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IMPACT OF DIGITAL MATURITY ON SUSTAINABLE DEVELOPMENT EFFECTS IN ENERGY SECTOR IN THE CONDITION OF INDUSTRY 4.0

Purpose. To study the impact of digital maturity of energy enterprises on achieving the effects of sustainable development in the conditions of the fourth industrial revolution.

Methodology. The study on energy enterprises' economic efficiency was based on the results of a statistical analysis of their activity economic indicators and a macroeconomic analysis of the prerequisites for the digitalization of Ukrainian energy companies, as well as considering the results of an analytical study of foreign companies' digital transformation. The application of the benchmarking method made it possible to highlight the best examples of digital changes of energy companies in the field of sustainable development. The generalization method made it possible to point out the effects of digitization of sustainable development for energy companies.

Findings. Effectiveness of energy enterprises due to the implementation of digital transformation is reasoned, which allows achieving the effect of sustainable development by ensuring environmental, economic, and social development. Based on the calculation of economic efficiency values, the most efficient energy enterprise was determined, whose activity is characterized by the highest level of digital transformations aimed at achieving the goals of sustainable development.

Originality. The dependence between the level of digital maturity of energy enterprises and their economic efficiency is substantiated. The spheres of energy enterprises activity have been established, whose efficiency and importance increases with the level of digitalization. The technical characteristics of energy enterprises' digitalization in the spheres of implementation of sustainable development goals, namely economic, social, and environmental ones, are highlighted.

Practical value. The main directions of energy enterprises' activity have been determined based on the selection of the effects of sustainable development, which are achieved thanks to digitalization. The efficiency of the enterprise because of digitalization is substantiated, considering the directions of sustainable development.

Keywords: *digital maturity, energy, sustainable development, Industry 4.0*

Introduction. The development of energy in the world takes place under the influence of economic, political, and environmental differences in the development of various countries of the world and focuses the attention of scientists and researchers on the use of modern innovative achievements. The study on the issue of digital maturity creates conditions for the implementation of the best business practices, the introduction of innovative technologies, the involvement and unification of all parties interested in global changes, by identifying and eliminating weak links in the implementation of current changes, technological inconsistencies, differences in economic development, etc. The study on digital maturity and, accordingly, digital transformation today is focused not only on technical and technological development itself, but also on solving various types of needs based on it, in energy resources, overcoming economic backwardness, and creating conditions for meeting the needs of sustainable development.

Sustainable development is an effort to stop the negative impact of human activity on the conditions and quality of life. An important feature of the sustainable development concept is that it cannot be ensured at the level of activity of a single organization or country. These are efforts that must be applied systematically, bypassing borders and nationalities. The state of digital maturity is precisely the potential of the enterprise that allows implementing measures for sustainable development, integrating the activities of business entities into supply chains and changing the managerial and technical components of development in accordance with the needs and goals of sustainable development.

The activity of energy companies deserves special attention. The desire to reduce dependence on traditional sources of energy supply stimulates countries to develop their own energy potential. However, it is impossible to eliminate this dependence. According to the measures implemented today in the field of energy independence, the structure of sources of energy resources is shifting from the dominant use of fossil energy resources to the use of alternative ones. As the result of today's trends, investments in the sustainable development are growing. There has been a more than 67 percent increase in deals since 2018, with a total of US $2 billion invested globally in sustainability-themed start-ups [1].

The study on digital maturity allows identifying those areas of the organization's activity that hinder the process of digital changes and focus attention on the possibilities of achieving goals. Thus, digitalization trends make it possible to implement tools of sustainable development, particularly in the energy sector, due to the introduction of new mindset and technologies. Therefore, the topic of the article is relevant and timely.

Literature review. The concept of digital maturity, which is quite often found in scientific sources, is associated with the ability of organizations to optimize their activities through data analysis, participation in information networks, use of technologies based on artificial intelligence, etc., to anticipate future needs and challenges and accordingly improve digital efficiency and the effectiveness of the organization. From here, we can say

that digital maturity is related to the maturity of the organization, that is defined as the readiness for a certain management model which aims at better performance of tasks and determines the necessary improvements by developing a system of criteria that will allow comparing results with competitors, strategic partners, or customers. Digital maturity is considered as a necessary condition of digital transformation for start-up companies and characterizes the degree of their ability to create value through the ability to predict potential success [2].

Noteworthy are the results of a study by Capgemini and the MIT Digital Business Centre [3], which focuses on digital maturity as a function of two dimensions, namely: digital intensity that covers the amount of investment of the enterprise in digitalization and is measured by agreed areas of digital transformation (for example, a portfolio of digital projects); the intensity of digital transformation management or digital support of the enterprise, which requires the presence of a digital vision, takes into account the effectiveness of the digital strategy, etc. In our opinion, these two dimensions are interdependent and complementary. After all, digital intensity depends on the intensity of digital transformation management, and it depends on investments in relevant digitization measures. We note that the digital transformation of an enterprise can take place with different dynamics and intensity, either evolutionary or revolutionary. This depends on the current digital maturity of the organization, hence determining the state of digital maturity at the start stage of digital transformation is the initial logical step towards digital changes.

The spread of the ideas of Industry 4.0 in the research of Ukrainian and foreign scientists allows us to conclude that there is no universal approach to how to achieve progress in the digital world. Below are examples of what digital transformation priorities companies are considering in different countries.

Thus, the manufacturing enterprises of the Central and Eastern Europe countries consider the following parameters to be the most important for assessing digital maturity: Internet of things, big data analytics and artificial intelligence [4]. Another example of assessing the digital maturity of enterprises distinguishes 4 levels and highlights such important areas as technology, organization and social dimensions and corporate strategy [5]. The next example of criteria for assessing the level of digital maturity points out preparation, computerization, connectivity, transparency, predictability, adaptability, which depend on specific criteria applied both to systems under development and to company systems [6]. The authors of studies [7] pay attention to the following two factors of digitalization – the technology that causes digital changes and the actor as subjects that determine and implement digital changes.

The results of consulting companies' research deserve attention as well. McKinsey confirmed the priority importance of technologies for digital transformation, and this was especially evident for substantiating the capabilities of companies in the post-pandemic period [8]. In addition to researching the drivers of digital change, another consulting company, Deloitte, considers 5 key areas where these changes should take place, including: consumers, strategy, technology, production, organizational structure, and culture [9]. According to the Acatech Industry Maturity Index 4.0, the German National Academy of Sciences and Technology considers the following four key areas of digital transformation: resources, information systems, culture and organizational structure developed and proposed [10]. As a result of the analysis of more than 400 large companies from various industries, the Centre for Digital Business and Capgemini Consulting has developed a model that identified three key areas of digital transformation, in particular: transformation of customer experience, transformation of operational processes and transformation of business models.

So, the certain experience of research and implementation of digital maturity concept has been formed. It is considered to be the development of digital technologies, automation, and the spread of digital networks. As a result of such significant experience of achieving the appropriate level of digital maturity, we can talk about the features of enterprise management in the context of digitalization, which is designed on digital alternatives, methods, techniques, measures, etc., and requires the creation of an appropriate environment for digital changes. It is worth noting that the processes of digital transformation, in the field of sustainable development at energy enterprises acquires resolving of some issues. Namely, it is important to investigate how Industry 4.0. agenda can follow achieving of sustainable development goals. Described at sources [11, 12] different opportunities for sustainable manufacturing in Industry 4.0 pointed out the economic, social, and environmental aspects that are possible to be improved by using the digital tools. They have pointed out advantages of the recent technological leap in Artificial Intelligent, Cloud Computing, and the Internet of Things. Distributed expert systems are some of the directions in the development of intelligent computing programs designed to simulate how an expert works and solves problems. The demand on systems of this type is currently caused by the ongoing globalization, and therefore, the decentralization and dispersion of the company's offices, as well as the need to process a large amount of information for decision-making [13].

Today the development of digital technologies is closely connected with energy industry. Digital instruments such as artificial intelligence, machine learning and deep learning are frequently used in electricity trading projects to promote digitalisation in energy markets [14]. Authors of this paper have analysed the new trends towards digitalisation driven by the rise of distributed generation; the application of artificial intelligence, machine learning, deep learning and Blockchain in energy sector. These trends develop new business models and create competitive advantages at the existing energy markets. In the context of digitalization in the field of energy, we note that in Ukraine this process was taking place together with the reform of the energy sector, in particular the adoption of the legislative framework and the development of market relations. The new electricity market in Ukraine was launched in 2019. Changes at the energy market activate its functioning with the support of digital instruments in such arears as bilateral contracts, as well as intra-day, day-ahead and balancing markets. But several additional legal elements still need to be introduced to comply with the EU requirements [15].

Specialists in the field of smart grid make accent on continuous modernization of the energy systems and necessity of maintaining the balance between production and consumption of electricity due to modern information and telecommunication technologies. In this direction, the implementation of controlled electricity transformation systems involves important components of a smart grid that provides power generation system and allows integrating of all its elements, in particular electricity generation sources, networks, and consumers to ensure sustainable and guaranteed power supply. They enable consumption of energy in the quantities demanded by people and society, accounting goals of sustainable development [16]. The European Bank for Reconstruction and Development surveyed more than 100 energy sector decision-makers in 32 countries to find out what measures are planned to be taken to restore the energy sector. The study says that for a sustainable recovery of the energy sector, the main priority is the modernization of the energy system with further investment in renewable energy sources. Clean energy and the digital transition also have high results [17].

Poland has been successful on the way of digitalization, particularly in the energy sector. This allowed the country to integrate into the European energy system. Poland's experience is valuable for Ukraine. During the pandemic, at least 3.6 million of new "digital" clients have emerged in Poland. Polish companies responded to this shift by increasing the number of economic sectors where digital services are regularly

used, and the share of such companies has grown by more than 60 %. To enhance the digital transformation, particularly in the energy sector, the Council of Ministers passed a resolution on the strategy of transformation of the Polish energy technology until 2040. It is based on three pillars: fair transformation, construction of a parallel zero-emission energy system, and air of good quality. According to the strategy, already by 2028, as many as 80 percent of households are to have modern remote reading meters at their disposal, the position of prosumers is to be strengthened and energy aggregation services are to be developed and popularized. These demands also require changes in the infrastructure, primarily in the scope of reading devices as well as advanced metering systems [18].

The development of smart power grids in Poland with support from the Operational Programme Infrastructure and Environment 2014–2020, which involves the installation of smart meters and network automation devices, is the result of digital transformations. The activity in this field is aimed at the improvement of energy consumption efficiency, for effective electric power system management and for power supply security [19].

Unsolved aspects of the problem. Thus, today sufficient attention is paid to broader understanding about the links between the Industry 4.0 and Sustainable Manufacturing by mapping and summarizing existing research efforts, identifying research agendas, as well as gaps and opportunities for research development. However, it is also important to study examples of how the digital maturity of enterprises contributes to the implementation of the principles of sustainable development through digital technologies and how the efficiency of the enterprises affects the variety and intensity of relevant measures implementation.

The purpose of the paper is to substantiate the relevance of digital maturity of energy enterprises in the era of Industry 4.0 for the achieving the goals of sustainable development, considering the relativeness between the level of its digital maturity and the policy of following the purposes of sustainable development.

Methods. To achieve the declared article purpose, it is proposed the consequent performance of the next steps: sustaining the actuality of digital maturity investigation in the time of Industry 4.0 revolution; backgrounding the connection between the digital maturity of energy companies and their ability to achieve goals of sustainable development; conducting the comparative analysis of energy companies digital maturity and their efficiency; analysing the obtained results for determining the directions and actions of Ukrainian energy enterprises in digital transformation; conclusions and perspectives of future research on the mentioned field.

The results of measures supporting sustainable development, under the influence of digitalization, comprehensively integrate its principles (economic, ecological, and social ones). In this regard, there is a need to highlight the effects of the digital transformation of the enterprise according to the signs of sustainable development (Fig. 1), which reflect the directions of potential changes and determine potential measures. The article proposes to consider the presented effects in more detail.

The experience of digital transformation impact on the economic results of enterprises is considered. There are many examples of assessing the energy enterprises' economic effect of digitalization abroad. There are already some examples in Ukraine of the economic effect of digital technologies introduction into the production and administrative processes of the DTEK company.

The article has used the algorithm and data from the German consulting company Roland Berger [5] to evaluate the effectiveness of digitalization, which, based on data analysis of the existing experience of energy enterprises digitalization, and have calculated the possible reduction of operating and capital costs and growth of the company's income because of digital transformation.

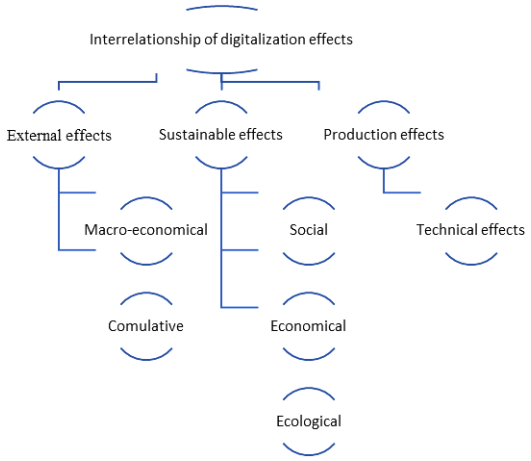

Fig. 1. Classification of the effects of sustainable development from the digitalization of energy enterprises

The production effect covers the increase in the technical capabilities of using the digital technologies, to achieve the effects of sustainable development in energy field. It is closely related to the economic component as well as external effects, namely the development of digital technologies in the energy sector and market transformations at energy markets.

To analyse the technical prerequisites of digitalization at energy enterprises, statistical analysis methods and benchmarking method were used, which made it possible to summarize the state and trends of digitalization.

The relationship between economic and other effects is considered through the study on the enterprise's efficiency based on the formula

$$E_d = \frac{\Delta}{c},$$

where Δ is expected income growth potential due to the digital transformation (the difference in income growth according to the pessimistic and optimistic forecast); C is investments for transformation (expenses for the implementation and development of IT – according to the investment programs of enterprises).

The study on the enterprise's digital maturity uses methods of comparative analysis, which provides an opportunity to get essential information about tendencies and dynamic of digitalization as well as leading energy enterprises' experience in digital transformation. All cases involve the processing of analytical material, which is obtained by conducting qualitative evaluations and analysis.

Investigating results description. Before proceeding to the direct analysis of the impact of digital technologies in energy companies on their sustainable development, it is advisable to assess their current state of digitalization. The analysis, conducted on the basis of data [20], given for enterprises supplying electricity, gas, steam and air conditioning, has demonstrated positive changes in current state at energy enterprises digitalization, namely during 2017–2021: the number of energy companies that use computers has grown by 12.67 %; the number of energy companies that have access to the Internet – by 17.08 %; ones that use social networks has been growing – by 19.35 %. Ukrainian energy companies start using 3D printing technology, although their number is quite small. Thus, Ukraine has prospects for the development of digital technologies in the energy sector.

Using the questionnaire method, information on digitalization was collected at energy enterprises of Ukraine. The results of survey data processing have allowed getting the following conclusions about the state of digitalization at 9 selected energy enterprises, three of which will be analysed below on their economic effectiveness (Table 1).

Table 1

Projected economic efficiency of digital transformation

Economic results	Current data of financial statements (2019) thousand UAN	Economic effect, thousand UAH	
		Pessimistic forecast	Optimistic forecast
JSC "Prykarpattiaoblenergo" (Enterprise 1)			
Income	1,662,574	33,251	49,877
Material costs	99,832	2,995	3,993
Fuel	32,489	650	1,462
Salary expenses	462,579	20,816	27,755
Repair costs	98,589	4,929	6,901
Administrative expenses	171,139	10,268	11,980
Sum	–	72,909	101,968
Economic efficiency = (49,877 – 33,251)/5,366.47 = 3.098			
PJSC "Lvivoblenergo" (Enterprise 2)			
Income	2,611,163	52,223	78,335
Material costs	948,414	28,452	37,937
Fuel	15,810	316	711
Salary expenses	693,905	31,226	41,634
Repair costs	109,957	5,498	7,697
Administrative expenses	135,085	8,105	9,456
Sum	–	125,820	175,770
Economic efficiency = (78,335 – 52,223)/5,813 = 4.492			
PJSC "DTEK Kyiv Regional Power Grids" (Enterprise 3)			
Income	3,336 329	66,727	100,090
Material costs	1,382,241	41,467	55,290
Fuel	15,764	315	709
Salary expenses	548,998	24,705	32,940
Repair costs	105,267	5,263	7,369
Administrative expenses	130,402	7,824	9,128
Sum	–	146,301	205,526
Economic efficiency = (100,090 – 66,727)/4,074 = 8.19			

Source: calculations made based on data from financial statements of enterprises

From the conducted survey, there was obtained information about 45 % of enterprises on their satisfactory level of digital development strategy, and for 9 % of them these criteria of assessment are very well developed. Cybersecurity is evaluated on a good level for 45 % and on a very good level for 27 % of the enterprises that have been surveyed. A weak level in the assessment of digital maturity is characteristic of the SMM indicator of technologies, which concerns 36 % of the respondents, as well as the absence of positions or structural divisions that deal with or serve digitalization. Instead, the implementation of measures for the development of digital literacy, digital skills, and staff qualifications has been sufficiently ensured (45 %).

According to the survey, there is potential for the implementation of digital measures in energy companies. The analysis result of the of energy enterprises digital maturity level was calculated based on the data from Table 1 and formula.

Thus, the predicted economic effect of the introduction and implementation of digital solutions at energy companies for the first enterprise – under the pessimistic scenario will amount to 72.909 thousand UAH, under the optimistic scenario – 101.968 thousand UAH. So, economic efficiency due to digital transformation is 3.098. By the same way there were calculated the efficiency of the second and third enterprises: $Ee = 4.492$ and $Ee = 8.19$ respectively.

Research results. To study the relationship between the level of digital maturity and the implementation of sustainable development measures, the results of investigation from the paper [20], conducted a study on energy enterprises' digital maturity was used. Based on the results, it was concluded that the assessment of digital maturity is a mandatory prerequisite carrying out the enterprise's digital transformation. The proposed model for assessing the enterprise's digital maturity was based on the following descriptors: strategy, personnel, organizational culture, technologies, structure, and marketing. There was considered the activity of three enterprises of regional electricity distribution. The results of 96 respondents survey allowed assessing the value of the digital maturity level (Table 2).

An enterprise that has a higher digital maturity has a higher economic efficiency, determined by the ratio of income and expenses that determined it. Studying and analysing such a connection will allow a better understanding of the company's

Table 2

Comparison the results of digital maturity level assessment with efficiency of the enterprise [20]

Elements of the enterprise	Values for each subsystem		General significance		
	Estimated value	Characteristics by a criterion scale	Estimated value of digital maturity	Efficiency of enterprise	Characteristics by a criterion scale of digital maturity
Enterprise 1					
Strategy	0.273	Beginners	0.254	3.098	Beginners Accelerate current digital efforts
Personnel	0.505	Experienced			
Organizational culture	0.741	Experienced			
Technology	0.453	Beginners			
Marketing	0.229	Observers			
Structure	0.453	Beginners			
Enterprise 2					
Strategy	0.298	Beginners	0.354	4.492	Beginners Accelerate current digital efforts
Personnel	0.397	Beginners			
Organizational culture	0.549	Experienced			
Technology	0.353	Experienced			
Marketing	0.489	Beginners			
Structure	0.705	Experienced			
Enterprise 3					
Strategy	0.518	Experienced	0.598	8.19	Experienced Take the experience of advanced companies
Personnel	0.397	Beginners			
Organizational culture	0.619	Experienced			
Technology	0.253	Beginners			
Marketing	0.282	Beginners			
Structure	0.409	Beginners			

capabilities to achieve digital maturity and the directions of personnel's work to achieve the expected results.

The conducted analysis of digital maturity [20] allowed supplementing the results of selected energy enterprises analysis' economic effectiveness (Table 1) and receiving data to be applied in Table 2. Obtaining the results of the assessment of energy enterprises' digital maturity and the entangled economic efficiency makes it possible to compare the value of the level of digital maturity and the efficiency of the enterprise in general (Fig. 2).

The advantages of digital economy implementations in different areas of business activity as well as in various spheres of human's life, supported by scientists are based on the idea that the digital economy will allow the usage of new management methods, including blockchain, big data, expert systems, and general decentralization. These methods have worldwide nature and are relevant for all industrial arears. But they have peculiarities that beside creating opportunities can pose significant threats. They also do not always fit into the framework of existing management technologies, strategic and project management, which are not always suitable for the digital economy.

As a result of low level of digital maturity as well as inefficient management, companies cannot transform their digital development strategy. So, it is important to find ways to boost this activity, namely by developing measures on sustainable development on the base of digitalization.

Directions of sustainable development in conditions of digitalization according to research results. The approaches and methods to investigate the impact of digitalization on sustainable development are considered in the article. They made it possible to identify examples of digitalization from the real sector of the economy that are relevant to the goals of sustainable development. Digitization makes it possible to generalize the capabilities of energy enterprises on application of digital technologies in the implementation of the principles of sustainable development (economic, social, and environmental) and their transformation into specific measures.

It should be noted that the goals and objectives of digital transformations differ significantly at different enterprises. We can see this from the results of evaluating the digital maturity of energy enterprises and their economic efficiency. Some consider the prioritizing of a new enterprise resource planning (ERP) system implementation that will optimize the usage of resources. Others tend to use cloud technologies to access and process large amounts of information to reduce uncertainty, use artificial intelligence (AI), or focus on new customer-centric mobile applications. However, we agree that digital transformation plans should go beyond implementing new digital tools just because they are becoming more accessible and trendier. Digital transformation must add real value to the organization. Therefore, the starting point of digital change should be a common vision (mission) and understanding

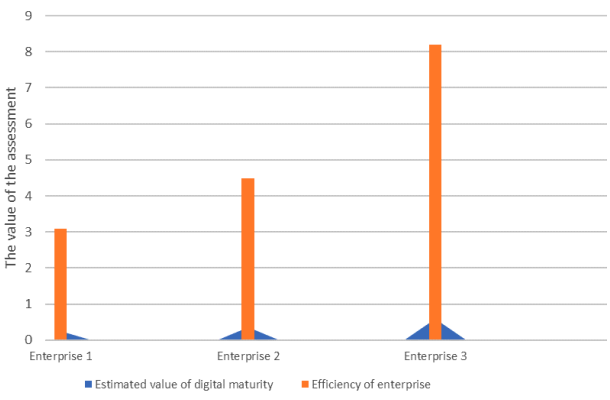

Fig. 2. The comparison of value of the digital maturity and economic efficiency assessment

(strategy) of why the transformation should be carried out, as well as a plan for how the transformed organization is expected to create value and competitive advantage [21].

Positive changes in the direction of the energy sector digitalization in Ukraine have been observed in recent years: for example, the country's largest energy company DTEK has launched a comprehensive digital transformation program, MODUS [22]. One of the most significant achievements of the MODUS program was the creation of a communication infrastructure at a depth of 500 m in the mine. An unprecedented example for Ukraine of "Wi-Fi in a mine" made it possible to increase the safety of miners and optimize the cycle of resource extraction. In addition, using a drone and development of automatic systems for analysing power networks help specialists to monitor the state of power transmission lines. The implementation of measures to automate production processes provides automatically the determining of the optimal operating modes of the plant's power units which provide users with recommendations in real time. The use of IoT, Machine Learning, Data Lake technologies reduces fuel consumption and has brought an economic effect of work.

An important result of digital transformation of sustainable development is the social consequences. This effect includes several components. One of them is the improvement of labour safety, the reduction of industrial injuries and, in general, the reduction of risks to the health and life of personnel due to the improvement of production conditions. The digital transformation of energy enterprises is aimed at the maximum use of automated, and then – unmanned technologies. As a result of digital changes, the minimization of human involvement in potentially dangerous operations during the operation and repair of equipment certainly has a positive effect.

The second component of the social effect is a change in the personnel structure of the energy industry, which is accompanied by the release of many personnel whose work is related to physical activity, the performance of rather narrow, routine operations (industry operators, repair personnel, support personnel, etc.). Instead, there is a need for a significantly smaller number of more qualified specialists who know how to work with digital technologies and other multifunctional technical specialists. Solving these problems requires significant costs and goes beyond the energy industry, affecting the entire economy and directly the education and science industry [23]. However, the costs on investments in new professionals, in retraining or employment of old professionals, including the creation of new jobs, possibly in other sectors, as well as costs of re-profiling personnel should also be considered alongside the direct economic effects.

The assessment of external effects expected from the digital development of the energy industries goes beyond the limits of fuel and energy complex and often – beyond the boundaries of a clear economic assessment, and plays an important role in solving many strategic tasks of energy development. The cumulative effect of economic growth goes from investments in new technological directions, creating additional activity in various industries, forming additional added value. The macroeconomic effect of digital transformation is largely related to ensuring an adequate level of energy security from the point of view of minimizing risks for reliable energy supply by reducing the emergency of energy facilities and systems, increasing self-sufficiency in energy resources of regions and the country as a whole, as well as increasing the degree of diversification "energy basket" of industries. The ratio of different types of external effect is often considered to improve the conditions for economic integration and competition. Currently, this effect is highly significant, for example, in the development of the network infrastructure of the European Union countries, the purpose of which is to remove restrictions on the flow of power and electricity in the intersections between regional energy associations and technically ensure the creation of a single market space in the EU electricity sector.

Table 3

Classification of sustainable development effects arising from the digitalization of energy enterprises [21–23]

Areas of activity	Economic effects	Social effects	Environmental effects
Macro-economic level	GDP growth; growth of export revenues; growth of the volume of science-intensive products and services in production and for export	Creation of new jobs; improvement of the life quality; emergence of human-replaceable control systems	Reduction of natural emissions of polluting substances, including greenhouse gases
Cumulative effects	Stabilization of retail electricity prices during the period of intense integration of RES and electric transport; reduction of costs for elimination of negative environmental consequences	Integration of electric transport; increase in the productivity of all public labour due to its increase at the level of individual energy enterprises	Integration of RES into the energy system; achieving the target level of electricity generation from RES
Production	Optimization of operating costs; saving capital costs; increase in revenue or decrease in fuel costs; saving capital costs; saving of fuel costs in the energy system as a whole; reduction of wholesale electricity prices	Reducing the number of accidents; reduction in damages from interruptions; reduction in errors while increasing control over the execution of assignments and works	Reduction in CO_2 emissions; reduction in emergency emissions; Reduction in fuel consumption; reduction in technological losses in electrical networks
Transmission and distribution	Increasing the economic efficiency of the energy system as a whole; optimization of repair costs; saving capital costs; reduction in electricity grid companies costs and tariffs	Reduction in damages from system crashes; reduction in damage from interruptions in power supply; reduction in equipment downtime for repair	
Consumption	Cost savings for the construction of new generation/networks; reduction in prices on the wholesale and retail markets; saving consumers' costs for energy supply	Increasing consumer participation; better consumers understanding; reduction in energy consumption; energy efficiency increasing	Reduction in the specific consumption of carbon-containing energy resources
Result	The enterprise's efficiency		

The list of effects of sustainable development, which are achieved due to digitalization, is presented in Table 3.

Discussion. The issue of digitization is a subject of attention for an individual enterprise, which must ensure compliance of the functioning operating system with the general technical, technological, and digital requirements of the energy system. However, the current technical condition of many enterprises is unsatisfactory with about 88 % of main power transmission lines that have been in operation for more than 30 years and require renewal. Therefore, even though digital changes are vital for energy companies, their implementation will take place individually. The proposed approach to the assessment of digital maturity can serve as a guideline for the implementation of digital changes, taking into consideration the purposes of sustainable development. And the example, used at the article, of economic effect calculation as digital transformation result could orient energy enterprises on digital transformation consequences.

In addition, the calculation of the economic effect of digital transformation has an orientational nature, namely, it demonstrates the potential for economic growth of an enterprise that has chosen digital transformation for itself. However, the experience of some companies may not correspond to the capabilities and needs of others. The presence of positive economic changes from digital transformation also deserves attention.

Conclusions. The article substantiates the relevance of energy enterprises' digital maturity in the era of Industry 4.0 in the achieving of Sustainable development goals. Considering the relativeness between the level of their digital maturity and the activity on sustainable development it was concluded that digital transformation has a potentially positive effect on sustainable development, in particular: increasing the observability and controllability of energy objects along with taking into account predictive analytics allows making the most accurate decisions regarding their operation, achieving higher efficiency, ensuring the minimization of negative impact on the environment, economical use of energy resources, minimizing the number of accidents or unplanned stops, creating safe and reliable working conditions; digital solutions stimulate the development of new energy technologies, which allows using the potential of alternative energy resources; digital solutions also ensure the integration of new energy technologies into industry product chains, which could reduce the use of traditional energy resources by replacing them with alternative ones or reducing the volume of their final consumption through the energy efficiency.

The authors of article underlined the topicality of digital maturity investigation in the time of Industry 4.0 by focusing their attention on working out the statistical analysis and analysis of conducted questionary at selected Ukrainian energy enterprises. They backgrounded the connection between the digital maturity of energy companies and their ability to achieve sustainable goals on the base of economic efficiency achieving. The article states that high level of efficiency causes more potential for implementing of digital changes and allows incorporating measures that boost sustainable activity at energy enterprises. The authors took into consideration the foreign countries' experience in this field by separating the effects of sustainable development in the context of digitalisation.

The further research requires more deeply focusing on managerial roles in providing sustainable development simultaneously with considering the possibilities of digital transformation at energy enterprises, regarding both technical and human resources.

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Вплив цифрової зрілості на ефекти сталого розвитку енергетичного сектору в умовах Індустрії 4.0

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Мета. Дослідження впливу цифрової зрілості енергетичних підприємств на досягнення ефектів сталого розвитку в умовах четвертої промислової революції.

Методика. Дослідження економічної ефективності енергетичних підприємств ґрунтувалось на результатах статистичного аналізу економічних показників їх діяльності та макроекономічного аналізу передумов цифровізації українських енергетичних компаній, а також із урахуванням результатів аналітичних досліджень цифрової трансформації зарубіжних компаній. Застосування методу бенчмаркінгу дозволило виділити кращі приклади цифрових змін в енергетичних компаніях у сфері сталого розвитку. Метод узагальнення дозволив виділити ефекти цифровізації сталого розвитку для енергетичних компаній.

Результати. Обґрунтована ефективність енергетичних підприємств за рахунок здійснення цифрової трансформації, що дозволяє досягати ефектів сталого розвитку шляхом забезпечення екологічного, економічного та соціального розвитку. На основі розрахунку значень економічної ефективності визначено найбільш ефективне енергетичне підприємство, діяльність якого характеризується найвищим рівнем цифрових перетворень, спрямованих на досягнення цілей сталого розвитку.

Наукова новизна. Обґрунтована залежність між рівнем цифрової зрілості енергетичних підприємств і їх економічною ефективністю. Установлені сфери діяльності енергетичних підприємств, ефективність і важливість яких зростає із рівнем цифровізації. Виділені технічні характеристики цифровізації енергетичних підприємств у сферах реалізації цілей сталого розвитку, зокрема економічній, соціальній та екологічній.

Практична значимість. Визначені основні напрями діяльності енергетичних підприємств на основі виділення ефектів сталого розвитку, що досягаються за рахунок цифровізації. Обґрунтована ефективність підприємства як результат цифровізації, зокрема з урахуванням напрямів сталого розвитку.

Ключові слова: *цифрова зрілість, енергетика, сталий розвиток, Індустрія 4.0*

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