JOURNAL
OF EUROPEAN ECONOMY
Vol. 24. № 3 (94). July–September 2025
Publication of West Ukrainian National University

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ENERGY INDEPENDENCE OF LOCAL COMMUNITIES: INTERNATIONAL EXPERIENCE AND DEVELOPMENT PROSPECTS IN UKRAINE

Abstract

This article examines the formation of energy independence among local communities in times of crisis. It studies the international experience of establishing energy communities in European countries, defining them as non-profit organisations that provide environmental, economic, and social benefits to communities. Using historical and logical methods combined with critical, statistical, structural, and graphical analyses within a systemic framework, the study examines the advantages of transitioning from centralised to distributed energy generation to ensure community energy independence. A multi-criteria methodology is proposed for assessing energy projects, taking into account economic, environmental, social, and innovation efficiency indicators. Key areas for achieving energy independence in territorial communities are identified, including the development of local energy plans, implementation of renewable energy sources, application of smart technologies, and creation of local energy communities. The study demonstrates the need for a systemic approach to forming energy-independent territorial communities as a foundation for sustainable development during crises.

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Key Words:

energy independence, energy threats, European experience, investment project, local energy community, model, smart technologies.

JEL: C52, F20, L59, O20, Q21.

1 formula, 6 figures, 34 references.

Problem Statement

Modern geopolitical challenges and energy crises have brought the issue of achieving energy independence to the forefront as a strategic national security priority. Global energy threats have fundamentally reshaped the landscape of European energy security, highlighting the urgent need to transition from centralised energy systems to a decentralised model of energy production and distribution.

The decentralisation of energy infrastructure involves developing distributed generation based on renewable energy sources, smart technologies, and energy storage systems. However, implementing such transformations requires significant capital investment and a comprehensive approach to managing investment risks during crises. Analysis of European practices shows that effective crisis management of the energy transition is achieved through a combination of state support mechanisms, investment attraction, and active local resident participation. Finding the optimal solution for forming energy security and attracting necessary investments is an urgent task at this stage of societal development. The rapid advancement of information technologies offers new opportunities to improve the effectiveness of tools that support community energy independence. Analysing global experience in ensuring community energy independence helps identify existing strengths and areas for improvement, while taking into account the unique characteristics of the Ukrainian economy.

The purpose of this study is to clarify the concept of community energy independence and, drawing on global experience, identify means to achieve it.

To this end, the following tasks were undertaken:

- analysing scientific approaches to defining energy independence and clarifying the concept of an energy-independent community;
- examining the dynamics of energy supply and energy consumption in Ukraine, the EU, and globally;
- systematising tools for ensuring community energy independence; and
- developing a model for assessing environmental projects at the local energy community level.

Literature Review

The energy sector is a key element in ensuring a country's national security. During various crises, scientists have consistently emphasized its importance (see, e.g., Ferreira, 2023; Kardaś, 2024; Niklas & Mey, 2023). Gernego et al. (2022) examined crisis management in Ukraine's energy sector in the context of epidemiological risks, noting that the COVID-19 pandemic accelerated the transition from fossil fuels to widespread use of renewable energy sources. They identified three crisis management concepts: responding only to actual crises, implementing temporary risk prevention measures, and adopting continuous strategic management. Detailed studies of the organizational characteristics of the Ukrainian energy system have been conducted by Holovko and Astakhova (2018), Kudrya (2024), and Yaroshovets (2025).

When pursuing a European integration strategy, it is important to simultaneously consider the specific characteristics of the national economy. Losada-Puente et al. (2023) identified particular barriers to and opportunities for the development of energy associations in individual countries. Using Spain, Italy, and Greece as examples, they demonstrated the necessity of adopting a tailored approach when identifying opportunities for cross-sector cooperation.

The role of energy communities in accelerating the energy transition and empowering consumers has been explored by Ponnaganti et al. (2023) and Bak-Jensen (2025). The potential benefits of this transition were outlined by Martyniuk et al. (2019) and Kaplun (2024). Stanytsina et al. (2023) analysed technologies deemed appropriate for use in this context.

Bartolini et al. (2020) analysed challenges in energy production and distribution from alternative sources at the community level. Specifically, they investigated how communities with a high capacity for uncontrolled electricity generation from renewable sources can consume this energy within the community, either directly or for other purposes. Ponnaganti et al. (2023) identified problems in the energy resource pricing system. Mokaramian et al. (2025), Otamendi-Irizar et al. (2022) studied possibilities for organizing energy distribution relations between communities.

As demonstrated by São José et al. (2021), scientific literature reveals various interpretations of the term «energy community», including community microgrids, renewable energy communities, smart building communities, crowd energy, energy societies, integrated community energy systems, and others. Bonfert (2024) examined the results of four pilot energy community projects in the Netherlands, Belgium, Sweden, and the United Kingdom. Drawing on interviews, observations, and document analysis, Bonfert identified several regulatory and organizational barriers to implementing the energy community model.

Park et al. (2022) investigated the role of internal resources in enhancing the resilience of local governments and their capacity for crisis management. Their study revealed that internal community resources are important for crisis management. However, government officials note the insufficient availability of critically important resources – a universal problem, regardless of the scale and organizational structure of local governments.

Thus, the literature analysis reveals a lack of a unified approach to achieving community energy independence, alongside distinct national contexts that shape how this issue is addressed.

Methodology

In the course of this study, the following general scientific and specialized research methods were employed: critical analysis, coupled with a combination of historical and logical methods, to analyse scientific interpretations of the term «energy independence»; statistical and graphical analyses to examine trends in energy production and consumption from various sources; structural analysis to determine the structure of energy production in Ukraine; and analysis and synthesis, alongside systems and project approaches, to develop a model for assessing local community energy projects.

To identify and analyse trends in energy production and consumption from various sources, selected indicators were used for Ukraine, the EU, the world, and groups of low-, upper-middle-, and high-income countries. Electricity access levels were also analysed within these groups. The information base of the study comprised statistical data from the World Bank. Due to limited data availability, the structure of energy production in Ukraine was analysed using open data from LLC «Ukrainian Energy Exchange» for 2022. The results of the Energy Transparency Index rating revealed problems with data accessibility and transparency. The theoretical foundation of the study is based on scientific works by Ukrainian and foreign scientists, as well as the regulatory frameworks governing energy issues in Ukraine and the European Union. Conclusions and proposals were developed based on a systemic approach.

Research Results

When considering the essence of a country's energy independence, experts most often define it as self-sufficiency in energy resources, reduced reliance on imported fuels, and minimized exposure to fluctuations in the global energy market (EESI, n.d.; Generation, n.d.). According to the EU regulatory framework, energy independence is understood as reducing dependence on fossil fuels while accelerating the transition to renewable energy sources (European Commission, 2022; Ferreira, 2023). The Energy Sovereignty Index, developed by the European Council on Foreign Relations (ECFR), evaluates energy security across four key dimensions: cleanness (the proportion of renewable energy sources compared to fossil fuels in the energy balance), independence (dependence on imported energy), efficiency (trends in primary and final energy consumption), and narrative (the scale and quality of the discourse on energy sovereignty among EU member states). Kardaś (2024) reports that the calculated value of this index for EU countries was 4.0 out of 10 in 2024, which is 0.4 points higher than in 2023, indicating a low level of energy dependence. In May 2022, the EU launched the REPowerEU plan, built around the objectives of energy saving, diversification of energy supply, and clean energy production (European Commission, 2022).

The concept of energy resilience, found in the scientific literature, refers to the ability to maintain a reliable and secure energy supply while withstanding disruptions or shocks to the related infrastructure (Niklas & Mey, 2023). Resilience also includes the ability to swiftly recover from disruptions and shocks and adapt to changing conditions while ensuring the continuous provision of essential energy services (IEA, 2022). The ongoing hostilities in Ukraine have severely affected its energy supply system, exposing a high level of vulnerability, particularly due to the centralized structure of the energy supply system. Disruptions in any part of the generation-distribution-supply chain result in power shortages affecting commercial facilities, household consumers, and the social sphere, underscoring the importance of energy sustainability rooted in energy independence.

By analysing scientific approaches, we can identify different levels of energy independence: the level of country associations and the national, regional, and local community levels. Accordingly, we find it appropriate to define the energy independence of a local community as the sufficient availability of its own energy resources, enabling all its members to function without interruption. According to EU regulatory documents, energy independence at the national level can be achieved by creating energy communities as local units.

Distributed generation presents the following advantages:

- It enhances energy independence within communities by enabling local energy systems to operate independently during power grid outages, ensuring uninterrupted power supply to critical infrastructure facilities.
- It promotes economic development through job creation and reduced energy costs associated with transmission and distribution.
- Environmental impact is mitigated by lowering greenhouse gas emissions, reducing the consumption of natural resources, and encouraging cleaner production methods.
- Social impact is generated through the involvement of community residents, businesses, and government representatives in joint projects, thereby nurturing a sense of belonging and responsibility (Sustainability Directory, 2025).

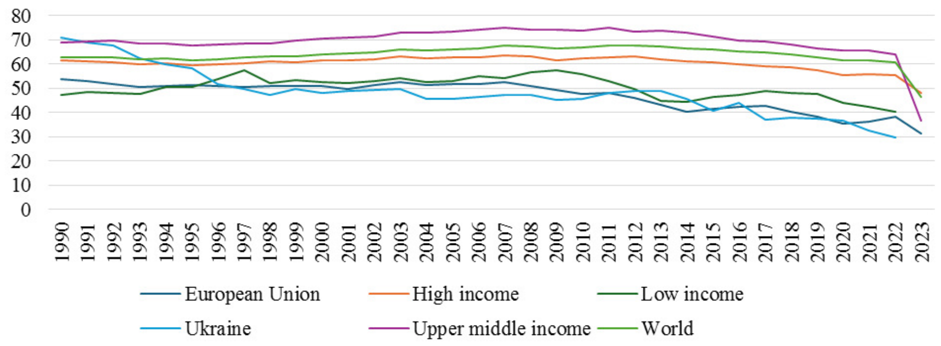
This study confirms the thesis that the practice of distributed generation is actively spreading in other countries. Analysis of statistical data indicates a change in global electricity production trends (see Figure 1). As shown in Figure 1a, oil, gas and coal collectively account for more than 60% of global electricity production, rising to over 70% in countries with above-average income levels. Conversely, the share of these sources in electricity production has sharply declined in the EU and Ukraine – from 54% to 31% in the EU and from 71% to 30% in Ukraine between 1990 and 2023. In contrast, the share of renewable sources has increased over the past thirty years (Figure 1b). At the global level, this share has grown from 0.9% in 1990 to 12.5% in 2021, while in the EU it surged from 0.1% to 24.9% over the same period. For comparison, Ukraine is also transitioning to renewable energy sources, albeit at a slower pace.

Statistical data on energy consumption from various sources are visualized in Figure 2.

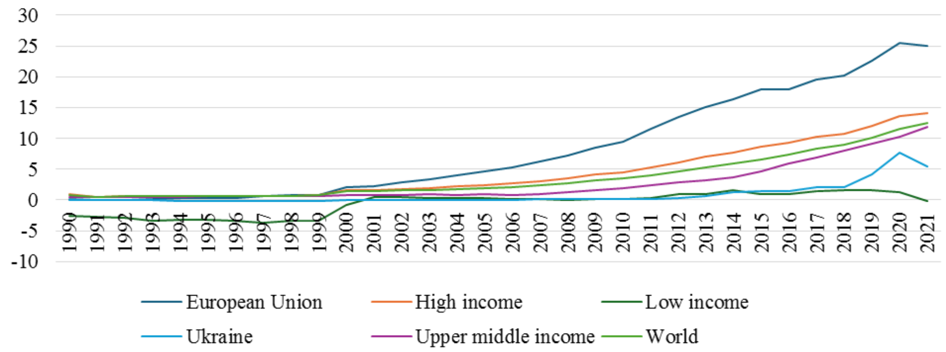
Figure 1

Dynamics of electricity production from various sources

1a. Electricity generation from oil, gas, and coal (% of total)



1b. Electricity generation from renewable sources, excluding hydroelectric power plants (% of total)

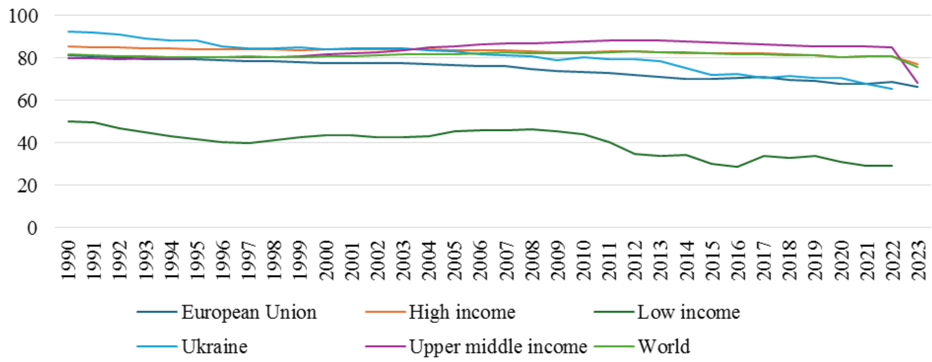


Source: constructed by the author based on data from the World Bank (n.d.).

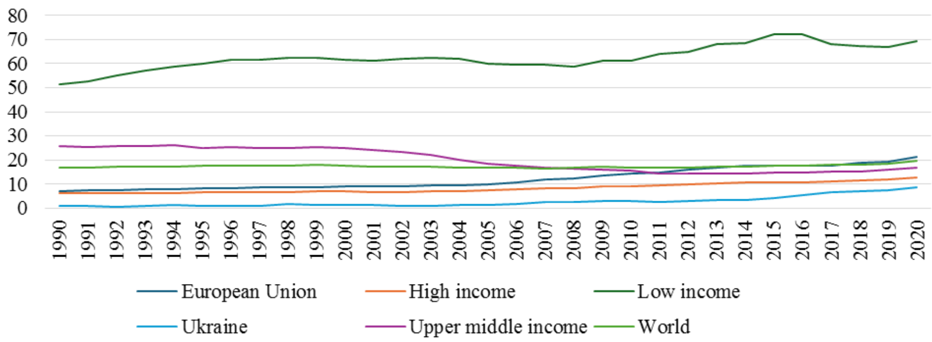
Figure 2

Dynamics of energy consumption from various sources

2a. Fossil fuel energy consumption (% of total)



2b. Renewable energy consumption (% of total final energy consumption)



Source: constructed by the author based on data from the World Bank (n.d.).

Analysis of energy consumption (Figure 2) reveals that fossil fuels account for a smaller proportion of energy consumption in low-income countries than renewables. This is most likely due to limited access to traditional energy sources and the high costs of distribution infrastructure. The construction and maintenance of such infrastructure (power plants and transmission lines) requires significant investment, which is often unavailable in poorer countries. Alternative sources such as solar energy, biomass, and hydropower are often more accessible and economically viable in these regions. Additionally, poor countries frequently lack strict environmental controls, which can lead to the continued use of polluting technologies. However, growing awareness of environmental issues and a desire to improve quality of life are prompting people to seek cleaner alternatives, as illustrated in Figure 2. In high-income countries, including EU countries and Ukraine, there is a trend toward an increasing share of energy consumption from renewable sources.

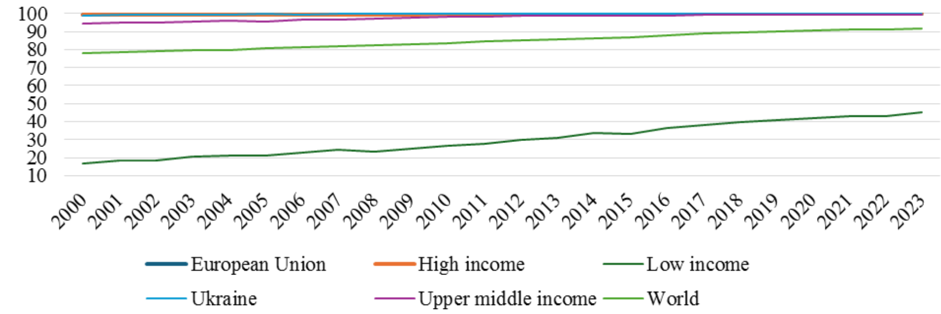
Analysis of the level of electricity supply shows nearly identical levels of access to electricity in rural and urban areas (Figure 3). The level of a country's development and well-being plays a more significant role in this context. Accordingly, low-income countries do not provide 100% electricity access to their urban and rural populations. In contrast, high-income countries, as well as EU member states and Ukraine, have nearly 100% electricity access among their populations (the lines for these groups of countries overlap in Figure 3 (a, b, c).

Although large companies still dominate the European energy market, local energy communities are gaining a growing presence (Otamendi-Irizar et al., 2022). The EU regulations provide two official definitions of energy communities: «citizen energy communities», defined in the Internal Electricity Market Directive (EU) 2019/944; and «renewable energy communities», defined in the Renewable Energy Directive (EU) 2018/2001. These two directives form the core of the EU legal framework governing citizen participation in the energy system. They describe energy communities as new types of non-profit organisation, whose main purpose is to provide environmental, economic, or social benefits to the community rather than prioritising profit (REScoop.EU, 2019). Recognising the potential of distributed energy generation, the REPowerEU Plan sets a target for EU countries to create one energy community for every community with a population over 10,000 by 2025 (European Commission, n.d.). A community energy management system developed in Denmark acts as the intelligent core of an energy community. It monitors local production, consumption, and electricity prices, and coordinates the operation of electric vehicle chargers, heat pumps, and batteries, optimising energy flows and reducing costs. In Poland, similar EMS solutions are employed in public buildings to manage rooftop photovoltaic systems, energy storage systems, and flexible loads, including heat pumps and electric vehicle chargers. In India, EMSs are being adapted for use in rural microgrids and smart buildings to manage energy access and reliability in areas with weak or no grid connectivity (Bak-Jensen, 2025). The Scottish Government's energy strategy sets a target for the country to generate 2 GW of local energy by 2030 (Scottish Government, 2017). Community energy involves implementing community-based renewable energy projects, either wholly owned and/or controlled by communities, or delivered in partnership with commercial or public organisations.

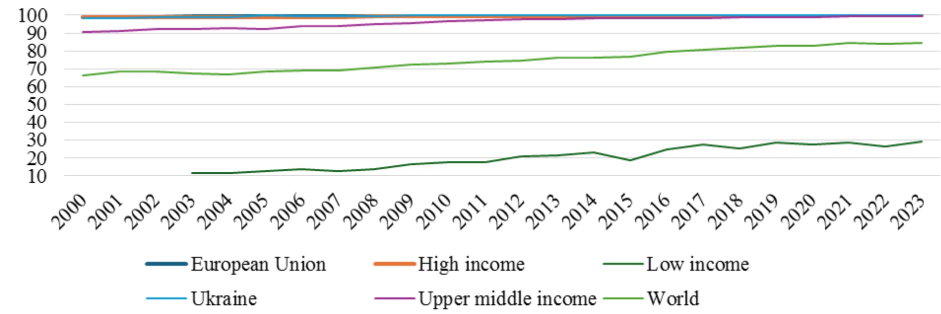
Figure 3

Population access to electricity

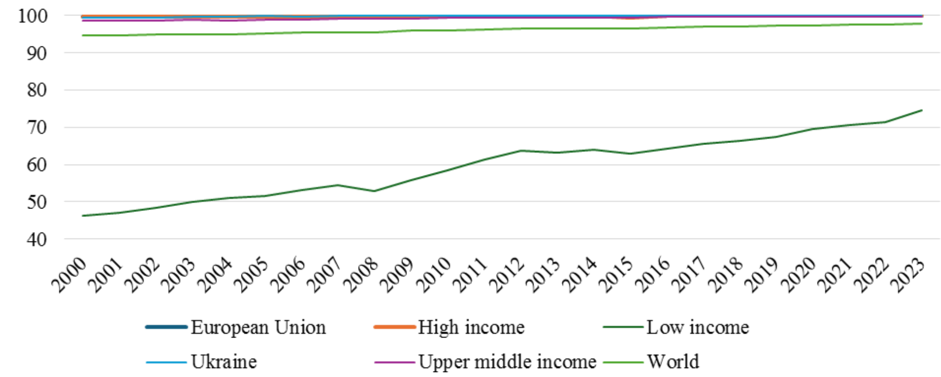
3a. Access to electricity (% of population)



3b. Access to electricity, rural areas (% of rural population)



3c. Access to electricity, cities (% of urban population)



Source: constructed by the author based on data from the World Bank (n.d.).

These projects provide energy services to local people within a defined geographical area. Local energy systems link energy supply and demand within a region, including electricity, heating, and transport, with the aim of growing the local economy while achieving zero emissions. Community residents who invest in renewable energy projects become co-owners and receive additional remuneration – often in the form of funds – provided by renewable energy companies to communities as part of commercial projects. Local energy plans also take into account the communities' existing and future energy needs (in terms of electricity, heat, and transport) and determine priority areas. As Otamendi-Irizar et al. (2022) note, this approach to organising the energy supply of local communities catalyses social innovation and sustainable local development.

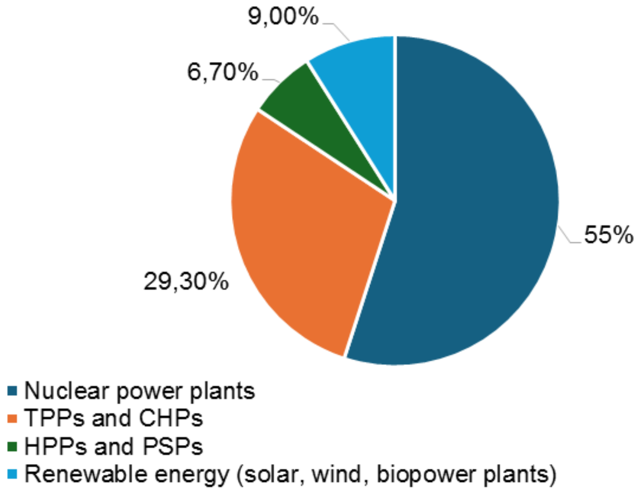
At the same time, it should be noted that technologies based on renewable sources have certain limitations: high cost of equipment, insufficient amount of generated energy, limited amount of relevant resources, and dependence on natural conditions. In particular, Bartolini et al. (2020) highlighted the challenges of regulating the volumes of energy produced from alternative sources in communities. Existing electricity markets, tariffs, and regulations often hinder effective and sustainable solutions in the field of energy supply as well (Ponnaganti et al., 2023).

The Ukrainian Unified Energy System (UES) is a set of power plants, electricity and heating networks, operating in the following modes: generation, transmission, and distribution of thermal and electrical energy. Nuclear, thermal, hydroelectric power plants, as well as stations on alternative sources, such as solar power plants, wind power plants, and others, are used to produce electricity (Ukrainian Energy Exchange, 2022). According to the Ministry of Energy of Ukraine, the country produced 156.5 billion kWh of electricity in 2021 – an increase of 5.2% over 2020. The structure of electricity production for this period is presented in Figure 4.

The Energy Transparency Index has been developed to comprehensively assess the availability and quality of information in the energy sector. This index comprises over 200 indicators based on regulatory requirements and best global practices for information disclosure. The indicators are grouped into eight categories: balances (annual and monthly balance sheet statistics), natural monopolies (activity of transmission and distribution system operators, operator independence, system development, tariff formation), supply (market barriers, concentration and level of competition, prices and pricing), reliability and safety (stocks and reserves, safety rules, reliability and safety reports), consumption (availability of metering devices, consumer service standards, consumer information), reporting (financial and management reporting, fiscal reporting, beneficiaries and corporate governance), policy (monitoring and reporting, energy efficiency, environmental protection and climate change mitigation, renewable energy sources), authorities (budget spending, transparency of public administration).

Figure 4

Structure of electricity production in Ukraine (beginning of 2022)



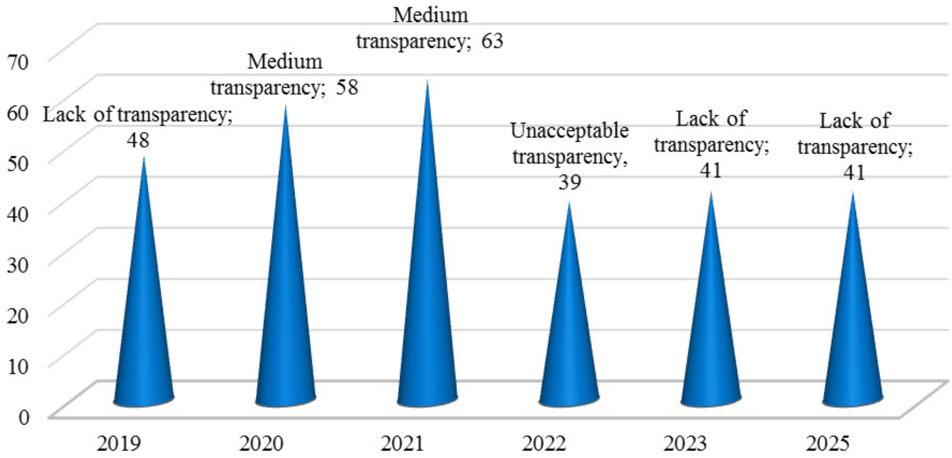
Source: constructed by the author based on data from the Ukrainian Energy Exchange (2022).

The assessment of a country's energy sector transparency is based on the analysis of open-source data concerning its functioning and development along the «from producer to consumer» chain (Energy Transparency Index, n.d.). This index covers five energy markets: natural gas, electricity, oil and liquid fuel, thermal coal, and thermal energy. Analysis of this indicator's dynamics from 2019 to 2025 indicates an insufficient level of energy transparency in Ukraine (Figure 5).

Correspondingly, limited access to information negatively affects the efficiency of organizing the energy supply system, hindering optimal selection of counterparties as well as effective monitoring and control. Since the onset of the Russian Federation's military aggression, Ukraine's energy sector has suffered significant destruction, which has negatively impacted both the country's economy and the daily lives of its citizens. This has created an urgent need for communities to find ways to ensure their energy independence as part of their sustainable development under crisis conditions. Consequently, transformations have taken place across all stages of energy generation, transmission, storage, distribution, and consumption. Experts identify the main solutions for community energy supply as follows: using alternative fuels and renewable energy sources, developing technologies, and creating and improving local micro-energy systems (Kaplun, 2024).

Figure 5

Dynamics of the Ukrainian Energy Transparency Index



Source: based on data from Energy Transparency Index (n.d.).

Historically, Ukraine's energy system was centralized, relying on large power plants that transmitted electricity to consumers through transmission and distribution networks (Holovko & Astakhova, 2018). Although relatively low-cost, such a system has certain drawbacks, including losses of electricity during transmission, negative impacts of emissions from coal-fired power plants, and safety concerns related to nuclear power plants. Under the conditions of the decentralization reform, the transition to decentralized (distributed) power generation has become a pressing issue. This system involves the production and transmission of generated energy to consumers, who simultaneously act as producers of electricity and heat for their own needs, with any surplus energy being transmitted into the general grid. Martyniuk et al. (2019) and Kaplun (2024) note that, despite a significant payback period, the shift to local resources for community energy supply is beneficial due to the synergistic effects that contribute to further development and economic growth of the community, improving its security and quality of life. Drawing on scholarly experience, it is important to highlight the preconditions necessary for such a transition:

- Active involvement of all local stakeholders in fostering teamwork. Utilising internal energy sources will enable savings on payments to external energy suppliers, allowing reinvestment of these funds to support the local community's economy.

- Development of a community energy plan based on the utilization of existing local energy resources, designed to meet community needs and stimulate further development. A community resource passport can serve as a useful tool in this process (Skorobogatova, 2025a);
- Cooperation with other (neighbouring) communities for the rational shared utilization of each community's existing advantages and resources (such as available land, human and financial resources, etc.);
- Implementation of comprehensive programs aimed at increasing energy utilization and developing renewable energy sources, with the goal of promoting energy savings and responsible consumption of community resources.

To ensure the transformations necessary to increase energy independence in communities facing crisis, it is crucial to maintain the effective functioning of the resource provision mechanism, which facilitates optimal provisioning, distribution, and consumption of all community resources, including energy (Skorobogatova, 2025a). The first stage of this mechanism is «planning», which involves identifying the community's needs for energy resources. During the «organization» stage, an appropriate organisational and management structure is established, with a clear division of functions and responsibilities. At the «control» stage, the adoption of smart technologies is recommended to enhance organizational effectiveness and promote the rational consumption of energy resources. Finally, the «evaluation» and «optimization» stages facilitate assessing the mechanism's efficiency and implementing necessary measures to improve its performance, thereby ensuring the community's energy independence in times of crisis.

Energy generation technologies encompass various methods for converting different forms of energy into electrical or thermal energy. These methods are categorized as either traditional – such as fuel combustion at thermal power plants or nuclear energy – or renewable energy sources, including cogeneration systems (e.g., solar panels, small wind turbines, cogeneration units, incineration plants for biomass and solid waste, and hydroelectric power plants). Most developed countries, including the United States, Germany, Spain, Sweden, Denmark, and Japan, have plans to increase the proportion of energy produced from renewable sources to 20-50% of total energy production (National Institute for Strategic Studies, 2010). Meanwhile, the Ukrainian government has approved the country's Energy Strategy until 2050. The document envisages achieving carbon neutrality in the sector by actively transitioning to and expanding modern, safe nuclear generation and renewable energy sources, as well as modernizing and automating transmission and distribution systems (Cabinet of Ministers of Ukraine, 2023). Ukraine's main Energy Strategy objectives are to achieve climate neutrality; reduce fossil fuel (coal) use in the energy sector; actively re-equip and modernize energy infrastructure; increase the efficiency of energy resource use;

increase the share of domestic resources in the sector's supply; and promote the innovative development of the industry.

It should also be noted that every technology has its advantages and drawbacks. In analysing various technologies, Stanytsina et al. (2023) conclude that fossil fuel-based technologies are best suited for either base generation or backup capacity. Renewable energy sources (solar, wind, hydroelectric power plants, and hybrid installations), on the other hand, enable communities to enhance their energy independence. Moreover, in addition to economic factors – such as the full life cycle cost of the corresponding energy sources – environmental requirements and legislative restrictions must also be considered. Technologies based on renewable energy sources provide the potential to somewhat reduce pollutant emissions and solid waste, leading to a positive environmental impact. To optimize energy production, each energy unit should be equipped with devices that facilitate integration with a central control system, allowing production volumes to be managed as necessary (Holovko & Astakhova, 2018).

We believe that the following measures must be implemented for communities to achieve energy independence:

- Development of local energy strategies, conducting energy audits, and creating maps of the energy potential of territories. Currently, the *Atlas of the Energy Potential of Renewable Energy Sources of Ukraine*, developed by Kudrya (2024), enables assessment of the potential of renewable sources at the national level. Furthermore, by the end of October 2025, local communities must have developed Local Energy Plans – a prerequisite for obtaining government and international support, as well as attracting investments (Yaroshovets, 2025).
- Replacement or reduction of fossil fuel use through solar and wind power plants, generators, batteries, co- and tri-generation plants, biofuels, heat pumps, and electric boilers (Stanytsina et al., 2023). It is important to distinguish between energy independence and the transition to renewable energy sources, as communities could theoretically rely on local fossil fuel resources to meet their energy needs. However, from the perspective of sustainable development, renewable energy sources contribute to solving environmental problems, while fossil fuels do not.
- Implementation of energy efficiency and energy-saving measures, including educational activities for the population; improvements to construction efficiency through better insulation, energy-efficient windows, and heating systems; installation of solar panels and energy storage systems; and the use of energy-efficient appliances.
- Development of public transport to reduce reliance on private vehicles and decrease the need for fuel.

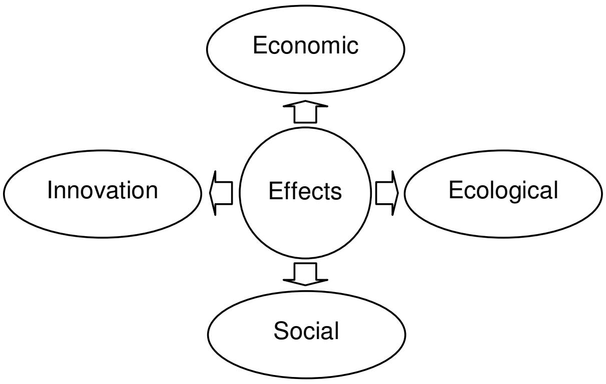
- Application of smart technologies in the energy system: implementing smart building energy management systems (BEMS), IoT-based energy monitoring sensors, automated street lighting systems, smart thermostats, and climate control systems (Skorobogatova, 2025b); applying AI-based forecasting systems for energy production based on weather, historical, and seasonal fluctuation data; deploying smart grids and local power grids with automated control (especially for critical infrastructure and residential areas); and utilising specialized mobile applications that allow users to control their energy consumption.
- Implementation of distributed generation through the establishment of energy communities, common in other countries, whereby residents, businesses, and local authorities collaborate to produce, distribute, and consume energy, including renewable energy. Energy communities are collective initiatives involving stakeholders such as citizens, local authorities, and businesses who jointly finance, own, manage, and carry out energy-related activities, such as production, consumption, storage, shared use, and aggregation of energy. These communities can take various legal forms, including cooperatives and non-profit organizations. Under this model, energy producers – whether public or private organisations – operate their own facilities to generate energy. Some of this energy is consumed independently by the producer, while the surplus is distributed to local consumers at more competitive prices (Mokaramian et al., 2025). They can utilize solar, wind, and biomass sources to produce energy for local consumption, potentially reducing dependence on centralised utilities and lowering energy costs (European Commission, n.d.; EESI, n.d.).

The implementation of projects focused on transitioning to distributed generation through the creation of local energy communities requires adequate financial, human, material, and equipment resources. In this context, a project approach is recommended, as it involves setting clear goals and objectives, defining deadlines, functional duties, and responsibilities of participants, ensuring resource provision, and focusing on balanced community development. We believe that the feasibility of implementing energy projects in local communities can be evaluated using a multi-criteria assessment that takes into account economic, environmental, social, and innovation indicators (see Figure 6).

Economic efficiency can be determined using well-known indicators such as net present value, payback period, and internal rate of return. The ecological effect should be assessed by measuring reductions in pollutant emissions and waste, and improvements in the ecological condition of the community. The social impact can be evaluated based on the number of jobs created, the reliability of electricity and other energy supply, and the social climate within the community. The innovation effect should be assessed according to the technological novelty of the proposed project solution, the duration of its operational phase, and its synergistic impact on community development. We also propose including a security element within the innovation component to account for the reduction in the community's dependence on external energy sources.

Figure 6

The effects of community energy project implementation



Source: author's own elaboration.

In addition, it is important to recognize that energy communities implementing such projects consist of various groups of participants: community residents, the business sector, the public sector, and others. Therefore, a full project assessment should be conducted for each group, taking into account economic, environmental, social, and innovation aspects, as formalized in Equation (1):

$$E = \sum_{n=1}^{N} (\alpha_1 EC_n + \alpha_2 EN_n + \alpha_3 S_n + \alpha_4 I_n) \rightarrow \max, , \quad (1)$$

Where: E – total (integral) effect of project implementation; n = 1, 2, ..., N – index of a project participant; EC_n – economic effect for the n^{th} participant; EN_n – environmental effect for the n^{th} participant; S_n – social effect for the n^{th} participant; I_n – innovation effect for the n^{th} participant; $\alpha_1, \alpha_2, \alpha_3, \alpha_4$ – weighting coefficients that reflect the significance of each corresponding component, with the constraint: $\alpha_1 + \alpha_2 + \alpha_3 + \alpha_4 = 1$.

When assessing the performance of environmental projects, it should be noted that they tend to be relatively inefficient economically (with low profits and long payback periods), but highly efficient in ecological and innovation terms. The indicators used to calculate total project efficiency have different units of measurement, so they must be normalised using the min-max method for quantitative parameters and a point-based scoring method (on a scale from 0 to 1) for qualitative parameters. To account for the specific nature of these projects, we propose the following balanced distribution of weight coefficients:

$\alpha_1 = 0.20$ – economic component;

$\alpha_2 = 0.30$ – ecological component;

$\alpha_3 = 0.20$ – social component;

$\alpha_4 = 0.30$ – innovation component.

Unlike traditional methods, which only allow projects to be assessed from the perspective of individual or group investors, the proposed approach takes into account the interests of all stakeholders in the energy community, including residents, businesses, the public sector, and local authorities. The innovation component is further enhanced by the addition of a unique security dimension, which accounts for reduced energy dependence on external energy sources, increased community security, and diversification of energy sources.

By implementing the suggested approach, we have demonstrated the feasibility of installing a 1 MW solar power plant in a community. The project's main stakeholders were local residents, local businesses, and local authorities. The resulting benefits for local residents include reduced energy tariffs and household expenses, lower CO_2 emissions, a stable energy supply, the creation of 15 jobs, deployment of modern technologies, and a 40% decrease in energy dependence. For local businesses, the positive effects include decreased energy costs, an enhanced reputation as part of an environmentally friendly community, increased investment attractiveness of the region, and access to modern energy solutions. Local authorities benefit from increased tax revenues, compliance with environmental requirements, improved quality of life of the population, and recognition as an innovative community. The main advantages of the proposed approach are its comprehensiveness, as it considers the interests of all stakeholders, and its flexibility, as it allows for adjusting the weighting coefficients to reflect the specific features of the project and conditions of its implementation.

Therefore, the proposed approach provides an opportunity to choose optimal methods for implementing energy projects during the transition to an energy-independent community under limited financial resources. This approach also enables the efficiency (or significance) of the project be substantiated when attracting investment and grant support.

Conclusions

Our analysis of existing approaches to defining energy independence revealed a lack of a unified terminological framework, which complicates the systematisation and analysis of data at the global level. We propose defining the energy independence of a local community as the sufficient availability of its own energy resources to ensure the uninterrupted functioning of all its members. This definition highlights a key factor – the community's self-sufficiency in terms of energy resources, with quantities adequate to meet its needs.

The comparative analysis of potential sources of energy generation, in the context of ensuring community energy independence, has demonstrated the feasibility of switching to renewable energy sources while simultaneously decentralising the country's energy system. This approach would reduce the risk to the community's energy security in the event of damage to the power grid or centralized generation facilities, which is especially pertinent given the ongoing war in the country. At the same time, a gradual transition from fossil fuels to renewable energy sources would reduce adverse environmental impacts, aligning with the principles of sustainable development.

The proposed measures to ensure energy independence in local communities encompass the development of local energy strategies, energy audits, and maps of territorial energy potential; replacement or reduction of fossil fuel use through alternative sources; implementation of energy efficiency and energy-saving measures, development of public transport; utilization of smart technologies in the energy system; and deployment of distributed generation through the creation of energy communities and energy projects. Due to the specific nature of these projects, their implementation and financing require the engagement of all stakeholders in order to achieve a significant socio-ecological impact and reduce the community's energy dependence. Given the relatively low economic efficiency of such projects compared to commercial projects, we propose a comprehensive assessment model that accounts for environmental, social, economic, and innovative aspects. We believe that this approach will enable the selection of the optimal implementation methods and facilitate thorough project evaluation when attracting investment or seeking grant financing.

Further research is required into the development of technical tools for organising community energy supply systems in the context of crisis management, as well as into improving marketing tools to increase the level of potential stakeholder involvement in community energy projects.

Acknowledgements

This article draws on materials from the research project «Resource Provision for Local Communities to Enhance Their Capacity to Respond to Crisis Situations» (0125U002065). The project is funded by the Ministry of Education and Science of Ukraine as part of international scientific and technological cooperation, in accordance with the Protocol of the Fifteenth Meeting of the Joint Ukraine-NATO Working Group on Cooperation in Science and the Environment dated July 4, 2017, and the Ministry of Education and Science's letter No. 1/3273-25 dated February 20, 2025, which provides funding for research work under the NATO Science for Peace and Security Program project.

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Received: August 7, 2025.
Reviewed: August 18, 2025.
Accepted: August 29, 2025.