and relationships between distant time intervals more efficiently than many traditional statistical and recurrent approaches. This improves prediction accuracy in complex dynamic systems where multiple factors influence future outcomes simultaneously.

Speech technologies represent another important direction of transformer applications [9]. Models such as Whisper utilize transformer architectures for high-quality speech recognition and audio transcription. In addition, modern AI systems can synthesize realistic artificial voices that are widely used in media production, communication platforms, and digital services.

Apart from the areas mentioned above, transformers are also employed in market forecasting, reinforcement learning, intelligent automation, and interactive

entertainment systems. In video game development, transformer-based models can be used to create adaptive NPCs (non-player characters) [10] capable of modifying their behavior according to player actions. As transformer technologies continue to evolve, their practical applications are becoming increasingly diverse.

Despite the successes of transformer architectures, their application is associated with several significant challenges [11]. Transformers require substantial computational resources both during training and inference, which limits their use in resource-constrained environments and real-time systems. For example, even the base BERT model may require up to 12 GB of GPU memory during inference, making deployment under heavy workloads more difficult.

Another important limitation involves the quadratic computational complexity of the self-attention mechanism. As the input sequence length increases, memory consumption and computational costs grow rapidly. Training large transformer models therefore requires powerful hardware infrastructures and significant energy consumption, which raises both economic and environmental concerns.

Different artificial intelligence tasks also require transformer models with specialized architectural properties. For instance, sentiment analysis tasks are often more effectively solved using models with strong contextual understanding, such as BERT, whereas text generation tasks rely on architectures designed for coherent sequence generation, such as T5. In addition, transformers are frequently described as "black-box" systems because their decision-making processes are difficult to interpret. This limitation becomes especially important in domains where explainability is critical, including medicine, finance, and law.

Another challenge involves domain-specific terminology. Specialized medical, financial, and legal texts often contain complex vocabulary and contextual nuances that transformer models may not interpret correctly. As a result, model accuracy can decrease in highly specialized applications. Nevertheless, despite these limitations, transformers and self-attention mechanisms remain among the most influential technologies in modern artificial intelligence.

Overall, transformer architectures and self-attention mechanisms represent one of the most influential innovations in contemporary artificial intelligence. Their introduction improved the efficiency of sequential data processing, enabled better modeling of long-distance relationships, and accelerated parallel computation. Because of these advantages, transformers are now widely integrated into natural language processing, computer vision, scientific research, speech technologies, and forecasting systems. Ongoing advances in this field suggest that transformer-based models will remain among the leading technologies shaping the future of artificial intelligence.

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УДК 378.14:004.8

EDUCATIONAL DATA ANALYTICS IN HIGHER EDUCATION: METHODS, INFRASTRUCTURE AND IMPLEMENTATION CHALLENGES

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Abstract. This paper provides a systematic analysis of data-driven approaches to educational management in higher education, drawing on empirical studies in Educational Data Mining and Learning Analytics. It examines predictive, adaptive and prescriptive methods alongside key infrastructure standards, and considers their implications for personalised learning, curriculum governance and teacher – student interaction. The study identifies critical challenges, including algorithmic bias, model interpretability, and unequal data literacy among faculty. The findings suggest that the effectiveness of educational analytics depends not on technical sophistication alone, but on methodological validity and institutional governance.

Keywords: educational data mining, learning analytics, predictive analytics, explainable AI, xAPI, digital transformation, higher education.

АНАЛИТИКА ОБРАЗОВАТЕЛЬНЫХ ДАННЫХ В ВЫСШЕМ ОБРАЗОВАНИИ: МЕТОДЫ, ИНФРАСТРУКТУРА И ПРОБЛЕМЫ ВНЕДРЕНИЯ

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Аннотация. В данной статье представлен систематический анализ подходов к управлению образованием в сфере высшего образования, основанный на данных, с опорой на эмпирические исследования в области интеллектуального анализа образовательных данных и аналитики обучения. Рассматриваются прогнозные, адаптивные и прескриптивные методы наряду с ключевыми стандартами инфраструктуры, а также анализируются их последствия для персонализированного обучения, управления учебными

программами и взаимодействия между преподавателями и студентами. Выявлены ключевые проблемы, в том числе алгоритмическая предвзятость, интерпретируемость моделей и неравномерный уровень грамотности в области данных среди преподавательского состава. Полученные результаты свидетельствуют о том, что эффективность образовательной аналитики зависит не только от технической совершенности, но и от методологической обоснованности и институционального управления.

Ключевые слова: анализ образовательных данных, учебная аналитика, предиктивная аналитика, объяснимый ИИ, xAPI, цифровая трансформация, высшее образование.

Introduction

Digital transformation has put universities in an odd position: they collect more data than ever, but often have little idea what to do with it. A student's digital footprint now goes well beyond grades – it includes interaction logs with course content, communication metadata, activity timestamps, and in some experimental settings, biometric readings. The data piles up fast. Yet volume alone does not make learning better, which should be obvious but is often forgotten in the rush to install analytics tools. Educational systems' risk is becoming what one might call "data-rich but meaning-poor" when they lack the means to interpret what they collect. The gap between data availability and the ability to draw practical lessons from it is what this paper is about [1, 2].

The international research has organised the analysis of educational data around two related fields: Educational Data Mining (EDM) and Learning Analytics (LA). Work from the United States, EU countries, and Australia shows a well-developed methodological toolkit. Over the past five years the emphasis has moved from descriptive statistics toward predictive and prescriptive approaches. Commonly used techniques now include Deep Knowledge Tracing for modelling knowledge acquisition, Social Network Analysis (SNA) for studying peer interactions, and multimodal analytics that combines text, audio, and video streams.

A careful reading of this literature, however, turns up several persistent weaknesses. First, predictive models dominate at the expense of prescriptive ones. Researchers can forecast dropout or academic performance with high accuracy using ensemble methods and neural networks, but far fewer studies say what to actually do with those forecasts [1–4]. Second, interpretability is a real problem: complex machine-learning algorithms work as black boxes, and teachers or administrators who cannot understand why a system reached a conclusion will not act on it. Third, most research monitors student behaviour while the information needs of teachers and administrators stay on the margins. Tools get built to watch students, not to support the people designing and running the courses.

Related to this is how indicators get chosen. Many studies simply use whatever metrics the local learning management system (LMS) happens to track, rather than metrics selected for pedagogical relevance. This is the "streetlight problem" - analysts look where the data is, not where the answer might be. Arbitrary indicator selection weakens the validity of findings and makes cross-study comparison nearly impossible.

Ethical risks around data privacy, combined with low digital literacy among teaching staff, compound the difficulties; both technical and organisational responses are needed [1–6].

The Russian context adds specific complications: open the Russian language datasets are scarce, and adapting foreign methods to national educational standards is slow. Domestic researchers have made progress on predicting academic performance and analysing digital traces, but work on indicator validation and integration with quality management systems remains thin [1–7].

The aim of this paper is to go beyond cataloguing methods. By organising EDM and LA approaches according to functional task and management level, and by examining the infrastructure and ethical constraints that shape their use in practice, the paper tries to bridge the gap between technical capability and real educational decision-making.

Methods and Levels of Educational Analytics

Modern learning processes generate large and varied data streams. Online platforms, performance records, survey results, student portfolios, and administrative systems together create an empirical base that is, on the whole, rich enough to support targeted decision-making. Analysing this base can reveal what helps or hinders learning, support adaptation of curricula, improve teaching practices, and track individual student trajectories.

The central analytical approach in this field is Learning Analytics (LA) – the measurement, collection, analysis, and reporting of data about learners and their contexts, with the goal of understanding and optimising learning. LA belongs to the broader area of Technology-Enhanced Learning (TEL) [19] and connects to the longer tradition of Intelligent Tutoring Systems (ITS), which has been developing for about forty years. Contemporary ITS platforms now include powerful algorithms that substantially expand what automated personalisation can do [2, 1].

Both EDM and LA operate across three management levels [1–3]:

Micro level focuses on the individual learner: diagnosing cognitive styles, adapting didactic resources, building personalised trajectories.

Meso level covers analysis of programme, department, and faculty effectiveness – content quality monitoring, performance trends, resource allocation.

Macro level supports strategic planning for a university or region: development policy, competitive positioning, large-scale quality assessment.

The relationship between EDM and LA, and their joint role in a multi-level decision-support system, can be represented as a conceptual schema (Figure 1). The model shows how educational data flows from automated pattern discovery through EDM to human-readable interpretation and visualisation through LA, producing an integrated analytics system that operates at all three levels.

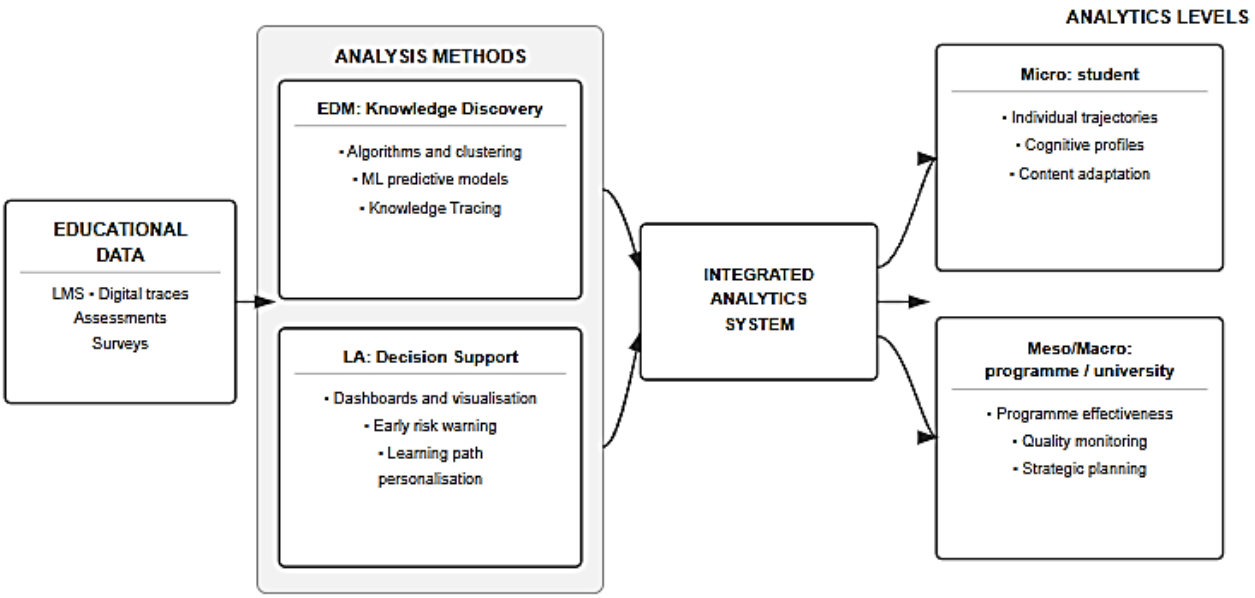


Figure 1. Relationship between EDM/LA methods and management levels

Within the LA toolkit several complementary approaches cover different analytical needs. Predictive analytics builds forecasting models to identify predictors of academic success and detect at-risk students early, enabling preventive action. Prescriptive analytics goes further, moving from prediction to specific recommendations about pedagogical interventions and resource allocation. Adaptive analytics dynamically adjust content and learning paths based on the student's current knowledge level and individual characteristics. Social Network Analysis methods study the structure and dynamics of peer interactions in group settings, identifying influential students and isolated ones, and linking network position to academic outcomes. Discourse analytics examines the quality of communication - argumentation patterns, language use, participation structures – offering a way to assess how deeply students engage with the actual content of discussions.

A clean distinction between EDM and LA helps organise this toolkit. EDM focuses on automated pattern discovery and algorithm development; LA focuses on human interpretation of those results to support pedagogical and managerial decisions. That distinction does not mean the two are separate: in practice, EDM models increasingly serve as the computational core of LA tools. Table classifies the main methods by functional task, showing the logical progression from prediction to action.

Table. Classification of educational data analytics methods by functional task

Method Group	**Specific Methods / Algorithms**	**Tasks Addressed**	**Analytics Level**
Predictive Analytics	Random Forest, XGBoost, SVM, LSTM, MLP	Forecasting academic performance, dropout, adaptability; identifying at-risk groups	Micro, Meso

Adaptive Analytics	BKT, DKT, AKT, recommender systems	Content personalisation; adapting learning paths to current knowledge level	Micro
Social Network Analysis (SNA)	Centrality analysis, graph density, clustering	Assessing collaboration; identifying opinion leaders and isolated students	Micro, Meso
Discourse Analytics	Sentiment analysis, LDA, BERTopic, rubric scoring	Analysing argumentation quality; measuring engagement in discussions	Micro
Prescriptive Analytics	Optimisation models, intervention scenario planning	Generating recommendations; planning pedagogical actions	Meso, Macro
Process Mining	α-miner, Heuristic miner, conformance checking	Reconstructing learning trajectories; detecting deviations and bottlenecks	Micro, Meso

In predicting academic outcomes, dropout, and adaptability to online learning, machine-learning methods from EDM dominate. Ensemble algorithms – Random Forest, Gradient Boosting (XGBoost, LightGBM) – and Support Vector Machines (SVM) reach classification accuracy of 93–99 % in some reported studies [1, 2]. Recurrent neural networks and multilayer perceptrons handle time series and non-linear dependencies well, which matters when tracking performance over a semester [3]. But accuracy alone is not enough for educational practice. Complex models work as black boxes, and that opacity erodes teacher and administrator trust. To address this, LA increasingly uses Explainable AI (XAI) tools, particularly SHAP (SHapley Additive exPlanations) and LIME (Local Interpretable Model-agnostic Explanations). These rank the contribution of each predictor – from attendance and entry-exam scores to LMS activity patterns – making predictions transparent enough to support real decisions [1–4]. Without that interpretability, a forecast is just a statistical artefact; it will not prompt anyone to intervene.

Modelling the dynamics of learning requires a different set of tools, focused on knowledge acquisition over time (Kaliisa & Dolonen, 2023). Knowledge Tracing is the key approach here. Probability-based and deep models – BKT (Bayesian Knowledge Tracing), DKT (Deep Knowledge Tracing), and AKT (Attentive Knowledge Tracing) – estimate a student's current competency level from the sequence of their responses, which is a core EDM task [1, 5]. Process Mining complements this. The α-miner and Heuristic miner algorithms reconstruct real learning trajectories from LMS logs, identifying deviations from intended course sequences, bottlenecks in instructional materials, and procrastination patterns [2, 3]. One important caveat: reconstructing behaviour does not always reveal understanding. A student can formally complete every step without grasping the concept. Process Mining data is therefore most useful when read alongside qualitative assessment results within an LA framework.

The expansion of data sources has pushed text and multimodal analytics forward. Natural language processing methods – topic modelling with LDA, BERTopic, and

sentiment analysis – automate rubric-based essay scoring and track the emotional tone of forum discussions [2, 3]. Multimodal approaches integrate diverse streams: interaction logs, eye-tracking data, video streams for engagement recognition (using architectures such as YOLO and VGG-16), and biometric readings from wearable devices [1 – 5]. This opens real-time assessment of cognitive load and emotional state. That said, multimodal data collection places heavy demands on infrastructure and raises legitimate privacy concerns; biometrics and video analytics invite justified questions about surveillance, which limits their adoption compared to standard LMS logs.

The social dimension of learning is studied through SNA and discourse analytics. SNA maps interaction structures within project groups, identifying opinion leaders, isolated students, and communication density, all of which correlate with academic success [2, 3]. Discourse analytics goes deeper into the content of those interactions – argumentation quality, language choices, and participation patterns. Visualisation tools such as CADA and SNAPP translate complex graph and text metrics into dashboards that teachers can actually read and act on, completing the translation from EDM output to LA use (Figure 2) [5–7].

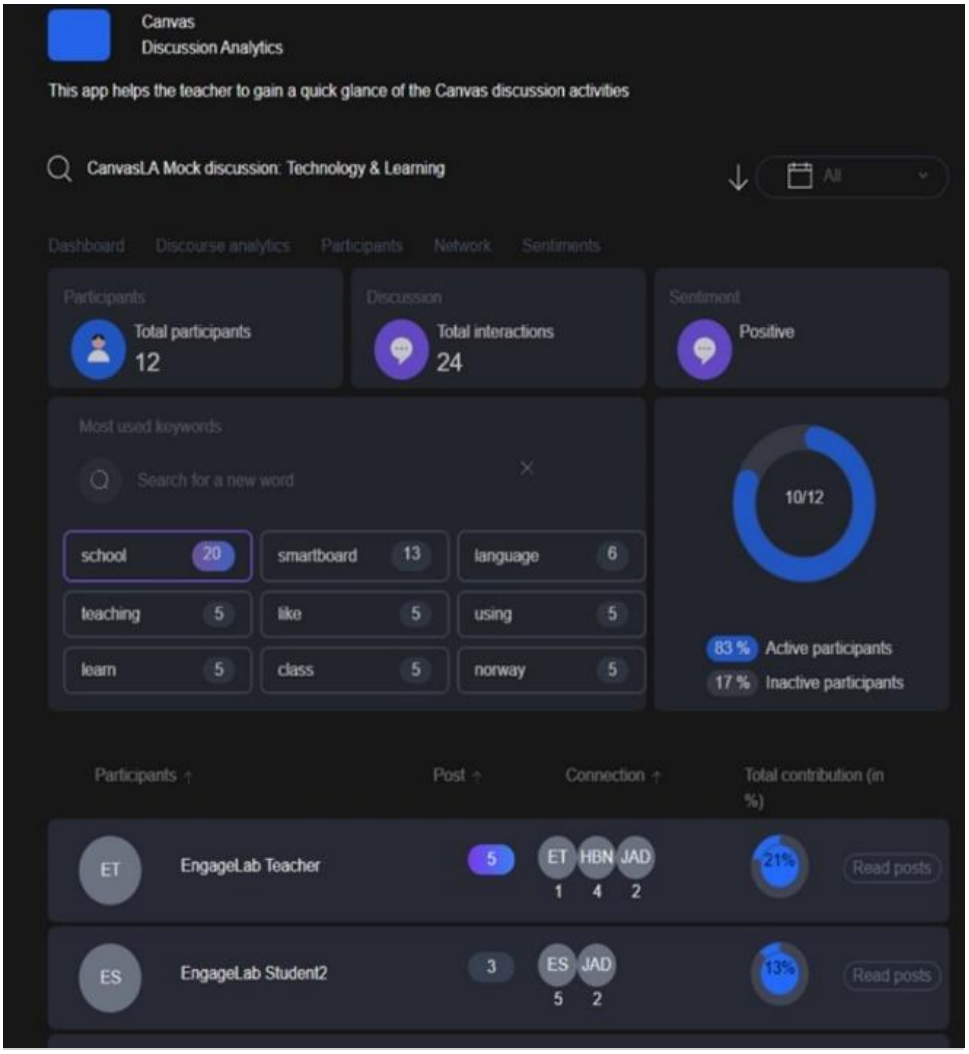


Figure 2. CADA interface: overall participation analytics (top), key-concept summary (centre), and connections between individual students (bottom) [5]

One caveat applies here too: high network activity is not the same as productive collaboration. A discussion can be busy but shallow. Centrality and graph density metrics need to be read alongside qualitative argumentation indicators to avoid drawing wrong conclusions about how well a group is actually working.

Implementing these methods at scale requires standardised data infrastructure, because each educational platform typically has its own internal analytics, which makes centralised data collection and cross-platform analysis hard. One partial solution is the combination of Learning Record Stores (LRS) with the xAPI (Experience API) specification. This standard defines a JSON-based statement format – essentially a record of a user action (e.g., "User completed lesson 1") – and supports data aggregation from heterogeneous platforms, including LMSs, mobile apps, and web courses, into a single repository [2]. At the scale of a university, the number of such statements can reach into the billions.

The xAPI specification is developed within the Total Learning Architecture (TLA) framework of the US Department of Defense's ADL initiative, and is supported by most popular LMSs (Moodle, WebTutor) and course authoring tools (Articulate Storyline, iSpring). An LRS validates incoming data against the standard, processes and sorts it, and feeds the results into analytics dashboards in specialised learning analytics systems or general-purpose BI tools (PowerBI, Tableau, Qlik). Some LRS implementations include built-in analytics, additional application layers, or direct integration into the LMS, allowing institutions to adapt the infrastructure to their specific needs [1–3]. At the institutional strategy level, frameworks such as SHEILA connect analytics outputs to university policy through a structured stakeholder feedback cycle [1]. In Russia, large-scale integration examples include the Moscow Electronic School (MES) and the Open Data Portal of the Moscow Government, as well as analytics modules developed at HSE University, ITMO University, and Tomsk Polytechnic University [1]. Across all these cases, successful implementation depends less on technical capability than on whether teaching staff can interpret data and adjust their practice accordingly. Low digital and data literacy remains the key constraint.

Over the past five years, the field has been moving away from complex black-box models toward approaches that offer transparency and causal interpretation. Under the term "black box," researchers mean a model whose internal logic is opaque or too complex for users to follow: inputs and outputs can be observed, but the mechanism linking them cannot be explained, and the contribution of individual factors to the outcome cannot be isolated [9]. This opacity lowers educator and administrator trust, makes it harder to detect biases in the model, and limits practical use in educational settings.

To go beyond correlation and overcome the black-box limitation, causal inference methods are increasingly used, including Do-calculus, Propensity Score Matching (PSM), and Difference-in-Differences. These allow genuine estimation of the effect of a pedagogical intervention, separating it from the influence of confounding factors – which is critical for evidence-based management decisions and for verifying that an educational strategy actually works [10]. Alongside this, generative AI has expanded rapidly. Large Language Model (LLM) agents are now used to generate personalized feedback automatically, create adaptive assessment rubrics, and support conversational

interaction with learners, significantly extending the reach of individualized instruction and reducing routine workload for teachers [11, 12].

Data ethics and privacy have become sharper issues alongside these technical advances. Privacy-by-design principles – embedding confidentiality mechanisms at the system design stage – are increasingly adopted, along with federated learning technologies that train models on distributed data without centralising it, reducing the risk of personal data breaches [13]. Explainable AI (XAI) is now expected, not optional: transparency about how algorithmic decisions are made is required by modern ethical guidelines from UNESCO IITE and the LAK Society, which stress learner rights, algorithmic fairness, developer accountability, and mandatory human oversight of significant decisions [14, 15].

In Russia, data ethics and privacy are governed by Federal Law No. 152-FZ "On Personal Data", which sets strict requirements for the collection, processing, storage, and protection of personal data – including mandatory localisation of databases on Russian territory and informed consent from data subjects [19]. Compliance is a prerequisite for any learning analytics implementation, and educational organisations must develop corresponding technical and organisational protection measures and conduct regular audits.

Despite the technical progress, systemic barriers to widespread adoption remain. In the Russian context, the biggest practical obstacle is the shortage of open, the Russian language datasets: without them, reproducing results, validating models, and adapting foreign methods to national educational standards is very difficult [16]. Low data literacy among teaching staff limits the capacity of educators to interpret analytics results, critically evaluate system recommendations, and integrate data into everyday pedagogical practice [17]. Algorithmic bias is also a growing concern: automated systems may unfairly classify students into risk groups or recommend learning paths based on skewed historical data, which calls for regular model auditing, fairness monitoring, and correction of detected biases [18].

Conclusion

The analysis confirms that the value of digital transformation in education depends not on the volume of data collected, but on the ability of educational organisations to turn that data into justified pedagogical and managerial decisions. Mapping EDM and LA methods by functional task and management level shows a consistent convergence of computational and interpretive approaches. Modern machine-learning algorithms produce accurate predictions, but their practical value is realised only when paired with explainability and causal reasoning mechanisms. Without transparent interpretation, even highly accurate models remain black boxes - unsuitable for responsible decision-making in educational settings.

The central challenge for successful implementation is closing the gap between computational complexity and what stakeholders actually need. Teachers and administrators do not need abstract metrics; they need prescriptive analytics tools that suggest specific adjustments to teaching and learning. The priority therefore shifts from monitoring student behaviour to supporting pedagogical interventions and optimising educational programmes. Standardised infrastructure built on xAPI and LRS plays an

important supporting role, enabling aggregation of heterogeneous data and interoperability between analytics tools.

Ethical and legal requirements must be taken seriously. Confidentiality, minimisation of algorithmic bias, and fairness of outcomes are non-negotiable for sustainable analytics systems. Privacy-by-design principles and federated learning reduce the risk of personal data exposure. In the Russian context, the most pressing tasks remain building open datasets, adapting foreign methods to national standards, and raising digital literacy among educators. A lack of methodological support and data interpretation skills among teachers is one of the main barriers to scaling analytics.

Promising directions for future work include integrating generative AI to automate personalised feedback, developing multimodal analytics further, and establishing regular model audit procedures for bias detection. Research should focus on developing methodologically sound indicator selection procedures, validating learning quality indicators, and creating organisational mechanisms that support the everyday use of data in educational practice. The potential of educational data to improve student outcomes can only be realised through the interaction of technical capability, methodological rigour, and domain expertise.

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УДК 621.3.049.77

EXTREME ULTRAVIOLET LITHOGRAPHY TECHNOLOGY: KEY PRINCIPLES, CURRENT STATUS AND PROSPECTS

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Abstract. This paper discusses extreme ultraviolet lithography – a key technology for manufacturing modern microchips. The study summarizes the production metrics achieved to date and identifies the principal technological barriers.

Keywords: extreme ultraviolet, EUV, microchip manufacturing, photolithography, semiconductor technologies, integrated circuit miniaturization, nanoscale defects, technological barriers.

ТЕХНОЛОГИЯ ЭКСТРЕМАЛЬНОЙ УЛЬТРАФИОЛЕТОВОЙ ЛИТОГРАФИИ: КЛЮЧЕВЫЕ ПРИНЦИПЫ, ТЕКУЩЕЕ СОСТОЯНИЕ И ПЕРСПЕКТИВЫ РАЗВИТИЯ

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Аннотация. В работе рассматривается технология экстремальной ультрафиолетовой литографии – ключевой метод производства современных микрочипов. В результате исследования обобщены достигнутые производственные показатели и выделены главные технологические препятствия.

Ключевые слова: экстремальный ультрафиолет, экстремальная ультрафиолетовая литография, производство микрочипов, фотолитография, полупроводниковые технологии, миниатюризация интегральных схем, дефекты нанометрового масштаба, технологические препятствия.

For decades, progress in computer chip manufacturing has depended on advances in photolithography – the key process that defines how small the transistors on a chip can be [1]. For a long time the whole industry used 193 nanometers immersion lithography as a primary tool, but when the size of transistors approached 10 nanometers, this technology reached its limits [2]. To make transistors even smaller, manufacturers had to use multiple patterning which is a method where several exposure steps are combined, and this made production way more complex and expensive [1].

The fundamental response to this technological challenge was the transition to

extreme ultraviolet lithography at a wavelength of 13.5 nanometers [1, 3]. According to the physical principle known as Rayleigh's equation, a shorter wavelength gives better resolution. This allows one-step patterning of features that previously required more than one step. However, building a working EUV system was very difficult so that engineers had to completely change the lithographic equipment architecture [4]. To implement the idea they had to replace refractive lenses with reflective mirrors, create high-power radiation sources based on ionized tin and develop fundamentally new photosensitive materials [1, 2].

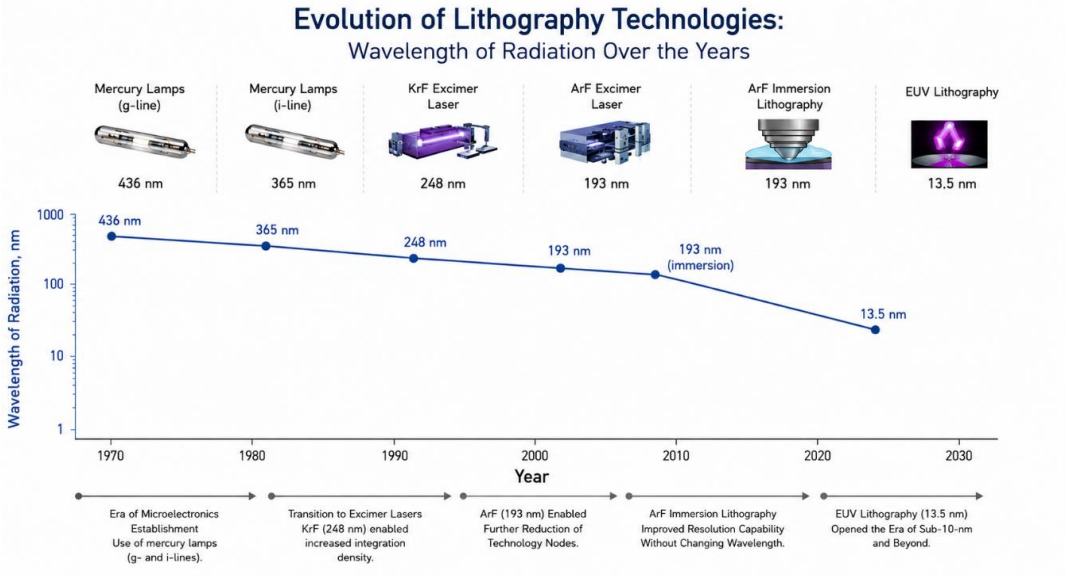


Figure 1. Evolution of lithography technologies

The purpose of this article is to present a review of the current state of EUV lithography technology. At the same time the survey examines and looks at the main parts of a modern EUV machine one by one – the light source, the special light-sensitive materials called photoresists and the masks that carry the chip pattern [1, 5, 6]. It also analyzes the achieved manufacturing results and identifies the main technological barriers to further scaling [7, 2]. Particular attention is paid to the next step in EUV technology – a new generation of machines with improved optics and new materials that are capable of enabling even smaller transistors [7, 6]. The primary research method was the analysis of leading international journals devoted to EUV lithography published within the last six years indexed in relevant and trustful databases such as Journal of Micro/Nanolithography, MEMS, and MOEMS, Nanomaterials, Journal of Materials Chemistry C, High Power Laser Science and Engineering, as well as the fundamental monograph by H. J. Levinson.

One of the most difficult and complicated tasks in the development of EUV lithography was creating a powerful and stable light source. To form a clear image on the thin, round slice of semiconductor material that serves as the base for manufacturing integrated circuits called wafer in an acceptable time, this source must generate light with a wavelength of 13.5 nanometers at a power of hundreds of watts. Realization of this idea at an industrial scale took many years of work [8].

At the beginning of the implementation of the technology, two competing approaches were considered: the first one was Discharge-Produced Plasma (DPP), and

the second was Laser-Produced Plasma (LPP) [8]. In DPP systems, plasma is created by passing a powerful electrical discharge through tin vapor between two electrodes. It should be noted that despite this method's design simplicity, it has a huge disadvantage: the electrodes are quickly destroyed by the high-energy plasma so this seriously limits the lifetime of the source and requires frequent replacement of its parts. Meanwhile in LPP systems, which finally became the dominant technology, plasma is created differently [8, 3]. A small droplet of pure melted tin, about 30 micrometers in diameter, is shot into an artificial vacuum chamber about 50,000 times per second. Special cameras inside the chamber track the movement and the actual position of the droplet, and when it reaches the target point, it is hit by two laser pulses one after another. The first pulse is weaker than the second and it flattens the droplet into a thin disk, increasing its surface area. The second pulse is more powerful, and it heats the disk to a temperature of around 500,000 degrees Celsius. For instance, the temperature of the Sun's surface is around 5,500 degrees Celsius, which makes the flattened droplet turn into a plasma, which then emits EUV light [3]. It is also important to mention that the EUV light exists only in vacuum, and is not found in nature. This double-pulse method turned out to be much more efficient than using a single pulse one.

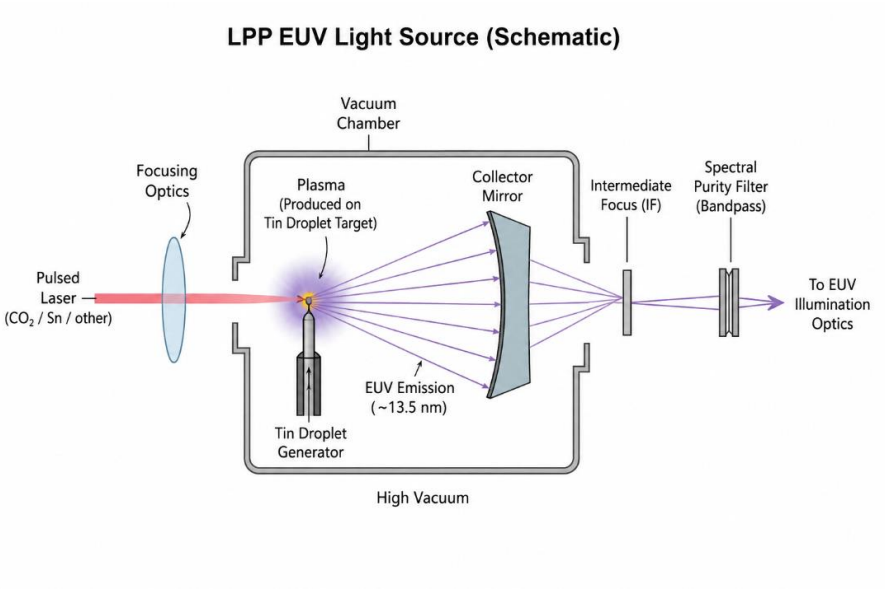


Figure 2. LPP source scheme

Despite the success of LPP technology, the problem of power remained critical for a long time. For economically viable mass production, the source must deliver at least 250 watts at the intermediate focus, but modern systems aim for levels of 600 watts and above [2]. Step-by-step improvements in laser systems and tin delivery have made it possible to reach these objectives, and current serial EUV scanners demonstrate stable source power of 350-400 watts, and the advanced research systems have shown levels above 1,000 watts [2].

Another serious problem is contamination of the optics by tin debris. Not every tin droplet is turned into plasma. Instead, it flies away as tiny particles and lands on the collector mirror – the mirror that gathers the whole EUV light and directs it into the projection system [3]. Even an atomic scale thin layer of tin on its surface dramatically reduces the mirror's ability to reflect light. To avoid this inconvenience, engineers have

developed complex protection systems: a flow of buffer gas (usually hydrogen) blows tin particles off the optics' surface, while special traps catch them before they can settle on the mirror [3].

The LPP source nowadays is the most complex engineering system humanity has ever made. It combines high-power lasers, precise mechanics for tin delivery, vacuum technology, gas-dynamic protecting system for the optics, and no less complexly designed architecture of reflectors [8, 3]. Further increases in power remain one of the top priorities, because every extra watt of EUV light directly improves the productivity of the lithography process [1, 2].

The next important part of the EUV scanner is a mask, or reticle, which is a plate with a microchip pattern on it. During lithography, this pattern is transferred onto the silicon wafer. In EUV, the mask is one of the most complicated and expensive components of the whole technology chain. The quality requirements for it are far higher than anything needed in the equipment of previous generations [8].

H.J. Levinson, describing this technology in his article "Extreme Ultraviolet Lithography" (2020), states that the fundamental principle is that the EUV mask does not work by letting light pass through, instead, it works by reflection. It is a multilayer Bragg mirror made of layers of molybdenum (Mo) and silicon (Si) that serves as a high-reflectivity coating for extreme ultraviolet (EUV) radiation, typically centered near 13.5 nm wavelength, and is commonly used in EUV lithography systems for semiconductor manufacturing. An absorbing pattern made of a dedicated absorber material is formed on the surface of this mirror. When EUV radiation strikes the mask at an oblique angle, it is reflected from the regions not covered by the absorber and subsequently directed into the projection optics [8].

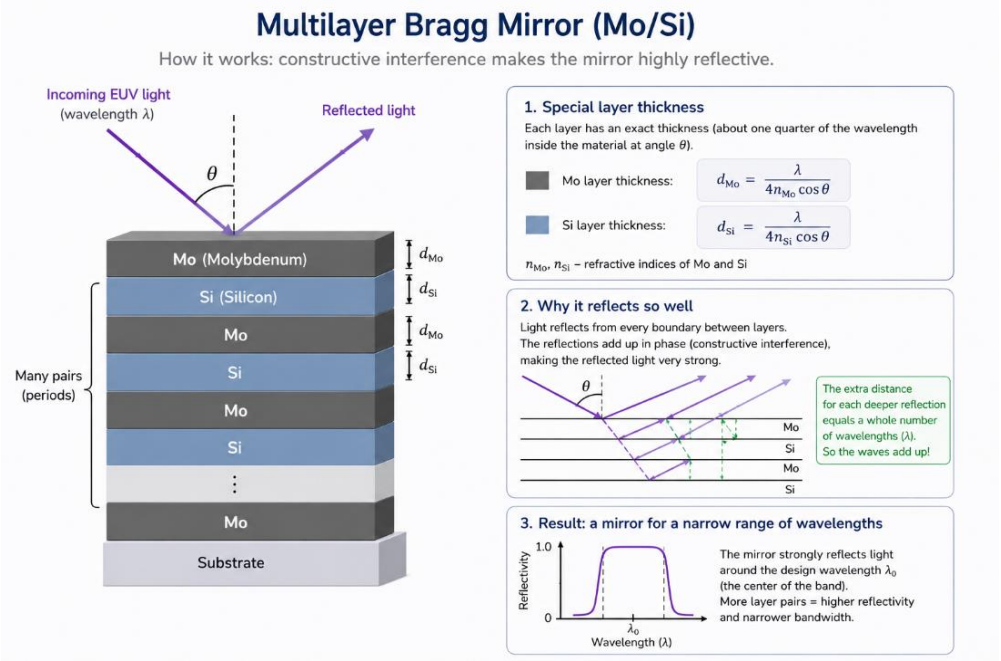


Figure 3. Multilayer Bragg mirror scheme

The main problem of EUV masks, which remains not completely solved, is defectivity. Even the smallest dust particle or a tiny bump on the multilayer surface can distort or completely ruin the resulting image. Defects that appear inside the multilayer

coating during its productions are particularly dangerous, as they lead to local phase distortions of the reflected light and give rise to the so-called phase effects, which are extremely difficult to detect and fix [9].

An additional difficulty is mask contamination during scanner operation. Even with all protective measures in place, some tin debris originating from the light source inevitably reaches the mask and deposits onto its surface, resulting in reduced reflectivity and the formation of new printing defects [3].

To protect the mask from falling contaminating particles of tin, a pellicle is used. Specifically, a pellicle is defined as an ultra-thin transparent membrane stretched on a frame above the mask surface. Consequently, contaminating particles settle on the pellicle rather than on the mask itself. Moreover, because the pellicle is located out of the local plane, its influence on the final image is considered to be minimized.

Nevertheless, some researchers indicate that manufacturing a pellicle for EUV systems remains a very difficult and expensive task in itself. As noted by previous studies, the membrane must be extremely thin – so that it does not absorb too much of the already precious EUV light – and, at the same time, it must be strong enough to withstand pressure changes and the heat load from the powerful light beam.

In modern EUV scanners with high source power, it has been observed that the pellicle can heat up to temperatures close to its thermal stability limit. As a result, this creates a high risk of rupture and, consequently, failure of the entire mask [8, 9].

Solving the zero-defect problem – both at the stage of mask fabrication and during its operation in the scanner – is widely recognized as a necessary condition for further improving production yield and for enabling the transition to next-generation technology nodes [8, 9, 3].

The transition of EUV lithography to high-volume manufacturing (HVM) took more than 30 years, as it is reported in several publications. Nevertheless, this technology has become the standard for producing the most critical chip layers at the 5nm or 7 nm nodes, as well as for smaller nodes [8, 2].

In the context of HVM, the main performance metric is productivity, measured in wafers per hour (wph). It has been shown that early EUV systems with a source power of approximately 125 W, could process only 60-80 wph, which was not considered economically viable [2]. By contrast, modern scanners such as the ASML NXE:3400C operate at 350-400 W and deliver over 200 wph. Accordingly, the next industry target is to surpass the 300 wph mark [1, 2].

The economic benefit of EUV arises from its ability to replace multi-pattering with single exposure. Specifically, whereas outdated DUV technology required up to five separate lithographic passes with intermediate etching steps, EUV accomplishes the same task in a single step. As a result, this reduces processing time, material consumption, and defect accumulation [8].

However, equipment cost is exceptionally high. For example, a single EUV scanner costs approximately 200 million US dollars and consumes about 1.5 megawatts of electricity. To put this figure into perspective, a small town’s yearly electricity consumption is typically around 50-100 megawatts, which means that one EUV machine requires about 1/50 of electricity of an entire town. Furthermore, operating costs are also substantial due to the need for vacuum conditions, protection against tin contamination for the optics, and regular component replacement [8, 2].

Another key parameter is uptime – defined as the proportion of time during which the scanner is productively operational. It has been reported that uptime now exceeds 85-90 % for modern EUV systems. Despite the high cost of this technology, EUV is considered fully economically justified, as it enables continued growth in transistor density and chip performance – something that previous technologies could not provide.

The current generation of EUV scanners features a numerical aperture (NA) of 0,33. NA is a quantity that describes the ability of an optical system to collect light and resolve fine details. In photolithography NA is widely recognized as a key parameter, comparable in importance to wavelength, that ultimately determines the resolution of the equipment. According to Rayleigh's equation, when the wavelength cannot be reduced further, resolution can only be improved by increasing NA. Consequently, this principle forms the basis for the next step – the transition to High-NA EUV lithography which employs an aperture of 0,55. As noted in the literature, this transition will improve resolution by approximately by about 40 % and enable printing features down to 8 nanometers without returning to multi-patterning [1].

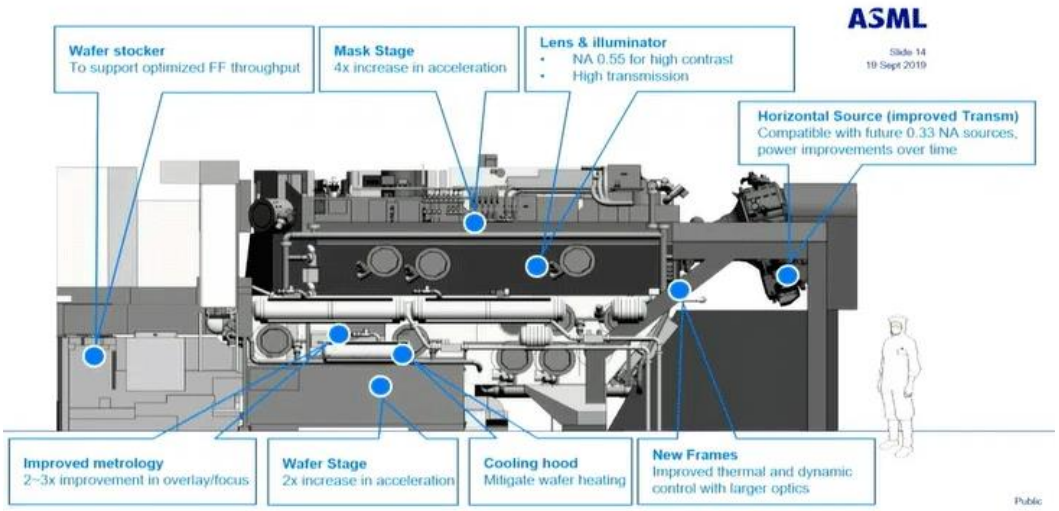


Figure 4. ASML's upcoming High-NA EUV scanner, is designed to produce a High-NA EUV with aperture of 0.55
© ASML, 2019

As A. Erdman states in his article, that increasing the NA, however, introduces a significant problem: in a traditional optical design, the exposure field shrinks, necessitating that the chip be assembled from a larger number of fragments. The solution to this problem is the use of so-called anamorphic optics, in which the image is compressed by different ratios along two axes – specifically, 4x and 8x. As a result, this approach keeps the field size acceptable; nevertheless, it renders mask design more complex and requires the reworking of optical proximity correction algorithms [1, 9].

Furthermore, High-NA EUV imposes tightens requirements on masks. It has been demonstrated that because EUV light strikes the mask at a sharp angle, shadowing effects become more pronounced and consequently limit image quality. To mitigate this issue, new, thinner absorber materials are currently being developed [9]. At the same time, mirror manufacturing tolerances have become stricter: as noted in the

publication by Wischmeier L. et al. (2020), deviations in shape and relative positioning must now be controlled at the level of fractions of a nanometer [1].

The first High-NA scanners, such as ASML EXE:5000, are currently undergoing testing and are expected to enter mass production around 2026-2027. With a cost of 300-400 million US dollars, these systems are even more expensive than current EUV scanners. Nevertheless, the expected gain in transistor density is widely considered to justify the investment [1]. High-NA EUV represents a logical continuation of EUV technology and is anticipated to define the development of the semiconductor industry for the decade to come [1, 9]. To put it simply, as noted by several sources, High-NA is the future.

To sum up, EUV lithography has moved from an initial concept to the foundation of high-volume manufacturing (HVM) for advanced chips – a journey that has taken three decades and has required solutions without parallel in the history of the semiconductor industry.

This survey has shown that technology rests on subsystems, each of which is still being actively improved. First, as reported in some research papers, the LPP source has reached industrial power levels; however, further power growth and technological improvements remain top priorities [8, 3]. Second, the EUV mask remains the main source of cost and risk. Consequently, achieving zero-defect masks is widely recognised as a critical condition for continued progress [8, 9].

The main conclusion is that EUV lithography represents a unique convergence of plasma physics, materials science, precision engineering, and computational modelling. It has been argued that this interdisciplinary approach has made it possible to overcome long-standing barriers and maintain the pace of miniaturization [5, 6]. Future research should focus on solving the key remaining challenges, evaluating their impact on semiconductor manufacturing, and exploring opportunities for expanding the technological and economic limits of the industry for the coming decade [1, 3, 9].

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При написании статьи были применены технологии искусственного интеллекта для генерации изображений.

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УДК 728.71

MODULAR GLAMPING TYPE UNITS FOR NORTHERN MOUNTAIN REGIONS

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Abstract. The aim of the work is to propose a promising solution to the housing issue for temporary residence of researchers, specialists and workers on expeditions in remote northern mountainous areas. As part of the final decision, a project for a "smart glamping house" is proposed, designed to accommodate 2-4 people. The house's is based on a geocuped structure, which has a number of significant advantages: high installation speed, rational consumption of building materials and increased earthquake resistance.

Keywords: designing, smart glamping house, geodesic dome, housing issue, remote northern mountainous areas.

МОДУЛЬНЫЕ ГЛЭМПИНГ-ДОМА ДЛЯ ОТДАЛЕННЫХ СЕВЕРНЫХ ГОРНЫХ ТЕРРИТОРИЙ

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Аннотация. Целью работы является предложение перспективного решения жилищного вопроса для временного проживания научных сотрудников, специалистов и рабочих в экспедициях в труднодоступных северных горных районах. Предлагается проект «умного глэмпинг-дома», рассчитанного на проживание 2-4 человек. В основе дома лежит геокупольная конструкция, которая обладает рядом существенных преимуществ: высокой скоростью монтажа, рациональным расходом строительных материалов и повышенной сейсмостойкостью.

Ключевые слова: проектирование, умный глэмпинг-дом, геодезический купол, жилищный вопрос, отдаленные северные горные районы.

The northern mountainous territories of Russia require scientific research and exploration. This entails the problem of temporary placement of specialists (scientists, researchers, workers) in harsh climatic conditions.

Glamping (a combination of glamorous and camping) is a format of autonomous accommodation in compact modular structures designed for 1-4 people and equipped with basic amenities (sleeping places, a kitchen unit, sanitary facilities). Usually, glamping is intended for tourists, but here we consider glamping as a type of building, with a new purpose.

The aim of the work is to offer a promising solution to the housing issue for expedition groups in hard-to-reach areas based on the concept of glamping as a "smart home".

The main advantage of this approach is the possibility of integrating renewable energy sources (solar panels/wind turbines) and energy-saving systems. This ensures the autonomy of operation and the maintenance of comfortable living conditions for people without relying on external infrastructure.

It is necessary to understand what characteristics the projected glamping house should have and which structures can be used in it.

According to the task, the glamping house must meet the following set of operational requirements: resistance to extreme climatic conditions in mountainous areas of northern regions; earthquake resistance; the ability to mount on difficult terrain; quick assembly from pre-fabricated modular elements; autonomy of operation, providing the possibility of long-term living without external support. According to these requirements, the most suitable type of glamping is a modern eco-house, which can be based on a number of designs [1].

The Glamping dome module "Expedition" has been chosen as a prototype (Fig. 1)



Dome module Glamping "Expedition"
(beach / forest area)

Type of construction: glass geocup;

Diameter: 6m
Area: 28
Frame: steel
From 2 to 4 beds;
The bathroom is inside;
Ventilation;
Heating.

Figure 1. Glamping dome module "Expedition"

In particular, the principle of a geodesic dome structure will be taken from the prototype, since its frame is assembled from pre-fabricated parts, and the overall shape is streamlined, which provides increased strength and resistance to strong winds. With an equal volume, the surface area of the sphere will be smaller than that of any other shape. This has a positive effect on both material consumption and energy consumption during operation [2,3].

As part of the research work, sketching was carried out to determine the exterior image of the house. The ski helmet became the figurative prototype of the expressive form (Fig. 2).



Figure 2. Sketching

The streamlined design will reduce windage, and the round roof slopes will ensure self-drainage of precipitation. The base is a spherical steel geodome structure.

Selection of structures

A glamping house is being developed for a mountainous area, in accordance with this, it is necessary to use a pile foundation structure as a base (Fig. 3).


Figure 3. Pile structure

The piles are screwed in to the bearing layer of the soil. Their length can reach 9 m, depending on the geological conditions. The number of piles is calculated based on the data of the test screwing.

The height of the foundation above the ground is 0.4 – 0.5 m; load-bearing beams adapted to the terrain are fixed at this level. Then the rough flooring is laid under the floor on a shard beam fixed on the side on the boards of the grillage (Fig. 4). The top of the flooring is lowered below the top of the grillage by 50 mm.



Figure 4. Construction of the floor base

After the foundation is erected, the steel frame of the geodesic dome itself is placed (Fig. 5).



Figure 5. Geodesic dome frame

The dome is divided into triangles, from which the polyhedron is assembled [4]. The peculiarity of this technology is that a large number of beams converge at one point [5, 6]. To ensure their reliable fixation, connectors are used – special devices made of steel that allow the elements of the supporting structure to be securely connected (Fig. 6).

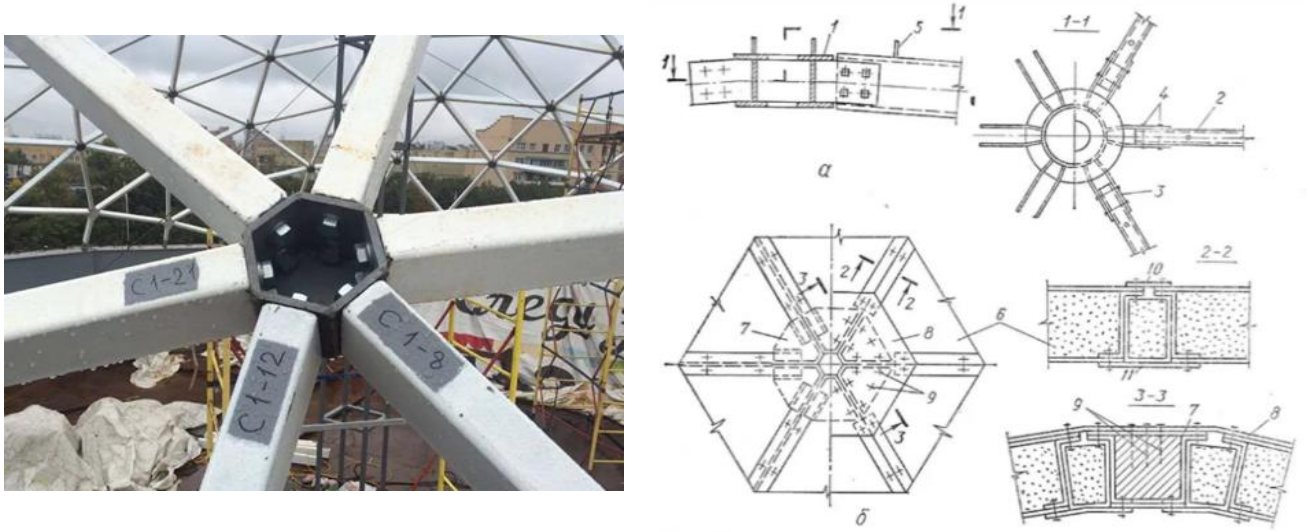


Figure 6. Dome assembly structures:
a – with metal ribs; b – made of three-layer panels; 1 – annular flanges; 2 – ribs; 3 – fittings; 4 – connecting bolts; 5 – pins for fixing plastic elements; 6 – three-layer elements; 7 – inserts; 8 – pressed hexagonal lining made of AG-4S; 9 – screws; 10 – upper cover; 11 – lower cover

The steel triangles are attached to each other, forming a geodesic dome (Fig. 7).

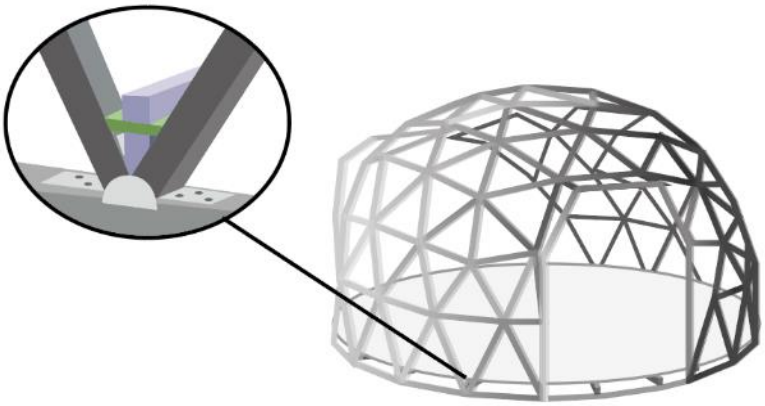


Figure 7. Connecting structures of the geodesic dome

The frame of this type is highly stable: the dome retains its integrity when up to 35 % of the elements are destroyed (tested in seismically active regions and during hurricanes). This allows you to place openings for doors and windows of almost any size at any spot, taking into account that they will be triangular or polygonal without additional add-ons. The frame is also resistant to twisting loads, but is sensitive to horizontal loads [7].

During assembly, the frame is first fully assembled and then sheathed. The main structure of the dome is made of steel beams, and the "pie" of the wall includes all the components for operation in harsh weather conditions (Fig. 8).

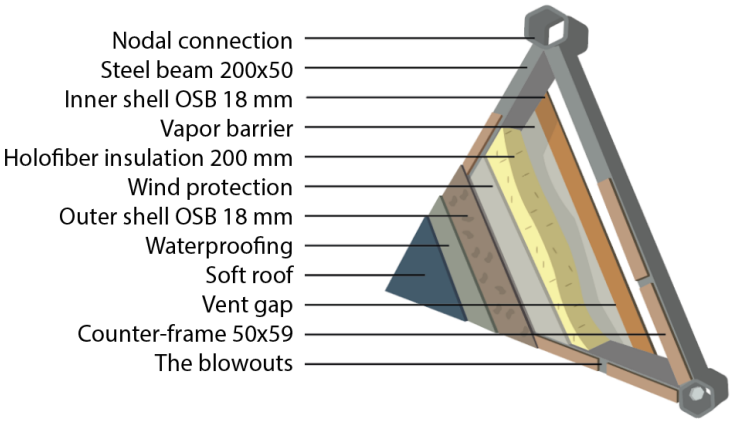


Figure 8. layered structure

The selected materials provide reliable thermal insulation, a high level of waterproofing, effective wind protection, as well as durability and safety. If it is necessary to install solar panels, they can be embedded in the outer layer of the wall pie [8, 9].

The room is heated by the built-in underfloor heating (Fig. 9).

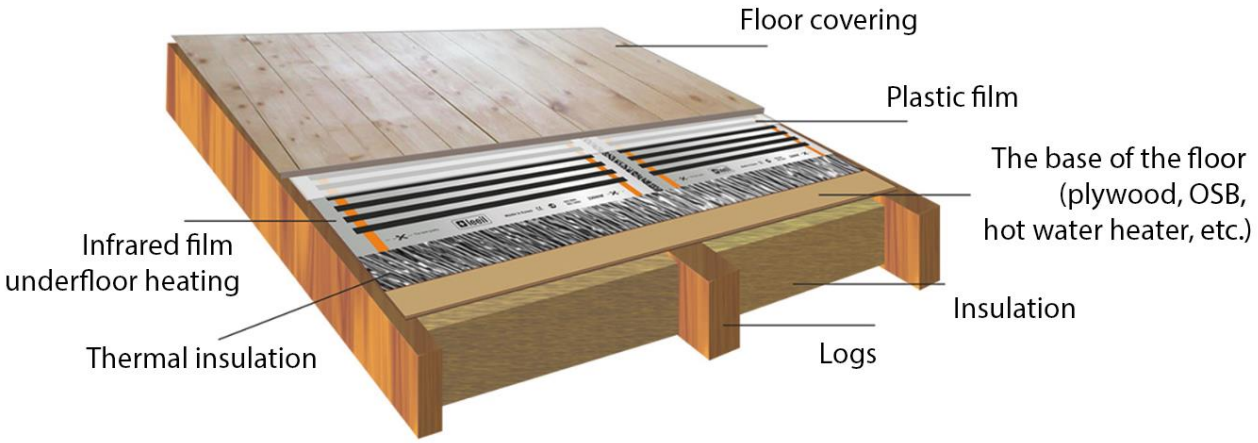


Figure 9. Floor section

Heating elements do not occupy an area inside the living space, this is important because compactness and functionality are a priority in this project.

Visualization

In accordance with the shape of the object, optimal dimensions were calculated and a 3D visualization was made (Fig. 10).

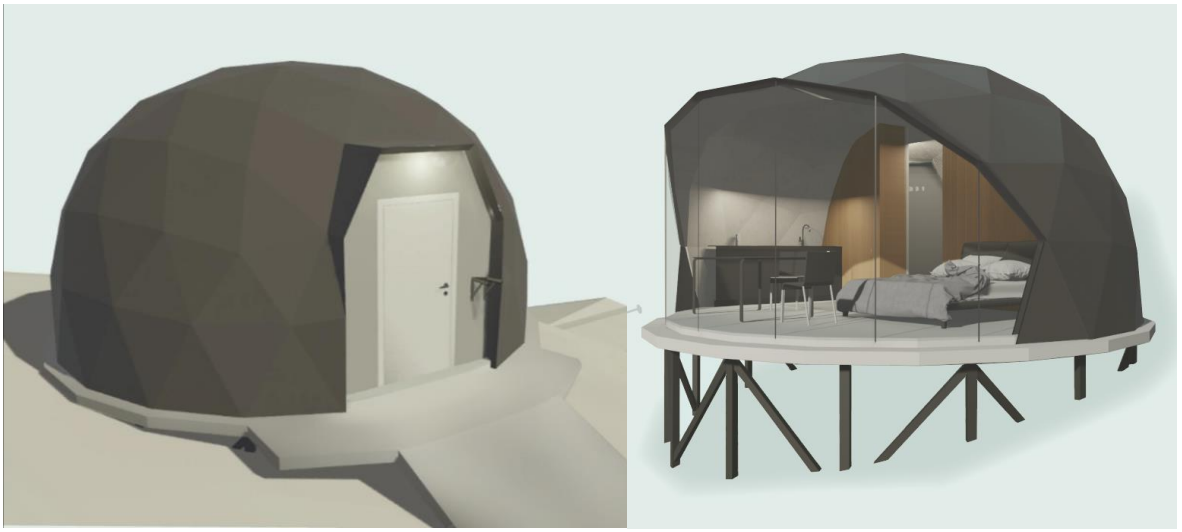


Figure 10. Visualization of the glamping house concept project in 3D

The house has an area of 28 m2 (enough for comfortable accommodation of two to four people). For the most complete picture of the object, glamping drawings were created as part of the work (Fig. 11).

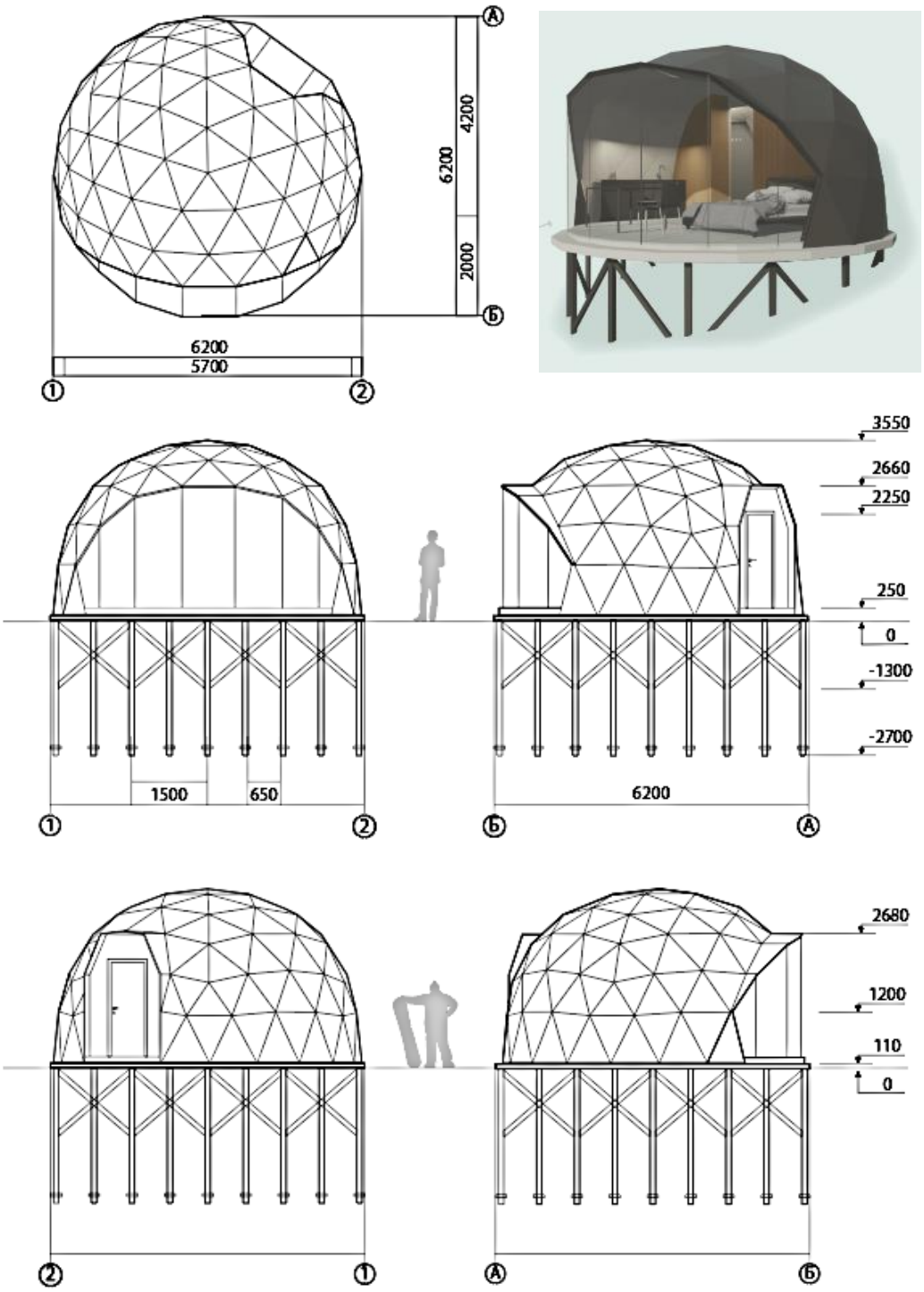


Figure 11. Drawings of the designed glamping house

The interior of the glamping house is divided into three areas: an entrance hall, a bathroom, and a living area with a bedroom and kitchen (Fig. 12).

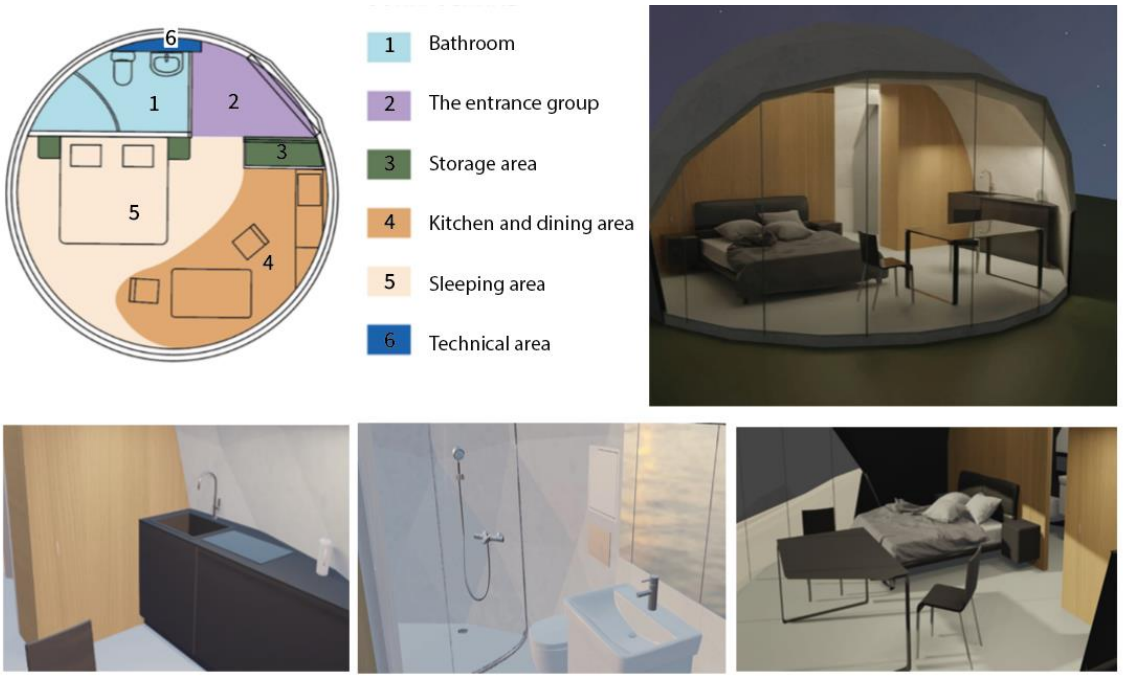


Figure 12. The internal contents of the glamping house. Zoning

The interior design uses calm natural colors and simple shapes, while creating conditions for a comfortable stay.

The glamping equipment includes everything necessary for working and resting – a kitchen, a bathroom with a shower, a double bed, a table and chairs, as well as a section for storing inventory and equipment.

As part of the work, the approximate cost of implementing the proposed solution was calculated.

The economic part

To implement the project of building a glamping house "from scratch", financing of the following stages will be required:

Initial permits – from 160,000 rubles.

Engineering surveys – from 90,000 rubles.

Project documentation – from 3,000,000 rubles.

Construction of one house – from 7,000,000 rubles.

Equipment and landscaping of the glamping hotel – from 3,000,000 rubles.

Total: from 13,250,000 rubles.

The cost of the project is indicated approximately.

It can be concluded that glamping houses are a promising area of development in Russia.

Usually, glamping has a tourist destination, but in this paper, glamping refers specifically to the type of structure, and a completely new purpose is proposed.

As part of the work, a concept project of a glamping house was completed, which can be a solution to the housing issue for temporary workers in the harsh conditions of northern mountainous territories far from populated areas.

As a result of studying structures, analogues, prototype analysis and sketching, a smart glamping house project was developed, based on a geocuped structure. The very essence of domed housing construction implies the absence of ceilings and load-

bearing supports. This provides not only up to 30 % savings on wall and floor materials: the structure becomes light and does not require a massive foundation.

The designed glamping house has an easy-to-assemble, practical design, multi-layer thermal insulation wall panels and underfloor heating. The equipment includes everything necessary for a comfortable stay of two or four people – a kitchen, a bathroom with a shower, beds, a table and chairs, as well as a storage section. The autonomous operation is ensured through the integration of renewable energy sources (solar panels/ wind turbines) and energy-saving systems, which allows the module to be maintained for a specified period of time without being connected to external systems.

This dwelling is a universal solution. Depending on the need, you can choose the number of houses to install, as well as their layout on the ground. Each of them occupies a small area and is a self-sufficient unit. The complex of glamping houses can be intended for both research and recreation facilities (for example, a ski resort, etc.)

The cost of a project with one glamping house starts at 13.25 million rubles, each subsequent house will add about 7 million to the total cost.

The project was executed using graphic visualization programs such as Adobe Illustrator, Adobe Photoshop, Blender (3D visualization), Procreate.

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УДК 697.3

DESIGN OF THE HEAT ENGINEERING COMPONENT OF A ROOFTOP BOILER HOUSE PROJECT

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Abstract. This article presents an analysis of the design project for a modern automated gas-fired hot-water boiler plant installed directly on the roof of a building. Key aspects of its engineering design are examined, including thermal scheme calculations for characteristic seasonal operating modes, selection of primary and auxiliary equipment, organization of gas supply and flue gas exhaust, implementation of a multi-level automation, remote monitoring, and industrial safety system, as well as the principles of independent consumer connection via individual heat substations.

Keywords: rooftop boiler plant, thermal scheme, heat loads, energy efficiency, energy engineering, heat supply automation.

РАЗРАБОТКА ТЕПЛОТЕХНИЧЕСКОЙ ЧАСТИ ПРОЕКТА КРЫШНОЙ КОТЕЛЬНОЙ

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Аннотация. Статья посвящена анализу проекта современной автоматизированной газовой водогрейной котельной, размещаемой непосредственно на кровле здания. Рассматриваются ключевые аспекты ее инженерного проектирования: расчет тепловой схемы для характерных сезонных режимов работы, подбор основного и вспомогательного оборудования, организация газоснабжения и дымовывода, внедрение многоуровневой системы автоматизации, диспетчеризации и промышленной безопасности, а также принципы независимого подключения потребителей через индивидуальные тепловые пункты.

Ключевые слова: крышная котельная, тепловая схема, тепловые нагрузки, энергоэффективность, энергетика, автоматизация теплоснабжения.

Introduction

All industry experts and market analysts have noticed and are discussing the trend of constantly increasing demand for various autonomous boiler installations. The boiler market today is very large and offers customers various options and modifications of domestically produced units [1]. Complexes of devices that generate thermal energy and ensure its delivery to consumers in the form of steam or hot water are called heat supply systems.

The primary purpose of any heat supply system is to provide consumers with the necessary amount of heat at the required parameters. With the centralization of heat supply and the closure of small, low-efficiency industrial and residential boiler houses, fuel consumption decreases, the number of maintenance personnel is reduced, and environmental pollution is minimized [2].

Thus, the development of heat supply for consumers is planned along the main lines of system centralization, based on combined electricity and heat generation at high-pressure combined heat and power plants (CHPs) and industrial CHPs, including heating-only CHPs; and centralization of heat supply systems for large district industrial-heating and heating-only boiler houses.

However, 95 % of cities and urban-type settlements will have a calculated thermal load of less than 500 Gcal/h, and for them, boiler houses will remain the main sources of heat supply [3]. The continuing rise in prices for all types of organic fuel and changes in equipment costs may reduce the calculated technical and economic indicators that are currently considered optimal for constructing CHPs.

Therefore, the use of industrial-heating and heating-only boiler houses will continue in the future, with plans for their consolidation, improved efficiency of organic fuel use, and equipping them with new modern equipment.

Installation of rooftop boiler houses is primarily carried out in new buildings; however, this technology is also in demand for modernizing heat supply systems in older buildings with inefficient central mains. The use of gas equipment ensures high-quality services and reduced costs. The optimal installation location is a flat roof. Factory-ready block-modular designs, which reduce commissioning time, are the most popular. System operation is fully automated and does not require the constant presence of operational personnel [4].

Methods and materials

The scheme was designed for an automated rooftop gas boiler house with a maximum capacity of 2300 kW, intended for heat supply to residential buildings (fig. 1).

The thermal scheme calculation was carried out for four characteristic operating modes of the heat supply system:

- Maximum winter mode;
- Mode of the coldest month;
- Average heating mode;
- Summer mode.

For each mode, the following were determined: thermal loads for heating/ventilation and domestic hot water (DHW), heat losses in networks and for own needs (assumed as 10 % of the total load), design temperatures of the heat carrier, flow rates of network and makeup water, as well as flow rates through heat exchangers and boiler units [5] (Tabl.).

Table. Thermal loads for design operating modes

Settlement mode	$Q'_{ов}$, MW	$Q'_{ГВС}$, MW	$Q_{пот}$, MW	$Q_{кот}$, MW
Maximum-winter	1,5	0,8	0,23	2,53
The coldest month	0,92	0,8	0,172	1,892
Medium-heating	0,73	0,8	0,153	1,68
Summer	0	0,53	0,053	0,583

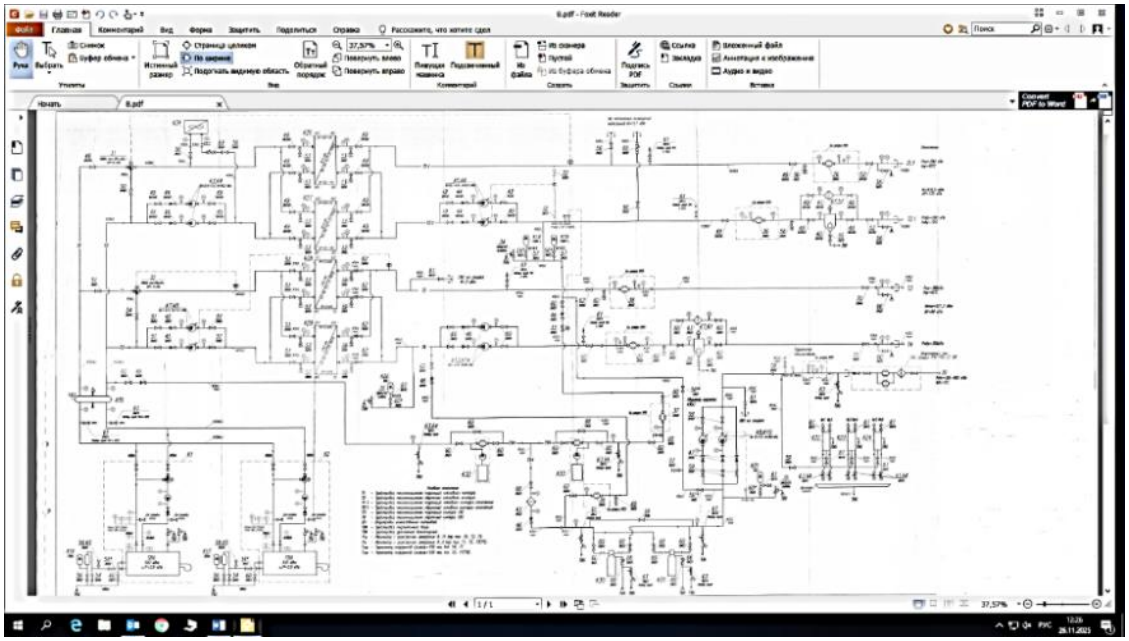


Figure. Thermal scheme of the rooftop boiler house

During the equipment selection process, the following boiler units, burners, pumps, heat exchangers, and other components were chosen:

Hot-water boilers:

Dorogobuzh 1250 boiler – 2 units

Burner devices:

Monoblock gas burner with electronic modulation DKM-1. 220.G.L.D.T.R/L.80-00

Pumping equipment:

Network pumps: 3 circulation pumps Grundfos TP 65-150/4 (2 operational + 1 standby)

Boiler pumps: 2 pumps Grundfos TP 50-180/2

Heat exchange equipment:

For the heating system: 2 plate-type water-to-water heat exchangers Teplotex 80-A

For the domestic hot water (DHW) system: 2 plate-type heat exchangers Teplotex 32-M

Gas equipment:

Shut-off and control valves: Fast-acting solenoid valve VR100F10T5F930

Gas filtration and metering: Gas filters FN8-6

Automation and instrumentation system:

Boiler automation units DKMATIK-100 (2 units)

General boiler automation system DKMATIK

Control panels with indicator lights

Flue gas pipes and ducts:

2 separate flue gas stacks (one for each boiler) (diameter: 400 mm, height: 28 m)

Chemical water treatment system:

Hydro-X complexone system for corrosion and scale prevention, and other related equipment.

Results and discussion

In the context of the inevitable aging of centralized heating networks, rising energy transportation tariffs, and increasingly stringent requirements for the quality of utility services, rooftop boiler houses are acquiring the status of a strategically important element of modern urban infrastructure.

The project of a modern rooftop block-modular boiler house clearly demonstrates a comprehensive engineering approach to creating autonomous heat supply sources that meet current requirements for energy efficiency, operational reliability, and environmental safety. The development of the thermal scheme, carried out for characteristic seasonal operating modes, made it possible not only to determine peak and average thermal loads accurately but also to optimally select primary and auxiliary equipment.

The use of natural gas as the primary fuel, combined with the high standard efficiency of boiler units and a modern chemical water treatment system, ensures minimal environmental impact, full compliance with current sanitary and hygienic standards, and stable equipment operation without scale formation or corrosion damage.

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УДК 621.313.344

AN ASYNCHRONOUS-SYNCHRONISED MACHINE AS AN OBJECT OF AN AUTOMATED ELECTRIC DRIVE SYSTEM

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Abstract. The asynchronous-synchronized machine is considered as an object of automated electric drive systems. Its design features, dynamic behavior in asynchronous and synchronous modes, and transient processes during synchronization are analyzed. A comparative review of electrical machine characteristics is carried out to identify advantages, limitations, and application areas. Special attention is paid to stability, excitation current control, and reactive power compensation.

Keywords: asynchronous-synchronised machine, asynchronous-start synchronous machine, automated electric drive system, induction motor, synchronous motor, drive control, synchronisation, reactive power compensation, energy efficiency.

АСИНХРОННО-СИНХРОНИЗИРОВАННАЯ МАШИНА КАК ОБЪЕКТ АВТОМАТИЗИРОВАННОГО ЭЛЕКТРОПРИВОДА

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Аннотация. Рассмотрена асинхронно-синхронизированная машина как объект автоматизированного электропривода. Проанализированы ее конструктивные особенности, динамические свойства в асинхронном и синхронном режимах, а также переходные процессы при синхронизации. Выполнен сравнительный анализ характеристик электрических машин, выявляющий преимущества, ограничения и области применения. Особое внимание уделено устойчивости, управлению током возбуждения и компенсации реактивной мощности.

Ключевые слова: асинхронно-синхронизированная машина, автоматизированный электропривод, асинхронный двигатель, синхронный двигатель, управление электроприводом, синхронизация, компенсация реактивной мощности, энергоэффективность.

At present, the development of industry and power engineering is accompanied by increasing requirements for the efficiency, reliability and controllability of electromechanical systems. Automated electric drive systems play a significant role in meeting these requirements and are widely used in various technological installations. The need to improve energy efficiency, extend the speed-control range and enhance the dynamic performance of electric drives necessitates advances in both control systems and the electrical machines themselves.

Induction and synchronous electrical machines are the most widely used in industrial applications. Induction motors are valued for design simplicity, high reliability and low cost; however, they have limited speed-control capabilities and relatively lower energy efficiency in variable-speed operation. Synchronous motors, in turn, provide high efficiency and stable rotational speed, but require more complex starting and control systems, which restricts their use in certain automated drives [1, p. 312].

In this context, the asynchronous-synchronised machine (ASM) is of considerable interest because it combines the structural and energy-related advantages of both induction and synchronous motors. The ability to start asynchronously and subsequently transfer to synchronous operation makes such machines suitable for drives with high requirements for stability, energy efficiency and control quality. However, their dynamic behaviour is more complex, which necessitates detailed analysis as objects of automated control.

In English-language technical literature, a similar concept is often associated with line-start synchronous motors (LSSMs). Although this term may refer to specific designs, including permanent-magnet or reluctance rotors with an additional squirrel-cage winding, the control-oriented analysis presented in this article remains relevant for machines that combine asynchronous starting with subsequent synchronous operation. In this article, the abbreviation ASM is retained in order to preserve correspondence with the Russian term used in the source material.

Despite the potential of ASM, issues related to its application in automated electric drive systems, along with control strategies and operational stability, remain insufficiently covered in educational and scientific literature. This determines the relevance of the study. The purpose of this paper is to analyse ASM as an object of an automated electric drive system and to assess its advantages, limitations and prospects for implementation in modern adjustable-speed drives. The article has a review-based analytical character and is aimed at systematising the operating features and application possibilities of ASM.

An asynchronous-synchronised machine is an AC electrical machine that integrates features of induction and synchronous motors. In the interpretation adopted in this paper, it provides asynchronous start-up by means of a squirrel-cage winding and then enters synchronous operation when direct current is supplied to the field winding.

The ASM stator is usually designed according to the conventional induction-motor arrangement and contains a three-phase distributed winding connected either directly to the mains or to the output of a variable-frequency drive (VFD). The rotor

has a hybrid construction and includes a squirrel-cage winding for asynchronous start-up and a field winding supplied with direct current [2, p. 15].

Depending on the design, the field current may be supplied to the rotor through slip rings or by means of a brushless excitation system. Brushless excitation reduces the maintenance requirements associated with sliding contacts and may improve reliability in industrial applications. In special certified designs, this feature can also be important for drives operating in harsh or hazardous environments.

The field winding generates a synchronous magnetic field and creates the conditions for pulling the rotor into synchronism when the rotor speed approaches the synchronous value. This design enables operation in two distinct modes, asynchronous and synchronous, as well as in transitional states between them. From the point of view of an automated electric drive system, this dual-mode capability introduces significant complexity into dynamic processes and requires careful consideration of the interaction between electromagnetic and mechanical subsystems.

The operation of ASM begins in asynchronous mode. In this mode, the rotating magnetic field of the stator induces currents in the rotor squirrel-cage winding and produces an electromagnetic torque similar to that of a standard induction motor. At this stage, the rotor speed is below the synchronous speed and slip is non-zero. As the rotor accelerates and approaches the synchronous speed, DC field current is applied. Under appropriate conditions of speed, load and field-current magnitude, a synchronising torque is produced and the machine is pulled into synchronous operation. In synchronous mode, the rotor speed is equal to the synchronous speed of the rotating stator magnetic field, and slip becomes zero.

The rotor equation of motion is used to describe the dynamics of the electric drive:

$$J \cdot d\omega/dt = M_e - M_l,$$

where J is the moment of inertia, ω is the angular velocity of the rotor, M_e is the electromagnetic torque and M_l is the load torque.

In synchronous mode, the electromagnetic torque depends on the load angle θ and can be expressed as follows:

$$M_e = M_{max} \cdot \sin\theta,$$

where M_{max} is the maximum electromagnetic torque of the machine. The magnitude of the electromagnetic torque is also affected by the field current, which provides an additional control channel for the electric drive.

Transient processes during synchronisation are particularly important for automated electric drives. They are accompanied by abrupt changes in electromagnetic torque and speed, which may compromise system stability if appropriate control algorithms are not applied. Since the machine starts in asynchronous mode, the mechanical characteristic of an induction motor may first be considered as an illustrative basis for the start-up stage.

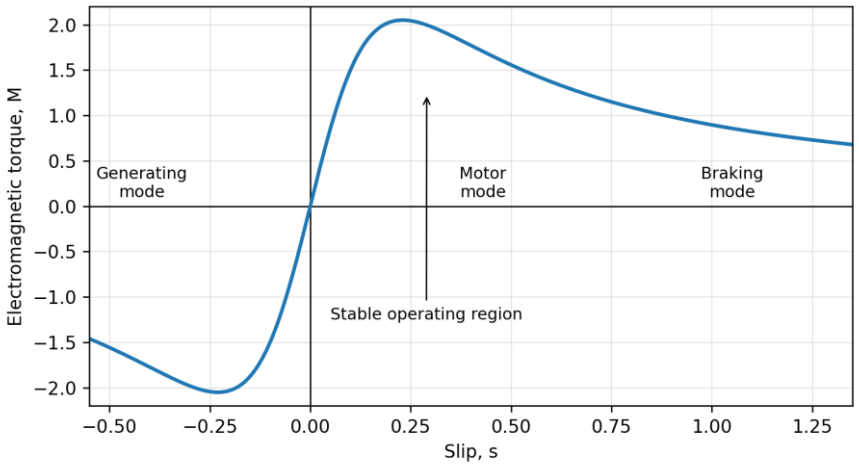


Figure 1. Electromagnetic torque and mechanical characteristic of an induction motor at the asynchronous start-up stage

Figure 2 schematically shows the transient changes in angular velocity and electromagnetic torque of ASM during the transition to synchronous operation.

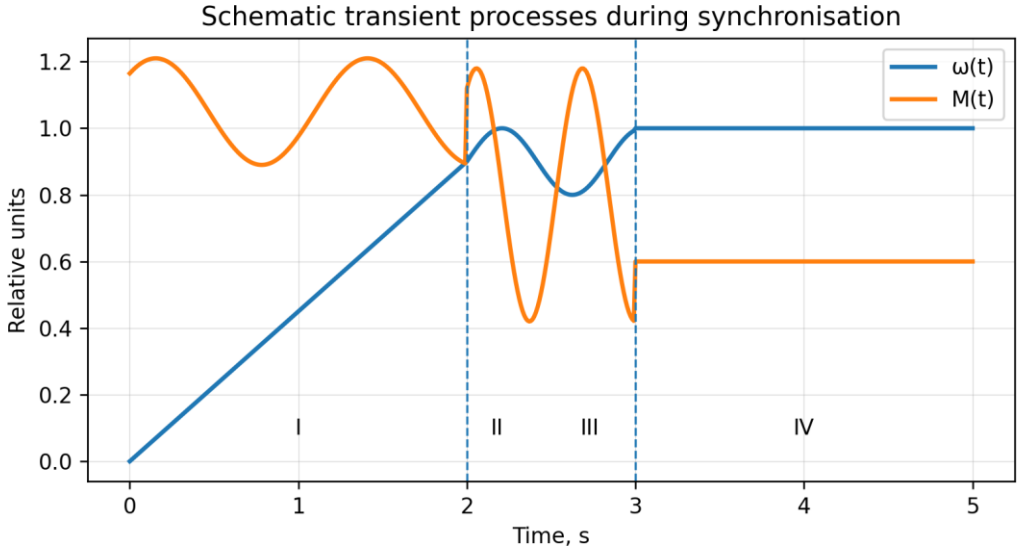


Figure 2. Schematic transient changes in angular velocity and electromagnetic torque of ASM during the transition to synchronous operation

Four characteristic stages can be distinguished in the synchronisation process:

Stage I – asynchronous acceleration of the rotor, characterised by a smooth increase in speed and oscillations of electromagnetic torque;

Stage II – application of field current and formation of synchronising torque;

Stage III – pull-in to synchronism accompanied by a short-term dynamic disturbance;

Stage IV – steady-state synchronous operation [3, p. 43].

Consideration of this schematic transient process makes it possible to identify the main factors affecting synchronisation stability, including the field-current control law

and the load characteristics of the electric drive. Therefore, ASM can be regarded as a complex, nonlinear control object whose parameters and dynamic properties change during the transition between operating modes.

From the standpoint of automatic control theory, ASM can be classified as an object with parametric uncertainty, since its equivalent parameters vary with the operating mode. The transition between asynchronous and synchronous operation changes the electromagnetic coupling between the stator and rotor and affects the transfer properties of the controlled object. During synchronisation, the sensitivity of electromagnetic torque to control inputs also changes, which must be taken into account when designing automatic control systems.

Successful pull-in to synchronism is possible only if the rotor speed is sufficiently close to the synchronous speed before the field current is applied. If the slip exceeds a critical value, the synchronising torque may be insufficient, which can lead to prolonged oscillations, hunting or failure to enter synchronous operation.

This determines the need for adaptive or multimode control algorithms capable of ensuring stability and the required quality of transient processes. In asynchronous mode, the frequency and amplitude of the supply voltage have the main effect on drive dynamics, whereas in synchronous mode field-current regulation becomes critical. If the permissible electromagnetic torque is exceeded, loss of synchronism may occur. Field-current control can therefore be used not only to maintain synchronous operation, but also to damp electromagnetic-torque oscillations during transient processes.

Modern control strategies for ASM may be based on field-oriented control (FOC) or direct torque control (DTC) implemented in a variable-frequency drive. These methods make it possible to control magnetic flux and electromagnetic torque more independently, which is important for reducing torque oscillations and dynamic disturbances during the pull-in process.

For an approximate comparative assessment, a typical electric drive with a rated power of 15 kW and a rated speed of 1500 rpm is considered.

The rated torque is calculated as follows:

$$M_{nom} = 9550 \cdot P_{nom}/n_{nom} = 9550 \cdot 15/1500 = 95.5 \text{ N} \cdot \text{m},$$

where P_{nom} is the rated power, kW, and n_{nom} is the rated speed, rpm.

The starting torque is determined by the expression:

$$M_{st} = k_{st} \cdot M_{nom},$$

where k_{st} is the starting-torque coefficient.

$$M_{st}(\text{IM}) = 2.2 \cdot 95.5 = 210.1 \text{ N} \cdot \text{m},$$
$$M_{st}(\text{SM}) = 1.1 \cdot 95.5 = 105.1 \text{ N} \cdot \text{m},$$
$$M_{st}(\text{ASM}) = 2.0 \cdot 95.5 = 191.0 \text{ N} \cdot \text{m}.$$

Power losses are calculated using the efficiency value:

$$\Delta P = P_{nom} \cdot (1/\eta - 1).$$
$$\Delta P(\text{IM}) = 15 \cdot (1/0.88 - 1) = 2.05 \text{ kW},$$
$$\Delta P(\text{SM}) = 15 \cdot (1/0.93 - 1) = 1.13 \text{ kW},$$
$$\Delta P(\text{ASM}) = 15 \cdot (1/0.92 - 1) = 1.30 \text{ kW}.$$

Table. Comparison of electrical machine characteristics

Parameter	IM	SM	ASM
Power P, kW	15	15	15
Efficiency η	0.88	0.93	0.92
Power factor cos φ	0.85	0.95	0.90
Starting torque ratio M_{st}/M_{nom}	2.2	1.1	2.0
Power losses ΔP, kW	2.05	1.13	1.30
Starting torque M_{st}, N·m	210.1	105.1	191.0

The efficiency values, power factor and starting-torque coefficient are given as typical approximate characteristics for electrical machines with a rated power of 15 kW. The data presented are comparative engineering estimates intended for a qualitative comparison of the considered machine types; they do not replace the calculation of a specific electric drive based on the rated data and operating conditions of the selected machine [4, p. 64].

The data in Table 1 show that ASM occupies an intermediate position between an induction motor and a synchronous motor, combining favourable starting characteristics with relatively high energy performance. The presented results should therefore be considered as an approximate comparative engineering assessment rather than as a universal proof of superiority.

The main advantages of asynchronous-synchronised machines include the possibility of asynchronous start-up without additional starting devices, high energy efficiency in synchronous mode, the possibility of improving operating stability under load changes by controlling the field current, and the extension of the operating-mode control range through field excitation.

A significant operational advantage of ASM over a standard induction motor is the possibility of reactive power control in synchronous mode. Unlike an induction motor, which requires reactive power for magnetisation, ASM can regulate its power factor by changing the field current. In the over-excited mode, the machine may operate with a leading power factor and partially compensate reactive power in the industrial electrical network. This can improve power quality and reduce the reactive power demand of the installation.

At the same time, the use of ASM is associated with several limitations: increased complexity of the control system, the need for a direct-current source for excitation and higher requirements for automatic control algorithms during the transition between operating modes [5, p. 52]. These limitations are especially important under variable-load conditions, where an incorrect field-current strategy may lead to loss of synchronism.

ASMs are most suitable for automated electric drive systems that impose increased requirements on energy efficiency, stability of operating modes and speed-control quality. Their use is most reasonable in adjustable-speed drives for pumps, compressor units, fans and technological systems with long steady-state operating modes. A promising direction is the use of ASM in frequency-controlled electric drives, where field-current regulation can be used to optimise energy performance and improve operating stability under variable loads.

This article is based on a review-based analytical approach and does not include original experimental data or numerical simulation of a specific asynchronous-synchronised machine design. The comparative analysis uses typical efficiency, power factor and starting-torque values for a 15 kW machine class. These values may vary depending on the actual machine design, manufacturer, excitation system and control method. Therefore, the quantitative estimates presented in the article should be interpreted as indicative engineering approximations rather than universal performance guarantees. Further research should include experimental validation and detailed simulation of transient synchronisation processes for specific machine configurations.

The article considers an asynchronous-synchronised machine as an object of an automated electric drive system. It is shown that its defining feature is the combination of asynchronous start-up with subsequent transition to synchronous operation when field current is supplied. This makes it possible to combine the favourable start-up characteristics of an induction machine with the improved energy performance of synchronous operation.

ASM can be regarded as a more complex control object than conventional induction and synchronous motors because its dynamic properties change during the transition between operating modes. The stability of the synchronisation process depends on load conditions, the timing and magnitude of field-current application and the automatic control algorithms used.

The results of the review-based comparative analysis suggest that ASM may be considered a promising option for industrial adjustable-speed drives, primarily in installations with long steady-state operating modes. At the same time, its application requires consideration of the increased complexity of the control system, the need for a direct-current field source and the provision of a stable transition to synchronous operation.

Further research may be aimed at developing adaptive and sensorless control algorithms, optimising field-current control strategies, implementing brushless excitation systems and analysing the influence of frequency-converter harmonics on synchronisation stability. These directions are important for improving transient performance, reducing maintenance requirements and expanding the operational reliability of ASM in modern industrial automation.

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УДК 620.193.4+621.35

CONCEPT OF METAL PROTECTION AGAINST OXIDATION BY ELECTRIC FIELD

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Abstract. Corrosion is the destruction of the surface of steels and alloys under the influence of various physical and chemical factors. Metal corrosion is a common problem that causes significant damage to parts and can lead to the degradation of metal structures. Corrosion occurs due to the interaction of metal with oxygen and water, as a result of which the metal's characteristics deteriorate, eventually leading to its complete destruction.

Keywords: electric field, oxidation, rust, conductor, alternating current, DC.

КОНЦЕПЦИЯ ЗАЩИТЫ МЕТАЛЛА ОТ ОКИСЛЕНИЯ ЭЛЕКТРИЧЕСКИМ ПОЛЕМ

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Аннотация. Коррозия – разрушение поверхности сталей и сплавов под воздействием различных физико-химических факторов. Коррозия металла является распространенной проблемой, которая наносит огромный ущерб деталям и может привести к повреждению и деградации металлических конструкций. Коррозия происходит из-за взаимодействия металла с кислородом и водой, в результате чего снижаются характеристики металла, и это приводит к его полному разрушению. Существуют различные способы защиты от коррозии: электрозащита, нанесение защитного покрытия, использование нержавеющего крепления, поддержание оптимального уровня влажности, регулярное очищение изделий от грязи.

Ключевые слова: электрическое поле, окисление, ржавчина, проводник, переменный ток, постоянный ток.

Contemporary corrosion-resistant coatings for metal surfaces rely on

multi-component formulations that combine several functional elements: corrosion inhibitors, film-forming agents, colour pigments, binders, and adjuvants. The efficacy of such coatings depends critically on the precise balance of these components [1, p. 24]. Among the most widely used types of protective paints, alkyd formulations stand out due to their durability and versatility in diverse environmental conditions. These paints are based on alkyd lacquer and prove effective in a range of applications. Acrylic paints, in turn, offer a fast-drying solution as water-dispersed formulations containing polyacrylates and corrosion inhibitors. For surfaces requiring a distinctive textured finish, hammer paints are employed – they combine alkyl styrene, acrylic, and epoxy components to achieve the desired effect. Finally, epoxy paints, which feature epoxy resins and curing agents, are valued for their strong adhesion and chemical resistance, making them suitable for demanding industrial environments.

The development of metallization techniques in the 20th century introduced new alternatives to traditional surface treatment methods. One of the most cost-effective approaches is thermal spraying, also known as dusting. In this process, powdered material is directed onto the metal surface, and upon impact, the particles deform and form a reliable bond with the substrate [2, p. 123]. Another method, vacuum metal sputtering, enables maximum adhesion of deposited metal layers through the use of vacuum equipment. Although this technique is fast and results in coatings highly resistant to wear and corrosion [3, p. 60], it comes with certain limitations, such as complex setup requirements and considerable energy consumption. Magnetron sputtering represents a further advancement, relying on ion bombardment of a molten metal target in a discharge plasma. This method excels in producing ultra-thin metal films and is also applied to coat dielectrics and semiconductors, including materials like silicon, germanium, and silicon carbide [4, p. 110].

In addition to coating technologies, corrosion rates can be reduced by modifying the surrounding medium. Practical approaches include removing corrosive substances from the operational environment through absorption or filtration. A particularly effective strategy involves introducing inhibitors into aggressive environments, which significantly slows down harmful electrochemical reactions [5, p. 19]. This approach proves especially valuable for vacuum-formed products, such as radio and incandescent lamp filaments, where it helps prevent oxidation and extends component lifespan.

Electrochemical protection (EHP) offers another powerful way to prevent metal oxidation by controlling electrochemical reactions through electrical methods. The core principle of this technique lies in creating an electrical environment that suppresses oxidation processes and reduces corrosion rates. For successful implementation, two key requirements must be met: first, there must be reliable contact between the protected structure and an external anode, typically established via a metal cable; second, the entire electrical circuit – including the protected object, the EHP cable, the anode, and the electrolyte – must be closed. Only then can a protective current flow through the system and effectively halt corrosion.

Scientific literature identifies three main types of electrochemical protection (Table) [6, p. 445].

Table. The main advantages of electrochemical protection

Advantage	Key Benefit	Outcome
High efficiency	Controls metal potential via electrical environment	Significantly reduces corrosion rate, maintains functionality of structures
Durability	Actively manages oxidation processes	Extends service life, preserves quality characteristics
Cost-effectiveness	Prevents corrosion damage	Reduces maintenance costs, avoids production losses

The future of electrochemical protection method is aimed at continuous improvement and development of technologies to improve the effectiveness and reliability of corrosion protection. Scientists have identified the following promising areas in the field of electrochemical protection development: use of more efficient materials for anodes and cathodes and introduction of innovative methods such as electrochemical corrosion deposition.

Fields of application of electrochemical protection. The method is widely used to protect objects against corrosion in various industries (Fig. 1):

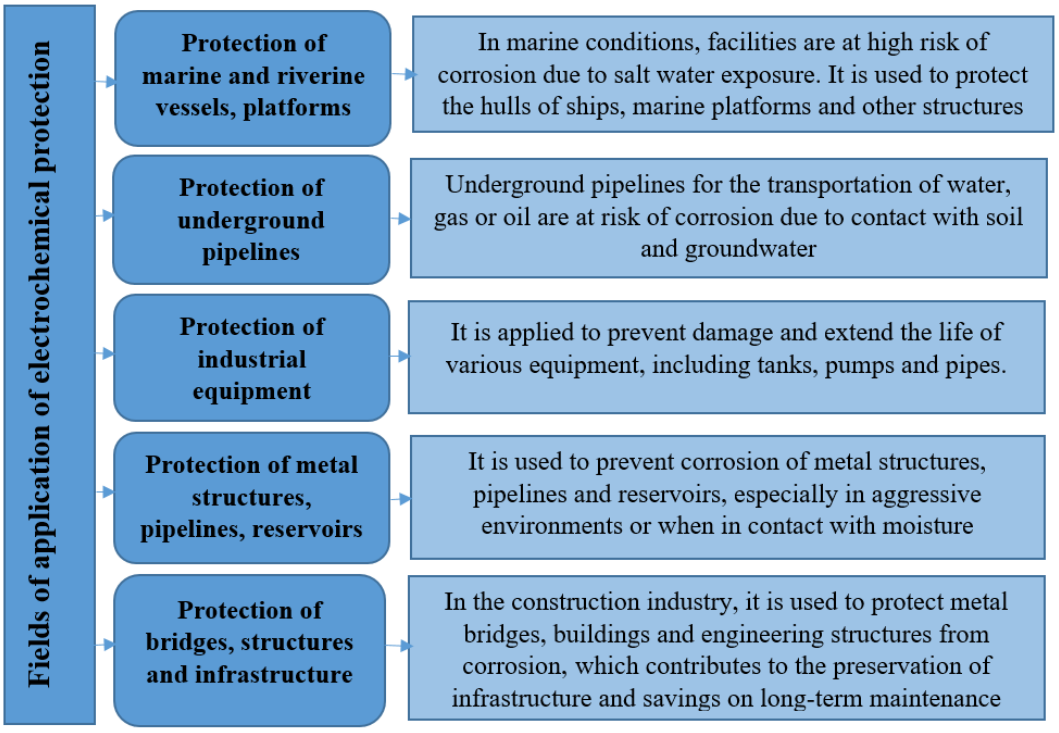


Figure 1. Fields of application of electrochemical protection

The various applications presented show the effectiveness of this method, its application in space will ensure reliable protection of ship's metal structures and instruments. The scientific literature presents three types of electrochemical protection against corrosion: anode; cathode and protective [6, p. 445]. Consider each of them.

Anode protection operates by shifting the potential in a positive direction using an external current source and introducing oxidants into the corrosive medium. This method is particularly suitable for carbon steels, high-alloyed and stainless steels, titanium alloys, and passivating metals. Its key advantages include a significant

reduction in the corrosion rate and the elimination of risks associated with corrosion products entering the environment or manufactured goods. However, anode protection has certain limitations – it places strict requirements on the protected object and is less commonly used than cathode protection. The equipment typically includes low-solubility elements such as platinum, stainless high-alloyed alloys, nickel, and lead.

Cathode protection, on the other hand, connects the metal to a DC source, applying external current from the negative pole to polarize cathode areas. In this setup, the protected metal (cathode) is connected to an anode – often made of zinc or magnesium – which corrodes instead, earning the name “sacrificial anode”. This mechanism effectively shields the primary structure from degradation. Cathode protection is widely applied to materials such as tin, aluminum, zinc, carbon, and alloy steels, and is especially effective in water or soil environments. The implementation relies on cathode protection stations as external current sources, ensuring reliable polarization and long-term durability.

Protective EPZ, or sacrificial anode protection, takes a slightly different approach by using a protector with a more negative potential than the protected structure. As a result, the protector gradually corrodes and requires periodic replacement, while the protected object remains intact. The effectiveness of this method depends on maintaining low transition resistance between the environment and the protector, as each protector has a limited action radius – the maximum distance at which it can provide adequate protection. This type of electrochemical protection is commonly used in neutral environments, including air, soil, sea water, and river water. For instance, protectors used in pipeline systems are typically made from magnesium, zinc, aluminum, or iron with additional alloying components.

To evaluate the effectiveness of different electrical potentials in preventing metal oxidation in air without current flow through the circuit, two experiments were conducted. The first experiment involved a high-power supply unit with variable output voltage and metal samples (Fig. 2).

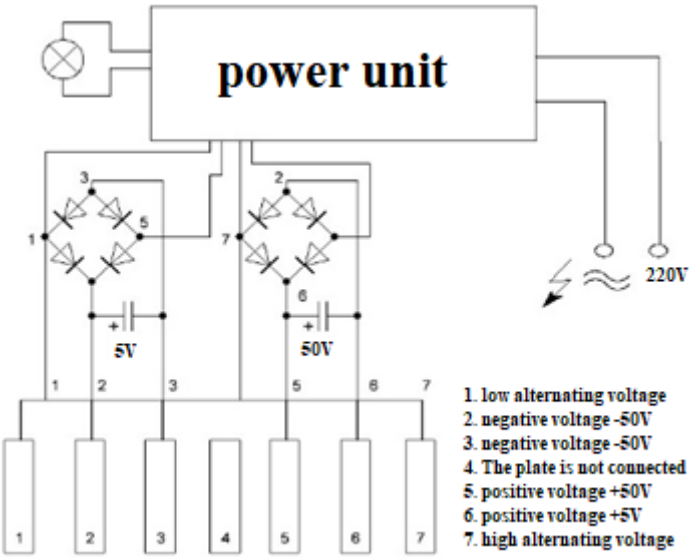


Figure 2. Diagram of the first installation

The method consisted of connecting various potentials to the metal and moistening the samples with water to accelerate the effects of air exposure. The voltage settings, arranged from left to right, included low AC voltage, negative voltage at 50 V and 5 V, no voltage, positive voltage at 50 V and 5 V, and high AC voltage. The results showed that low AC voltage provided the most effective protection. After wet treatment, part of the rust was removed, leaving only embedded corrosion (Fig. 3).



Figure 3. Status of the installation as at 21.01.2025 (after 2 hours of operation)

Unfortunately, the experiment had to be halted prematurely due to a failure of the power supply unit, which could not withstand continuous operation.

The second experiment aimed to assess the impact of frequency and voltage using a self-made voltage source. The setup included two rectifiers connected to a 220 V network, a transformer, and metal plates (Fig. 4).

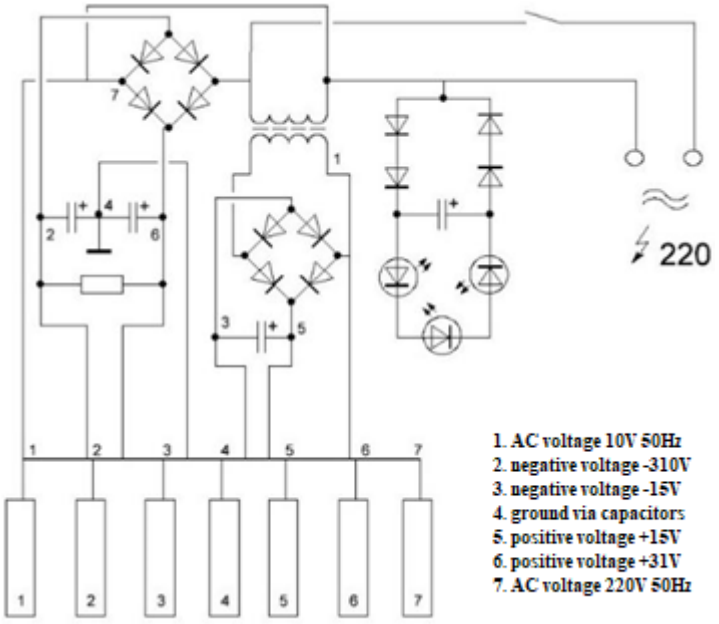


Figure 4. Diagram of the second installation

The method involved creating constant voltage capacities at a frequency of 50 Hz. The voltage settings followed a similar pattern: AC voltage at 10 V and 220 V (both at 50 Hz), negative voltage at 310 V and 15 V, grounded through capacitors, and positive voltage at 15 V and 310 V. The findings indicated that a negative potential at 50 Hz offered the best protection, as the metal oxidized more slowly compared to higher frequencies (Fig. 5).



Figure 5. Start of the experiment (11.05.2025) before applying water

Based on the experimental data, it becomes clear that low AC voltage provides the most effective protection against corrosion in air environments. The changing electric field around the conductor acts as a shield, and reducing the voltage enhances this protective effect. Interestingly, variations in current frequency had little impact on the overall effectiveness of protection. In all cases, increasing the voltage on the electrodes weakened the protection and led to a greater number of rusty spots on the connected samples.

In conclusion, corrosion remains a serious threat to metal structures, causing degradation through chemical and electrochemical reactions with the environment. Effective prevention strategies, such as electrochemical protection, play a crucial role in extending equipment lifespan, reducing maintenance costs, and ensuring operational reliability – especially in critical fields like space exploration. As technologies continue to advance, further improvements in corrosion protection methods will benefit a wide range of industries, from construction and manufacturing to aerospace and energy.

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УДК 628.543.665

PROCESSING LEAF LITTER AS AN ECOLOGICAL SORBENT: TECHNOLOGICAL ASPECTS AND APPLICATION PROSPECTS

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Abstract. This article examines the pressing issue of leaf litter disposal, traditionally classified as municipal solid waste. The feasibility of processing it into a sorption material for removing pollutants from aquatic environments is substantiated. An analysis of literature data demonstrates that leaf litter has significant potential due to the presence of functional groups capable of ion exchange and sorption. Methods for material preparation, including grinding, chemical activation, and compaction, are discussed. Particular attention is paid to the experience of using similar plant materials as sorbents. Technological solutions for integrating leaf litter processing into enterprise wastewater treatment systems within the framework of the circular economy concept are proposed.

Keywords: leaf litter, sorbent, ion exchange capacity, waste recycling, water purification, circular economy, humic substances.

ПЕРЕРАБОТКА ЛИСТОВОГО ОПАДА В КАЧЕСТВЕ ЭКОЛОГИЧЕСКОГО СОРБЕНТА: ТЕХНОЛОГИЧЕСКИЕ АСПЕКТЫ И ПЕРСПЕКТИВЫ ПРИМЕНЕНИЯ

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Аннотация. В статье рассматривается актуальная проблема утилизации листового опада, который традиционно относится к твердым коммунальным отходам. Обоснована целесообразность его переработки в сорбционный материал для очистки водных сред от загрязняющих веществ. На основе анализа литературных данных показано, что листовой опад обладает значительным потенциалом благодаря наличию функциональных групп, способных к ионному обмену и сорбции. Рассмотрены методы подготовки материала, включая измельчение, химическую активацию и компактирование. Особое внимание

уделено опыту использования аналогичных растительных материалов в качестве сорбентов. Предложены технологические решения по интеграции переработки листового опада в системы очистки сточных вод предприятий в рамках концепции циркулярной экономики.

Ключевые слова: листовой опад, сорбент, ионообменная емкость, переработка отходов, очистка воды, циркулярная экономика, гуминовые вещества.

The annual autumn leaf fall creates a major problem for organic waste disposal in urbanized landscapes. Traditionally, fallen leaves, classified as municipal solid waste (FKKO 7 31 300 02 20 5), are sent to landfills or incinerated, resulting in additional environmental burdens: greenhouse gas emissions during decomposition, air pollution from combustion products, and the irreversible loss of a potentially valuable resource. At the same time, there remains a persistent need for efficient, cost-effective, and environmentally friendly technologies for water treatment, particularly for pollutants such as heavy metal ions and persistent organic compounds.

In the context of a circular economy and the search for "green" solutions, fallen leaves are no longer considered waste but are becoming a promising renewable resource. Its chemical composition, including cellulose, lignin, hemicelluloses, and a complex of humic substances, provides numerous functional groups (carboxyl, hydroxyl, phenolic) capable of ion exchange, complexation, and physicochemical sorption. Research confirms the significant potential of leaves of various tree species as a sorption material, the effectiveness of which can be regulated by changing the pH of the environment.

The importance of developing leaf litter processing technologies is determined by their dual environmental benefits. First, they enable the direct utilization of seasonal organic waste, transforming it from an environmental problem into a resource. Second, the resulting sorbent can replace or complement more expensive and energy-intensive synthetic materials in water treatment systems, industrial wastewater treatment, and stormwater treatment. Successful use of other secondary products, as well as the proven effectiveness of natural sorbents (peat, moss) in binding pollutants, serve as a compelling precedent and confirm the technical and economic feasibility of such solutions. Thus, developing a comprehensive process chain–from the collection and preparation of leaf litter to the production of a standardized sorbent–represents a pressing scientific and applied challenge. Its solution promotes resource conservation, reduces the anthropogenic impact on the environment, and creates new environmental technologies within the framework of sustainable development.

Currently, the primary methods for leaf litter management in urban areas are landfill disposal and incineration. Both methods have significant environmental and economic drawbacks. Landfill disposal results in long-term land use loss, and in landfills, where controlled aerobic processes are often absent, it leads to leachate formation and methane emissions. Incineration, even in modern facilities, is associated with energy costs, CO_2 emissions, and the risk of dioxin formation during uncontrolled combustion. An alternative method, composting, is more environmentally friendly, but requires a significant amount of time, space, and does not create a high-value-added

product. Consequently, leaf litter remains an underutilized resource, although its potential for creating products with functional properties, particularly sorbents, has been well documented.

Experience using plant materials as natural sorbents.

The use of natural organic materials for water purification dates back decades. Peat and sphagnum mosses are the most studied and widely used. Their high efficiency is due to their developed porous structure and the presence of humic and fulvic acids, which have pronounced ion-exchange and complexing properties. Similar components are found in leaf litter. Research also demonstrates the potential of other agricultural and industrial wastes Forest industry waste: husks, sawdust, bark, and straw. Their common advantage is low cost and renewable nature. However, many of these materials have problems with mechanical strength, high buoyancy, or leaching of coloring agents (humic compounds). This requires an additional modification step or use in composite materials.

Leaf litter is a complex heterogeneous system. Its organic matrix consists of cell wall polymers: cellulose (which provides the structural framework), hemicelluloses, and lignin (an aromatic polymer responsible for strength). During leaf aging and partial decomposition, humic substances – high-molecular compounds containing carboxyl, phenolic, quinone, and other functional groups – form on the surface and within the tissue. These groups are the main sites for the sorption of metal cations through ion exchange and chelation mechanisms. A study of the acid-base properties of leaf litter surfaces using potentiometric titration demonstrates that the material is amphoteric, and its exchange capacity varies depending on the pH of the medium. This allows for selective adjustment of the sorption process. Unlike peat, leaf litter typically has lower ash content and a more uniform morphological composition, which can simplify the process of its preparation and standardization as a sorbent. Thus, literature data confirm the fundamental possibility and technical feasibility of processing leaf litter into an effective sorption material for water treatment.

Research Methodology.

This study is based on the principles of systems analysis and comparative evaluation, aimed at developing a concept for processing leaf litter into a sorbent. This work is of a review and analytical nature, with elements of synthesis based on secondary data.

The methodology is based on a critical analysis of scientific publications and experimental data. The key sources of research included studies assessing the ion-exchange properties of leaf litter, technologies for using fly ash as a composite reagent, and the chemical composition and sorption characteristics of moss and peat. The analysis was conducted taking into account regulatory documents governing coagulant requirements and biofuel classification.

To objectively assess the potential of leaf litter as a sorbent, the following criteria were defined and applied:

Sorption efficiency: The ability to reduce water color and remove marker pollutants, expressed as a percentage.

Influence of pH: Analysis of the dependence of ion-exchange capacity on the acidity of the aqueous phase as a key factor determining the state of functional groups

and the sorption mechanism.

Preparation technology: Comparison of leaf litter processing stages with known methods for activating other natural sorbents and producing composite reagents from waste. Ecological and economic feasibility: A qualitative assessment based on the principle of cyclicality – converting waste into a resource, reducing disposal costs, and potentially replacing commercial reagents.

Data from various sources was integrated using a comparative analysis method. This allowed us to extrapolate the sorption mechanisms established for humic substances in peat and moss to chemically similar components of leaf litter, as well as transfer successful technological principles of activation and application of other types of secondary raw materials to the leaf material preparation process. A generalized process flow diagram was formulated, combining the stages of collection, preparation, activation, and application of the sorbent.

Developing a technology for processing leaf litter into sorbent requires the creation of a standardized chain of operations that ensures consistent quality of the final product. Based on an analysis of processing methods for similar materials, the following key stages can be identified:

Collection, drying, and preparation of raw materials.

The optimal collection period is the phase of mass leaf fall, which ensures maximum raw material yield. To prevent the onset of anaerobic processes. To prevent decomposition and the development of pathogenic microflora, collected leaves must undergo primary processing as quickly as possible. Initial preparation includes the removal of large debris (branches, stones) and uniform drying to a constant weight at a temperature not exceeding 60–70 °C to preserve heat-labile organic compounds. Air drying is also acceptable, but requires more time and controlled conditions to prevent mold growth.

Mechanical processing (crushing, sifting).

To increase the specific surface area and accelerate subsequent physicochemical processes, the raw materials must be crushed. The optimal particle size depends on the intended use of the sorbent: a fraction of 1–5 mm is suitable for loose-fill filters, while less than 1 mm is suitable for use as a suspension or in stirred reactors. Crushing can be accomplished using rotary, hammer, or knife crushers. Subsequent sifting produces a fraction with a specified particle size distribution, which is important for ensuring predictable hydrodynamics in filtration systems. Chemical and thermochemical activation.

This stage is aimed at increasing the number of active sorption sites and enhancing the overall capacity of the material. Based on experience with the activation of carbon sorbents and mineral waste for leaf litter, the following methods can be proposed:

Alkaline treatment (with moderately concentrated NaOH or KOH solutions): promotes the dissolution of some hemicelluloses, "opening" the structure, and increasing the availability of the functional groups of humic substances.

Acid treatment (with HCl or H_2SO_4 solutions): used to remove some mineral impurities, stabilize the material, and modify its surface properties. This can be carried out in a similar manner to acid "decomposition" of ash to convert the components into an active state.

Heat treatment in an inert atmosphere (carbonization): Heating to temperatures of 300–500 °C produces a porous carbon material with a developed surface area, but this also results in partial destruction of the humic acids. The choice of activation method is determined by the target pollutants and economic considerations. Alkaline or acidic treatment is the simplest and most cost-effective for initial use.

Sorbent Formation and Granulation.

For ease of transportation, dosing, and use in industrial equipment, it is advisable to convert bulk sorbent into granular form. Granulation can be accomplished by pressing (extrusion) with the addition of binders (e.g., starch, lignosulfonates) or without them, provided the material has sufficient binding capacity after activation. An alternative is the creation of composite filter blocks or mats, where leaf litter acts as a filler and a polymer matrix acts as a binder.

Sorption Properties of Leaf Litter.

The effectiveness of leaf litter as a sorbent is determined by a combination of its physicochemical characteristics, the most important of which are ion-exchange capacity and the dependence of sorption on environmental conditions.

Leaf litter is a multifunctional ion exchange resin. Its exchange capacity is determined by the presence of carboxyl (–COOH) and phenolic (–OH) groups in humic acids and lignin. Capacity varies among tree species. Generally, the leaves of broadleaf trees (maple, oak, linden) exhibit higher values than those of conifers, due to differences in the composition and structure of lignin.

The key factor regulating sorption is the pH of the aqueous medium. In an acidic environment (pH < 5), the carboxyl groups are protonated (–COOH), which limits cation exchange but can promote anion sorption through electrostatic attraction. As the pH increases (6–8), the carboxyl groups dissociate ($–COO^-$), becoming active sites for binding metal cations (Pb^{2+}, Cu^{2+}, Cd^{2+}, Zn^{2+}) via the ion exchange mechanism. Thus, by controlling pH, it is possible to specifically treat wastewater from specific types of pollutants.

The organic matrix of leaf litter exhibits activity against a wide range of pollutants: Heavy metals: Sorption occurs primarily through chelation and ion exchange. The material exhibits the greatest efficiency for lead, copper, and cadmium ions. Capacity can reach 0.5–1.5 mg-eq/g, depending on pretreatment.

Organic compounds (dyes, phenols, petroleum products): Sorption in this case is due to both hydrophobic interactions with lignin and bitumen components and the formation of hydrogen bonds. Humic acids can also undergo oxidation-reduction reactions with some organic pollutants.

In terms of sorption capacity, leaf litter is inferior to specially synthesized ion-exchange resins or activated carbons, but is comparable or superior to many natural analogs (certain types of clay, non-activated peat). Its key advantage is the extremely low cost of raw materials and the ability to be used in unprivileged conditions, such as in passive stormwater treatment systems or for the post-treatment of low-concentration wastewater. Compared to moss or peat, leaf litter typically has a more predictable composition and does not require extraction, which disrupts natural ecosystems.

Practical Application and Technological Solutions. Implementing a leaf litter-based sorbent requires the development of specific engineering solutions integrated

into existing or newly developed technological processes.

–Use in Industrial Wastewater Treatment Systems

In industrial facilities, especially in the wood processing industry, prepared leaf litter can be used:

As a filter bed in the post-treatment stage to remove residual metal ions and organic matter after the main treatment stages.

As a sorption additive in aeration tanks or settling tanks to intensify the contaminant extraction process (similar to the use of powdered activated carbons).

For localized treatment of individual streams, such as wash water or condensate.

–Application in storm sewers and aftertreatment filters

The most promising and cost-effective application is surface runoff treatment. The sorbent can be used:

As backfill in stormwater inlets or sorption biofilters (bioretention cells).

For the manufacture of filter cartridges or booms installed at the outlet of stormwater collectors before discharge into water bodies.

As part of drainage layers in parking lots, gas stations, and warehouses for the capture of petroleum products and heavy metals.

In summary, leaf litter, a common seasonal waste, has significant potential as a raw material for the production of sorption materials due to its rich content of humic substances, lignin, and cellulose with reactive functional groups. A generalized processing chain is proposed, including the stages of collection, drying, grinding, chemical activation, and molding. The greatest environmental and economic benefits are expected from the use of relatively simple activation methods (acid or alkaline treatment).

The leaf litter-based sorbent exhibits a pronounced efficiency dependence on the pH of the medium, allowing it to be used for the targeted extraction of heavy metal cations in the neutral-alkaline range, as well as for the sorption of organic compounds.

The most promising areas of application are post-treatment systems for industrial and, especially, stormwater wastewater, where sorption capacity requirements are less critical, while low cost and ease of use are important.

The implementation of this technology contributes to two objectives within the circular economy: the recycling of organic waste and the creation of an inexpensive tool for environmental protection, thereby providing a double environmental benefit. Prospects for further research include conducting large-scale laboratory tests of sorption capacity for specific pollutants, optimizing activation parameters for different types of leaf litter, developing technical regulations, and pilot testing the technology at real sites.

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При подготовке статьи были применены технологии искусственного интеллекта.

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SECTION 3. HUMANITARIAN ASPECTS OF SOCIETY DEVELOPMENT

УДК 001.891(85)

RESEARCH TRENDS IN PERU-RELATED STUDIES

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Abstract. The paper aims to identify research trends in Peru-related studies. The material includes 462 articles available in open access and indexed in Scopus. The study applies a scoping review design supported by thematic modelling of publication titles, abstracts and keywords. The results reveal 18 leading research directions, including financial inclusion, trade, management, education, tourism, environmental resources, energy, women's entrepreneurship and digital consumer behaviour. The findings show the thematic structure of the selected corpus and identify areas relevant for further studies in international business.

Keywords: Peru, thematic modelling, trends, financial inclusion, trade, international business.

ИССЛЕДОВАТЕЛЬСКИЕ ТЕНДЕНЦИИ В ИЗУЧЕНИИ ПЕРУ

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Аннотация. Цель статьи – выявление исследовательских тенденций в изучении Перу. Материалом послужили 462 статьи, находящиеся в открытом доступе и индексируемые в международной базе Scopus. В работе применяется обзор предметного поля, основанный на тематическом моделировании. В результате анализа выделено 18 ведущих направлений: доступность финансовых услуг, торговля, управление, образование, туризм, природные ресурсы, энергетика, женское предпринимательство и поведение потребителей в цифровой среде. Полученные результаты раскрывают тематическую структуру выбранного корпуса и позволяют выделить направления, значимые для дальнейшего изучения международного бизнеса.

Ключевые слова: Перу, тематическое моделирование, тренды, финансовая доступность, торговля, международный бизнес.

Peru occupies a special position in Latin American studies because the country combines economic, cultural and educational significance. According to Statista, Peru

is rich in minerals, while mining, manufacturing and industry have played an important role in its economic development. The service sector is also becoming stronger and employs almost half of the country's workforce [1].

Peru also has strong cultural and tourism potential. The country is associated with major historical and natural sites, including Cuzco, Machu Picchu and Lake Titicaca. Educational statistics add another important dimension: the largest group of undergraduate students in Peru studied administrative and commercial sciences, with more than 223 thousand enrolled students, followed by health sciences, with almost 175 thousand students [2]. These features make Peru a relevant case for analysing development, structural change and international business.

Peru-related publications form a broad and heterogeneous research field. They cannot be reduced to a single discipline or research problem. A review is therefore necessary because it provides a systematic way to describe the existing body of literature, determine its thematic structure and show which areas have already received scholarly attention.

The aim of this paper is to identify the main themes in Peru-related studies. The study is guided by the following research question: What research themes shape the contemporary study of Peru?

To answer this question, the paper applies a scoping review design aimed at mapping the selected publication corpus and identifying its thematic structure [3]. The analytical stage is based on topic modelling of publication titles, abstracts and keywords. The dataset was processed in Google Colab, and BERTopic was used to group the publications into thematic clusters according to repeated semantic patterns. The labels of the clusters were interpreted on the basis of frequent words, representative publications and the most cited works within each group. The resulting clusters were then considered as research directions within Peru-related studies. The search was conducted in Scopus using the keyword "PERU". The initial search returned 9,487 publications available in open access. In order to focus the analysis on publications relevant to international business and related social research, the dataset was limited to two Scopus subject areas: Economics, Econometrics and Finance; Business, Management and Accounting. After applying filters, the final dataset included 462 publications.

The most cited publication in the dataset is Field's study on urban property rights and labour supply in Peru [4]. Other highly cited works cover child labour and schooling, rural ecotourism, renewable energy systems, child health during economic crisis, retail strategy and tax digitalization [5-10]. These publications indicate that the most visible part of Peru-related research is concentrated around development mechanisms and their social effects. Therefore, they may serve as relevant reference points for further studies in international business and cooperation.

The distribution of documents by topics is uneven. Figure 1 presents the 18 topic groups identified through thematic modelling.

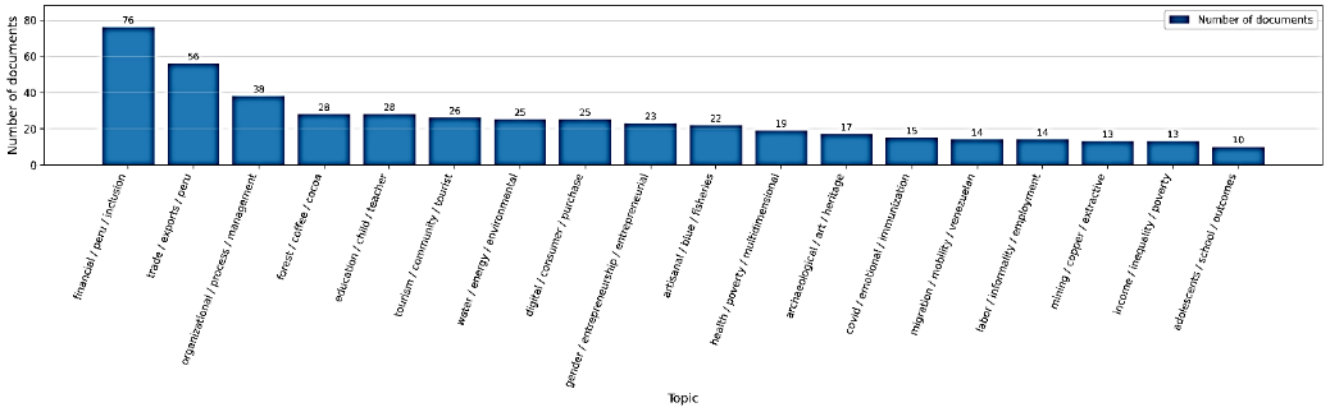


Figure 1. Distribution of documents by topic

The largest topic group is related to finance and inclusion, with 76 documents, or 16.5 % of the dataset. The second group concerns trade and exports, with 56 documents, or 12.1 %. Together, they form the economic core of the analysed field. The third group, focused on organizational processes and management, includes 38 documents and reflects the business dimension of Peru-related research.

The dynamics of the main topics are presented in Figure 2. The figure shows that the field developed most actively after 2020, with a particularly noticeable increase in 2023-2025. In 2025, the dataset contains 82 publications, the highest annual value for the analysed period. In recent years, finance and inclusion, trade, management, education, tourism, women's entrepreneurship and digital consumer behaviour have become especially prominent. This indicates that contemporary Peru-related studies increasingly combine economic issues with social, environmental and digital perspectives.

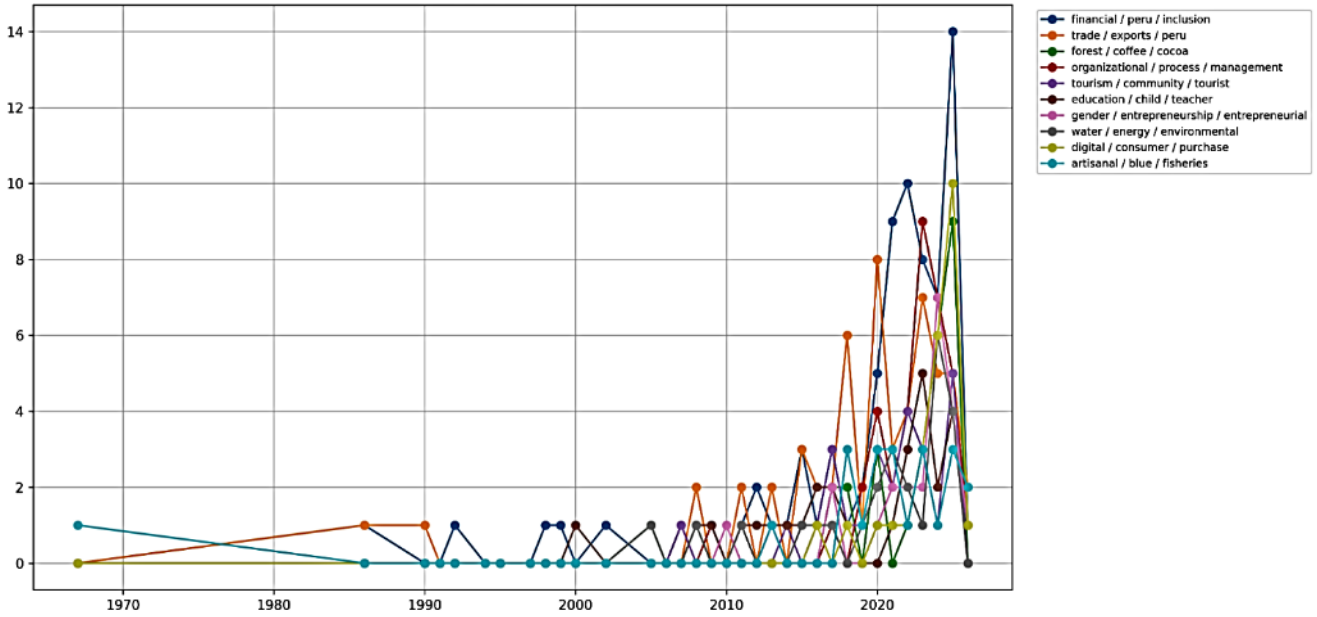
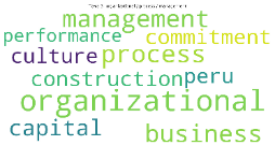
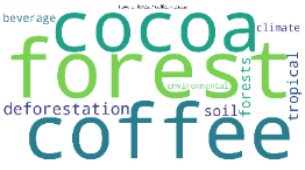
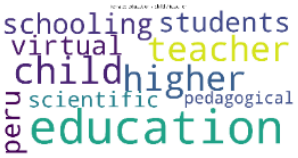
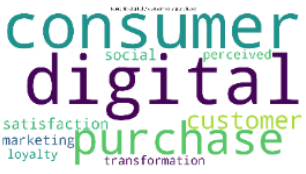


Figure 2. Dynamics of main topics by year

Although the topic model identified 18 thematic groups, for the purposes of this study the detailed presentation was limited to the 10 largest groups. These groups

represent the most frequent topics in the dataset. Table indicates the number of publications in each group and the most cited authors related to these topics.

Table. Results of the thematic modelling

Theme	Documents	Keywords	Most cited authors
1. Financial inclusion and macroeconomic risks	76		Bellon [10]
2. Trade, exports and economic growth	56		Parnell [9], Schuster [20]
3. Organizational management and business processes	38		Mauceri [17]
4. Forests, coffee, cocoa and deforestation	28		Bax [13], Perz [15]
5. Education, children and teachers	28		Ray [5], Arias Velásquez [16], Vom Hau [19]
6. Tourism, communities and sustainability	26		Gabriel-Campos [6], Zorn [18]
7. Water, energy and environmental infrastructure	25		Rinaldi [7], Lin [21]
8. Digital consumer behaviour and marketing	25		Payntar [12]
9. Gender and entrepreneurship	23		Polas [14], Alvarez-Risco [11]
10. Health, poverty and multidimensional development	19		Paxson [8]

The largest thematic group concerns financial inclusion, credit, public finance, tax policy and inflation. Its prominence is supported by studies on digital instruments for tax compliance, including VAT e-invoicing [10]. The second major cluster is formed by trade and export studies, which connect Peru with international markets, agricultural exports, private standards and firm-level export performance [20].

The environmental and resource dimension is also significant. A number of publications examine tropical landscapes, agricultural commodities and deforestation. Bax and Francesconi analyse environmental predictors of forest change in the tropical Andes region [13], while Perz and co-authors examine the relationship between population, land use and deforestation in the Pan-Amazon region [15]. Environmental infrastructure constitutes another important line of research, covering rural electrification, sanitation and water-sector performance [7, 21].

The social and cultural dimension includes education, health, poverty, women's entrepreneurship, tourism and labour-related topics. Ray's work on child labour and schooling demonstrates the relationship between household labour strategies and educational outcomes [5]. Paxson and Schady show the importance of economic crisis for child health [8]. Studies on women's entrepreneurship address economic participation, green entrepreneurship and digital technologies [11, 14]. Tourism forms another independent cluster, where publications focus on rural communities, resilience, sustainability, heritage sites and tourist behaviour [6, 12, 18].

The analysis has shown that Peru-related publications form a broad yet structured research field. Its most visible areas are access to financial services, trade and exports, management, and organizational processes. These directions demonstrate that Peru is often examined through market participation, international integration, business development and institutional change.

The field also includes education, public health, poverty, tourism, natural resources, environmental infrastructure, energy and women's entrepreneurship. This range of topics requires an interdisciplinary perspective, since business and economic processes are closely linked with social conditions, infrastructure, environmental resources and local communities.

It should be noted, that study is limited to open access publications indexed in Scopus within the selected subject areas. Therefore, the results should be interpreted as a structured map of the selected publication corpus.

The main result of the study is that the scoping review makes it possible to move from a broad field of Peru-related studies to a more focused set of thematic clusters suitable for further systematic review. In this sense, the article identifies a research direction for subsequent work in international business. The most promising direction is the intersection of trade, management, digital transformation, access to financial services and cross-cultural interaction.

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При подготовке статьи были применены технологии искусственного интеллекта.

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УДК 378.147:7.05

COMPARATIVE CURRICULUM ANALYSIS OF GRAPHIC DESIGN EDUCATION IN RUSSIA AND THE UK

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Abstract. The article compares university programmes in graphic design in Russia and the United Kingdom. The study examines programme duration, educational levels, admission requirements, subject structure, practical training, internship opportunities and graduation project formats. The analysis shows that Russian curricula is characterized by a longer study period and a stronger academic-artistic foundation, while the British ones tend to be more intensive and industry-oriented. The findings may be useful for students, educators and specialists involved in design education.

Keywords: Russia, United Kingdom, graphic design, university, comparative analysis, higher education, professional training.

СРАВНИТЕЛЬНЫЙ АНАЛИЗ УЧЕБНЫХ ПЛАНОВ ПО ГРАФИЧЕСКОМУ ДИЗАЙНУ В РОССИИ И ВЕЛИКОБРИТАНИИ

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Аннотация. В статье представлен сравнительный анализ учебных планов по графическому дизайну в России и Великобритании. Рассматриваются: продолжительность обучения, уровни образования, требования к поступлению, структура учебных программ, практическая подготовка, возможности стажировок и формат выпускного проекта. Показано, что российская модель характеризуется более длительным сроком обучения и глубокой академической и художественной основой, тогда как британская модель отличается интенсивностью и отраслевой направленностью. Результаты могут быть полезны студентам, преподавателям и специалистам в области дизайн-образования.

Ключевые слова: Россия, Великобритания, графический дизайн, университет, сравнительный анализ, высшее образование, профессиональная подготовка.

University-level training in graphic design is becoming increasingly significant in the context of digital technologies and visual communication. Future specialists are expected to combine artistic thinking, digital competence, project work, branding skills and knowledge of art history and theory. Educational content in this field reflects both national academic traditions and current labour market demands.

The relevance of the topic is supported by the growing economic and social role of creative industries. According to UNCTAD, the creative economy contributes from 0.5 to 7.3 percent of GDP and employs from 0.5 to 12.5 percent of the workforce in countries for which data are available [1]. UNESCO also emphasizes the importance of culture and arts education for developing creative skills, professional opportunities and participation in cultural and creative sectors [2].

The United Kingdom represents an important context for comparison because design is a major part of its economy. The Design Council reports that the UK design economy contributed £97.4 billion in gross value added in 2019 [3]. Russia also provides a relevant case for analysis. According to the Higher School of Economics, the Russian creative economy employed 4.9 million people in 2019, which accounted for 6.8 percent of total employment [4]. These data confirm the importance of professional training in design and related creative fields for both education systems and labour markets.

Contemporary research on the professional preparation of designers shows that this field is no longer limited to artistic techniques and compositional rules. Findeli argues that design education for the twenty-first century should be reconsidered from theoretical, methodological and ethical perspectives, since designers work not only with form and function, but also with cultural, social and human-centred problems [5]. Meyer and Norman similarly emphasize that universities must prepare designers for complex contemporary challenges and should include studio work, experiential learning and broader professional competencies [6].

Digital transformation is one of the key factors influencing programme development. González-Zamar and Abad-Segura show that digital design in university-level education is related to the development of transferable skills, student autonomy and self-critical capacities [7]. For specialist training in visual communication, such integration is necessary because professional work increasingly includes typography, visual identity, digital media, user interface design, motion graphics, interactive formats and multimedia presentation.

Another important research line concerns studio pedagogy and project-based learning. Fleischmann notes that contemporary design studio pedagogy should be aligned with industry practice, since students need to learn how to work with briefs, feedback, digital tools and collaborative processes [8]. Oo, Habók and Józsa also demonstrate that design-based learning can support students' motivation, creativity and design skills [9]. These findings are directly relevant to the present comparison because national models may differ in the balance between academic-artistic training and practice-oriented project work.

The transition from university to employment is another significant issue in design education research. Davies, Reid and Petocz introduce the concept of portfolio literacy and show that a portfolio is not merely a collection of student works, but a professional communication tool that demonstrates design thinking, visual competence, problem-solving ability and readiness for employment [10].

National educational traditions also shape the structure of design programmes. Aristova and Rivchun show that Russian art and design education has historically been closely connected with fine arts and with the training of specialists in fine and applied arts [11]. Aristova and Zhilina emphasize the role of pedagogy in Russian art and design education, which helps explain the structured academic basis of national curricula [12]. In contrast, studies of European design training, including the British context, often emphasize professionalization, institutional flexibility and links with industry [13].

Taken together, the literature suggests that contemporary design training develops along several interconnected lines: response to complex social and technological challenges, integration of digital tools, studio and project-based pedagogy, portfolio literacy, employability and national educational traditions [5, 6, 7, 8, 9, 10, 11, 12, 13].

The aim of this article is to compare graphic design education in Russia and the United Kingdom on the basis of university curricula. To achieve this aim, the following objectives were set:

- to examine theoretical approaches to contemporary design education;
- to identify the main criteria for comparing graphic design curricula;
- to analyse the structure of selected Russian and UK university programmes;
- to conduct comparative analysis;
- to determine the key differences between the Russian and British models.

The main method is comparative curriculum analysis. The programmes were compared according to duration of study, educational levels, admission requirements, disciplinary structure, internship opportunities, employment outcomes, graduation project format and tuition model. Elements of thematic analysis were also used to group the findings into academic-artistic training, digital skills, professional practice, employability and accessibility. The empirical material includes publicly available curriculum data from six institutions: Saint Petersburg State University of Industrial Technologies and Design, National Research University Higher School of Economics, Saint Petersburg Stieglitz State Academy of Art and Design, University of the Arts London, University for the Creative Arts and University of Hertfordshire. The comparative data are summarized in Table.

Table. Results of the Comparative Analysis

Indicator	Saint Petersburg State University of Industrial Technologies and Design	National Research University Higher School of Economics	Saint Petersburg Stieglitz State Academy of Art and Design	University of the Arts London	University for the Creative Arts	University of Hertfordshire
Country	Russia	Russia	Russia	UK	UK	UK
Duration and levels	Bachelor's degree 4 years. Specialist's degree 6 years. Master's degree 2 years.	Bachelor's degree 4 years. Master's degree 2 years.	Bachelor's degree 4 years. Master's degree 2 years.	Bachelor's degree 3 years; Master's degree 1 year	Bachelor's degree 3 years; Master's degree 1 year	Bachelor's degree 3 years; Master's degree 1 year full-time or 2 years part-time
Programs	Graphic Design in the Art Space; Graphic Design in Advertising; Digital Media Design; Animation and Computer Graphics Artist; Master's Programmes in Graphic Design in Advertising and Digital Media Design.	Communication Design; Digital Product Design.	Graphic Design	Graphic Communication Design; Illustration; Advertising; Graphic Design; Interaction Design Arts; Illustration and Visual Media; User Experience Design; Animation; Graphic Branding and Identity; Design Management	Bachelor's Degree: Graphic Design; Visual Communications. Master's Degree: Graphic Design; Visual Communications; UX Design.	Bachelor's Degree: Branding, Experience and Retail Design; Graphic Design; Graphic Design: Advertising and Branding; Illustration. Master's Degree: Graphic Design and Branding; Illustration.
Main disciplines	Visual Narrative; Sculpture and Plastic Modelling; Typography for Design; Communication Design; Directing and Screenwriting; Photography and Videography; UX/UI Design; Music and Sound Design; Immersive Technologies in Design; Motion Design; Digital Identity; Video Editing; Introduction to Game Design; Introduction to Web Programming; Interactive Infographics; Digital	Design Theory; Visual Communications; Digital Technologies in Design; Marketing; Art History; Academic Drawing; Academic Painting; Propaedeutics; Colour Science and Colouristics; History and Theory of Design; Design Graphics; Plastic Anatomy; Social Design Contexts; Linear and	Foreign Language; Pedagogy and Psychology of the Creative Process; Art History; Introduction to Information Technology; Academic Drawing; Academic Painting; Propaedeutics; Colour Science and Colouristics; History and Theory of Design; Project Graphics; Plastic Anatomy; Social Communications in the	Typography; Digital Imaging; Contemporary Presentation Techniques; Commissioned and Live Projects; Communication Design Studies; Multimedia Design; Portfolio Development.	Communication Design; Branding; Digital Media; Creative Projects; Industry Skills.	Typography; Logo Design; Branding; Layout; Technical Skills; Experimentation; Risk-Taking.

	Portfolio and Multimedia Presentation; Information Technology in Graphic Design; Fundamentals of Design; Fundamentals of Drawing and Perspective; Fundamentals of Painting and Colour Science; Art History; Fundamentals of Composition; Organisational Behaviour; Fundamentals of Project Work; Computer Graphics and Animation; Design in the Digital Environment; Economics; Fundamentals of Pedagogy; History of Design; Exhibition Organisation; Research Work in Design; Collage in Design.	Constructive Drawing.	Professional Sphere; Linear and Constructive Drawing; Visual Communications; Poster Design; Packaging Design; Printed Publications; Economics and Management of Creative Activity; Marketing; History of Photography; Digital Painting; History of Typography; Modern Font Technologies; Technical and Artistic Editing; Vector Graphics Editors; Raster Graphics Editors; Layout Software; 2D Animation; Introduction to Web Programming; Applied Graphics; Prepress Preparation; Printing Technologies; Photography			
Cost of tuition at university	Bachelor's Degree: full-time study, approximately €5,421 to €5,872 per year; part-time study, approximately €3,953 per year. Master's Degree: approximately €5,872 per year.	Bachelor's Degree: approximately €8,357 per year.	Approximately €6,079 per year.	Approximately €35,832 per year.	Bachelor's Degree: approximately €11,356 per year. Master's Degree: approximately €11,356 per year	Bachelor's Degree: UK students, approximately €11,356 per year; EU and international students, approximately €20,242 per year. Master's Degree: UK students, approximately €11,971 per year full-time or €9998 per year part-time; EU and international students, approximately €20,822 per year full-time or €1,734 per year part-time.

Admission requirements	Bachelor's Degree: entrance examinations in Drawing, Painting, Composition and History of Art; Unified State Examination in Russian Language and Literature. Master's Degree: entrance examination in Graphic Design and a Graphic Design portfolio.	Bachelor's Degree: school Olympiad results; entrance examinations in Creative Test, Russian Language and Literature; individual achievements. Master's Degree: portfolio-based competition, motivation letter and, for the "Communication Design: Foundation Course", a video presentation of up to 3 minutes.	Bachelor's Degree: entrance examinations in Drawing, Painting and Composition; Unified State Examination in Russian Language and Literature. Master's Degree: portfolio and interview.	Bachelor's Degree: 112 UCAS tariff points or equivalent qualifications; GCSE requirements. Master's Degree: honours degree 2:1, equivalent qualification, completed practical or vocational training, or a combination of relevant qualifications and experience.	Bachelor's Degree: 112 UCAS tariff points; Foundation Diploma in Art and Design; BTEC Extended Diploma or BTEC National Extended Diploma; UAL Extended Diploma; Access to Higher Education Diploma; International Baccalaureate; four GCSEs, including English. Master's Degree: honours degree or equivalent qualification in a related subject and/or relevant professional experience	Bachelor's Degree: IELTS 6.0 overall, with at least 5.5 in each component, for applicants whose first language is not English. Master's Degree: degree 2:2 or higher in a related subject; IELTS 6.5 or equivalent for non-native speakers.
Internship opportunities	Internships are available from the third year through the Center for Practical Training and Career Development. Students may complete paid internships in production units and research departments, cooperate with leading enterprises in Saint Petersburg and participate in the "Professional Internships 2.0" project.	Internships are offered in design and engineering organisations, design studios, advertising agencies, museums, theatres, event agencies, consulting companies, think tanks, research and patent organisations, creative organisations, and institutions related to urban development, culture and heritage protection.	Internships are organised through the academy, the Career Centre, department curators and partner organisations, including Minin and Pozharsky Creative Association LLC, Terminal Design LLC, the Imperial Porcelain Factory, the Russian Ethnographic Museum, Lenfilm, design studios and advertising agencies in Saint Petersburg.	Internships are offered in leading creative organisations. Students also work on real projects as part of their professional training.	Internships are offered in leading creative organisations. Students also work on real projects as part of their professional training.	The programme focuses on developing career-oriented skills for work in the contemporary design industry, with particular emphasis on entrepreneurial competence.
Employment of graduates	Graduates receive career support through the Center for Practical Training and Career Development,	Graduates work as graphic and UI/UX designers, art directors, brand	Graduates work as graphic, web and UX designers, interface, packaging and type	According to the source table, 93 % of graduates are employed within one	Graduates demonstrate a high employment rate and work in design studios,	Graduates work in leading design studios and advertising agencies.

	including resume review, career planning and job search guidance. They find employment in production companies working with video, light installations, multimedia and visual products.	managers, website and mobile application designers, interactive system designers, and specialists in game design, animation, CGI, media and advertising.	designers, digital artists and texture artists in publishing houses, advertising agencies, mass media, design studios and other organisations.	year. They work in leading design studios, advertising agencies and freelance practice.	advertising agencies and freelance practice.	
Graduation project	The graduation project includes a theoretical and a practical part. The theoretical part presents the relevance, aim, objectives, literature review and methodology. The practical part may involve the development of a brand book, exhibition or festival design, visual communication for an art object, an interactive installation, a poster series, illustrations or a website for an art space.	The graduation project is a comprehensive design project in which the graduate acts as both art director and designer. Its key component is a production project for an exhibition and/or event.	The graduation project is a comprehensive work demonstrating the graduate's readiness for independent professional practice. It may include elements of scientific and artistic research and an independent practice-oriented creative project.	The graduation project includes portfolio development and defence of creative work.	The graduation project includes project work that is later exhibited at the UCA Online Show, with the best works receiving awards.	The graduation project includes the development and defence of creative work.
Tuition model	In 2026, the Design programme provides 84 places funded from the Russian Federal Budget and 500 fee-paying places.	In 2026, the Bachelor's programme "Design" provides 65 places funded from the Russian Federal Budget, 375 fee-paying places for Russian citizens and 10 fee-paying places for foreign citizens.	In 2026, the Bachelor's programme "Graphic Design" provides 14 places funded from the Russian Federal Budget and 25 fee-paying places.	Only fee-paying places are available.	Only fee-paying places are available.	Only fee-paying places are available.

The data presented in Table reveal that the selected programmes in Russia and the United Kingdom are organised according to different structural and methodological principles. The Russian sample generally offers longer educational pathways. Bachelor's degree programmes last four years and master's degree programmes usually last two years. In the British sample, bachelor's degree programmes last three years, while master's degree programmes are commonly completed in one year, or in one year full-time and two years part-time at the University of Hertfordshire. This distinction suggests that the first model provides more time for gradual academic and artistic development, whereas the second is more intensive and oriented toward a faster transition to employment.

The comparison of subject structure demonstrates a pronounced academic-artistic basis in the Russian universities included in the study. Their programmes contain disciplines connected with drawing, painting, composition, art history, colour science, design theory and visual communication. At the same time, these curricula also include contemporary digital and professional components, such as UX/UI design, digital media, motion design, digital identity, web programming, animation, multimedia presentation, packaging, typography and prepress preparation. Consequently, this model cannot be described as purely classical or traditional. It combines artistic continuity with digital and project-based elements. The British sample demonstrates a clearer orientation toward industry practice and portfolio development. University of the Arts London includes commissioned and live projects, communication design studies, multimedia design and portfolio development. University for the Creative Arts focuses on communication design, branding, digital media, creative projects and industry skills. University of Hertfordshire emphasizes typography, branding, layout, technical skills, experimentation, risk-taking and career-oriented preparation for the design sector. These features point to a training model closely connected with creative industry expectations and graduate employability.

Admission criteria also reflect different educational priorities. The Russian universities place strong emphasis on creative entrance examinations. Applicants are assessed through drawing, painting, composition, history of art, creative tests, portfolio review or interviews. This confirms that artistic preparation is treated as a central condition for entering the field. In the United Kingdom, admission is based on a points system used by UCAS (Universities and Colleges Admissions Service), the central organisation through which applicants apply to universities. Applicants receive UCAS tariff points for previous qualifications, such as A Levels, foundation diplomas or equivalent international certificates. Universities may also require GCSE (General Certificate of Secondary Education) results, which are school-leaving qualifications usually taken at the age of 16, relevant experience and proof of English language proficiency for international applicants. This suggests that the British system relies less on formal creative entrance examinations and more on previous qualifications, portfolio evidence, relevant experience and readiness for project-based study.

Internship and career opportunities are present in both systems, but they are organised differently. In Russia, practical training is often supported through institutional structures, including career centres, department curators, partner organisations and cooperation with enterprises, museums, design studios and advertising agencies. In the UK, professional experience is more directly embedded in

the learning process through live projects, commissioned work, internships in creative organisations, portfolio development and industry-oriented tasks. This distinction highlights different mechanisms of employability support: the Russian universities tend to rely on university-based services and external partnerships, while the British programmes more often integrate professional experience into course design.

Employment data also point to different forms of professional preparation. Graduates of the Russian institutions are described as entering a wide range of design-related occupations, including graphic and UI/UX design, art direction, brand management, website and mobile application design, game design, animation, media, advertising, packaging and type design. Graduates of the British institutions are presented as working mainly in design studios, advertising agencies or freelance practice. The clearest quantitative indicator is provided for University of the Arts London, where 93 percent of graduates are reported to be employed within one year. This suggests that employability and portfolio-based transition into the creative labour market are important components of the UK programmes included in the sample.

Graduation project formats reveal another major difference. In the Russian sample, final projects often combine theoretical justification with practical creative work. At Saint Petersburg State University of Industrial Technologies and Design, the project includes a theoretical part with relevance, aim, objectives, literature review and methodology, followed by a practical design solution. At Saint Petersburg Stieglitz State Academy of Art and Design, the graduation project is described as a comprehensive work that may include scientific and artistic research. In the British sample, the final stage is more closely associated with portfolio development, creative work defence, exhibition or public presentation. This means that the two models prioritise different competencies: the Russian model requires explicit research justification of the graduation project, whereas the British model assesses the professional presentation of creative output.

The comparison of tuition models and study places identifies a significant difference in accessibility. Russian universities provide places funded from the Russian Federal Budget together with fee-paying places. This gives applicants an opportunity to enter design programmes through competitive publicly funded admission. In the British sample, only fee-paying study is available. This indicates that the Russian sample provides a mechanism of access, whereas the British sample is market-oriented.

The findings identify two approaches to specialist training. The Russian sample is characterized by longer study duration, academic-artistic depth, formal creative entrance examinations and graduation projects that combine theoretical and practical components. The British sample is shorter, more intensive and industry-oriented. These differences suggest that an effective contemporary curriculum should combine fundamental artistic preparation, digital technologies, project-based learning, portfolio development and a clear transition from university study to work in the creative industries.

The main methodological principle of this study was a comparative approach. The study examines the curricula of graphic design programs. The material was six university programs, and the methods were comparative analysis and thematic grouping of criteria. Further research may include a larger sample of institutions, employment statistics and analysis of graduate portfolios.

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УДК 72.036

ARCHITECTURE AS A MANIFESTO: THE CREATIVE PATH OF RENZO PIANO AND THE EVOLUTION OF CULTURAL SPACES ON THE EXAMPLE OF THE CENTRE GEORGES POMPIDOU

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Abstract. This article analyzes the key stages in the development of Renzo Piano, a prominent Italian architect and one of the leaders of the high-tech style. The paper examines the biographical background to the development of his philosophy of "honest architecture" and the transition from early experiments to global projects. Particular attention is paid to the architect's key manifesto, the Centre Georges Pompidou in Paris. The article examines in detail the architectural concept of the "inside-out building", functional color coordination, and the principles of organizing interior and exterior space, which radically changed the concept of the modern museum.

Keywords: Renzo Piano, high-tech, Centre Pompidou, inside-out architecture, color coding, museum design, cultural center, Beaubourg.

АРХИТЕКТУРА КАК МАНИФЕСТ: ТВОРЧЕСКИЙ ПУТЬ РЕНЦО ПИАНО И ЭВОЛЮЦИЯ КУЛЬТУРНЫХ ПРОСТРАНСТВ НА ПРИМЕРЕ ЦЕНТРА ЖОРЖА ПОМПИДУ

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Аннотация. Статья посвящена анализу ключевых этапов становления выдающегося итальянского архитектора Ренцо Пиано, одного из лидеров стиля хай-тек. В работе рассматриваются биографические предпосылки формирования его философии «честной архитектуры», переход от ранних экспериментов к глобальным проектам. Особое внимание уделяется главному манифесту архитектора – Центру Жоржа Помпиду в Париже. Подробно анализируются архитектурная концепция «здания наизнанку», функциональная цветовая координация, а также принципы организации интерьерного и экстерьерного пространства, которые радикально изменили представление о современном музее.

Ключевые слова: Ренцо Пиано, хай-тек, Центр Помпиду, архитектура наизнанку, цветовое кодирование, музейный дизайн, культурный центр, Бобур.

The Centre Georges Pompidou, which opened its doors in 1977, remains more than just a museum, but one of the most recognizable architectural icons of modern times. Described by critics as an "oil refinery" and a "factory", decades later this

building became a symbol of the Parisian avant-garde. Behind this daring project was the young but already ambitious Italian architect Renzo Piano, whose name is now inextricably linked with the development of high-tech style and the philosophy of "transparent" architecture. The aim of this paper is to trace Renzo Piano's development as an architect, highlighting the influence of his family context and early professional contacts, and then to examine in detail the architectural and color concept of the Centre Pompidou as the quintessence of his creative method.

Renzo Piano was born in Genoa in 1937 to a family where construction was not just a profession, but a way of life. His grandfather, father, three uncles, and brother worked in the family firm. The architect's childhood, which coincided with the years of World War II and the post-war devastation, paradoxically shaped his optimistic view of creation. Observing the country's reconstruction, he saw architecture as a "miracle". "If you watch construction from childhood and see that the column you help build grows higher and higher every day, that it can be done with your own little hands, then you understand that architecture is a miracle", Renzo Piano said [1].

Having studied at the Politecnico di Milano School of Architecture, Piano didn't limit himself to academia. He collaborated with the firm of Franco Albini, one of the leading architects of his time, which instilled in him a respect for the traditions of Italian design. A decisive step in broadening his horizons was working abroad: with the legendary Louis Kahn in Philadelphia, whose monumental poetics influenced his understanding of light and material, and with the Polish engineer Zygmunt Stanisław Makowski in London.

Piano's first major success came at the age of 32–his design for the Italian industrial pavilion for Expo '70 in Osaka. Made of steel and reinforced polyester, the pavilion was striking in its lightness and technological sophistication. It was this work that attracted the attention of the British architect Richard Rogers, with whom Piano discovered "much in common". Their collaboration (1971–1977) marked a turning point: the joint firm "Piano and Rogers" created the B&B Italia administrative building, where they pioneered the techniques that would become the hallmark of the future Pompidou Centre: an exposed load-bearing structure and exposed utility lines painted in vibrant colors.

The design for the Centre Georges Pompidou, which forever changed Piano's fate, arose from a social crisis. Following the events of the Red May of 1968, a change of government took place in France: Charles de Gaulle was replaced by Georges Pompidou. The new president initiated the creation of a multidisciplinary cultural center on the Beaubourg plateau, the goal of which was to unite various forms of contemporary art and restore Paris's status as the world's art capital. In 1971, an international competition for the design of the new complex was held, becoming one of the largest in history: 681 projects from 49 countries were submitted. The victory of the young international team of R. Piano and R. Rogers was a triumph of innovative thinking. The opening of the Center on January 31, 1977, shocked a public accustomed to classical museum facades, but it was precisely this provocation that marked the beginning of a new era in museum architecture [2].

The architects' main idea was to liberate interior space. By moving all supporting structures, staircases, elevators, ventilation, and water pipes to the facade, the

building's interior was created as vast, wall- and column-free platform floors, each approximately 7,500 square meters in area. This allowed for the creation of any exhibition hall configuration, adapting them to specific exhibitions. R. Piano himself described the Beaubourg as "a joyful urban machine, a creature that could have emerged from a Jules Verne novel... a double provocation: a challenge to academicism and a parody of the images of modern technology".

The color on the Pompidou façade is not just decoration, but a functional diagram, a visual instruction manual for the building's operation. All functional elements are subject to a strict chromatic logic, making the "unsightly interior" comprehensible to the viewer:

- Blue – ventilation pipes.
- Green – plumbing systems.
- Yellow – electrical wiring.
- Red – elevators, escalators, and safety equipment.
- White – supporting structures (reinforcement).

The dominant feature of the façade is a giant transparent escalator tube, zigzagging upwards (150 meters long). It serves not only as a means of transportation but also as a panoramic view, turning the journey to the museum into a separate architectural experience.

A major urban planning success was the decision to leave half the area allocated for development open. The newly-created square in front of the Centre (Plateau Beaubourg) has become a vibrant public space, an "oasis of street life" in the city center, where street performers, musicians, and artists perform. Nearby, on Place Stravinsky, is an extravagant fountain by Jean Tinguely and Niki de Saint Phalle with moving mechanical sculptures, which seamlessly complements the playful and nonconformist spirit of the entire complex [3].

The interiors of the Pompidou Center are a direct continuation of its exterior design. Inside, the building is clearly divided vertically:

- Floors 1–3 – public library (BPI) with open access.
- Floors 4–5 – Museum of Modern Art (MNAM).
- Floor 6 – temporary exhibitions.

The space was designed so that visitor flows from the museum, library, and observation deck do not overlap, while still maintaining the overall atmosphere of a cultural forum. Ergonomics was a priority from the outset. The red elevators and escalators, located outside, allow for a smooth flow of up to 45,000 visitors per day. The architect also considered social awareness: in the early 2000s, computers were installed in the lobby for searching information. Visually, the interior is designed in an industrial aesthetic of concrete and glass, where color continues to serve as a navigational aid (red for movement, neutral tones for exhibitions). As part of the large-scale renovation planned for 2025–2030, special attention will be paid to further improving accessibility. Plans include widening the staircase in the central Forum, creating new reception areas, and opening the roof to the public to improve connections with the city [4].

Particular attention should be paid to the complex's exhibition space. The Pompidou Centre's activities cover a wide range of topics dedicated to 20th and 21st-

century art. The permanent collection of the National Museum of Modern Art, one of the largest in the world, is divided chronologically into two sections:

- Modernism (1905–1960): Fauvism, Cubism, Surrealism, Russian Avant-Garde (Matisse, Picasso, Kandinsky).
- Contemporary Art (since 1960): Pop Art, Minimalism, New Media (Warhol, Beuys, Bourgeois).

The themes of temporary projects are also extremely diverse: from monographic exhibitions of classic modernists and pioneers of abstraction to conceptual projects exploring global themes. Exhibitions are often interdisciplinary, bringing together art, design, architecture, and performance. An example of an innovative approach is the exhibition of works by architect Norman Foster, which, instead of chronologically organizing, opted for a thematic approach ("Nature and the City", "Vertical City", "Future"). Lighting became a key narrative tool in this exhibition: the darkened "drawing gallery" at the beginning contrasted with the sunlit space of the scale models, metaphorically representing the journey from concept to realization [5].

The Centre Pompidou was not only a triumph, but also a point of divergence. In 1977, Piano ended his collaboration with Rogers and began a new phase in partnership with engineer Peter Rice. If Beaubourg was a manifesto of external technology, then his next landmark building, the Menil Museum (Ménil Collection) in Texas, became a manifesto of hidden technology. Here, he used a complex system of louvers to allow natural light, concealing innovations within. Renzo Piano himself noted the paradox: "The building of the Menil Collection, with its serenity... is much more modern from a scientific point of view than Beaubourg".

Nevertheless, the principles laid down in Paris can be traced in many of the master's later works: the Jérôme Seydoux-Pathé Foundation Headquarters (a glass "shell" embedded in its historical context) and the Moscow Hydroelectric Power Station-2 reconstruction project. In Moscow, Piano once again made utility lines partially visible, creating a "transparent" space using solar energy and landscaping (a birch grove in the courtyard).

Renzo Piano rose from the son of a Genoese builder to one of the most sought-after architects of our time. His development is a synthesis of his family's craftsmanship, the Italian design school, and international engineering thought. The Centre Georges Pompidou was not only a project that transformed his career but also a manifesto of the era, affirming the principles of "honest architecture" and accessibility to art. The color concept of this building is a unique example of a semiotic approach to environmental design, where each shade carries a functional load. An analysis of this project suggests that true innovation in architecture lies not in the rejection of tradition, but in a radical rethinking of the functionality and publicity of space, as demonstrated by the legacy of Renzo Piano.

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УДК 7.071.1

THE ARTISTIC RECEPTION OF TIBETAN BUDDHISM IN MARINA ABRAMOVIC'S MATURE SOLO PERFORMANCES

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Abstract. This paper discusses methods of reception of Tibetan buddhism in Marina Abramovic's mature solo performances. As a result of the analysis, two ways of reception are discovered, such as conceptual analogy and iconographic citation.

Keywords: performance art, Tibetan practices, presence, meditation, death.

ТИБЕТСКИЙ БУДДИЗМ В ЗРЕЛЫХ СОЛЬНЫХ ПРОЕКТАХ МАРИНЫ АБРАМОВИЧ

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Аннотация. В данной статье рассматриваются методы рецепции тибетского буддизма в зрелых сольных выступлениях Марины Абрамович. В результате анализа выявлены два способа рецепции, такие как концептуальная аналогия и иконографическая рецепция.

Ключевые слова: перформанс, тибетские практики, присутствие, медитация, смерть.

Introduction

Marina Abramović is a Serbian performance artist who entered the art world in the second half of the 20th century, at a time when it was already moving away from the concept of art as the creation of objects. She introduced the concept of the present, the "here and now," and the experiences that arose during the performance.

Although Abramović was born and raised in a communist family, many of her performances are infused with Buddhist concepts. Her development as an artist and her subsequent interest in Buddhist practices were greatly influenced by the environment in which she grew up. On one hand, there were her strict communist parents who subjected her to violence, as well as bullying at school – from childhood, Marina learned to endure physical pain. The conditions in which Marina lived fostered in her an overwhelming need to escape reality: she found joy in dreams and in reading books. Starting with reading Rilke, Abramović's heart awakened a sympathy for Eastern philosophy. In her autobiography, she says that "his expression of cosmic suffering and

universal knowledge was connected to the ideas of Zen Buddhism and Sufism, which she would later discover for herself. When she first encountered them, she was already thoroughly imbued with them" [1].

At the beginning of her career, Abramović spent three months in a Tibetan community in India, where they made small clay images of the Buddha and then immersed the finished figurines in water, where they dissolved. This experience was an important spiritual lesson for her, emphasizing the importance of focus on process and discipline.

Subsequently, Abramović several times undertook long retreats, where she practiced Vipassanā, various principles of self-restraint, and etc. Under the influence of Tibetan Buddhism, Abramović developed an approach whereby the viewer should see not "art" but a pure energetic field of interaction. In her book with C. Harris, Abramović states: "I went on retreats and looked at different cultures in order to learn from them and to develop myself. I have then sought to use this knowledge in my art practice to translate the things I have learnt to the public, which is not easy at all." [2, p. 56]. Abramović emphasizes that it was during the working process that she began to study what she would later compare to Buddhist meditative practice. She also mentions a crucial detail that explains her principle of artistic reception of Buddhist practices. Thus, Abramović says: "I am not so interested in the objects, paintings, and sculptures that Tibetan Buddhist artists make. What I'm most keen on is the process of change that you can only make through very rigorous spiritual practice. This is incredibly valuable" [2, p. 56].

Thus, by practically studying the concepts of Tibetan Buddhism, Abramović reflects in her work precisely its semantic content, rather than its visual component. According to D. Zuber, Abramović, perhaps unconsciously, sought to become a "bridge" between East and West and to restore an authentic sense of spirituality through her performances, which might not be as far from the supposed hyper-security of modern Europe as it might first seem [1].

1. Visualization of Death and the Reception of the Chöd Practice in the Performances of Marina Abramović

In 1995, Marina replicated the practice of Buddhist monks who sleep with a corpse, observing the different stages of its decomposition. It is believed that through this practice, one gains an understanding of the essence of death. In the Great Sutra on the Foundations of Mindfulness (Satipaṭṭhāna Sutta), this practice is described as follows: "When a monk sees a body that has been discarded on a charnel ground one day after death, two days after death, swollen and decomposing, then he applies that perception to his own body: 'This body, too, is of the same nature, it will become like that, it is not exempt from that fate' " [3]. The purpose of this practice is to weaken attachment to one's own body and to the bodies of others.

Cleaning the Mirror I, II and III are three interconnected works that Abramović created in Oxford for an exhibition. The performance Cleaning the Mirror I (Fig. 1) lasted three hours, during which Abramović sat on a chair and washed a human skeleton with soapy water. At the end of the action, the skeleton became clean, while the artist, conversely, was covered in dirt. From Abramović's perspective, "this is a metaphor not only for the purification of the physical body but also for the purification

of the soul" [3, p. 5]. Five video monitors were also placed in the gallery, each showing one part of the skeleton being cleaned: the head, ribs, stomach, hands, and feet. The soundtrack consisted of recordings made directly during the performance.

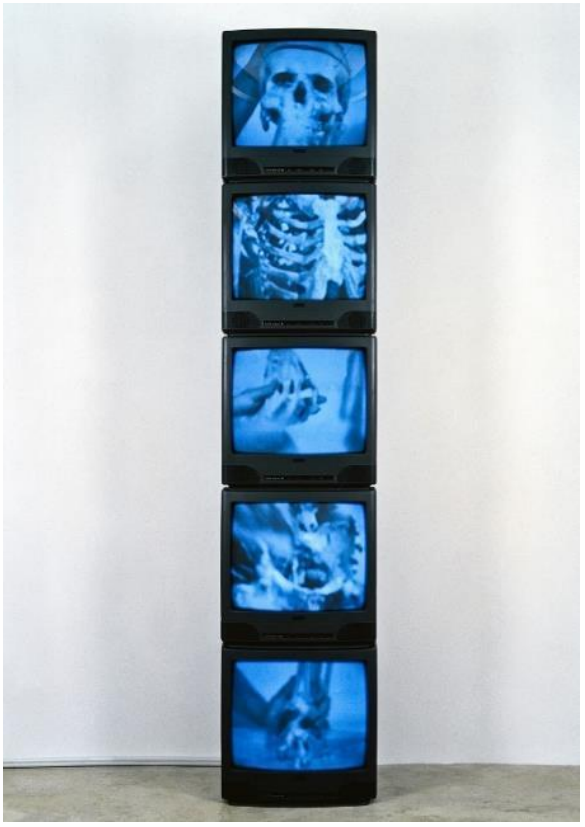


Figure 1. Cleaning the Mirror I. Abramovic M., 1995. Solomon R. Guggenheim Museum, New York

In the performance Cleaning the Mirror II, Marina Abramović took seven different magical objects used in various parts of the world: shoes made of feathers from Australian aboriginals, a box of magical potions from Nigeria, a mandrake from Southern Italy, an Eskimo pouch made of albatross skin, and a mummified ibis from an Egyptian tomb. These objects lay on a table, and the artist brought her hands close to them, trying to feel their energy. A video monitor was also installed in the room, showing Marina washing a human skeleton and then lying down and placing it on top of her body. When Marina begins to breathe slowly, the skeleton moves with her. The skeleton lay on the artist for 90 minutes. According to Abramović, she breathes onto the skeleton to show "how the living combines with the dead" [3, p. 5]. It was important for her that the sound of her breathing spread throughout the gallery.

In the 2000s, the artist increasingly turned to Eastern practices of meditation, self-purification, and the comprehension of energetic essences. Thus, the video performance Nude with Skeleton (Fig. 2), repeated by Abramović three times – in 2002, 2005, and 2010 – also, like the previous series, refers to the ancient practice of Tibetan monks meditating next to a dead body. The artist lies on her back, and a skeleton is placed on top of her, moving in time with her breathing. In the 2005 performance, the size of the skeleton visually resembled the artist's own measurements, which intensified the emotional intensity of the performance. As in the work Cleaning

the Mirror, Abramović, through the artistic reception of this ancient Buddhist practice, sought to accept death and to inspire viewers to cherish the present moment of life, mindful of death's irreversibility.



Figure 2. Nude with Skeleton, Abramovic M. 2002–2005. MoMA, New York

2. Meditation as Performance in the Mature Work of Marina Abramović.

The next Buddhist practice that Marina Abramović artistically reinterpreted in her work was the practice of meditation. According to D. Zuber, "in Abramović's new productions starting from the 1990s, whether Balkan Baroque or The House with the Ocean View, the artist continued and expanded her preoccupation with time" [2].

Thus, in 2002, at the Sean Kelly Gallery (New York), Marina Abramović created the performance The House with the Ocean View (Fig. 3). The artist spent 12 days in an improvised house where viewers could observe her movements. The house had three rooms, and instead of steps, the staircase had knife blades. During this time, she drank only pure water and ate nothing. In this performance, great importance was given to the practice of mindfulness and asceticism, which are also practiced in Buddhism. The Great Sutra on the Foundations of Mindfulness contains detailed instructions: "Here, a monk, when walking or standing, clearly comprehends what he is doing; when looking forward or looking away, he clearly comprehends what he is doing; when bending or stretching, he clearly comprehends what he is doing; when wearing his robes or carrying his bowl, he clearly comprehends what he is doing; when eating, drinking, chewing, or tasting, he clearly comprehends what he is doing; when defecating or urinating, he clearly comprehends what he is doing; when walking, standing, sitting, falling asleep, waking up, speaking, or remaining silent, he clearly comprehends what he is doing." [3]. Similarly, it was important for Marina to act slowly and consciously. According to her, "it was very important that all my actions were performed with a high level of mindfulness, whether I was taking a shower, writing, sitting on a chair and drinking water, resting lying on the bed, or, especially, standing on the edge of the platform in front of the blade ladder for as long as possible." According to Alex Chase, "often disrupting the viewer's sense of time, Abramović certainly drew on her many years of studying Buddhist traditions, particularly Zen" [4, p. 39].



Figure 3. The House with the Ocean View, Abramovic M. 2002. MoMA, New York

During The House with the Ocean View, the artist learned to create a wordless channel of communication with the viewers, which helped conserve energy under conditions of harsh asceticism. At that time, she was isolated from the public, and she continued this in her next performance. Having gained this experience, she was able to take a step towards a personal encounter with the audience. In 2010, Abramović performed The Artist is Present. For three months, every day for eight hours, she sat on a chair, and anyone who wished could sit on the chair opposite and look into her eyes; talking and physical contact were forbidden. Over 736 hours of performance, she looked into the eyes of 1,675 viewers. For the participants, this experience was a kind of meditation, a way to delve into themselves. For Marina herself, it was a kind of meditation, an immersion into the other person, as she tried to focus completely on whoever was sitting opposite her. Marina says: "I think people were surprised by the welling up of pain inside them. On one hand, I think people never really look inside themselves – we all try to avoid this confrontation as much as possible. But here it was different. First, you wait 294 hours to sit down. Now you are seated. The audience is watching you. You are being filmed and photographed. I am observing you. There is nowhere to escape except inside yourself. And that is the whole point. We experience so much pain and always try to suppress it. And if you suppress emotional pain for a long time, it turns into physical pain." Thus, through this analogue of meditation, the artist sought to better understand herself and, moreover, to offer the same opportunity to the viewer-participant. Alex Chase mentions that such an experience does not make the artist more spiritual or "transform her into some exalted bodhisattva" [4, p. 43], as she was not detached or impartial: on the contrary, she cried many times, confronted with the pain, anger, or simple curiosity in the eyes of the person looking at her, feeling herself a kind of mirror.



Figure 4. The Artist is Present, Abramovic M. 2010. MoMA, New York

In 2014, at the Serpentine Gallery in London, the artist created the exhibition 512 Hours, which ran all summer. She embodied the Buddhist concept of "nothing," maintaining the space's energy through simple objects and exercises. Within the framework of the event, Abramović tried to convey to visitors her experience of a twenty-two-day Vipassanā retreat. According to Abramović, "Vipassanā is directly connected to mindfulness – of breathing, thoughts, feelings, actions." Thus, the artist invited the viewer to be in the present moment. Upon entry, viewers had all their technology taken away and were given noise-canceling headphones. The exhibition had several rooms. In one, one could lie on a bed with closed eyes. In another room, visitors were given mixed grains of rice and lentils to sort. In a third room, visitors could simply stand or sit on chairs facing the wall. Visitors were also taught slow walking. Vipassanā later became one of the most important sources of inspiration for the artist.

The next project dedicated to altered states of consciousness and transitional states of being was the performance-exhibition Gates and Portals (Fig. 4), which took place from September 24, 2022, to March 5, 2023, at the Museum of Modern Art in Oxford. Visitors were admitted in small groups and given instructions by Abramović that they had to follow. First, they were shown a video installation and drawings by the artist and introduced to various religious practices, including the concepts of "gates" and "portals." The visitor stood facing the wall or sat in a chair for some time. After a while, they passed through simple copper gates that emitted light and found themselves in another place. There was a selenite portal where the visitor was supposed to lie down, neither stand nor sit. K. Harris believes that this exhibition is more like a lucid dream or a different perception of reality. "At the Museum of Modern Art in Oxford, you don't just observe what is happening, but you yourself participate in the process, and something happens to you" [2].

This project analyzes the Buddhist concept of transition and transformation. In Tibetan Buddhism, as in many other religions, "gates" and "portals" are metaphors for transitioning between worlds, states of consciousness, or stages of the spiritual path.

For example, in the Tibetan tradition, there are concepts of "hidden lands" (e.g., Shambhala or Pemako), which are accessible only through special "gates" or "portals" [5]. In such sacred places, a person undergoes spiritual transformation, and opening the gates to them requires ritual.



Figure 5. Gates and portals, Abramovic M., 2017 г. Lisson Gallery, London

Conclusion

Thus, the essay analyzed the solo performances of Marina Abramović. A direct reception of the Tibetan practice of Chöd was identified in the performances Cleaning the Mirror and Nude with Skeleton. Abramović, continuing to work with duration, asceticism, and immobility, reinterprets the idea of death in accordance with Buddhist concepts of its acceptance. Her projects from the 2010s-2020s adapt the artist's spiritual experience for a mass audience. Thus, in The House with the Ocean View, Abramović visualizes the Buddhist practice of mindfulness, and in The Artist is Present, she transforms herself into a mirror for the viewer, thereby adapting Buddhist practices of compassion and emptiness.

The conducted research allows us to identify two types of reception of Buddhism in Abramović's work. The most frequent mode of citation is conceptual analogy, within which Abramović translates Buddhist ideas into the language of art, without relying on external resemblance to Buddhist sources. We see this reception in performances such as Energy of Stillness, Crossing the Night Sea, 512 Hours, and etc. Less frequent is direct iconographic citation. For example, in Nude with Skeleton, the iconographic source is the Tibetan meditation on the charnel ground and the practice of Chöd, where the skeleton serves as a tool for cutting off attachments.

The analysis conducted allows us to assert that the engagement with Buddhist practices in her art was part of Marina Abramović's artistic method. At the same time, what interests the artist in Buddhism is a method of working with the body and consciousness, which Abramović separates from its religious context and translates into the language of performance art.

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УДК 616-72

THE EDUCATIONAL AND MORAL POTENTIAL OF MANGA FOR ADOLESCENT READERS

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Abstract. This article examines the potential influence of manga on the moral and psychological development of adolescents. Through a qualitative analysis of selected works, including *Vagabond, The Climber, Call of the Night, Naruto, and Jujutsu Kaisen,* the paper discusses how manga narratives may contribute to empathy, resilience, self-reflection, and social identity formation. Particular attention is paid to character growth, interpersonal relationships, creativity, and fandom communities as possible factors in adolescent moral development.

Keywords: manga, adolescent readers, moral education, personal development, emotional intelligence, self-discipline, social integration.

ОБРАЗОВАТЕЛЬНЫЙ И НРАВСТВЕННЫЙ ПОТЕНЦИАЛ МАНГИ ДЛЯ ЧИТАТЕЛЕЙ ПОДРОСТКОВОГО ВОЗРАСТА

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Аннотация. В данной статье рассматривается потенциальное влияние манги на моральное и психологическое развитие подростков. На основе качественного анализа отдельных произведений, включая «Бродягу», «Альпиниста», «Зов ночи», «Наруто» и «Дзюцу Кайсен», обсуждается, как повествования манги могут способствовать развитию эмпатии, жизнестойкости, саморефлексии и формированию социальной идентичности. Особое внимание уделяется развитию персонажей, межличностным отношениям, творчеству и фандомным сообществам как возможным факторам морального развития подростков.

Ключевые слова: манга, читатели-подростки, нравственное воспитание, личностное развитие, эмоциональный интеллект, самодисциплина, социальная интеграция.

Manga has evolved beyond simple entertainment, becoming a significant foundation for the formation of moral concepts such as perceived good, evil, and social navigation in adolescents. The article focuses on selected manga genres and narrative

types, including shonen, seinen, romance, and psychological drama. A recurring idea in many manga narratives is that personal development depends not only on innate ability, but also on discipline, persistence, and repeated effort. Such narratives emphasise the importance of cooperation, trust, and social support in overcoming personal and external challenges. Adolescents see that mistakes are not a reason to give up, but a valuable experience. This builds a habit of not giving up when things do not work out the first time. Manga like *"Naruto"* or *"Jujutsu Kaisen"* teaches that trusting others is not a weakness. Hero cannot save the world alone, and life works the same way. While *Jujutsu Kaisen* and *Naruto* convey simpler messages, works like *Vagabond* and *Climber* tell the stories that examine psychological and philosophical dimensions, raising significant mature issues.

Vagabond is a profound narrative that explores the life of Shinmen Takezo, later known as the legendary swordsman Miyamoto Musashi, as he transitions from a violent youth into a disciplined master. The story serves as a deep psychological and philosophical examination of what it means to be "truly strong," moving beyond mere physical dominance toward spiritual enlightenment. Through its detailed portrayal of martial arts and personal growth, the manga addresses complex themes of ego, the sanctity of life, and the pursuit of one's purpose. It illustrates the protagonist's internal struggle to reconcile his ambition for fame with a growing understanding of harmony and the interconnectedness of all things. Ultimately, the work functions as a meditative study on the human condition, suggesting that the most significant battles are those fought within oneself. For an adolescent audience, this manga can serve as a compelling case study on the importance of self-reflection and the transformation of raw impulse into disciplined character. It demonstrates that true maturity is found not in the assertion of dominance over others, but in the mastery of one's own internal conflicts and ego.

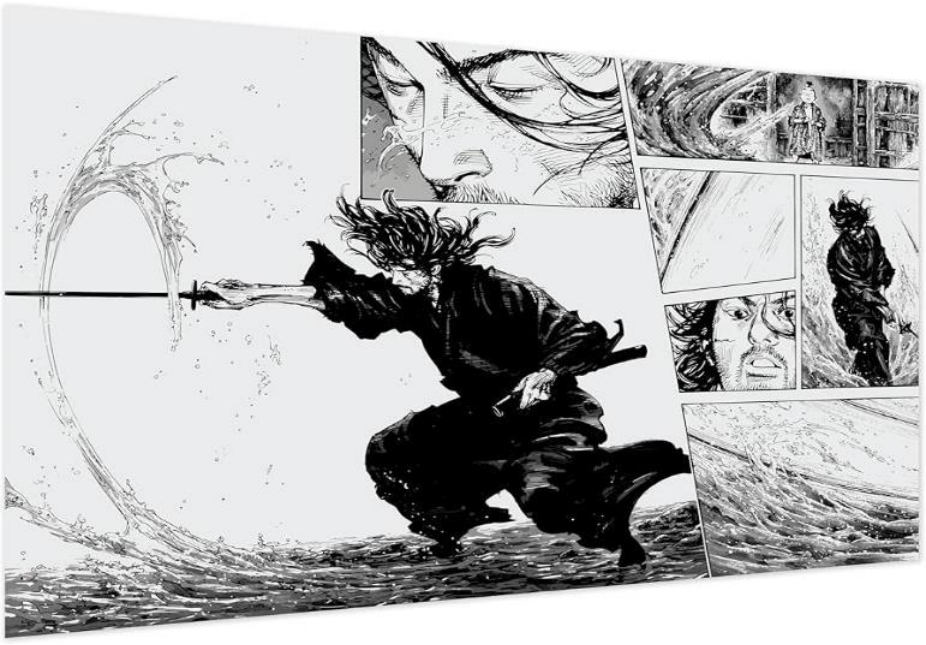


Figure 1. Description of the visual evolution of Musashi in *Vagabond*

The Climber offers a rigorous exploration of the human spirit through the lens of Mori Buntarou’s obsession with solo mountain climbing. The narrative meticulously tracks the protagonist's transition from a socially isolated teenager into a man who finds profound clarity and existential purpose amidst the life-threatening conditions of high-altitude peaks. It functions as a psychological study of solitude, illustrating the immense mental fortitude required to face both the indifference of nature and the complexities of human society. For adolescent readers, this manga potentially serves as a powerful testament to the value of unwavering dedication and the pursuit of individual excellence. It encourages a shift in perspective, suggesting that being "different" or socially withdrawn can be channeled into extraordinary personal achievement through discipline and self-reliance. By witnessing Buntarou’s journey, teenagers may learn that the path to self-discovery often requires enduring significant hardship and that true fulfillment stems from internal milestones rather than external validation.

The romance genre in manga facilitates the development of empathy by requiring readers to reflect on character motivations and boundaries. Contrary to traditional tropes, titles such as *Call of the Night* explore themes of alienation and the search for authentic connection. The relationship between Ko Yamori and Nazuna emphasizes that healthy partnerships are built on dialogue and mutual respect rather than manipulation. The narrative suggests that emotional intelligence involves the recognition that genuine feelings cannot be manufactured, advocating instead for patience and self-honesty within adolescent relationships. The romantic arc begins when the protagonist encounters a peer who understands his sense of alienation, providing an introduction to a world where the pressures of being a 'constrained teenager' are absent. For an adolescent audience, this may serve as a vital message that non-conformity is a valid social state. The manga illustrates that while falling in love is a primary goal, the process cannot be forced, reinforcing the idea that emotional authenticity is paramount. Love is presented not merely as a chemical reaction but as a profound desire for mutual understanding. Within this framework, the relationship is depicted as a partnership of equals characterized by voluntary engagement rather than social obligation. This dynamic can potentially foster a more sophisticated understanding of emotional intelligence, demonstrating that healthy relationships are built on comfort and partnership rather than ownership. Ultimately, the work reveals the complexities of interpersonal connections and may encourage readers to view their uniqueness as a positive attribute rather than a social deficit.



Figure 2. The final chapter of *Call of the Night*

Creativity and social integration in manga acts as more than just a source of information - it is a powerful catalyst for self-expression. It provides teenagers with the tools to communicate their feelings through art and storytelling. The breathtaking detail in works like Vagabond or the dynamic flow of Jujutsu Kaisen inspires teenagers to pick up a pencil or a stylus for the first time. It is not just copying – it is an education in anatomy, perspective, and composition. Writing fanfiction or creating original comics allows teens to process personal issues. If expressing pain in words is too difficult, a character can convey it instead. This helps prevent emotional supression and provides a constructive creative outlet. Unlike filmmaking, which requires budgets and crews, manga only requires paper and a pen. Manga is a portal into a culture vastly different from Western norms, which fosters mental flexibility. By reading manga, teens unconsciously learn Japanese traditions, etiquette, and philosophy. This nurtures the realization that the world is massive and their own "right things" can look different in different places. Manga often tackles themes that might be taboo in a teenager’s immediate surroundings. When a reader sees the world through the eyes of a character different from themselves, their horizons may expand.



Figure 3. Anime festival in Chiba, Japan 2018

Manga can radically change the perception of routine. Instead of seeing education as a "sentence" or a boring chore, a teenager begins to view it as a new phase for their life. In most popular titles, especially sports manga or shonen, success never falls from the sky. Manga showcases "training arcs" where the hero repeats the same movement thousands of times. This teaches a crucial principle: monotonous work is not boring – it is the path to mastery. When teenager sees the protagonist of *The Climber* training his grip - routine starts to feel like a vital "training session" before a big challenge. Heroes often set impossible tasks and break them down into small steps. This suggests that goal attainment stems from the persistent repetition of a schedule.



Figure 4. Training arc in *Boku no Hero Academia*

Additionally, manga instills the idea that a person is a project that needs lifelong work. Heroes constantly challenge themselves. For a teenager, this becomes the motivation to join a club, start learning a new language, or take on a difficult university project. The "master-to-student" relationship in manga is often very profound. It

teaches teenagers to respect mentors in real life and seek out those they can learn from, rather than simply clashing with teachers.

The manga and anime community is incredibly large, which can help a teenager find friends or acquaintances. Manga and anime have long moved beyond being just a private hobby. Today, they form a global social network that helps teenagers stop feeling isolated and find their place in society. For many teens who feel like "outcasts" at school or university, the fandom can become a friendly community. Discussing the latest chapter in comments or on forums provides the realization that thousands of people worldwide share your thoughts and feelings. Debating who is stronger or whether a character's choice was right is excellent training for soft skills. Teenagers learn to articulate their thoughts, defend their positions, and, more importantly, listen to others. Conventions, cosplay events, and local meetups are ways to step out of one's comfort zone. Meeting like-minded people in real life teaches them how to make friends without the fear of being judged for their interests. Modern platforms like TikTok and other social media have transformed manga consumption into an active creative process. Creating video edits requires editing skills, sound design, and a sense of rhythm. A teenager does not just consume content; they reimagine it and creating something new. This turns a hobby into a learning experience for valuable digital skills. Cosplay teaches everything from sewing and crafting to makeup and acting. It requires immense discipline and patience. Moreover, it helps teenagers accept their bodies and learn how to present themselves in public. A teenager from one country can participate in the same challenge as a peer from Japan or Brazil. This erases language and cultural barriers, making the new generation more open-minded and cosmopolitan.

In conclusion, the analysis suggests that manga can be considered a multifaceted medium with potential educational and moral significance for adolescent readers. Through training arcs, introspective journeys, and complex interpersonal relationships, manga narratives may encourage readers to reflect on discipline, empathy, resilience, and personal identity. Works such as *Vagabond*, *The Climber*, and *Call of the Night* show that personal growth is often connected not only with external success, but also with self-understanding, emotional honesty, and the ability to build respectful relationships.

At the same time, the influence of manga should not be presented as automatic or universal. Its effect depends on the reader's age, personal experience, cultural background, and the way the text is interpreted. Therefore, manga may be viewed as a valuable cultural and educational resource, but its role in adolescent development requires careful and context-sensitive analysis.

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УДК 159.9:81'243

PSYCHOLOGICAL BARRIERS IN FOREIGN LANGUAGE LEARNING AND WAYS TO OVERCOME THEM

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Abstract. This article examines psychological barriers that hinder foreign language learning, including fear of mistakes, language anxiety, low self-esteem and insufficient motivation. It analyses the role of the educational environment, digital communication and teacher support in reducing anxiety. The article also offers practical recommendations for developing communicative confidence and overcoming the affective filter.

Keywords: foreign language, psychological barriers, language anxiety, motivation, self-esteem, communication barrier, digital anxiety.

ПСИХОЛОГИЧЕСКИЕ БАРЬЕРЫ ПРИ ИЗУЧЕНИИ ИНОСТРАННОГО ЯЗЫКА И СПОСОБЫ ИХ ПРЕОДОЛЕНИЯ

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Аннотация. В статье рассматриваются психологические барьеры, затрудняющие изучение иностранного языка: страх ошибки, языковая тревожность, низкая самооценка и недостаточная мотивация. Анализируется влияние образовательной среды, цифровой коммуникации и педагогической поддержки на снижение тревожности. Предлагаются практические приемы, направленные на развитие коммуникативной уверенности обучающихся в учебном процессе.

Ключевые слова: иностранный язык, психологические барьеры, языковая тревожность, мотивация, самооценка, коммуникативный барьер, цифровая тревожность.

Introduction

In the modern world, proficiency in a foreign language is an important condition for professional development, academic mobility and intercultural communication. Specialists increasingly need to work with international sources, take part in

professional communication and use digital platforms in educational and professional contexts. For this reason, foreign language learning cannot be reduced only to vocabulary and grammar. It also involves psychological factors that may either support or hinder learning.

Many learners experience fear of mistakes, lack of self-confidence, anxiety during oral communication and unstable motivation. Even students with sufficient knowledge of grammar and vocabulary may avoid speaking because they are afraid of negative evaluation. As a result, classroom participation decreases, oral practice becomes limited and a stable language barrier may develop.

In recent years, researchers have also paid attention to digital anxiety in foreign language learning. This form of anxiety is connected with online platforms, video conferences, the need to speak spontaneously in a virtual classroom and the feeling of being constantly observed or recorded [1, 2].

The problem of psychological barriers is especially relevant in modern education, where the development of communicative competence is one of the main aims. It is not enough to know language rules; learners must be able to use the language in real communication. Therefore, the study of psychological barriers and ways to overcome them is both theoretically and practically significant.

The aim of this article is to describe the main psychological barriers in foreign language learning and to summarise pedagogical and psychological strategies for overcoming them on the basis of scholarly and methodological literature.

1. Theoretical Foundations of Psychological Barriers

A psychological barrier is an internal obstacle that prevents a person from performing an activity effectively. In foreign language learning, such barriers are usually expressed through emotional tension, fear of communication, uncertainty about one's abilities and avoidance of speaking practice.

One of the best-known theories explaining the role of emotions in language learning is Stephen Krashen's Affective Filter Hypothesis [3]. According to this hypothesis, emotional factors can either facilitate or prevent language acquisition. High anxiety, fear of making mistakes and low self-esteem may create an affective filter that makes it harder for learners to understand, remember and use new language material.

L. S. Vygotsky's theory of the zone of proximal development is also important for understanding the role of support in learning. Vygotsky emphasised that learning becomes more effective when it takes place through cooperation with a teacher or more experienced peers. If learners feel emotionally safe and receive support, their anxiety may decrease and their confidence may increase [4].

Self-determination theory also helps to explain the role of motivation in language learning. According to Ryan and Deci, motivation is supported when the learner's basic psychological needs for autonomy, competence and relatedness are satisfied [5]. If a student experiences constant pressure, does not believe in their own ability or feels unsupported, motivation gradually decreases.

Emotional state directly affects cognitive processes. Anxiety may reduce concentration, weaken memory and prevent learners from using language freely in communication. Foreign language anxiety is therefore considered one of the significant factors influencing successful language acquisition [6, 7].

2. Main Types of Psychological Barriers

2.1. Fear of Making Mistakes

Fear of making mistakes is one of the most common psychological barriers. Many students worry about incorrect pronunciation, grammatical errors or insufficient vocabulary. This fear is especially typical of learners with high anxiety and perfectionist tendencies [8].

Fear of mistakes often leads students to avoid speaking. They may remain silent in class, refuse to answer questions or avoid discussions. As a result, the amount of speaking practice decreases and communicative skills develop more slowly [9].

It is important to understand that mistakes are a natural part of the learning process. Without practice, it is impossible to achieve a high level of language proficiency. Moreover, mistakes help learners identify gaps in knowledge and improve their command of the language.

2.2. Language Anxiety

Language anxiety is a state of emotional tension and worry that appears when a person has to use a foreign language [10]. Its main manifestations include:

1) increased heart rate;
2) fear of forgetting words;
3) difficulty concentrating;
4) a feeling of inhibition;
5) avoidance of communication.

Language anxiety is especially strong during public speaking, oral examinations and communication with native speakers. A high level of anxiety may negatively affect memory and reduce the ability to process information.

Digital anxiety can be considered a specific form of language anxiety in online learning. It arises when learners have to speak a foreign language in a virtual environment where non-verbal cues are limited, technical problems are possible and the recording of a session may increase the feeling of being evaluated [1, 2].

2.3. Low Self-Esteem

Self-esteem plays an important role in foreign language learning. Students who are not confident in their abilities tend to doubt themselves and give up more quickly when difficulties appear. Low self-esteem may develop under the influence of:

1) constant criticism;
2) negative learning experience;
3) comparison with more successful classmates;
4) excessively high expectations from teachers or parents.

As a result, the learner begins to see themselves as incapable of learning languages. This reduces motivation and negatively affects academic results [8].

2.4. Insufficient Motivation

Motivation is one of the key factors in successful learning. If a student does not understand the practical value of a foreign language, learning may become formal and ineffective.

A distinction is usually made between extrinsic and intrinsic motivation. Extrinsic motivation is connected with grades, institutional requirements or examinations.

Intrinsic motivation is based on personal interest, the desire to communicate, travel, study and develop oneself [5, 11].

Research and teaching practice show that intrinsic motivation usually produces more stable learning outcomes. Social media and digital environments may also influence motivation. Publishing posts in the target language, participating in online language communities and receiving feedback may support motivation. However, excessive dependence on virtual recognition can increase anxiety and weaken learner autonomy.

2.5. The Communicative Barrier

The communicative barrier is the inability to use a foreign language freely in real communication. A student may know grammar well but still experience difficulties in speaking. For example, a learner may correctly complete exercises on the Present Simple, but in a real situation, such as at an airport or in a cafe, be unable to say, "Can I have a glass of water, please?" because of fear of incorrect pronunciation or a forgotten word. This gap between knowledge and practical ability is the essence of the communicative barrier.

The main causes of the communicative barrier are:

1) lack of speaking practice;
2) fear of negative evaluation;
3) limited vocabulary;
4) uncertainty about pronunciation.

This problem is especially common among students who have mainly studied the language theoretically and have had little oral practice.

The formation of language anxiety can be presented as a closed cycle:

1) a mistake occurs;
2) the learner experiences fear of negative evaluation;
3) the learner avoids speaking situations;
4) speaking practice decreases;
5) speech skills do not become automatic;
6) a new mistake occurs;
7) anxiety increases.

In this case, the new mistake is caused not by a lack of ability, but by a lack of communicative experience.

3. Causes of Psychological Barriers

3.1. Influence of the Educational Environment

The educational environment has a strong influence on learners' emotional state. An excessively strict teaching style, constant criticism and an exclusive focus on errors may cause anxiety and self-doubt.

If a student is afraid of a negative reaction from the teacher or classmates, they begin to avoid active participation in class. This lowers communicative activity and reduces the quality of learning.

By contrast, a supportive and respectful atmosphere helps learners become more confident and reduces anxiety.

The digital environment may also influence anxiety. An inconvenient platform interface, technical failures, the visibility of one's own image on screen and the possibility of being recorded can all increase tension during online communication [2].

3.2. Social Factors

A learner's social environment also affects psychological barriers. Negative comments from peers, pressure from parents and fear of public opinion can increase emotional tension.

Adolescents and young people are particularly sensitive to such factors because the opinion of others is often very important to them.

3.3. Individual Psychological Characteristics

Each learner has individual character and temperament features. Some students communicate easily and are not afraid of mistakes, while others are shy or highly anxious.

Introverted students may need more time to formulate their thoughts before speaking. Perfectionism may also become a problem because the desire to produce a perfect answer often leads to fear of mistakes.

3.4. Negative Learning Experience

An unsuccessful experience of learning a foreign language may form a stable negative attitude towards the subject. If a learner has previously faced ridicule, humiliation or repeated failure, they may develop the belief that they are incapable of learning languages.

Such attitudes reduce motivation and prevent further development of language skills.

4. Ways of Overcoming Psychological Barriers

4.1. Building Sustainable Motivation

One of the most effective ways to overcome psychological difficulties is to develop sustainable motivation for learning. Students need to understand the practical value of a foreign language and see the results of their efforts. To maintain interest, learners are advised to:

1) set achievable goals;
2) record their progress;
3) use the language in real situations;
4) study topics that are personally interesting;
5) watch films and read books in the foreign language.

Emotional involvement in learning increases the effectiveness of language acquisition.

4.2. Creating a Supportive Educational Environment

The teacher should create a comfortable atmosphere in the classroom. It is important to support learners, encourage initiative and treat mistakes as a natural part of learning.

Modern teaching methods should focus not on punishment for mistakes, but on the development of communicative competence. Pair work and group work help reduce the fear of public speaking and develop learner confidence.

4.3. Using Cognitive-Behavioural Techniques

Cognitive-behavioural techniques help students change negative attitudes and develop a more positive view of their own abilities. Useful techniques include:

1. positive self-talk;
2. analysis of negative thoughts;
3. gradual involvement in communicative situations;
4. development of self-regulation skills.

These methods can reduce anxiety and increase self-confidence [12].

4.4. Developing Communicative Skills

Regular speaking practice is an essential condition for overcoming the language barrier. However, students with a high level of anxiety need special techniques that help them gradually enter oral communication.

The following techniques may be used:

1. Delayed error correction. The teacher notes typical mistakes during the student's answer but does not interrupt the speaker. This reduces the fear of being corrected in front of the group.

2. Pair work before public speaking. Students first discuss the topic with a partner in a safe, non-evaluative environment and then present the result to the group.

3. Language anxiety journal. After class, the student spends two to three minutes writing down the situation in which they felt afraid to speak and analysing whether this fear was justified.

4. Gradual complication of speaking tasks. The student moves from simple tasks to more difficult ones: repetition after the teacher, answers to short questions, a mini-monologue and free conversation.

5. Traditional communicative activities. Discussions, role plays, group projects and conversation clubs are used after preliminary preparation, so that they do not increase anxiety.

Gradual immersion in communication helps develop confidence and reduce fear of speaking [13].

4.5. Use of Modern Technologies

Modern digital technologies expand the possibilities of foreign language learning. Online platforms, mobile applications and interactive services allow students to:

1) learn at a comfortable pace;
2) receive immediate feedback;
3) reduce fear of public evaluation;
4) develop listening and pronunciation skills.

Gamified tasks and interactive exercises can make learning more engaging and emotionally comfortable. At the same time, digital tools should be used carefully, because online learning may both support flexibility and increase anxiety in students with low confidence or weak digital skills [2].

5. The Role of the Teacher in Overcoming Psychological Barriers

The teacher plays a key role in shaping the psychological climate of the classroom. Learners' emotional state and motivation largely depend on the teacher's professional approach. A modern teacher should:

1) take into account students' individual characteristics;

2) maintain a positive classroom atmosphere;
3) develop learners' confidence;
4) use communicative teaching methods;
5) motivate students to participate actively.

Emotional support is particularly important. Even small encouragement can increase a student's confidence and stimulate active participation.

The teacher should remember that excessive criticism may cause fear and reduce motivation to learn.

6. Practical Recommendations for Students

To overcome psychological barriers, students are advised to follow these principles:

1. Do not be afraid of mistakes, because they are a natural part of learning.
2. Practise speaking regularly.
3. Set realistic goals and track progress.
4. Use the foreign language in everyday life.
5. Avoid constant comparison with other learners.
6. Develop emotional resilience and self-regulation skills.
7. Maintain a positive attitude towards learning.

Following these recommendations can help reduce anxiety and increase the effectiveness of foreign language learning.

Conclusion

The theoretical analysis shows that psychological barriers are not only an additional difficulty, but also one of the major factors that hinder foreign language learning. The problem often lies not in a lack of ability, but in the absence of a safe communicative environment. Fear of negative evaluation leads to avoidance of speaking practice and prevents students from applying grammatical knowledge in real communication.

The most productive strategy is to shift attention from formal accuracy to the meaning of the utterance. Supportive feedback, gradual speaking practice and cognitive-behavioural techniques help reduce anxiety and encourage students to participate more actively in communication.

The practical significance of the article lies in the fact that it presents a set of pedagogical and psychological strategies that may be used by teachers and students. A promising direction for further research is the integration of digital tools with methods of emotional self-regulation in order to create personalised learning pathways that take into account the psychological profile of the learner.

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При подготовке статьи были применены технологии искусственного интеллекта.

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УДК 008

HISTORICAL, RELIGIOUS AND SECULAR HOLIDAYS AS MIRRORS OF CULTURAL IDENTITY: A COMPARATIVE STUDY OF RUSSIAN AND EAST ASIAN TRADITIONS

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Abstract. The article discusses national holidays as a way to improve intercultural communication. There is a comparative analysis of historical, religious, and secular pairs of holidays in Russia and East Asian countries. The analysis reveals similarities and differences between these traditions and and the study concludes the importance of increasing interest in holidays as part of cultural identity.

Keywords: holidays, cultural identity, Russia, East Asia, international communication, historical holidays, religious holidays, secular holidays.

ИСТОРИЧЕСКИЕ, РЕЛИГИОЗНЫЕ И СВЕТСКИЕ ПРАЗДНИКИ КАК ЗЕРКАЛА КУЛЬТУРНОЙ ИДЕНТИЧНОСТИ: СРАВНИТЕЛЬНОЕ ИССЛЕДОВАНИЕ РУССКИХ И ВОСТОЧНОАЗИАТСКИХ ТРАДИЦИЙ

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Аннотация. В статье рассматриваются национальные праздники как способ улучшения межкультурной коммуникации. Проведен сравнительный анализ исторических, религиозных и светских праздников России и восточноазиатских стран. В результате анализа выявлены сходства и различия, на основе полученной информации сделан вывод о важности повышения интереса к праздникам как к части культурной идентичности.

Ключевые слова: праздники, культурная идентичность, Россия, Восточная Азия, межкультурная коммуникация, исторические праздники, религиозные праздники, светские праздники.

Today, people from different countries communicate more and more often. We travel, study abroad, work in international companies, and talk with colleagues and friends from other cultures. To make this communication successful, it is not enough to simply learn a foreign language. More important is knowing another culture – its values, habits, and attitudes toward family, work, and time, as well as what they find respectful or offensive.

Without cultural understanding, it is easy to find yourself in an awkward situation. You might give an inappropriate gift or forget a holiday that is important to people. That is why learning about culture is not only interesting but also practical for anyone who wants to build good relationships with people from other countries.

Culture is made up of many things: language, literature, history, food, and customs. It is difficult and time-consuming to study everything at once. However, there is one approach that gives a lot of information while still being accessible and enjoyable for beginners. That approach is holidays. They work like a mirror – they show history, religion, and social change. They reveal what a people value most: respect for ancestors, faith in God, memory of great events, or the joy of changing seasons. You don't need a special education to understand them. It is enough to look at how people decorate their homes, what they cook, and what they talk about on that day. Starting with holidays, you can easily take your first step into any culture.

In today's globalized world, comparing the traditions of different peoples helps us better understand national identity. This article compares historical, religious, and secular holidays in Russia and East Asia – China, Japan, and Korea.

Even in big cities and with modern lifestyles, holidays help people keep their cultural memory alive and pass it on to new generations.

The goal of this article is to explore how holidays create and maintain cultural identity in Russia and East Asian countries. The research method is comparative analysis using ethnographic and official sources.

Let us now examine the pairs of historical, religious, and secular holidays more carefully. The first holidays we will compare are Constitution Day of the Russian Federation and Gaecheonjeol (National Foundation Day) in South Korea. These historical dates show different ways to form national identity: Russia puts emphasis on its modern state based on law, which

Constitution Day of the Russian Federation is celebrated on December 12. On this day in 1993, the current Constitution of the country was adopted. This event marked the end of the conflict between the President and the Supreme Soviet. The holiday was introduced in 1994 by a decree of Boris Yeltsin. On this day, official events take place, including lectures on human rights and concerts. This holiday shows the move to democracy, federalism, and a market economy after the Soviet Union collapsed. Since 2005, it is no longer a public day off, and people celebrate it more quietly. Still, it keeps highlighting national unity and respect for the rule of law [1].

Gaecheonjeol (National Foundation Day) is celebrated on October 3 in South Korea. The holiday connects to ancient times. People believe that in 2333 BC, the first state of the Korean people – Joseon – was founded. Gaecheonjeol became an official national holiday in 1919. At first, it followed the lunar calendar. In 1949, the date was moved to October 3 and was established by law. On this special day, various ceremonies take place, including parades, fireworks, national costumes, and festivals with traditional music. The holiday strengthens Korean identity, pride in history, and resistance to colonialism [2, 3].

Table 1. Comparison of historical holidays

Comparison criterion	Constitution Day of the Russian Federation	Gaecheonjeol / National Foundation Day
Historical signification	Adoption of the Constitution in 1993	Founding of the first state of the Korean people, symbolizing independence
Traditions and events	Official events, lectures on human rights, concerts	Parades, fireworks, national costumes, festivals with traditional music
Symbolic meaning	Transition to democracy, federalism	Strengthening Korean identity, pride in history, resistance to colonialism
Goals of the holiday	National unity, rule of law	National identity, historical pride

Both holidays promote national unity. The Russian one focuses on the country's modern transformation, while the Korean one looks back to ancient history and the struggle against colonial rule. Constitution Day highlights legal values associated with Western democracy, whereas Gaecheonjeol reflects Confucian loyalty and devotion. In both cases, the holidays remind people of the importance of unity during times of major historical change.

Next, we will look at religious holidays – Easter in Russia's Orthodox tradition and Obon's Buddhist festival in Japan. Both holidays connect to remembering ancestors and family values, but they differ in how they understand time and their religious foundations.

Easter is the most important holiday of the Russian Orthodox Church, dedicated to the Resurrection of Jesus Christ. The date of the holiday is calculated using the lunar calendar: it falls on the first Sunday after the first full moon of spring. This bright celebration of Christ's Resurrection came from Byzantium together with the baptism of Rus at the end of the 9th century. Traditions connected with this holiday include a midnight church service with a religious procession, preparing and blessing special Easter cakes called kulich, decorating eggs, and family feasts. It is important to note that Easter is one of the most popular holidays for Russians. This day brings believers together, emphasizes sacrifice and hope, and symbolizes rebirth and renewal [4].

Obon is a Day of Remembrance for the Dead that came to Japan with Buddhism and absorbed elements of Shinto beliefs about the return of deceased ancestors' souls to the places where they used to live. The Obon festival lasts three days; however, its starting date varies in different regions of Japan: in some areas it begins in mid-July, while in others it starts in mid-August. Although the Day of Remembrance for the Dead might seem like a sad holiday, it is celebrated in a cheerful, colorful, and lively way. During Obon, many lanterns are lit everywhere, which is why it is also called the Festival of Lanterns. The celebration traditionally includes a dance known as Bon Odori, food offerings at graves and altars. Families gather together and decorate their homes. In recent years, the ceremony from Kyoto has been broadcast on television. In general, the Obon festival receives a lot of attention in the media. Obon shows how a syncretic folk Buddhist custom has turned into a festival of family reunion, during which people return to their ancestral homelands, visit and clean their ancestors' graves [5, 6].

Table 2. Comparison of religious holidays

Comparison criterion	Easter	Obon
Historical signification	Resurrection of Jesus Christ	Buddhism: remembrance of deceased ancestors
Traditions and events	Midnight church service with religious procession; blessing of kulich and decorating eggs	Lighting lanterns, Bon Odori dance, food offerings at graves and altars, families gather and decorate homes
Symbolic meaning	Rebirth, renewal, sacrifice and hope, individual salvation	Family reunion, cycle of life and death, harmony between living and dead
Goals of the holiday	Celebrate spiritual rebirth and salvation	To honor ancestors' souls and strengthen family bonds through reunion

Both holidays are connected with the memory of the dead and family values. Easter is a linear holiday: Christ rose once and for all time. Obon is cyclical: the souls of ancestors return every year. The celebration of Easter in Russia symbolizes resurrection and salvation through sacrifice. Obon, in contrast, emphasizes collectivism, cycles, and harmony between worlds. Both holidays are gradually becoming more secular in modern times.

The comparison will be completed by secular holidays: New Year in Russia and the Lunar New Year (Spring Festival, or Chūnjié) in China. Despite sharing a common purpose – welcoming a new cycle – these holidays are based on different calendars and reflect different cultural priorities.

New Year in Russia is the main winter holiday, celebrated on the night of December 31 to January 1, accompanied by public holidays lasting 8 days. At the end of December 1699, Peter I issued a special decree about celebrating the New Year. After the revolution in 1918, the holiday was temporarily cancelled, but in 1935 New Year was brought back. The companions of this cheerful holiday gradually became Ded Moroz (Grandfather Frost) and his granddaughter Snegurochka (Snow Maiden), tangerines and Olivier salad, New Year lights and the chiming of the Kremlin clock, a festive speech by the country's leader and holiday songs, fireworks, parties, and corporate celebrations until morning. New Year symbolizes renewal and national unity, mixing pagan and Western elements [7].

Chunjie – Chinese New Year, which literally translates as "Spring Festival" and unofficially is called "Lunar New Year," has been the main and longest holiday in China since ancient times. According to the story in Shangshu (an ancient Chinese text), the first day of the New Year became the day when Shun took the throne. In Chinese people's opinion, on this first day of spring nature awakens [8].

There was also a belief that evil spirits are afraid of the color red, so during the festive days, red was the dominant color everywhere. Before New Year, people stuck red paper strips on all kinds of objects. A few days before celebrating Chinese New Year, people usually do a thorough cleaning of their homes. During the holiday, adults traditionally give children red envelopes with money, and various folk performances are always organized, such as lion dances, dragon costume parades, and stilt walking.

Lunar New Year especially emphasizes the importance of family and preserving cultural traditions [9].

Table 3. Comparison of secular holidays

Comparison criterion	New Year	Chunjie
Historical origin	December 1699 (decree of Peter I)	Ancient times; mentioned in Shangshu
Traditions and events	Ded Moroz and Snegurochka, tangerines, Olivier salad, New Year lights, Kremlin clock chiming, leader's speech, festive songs, fireworks	Thorough home cleaning, red paper strips on objects, red envelopes with money for children, lion dances, dragon costume parades
Symbolic meaning	Renewal, national unity, mixing pagan and Western elements	Nature awakening in spring, good fortune, importance of family
Goals of the holiday	To celebrate renewal of the year and unite the nation	To emphasize importance of family and preserve cultural traditions

Both holidays are dedicated to the beginning of a new cycle. They bring families together and bring hope for good luck. However, Russian New Year is tied to a fixed date – January 1 according to the Gregorian calendar. Chinese Chunjie depends on the lunar cycle and falls on different dates each year. In Russia, the president's New Year address is an important part of the holiday, while in China, Chunjie remains primarily a cultural celebration without a strong political emphasis.

Comparing Russian and East Asian holidays shows that behind the external differences in symbols, rituals, and dates lie values that are common to all people: memory of ancestors, family unity, and preservation of traditions. Each culture has its own language for expressing these meanings. Understanding this language gives us the key to successful cross-cultural communication. When we know why a Korean is proud of an ancient myth, why a Japanese person returns home for Obon, and why a Chinese person gives red envelopes, we stop being strangers to each other. Holidays in this sense are not just traditions, but living lessons in mutual respect.

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УДК 659.15

ADVERTISING AND PUBLIC RELATIONS AS A TOOL FOR SHAPING CULTURAL ENVIRONMENT

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Abstract. This report examines the role of advertising and public relations in shaping the contemporary cultural landscape. The relevance of the topic is driven by the active development of creative industries and digital communications, which exert a growing influence on society and the cultural environment. The paper analyzes the principal tools of PR and advertising employed in the promotion of cultural initiatives, brands, and events. The particular attention is paid to the impact of media communications on the perception of culture and audience engagement.

Keywords: advertising in cities, public relations, cultural space of the city, creative city campaigns, interactive installations, street art and murals, audience engagement.

РЕКЛАМА И СВЯЗИ С ОБЩЕСТВЕННОСТЬЮ КАК ИНСТРУМЕНТ ФОРМИРОВАНИЯ КУЛЬТУРНОГО ПРОСТРАНСТВА

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Аннотация. В докладе рассматривается роль рекламы и связей с общественностью в формировании современного культурного пространства. Актуальность темы обусловлена активным развитием креативных индустрий и цифровых коммуникаций, оказывающих влияние на общество и культурную среду. В работе анализируются основные инструменты PR и рекламы, применяемые при продвижении культурных инициатив, брендов и мероприятий. Особое внимание уделяется влиянию медиакоммуникаций на восприятие культуры и взаимодействие с аудиторией.

Ключевые слова: реклама в городах, связи с общественностью, культурное пространство города, креативные городские кампании, интерактивные инсталляции, стрит-арт и муралы, вовлечение аудитории.

Advertising and PR have long ceased to be purely commercial tools. They influence not only consumer habits but also cities and culture. According to expert opinion, urban spaces are gradually being transformed into media environments with streets, parks and public areas functioning as “brand carriers” in a human and experiential sense, rather than merely in the conventional advertising context. Brands are returning to offline channels to reinforce consumer trust through real-world experiences. In the era of information overload, targeting alone no longer works: live street interaction restores brands' “proof of reality”. The purpose of this article is to show how contemporary campaigns generate new cultural meanings in the city through non-standard formats. The objectives are:

1) to describe the theory of advertising's influence on culture;
2) to trace historical and contemporary examples;
3) to analyze methods and effects.

The cultural space of a city is the sum of symbols, meanings, and practices that are associated with streets and public places by residents. Advertising and PR enter this context as visual and social signals. Advertising performs not only an informational function (speaking about a product) but also an aesthetic and social one: it creates atmosphere and sets trends. According to analysts, offline advertising is a means of perception management: the physical presence of a brand allows it to restore a depth of contact and emotional authenticity. Cities become a stage for storytelling: through form, context and interactivity companies tell brand stories without words. For example, pop-up formats, interactive installations, and branded objects engage multiple sensory channels (sight, sound, touch) and make the advertising message a part of the street reality. Offline projects become catalysts for online activity: people photograph different objects and share them on social media.

Key tools include: multimedia screens and projections, AR/VR, street art and graffiti, and spatial activations (flash mobs, performances). These allow brands not merely to talk about themselves, but to demonstrate their values – care for residents, innovation, or openness. The urban culture is changing in the process: some symbols become branded, while others acquire a social dimension (for example, slogans or art objects). An important effect is audience engagement. Whereas classical advertising merely informs, interactive projects invite residents to participate in a “cultural dialogue” with the brand.

The history of advertising reflects a transition from static posters to dynamic urban activations. In the twentieth century artists used streets to create visual culture: Soviet and pre-revolutionary posters on buildings became a part of the urban aesthetics. With the rise of television and the internet, digital media temporarily displaced offline formats. However, by the early twenty-first century a reverse trend began: brands returned to the streets with art projects. For instance, in 2008 street installations by Coca-Cola and IKEA gained worldwide popularity, and music festivals became an important PR channel for ticketing services. In Russia the first creative advertising campaign integrated into urban landscapes became prominent in the 2010s: art objects created for cinema anniversaries and vivid neon signs on building façades became a part of the urban identity. This has given rise to the concept of “advertising as an art”: a brand's striking visual identity can be perceived as an element of the urban culture.

One prominent example is the MTS project in the Moscow Metro in 2023 [1]. In March 2023 MTS having been in the partnership with the Moscow Metro launched the art installation titled ‘‘Internet on the BCL Flies’’ at Rizhskaya station on the Big Circle Line (BCL) (see Fig. 1). On a curved 4 × 2.5-metre LED screen, a multimedia ‘‘magic carpet’’ was displayed – a stream of images created using neural networks and generative graphics. The visualization symbolized the high speeds of underground internet connectivity: passengers experienced the illusion of flying over the city, which reinforced the association with the “magic’’ of technology. The campaign ran across train carriages and included promotional codes for MTS services – KION (a cinema streaming service) and Stroki (a book service). The metro installation ran from 1 to 13 March 2023 and became the subject of discussion on both media and social networks. The core message was: MTS mobile internet is so fast that it ‘‘flies’’ along the BCL like a fairy-tale carpet. Social impact: hundreds of thousands of passengers engaged with the installation, involvement with MTS services increased, and the brand reinforced its technological image.

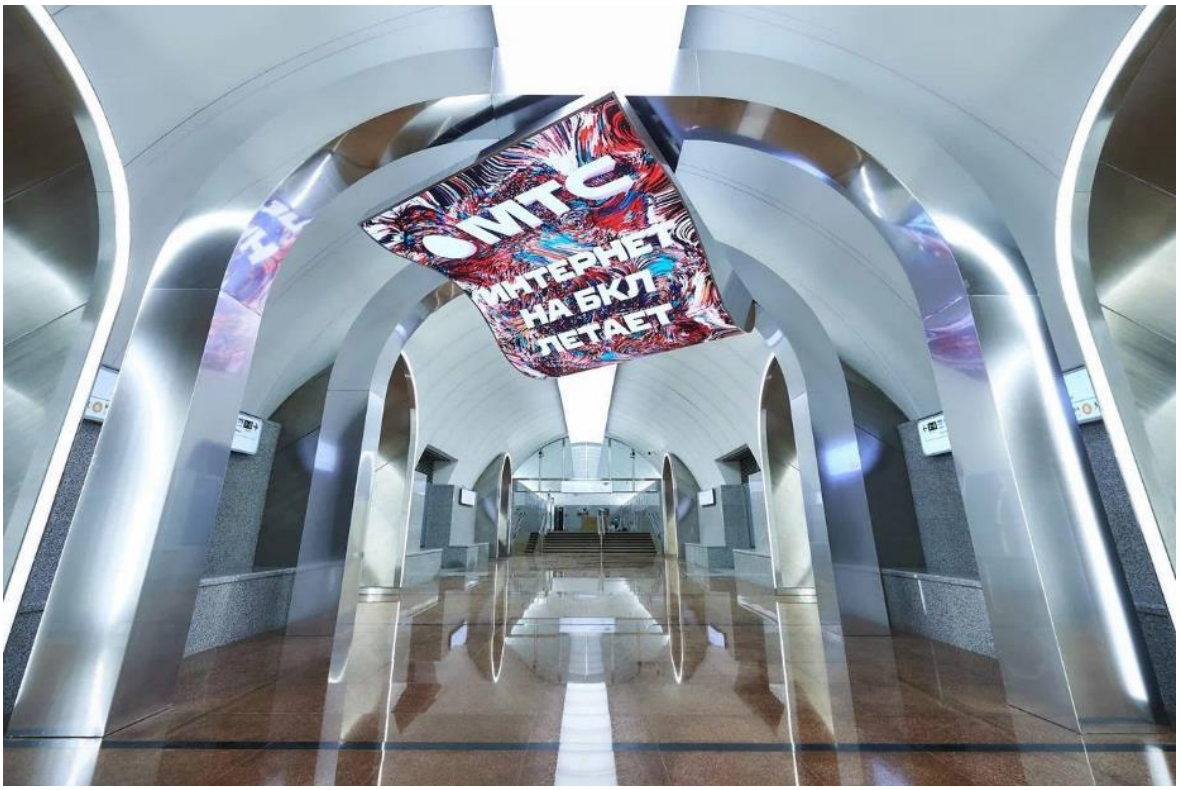


Figure 1. MTS project in the Moscow Metro in 2023

Another MTS case study is the AR project for Stroki (2022) [2]. During the rebranding of the book service ‘‘LitRes: Chitay!’’ as ‘‘Stroki’’, the company in collaboration with the Moscow Metro created a ‘‘literary portal’’. QR codes were placed on advertising posters inside carriages. Passengers scanned them, opened a landing page and pointed their phone camera at a Troika card. On their smartphone screen the scenes from the well-known books entered into life – three-dimensional animated fragments of works from the service's catalogue. For example, one could see locomotives from a novella or a ‘‘magical garden’’ from a fantasy novel, appearing directly above their transit card. Engagement was rewarded through viewing time, and

all participants received one free month of Stroki. The Moscow Metro was chosen as the main location because millions of passengers use it every day, making it not only a transport system, but also an important part of the city’s cultural environment.

Location: Moscow Metro trains, 2022.

Key partners: MTS and the Moscow Metro.

Format: augmented reality via Troika card.

Message: reading can be technological and engaging, and time spent on the metro can be culturally enriching.

Effect: passengers unexpectedly connected with literature; the innovative format attracted media attention; and Stroki gained thousands of new downloads.

Another example of how PR campaigns can influence urban cultural environment is the Nike project in Manchester (United Kingdom, 2024) (see Fig. 2). During the summer of 2024, following the Olympic Games, Nike organized a surprise for local athlete Keely Hodgkinson after she won gold [3]. Overnight, several giant portraits of the champion unexpectedly appeared along the city's streets – painted by artists on colored freight containers and gates in the Stevenson Square area. By morning, residents and tourists discovered that the city had become a venue for celebration: people posed for photographs beside the artwork and actively shared images on social media. Major outlets including ITV News and the Manchester Evening News gave the activation wide coverage. This campaign combined elements of street art, emotional storytelling and urban performance, turning public space into a temporary cultural landmark.

Format: street art murals on containers.

Message: ‘‘No guts, no gold’’ – a tribute to athletes' perseverance.

Effect: viral attention for the Nike brand, amplified by the city's joy over the Olympic victory.

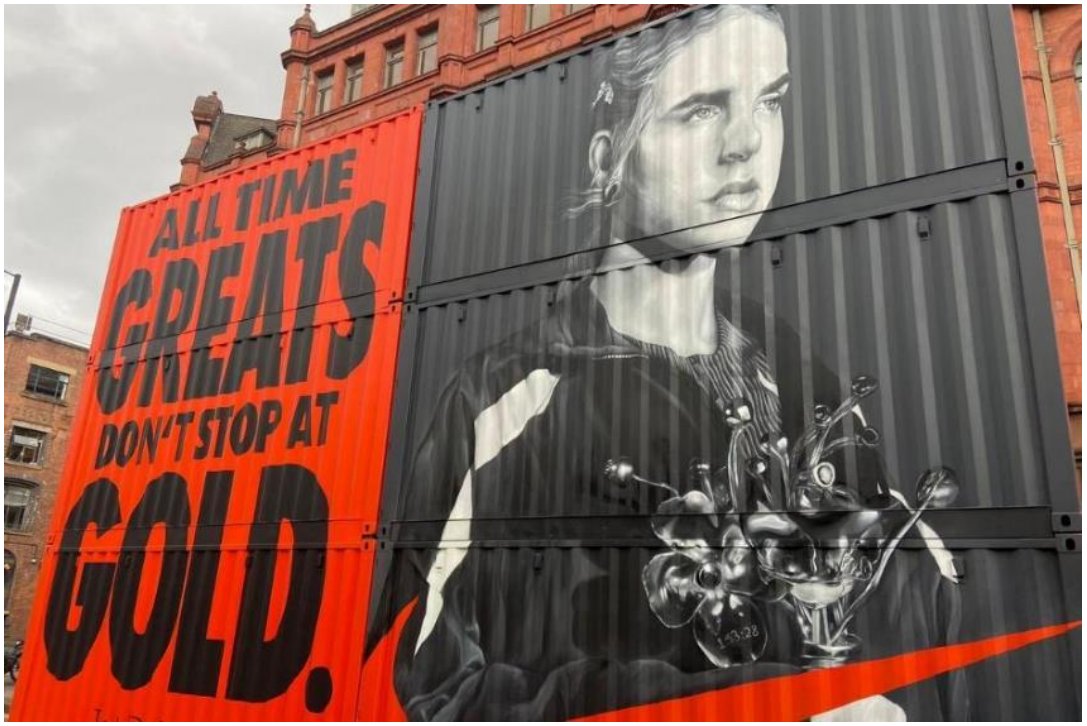


Figure 2. Portraits of the champion Keely Hodgkinson

A different approach to shaping cultural space through PR activities was demonstrated by *Yandex.Travel in Sochi (2023-2025)* (see Fig. 3). According to available information, the company organized several beach-themed activations during the summer period [4]. The brand displayed its logos on large beach towels hung from hotel balconies along the seafront promenade. In this way each balcony became a mini ‘‘media façade’’ – holidaymakers involuntarily encountered the advertising while relaxing. The core message was: ‘‘Yandex Travel is with you – at any resort’’, – the format transformed banners into the part of the landscape. As a result, the campaign blended naturally into the resort atmosphere and attracted public attention. Thus, the social effect was reached when tourists discussed an unusual format and actively shared their impressions.



Figure 3. *Yandex.Travel* – ‘‘beach’’ activations in Sochi

A more socially focused approach to shaping cultural space was demonstrated by *Yandex.Pro (Moscow, 2025)*. The platform for drivers launched a campaign against gender stereotypes [5]. As part of the activation, a street art object was installed: a ‘‘High Heel’’ sign (denoting ‘‘female driver’’), constructed from live flowers (see Fig. 4). Passersby were invited to ‘‘peel off’’ flowers from the sign and take with them small cards having motivational messages. In this way, each participant ‘‘dismantled’’ a stereotype by taking a flower and a message.

Format: outdoor installation and performance based on gender stereotypes.

Effect: people became active participants; photographs of the activation spread widely across social media.

Analysts at AdIndex [6] noted that the video and installation sparked a dialogue about women drivers, demonstrating the brand's social mission.

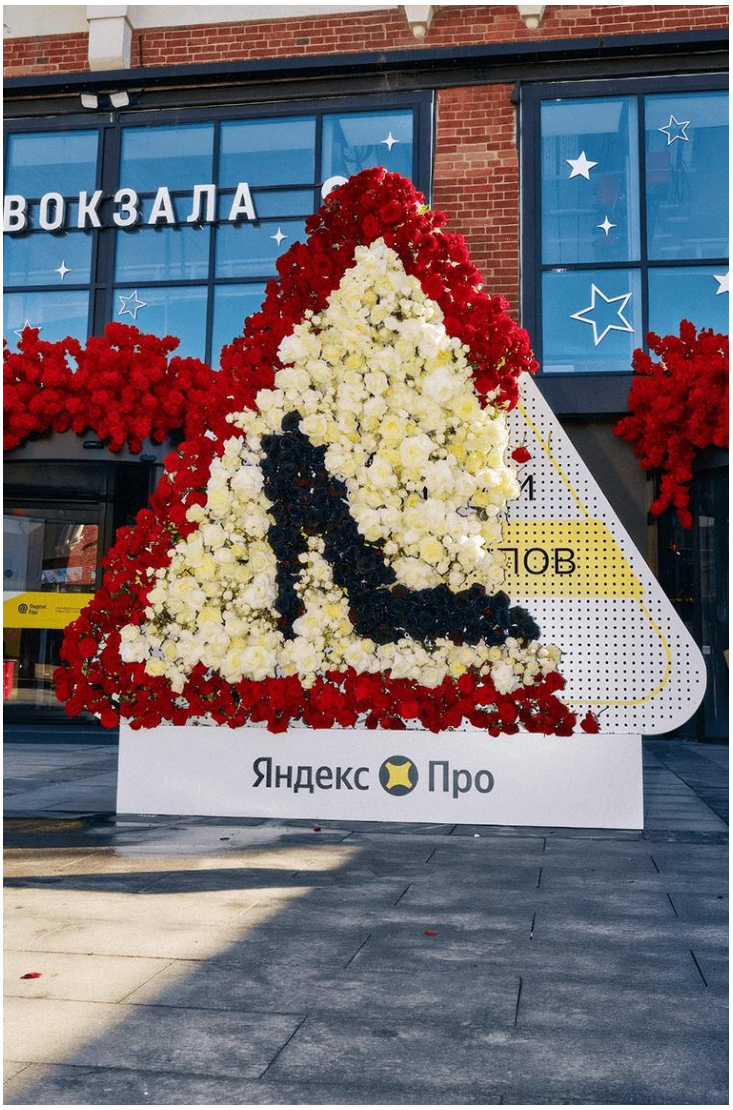


Figure 4. Yandex.Pro – project ‘‘Peeling off stereotypes’’

The use of AR, QR codes, and multimedia creates an immersive experience. MTS's projects transported passengers into literary-historical worlds or into a fairy-tale flight – this activated their attention over a sustained period. The Nike mural turned a metropolis into a gallery: it drew people into a discussion of athletic competition and celebrated victory on the street. Street art often produces a stronger emotional effect than a banner or television advertisement, as people take a photo of it and share their impressions.

Summarizing what have been discussed before, it should be noted that all the examples were implemented with the city's approval: MTS with the Moscow Metro, Nike with local authorities, Yandex through official channels. Collaboration with public organizations lends projects legitimacy and provides access to unique venues (metro stations, central streets).

Yandex.Pro demonstrated that advertising can reflect pressing social issues. This project illustrated the synergy of advertising and PR with social trends (challenging stereotypes).

Physical activity is enhanced with online elements such as videos, promotional codes, and social media engagement. The projects gain depth: each participant acts as

a ‘‘promoter’’ in social networks (for instance, by taking photos with a Nike mural and sharing them).

Taken together, these approaches lead to changes in the cultural landscape. Advertising is no longer simply ‘‘shouting’’ slogans – it is becoming the part of the urban narrative. Art objects and performances begin to be perceived as a cultural ‘‘language’’ of the city: people discuss them not only as an advertising product but as a sign of the times. Urban marketing campaigns also demonstrate a new approach to PR: brands work in an environment where attention is scarce, keeping people engaged through meaningful experiences and emotions instead of aggressive advertising.

Nevertheless, certain risks warrant consideration: an excess of visual stimuli may contribute to cognitive fatigue, while the tension between commercial and cultural values is liable to provoke criticism. For sustained success, such projects must be relevant to the local context and must not overburden public space.

Advertising and PR have clearly become instruments for the creation of an urban culture. As the case studies demonstrate, brands can influence the perception of space by introducing new iconic objects and narratives. Contemporary creative campaigns transform streets into cultural venues. The examples from MTS, Nike, and Yandex demonstrate that audience engagement and positive media are often higher than those of classical advertising formats. The effect is created when advertising steps ‘‘beyond the screen’’ and offers an experience. Technological solutions – generative graphics, AR – imbue messages with an atmosphere of innovation and wonder. Successful campaigns reflect public themes: information technology, sport, gender issues, and so on. This enhances a project's significance and allows city residents to ‘‘read’’ advertising as a cultural marker.

Brands should continue using offline channels as an extension of digital. It is important to select high-engagement formats: interactive screens, street art, AR projects. At the same time, ethical conduct and respect for the city are essential: integration into the urban landscape must take into account the aesthetic and practical interests of residents. Cities and cultural institutions, in turn, can incorporate such projects into strategies for developing public spaces – partnering with companies so that advertising enriches rather than pollutes the urban environment.

With the continued advancement of technology, a growth in hybrid formats is expected – combining offline and online, location-based personalization of advertising, and gamification of the urban experience. Advertising in public space will increasingly be perceived as an element of urban culture that shapes the city's image.

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УДК 659.4:808.5

STRATEGIES AND TECHNOLOGIES OF EFFECTIVE PUBLIC SPEAKING IN ADVERTISING, PUBLIC RELATIONS AND THE ARTS

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Abstract. This article examines the evolution of public speaking in digital advertising, public relations, and artistic communication. It analyzes how classical rhetorical strategies adapt to new media formats. Special attention is given to trust-building technologies and overcoming glossophobia. The article argues that authentic oratory has become a key competitive advantage in creative industries.

Keywords: public speaking, public relations, advertising, oratory, digital communications, reputation management, glossophobia, media discourse.

СТРАТЕГИИ И ТЕХНОЛОГИИ ЭФФЕКТИВНОЙ ПУБЛИЧНОЙ РЕЧИ В РЕКЛАМЕ, СВЯЗЯХ С ОБЩЕСТВЕННОСТЬЮ И ИСКУССТВЕ

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Аннотация. В статье рассматривается эволюция публичной речи в цифровой рекламе, связях с общественностью и художественной коммуникации. Анализируется адаптация классических риторических стратегий к новым медиаформатам. Особое внимание уделяется технологиям построения доверия и преодолению глоссофобии. Авторы доказывают, что аутентичное ораторское мастерство становится ключевым конкурентным преимуществом в креативных индустриях.

Ключевые слова: публичная речь, связи с общественностью, реклама, ораторское мастерство, цифровые коммуникации, управление репутацией, глоссофобия, медиадискурс.

Effective public speaking in the modern world is no longer just an art or a linguistic discipline – it has become a strategic asset in advertising, public relations, and the arts. In an era of information overload, shrinking attention spans, and declining trust in traditional advertising, the ability to speak publicly with clarity, authenticity,

and emotional intelligence directly determines the success of a brand, a campaign, or a cultural project. Politicians, business leaders, artists, and PR professionals all face the same challenge daily: they must persuade, inspire, and motivate their audiences. However, true oratorical success is rarely a natural gift. It is the result of deliberate, systematic work on verbal and non-verbal communication, psychological self-regulation, and deep audience analysis. The digital transformation of the last decade has fundamentally changed not only the channels of communication but also the very expectations of listeners. Today's audience is no longer a passive recipient of information; it is an active participant who can interrupt, question, or simply scroll away. This new reality demands from speakers not only rhetorical skill but also genuine authenticity and the ability to build trust in seconds.

Ethical considerations in public communication deserve special attention, particularly in advertising and PR, where the line between persuasion and manipulation can easily blur. The concept of responsible oratory is gaining traction in professional circles. It implies that the speaker must be fully aware of the power their words have over the audience. Ethical speaking rests on three pillars: respect for listeners, truthfulness of information, and transparency of intent. Using so-called «dark» rhetorical devices – such as equivocation, straw man arguments, or appeals to base emotions – may produce short-term results, but it ultimately destroys trust in the speaker and the brand they represent [1, p. 87]. This problem is especially acute in political discourse and crisis PR, where the temptation to manipulate public opinion is strongest. In the arts, ethical speaking also matters: a curator, director, or artist addressing the public must balance personal expression with social responsibility. Moreover, the rise of cancel culture and public accountability has made ethical communication not just a moral choice but a strategic necessity. A single unethical statement, even if later retracted, can permanently damage a reputation built over years. Therefore, modern speakers in advertising and PR must internalize ethical principles as a core component of their professional competence.

Modern research in neurolinguistics and behavioral psychology reveals that audiences react subconsciously not only to the content of a speech but also to numerous paralinguistic factors. Voice timbre, speech rate, strategic pausing, and eye contact all contribute to what communication experts call the «presence effect» – a state of deep engagement that dramatically amplifies the impact of a performance. According to Albert Mehrabian's widely cited studies, in communication of feelings and attitudes, only 7 % of the message is conveyed through words, 38 % through tone of voice, and 55 % through body language [2, p. 45]. While these exact figures do not apply to all types of information, they powerfully illustrate a crucial point: in public speaking for PR, advertising, or the arts, how you say something often matters more than what you literally say. For a spokesperson managing a reputation crisis, a warm, steady voice and open posture can communicate honesty far more effectively than any carefully scripted apology. Furthermore, recent neuroimaging studies have shown that when a speaker uses congruent verbal and non-verbal signals, the listener's brain exhibits increased activity in regions associated with empathy and trust. Conversely, mismatched signals – such as a smile paired with critical words – trigger alertness and skepticism. This biological evidence underscores the importance of holistic preparation

for any public performance. Speakers must train not only their vocabulary but also their breathing, posture, and gestural expressiveness to ensure that all channels of communication work in harmony.

Media discourse imposes unique demands on today's speakers. In conditions of extreme information overload and declining audience attention, any public communicator – whether a PR manager, a brand ambassador, or a cultural influencer – must adapt their speech to multiple media formats. A television interview, a podcast episode, a Zoom conference call, and a TikTok livestream each require a completely different rhetorical approach. For television, the ability to formulate thoughts into concise, memorable «sound bites» is critical. For podcasts, a more relaxed, almost conversational style works best. Social media, particularly short-video platforms, reward emotional authenticity, spontaneity, and the ability to create «viral» content that balances information with emotional resonance [3, p. 112]. PR professionals today must train their spokespeople not to deliver polished monologues, but to engage in agile, responsive dialogue across platforms. The concept of «transmedia rhetoric» has emerged to describe this phenomenon: a single core message must be adapted into multiple formats, each with its own temporal constraints, stylistic expectations, and audience engagement patterns. For example, a product launch might involve a detailed keynote presentation for industry partners, a series of short teaser videos for social media, a press release for journalists, and an informal Q&A session for live streaming. Each of these formats requires a distinct oratorical strategy while maintaining a consistent brand voice. Failure to adapt leads to either boring the audience with excessive detail or frustrating them with insufficient substance.

Diplomatic discourse offers valuable lessons for PR and reputation management. Diplomatic speech is a constant balancing act between clarity and tact, between stating a position firmly and leaving room for continued dialogue. Its characteristic features include the use of conditional moods («we might consider»), avoidance of categorical statements, and active employment of euphemisms and standardized diplomatic phrases. For example, «We have taken note of our partners' position» often signals polite disagreement, while «We are deeply disappointed» indicates a very strong negative reaction. For a PR professional handling a sensitive issue – such as a product recall, a data breach, or an artistic controversy – mastering this kind of calibrated language is essential. Moreover, when working with translation or cross-cultural communication, one must account not only for the literal meaning of words but also for their cultural connotations and emotional weight. In international advertising campaigns, a phrase that is perfectly acceptable in one culture may be offensive or confusing in another. Therefore, global brands increasingly employ cross-cultural communication specialists who adapt speeches and statements for local markets. This process, known as localization, goes beyond simple translation; it requires a deep understanding of cultural values, humor, taboos, and rhetorical traditions. A speaker who ignores these cultural dimensions risks not only miscommunication but also reputational damage that can affect an entire global brand.

Political rhetoric has a long and rich history, from Cicero to modern televised debates. The core principles of persuasion have remained remarkably consistent across centuries. However, contemporary political discourse has been radically transformed

by new media. «Twitter diplomacy,» Instagram live sessions, and TikTok election campaigns now require politicians and their communication teams to master entirely new strategies. Classical rhetorical devices are being adapted to the digital environment in fascinating ways. For instance, repetition – which Aristotle considered one of the most powerful tools of persuasion – works today in the form of hashtags, memes, and viral slogans. For advertising and PR specialists, this convergence of ancient rhetoric and digital distribution offers a rich toolkit. Understanding how ethos (credibility), pathos (emotion), and logos (logic) function on different platforms is now a fundamental skill in content strategy and brand storytelling. Furthermore, the speed of digital communication has compressed the traditional rhetorical timeline. In the past, a speaker had days or weeks to craft a response to an opponent's argument. Today, social media demands near-instantaneous reactions. This pressure has given rise to new genres of political oratory, such as the «thread» on X (formerly Twitter) or the «story» on Instagram, where arguments are built incrementally across multiple posts. These formats reward brevity, wit, and emotional directness while punishing hesitation and overly complex reasoning. Successful modern politicians, like successful brand managers, have learned to think in «micro-content» – small, self-contained rhetorical units that can be deployed quickly and combined flexibly.

For those seeking to improve their public speaking skills in advertising, PR, or the arts, numerous tested techniques are available. Deep audience analysis remains the most critical preparation step. One must study demographic characteristics, values, prior knowledge, and emotional expectations of the listeners. Structuring a speech according to Simon Sinek's «Golden Circle» (Why – How – What) helps create a logical, persuasive, and emotionally resonant narrative [4, p. 78]. This method suggests starting with the purpose («why this matters»), then moving to the method («how we can achieve it»), and only then describing the concrete outcome («what we offer»). In PR, this sequence transforms a product announcement into a mission-driven story. Voice training must go beyond diction exercises to include techniques for controlling intonation, volume, and tempo. Slowing down at key moments or using dramatic pauses can dramatically increase the emotional impact of a message. Non-verbal communication – posture, gestures, facial expressions, and stage movement – deserves at least as much attention as verbal content. Research shows that speakers who consciously adopt «power poses» before going on stage perform more confidently and are perceived as more competent by audiences. Preparing for questions and objections is another often underestimated aspect. Experienced speakers do not merely anticipate possible questions; they develop structured response strategies. The «bridge» technique, for example, allows a speaker to acknowledge a difficult question and then seamlessly transition to a key message: «That's an important point, and what it reveals is...» Digital tools – from speech analytics software that tracks filler words and pacing to virtual reality applications that simulate audience reactions – are becoming indispensable in modern oratorical training. Finally, systematic practice with structured feedback remains the only reliable path to continuous improvement. Many successful speakers maintain practice journals, record their performances, and work with professional coaches who provide objective, detailed critiques.

The psychological dimension of public speaking deserves special emphasis, especially for professionals in the arts and communications who face intense public scrutiny. Glossophobia – the fear of public speaking – affects up to 80% of people according to recent studies [5, p. 47]. Overcoming this fear requires not only technical coping strategies such as breathing exercises and visualization but also deeper cognitive work on one's beliefs and self-image. Cognitive-behavioral therapy offers effective methods for changing the thought patterns associated with performance anxiety. For a PR executive or an artist, conquering glossophobia is not a luxury – it is a professional necessity. In the creative industries, the ability to speak about one's work with confidence and passion directly affects funding, audience reach, and critical reception. Moreover, the physiological symptoms of glossophobia – racing heart, dry mouth, trembling hands – can be reframed not as signs of weakness but as indicators of readiness and excitement. This psychological shift, known as «anxiety reappraisal» has been shown to improve performance significantly. Speakers who learn to interpret their body's stress response as preparation rather than panic deliver more dynamic and engaging presentations. Workshops and training programs that combine practical speaking exercises with cognitive techniques have proven highly effective. They help participants gradually expand their comfort zones through repeated, low-stakes exposures to public speaking situations. Over time, the fear diminishes not because it disappears entirely but because the speaker develops confidence in their ability to manage it.

In conclusion, in the age of artificial intelligence, deepfake videos, and algorithmically generated content, the genuinely human element of communication has become more valuable than ever. Sincerity, empathy, and the ability to establish authentic contact with an audience are qualities that cannot be fully automated. For advertising and PR professionals, developing oratory skills is not merely a professional requirement – it is a strategic investment in long-term trust. For artists and cultural figures, it is the key to transforming a passive spectator into an engaged participant. Effective public speaking, when practiced ethically and skillfully, remains one of the most powerful tools for shaping meaning, building communities, and driving change [6, p. 15]. Looking ahead, the demand for authentic, skilled oratory will only increase as audiences become more sophisticated and less tolerant of inauthentic communication. Artificial intelligence may be able to generate grammatically perfect speeches, but it cannot replicate the warmth of a genuine smile, the power of a well-timed pause, or the connection created by shared laughter. These uniquely human qualities will continue to distinguish exceptional communicators from merely competent ones. Therefore, investing in public speaking skills is not a short-term tactic but a long-term strategy for anyone seeking to lead, persuade, or inspire in the 21st century.

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УДК 811.111'27:004.77

DISCOURSE MARKERS AS A TOOL OF CULTURAL COMMUNICATION IN THE DIGITAL AGE

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Abstract. This article analyzes the grammatical status and pragmatic functions of English discourse markers in digital cultural communication. It examines how markers such as «so», «well», «actually», and «like» compensate for the absence of paralinguistic cues in text-based online interaction. Special attention is given to their adaptation across digital genres and pragmatic risks. The article argues that mastering discourse markers is essential for digital cultural and artistic communication.

Keywords: discourse markers, digital communication, cultural communication, pragmatics, online discourse, communicative competence.

ДИСКУРСИВНЫЕ МАРКЕРЫ КАК ИНСТРУМЕНТ КУЛЬТУРНОЙ КОММУНИКАЦИИ В ЦИФРОВУЮ ЭПОХУ

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Аннотация. В статье анализируется грамматический статус и прагматические функции английских дискурсивных маркеров в цифровой культурной коммуникации. Рассматривается, как маркеры (so, well, actually, like) компенсируют отсутствие паралингвистических средств в текстовом онлайн-общении. Особое внимание уделяется их адаптации в различных цифровых жанрах и прагматическим рискам, а также владению дискурсивными маркерами для цифровой культурной и художественной коммуникации.

Ключевые слова: дискурсивные маркеры, цифровая коммуникация, культурная коммуникация, прагматика, онлайн-дискурс, коммуникативная компетенция.

The language of digital communication constitutes a dynamic and hybrid linguistic system shaped by technological, social, and cognitive factors. This system operates within a fundamentally different communicative paradigm, characterized by

asynchrony, multimodality, high-speed information exchange, and the absence of traditional paralinguistic cues such as intonation, gestures, and facial expressions. A distinctive feature of this language is not only its specific lexicon (abbreviations, acronyms, neologisms) and simplified syntactic structure, but also the particularly enhanced role of discourse markers. These words or expressions (well, so, like, you know, I mean, anyway, actually, however, therefore), traditionally considered peripheral in grammar, assume a central pragmatic load in the digital environment. They become a key tool for organizing utterances, conveying the speaker's intentions and emotional nuances, managing the interlocutor's attention, and regulating the interaction process itself. In the context of emotional and contextual deprivation of text-based communication, discourse markers compensate for the absence of non-verbal signals, ensuring pragmatic clarity, preventing communicative breakdowns, and maintaining social connection between dialogue participants [1, p. 45].

The digital transformation of recent years has further amplified the importance of these linguistic elements. As more professional and artistic communication moves online – from remote work meetings to virtual art gallery openings and digital PR campaigns – the ability to convey tone, intent, and relationship through text alone has become a critical professional skill. Discourse markers serve as the primary tool for this task, functioning as the digital equivalent of a raised eyebrow, a knowing smile, or a hesitant pause. Without them, text-based interaction risks becoming flat, ambiguous, and even hostile, as the absence of vocal and visual cues often leads to misinterpretation. Thus, mastering discourse markers is not merely a linguistic exercise but a practical necessity for anyone engaged in modern cultural, artistic, or professional communication [2, p. 78].

Discourse markers in the digital environment perform several key pragmatic functions. First, they serve a structuring and metatextual function, organizing fragmented and non-linear information flow. Markers such as «anyway» signal a return to the main topic after a digression, while «as I was saying» resumes an interrupted thought. In long email threads or complex chat conversations, these markers act as signposts, helping readers navigate the logical structure of a message. Without them, digital discourse can become confusing, requiring readers to reread and reorient themselves constantly. Second, they perform a modal, emotive, and evaluative function, conveying the author's subjective attitude, assessment, degree of certainty, or emotional state. «Actually» can introduce polite correction, softening potential conflict. «Literally» often hyperbolizes an assessment for emotional emphasis. «I guess» and «I suppose» express assumption, uncertainty, and politeness, reducing the categorical nature of a statement – especially important in intercultural and professional communication [3, p. 112].

Third, discourse markers fulfill an interactive and cooperative function, directly managing the attention of the virtual interlocutor and maintaining dialogue. Markers such as «look», «listen», «you know», «right?», and «see what I mean?» act as interactive anchors, keeping the addressee within the shared communicative space and stimulating reaction. In a group chat or a collaborative work environment, these markers prevent participants from drifting away or multitasking inattentively. Fourth, they perform a phatic and contact-establishing function. In the absence of physical co-

presence, simple markers like «well...», «so...», or «hmm...» in a response signal that the message has been received, is being processed, and the communication channel remains open. This creates an effect of co-presence and prevents the feeling of talking into a void [4, p. 78]. In customer service chats or PR crisis management, these small markers can mean the difference between a frustrated customer feeling ignored and feeling heard.

The digital environment not only uses existing markers but also actively transforms them, giving rise to new hybrid forms. Graphic and punctuational enhancement compensates for the lack of intonation. An ellipsis after «well...» enhances the effect of a pause or understatement. Caps lock («I mean – SERIOUSLY?») conveys indignation or surprise. Letter reduplication («sooooo...», «okaaaaay») mimics drawn-out pronunciation, expressing doubt, sarcasm, or irritation. Emojis following a marker visualize the emotional tone set verbally [5, p. 134]. This creative adaptation demonstrates the flexibility of language in response to technological constraints. Unlike spoken conversation, where intonation and facial expression are automatic, digital communicators must deliberately choose typographic strategies to achieve similar effects. The choice between «okay», «okaaaay», and «O...K...» carries dramatically different pragmatic meanings, ranging from neutral acceptance to reluctant agreement to sarcastic disbelief. Skilled digital communicators develop an intuitive sense of these distinctions, much as skilled speakers develop control over their vocal tone and pacing.

The functional repertoire of discourse markers strongly depends on the digital genre. In formal email correspondence, structuring and logical markers of the literary register («therefore», «however», «consequently», «furthermore») predominate. In messengers and social networks, colloquial-style markers dominate, often undergoing reduplication to convey lively intonation and emotions («like-like-like», «no-no-no», «okay okay okay»). Digital communication also facilitates the active borrowing and reinterpretation of markers. Internet acronyms such as «btw» (by the way) perform the same introductory function as the full form, while «ikr» (I know, right?) acts as a holistic marker of agreement and empathy. Such elements not only perform a pragmatic function but also carry social-identifying nuance, indicating belonging to a specific online group or subculture [6, p. 201]. For professionals in advertising, PR, and the arts, this genre sensitivity is crucial. A press release sent to journalists requires a completely different marker profile than a social media post aimed at engaging young audiences. Using informal markers like «like» or «you know» in a formal business proposal undermines credibility, while omitting relational markers like «just» or «maybe» from an internal team chat can make a manager seem cold and authoritarian. Context awareness is therefore the foundation of effective digital communication.

Despite their usefulness, incorrect or excessive use of discourse markers can lead to serious pragmatic failures. Overusing mitigating markers and hesitatives («like», «you know», «I mean», «kinda») in business or academic digital correspondence can create an impression of the author's lack of confidence or weak argumentation. Excessive saturation of text with markers, especially in long messages, can hinder perception of the main idea, making discourse «watery» and unstructured. Some markers can be used for manipulative influence: frequent use of «obviously» or

«everyone knows» can present a subjective opinion as universally acknowledged truth, putting pressure on the interlocutor. In diplomatic or high-level business correspondence, an excess of markers creating false significance or ambiguity may be perceived as dishonesty or evasiveness [7, p. 47]. Thus, ethical and effective digital discourse requires a high level of metapragmatic awareness – the ability to select markers in strict accordance with communicative goal, social context, communication channel, and status-role relationships of participants. This ethical dimension is particularly important in advertising and PR, where discourse markers can be used either to build genuine rapport or to manipulate. A brand that overuses friendly markers like «just» and «maybe» while avoiding direct answers may be perceived as deceptive. Conversely, a brand that uses appropriate markers to acknowledge customer concerns and express genuine empathy builds lasting trust. The difference lies not in the markers themselves but in the speaker's intent and self-awareness.

The following practical recommendations can be offered for developing digital communicative competence. Before using a marker, one should clearly define which function it is intended to perform: structuring information, softening criticism, expressing solidarity, or attracting attention. Communicators should consciously select a set of markers appropriate to the communication format, developing a palette of markers for formal writing, semi-formal chats with colleagues, and informal communication on social networks. One should avoid tautology and excessive saturation of text with markers, remembering their purpose is to facilitate understanding, not to overshadow main content. To enhance pragmatic effect and compensate for limitations of the text channel, it is appropriate to combine markers with visual means: emojis for emotions, stickers for reactions, and formatting (bold, italics for emphasis). Finally, regular self-monitoring is essential: rereading sent messages and analyzing the appropriateness and frequency of markers used [1, p. 51]. For non-native English speakers in particular, developing sensitivity to discourse markers presents a significant challenge. Unlike vocabulary or grammar rules, markers are rarely taught explicitly in language classrooms. Their meanings are subtle, context-dependent, and often untranslatable. A Russian speaker learning English, for example, may struggle to distinguish between «actually» (polite correction), «well» (hesitation or disagreement), and «so» (transition or conclusion). Therefore, deliberate study and practice – including reading authentic digital texts, analyzing marker usage in different genres, and seeking feedback from proficient speakers – is essential for achieving true communicative competence in international professional contexts.

In the digital age, discourse markers have transcended their status as optional elements of spoken language and have transformed into a crucial grammatical-pragmatic tool ensuring coherence, clarity, emotional richness, and social harmony in online interaction. They are the glue that holds discourse together amidst fragmentation and the compass that helps interlocutors navigate each other's subtexts and intentions. Understanding their evolution, their specific functioning in different genres, and mastering the skills of their appropriate and effective use constitute the core of digital communicative competence for the modern individual. This competence allows not only for avoiding misunderstandings and conflicts but also for building higher-quality, more productive, and ethical dialogues in virtual space, which has become an integral

part of our social reality. Thus, the study of the grammar and pragmatics of discourse markers is key to mastering the art of digital communication in advertising, public relations, and the arts. As artificial intelligence begins to generate increasingly fluent text, the human ability to use discourse markers with genuine pragmatic awareness – to know when to hesitate, when to emphasize, when to soften, and when to commit – will become an even more distinctive marker of authentic, trustworthy communication. Those who master this subtle art will lead the future of digital cultural exchange.

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УДК 378.4

PROSPECTS FOR THE DEVELOPMENT OF INTERCULTURAL INTERACTION BETWEEN THE UAE AND RUSSIA IN THE CONTEXT OF EDUCATIONAL, SCIENTIFIC AND HUMANITARIAN COOPERATION

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Abstract. This paper examines the prospects for intercultural interaction between Russia and the UAE in higher education, science, and humanitarian policy, while also analysing the economic, political, legal, and cultural factors that influence the feasibility of deepening the partnership. The findings indicate that the UAE represents a promising partner for Russia in these fields, and successful cooperation requires a phased format that takes cultural specific features into account. Furthermore, it is concluded that such interaction strengthens soft power and helps overcome sanctions-driven isolation.

Keywords: Russia, UAE, higher education, humanitarian policy, intercultural interaction, soft power, sanctions isolation, strategic partnership, cultural specific features.

ПЕРСПЕКТИВЫ РАЗВИТИЯ МЕЖКУЛЬТУРНОГО ВЗАИМОДЕЙСТВИЯ МЕЖДУ ОАЭ И РОССИЕЙ В КОНТЕКСТЕ ОБРАЗОВАТЕЛЬНОГО, НАУЧНОГО И ГУМАНИТАРНОГО СОТРУДНИЧЕСТВА

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Аннотация. В работе рассматриваются перспективы межкультурного взаимодействия России и Объединенных Арабских Эмиратов (ОАЭ) в сфере высшего образования, науки и гуманитарной политики, при этом анализируются экономические, политические, правовые и культурные факторы, влияющие на целесообразность углубления партнерства. Результаты показывают, что ОАЭ выступают перспективным партнером для России в заявленных областях, а успешное сотрудничество предполагает поэтапный формат с учетом культурной специфики. Кроме того, делается вывод, что такое взаимодействие способствует

укреплению «мягкой силы» и помогает преодолевать санкционную изоляцию.

Ключевые слова: Россия, ОАЭ, высшее образование, гуманитарная политика, межкультурное взаимодействие, мягкая сила, культурная специфика.

Higher education in Russia is currently undergoing significant changes, and one of the key areas of this transformation is expanding into foreign educational markets and strengthening international cooperation. The United Arab Emirates (UAE) has established itself as a reliable economic and political partner for Russia, making an analysis of the opportunities and conditions for deepening bilateral cooperation in education, science and the humanities particularly important.

This research examines the combination of factors (economic, political, legal and cultural) that influence the decision of the feasibility of deepening Russia's partnership with the UAE in higher education, science and humanitarian policy.

The object of this study is the Russian-UAE cooperation in higher education, science and humanitarian policy.

The objective of this study is to determine whether the UAE is a promising partner for expanding international cooperation in these fields. The UAE's domestic policy is based on a model unique in the modern world: it is a federal constitutional monarchy consisting of seven emirates: Abu Dhabi, Dubai, Sharjah, Ajman, Umm al-Quwain, Ras al-Khaimah and Fujairah. Formally, the head of state is the President, elected by the Supreme Federal Council from among the hereditary emirs; however, de facto, this position is inherited by the ruler of the largest emirate, Abu Dhabi.

The administrative division is a two-tier system: each of the seven emirates maintains a high degree of autonomy, controls its own natural resources, and has its own local governments, while the federal center is responsible for defense, foreign policy, security and immigration. There are no political parties or trade unions in the UAE; the Federal National Council, which serves as a parliamentary body, serves as an advisory body. Political stability in the country is rated as high: the UAE avoids internal conflicts and mass protests thanks to a combination of factors:

– a centralized monarchy, zero tolerance for any criticism of the government, the country ranks 164th out of 180 in press freedom;

– an active foreign policy. The UAE builds multi-layered partnerships with all key players (the US, China, Europe, Russia), avoiding excessive dependence on a single partner;

– an economic model (creation of free economic zones, zero taxation, a liberal visa regime) that attracts capital and talent from around the world. Over the past 25 years, the population has grown 3.25-fold, from 3,493,575 to 11,346,000 people. Approximately 80-90 % of the UAE's population are foreign citizens not involved in domestic political life.

The UAE also boasts a high level of education among its citizens, approximately 98 %, which doesn't lead to increased political demand but rather dampens it. Educated Emiratis gain access to prestigious and highly paid positions in the public sector. They have housing, social security and a stable high income. Urbanization at 87 % ensures that these benefits are concentrated in cities. As a result, educated citizens become the

main beneficiaries of stability and have no economic incentive to disrupt it.

Furthermore, the UAE has developed a comprehensive system of national programs, including the national strategies “We Are the UAE 2031”, “Investment Strategy 2031”, and “UAE Century 2071”. These programs are aimed at developing education, reforming the legislative framework, and creating a competitive national economy.

According to the “We Are the UAE 2031” strategy it was planned to double the country's gross domestic product (GDP). From US$405.7 billion to US$816.9 billion by 2031 [1]. Since the program's inception in 2022, GDP has increased by 14%, reaching US$571.6 billion in 2025, representing 70 % of the target. Since 1980 this figure has increased 13,700,252-fold.

At the same time, the non-oil sector's share of the UAE's real GDP has also steadily increased in recent years and as of 2025 will reach approximately 75.5 %. According to the Federal Center for Competitiveness and Statistics, wholesale and retail trade made the largest contribution to non-oil GDP at 16.1 %, followed by manufacturing at 13.9 %, financial services at 13.5 %, and construction at 11.9 %. These figures indicate that the country is successfully transitioning away from the oil dependence and building a diversified economy. Oil is no longer the primary driver, but logistics, tourism, finance and innovation have taken its place. The UAE economy is becoming more resilient to external shocks and fluctuations in energy prices.

The National Investment Strategy 2031 program aims to transform the UAE into an investment hub by accumulating foreign direct investment to $354 billion and tripling the investment balance to $599 billion by 2031. Although the program was only presented in March 2025, a fund with an initial capital of $10 billion was launched in November 2025. These investments will serve as a tool for the development of five sectors: industry, logistics, finance, renewable energy and IT.

All these programs are included in the main long-term strategy, the UAE Centennial 2071. According to the UAE’s official website the essence of the strategy is to prepare the UAE for its centenary and to become the “best state in the world” across all key indicators of the quality of life, economy and governance. The strategy is based on four fundamental pillars: a future-oriented government; outstanding education (training future specialists with an emphasis on advanced sciences); a diversified economy; and a happy and cohesive society [2].

According to Forbes, the UAE is achieving its goal, strengthening its reputational rankings: 9th place in the Kearney Investment Confidence Index; 10th place among all countries in the Global Soft Power Index; and 7th place among the best countries according to Inter Nations Expat Insider [3].

Artificial intelligence occupies a special place in the “UAE Centennial 2071” strategy, which is seen as a key driver of public administration transformation. Starting in 2026, within two years, 50 % of government sectors, services, and operations will be transferred to autonomous AI-based systems. As part of this program, all government employees will undergo training to develop their AI expertise, making the UAE government one of the most technologically advanced in the world.

Artificial intelligence training is also developing in higher education institutions in the UAE, with leading universities widely integrating AI programs into their curricula. A key milestone was the opening of the Mohamed bin Zayed University of Artificial Intelligence in 2019, the world's first specialized university dedicated entirely to AI.

Significant investments are also being made in scientific research in this field. One example is the opening in 2025 of a joint laboratory between the Abu Dhabi Institute of Technology Innovation and Nvidia – Nvidia's first AI technology center in the Middle East. The laboratory will develop advanced AI models and next-generation robotics platforms. These efforts are aimed at strengthening the UAE's position on the global technological stage and establishing its own technological sovereignty.

Overall, the UAE's higher education system is experiencing rapid growth and is becoming increasingly attractive to students from around the world. The UAE's strategy has focused on developing education, artificial intelligence, and attracting international students, is fully aligned with Joseph Nye's concept of “soft power”, in which a state strengthens its influence not through military coercion, but through the attractiveness of its cultural, technological and educational environment. According to the Ministry of Higher Education in the 2024-2025 academic year 66 higher education institutions reporting enrollment enrolled 57,035 students, a 13 % increase from the previous year and the highest figure in the past decade [4].

The UAE's education system comprises 153 officially recognized higher education institutions across all seven Emirates. Among the country's leading universities are the United Arab Emirates University, Khalifa University, New York University Abu Dhabi, Mohammed bin Rashid University, and University College London in Dubai. Eleven UAE Universities are included in the prestigious QS World University Rankings 2025.

The country offers British, American and French degrees with modern infrastructure, favorable visa regulations, and a safe environment, making it an increasingly attractive alternative to studying in the US or Europe. In 2025 the government passed the Federal Law on Higher Education and Scientific Research, which created a comprehensive legislative framework for regulating the sector, including a national framework for licensing universities, qualifications and scientific research. Thus, the UAE is consistently implementing the “Centennial 2071” strategy, transforming itself not only into an economic and investment hub, but also into a global center of education, science and technology, where artificial intelligence is becoming the foundation of public administration and the training of future generations.

Participation in international organizations is a crucial instrument of foreign policy. The country is building a comprehensive network of institutional ties, actively participating in the work of the Gulf Cooperation Council, the Economic and Social Council of the League of Arab States, the United Nations Economic and Social Commission for Western Asia, and the Standing Committee on Economic and Trade Cooperation of the Organization of Islamic Cooperation. In 2025 the UAE joined the UN Statistical Commission for the period 2025-2028 for the first time, underscoring the country's global leadership in the development of statistical systems and digital

transformation.

Bilateral relations between Russia and the UAE are demonstrating positive momentum, reaching the level of strategic partnership by 2026. By the end of 2025, mutual trade turnover reached a historic high, exceeding $12 billion. A key driver of this growth was the signing of two preferential agreements: the free trade agreement between the EAEU and the UAE, which establishes preferential treatment for 96% of Russian exports, and the agreement on trade in services and investment between Russia and the UAE, which opens access for Russian companies to the UAE market in 64 new areas, including computer, educational, medical services and geological exploration. These situations serve as a classic example of "complex interdependence" according to Kohane and Nay, where multiple channels of communication – from education to trade – make severing the relationship extremely costly for both parties [5]. Educational and scientific cooperation are an important component of the Russian-UAE partnership. According to the Ministry of Science, more than 100 direct cooperation agreements are in effect between universities in Russia and the UAE. A successful example is the Plekhanov Russian University of Economics' branch in Dubai, which opened in 2024. Negotiations are underway to coordinate documents on the mutual recognition of diplomas and qualifications, and the opening of a representative office of the National Research University Higher School of Economics in Abu Dhabi is also underway. This institutionalization of educational ties creates a stable foundation for long-term humanitarian cooperation between the two countries.

The cultural and communicative specific features of the UAE include several key aspects that are important to understand and consider in order to build an effective cooperation with Russia in education and humanitarian policy. First, there are national communication characteristics: UAE culture is based on an indirect communication style, avoiding public conflicts and a lengthy phase of establishing personal relationships before moving on to business. Russia's direct and pragmatic negotiating style requires patience and a willingness to engage in lengthier preliminary communication. Understanding that evasive language from the Emirati side does not always mean refusal helps avoid misunderstandings. Secondly, there are language barriers: the official language of the UAE is Arabic, but English is dominant in education and research. It is important for Russian teachers, researchers and administrators to have a sufficient level of English for an effective academic and business communication. Thirdly, business culture in the UAE includes strict formal rules: a dress code (covered attire for women, suits for men), presenting business cards and handshakes only with the right hand, obligatory acceptance of refreshments (coffee, tea), respect for prayer times and religious holidays, and a non-working Friday.

Thus, the cultural and communicative specific features of the UAE do not pose an obstacle to the Russian-UAE cooperation in education and humanitarian policy, but rather represent a set of characteristics that, with a conscious approach, can be successfully integrated into joint work. An understanding of indirect communication, a willingness to engage in lengthy preliminary communication, a sufficient level of English proficiency, and adherence to local business etiquette standards enable the development of trusting and productive relationships.

Amid sanctions pressure and the need to reorient economic ties toward “friendly” countries, cooperation with the UAE is strategically essential for Russia. The UAE provides Russia with a window onto the rapidly growing markets of the Middle East, Africa and Asia. The 2025 agreements secured preferential access for 96 % of Russian exports, and the record trade turnover in 2025 confirms the high potential of bilateral trade. However, the success of cooperation depends less on macroeconomic agreements than on the ability to build personal, trusting relationships while respecting local cultural norms. Russia's cooperation with the UAE in education and humanitarian policy is no less beneficial than its economic and financial partnership, as it creates the foundation for long-term cultural influence. The following key benefits of the Russian-UAE cooperation can also be highlighted:

First, the UAE is actively investing in artificial intelligence, opening up opportunities for Russia to pursue joint educational programs and academic exchanges: Russian universities offer strong mathematical and algorithmic expertise, while the UAE offers advanced infrastructure and funding, enabling the training of qualified personnel and joint research in automation, cybersecurity, and the application of AI in the oil and gas sector.

Secondly, humanitarian policy through cultural festivals, student exchanges, and the study of official languages fosters mutual trust and a positive image of Russia in the Arab world, which is important for countering information isolation and attracting investment to Russia. This can also lead to political support – in other words, it creates a soft power effect for decades to come.

Thirdly, through student and faculty exchange programs, as well as joint scholarships, Russia gains the opportunity to integrate into the global scientific community through UAE platforms, which act as a neutral hub for conferences, joint publications, and research collaborations with scientists from Asia, Africa, and other regions, thereby circumventing sanctions-related restrictions.

Furthermore, the cooperation between Russia and the UAE should proceed in stages with mandatory cultural preparation. The initial stage will include pilot projects (summer schools, short-term internships, online courses), followed by network programs with dual degrees and joint research centers with remote participation from scientists from both countries. Key elements of the format include mandatory courses in business etiquette, the fundamentals of Islamic culture, and English, as well as the involvement of cultural assistants. This format minimizes risks associated with cross-cultural misunderstandings; language barriers; reputational damage from violations of dress codes and etiquette; clashes in business calendars; and political and censorship restrictions in the humanitarian sphere. The phased approach and remote format allow for testing collaboration without significant investment, adapting to local norms, and avoiding project disruption due to cultural differences.

Thus, the Russian-UAE cooperation in educational and humanitarian fields extends far beyond the cultural exchange. It achieves three strategic objectives:

– it ensures technological sovereignty through joint training of AI personnel,

– creates long-term soft power by fostering loyal elites and a positive image,

– and serves as a tool for overcoming sanctions-related isolation by providing

Russian scientists and students with access to global scientific infrastructure through neutral UAE venues.

By investing in human capital today, Russia and the Emirates are laying the foundation for a sustainable, multifaceted partnership for decades to come. For a successful cooperation, it is desirable that it can be carried out in a phased format with a mandatory cultural preparation.

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При подготовке статьи были применены технологии искусственного интеллекта.

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УДК 81.25+316.77

INTERNATIONAL TERMINOLOGY: HOW TO ACHIEVE MUTUAL UNDERSTANDING IN A MULTILINGUAL SCIENTIFIC COMMUNITY

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Abstract. This article offers a systematic overview of the main aspects of international terminology using the example of several widely used languages of the world (English, Latin, Japanese). We will examine the peculiarities of term formation in different cultural environments, differences in the meanings and usage of the same concepts, as well as the influence of historical context on the development of linguistic terminology. Special attention is paid to the specifics of translating technical and professional terms, the impact of borrowing foreign words and adapting existing concepts to new conditions. The author seeks to show how important it is to take into account linguistic and cultural aspects when translating and interpreting specialised terms.

Keywords: international terminology, historical context, term translation, international communication, cultural adaptation, terminology standardization.

МЕЖДУНАРОДНАЯ ТЕРМИНОЛОГИЯ: КАК ДОБИТЬСЯ ВЗАИМОПОНИМАНИЯ В МНОГОЯЗЫЧНОМ НАУЧНОМ СООБЩЕСТВЕ

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Аннотация. Данная статья предлагает систематизированный обзор основных аспектов международной терминологии на примере нескольких широко используемых языков мира (английский, латинский, японский). Были рассмотрены особенности формирования терминов в разных культурных средах, различия в значениях и употреблении одних и тех же понятий, а также влияние исторического контекста на развитие языковой терминологии. Особое внимание уделяется специфике перевода технических и профессиональных терминов, влиянию заимствования иностранных слов и адаптации существующих понятий

к новым условиям. Автор стремится показать, насколько важно учитывать лингвистические и культурные аспекты при переводе и интерпретации специализированных терминов.

Ключевые слова: международная терминология, исторический контекст, перевод терминов, международная коммуникация, культурная адаптация, стандартизация терминологии.

Terminology plays a key role in communication between people from different cultures and countries. The modern world is characterized by globalization and the strengthening of international ties, which makes the study of international terminology particularly important. Proficiency in correct terminology enables effective information exchange, negotiations, scientific collaboration, and the solution of practical tasks in the fields of economics, politics, culture, and technology. Thus, understanding the peculiarities of terminological differences becomes a necessary condition for successful interaction at the international level.

The aim of this article is to examine the features of international terminology, identify general patterns and trends in the development of term systems in different languages, and propose recommendations for the effective use of terms in intercultural communication.

Language Barrier. One of the key issues is the language barrier that arises when representatives of different peoples interact. English, having become the international language of communication, is often used as a means of conveying specialized information. However, even with a common international language, difficulties in understanding arise due to differences in the interpretation of individual terms. For example, the word *“agreement”* has a wide range of meanings in English, including a legal contract, an agreement between parties, and even consensus. In Russian, this concept is conveyed by different words: *“соглашение”*, *“контракт”*, and *“консенсус”*. This phenomenon requires special attention when drafting documents and agreements. As the renowned linguist Viktor Vladimirovich Vinogradov emphasized, the precise choice of term in the translation of specialized texts is crucial, since an incorrectly selected equivalent can lead to a distortion of meaning and a breakdown in mutual understanding [1, p. 38].

Borrowing Terms and Adapting to Local Realities. Borrowing terms from one language into another is an important process that enriches vocabulary and facilitates communication. This phenomenon is especially prominent in scientific and technical fields, where international terms spread rapidly due to their universality. Examples include such terms as *“computer”*, *“internet”*, and *“technology”*, which are actively used by almost all countries regardless of their native language. However, during the borrowing process, changes in the meaning and form of a term often occur, driven by local traditions and culture. For instance, the French term *“café”* (coffee), which entered the Russian language, acquired additional meanings associated with a cozy place for relaxation and pleasant conversation. Such cases illustrate the complexity of the internationalization of terminology and the need to take local conditions into account when selecting equivalents.

The Influence of Professional Communities on Terminology Standardization. Professional communities and international organizations play a key role in the standardization of terminology, which is especially important for intercultural communication. For example, in the field of information technology, the English term *"software"* has gained universal recognition and has entered most languages with little or no change (*"software"* in German, *"software"* in French). However, in some cases, national communities prefer to create their own equivalents: in French, alongside the borrowing *"logiciel"*, the calque *"programme informatique"* is used, highlighting the connection with programming and computer science. In German, the term *"Software"* has also become established, but *"Programmware"* exists in parallel, reflecting the tendency to create composites from native linguistic resources. This duality demonstrates a balance between globalization and the preservation of linguistic identity.

The Role of International Organizations in Unification. International organizations such as ISO (International Organization for Standardization) and IEC (International Electrotechnical Commission) are actively working to unify terminology. For example, ISO 8601, the standard for date representation (YYYY MM DD), has been adopted by many countries, although national habits persist (in the USA, the MM/DD/YYYY format is common). In the field of ecology, the English term *"carbon footprint"* has achieved global spread, but its translations vary: *"empreinte carbone"* in French emphasizes the "imprint", while *"Kohlenstofffußabdruck"* in German literally means "carbon trace". This shows that even with international standards in place, local peculiarities continue to influence terminology.

Historical Formation of Terminology. Historical context also significantly influences the development of terminology. Terms are shaped by political, economic, and social factors that occurred during a specific period. Take, for example, Latin, which served as the foundation of scientific knowledge up until the Enlightenment. Many modern scientific terms have Latin origins (*"terminus"*, *"definition"*, *"experimentum"*). Their spread was driven by the Age of Discovery and the beginning of intensive knowledge exchange between the peoples of Europe and Asia. The prominent Russian philologist and philosopher Mikhail Mikhailovich Bakhtin emphasized that terms reflect the historical experience of a people and serve as a kind of mirror of the cultural heritage of society [2, p. 301].

Terminological Differences in the Legal Sphere. In the legal field, discrepancies in terminology can lead to serious misunderstandings. The English term *"liability"* covers the concepts of responsibility, obligations, and debt, whereas in Russian these meanings are conveyed by different words: *"ответственность"*, *"обязательства"*, and *"задолженность"*. In French, *"responsabilité"* (responsibility) and *"passif"* (in an accounting context) are used for *"liability"*, while in German *"Haftung"* (legal responsibility) and *"Verbindlichkeiten"* (obligations) are employed. A similar situation occurs with the term *"consideration"* in English contract law, which has no direct equivalent in many languages and requires detailed explanation: in French it is *"cause légitime"*, in German *"Gegenleistung"*. These examples illustrate the need for precise contextual translation in legal documentation.

Economic Lexicon and Cultural Connotations. Economic terms often acquire

additional connotations when transferred to another language. The English *"startup"* has become a global phenomenon, but in French it is often replaced by *"jeune entreprise innovante"* (young innovative enterprise), emphasizing not only novelty but also innovation. In German, *"Startup"* is used (retaining the English form), but *"Gründerzeit"* (time of founding) also exists, referring to the historical context of economic booms. The term *"venture capital"* is rendered in French as *"capital-risque"* (risk capital), highlighting the risk component, and in German as *"Wagniskapital"*, where the root *"Wagnis"* carries the connotation of "adventure" or "bold enterprise". These examples demonstrate how cultural attitudes influence the perception of economic concepts.

Technical Terms and Localization. In technical fields, the localization of terms can lead to differences in understanding. The English *"user interface"* is rendered in French as *"interface utilisateur"*, preserving the structure of the original, and in German as *"Benutzeroberfläche"* (user surface), where the composite emphasizes functionality. The term *"cloud computing"* is often replaced in French by *"informatique en nuage"* (computing in the cloud), which sounds more figurative, while in German *"Wolkenrechnung"* or *"Cloud-Computing"* are used, demonstrating flexibility in choosing between calque and borrowing. Such differences require specialists to have not only language knowledge but also an understanding of the technical standards adopted in a given country.

Cultural Differences and the Specifics of Term Perception. Cultural environment influences the perception and use of terminological vocabulary. For instance, Japanese culture is distinguished by a special attention to detail and precision in formulations, which is reflected in the way Japanese terms are constructed [3, p. 391]. For example, the Japanese term *「コンピューター」 ("konpyūtā") * precisely corresponds to the English word *"computer"*. Nevertheless, its meaning and scope of use differ significantly, taking into account local conditions of technology use and work organization. For example, the term *「リモートワーク」("rimōto wāku") – "remote work"* appeared in Japanese relatively recently and reflects a change in work practices; it carries additional connotations related to corporate culture and work-life balance. This point is confirmed by the philologist and specialist in the field of intercultural communication and translation Viktor Alexandrovich Maslov, who asserts that the correct use of terms is only possible when taking into account the cultural peculiarities of a country and the mentality of its inhabitants [4, p. 435].

Problems in Term Translation. Translation practice faces several difficulties related to the lack of unambiguous correspondences between terms in different languages. The use of bilingual dictionaries and glossaries facilitates specialists' work, but often the accuracy of translation depends on the translator's qualifications and their level of subject-matter expertise. Even the best reference works cannot replace a deep knowledge of the subject and the context in which a given term is used. Let us illustrate this with examples: the English word *"context"* – in French *"contexte"* has a narrower meaning ((more often refers to text), while in German *"Kontext"* is closer to the English meaning. The Russian word *"сопровождение"* (in IT – *"support"*) can change its meaning and be translated differently: in German, *"Betreuung"* emphasizes the process of сопровождение (accompaniment/support), whereas in French,

"assistance" focuses on помощь (help).

Thus, the linguist and specialist in translation theory and computational linguistics Igor Alexandrovich Mel'chuk emphasizes the importance of a deep understanding of the subject area for the effective translation of specialized terminology [5, p. 152]. According to Mel'chuk, an accurate comprehension of the source text ensures the correct selection of the corresponding term in the target language.

Conclusion. International terminology is a complex mechanism that enables effective interaction among representatives of different countries and cultures. It is shaped by historical processes, cultural traditions, and the national characteristics of each people. The success of cross-linguistic communication depends on the careful selection of appropriate terms, consideration of local peculiarities, and the ability to adapt to new situations.

For effective professional activity, it is necessary to have a deep knowledge not only of the language itself but also of the cultural norms prevailing in a given country. Consequently, international terminology can be viewed as a powerful tool for integration and cooperation in today's global environment.

Proper command of terminology facilitates mutual understanding and opens new opportunities for constructive dialogue and productive collaboration among professionals from different countries. This, in turn, allows for more effective implementation of international projects – from scientific research to business initiatives, reduced risks of misunderstanding in diplomatic, legal, and economic negotiations, accelerated adoption of technologies and innovations through clear and unambiguous communication among specialists, strengthened academic cooperation via the standardization of scientific terminology, the development of a shared information space where linguistic and cultural differences do not act as barriers but instead enrich the interaction process.

Therefore, the competent use of international terminology does not merely simplify communication – it serves as the foundation for the sustainable development of a global community based on mutual respect, transparency, and joint work towards common goals.

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МАТЕРИАЛЫ
XIX Международной научно-практической конференции на английском языке «ДИАЛОГ КУЛЬТУР»

2026 ● Часть II

PROCEEDINGS
of the XIX International Scientific and Practical conference in English “DIALOGUE OF CULTURES”

2026 ● Part II

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Научное электронное издание сетевого распространения

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Дата подписания к использованию 27.08.2026. Изд. № 5280/26

Высшая школа технологии и энергетики СПбГУПТД
198095, СПб., ул. Ивана Черных, 4.