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A conceptual analytical model for the decentralized energy-efficiency management of the national economy

Abstract: The aim of the article is to consider current global and European trends in ensuring a sufficient level of energy efficiency, to provide an analysis of the institutional environment for energy security, and the development and justification of a conceptual and analytical model of energy generation and consumption at the regional level in decentralization reform in Ukraine. The current trends of world energy consumption are illustrated, the forecast of renewable energy development is built and an analysis of energy efficiency of the national economy is performed. The article presents a study of the formation of an integrated municipal energy-management system of Ukrainian com-

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munities and municipalities depending on their urbanization and offers the use of conceptual analytical model of generation-consumption. A number of normative and organizational-institutional proposals on the standardization of energy-efficiency improvement processes are provided. Analysis of the energy efficiency of communities can be modeled at the conceptual level with the study using an analytical model: a) energy-efficiency factors of this model, financial instruments for its effective functioning as a mechanism of interest budget revenues and specialized funds functional dependence of the target function of the energy generation-consumption model, taking into account the generation methods and the main consumers at the appropriate levels; b) the risks and shortcomings of this process, which propose a number of regulatory and institutional changes to improve the effectiveness of effective energy efficiency policies of communities and energy security of the state on the basis of energy cooperation and organization of the biofuel exchange. The model of organization and functioning of the cooperative for generation and consumption of solar energy, which is based on the regulatory framework, is represented as a model structural and functional solution. This allowed the development of scientific and applied recommendations for improving the legal provisions, which would allow the community to become an effective player in the wholesale energy market, selling it at a "green" tariff.

Keywords: energy efficiency, energy security, decentralization, local communities, renewable energy, energy generation-consumption model

Introduction

The principle of sustainable development has mostly determined the trends in the evolution of world energy since the beginning of the twenty-first century. The emphasis on energy security, energy efficiency, decarbonization and low-carbon energy with the active construction of renewable energy sources (RES) are the challenges and major trends of today. The current energy map of the planet is changing dynamically, from the structure of the generating capacity and the configuration of energy systems to the state of national energy markets (Qazi et al. 2019).

A significant development of renewable energy is that distributed generation systems have become the basis for the construction of energy-storage systems (Energy Storage). An innovative trend is the development of the Smart Grid – smart grids that include Smart Metering technologies (smart metering and billing systems), as well as Demand Response (demand management systems) (Szablicki et al. 2019).

For the purpose of effective further integration into the world economic environment, Ukraine, which currently has a high contribution of energy to their gross domestic product, must effectively adapt the world experience of energy efficiency, thus ensuring its own energy security and using existing national levers, including decentralization processes, that have given significant impetus and financial opportunities for the implementation of regional and local initiatives. At the same time, the national potential for energy efficiency remains high, but its slow involvement is due to regulatory and institutional imperfections, inertia on the ground, a lack of

adequate sectoral investment and low public awareness. Current trends in greening and energy efficiency in the regional and local dimensions should be comprehensively stimulated at the state level and implemented at the regional and local levels.

Energy efficiency at the lower territorial levels as a guarantee of energy security of the state, as well as renewable and "green" energy and decarbonization processes are the most relevant current trends in world energy. The large-scale process of decentralization and territorial reform in Ukraine opens at the basic levels, according to the NUTS (European Commission 2021) methodology (households, communities, cities, districts), there are additional opportunities for integration into socio-economic infrastructure, intensification of innovative models of energy generation and consumption.

The purpose of this article is to consider current global and European trends in ensuring a sufficient level of energy efficiency, provide an analysis of the institutional environment for energy security, and the development and justification of a conceptual and analytical model of energy generation and consumption at the local level in decentralization reform in Ukraine.

1. Literature review

In the context of studying and solving the scientific and applied problems of the energy efficiency of communities and the energy security of the state, it is worth emphasizing that the theoretical and applied developments of this scientific field are devoted to the development of many scientific institutions and economists of Ukraine. In particular, among the prominent scientists who are concerned with improving energy efficiency in the new model of the decentralized administrative-territorial organization of Ukraine, we can highlight such well-known scientists as Shvets et al. (2013), Kucheriava and Sorokina (2020), Mykytenko and Sheludko (2021).

Thus, the issues of energy efficiency in the conditions of SMART – specialization of mining old industrial regions are covered in the works of Amosha et al. (2018), the use of a reflective approach to solving problems of economic development of regions, including energy efficiency, were the object of scientific interests of Shkarlet (2019), which allows us to draw conclusions on the effectiveness of economic and mathematical modeling to build predictive models of regional development. Sectoral issues of energy efficiency are widely covered in the works of Jenniches (2018). A significant contribution to the study of theoretical and conceptual approaches to energy efficiency of regional industrial complexes have been made by scientists Korosec (2012), Mykytenko and Sheludko (2021). The works of native economists contain details of the content and the essence of the main categorical definitions of the process of energy efficiency, and evaluate the effectiveness of energy-efficiency management in regional industrial complexes. A number of scientists have focused on studying the problems of global electricity development (Serr 2019), the use of alternative sources in this field, attracting innovative energy-saving tech-

nologies (Korosek 2018), the use of renewable energy, and the classification of types of energy sources, its production and efficiency increases in its application (Olczak et al. 2021).

Recognizing the unconditional importance and scientific value of previous works, in our opinion, the issues of building legislation on the effective functioning of the legal framework for energy cooperation in Ukraine, as well as building applied models of the generation of energy consumption at the local level (not only community but also household) can turn from a sole consumer into a producer of energy resources and a player in the wholesale energy market.

The methodology of the article involves the use of both general scientific methods (system analysis, modeling, abstraction and specification) and special methods, namely forecasting based on analysis of retrospective endogenous and exogenous factors, correlation, and factor and cluster analysis.

2. Results and discussion

2.1. Analysis of the development of renewable energy production capacities

The European Union has declared a course for making all spheres of the economy and public life greener. We can already say that the new policy has radically changed the life of the EU, and not only the EU. Ukraine immediately announced its intention to be a part of this ambitious plan. Despite this, the Ukrainian expert community and business still do not have a single assessment of what consequences participation in the Green Deal – the European Green course – will have for our country. The article's research is aimed at analyzing the potential opportunities of modern decentralization processes in Ukraine for the development of the energy efficiency of the national economy. The conceptual basis of the article is the analysis of foreign experience on these issues and the formation of a national energy-management system at the local level. According to analytical studies (Enerdata 2021), by 2050 there will be a global trend to reduce the consumption of petroleum products as an energy source, and instead, the leading positions will be occupied by renewable electricity and green energy (Fig. 1). EnerBase, the business-as-usual scenario, EnerBlue, the Paris-agreement-compatible scenario, and EnerGreen, the scenario exploring how to contain global warming under 2°C.

Figure 2 shows data on the capacity of renewable energy in the world's leading countries and regions of the world as of 2020, as well as the inertial and accelerated forecast for the development of renewable energy until 2024. China is currently showing the most intensive development in this industry. In general, by extrapolating the data to the period up to 2040, it can be argued that according to the scenario of even sustainable development, almost 2/3 of all global energy production will be renewable and green energy by 2040 (IEA 2021).

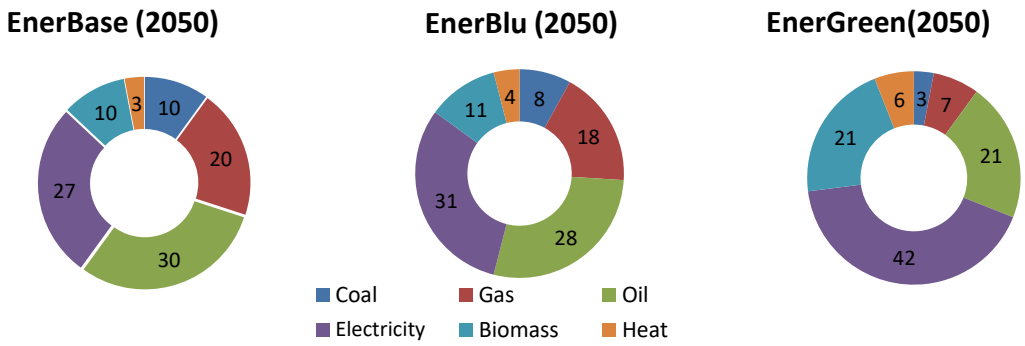

Fig. 1. Scenario trends of world energy consumption by sources of supply

Rys. 1. Scenariusze w zakresie trendów światowego zużycia energii według źródeł dostaw

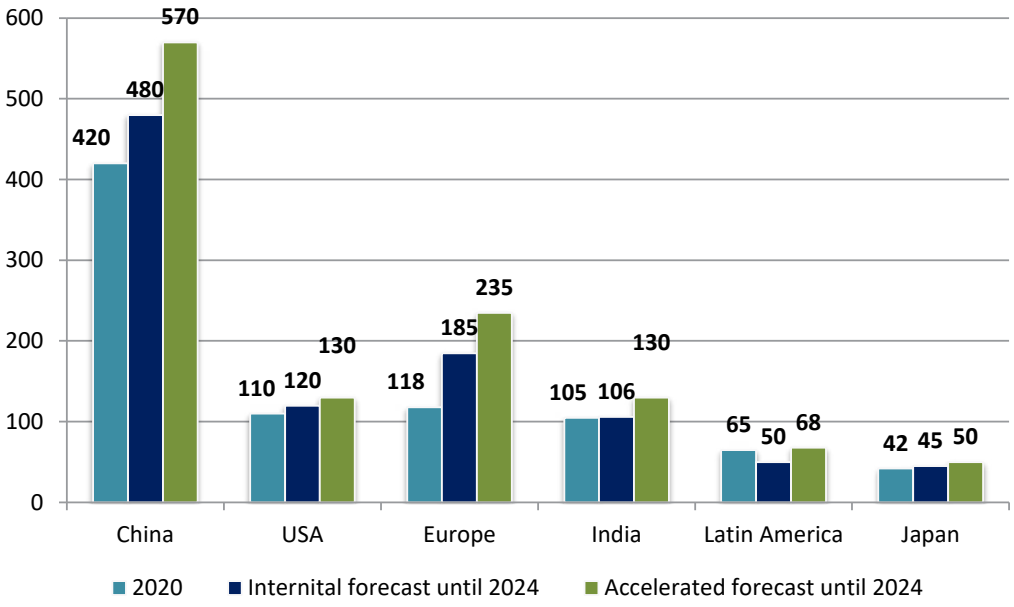

Fig. 2. Dynamics of development of renewable energy production capacities in countries and regions of the world (IEA 2021)

Rys. 2. Dynamika rozwoju mocy wytwórczych OZE w krajach i regionach świata

2.2. The formation of an integrated energy management system at the local level in the context of decentralization

The processes of decentralization and local autonomy, when the local level of territorial organization of the country has changed from only energy consumers to its producers, as well as full participants in the wholesale electricity market, have become a global trend.

The economic system of Ukraine, as well as that of the whole world, is moving in the direction of "green" energy and decarbonization. Therefore, energy efficiency has a special priority. At the same time, the analysis of the current situation of sectoral infrastructure in Ukraine gives grounds to state its archaic nature, the presence of an administrative system of tariff formation and the conservation of the existing generation structure, in which the main dominant energy units are nuclear and thermal power plants. The latter, by the way, are systematically worn out. Similar processes are inherent in the energy-supply infrastructure, which unfortunately, is free of modern technologies (Ostapenko et al. 2022).

Therefore, the urgent need for the effective transition into global energy trends, as well as the reform of administrative-territorial structures (ATS) related to this process in Ukraine has led to the relevance and practicality of this study, namely: to consider the current processes in energy saving at the level of regions and communities in the field of real processes of decentralization; to highlight the advantages and disadvantages of these transformations; to provide effective recommendations for improving their effectiveness. Large-scale decentralization processes have accelerated the "cross" development of two important areas of state development, on the one hand, energy security at the level of Ukraine, and on the other, ensuring energy independence of communities, given a number of powers energy carriers. The third global factor is the global trend of the transition to renewable energy sources (Koval et al. 2021). In addition, the need to introduce European energy saving standards, taking into account the price-quality-income scheme, gives impetus to the search for new management systems at the local level. However, such a search should be conducted with the participation of the community and should be an important sector of the unified municipal policy on the use of energy and resource-saving technologies (Lowitzsch et al. 2020).

In order to normalize the process of building an energy-efficient society, integrating national energy networks into the EU energy space and ensuring the energy security of the state, in 2013, the Energy Strategy of Ukraine until 2030 "Security, Energy Efficiency, Competitiveness" (Cabinet of Ministers of Ukraine 2013) was adopted, the tasks of which are the declared principles: a) energy efficiency; b) energy management; c) alternative energy sources as the key to an environmentally sustainable future for every Ukrainian; d) energy security, e) understandable energy tariffs; g) European level of energy services, h) energy independence as the foundation of economic development; i) each household as an energy supplier; j) managing its own demand; k) rational energy consumption. In 2017, the strategy was concretized in connection with the political and social changes that have occurred in Ukraine since the beginning of 2014 and radically changed the situation in the energy sector, which is why the country's basic strategic document no longer meets reality (Cabinet of Ministers of Ukraine 2017).

The main target parameters declared in the Energy Strategy of Ukraine until 2035 are (Cabinet of Ministers of Ukraine 2013):

- reduction of the energy intensity of gross domestic product to the level of 0.17 kg n. e. for 1 US dollar GDP of Ukraine (PPS) by 2035 and approximation on this indicator to countries with similar climatic, geographical and economic parameters;
- optimization of the structure of the energy balance of the state based on the requirements of energy security and ensuring the share of renewable energy at 20.0%;
- achieving the level of dependence on supplies from one country to not more than 30.0% of the total consumption of all types of energy resources by 2035;
- ensuring guaranteed compliance of generating capacities with volumes and modes of electricity consumption in the unified energy system of Ukraine, in particular with regard to the availability of regulatory capacities;
- ensuring the technical integration of the electricity and gas markets of Ukraine and the EU (the availability of cross-border transmission networks) at a level of at least 15.0% relative to the volume of the domestic market of Ukraine by 2025.

The share of renewable energy by 2035 should be 25.0%, although currently this figure is only slightly above 1.0% (in the developed world, this figure already reaches 25.0%, Fig. 3).

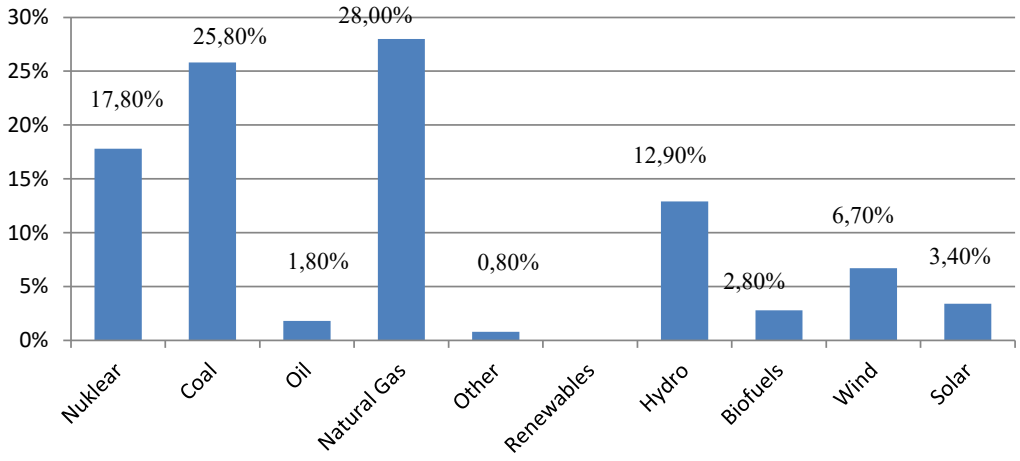

Fig. 3. The share of renewable energy in total production of electricity in developed countries (Kucheriava and Sorokina 2020; Global Change Data Lab 2021)

Rys. 3. Udział energii odnawialnej w całkowitej produkcji energii elektrycznej w krajach rozwiniętych

This situation is a consequence of the historically established structure of the construction of domestic energy in which the dominant role in regulating domestic energy consumption was assigned to nuclear and thermal power plants.

In other words, for the Ukrainian energy sector, this means a fully fledged revolutionary process reformatting the industry, the implementation of which will require large-scale, powerful and revolutionary tools. However, at present, Ukrainian communities have their own energy

goals and challenges to achieve these goals. Decentralization has enabled communities to decide for themselves on the ground, in particular to manage their own budgets. So, at present, each united community has received resources – taxes and fees that remain on the ground and are not transferred to the center – and this community can use for its own needs. The reform itself is complex and, at present, extremely complex in terms of coverage and synchronization tools, but it is focused on the development of united territorial communities (UTC), which would be able to effectively use their financial flows, based on the further development of Ukraine.

2.3. Integration into the socio-economic development at the local level of the model of the structure of energy generation and consumption

In general, decentralization reform and the acquisition by communities of certain levers of power and financial resources provide opportunities to create interconnected models of the structure of energy generation and a rational model of the structure of energy consumption at the local level (households, communities, cities and districts).

Note that the Ukrainian economy is one of the most energy-intensive in the world and has great potential for energy conservation. Thus, it consumes about 100 million tons of oil equivalent annually, and if this figure were at the global average, it could save energy almost twice (Fig. 4).

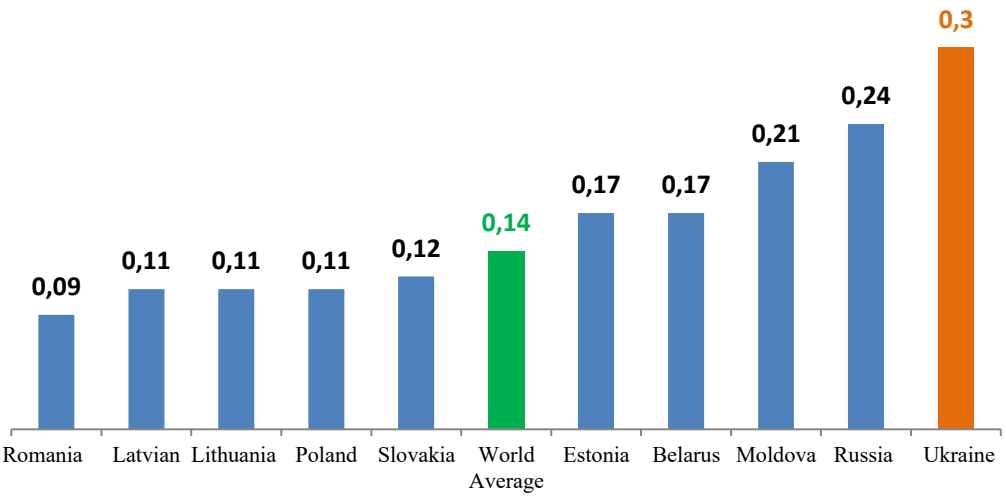

Fig. 4. Energy intensity of national economies of some countries in 2020 (kg of oil equivalent/USD of GDP at purchasing power parity in 2019) (European Commission 2019)

Rys. 4. Energochłonność gospodarek wybranych krajów w 2020 r. (kg ekwiwalentu ropy naftowej/USD PKB, według parytetu siły nabywczej w 2019 r.)

Almost half of the energy produced or imported is lost during transportation to the final consumer. This is explained both by the low efficiency of electric networks and losses during the transportation of energy through them, and by the low efficiency of energy production in traditional coal-fired energy sources (explanatory note to the Draft Law on Energy Efficiency). Thus, the proposed model of the structure of generation and consumption at lower levels according to the NUTS classification (Nomenclature of territorial units for statistics) (European Commission 2021) has a double factor of energy efficiency because:

1) energy production is as close as possible to consumption that prevents artificial losses;

2) the local level of energy consumption (households, communities, cities, districts) is transformed from exclusively consumers to producers of energy of various types (thermal energy consumption is reduced and the production of solar, bio- and renewable energy is increased). The unconditional components of such a transformation are financial, technological and institutional instruments.

Thus, the financing of such a model of generation-consumption at the local level should be provided by a comprehensive mechanism:

1) in the framework of budget decentralization as interest revenues from higher budgets, such as targeted revenues from the regional budget;

2) in the framework of decentralization – the use of the funding mechanism. For example, the use of the Revolving Fund at the level of the organization of co-owners of an apartment building. It is the revolving fund that can be an effective mechanism for supporting certain activities (by providing loans), and funds from repaid loans, on the principle of the revolver, become the basis for subsequent loans.

The revolving fund is created in accordance with the decision of local governments; at the same time, the use of its funds is available to all residents of the community, or its specific categories. It should be noted that so far, this mechanism has not become widespread among the united territorial communities.

We consider it expedient to suggest a system of community incentives for the creation of revolving funds through financial tax preferences, in particular, to provide for their filling with income from interest from the budgets of the respective levels, and, in case of foreign investment, a system of tax preferences for investors. The organization and operation of revolving funds fully allows the community, subject to the political will of the leadership, to implement measures that vary in duration from short-term to long-term. An important advantage of such a tool for local conditions is its simplicity and accessibility.

Decentralization reform makes it possible to integrate the model of generation and consumption structure into socio-economic development at the local level, and the functional dependence of multicriteria energy efficiency at the respective territorial level will be simplified to reproduce according to the following scheme (1):

$$E = F(x_i, y_i, \ldots z_i) \quad (1)$$

where:

x_i – a set of ways to generate energy resources;

y_i – a set of main consumers at the regional level.

Elements of such a dependence should also be a set of tools for reform, institutional and technological factors.

A real applied model for the implementation of the mechanism of generation and consumption at the level of law is the consideration of the organization of an energy production cooperative for the generation of electricity using a solar power plant (based on solar panels). Statistically, it should be noted that in 2021, almost 15,000 Ukrainian families installed solar installations with a total capacity of 426 MW, which is twice as much as in 2020 (State agency for energy efficiency and energy saving of Ukraine 2022). The process of the installation and operation of solar power plants at the household level, according to the State Agency for Energy Efficiency, is presented in Figure 5.

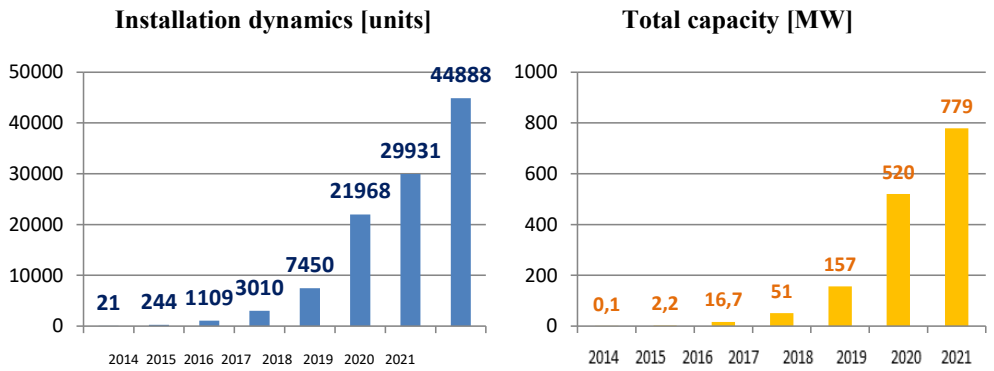

Fig. 5. Dynamics of the development of solar power plants in private households of Ukraine for 2014–2021 (State Agency on Energy Efficiency and Energy Saving of Ukraine 2022)

Rys. 5. Dynamika rozwoju elektrowni słonecznych w prywatnych gospodarstwach domowych Ukrainy w latach 2014–2021

2.4. Energy cooperation as a tool of rational management

For communities in the new economic environment, there is an urgent need to find new sources of funding as well as calculating the available financial resources, control of the community's energy resources argue, in turn, the need for energy efficiency and energy conservation. From this, it should be noted that energy cooperation is a very effective solution to a number of these tasks. It is precisely this scheme of joint work that allows community residents solve energy challenges and find innovative solutions through joint investments. The United States is considered a world pioneer of energy cooperation. In the United States, the vast majority (energy

cooperatives) own electricity grids and supply energy to consumers. European countries (in particular, Austria, Germany, Denmark and Great Britain) also show the dynamics of increasing the number of economically active energy cooperatives over the past four decades (Fig. 6).

In fact, energy cooperatives can solve a wide variety of tasks for the community, namely residents coming together to buy fuel at lower wholesale prices, or installing biogas equipment, growing energy crops, insulating homes, and more.

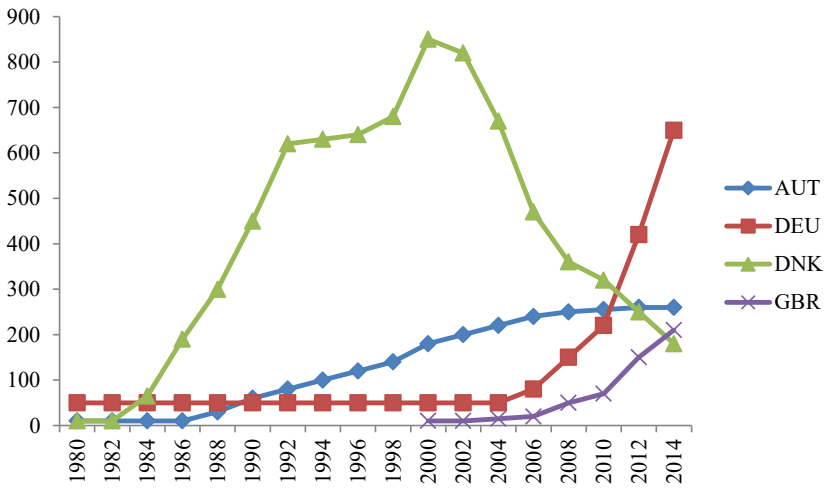

Fig. 6. Dynamics of energy cooperatives in some European countries in recent decades (IEA 2021)

Rys. 6. Dynamika rozwoju spółdzielni energetycznych w wybranych krajach europejskich w ostatnich dziesięcioleciach

The cooperative form of organization is one of the key elements in the decentralization system at the local level and provides a number of advantages. Regarding the economic component of the advantages of the cooperative structure, the following should be noted: 1) it assists in the building of the appropriate infrastructure without attracting additional foreign investment or credit, which is almost impossible for single residents or small businesses; 2) it can significantly reduce the community's dependence on large energy companies, which are unconditionally monopolistic in the relevant market; 3) in case of sufficient resources of their own, the community can even make money on "green" energy by selling surplus energy.

The economic benefits of the cooperative are inherent in its very nature, because the ultimate goal of the cooperative is not to make a profit. Each member of the cooperative, regardless of the number of shares, receives one vote to make a decision. An indisputable advantage is also the argument of environmental friendliness of the energy cooperative, given the transition to renewable sources and bio-energy resources.

In Ukraine, rural areas are the most suitable for the establishment of energy cooperatives. Voluntary reunification of farmers into energy communities can significantly reduce electricity costs, for example, through the use of biomass.

A conceptual model of the organization of an energy production cooperative for the generation of electricity using a solar power plant (based on solar panels) is proposed for implementation in the practice of management (Fig. 7).

In fact, it is possible to interpret the model represented by the author in Figure 6 using the apparatus of mathematical logic as follows:

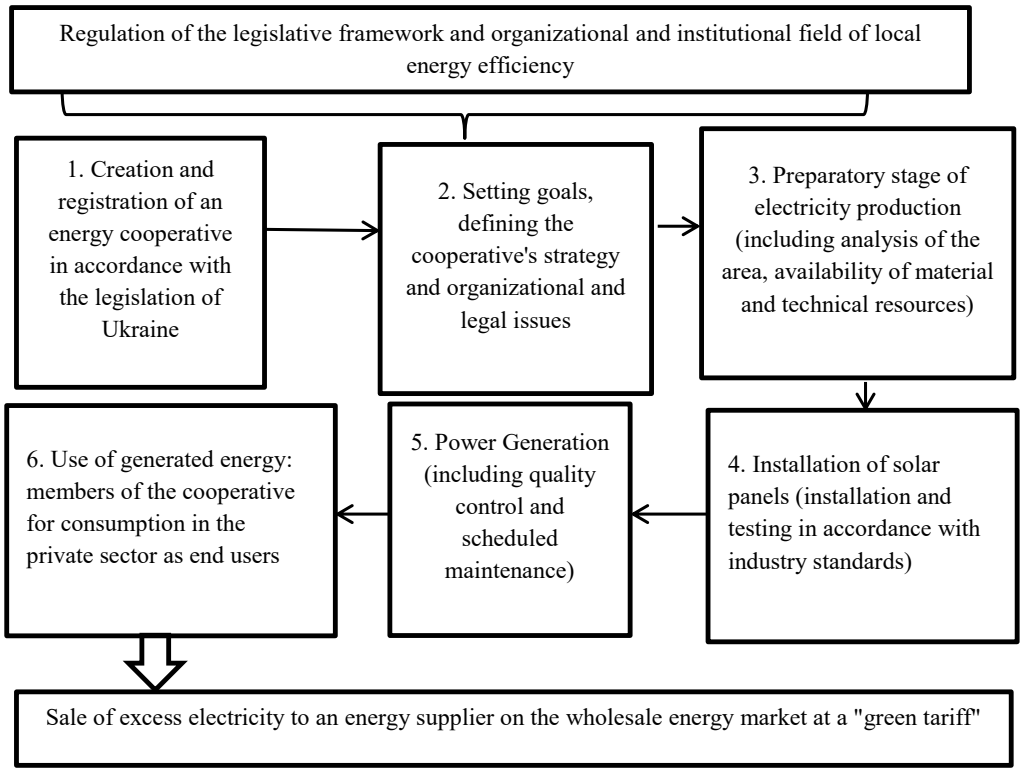

Fig. 7. Model of organization of energy production cooperative for the generation of electricity by a solar power plant (based on solar panels)

Rys. 7. Model organizacji spółdzielni energetycznej przez elektrownię słoneczną (na bazie PV)

To achieve and ensure the sale of excess electricity to the energy supplier in the wholesale energy market at the “green tariff”, it is necessary to gradually implement a set of six economic, institutional and regulatory measures into practice: 1. Establishment and registration of an energy cooperative in accordance with the legislation of Ukraine; 2. Setting goals, defining the strategy of the cooperative and organizational and legal issues; 3. Preparatory stage of electricity production (including site analysis, availability of material and technical resources); 4. Installation of solar panels (installation and testing in accordance with industry standards); 5. Electricity generation (including quality control and scheduled maintenance); 6. Use of generated energy – members of the cooperative for private sector consumption as final consumers belonging to

many processes of the standardization of the legal framework and the organizational and institutional field of local energy efficiency.

Therefore, the formalization of the conceptual-analytical model of the organization of an energy production cooperative for the generation of electricity by a solar power plant (based on solar panels) has the following form, given in formula (2):

$$SALE^{srplus} \approx \left\{ Es^{reg} \cup St^{g} \cup Pr^{st} \cup In^{solar} \cup El^{g} \cup Use^{generl} \right\} \in STAND^{Legal\_organz} \tag{2}$$

where:

- $SALE^{srplus}$ – sale of surplus electricity to the energy supplier on the wholesale energy market at a "green tariff",
- Es^{reg} – establishment and registration of an energy cooperative in accordance with the legislation of Ukraine,
- St^{g} – setting goals, defining the strategy of the cooperative and organizational and legal issues,
- Pr^{st} – preparatory stage of electricity production (including site analysis, availability of material and technical resources,
- In^{solar} – installation of solar panels (installation and testing in accordance with industry standards),
- El^{g} – electricity generation (including quality control and scheduled maintenance),
- Use^{generl} – use of generated energy: members of the cooperative for private sector consumption as final consumers,
- $STAND^{Legal\_organz}$ – standardization of the legal framework and organizational and institutional field of local energy efficiency.

From this, it should be noted that the purpose of the cooperative is that it operates on the basis of the Statute and is organized by the initiative group to generate electricity through a solar power plant with subsequent consumption of electricity produced by members of the cooperative in the private sector and the sale of excess electricity on the wholesale energy market at a "green tariff". Thus, one of the key priorities for Ukraine is gaining energy independence and sustainable development. The growth of "green" energy and renewable energy sources are effective and efficient tools in achieving this goal.

Of course, this course correlates with global trends, as well as the goals of the Paris Climate Agreement and the activities of the new EU program "European Green Deal" (European Commission 2019), which Ukraine plans to join. By 2030, the potential for financing green energy projects, according to IFC, could reach 70 billion euros (International Finance Corporation 2021). The processes of decentralization and the replacement of gas imports and savings due to local fuel are extremely important processes.

2.5. Risks and disadvantages of the standardization of energy efficiency processes

Energy cooperation in Ukraine is still at an early stage of development. Despite a lot of benefits, there are several significant risks and drawbacks.

Firstly, bioenergy development and energy efficiency measures are potentially promising at the community level. Such arguments should be the focus of attention of community leaders who seek to save energy for the efficient passage of the heating season, provide jobs and stimulate local economic processes (Hutsaliuk et al. 2020). However, the legislative framework of these processes remains unregulated.

Thus, a package of bills has been developed to intensify the substitution of imports of traditional energy resources but has not been adopted, for example (Cabinet of Ministers of Ukraine 2020; Verkhovna Rada of Ukraine 2019, 2020):

1) a bill on the regulation and development of the competitive market of solid biofuels on the basis of development and commissioning of the system of electronic trade in biofuels;

2) a bill obliging the transport industry to use liquid biofuels;

3) a bill regulating the infrastructure for growing energy crops;

4) a bill on preferential taxation of biofuels from the tax on CO_2 emissions.

Secondly, the process of organizing and ensuring the effective operation of energy cooperatives requires special knowledge and skills, namely theoretical and practical aspects of the basics of cooperation, industry regulatory and production base, marketing and more.

There is also a problem with insufficient attention to investment in the development of alternative energy at the community level. The advisory and organizational efforts of state institutions to support communities in meeting their own needs in environmental energy production and use projects should be focused. The authors consider it expedient to purposefully help Ukrainian communities to master cooperative tools and become more energy sustainable, in particular, involving the best international and Ukrainian experience of energy cooperation, as well as professional experts in the field.

According to the European Commission, the current trends in the energy market are decentralization trends related to the transition to distributed generation systems. This step of the domestic sectoral policy of the state allows increasing the share of energy microsystems in the total electricity production. The transition to such a new stage in the development of the energy market requires the development of innovative methods of storage and distribution of electricity, as well as SMART-solutions for energy management, namely the control and management of such systems.

Radical changes in energy generation and distribution would lead to greater flexibility and adaptability of the European energy market, will increase the amplitude of the response to peak loads, and will allow variability of tariffs within the consumption and overproduction of electricity.

The slow spread of the energy cooperation movement in Ukraine can be justified, in particular, by the lack of legal framework. In addition, the specifics of charging a “green” tariff are

defined by law – the activity of an energy cooperative is legally possible, but it is not regulated enough due to specific aspects of their activity.

Therefore, in order to normalize the regulatory framework and institutional environment, increase the effectiveness of energy efficiency policies of communities and ensure energy security of the state, we consider it necessary to recommend the implementation of the following measures:

- There should be the recommendation for working on a draft law on the organization of a market mechanism for the production and trade of solid biofuels in Ukraine. Measures to create a new model of a competitive heat market, as well as the creation of a biofuel exchange, should be an integral part of such a bill.
- A set of activities should be developed at the level of regions and communities (seminars, trainings, workshops, focus groups) to gain professional skills and knowledge of cooperation, economic and technical foundations and realities of energy, modern legislative and regulatory field, business planning skills.
- There should be the development and proposal of a system of incentives for communities to create revolving funds through financial tax preferences, in particular, provide for their filling with interest income from the budgets of relevant levels, and in case of foreign investment – a system of tax preferences for investors.

Conclusions

Summarizing the results of the study, it should be noted that the harmonious development of the state economy involves effective energy supply, which is formed with the help of and on the basis of complementary economic policy in the energy sector. Such a policy, in the current context of a large-scale decentralization process in Ukraine, is characterized by additional opportunities and resources at the regional and local levels. The use of existing potential with the involvement of the global experience of models of the generation and consumption of electricity at the community level, the synergistic effect of the use of complex structures, the use of renewable energy sources should be the key to providing all sectors of Ukraine with different energy and fuels.

The dualism of decentralization for the local level in Ukraine is characterized by the presence of a mutual trend: an increase in ample opportunities to fill the local budget, but also a significant increase in expenditure. One of these proven tools is the relevant funds, which combine two trends: national – to obtain funds for development through the relevant state institution; European – to obtain funding through the relevant fund.

The conceptual model of electricity generation-consumption which has been proposed and mathematically formalized in the study proves the possibility and the necessity of the phased implementation of a set of six organizational and economic, institutional and regulatory measures.

Such a comprehensive approach will significantly increase the degree of influence of decentralization on the modernization of Ukraine's economy and the spread of the energy cooperation movement.

Energy cooperatives are a significant step towards community energy independence and energy security, and using existing opportunities to engage cooperatives in the study model of the local government-generation of electricity consumption will reshape the wholesale market and bring households and communities to the level of effective market players. Thus, Ukraine has several real opportunities to increase energy security, energy efficiency, decarbonization and the implementation of low-carbon energy, which in turn will reduce energy imports, intensify economic processes, accelerate decentralization and ensure sustainable development.

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Konceptualny model analityczny zdecentralizowanego zarządzania efektywnością energetyczną gospodarki narodowej

Streszczenie

Celem artykułu jest propozycja uwzględnienia aktualnych światowych i europejskich trendów w zapewnianiu odpowiedniego poziomu efektywności energetycznej, analiza otoczenia instytucjonalnego dla bezpieczeństwa energetycznego oraz opracowanie i uzasadnienie koncepcyjnego i analitycznego modelu wytwarzania i zużycia energii na poziomie regionalnym w reformie decentralizacyjnej w Ukrainie. Zobrazowane zostały aktualne trendy światowego zużycia energii, zbudowana została prognoza rozwoju energetyki odnawialnej oraz przeprowadzano analizę efektywności energetycznej gospodarki narodowej. W artykule przedstawiono studium kształtowania się zintegrowanego miejskiego systemu energetyczno-gospodarczego społeczności ukraińskich i gmin w zależności od ich urbanizacji oraz zaproponowano wykorzystanie modelu koncepcyjno-analitycznego. Przedstawiono szereg propozycji normatywnych i organizacyjno-instytucjonalnych dotyczących standaryzacji procesów poprawy efektywności energetycznej. Efektywność energetyczną gmin można modelować na poziomie koncepcyjnym za pomocą wykorzystania w modelu analitycznym: a) współczynników efektywności energetycznej, są to: instrumenty finansowe efektywnego funkcjonowania jako mechanizmu odsetek dochodów budżetowych i funduszy specjalistycznych, zależność funkcjonalna wytwarzania-zużycia energii z uwzględnieniem metod wytwarzania i głównych odbiorców na odpowiednich poziomach; b) ryzyka procesowego, które związane jest z szeregiem zmian regulacyjnych i instytucjonalnych w celu poprawy efektywności i polityki bezpieczeństwa energetycznego państwa w oparciu o współpracę energetyczną i organizację giełdy biopaliw. Model organizacji i funkcjonowania spółdzielni wytwarzania i zużycia energii słonecznej, oparty na ramach regulacyjnych, przedstawiany został jako modelowe rozwiązanie konstrukcyjne i funkcjonalne. Pozwoliło to na wypracowanie naukowych i aplikacyjnych rekomendacji poprawy przepisów prawnych, które pozwoliłyby gminie stać się efektywnym graczem na hurtowym rynku energii, sprzedając ją po „zielonej" taryfie.

Słowa kluczowe: efektywność energetyczna, bezpieczeństwo energetyczne, decentralizacja, społeczności lokalne, energia odnawialna, model wytwarzania-zużycia energii