

## CONCEPTUALIZING “GREEN” HUMAN CAPITAL IN THE PARADIGM OF THE GLOBAL ENERGY TRANSITION<sup>1</sup>

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The global energy transition, driven by the need to decarbonise the economy and implement the goals of sustainable development, is radically changing the understanding of the driving forces of economic growth. The traditional theory of human capital, which for a long time was based on the anthropocentric principle of *homo economicus* and ignored the environmental context, has proven to be conceptually limited. The realisation that human capital cannot exist in a vacuum and that the degradation of the biosphere accelerates its depreciation has necessitated a revision of established paradigms. Modern science requires new approaches to the interpretation, structuring, and assessment of "green" human capital (GHC) as a key factor in ensuring competitiveness in the context of low-carbon transformation.

The purpose of this chapter is to conceptualise "green" human capital within the paradigm of the global energy transition, as well as to substantiate the mechanisms for the transformation of personnel competencies and the capitalization of "green" knowledge in the corporate governance system.

### **1. The evolution of human capital theories in the context of environmental challenges**

The emergence of human capital theory in the 1960s, marked by the seminal works of Theodore Schultz and Gary Becker, was a true Copernican revolution in economic thought. The recognition of knowledge, skills, and health of the individual as a key factor in economic growth allowed us to overcome the limitations of the classical triangle of labor-land-capital. However, from the perspective of a retrospective analysis of the 21st century, it becomes obvious that the neoclassical foundation of this theory contains a deep conceptual lacuna - a complete disregard for the ecological context of the reproduction of human potential.

G. Becker's methodological approach was based on the principle of *homo economicus*, where investments in a person were considered exclusively through the prism of maximizing individual utility and future income. In this model, "human capital" appears as an isolated autonomous unit, whose productivity depends only on internal investments (education, medicine).

However, this model is extremely anthropocentric. It considers the natural environment only as a passive background or a free repository of resources. Neoclassicists have effectively taken environmental conditions out of the calculation, assuming that the biosphere is an unchanging constant that does not affect the depreciation of human capital.

The main complaint about the approaches of Schultz and Becker is that they treat the environmental consequences of activities as “externalities” that are not included in the cost of human capital reproduction. Within the neoclassical paradigm:

– erosion of health as depreciation -Becker viewed health as a capital asset that depreciates with age. However, he did not take into account the accelerated depreciation of this capital due to environmental

degradation (air pollution, microplastics, climate change). Thus, the social costs of treating the effects of environmental pollution were not included in the investment model;

– education beyond eco-ethics -T. Schultz emphasized the role of education in increasing labor productivity. However, in his works, education was viewed as a tool for intensifying the exploitation of natural resources. Knowledge that leads to the destruction of ecosystems was considered by neoclassicists as a positive capital gain, since it generated short-term profits.

The neoclassical approach relied on the principle of “weak substitutability,” where human capital could supposedly compensate for the loss of natural capital. This illusion of “technological optimism” claimed that the more we invested in brains (human capital), the faster we would find substitutes for depleted natural resources.

Today we understand the fallacy of this thesis: human capital cannot exist in a vacuum. If the ecological system collapses, no amount of IQ or accumulated degrees will be able to ensure the functioning of the economic system.

A critical review of the legacy of Schultz and Becker forces us to move from a “linear” model of human capital to a “circular” or “planetary” one. Modern theory must recognize that:

– the ecological environment is a basic asset that determines the quality of human capital;  
– Investments in humans that harm the biosphere are not capital gains, but hidden losses (decapitalization of the future);  
– Environmental externalities must be internalized into the assessment of the value of human labor and its reproduction.

Thus, the rejection of narrow neoclassical anthropocentrism is not only a requirement of ethics, but also a condition for the survival of economic science in the Anthropocene era.

The publication of the Brundtland Commission report “Our Common Future” (1987) and the subsequent UN Conference in Rio de Janeiro (1992) marked the emergence of humanity beyond the limits of purely economic determinism. The concept of sustainable development did not simply add an “ecological block” to the agenda, it radically changed the architecture of human capital, transforming it from a highly specialized productive resource into the intellectual foundation of the triune system “economy – society – ecology”.

Within the concept of sustainable development, human capital ceases to be just a means of maximizing added value. Its new role is to ensure a dynamic balance between three vectors:

1. economic efficiency -knowledge as a tool for resource conservation and transition to a circular model;
2. social justice -intellectual development as a path to overcoming inequality and inclusion;
3. ecological integrity -understanding the limits of the biosphere and ethical responsibility for preserving natural capital for future generations.

In the sustainable development paradigm, there is a “qualitative leap” in determining what knowledge and skills constitute value. If in the era of industrialism, capital was considered knowledge that allowed for the most effective “conquest” of nature, today the emphasis is shifting to systems thinking (the ability to see the relationship between local production decisions and global climate change); eco-innovation literacy (knowledge aimed at decarbonizing the economy and developing renewable energy sources); ethical competence (the ability to make decisions based on the long-term principle of “do no harm”).

The concept of sustainable development has introduced a critically important distinction between “weak” and “strong” sustainability. While neoclassical assumed that human capital could replace natural capital (technogenic optimism), within sustainable development, human capital is recognized as a tool for preserving, not replacing, nature. Knowledge is now seen as a resource that should prevent the degradation of ecosystems, since the latter are recognized as irreplaceable (critical natural capital).

Sustainable development requires continuous adaptation of human capital to the conditions of ecological turbulence. Education ceases to be a stage of preparation for a profession; it becomes a process of constant rethinking by a person of his place in the ecosystem. This leads to the formation of the concept of “green skills”, which become a mandatory attribute of a competitive employee in any industry - from agribusiness to IT.

Thus, the emergence of the concept of sustainable development transformed the theory of human capital, integrating the ecological dimension into it. Knowledge within the triad “economy - society - ecology” began to be considered not as a means of extracting natural rent, but as the main safeguard against global disasters. Human capital in the 21st century is the ability of civilization to develop without destroying the biological platform of its own existence.

The modern management paradigm, based on the resource-based approach (Resource-Based View - RBV), traditionally considers human and intellectual capital as strategic assets that provide a sustainable competitive advantage due to their rarity and irreproducibility. However, in the context of the global environmental crisis, this approach requires a fundamental rethinking. The theoretical synthesis of the resource approach and environmental ethics allows transforming the classical structure of intellectual capital (human, structural and relational capital) into a new quality - "green" intellectual capital.

The integration of environmental ethics into the individual level of human capital entails the transformation of professional competence, which is now incomplete without "ecological intelligence" - a synthesis of the resource and ethical aspects of activity. In the resource dimension, this allows the organization to accumulate specialists capable of critically minimizing the material intensity of processes, while in the ethical dimension, the employee begins to be guided by an internal moral imperative, where the preservation of the ecosystem becomes a priority over short-term operational efficiency. Thus, the accumulated knowledge is transformed into professional "wisdom," which acts as a safeguard against making technologically advanced, but environmentally destructive decisions, ensuring the sustainability of development at the anthropological level.

Structural capital (databases, processes, patents) in the light of environmental ethics ceases to be just a repository of corporate knowledge. It becomes the architecture of "regenerative management". Organizational knowledge is encoded in the algorithms of the circular economy. Patents and technologies are evaluated not by the volume of future royalties, but by their ability to reduce anthropogenic pressure. Environmental ethics is institutionalized in internal regulations, transforming an "intangible asset" into "ecological brand capital".

In parallel, the transformation of relational capital within the framework of environmental ethics expands the classical understanding of market relations, including the "silent partner" - Nature - in the circle of stakeholders, which requires a revision of strategies for interaction with customers and counterparties. In the new structure, relational capital encompasses community trust in the company's environmental policy and ethical synergy with suppliers, where knowledge about building waste-free supply chains becomes the most valuable element of intellectual capital. This approach converts environmental responsibility into long-term loyalty of a conscious consumer, creating an intangible asset that ensures the strategic stability of the organization in the face of global eco-challenges.

As a result of theoretical synthesis, we obtain a model where environmental ethics is not an external constraint, but an "operating system" of intellectual capital:

- resource approach provides tools (how to do);
- environmental ethics provides goal setting (why do it).

This leads to the emergence of "green innovation capacity" - a higher form of intellectual capital that allows an organization to create economic value in parallel with the restoration of natural capital.

The integration of environmental ethics into the structure of intellectual capital marks the transition from "extractive management" (resource extraction) to "holistic management". In this new retrospective, the most valuable resource of an organization is not just a "smart person", but an "ethical person", whose intellectual efforts are integrated into the natural cycles of the biosphere. Such a theoretical synthesis lays the foundation for the creation of a new type of organization, where intellectual capital becomes the main guarantor of planetary sustainability.

## **2. Terminological field and structure of "green" human capital (GHC)**

In the current conditions of the global energy transition, accompanied by the decarbonisation of the economy, the development of renewable energy sources and the implementation of the principles of the circular economy, a significant transformation of the content and functional purpose of human capital are taking place. These processes are not isolated, but form a new paradigm of socio-economic development, in which the human factor acts not only as a production resource, but also as an effective agent of environmental change.

Traditional approaches to the interpretation of human capital, which focused mainly on labour productivity, professional skills and individual returns on investment in education, are gradually being supplemented by an environmental component, reflecting new requirements for employee competencies. Within the framework of classical concepts, human capital was considered as a factor of economic growth, but its impact on environmental sustainability and long-term balanced development was ignored.

In this context, the concept of «green» human capital is being formed (Green Human Capital, GHC), which is increasingly used in scientific discourse to describe the ability of workers to ensure environmentally friendly development of economic systems. As modern research shows, human capital is becoming an

important factor in achieving sustainable development, since it is the knowledge, innovation and behavioural attitudes of people that determine the efficiency of resource use and the level of environmental load (Šlaus & Jacobs, 2011).

It is important to emphasize that in the context of energy transition, human capital ceases to be a passive element of the economic system. It takes on an active transformational role, influencing the speed and quality of the implementation of low-carbon technologies, the formation of new labour markets, and the adaptation of organizations to environmental challenges.

The analysis of the scientific literature allows us to distinguish several approaches to understanding «green» human capital. First, it is considered as an extension of classical human capital, encompassing environmentally oriented knowledge and skills (Kaushiva, 2025). This approach is evolutionary and reflects the gradual integration of the environmental component into existing theoretical frameworks.

Secondly, GHC is interpreted as a tool for economic transformation, ensuring the transition to a low-carbon development model through the formation of new competencies and professional standards (Nofriansyah and al., 2025). In this case, human capital becomes a catalyst for structural change.

Third, GHC is seen as a corporate sustainability factor that contributes to reducing carbon emissions, increasing energy efficiency, and implementing innovation (Li and al., 2026). This approach focuses on the micro level (organizational level).

Thus, it can be stated that the concept of «green» human capital is multidimensional and encompasses both the individual characteristics of employees and their role in the functioning of economic systems at different levels.

A feature of the current stage is that human capital ceases to be neutral in relation to the environment. It acquires a clearly expressed environmental orientation, which is manifested in the ability of employees to make decisions taking into account the principles of sustainable development, optimize the use of resources and implement environmental innovations. In this sense, «green» human capital becomes not only an economic, but also a socio-ecological category, combining material and non-material aspects of development.

Taking into account the analysis conducted, it is advisable to formulate the following definition: «Green human capital (GHC) is an integrated set of environmentally oriented knowledge, professional skills, innovative abilities, and value and motivational attitudes of individuals that ensure the effective functioning and development of economic systems within the framework of a low-carbon, resource-efficient paradigm and the principles of sustainable development».

The proposed definition emphasizes the multidimensionality of GHC and its role as a systemic driver of the energy transition, and also allows for the integration of economic, environmental, and social dimensions of development.

The formation of the GHC concept occurs at the intersection of several scientific areas: human capital theory, environmental economics, human resource management, and sustainable development theory, which results in a wide terminological field.

One of the important elements of this field is the concept of «green skills», which refers to the knowledge and competences necessary to function in a «green» economy. As Fuchs (2024) notes, such skills are heterogeneous in nature and encompass both technical competences related to the use of renewable energy sources and increasing energy efficiency, and universal competences, including systems thinking, the ability to interdisciplinary interaction and environmental responsibility.

Green skills become the basic tool for adapting the workforce to new conditions, as the energy transition is accompanied by the emergence of new professions, the transformation of existing activities and increased requirements for employee qualifications (Kaushiva, 2025). At the same time, the insufficient level of development of such skills forms the so-called «green skills gap», which slows down the pace of transition to a sustainable economy.

Another important concept is «green human resource management» (Green HRM), which involves the integration of environmental principles into all HR practices: recruitment, training, evaluation and motivation of personnel (Papademetriou and al., 2025). The application of GHRM contributes to the formation of an organizational culture focused on sustainable development and creates institutional conditions for the accumulation of «green» human capital.

The concept of «green workforce readiness» reflects the degree to which existing competencies are relevant to sustainable development. Research shows that the main problem is the gap between the demand for green skills and their supply, which necessitates the reform of the education and training system (Organisation for Economic Cooperation and Development, 2017).

In a broader context, GHC is a component of human capital for sustainable development, which encompasses not only environmental but also social aspects, including quality of life, educational attainment, and social responsibility (Šlaus & Jacobs, 2011).

Given the multidimensional nature of GHC, it is appropriate to consider it as a system of interconnected components.

1. Ecological cognitive resource:
  - knowledge about climate change;
  - understanding the principles of the circular economy;
  - awareness in the field of energy efficiency.

Research shows that knowledge is the basis for shaping environmentally responsible behaviour and decision-making (Darwisman and al., 2025). They ensure the ability of employees to integrate environmental criteria into professional activities.

2. Green Skills (functional and operational component, practical skills): - work with renewable energy sources; - environmental risk management;- implementation of eco-innovations.

Green Skills are critical for the implementation of the energy transition, as they ensure the practical implementation of technological changes (Kaushiva, 2025; Fuchs, 2024).

3. Innovative and adaptive potential – the ability to:
  - generation of new ideas;
  - adaptation to technological changes;
  - participation in the processes of digital-green transition.

Empirical research shows that human capital development combined with digital competencies significantly enhances the effectiveness of decarbonisation (Javed and al., 2025).

4. Value-motivational component (ecological identity):
  - environmental values;
  - environmental responsibility;
  - willingness to change behavioural patterns.

It is this component that determines the depth of integration of environmental principles into the activities of employees and organizations (Papademetriou and al., 2025).

GHC performs a number of basic functions:

1. Innovation function – ensures the development and implementation of green technologies (International Energy Agency, 2023).

2. Transformational function – contributes to changing the structure of the labour market.

3. Environmental function – reduces the carbon footprint of organizations (Li and al., 2025).

4. Institutional function – forms new management standards (ESG, GHRM).

We propose an author's model of the GHC structure (Fig. 1).

The proposed author's model allows us to systematize the structure of GHC and can be used as a methodological basis for further empirical research and practical developments in the field of HRM and energy management.

Thus, «green» human capital is a complex multi-level category that combines knowledge, skills, innovative abilities and values aimed at achieving sustainable development. Its formation is a basic prerequisite for a successful energy transition, since it is the human factor that determines the effectiveness of the implementation of environmental innovations and the transformation of economic systems.

In the current conditions of the intensification of the global energy transition, the problem of not only conceptualizing «green» human capital, but also developing methodological approaches to its assessment and development, is becoming particularly relevant, which is due to the need to form effective human resources management tools capable of ensuring the achievement of the goals of sustainable development and climate neutrality.

At the international level, the issue of developing «green» human capital is in the focus of the activities of leading organizations, in particular the International Labour Organization, Organization for Economic Cooperation and Development and European Commission (ILO, 2018; OECD, 2017; European Commission, 2019). Their analytical and policy documents from the methodological basis for assessing the competences needed for the transition to a green economy.

In particular, within the framework of the International approaches Labour Organization focuses on the concept of «green jobs» and the need to integrate environmental competencies into the vocational education system. The organization defines «green» jobs as those that contribute to the preservation or restoration of the

environment, which, in turn, requires the formation of appropriate human capital. In this context, the GHC assessment involves an analysis of the level of employment in «green» sectors, as well as the degree to which qualifications meet the requirements of sustainable development.

Analytical approaches Organisation for Economic Cooperation and Development are based on the concept of «skills for green transition», which involves identifying, measuring and forecasting needs for «green» skills. The OECD suggests using comprehensive indicators covering:

- the level of environmental education of the population;
- intensity of professional training in the field of sustainable development;
- adaptability of the workforce to technological changes.

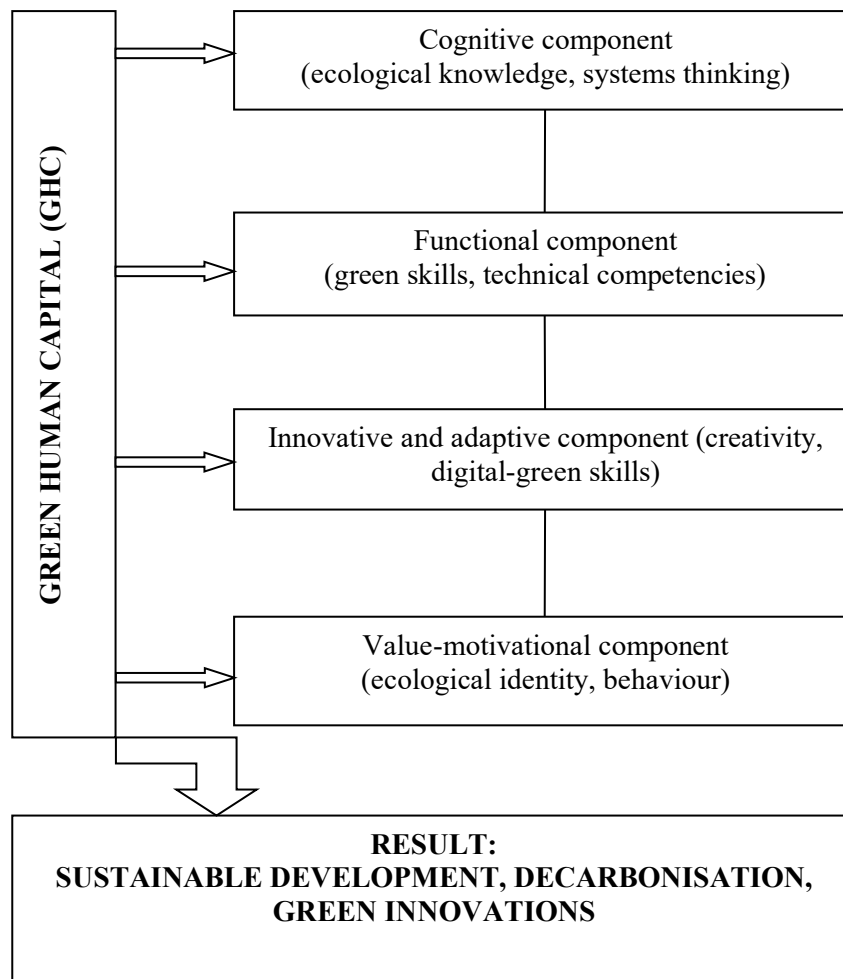
Particular attention is paid to the assessment of the so-called «green skills gap», which characterizes the imbalance between demand and supply of environmental competencies.

Within the framework of the European policy Commission, in particular in the context of the European Green Deal (EGD), human capital development is seen as a key prerequisite for achieving climate neutrality. The European Commission is implementing a number of initiatives aimed at creating a «green» workforce, including retraining programs, developing STEM education, and supporting innovation ecosystems.

Methodologically, the assessment of «green» human capital can be carried out at three levels:

1. Individual level – is basic, since it is individual characteristics that form the overall potential of human capital. It involves assessing:

- level of environmental knowledge;
- availability of green skills;
- formation of environmental values.



*Figure 1. GHC structure model*  
*Source: proposed by the authors.*

2. Organizational level – includes: - integration of GHRM principles; - investments in «green» personnel training; - participation in ESG practices.

At this level, GHC is a factor in the competitiveness of enterprises and their ability to innovate.

3. Macroeconomic level – at this level, the strategic context for GHC development is formed:

- employment structure in «green» sectors;
- state policy in the field of education and the labour market;
- the level of development of the «green» economy.

Synthesizing international approaches, we can identify the following main indicators for assessing «green» human capital: - share of employees with «green» competencies; - level of participation in sustainable learning programs; - intensity of innovations in the field of «green» technologies; - indicators of environmental efficiency of organizations (Table 1).

**Table 1.** GHC Evaluation Indicator System

| Assessment level | Indicator group | Indicators   | Source (assessment method)  |
|------------------|-----------------|--|-----------------------------|
| Individual       | Cognitive       | Level of environmental knowledge; awareness of climate change          | Tests, certification        |
|                  | Green skills    | Proficiency in renewable energy technologies; energy efficiency skills | Professional standards      |
|                  | Valuable        | Environmental awareness; willingness to adopt sustainable practices    | Surveys, ESG questionnaires |
| Organizational   | HRM practices   | Availability of Green HRM; environmental training for staff            | HR reports                  |
|                  | Innovation      | Number of «green» innovations; introduction of eco-technologies        | R&D indicators              |
|                  | ESG             | ESG rating; CO <sub>2</sub> emissions level                            | ESG reporting               |
| Macro level      | Labour market   | Share of green jobs  | Employment statistics       |
|                  | Education       | Share of sustainable development programs                              | Educational data            |
|                  | Economy         | Level of decarbonisation; development of renewable energy sources      | National statistics         |

Source: compiled by the authors based on (ILO, 2018; OECD, 2017; European Commission, 2019; Kaushiva, 2025; Fuchs, 2024)

An important aspect is that the development of GHC should be continuous and integrated into the education system throughout life (lifelong learning), which meets modern challenges associated with rapid technological change and the need for constant updating of competencies.

Thus, methodological approaches to the assessment and development of «green» human capital are based on a combination of individual, organizational and institutional factors, and also take into account international experience and recommendations of leading organizations. Their application allows providing a systematic approach to the formation of human potential capable of functioning effectively in the conditions of global energy transition.

Summarizing the conducted research, it should be noted that «green» human capital is being formed as a qualitatively new category in the context of the global energy transition, integrating economic, environmental and social dimensions of development. Its essence is revealed through a set of environmental knowledge, specialized skills, innovative potential and value orientations that ensure the adaptation of economic systems to the requirements of decarbonisation. The proposed structural model of GHC allows us to systematize its main components and substantiate methodological approaches to assessment. At the same time, international experience confirms the decisive role of human capital as a driver of sustainable development and ecological transformation.

### 3. Impact of energy transition on transformation of personnel competencies

The connection of the energy transition with global trends in sustainable development, ESG and climate policy is crucial for understanding modern transformations in the field of human resources management. The energy transition, which involves the gradual abandonment of fossil energy sources in favor of renewable ones, is a key tool for achieving sustainable development goals, in particular in terms of ensuring environmental safety, rational use of resources and reducing greenhouse gas emissions. In this context, the transformation of personnel competencies becomes not only a consequence of technological changes, but also a necessary condition for their effective implementation.

The concept of sustainable development emphasizes the balance between economic, social and environmental aspects of development, which directly affects the formation of new requirements for human capital. Enterprises are forced to adapt to new standards of operation, implement environmentally friendly technologies and ensure responsible use of resources, which, in turn, requires employees to have the appropriate knowledge, skills and values. Thus, the demand for so-called "green" competencies is growing, which include an understanding of environmental processes, energy efficiency and the principles of the circular economy.

An important role in this process is played by the ESG concept, which integrates environmental, social and governance criteria into the activities of companies. The implementation of ESG approaches stimulates businesses to increase transparency, social responsibility and environmental awareness, which is directly reflected in human resource management policies. In particular, companies are increasingly investing in the development of employee competencies in the field of sustainable development, energy efficiency and digital technologies, as well as forming a corporate culture focused on long-term sustainability.

Climate policy, implemented at the global and national levels, is also a powerful driver of change. Strengthening regulatory requirements for reducing emissions, implementing carbon regulation and developing "green" energy create new conditions for the functioning of enterprises. In these conditions, the ability of personnel to quickly adapt to changes, master new technologies and work in conditions of uncertainty becomes of particular importance. This necessitates continuous training, retraining and development of flexible skills.

Therefore, the energy transition is an integral part of global transformations covering the economic, social and environmental spheres. Its implementation is impossible without a corresponding transformation of personnel competencies, which becomes a strategic priority for enterprises and the state. It is through the prism of these global trends that a new model of human capital development is being formed, focused on sustainability, innovation and responsibility.

The essence of the energy transition from fossil fuels to renewable energy sources is a profound transformation of the ways in which energy is produced, distributed and consumed in order to ensure environmental sustainability, economic efficiency and energy security. The traditional energy model, based on the use of coal, oil and natural gas, has long ensured industrial development, but at the same time has become a source of significant environmental problems, in particular climate change, air pollution and depletion of natural resources. In this regard, there is an objective need to transition to a new energy paradigm based on the use of renewable energy sources.

The energy transition involves the gradual abandonment of carbon-intensive technologies and their replacement with cleaner alternatives, such as solar, wind, hydropower, bioenergy and geothermal energy. These sources are characterized by inexhaustibility, environmental safety and significantly lower greenhouse gas emissions. At the same time, the transition is not limited to changing energy resources, but encompasses comprehensive structural changes in the energy system, including infrastructure modernization, the development of smart grids, the introduction of energy storage technologies and the digitalization of management processes.

An important component of the energy transition is the decentralization of energy systems, which involves increasing the role of local generation sources and actively involving consumers in the energy production process. This model contributes to increasing the flexibility and reliability of energy supply, reducing losses during energy transmission and developing energy democracy. In addition, the concept of "prosumers" is gaining significant popularity, when consumers simultaneously act as energy producers, for example, by installing solar panels.

The energy transition also has a significant economic dimension, as it stimulates the development of new industries, job creation and investment. At the same time, it is accompanied by certain challenges, in particular the need for significant capital investments, the transformation of traditional energy sectors and ensuring social justice in the process of change. Of particular importance is the issue of a "just transition", which involves supporting workers and regions dependent on fossil fuels.

Therefore, the energy transition is a multidimensional process that encompasses technological, economic, social and institutional aspects of development. Its implementation is aimed at creating a low-carbon economy capable of ensuring long-term sustainability and competitiveness. In this context, the transition to renewable energy sources is not only an environmental necessity, but also a strategic direction for global development.

The concept of personnel competencies in modern conditions of economic development encompasses a set of knowledge, skills, abilities, experience and personal characteristics that ensure the effective performance of professional tasks and the ability to adapt to a changing environment. In the context of transformations caused by digitalization, globalization and energy transition, a comprehensive approach to the formation of competencies, which includes hard skills, soft skills, green skills and digital skills, is of particular importance. It is their combination that forms a competitive employee who is able to act effectively in the new economic reality.

Hard skills, or professional (technical) competencies, are specialized knowledge and practical skills required to perform specific work tasks. They are usually acquired in the process of formal education or vocational training and can be clearly measured and assessed. Such competencies include, for example, knowledge of technological processes, possession of specialized software, engineering skills, financial analysis or agronomic knowledge. In traditional industries, hard skills have long been a determining factor in professional success, but in modern conditions they are no longer enough to ensure high employee efficiency.

Soft skills, or flexible (superprofessional) competencies, include social, communicative and personal qualities that determine a person's ability to interact with others, work in a team, resolve conflicts and make decisions under conditions of uncertainty. These include emotional intelligence, critical thinking, creativity, leadership, adaptability, learning ability and time management. In today's dynamic environment, soft skills are becoming key to ensuring the organization's flexibility and its ability to respond quickly to changes. They complement professional knowledge and allow them to be effectively applied in practical activities.

In connection with the intensification of environmental challenges and the development of the concept of sustainable development, a new group of competencies is being formed - green skills. They include knowledge, skills and values related to the rational use of natural resources, reducing negative environmental impact and implementing environmentally friendly technologies. Green skills include understanding the principles of energy efficiency, waste management, knowledge of renewable energy sources, environmental thinking and responsible behavior. These competencies are becoming increasingly important in the context of energy transition, as they ensure the ability of personnel to work in accordance with new environmental standards and requirements.

Digital skills, or digital competencies, are another key element of the modern system of personnel competencies. They include the ability to effectively use digital technologies, work with information systems, analyze data and apply modern automation tools. They include both basic computer skills and digital platforms, as well as more complex competencies related to programming, cybersecurity, big data processing or the use of artificial intelligence. In the context of the digital transformation of the economy, digital skills are becoming a necessary condition for professional activity in almost all areas.

The relationship between technological changes and personnel requirements is one of the key factors in the transformation of modern organizations and the labor market. The development of new technologies, in particular automation, digitalization, artificial intelligence and energy-efficient solutions, leads to significant changes in the content of work, employment structure and the nature of professional activity. In these conditions, personnel requirements are constantly evolving, which necessitates the adaptation of competencies to new technological realities.

Technological changes, on the one hand, contribute to increasing labor productivity and optimizing production processes, and on the other hand, lead to the displacement of traditional professions and the emergence of new types of activities. Automation of routine operations reduces the need to perform standard tasks, while the demand for employees who can work with complex systems, analyze data and make management decisions is growing. This means that a modern employee must possess not only professional knowledge, but also analytical skills, critical thinking and the ability to learn quickly.

A special role in shaping new requirements for personnel is played by digitalization, which changes the ways of organizing work, communication and management. The use of information systems, digital platforms and cloud technologies requires employees to develop digital competencies and readiness to work in a virtual environment. In addition, the integration of artificial intelligence technologies and big data analysis is changing the nature of decision-making, which increases the importance of information interpretation and interdisciplinary knowledge.

At the same time, technological changes increase the importance of flexible skills, as the speed of knowledge and technology renewal requires employees to be highly adaptable. The ability to work in a team, communicate effectively, solve problems and manage change becomes no less important than technical competencies. In this context, the concept of lifelong learning, which involves constant updating of knowledge and development of new skills throughout professional life, acquires particular importance.

In addition, technological transformations associated with the energy transition are creating a demand for environmentally-oriented competencies. The introduction of renewable energy sources, energy-efficient technologies and sustainable development principles requires staff to understand the environmental aspects of their activities and the ability to work in accordance with new standards. Thus, technological changes not only change the tools of work, but also form a new system of values and approaches to professional activity.

Therefore, the relationship between technological changes and personnel requirements is dynamic and interdependent. Technologies determine the direction of competence development, while the level of personnel training affects the effectiveness of their implementation. In these conditions, the success of organizations largely depends on the ability to timely adapt personnel policies to new challenges, invest in human capital development, and create an environment conducive to innovation and learning.

In today's dynamic economic and technological changes, the concepts of reskilling and upskilling, as well as rethinking the role of human capital in transformation processes, are of particular importance. These approaches form the basis for adapting personnel to new labor market requirements caused by digitalization, automation, globalization, and energy transition. They are aimed at ensuring the competitiveness of employees and the sustainable development of organizations in the long term.

The concept of upskilling involves increasing the level of existing competencies of an employee within the framework of his current professional activity. It is about deepening knowledge, improving skills and expanding functional capabilities without changing the main job profile. Upskilling is a response to gradual changes in the requirements for professions, when traditional roles are transformed under the influence of new technologies. For example, the introduction of digital tools in production or management requires employees to master new software products, analytical approaches and methods of working with data. Thus, upskilling contributes to increasing labor productivity, more efficient use of resources and maintaining employment.

Instead, reskilling involves acquiring fundamentally new competencies necessary to perform a different professional activity or transition to a new field. This concept becomes especially relevant in the context of structural changes in the economy, when certain professions disappear or lose their relevance, and new ones appear in their place. Reskilling allows employees to adapt to such changes, avoid unemployment and integrate into new segments of the labor market. In the context of the energy transition, this may mean retraining employees of the traditional energy industry to work in the field of renewable energy sources, energy efficiency or environmental management. Thus, reskilling performs an important social function, contributing to the preservation of human potential.

Both concepts are closely related to the idea of continuous learning, which involves the constant updating of knowledge and skills throughout life. In modern conditions, knowledge quickly becomes obsolete, so the ability to learn becomes a key competency of an employee. Organizations, in turn, are interested in creating corporate learning systems, developing internal educational platforms and forming a knowledge culture that ensures their adaptability and innovation.

In this context, the concept of human capital, which considers employees as a strategic resource that forms the competitive advantages of the organization, is of particular importance. Human capital includes not only professional knowledge and skills, but also motivation, values, creativity, the ability to innovate and adapt. In the context of economic transformation, the role of human capital is being reassessed: it becomes not just a factor of production, but a key driver of development.

Transformational processes are changing approaches to human capital management. The importance of investing in training and development of personnel, forming flexible organizational structures, supporting innovative thinking and creating a favorable environment for employee self-realization is growing. Particular attention is paid to the development of interdisciplinary competencies, a combination of technical, digital and social skills, which allows you to act effectively in conditions of uncertainty.

Therefore, the concepts of reskilling and upskilling are key tools for adapting human capital to modern challenges. They ensure flexibility and mobility of the workforce, contribute to reducing social risks and increasing the efficiency of economic systems. Combined with a new understanding of the role of human capital, these approaches form the basis for the sustainable development of organizations and society in conditions of deep transformations.

The energy transition from traditional fossil energy sources to renewables is significantly transforming the structure of labor demand, which directly affects the formation of new requirements for personnel competencies. This process is accompanied by profound structural shifts in the economy, in particular, a change in the sectoral structure of employment, the redistribution of labor resources and the emergence of new professional roles. As a result, there is a gradual reduction in the demand for workers in traditional energy sectors, such as coal, oil and gas, and at the same time an increase in the need for specialists in the field of renewable energy, energy efficiency and environmental management.

The change in the structure of labor demand is manifested primarily in the transition from physically oriented work to intellectually and technologically intensive activities. If earlier a significant part of the work was associated with the extraction and processing of natural resources, now the role of knowledge, analytical abilities and digital skills is increasing. This means that companies increasingly need employees who are able to work with modern technologies, manage complex systems and make informed decisions based on data analysis. Accordingly, the structure of competencies is changing: along with traditional technical knowledge, the importance of digital, environmental and interdisciplinary skills is increasing.

Another important aspect is the emergence of new professions related to the development of renewable energy sources, such as solar and wind energy engineers, energy management specialists, energy auditors, energy data analysts. At the same time, existing professions are being transformed, adapting to new conditions by integrating environmental and digital components into their activities. This creates a demand for workers who are able to learn quickly and change their professional trajectory in accordance with market needs.

The changing structure of labor demand also has a regional dimension; as different territories depend differently on traditional energy resources. In regions dominated by fossil energy, there is a risk of employment reduction, which requires the implementation of retraining and support policies for workers. At the same time, in regions focused on the development of "green" energy, new jobs are created, which stimulates economic growth and investment.

In addition, not only the quantitative but also the qualitative structure of demand for labor is changing. Companies are increasingly focusing on employees with a high level of adaptability, the ability to innovate and interdisciplinary thinking. Teamwork, communication and change management skills are becoming important, ensuring the effective integration of new technologies into production processes. In this context, the role of continuous learning and competence development throughout professional life is significantly increasing.

Thus, the energy transition is leading to a profound transformation of the structure of labor demand, which is manifested in changing industry priorities, the emergence of new professions, and increasing requirements for personnel qualifications. This process is shaping a new employment model focused on innovation, environmental responsibility, and digital competence, which determines the directions of human capital development in the context of modern global changes.

The energy transition, accompanied by the introduction of renewable energy sources, digital technologies and sustainable development principles, is not only changing the structure of labor demand, but also actively creating new professions and transforming existing ones. This process is systemic and covers both technical and managerial, analytical and service areas of activity. As a result, a new professional ecosystem is being formed, focused on innovation, energy efficiency and environmental responsibility.

The emergence of new professions is a direct consequence of the development of "green" energy and related technologies. In particular, there is a growing demand for specialists in the field of solar, wind, bio- and geothermal energy, who are engaged in the design, installation, operation and maintenance of relevant systems. Such professions include renewable energy engineers, solar panel maintenance technicians, wind turbine specialists, energy project managers. In addition, the development of intelligent energy systems contributes to the emergence of professions related to digital energy management, such as energy data analysts, smart grid specialists, and cybersecurity specialists in the energy sector.

At the same time, traditional professions are being transformed, adapting to new operating conditions. Workers in the fossil energy sector are forced to master new competencies related to environmental standards, digital technologies and energy-efficient solutions. For example, engineers and technical personnel are moving from working with traditional equipment to managing automated systems, monitoring energy processes in real time and using software to optimize production. This means that even within the same profession, the content of work is changing significantly, its intellectual component and qualification requirements are increasing.

Special attention is paid to the emergence of interdisciplinary professions that combine knowledge from different fields, including energy, information technology, ecology and management. Such specialists are able to

comprehensively solve problems related to the implementation of innovative solutions, assessing their effectiveness and managing risks. For example, energy managers combine technical knowledge with management skills, and ESG strategy specialists integrate environmental and social aspects into business processes.

The transformation of professions is also accompanied by a change in the role of the employee in the organization. If earlier the emphasis was on the performance of clearly defined functions, now the importance of versatility, flexibility and the ability to continuous learning is increasing. Employees must be ready to change their professional trajectory, master new roles and perform tasks that go beyond traditional job responsibilities. In this context, the skills of adaptation, creativity, critical thinking and teamwork become important.

In addition, the process of transformation of professions has a social dimension, as it affects employment, income levels and professional mobility of the population. There is a need to create effective mechanisms for retraining and upgrading of skills of workers, which allows to reduce the risks of unemployment and ensure social stability. Educational institutions and enterprises should closely cooperate to form relevant educational programs focused on the needs of the "green" economy.

The energy transition, accompanied by the active implementation of renewable energy sources, digital technologies and sustainable development principles, is leading to a profound transformation of personnel competencies. In this context, several key areas of change can be identified, among which the development of digital competencies, the formation of green skills, the formation of innovative thinking, as well as increasing the level of adaptability and flexibility of employees are of particular importance.

One of the leading directions of transformation is the development of digital competencies, which are becoming a necessary condition for effective operation in the modern energy system. The introduction of smart grids, automated control systems, Internet of Things technologies and big data analysis is changing the nature of professional activity, requiring employees to be able to work with digital platforms, process and interpret information, and make decisions based on analytical data. In particular, the analysis of energy flows, demand forecasting and optimization of resource consumption are becoming an integral part of the work of modern specialists. This means that even traditional technical professions require the integration of digital knowledge and skills, which increases the requirements for the level of personnel training.

In parallel with digitalization, the importance of environmental competencies, or green skills, is growing, reflecting the ability of employees to act in accordance with the principles of sustainable development. In the context of increasing environmental requirements and the transition to a low-carbon economy, employees must have knowledge of energy efficiency, resource management, waste minimization and the impact of production activities on the environment. Green skills include not only technical knowledge, but also the formation of ecological thinking, a responsible attitude to natural resources and an understanding of global environmental challenges. They are becoming an important component of professional competence in many industries, in particular in the energy, industry, construction and agricultural sectors.

Another important direction is the development of innovative thinking, which involves the ability to generate new ideas, find non-standard solutions and implement innovations in practical activities. The conditions of rapid technological change require employees not only to perform the assigned tasks, but also to actively participate in the processes of improving production, optimizing processes and creating new products and services. Innovative thinking is based on creativity, critical analysis, openness to change and willingness to experiment. It helps to increase the competitiveness of organizations and allows them to effectively respond to the challenges of the external environment.

An important component of the transformation of competencies is also the development of adaptability and flexibility of personnel. In today's conditions of instability and uncertainty, the ability to quickly adapt to change is becoming one of the key characteristics of a successful employee. This includes the willingness to master new knowledge, change professional roles, work in interdisciplinary teams and use new technologies. Flexibility is also manifested in the ability to work effectively in different organizational conditions, including remote formats, project activities and dynamic work environments.

These areas of competence transformation are interconnected and complement each other. Digital skills enhance the capabilities of innovative activity, environmental competences form a responsible basis for decision-making, and adaptability ensures the effective application of this knowledge in a changing environment. Together, they form a new model of professional competence that meets the requirements of the energy transition and the modern economy in general. This, in turn, determines the need to revise approaches to education, professional training and personnel management in order to ensure the sustainable development of organizations and society.

The model of personnel competence transformation in the context of energy transition should be considered as a multi-level dynamic system, formed under the influence of interrelated technological, economic and regulatory factors and implemented at the individual, organizational and national levels. Such a model reflects the complex nature of changes in human capital requirements and allows for a systematic approach to managing competence development in the context of the transition to a low-carbon economy.

At the heart of the model is the process of transformation of competencies, which involves updating, expanding and deepening the knowledge and skills of employees in accordance with the new conditions of the economy. The key factors determining the direction and intensity of these changes are technological, economic and regulatory influences. Technological factors include the development of renewable energy sources, digitalization, automation of production processes, the introduction of intelligent energy systems and data processing technologies. They are the ones that shape new requirements for professional and digital competencies, stimulating the demand for interdisciplinary knowledge and innovative thinking.

Economic factors determine the resource capabilities and motivation for the transformation of competencies. These include changes in the structure of the labor market, increased competition, investment activity in the field of "green" energy, as well as the need for enterprises to increase efficiency and reduce costs. Economic incentives encourage organizations to invest in personnel development, implement training and retraining programs, and employees to increase their own competitiveness by acquiring new skills.

Regulatory factors include government energy policies, environmental standards, international commitments to reduce emissions, and educational and social policies. They create an institutional environment that defines the rules of the labor market and stimulates the development of certain competencies. For example, the introduction of energy efficiency standards or support for "green" energy contributes to the formation of demand for relevant knowledge and skills.

These factors are implemented through a system of levels of competence transformation. At the individual level, the key role is played by the employee's ability to learn, adapt and self-develop. It is here that the direct formation of new competences takes place through the processes of upskilling and reskilling, mastering digital tools, developing ecological thinking and flexible skills. Motivation for learning, openness to change and readiness to change professional trajectory are important.

At the organizational level, the transformation of competencies is associated with the formation of an effective human resource management system, which involves the implementation of corporate training, the development of internal educational platforms, the creation of conditions for knowledge exchange and the support of an innovative culture. Organizations are key agents of change, since they are the ones who define the requirements for competencies, invest in the development of employees and create an environment for the realization of their potential. In this context, strategic planning of personnel development, the integration of sustainable development principles into personnel policy and the use of modern learning technologies are important.

At the national level, the transformation of competencies is ensured through state policy, the education system and the labor market. The state plays an important role in shaping the regulatory framework, supporting educational reforms, developing vocational training and retraining programs, as well as stimulating cooperation between educational institutions and business. It is also important to ensure social support for employees in the transformation process, which helps reduce the risks of unemployment and social tension.

Thus, the proposed model of personnel competence transformation reflects the complex nature of changes occurring under the influence of the energy transition. It emphasizes the need for coordinated actions at all levels — from individual to national — and taking into account key influencing factors that determine the effectiveness of this process. The implementation of such a model contributes to the formation of competitive human capital, capable of ensuring sustainable economic development in the context of global transformations.

In the current conditions of energy transition and rapid technological transformation, enterprises are faced with the need not only to adapt production processes and technologies, but also to form highly qualified human capital capable of functioning effectively in new realities. Practical aspects of staff competency development in the context of these changes are of particular importance, since the organization's ability to innovate, energy-efficient management, and integrate sustainable development principles into its own practice depends on the level of employee training. The main recommendations for enterprises concern the development of personnel training systems and the implementation of the concept of lifelong learning.

The development of personnel training systems is a basic mechanism for forming the necessary competencies in response to changes in the technological, economic and regulatory environment. To effectively implement such systems, enterprises should focus on several key principles. First, training

programs should be comprehensive and include both professional and technical and interdisciplinary components that cover digital skills, innovative thinking and environmental responsibility. For example, employees of energy enterprises should have knowledge of smart grid management, energy data analysis, energy audit and assessment of the impact of production activities on the environment. Such comprehensive training provides the opportunity to effectively adapt to new technologies and market conditions. Secondly, learning systems should be integrated into the internal organizational structure and processes. This involves creating corporate educational platforms where employees can take online courses, participate in workshops and practical training, and receive mentoring from experienced colleagues. Integrating learning into work processes allows you to combine theoretical training with practical application of knowledge, increases motivation for learning, and contributes to the formation of a culture of continuous professional development. Special attention should be paid to adaptive training programs that can be adjusted to the level of training and individual needs of employees.

Third, an effective training system should provide for regular assessment of personnel competencies and feedback. Assessment of knowledge and skills allows you to identify gaps in training and timely adjust training programs. The use of assessment tools, such as testing, simulations, case studies and project tasks, allows you to determine the level of practical training and the effectiveness of mastering new competencies.

The implementation of the concept of lifelong learning is the next critically important aspect of transforming personnel competencies. In today's conditions of rapid technological change, knowledge and skills become obsolete much faster than before, so continuous learning is becoming a prerequisite for maintaining the competitiveness of the enterprise and the personal development of employees. Lifelong learning involves the formation of employees' sustainable motivation for self-learning, the ability to quickly master new technologies, adapt to new professional requirements and actively participate in the process of updating knowledge.

The practical implementation of lifelong learning includes several elements. First, companies should create internal incentives for learning, including a system of bonuses, career prospects and recognition of achievements in the development of competencies. Second, it is important to provide access to a variety of learning resources - online courses, webinars, internal knowledge libraries, the opportunity to participate in industry conferences and professional associations. Third, it is necessary to integrate learning into daily activities through project work, mentoring and knowledge exchange between employees of different departments and levels. This approach contributes to the formation of systems thinking and the ability to quickly adapt to change.

Special attention should be paid to the development of competencies in the field of digital technologies and green skills. Employees should regularly improve their skills in working with intelligent energy systems, data analysis technologies, energy efficiency software, as well as master the principles of environmentally responsible production and resource management. This knowledge ensures the effective integration of innovations and supports the organization's sustainable development strategy.

Thus, the practical aspects of transforming personnel competencies boil down to creating an effective training system that combines corporate educational programs, adaptive training and performance assessment, as well as implementing the concept of continuous learning. This allows enterprises to form highly qualified, adaptive and innovatively oriented personnel capable of effectively responding to changes in the technological and economic environment, supporting the energy transition and contributing to the long-term competitiveness of the organization.

The energy transition, driven by the global drive to decarbonize the economy and develop renewable energy sources, is significantly transforming the requirements for personnel competencies and creating demand for so-called "green" professions. In these conditions, it is important for employees not only to adapt to new technological realities, but also to proactively shape their own trajectory of professional development, focused on the principles of sustainable development. The practical aspects of such an orientation include, first of all, awareness of changes in the structure of the labor market, where the need for specialists in the fields of renewable energy, energy efficiency, circular economy and environmental management is growing. It is advisable for employees to regularly monitor industry development trends, analyze the demand for competencies and identify promising areas of professional implementation.

An important practical step is the development of digital and technical skills, which are becoming basic for most "green" professions. In particular, knowledge in the field of data analysis, automation of production processes, work with energy systems and software for monitoring resources significantly increase the competitiveness of an employee. Along with this, the role of interdisciplinary competencies that combine

technical knowledge with environmental thinking, economic analysis and management skills is growing. Therefore, employees should invest in lifelong learning, including online courses, certification programs and professional training focused on sustainable development and "green" technologies.

Equally important is the formation of environmental awareness and a responsible attitude towards resources, which is manifested both in professional activities and in everyday behavior. Employees must understand the principles of energy efficiency, emission reduction and waste management, as well as be prepared to implement appropriate practices in the workplace. In this context, it is important to develop the so-called "soft" skills, including the ability to adapt, critical thinking, teamwork and innovation, which contribute to effective functioning in conditions of constant change.

Among the recommendations, it is also worth highlighting the need for active interaction with professional communities, participation in industry events, internships and projects related to the green economy. This allows not only to obtain relevant knowledge, but also to expand professional contacts and increase one's own mobility in the labor market. In addition, it is advisable for employees to form individual plans for the development of competencies focused on specific "green" professions, taking into account their own experience and potential.

Summarizing the above, it is appropriate to emphasize that the energy transition is a system-forming factor of deep transformations in global and national economies, labor markets and approaches to human capital management, integrating key imperatives of sustainable development, the ESG paradigm and modern climate policy. Its essence goes far beyond purely technological changes in the energy sector, encompassing the structural restructuring of economic systems, changes in production and consumption models, as well as the transformation of social and labor relations. In this context, the energy transition should be considered as a multidimensional process that forms a new economic reality focused on low-carbon development, resource efficiency and innovation.

It is important to emphasize that the implementation of the energy transition entails significant changes in the structure of labor demand, which is manifested in a gradual reduction in employment in traditional energy sectors and a simultaneous increase in demand for specialists in the fields of renewable energy, energy efficiency, digital technologies and environmental management. This leads to the emergence of new professions, transformation of the content of existing activities and strengthening the role of interdisciplinary competencies. As a result, a new professional ecosystem is formed, dominated by intellectually rich, technologically complex and environmentally oriented types of work.

In such conditions, the key factor in ensuring the competitiveness of both employees and organizations is the ability to transform competencies in a timely and effective manner. A modern employee must possess a set of interrelated competencies, including professional (hard skills), flexible (soft skills), digital (digital skills) and environmental (green skills). It is their synergy that ensures the ability to function effectively in a dynamic, uncertain and technologically saturated environment. In this case, such characteristics as adaptability, the ability to continuous learning, critical thinking, innovation and responsibility for the environmental consequences of professional activity become particularly important.

No less important is the realization that the transformation of competencies cannot occur spontaneously or fragmentarily. It requires a systemic approach that covers the individual, organizational and national levels. At the individual level, the employee's desire for self-development, readiness to master new knowledge and change the professional trajectory are decisive. At the organizational level, an effective personnel management system plays a key role, which involves investing in training, developing corporate educational platforms, forming a knowledge culture and supporting innovative activities. At the national level, it is necessary to create a favorable institutional environment that includes a modern education system, state retraining programs, supporting employment and stimulating the development of a "green" economy.

A special role in ensuring effective transformation of competencies is played by the concepts of upskilling and reskilling, which allow both to deepen existing professional knowledge and to master new types of activities in accordance with the needs of the labor market. In combination with the concept of lifelong learning, they form the basis for ensuring flexibility and mobility of the workforce, reducing social risks and maintaining stability in the face of structural changes. At the same time, these approaches contribute to increasing the efficiency of the functioning of organizations, as they ensure the availability of personnel capable of implementing innovations and effectively using modern technologies.

In addition, the transformation of personnel competencies in the context of energy transition has an important social and value dimension. The formation of environmental awareness, a responsible attitude to natural resources and an understanding of global environmental challenges is becoming an integral part of

professional training. This contributes not only to increasing the efficiency of production processes, but also to the formation of a new management culture focused on long-term sustainability and social responsibility.

Thus, the transformation of personnel competencies in the context of energy transition is not just a response to external challenges, but a strategic prerequisite for the formation of a new model of human capital development. It determines the ability of the economy to innovative development, ensures its competitiveness in the global environment and contributes to the achievement of sustainable development goals. In the long term, it is the effective combination of technological change, human capital development and institutional support that will become a key factor in the successful implementation of the energy transition and ensuring environmentally safe and socially oriented development of society.

#### **4. Mechanisms of capitalization of “green” knowledge in corporate governance**

In the context of modern financial globalization, the assessment of a company's market value depends less and less on tangible assets and more and more on the ability of management to effectively manage sustainable development risks, where the key indicator of the quality of Green Human Capital (GHC) is non-financial reporting according to ESG (Environmental, Social, Governance) standards. In this scientific context, investments in "green" education of employees are transformed from the category of operating expenses into a strategic asset, which directly correlates with business capitalization through the mechanism of reducing risk premiums.

The environmental component (E) is due to the fact that personnel with competencies in the field of energy efficiency and waste management minimize the likelihood of environmental fines and man-made accidents, which signals to the investor the low volatility of future cash flows.

At the same time, the management component (G) demonstrates that the presence of educational programs in ethical management and sustainable development indicates a high quality of corporate governance, where the transparency of processes, based on the professional knowledge of the staff, significantly reduces agency costs.

The market value of public companies often significantly exceeds the value of their net assets, and this gap, known as goodwill, is largely filled by intellectual capital, where the signaling function of reporting plays a special role: when a company displays data on the number of hours of “green” training per employee and the percentage of certified eco-managers in an ESG report (for example, according to GRI or SASB standards), it sends a signal to the market about the high quality of its green human capital (GHC), which causes an appropriate reaction from investors, as funds focused on socially responsible investment (SRI) include such companies in their portfolios, creating additional demand for shares and stimulating the growth of their exchange value.

The process of converting employee knowledge into market value can be represented as a logical sequence:

1. investment - in expenses for training on decarbonization, circular economy and eco-design,
2. GHC accumulation - with growth of intellectual potential and change of corporate culture,
3. efficiency - in implementing eco-innovations, reducing resource consumption, improving operational performance,
4. reporting (ESG) - in verification of the achieved results by independent auditors,
5. market valuation - with decreasing cost of capital (WACC) and increasing multipliers (P/E, EV/EBITDA).

The transition from qualitative descriptions (“we care about nature”) to quantitative indicators of knowledge capitalization requires the use of specific metrics:

– ROI in eco-education - with half the ratio of resources saved due to employees' ideas to the cost of their training,

– Green Engagement Index - in knowledge flow on staff turnover (highly qualified specialists are more likely to choose companies with a clear eco-mission, which reduces recruitment costs).

ESG reporting has ceased to be a PR tool and has become a mirror of the quality of human capital. Companies that invest in "green" education receive a double effect: direct resource savings internally and higher external valuation. Thus, GHC is not just an ethical choice, but a fundamental financial asset that determines the winners in the competition for capital in the 21st century.

In the system of modern corporate governance, the concept of L&D (Learning and Development) is undergoing a fundamental transformation under the influence of environmental challenges. Green L&D appears not simply as a set of educational programs on ecology, but as a strategic model for the formation of eco-oriented thinking, integrating environmental responsibility into the professional DNA of each employee.

Knowledge capitalization in this context occurs through the creation of an intellectual environment where the ability to ecological reflection becomes part of the qualification.

**1. The “70-20-10” model in the mirror of greening.** The traditional 70-20-10 learning model (experience, interaction, courses) takes on a specific “green” color:

– 70 % - practical experience (Green Action Learning). Involving employees in real projects on energy audits, reducing carbon footprints, or transitioning to a paperless office. Knowledge is capitalized directly in the process of solving the organization's environmental problems.

– 20 % - social learning (Green Mentoring). Forming communities of eco-ambassadors within the company. Sharing experience between departments on the implementation of sustainable practices creates a knowledge "cross-pollination" effect.

– 10 % - formal education (Green Micro-learning). Distance learning courses, webinars, and certifications (e.g., ISO 14001 or GRI standards) that provide a theoretical basis.

**2. The concept of continuous eco-education (Green Lifelong Learning).** Developing eco-friendly thinking requires a transition from discrete learning to a continuous cycle. This is achieved through:

– eco-onboarding - with hiring with the company's environmental values from the first day of work.

– gamification of eco-initiatives - using mobile applications to track an employee's individual contribution to the company's environmental sustainability (for example, collecting points for sorting garbage or saving resources), which stimulates curiosity and engagement.

**3. Models of thinking transformation: from anthropocentrism to ecocentrism.** The key task of Green L&D is to change mental models. We identify three stages of this transformation that should be supported by educational mechanisms:

– cognitive level - understanding environmental facts and risks,

– affective level - development of empathy for nature and a sense of personal responsibility,

– behavioral level - automation of "green" habits in professional activities.

Modern learning platforms allow for the use of adaptive algorithms to personalize eco-education. Using VR simulators to practice scenarios of responding to environmental risks or simulate the product life cycle allows employees to “feel” the consequences of their decisions, which significantly accelerates the capitalization of the acquired experience.

Green L&D is the main mechanism for reproducing “green” human capital. Continuity of learning ensures that eco-oriented thinking becomes not a temporary trend, but a stable characteristic of organizational culture. Capitalization here is manifested in the company’s increased adaptability to changes in the regulatory environment and the ability of personnel to generate innovations that meet the requirements of sustainable development.

In modern strategic management theory, an organization's ability to innovate is considered as a function of its intellectual base. However, in the context of energy transition, a specific dependence arises: the implementation of energy-saving technologies (EST) requires not just a general high level of qualification, but the availability of specialized "green" human and structural capital. Knowledge capitalization in this segment occurs through the mechanism of lowering barriers to the adoption of technological innovations and accelerating the diffusion of eco-efficient practices within the company.

The direct connection between the level of "green" capital and the implementation of EOT is based on the phenomenon of "Absorptive Capacity", according to which a company with a high level of eco-knowledge is able to identify and recognize the potential of new energy-saving solutions (for example, heat pumps, recuperation systems or AI-optimization of energy networks) at an early stage, assimilate and integrate these solutions into existing production cycles without destabilizing processes, and commercialize the results obtained, turning saved energy resources into a competitive advantage in the form of lower product costs.

A high level of "green" capital changes the vector of technological development from reactive, which involves only the implementation of environmental regulations, to proactive, aimed at independently finding ways to achieve energy independence, with the human factor playing a key role, where employees with "green" thinking act as initiators of micro-innovations and kaizen proposals, which together provide a significant energy-saving effect, as well as a structural factor, since the presence of energy audit databases and carbon footprint monitoring systems in the company allows making informed decisions about implementing the latest technologies based on accurate calculations of the return on investment (ROI).

Energy-saving technologies are the material embodiment of "green" knowledge. The capitalization process in this chain looks like this:

1. Investment in intelligence -training personnel in lean production methods (Lean Green).
2. Technological implementation -implementation of closed-loop systems or energy-efficient equipment, which was made possible thanks to the competencies of engineers.
3. Financial result -direct reduction in operating costs for energy carriers (OPEX).
4. Market valuation -capitalization of energy efficiency through net profit growth and improved ESG rating, which makes the company more attractive for "green" investments.

One of the main obstacles to energy modernization is the internal resistance of personnel to new, more complex management systems. "Green" capital acts as an antidote to this resistance. When employees understand the environmental and economic logic of energy saving, they become not just users, but co-developers of innovations. This shortens the implementation period of energy saving projects and increases their actual effectiveness.

Thus, "green" capital is a critical catalyst for eco-innovation. The direct correlation between the level of environmental education of personnel and the intensity of the implementation of energy-saving technologies proves: the capitalization of knowledge in modern corporate management occurs not only in the cloud of intellectual assets, but also in the completely physical dimension of saved joules and kilowatt-hours. Energy efficiency is intelligence frozen in metal and software.

The research conducted within this section allows us to formulate a number of conceptually important conclusions that have both theoretical and applied significance for shaping personnel policy in the context of the global energy transition. In the 21st century, green human capital is a fundamental financial asset and the main guarantor of civilization's ability to develop without destroying the biological platform of its own existence. Further research should be directed toward the development of quantitative methods for assessing GHC, the adaptation of educational programs to the requirements of the green economy, and the formation of institutional mechanisms to stimulate eco-oriented behavior at all levels of management.

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