“Rethinking energy poverty alleviation through energy efficiency: Evidence from Ukraine”

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RETHINKING ENERGY POVERTY ALLEVIATION THROUGH ENERGY EFFICIENCY: EVIDENCE FROM UKRAINE

Abstract

Providing people with access to sustainable energy and overcoming energy poverty are essential tasks of the energy transition to a climate-neutral economy. The paper aims to examine the financial measures to alleviate energy poverty in Ukraine, such as the provision of energy subsidies and the financing of local programs to improve the energy efficiency of buildings through the Energy Efficiency Fund. Using statistical data of the International Energy Agency, Eurostat, the Ministry of Energy of Ukraine, and the State Statistics Service of Ukraine, the paper analyzes the state of energy poverty in Ukraine compared to EU countries. In the context of Ukraine's intensifying energy and economic crises, the assessment of the fiscal cost of energy subsidies reflects a significant increase in an additional burden on the state budget. The fiscal cost of subsidies was assessed using the price-gap approach. The paper presents the results of energy modernization of buildings in Ukraine through the Energy Efficiency Fund. Implementation of energy modernization projects for buildings reduces energy costs and CO2 emissions, increases housing energy efficiency, and expands the possibilities of overcoming energy poverty. The application of the cost-benefit analysis method to sustainable housing renovation projects is demonstrated to more accurately assess energy and carbon impacts and to obtain financial support. The formulated proposals aim to raise awareness of power structures and support informed decision-making to overcome energy poverty and build a sustainable energy future for Ukraine.

Keywords sustainable development, energy transition, energy poverty, fossil-fuel subsidies, energy efficiency, Ukraine

JEL Classification D62, I38, Q41, Q48

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INTRODUCTION

The green and energy transitions are seen as a common foundation for building a sustainable economy. The main goal to be achieved by 2030 is "ensuring access to affordable, reliable, sustainable and modern energy for all" (UN, 2021a).

A crucial task of the green energy transition is not only to restore the energy sector's stable functioning, stimulate energy efficiency, and develop renewable energy but also to provide access to sustainable energy for broad population segments and overcome energy poverty. According to the updated energy strategy of Ukraine, by 2050, the energy sector "should be as close as possible to climate neutrality, which means the availability of clean energy, overcoming energy poverty, developing an innovative and decentralized energy system, fully functioning national energy markets and their integration into international ones" (Ministry of Energy of Ukraine, 2022).

The high volatility of energy prices, combined with the low energy efficiency of buildings, significant destruction of housing and social in-

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frastructure, and a sharp drop in the population's income during wartime, exacerbate the problems of the rapid growth of energy poverty in Ukraine. The deficit of energy capacities enhances Ukraine's energy dependence, increases electricity prices, and accelerates the spread of energy poverty.

According to foreign practice, there are different options for overcoming energy poverty via energy policy, social policy, or a combination of various regulatory decisions. At the country level, various measures are applied, ranging from price controls and tax incentives to restrictions on disconnections, social tariffs, energy efficiency, and energy conservation (EC, 2024; EU, 2023).

What are the features of implementing measures to support vulnerable population groups and alleviate energy poverty in Ukraine? One of such measures is energy subsidies for electricity and gas. There is a difference between the terms "energy subsidies" and "fossil-fuel subsidies." According to the methodological approaches of the IMF, OECD, and IEA, the cost of state support for energy consumers and producers differs. Therefore, it is necessary to conduct a comparative analysis of these approaches and more accurately determine the increase in the additional burden on the state budget.

Implementing energy efficiency programs locally is critical to support vulnerable population groups and prevent the spread of energy poverty in Ukraine. The large-scale destruction of public infrastructure in Ukraine during the war increased the costs of reconstruction and restoration of housing stock. Consequently, the just energy transition requires improved cost-benefit analysis (CBA) to carefully analyze the social costs and benefits, taking into account the long-term benefits of decarbonization when implementing sustainable housing renovation projects in practice. Thus, a significant share of CO_2 emissions falls precisely on the residential and public buildings sector and enters the atmosphere during the heating process. Therefore, these sectors have a significant potential for reducing pollution after the energy modernization of buildings based on implementing the Build Back Better principle with an emphasis on increasing the comfort, energy efficiency, and environmental friendliness of housing following European standards.

1. LITERATURE REVIEW

The International Energy Agency's information reflected the results of the energy industry's development in the conditions of growing energy demand (IEA, 2024a, 2024b). The International Renewable Energy Agency (IRENA) presents the perspectives of the energy transition (IRENA, 2020, 2024). Most European countries are stepping up efforts to implement National Energy and Climate Plans (NECPs) on the energy transition path (EC, 2019; UN, 2015a; Council of the European Union, 2021).

Energy efficiency is identified as a key action area in the fight against energy poverty (Council of the European Union, 2023). Considering deteriorating energy market, concerns about energy supply, rising energy prices, and the EU's ongoing transition to climate neutrality, the issue of energy poverty will become a key one in the coming years (EU, 2023). Energy poverty is a critical concept in the Clean Energy for All Europeans legislative package, which aims to promote a just energy transition. The Energy Efficiency Directive defines energy poverty as a household's lack of access to essential energy services that provide basic levels and decent standards of living and health. These include adequate heating, hot water, cooling, lighting, and energy to power appliances. Some countries suffer from existing social policy and other relevant policies caused by a combination of factors, including but not limited to non-affordability, insufficient disposable income, high energy expenditure, and poor energy efficiency of homes (Council of the European Union, 2023).

Energy poverty is considered in the context of complex global economic and climate change issues (Li et al., 2014; Nussbaumer et al., 2012) and social issues related primarily to economic inequality. For example, Boardman (1991) first introduced the term "affordable warmth" and defined fuel poverty in the UK: Fuel poverty occurs when a household has to spend more than 10% of its income on fuel to maintain a suitable indoor

temperature. The term fuel poverty continues to be used alongside energy poverty, although there is a distinction between the two, as noted by Li et al. (2014). Moore (2012) explored the content and formulation of fuel poverty targets. Walker and Day (2012) presented fuel poverty as a complex form of inequity that hinders access to energy services. Legendre and Ricci (2015) studied fuel poverty in France and developed the concept of fuel vulnerability. Bartiaux et al. (2019) defined energy poverty as energy inequity and examined the impact of energy transitions on social inequality.

There are different points of view on forming policies to overcome energy poverty. Koďousková and Lehotský (2021), having studied the problem of energy poverty in Central and Eastern European countries, drew attention to the existence of two competing models at the state and regional level. Mulder et al. (2023) found that energy poverty is much more spatially concentrated than income poverty. They stressed the importance of developing an analytical basis for establishing national energy poverty monitoring in the Netherlands. Sareen et al. (2020) explored energy poverty metrology as a complex, socially determined phenomenon. Kashour and Jaber (2024) presented the results of energy poverty research based on calculating a composite index. Nussbaumer et al. (2012) proposed calculating the multi-dimensional energy poverty index (MEPI).

Many countries have programs to help low-income households with energy (Murray & Mills, 2014; Lausberg & Croon, 2023). Kyprianou et al. (2019) analyzed energy poverty reduction measures in five EU countries (Bulgaria, Cyprus, Spain, Portugal, and Lithuania). They concluded that a regional approach is more effective than a national one in combating energy poverty. Croon et al. (2024) examined the issue of social housing. They noted that the choice of target group is a fundamental part of the targeting policy, and data limitations are a major challenge in combating energy poverty. Clements et al. (2013) and Kojima and Koplow (2015) identified the peculiarities of estimating the fiscal cost of expenses based on the provision of energy subsidies. Kocheshkova (2019) analyzed the problem of energy poverty in Ukraine and emphasized the need to separate measures to combat energy poverty from the general system of support for low-income households.

In Ukraine, attention has increased to the problem of overcoming energy poverty, but financial conditions for implementing state programs to support vulnerable groups of the population are limited (National Recovery Council, 2022; Mishchenko et al., 2016; Zhuravka et al., 2024). According to the Law of Ukraine on Energy Efficiency (Verkhovna Rada of Ukraine, 2015), a course has been taken to introduce modern European practices to stimulate the production of green energy, energy saving, and energy efficiency. The Law of Ukraine on the Energy Efficiency of Buildings defines the legal, socio-economic, and organizational principles for ensuring energy efficiency of buildings. It aims to reduce energy consumption in buildings (Verkhovna Rada of Ukraine, 2017).

Methodological approaches to evaluating the results of a fair energy transition need to be harmonized with those used in most European countries, based on fundamental and internationally recognized methodological principles (IEA, 2020; Naumenkova et al., 2022; Naumenkova et al., 2023). The EC (2014) defines cost-benefit analysis (CBA) as a basis for decision-making on the co-financing of projects and a real management tool for national and regional authorities. OECD (2018) presents the application of the CBA method to projects or policies that have the deliberate aim of environmental improvement or are actions that affect the natural environment as an indirect consequence. Liu et al. (2018) proposed a methodological framework to conduct an economic cost-benefit analysis for EER projects. CBA method for building solutions and energy efficiency projects was developed by Araújo et al. (2016) and Mihic et al. (2012). Siller et al. (2007) constructed the model to describe the dynamics of the energy-relevant properties of the residential building stock.

The worsening energy crisis in Ukraine requires rethinking of policies to protect vulnerable households based on the development of national energy poverty indicators that should be consistent with energy sector development targets and strategic documents for Ukraine's economic recovery.

The paper aims to examine the financial measures to combat energy poverty in Ukraine, such as the provision of energy subsidies and the financing of local programs to improve the energy efficiency of buildings through the Energy Efficiency Fund.

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2. METHODS

The content and focus of monitoring measures to combat energy poverty are presented in the context of sustainable financing in accordance with the legal framework of the EU countries (Figure 1).

The European Pillar of Social Rights includes the right to access energy, which must be guaranteed to every person (EC, 2017). Energy poverty is a situation in which households do not have access to basic energy services.

The focus is on measures for a just energy transition with climate impact, combined with social finance and responsible investment measures. The research direction involved the sequential implementation of the following main stages:

1) analysis of energy poverty in EU countries and Ukraine;

2) evaluation of government support measures to address energy poverty, including through the provision of energy subsidies in the context of the transition to a low-carbon economy;

3) assessment of the effect of energy modernization programs for multi-storey buildings implemented at the local level through the Energy Efficiency Fund during the reconstruction in Ukraine.

The statistical analysis of energy poverty in EU countries was carried out based on data from Eurostat, Energy Poverty Advisory Hub, in accordance with the European Pillar of Social Rights (Figure 1). The issue of the possibility of mitigat-

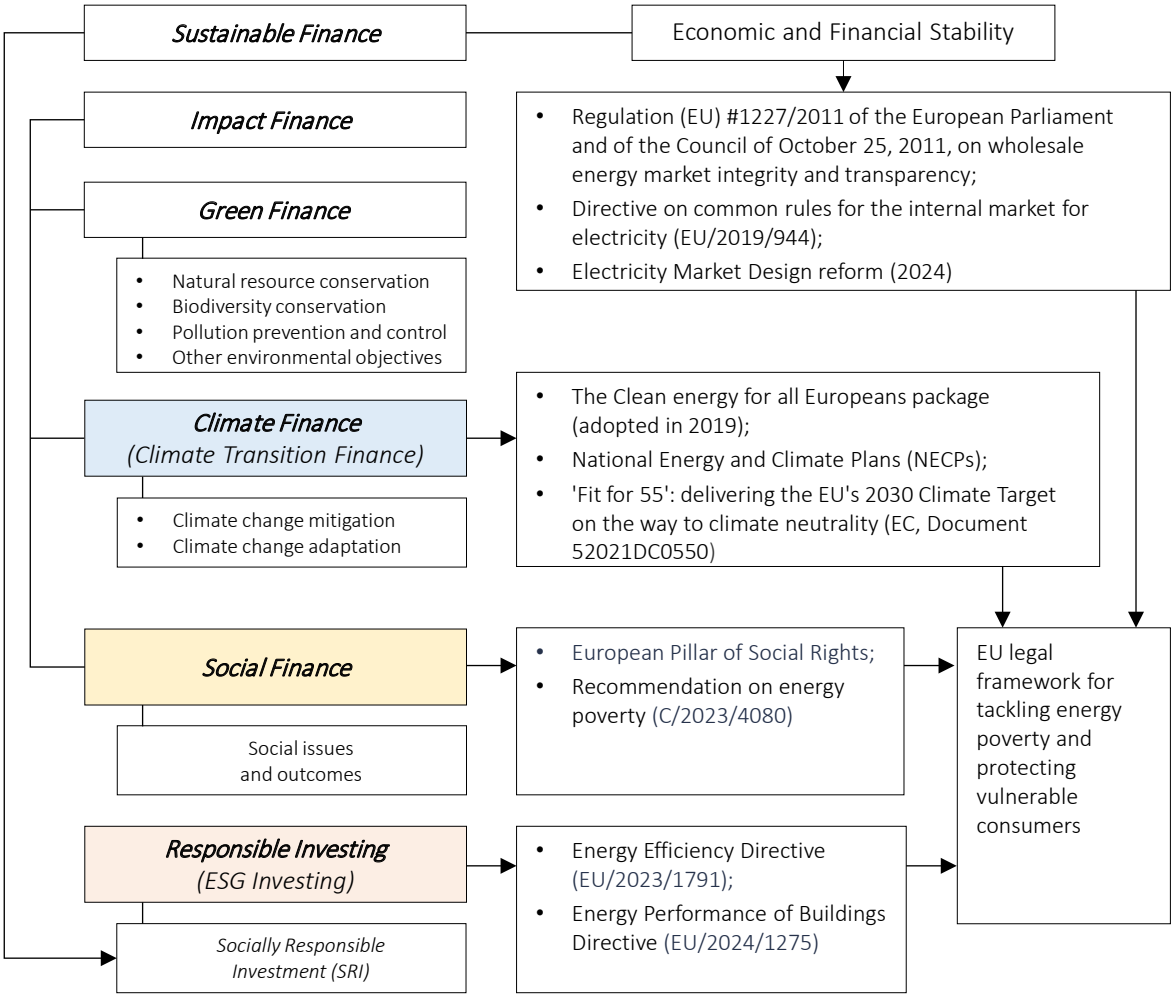


Figure 1. A legal framework for combating energy poverty based on sustainable financing in the EU countries

ing the consequences of energy poverty based on energy subsidies, which is relevant in the context of Ukraine, is analyzed. Fossil fuel subsidies were assessed using the IEA price-gap approach:

$$Sub = (P_{reference} - P_{end-user}) \cdot U_c, \quad (1)$$

where Sub – subsidy; $P_{reference}$ – reference price; $P_{end\text{-}user}$ – end-user price; U_c – units consumed.

The price gap is the difference between the reference price and the end-use price. This method was used to compare the amount of subsidies in Ukraine and other countries and develop recommendations for policy formation in the energy sector.

The assessment of the indirect impact of energy modernization projects for buildings on the environment is based on the use of the CBA method. For this purpose, the indicator, reduction of CO_2 emissions per m^2 of heated area, is proposed to be used when implementing renovation and energy modernization projects for buildings.

The following formula was used to calculate emissions for the reporting year:

$$V_j = 10^{-6} k_j Q_i E^r{}_i, \quad (2)$$

where Vj – gross emission of j-th pollutant during combustion of i-th fuel for the reporting year, tons; k_j – emission index of j-th pollutant for i-th fuel, g/GJ; Q_i – consumption of i-th fuel for the reporting year, tons; $E^r{}_i$ – lower heating value of i-th fuel, MJ/kg.

The volumes of emissions of pollutants from fuel combustion related to greenhouse gases must be converted into CO_2 equivalents using the ratio:

- 1 t of CO_2 = 1 t of CO_2 equivalent;
- 1 t of NO_2 = 31 t of CO_2 equivalent;
- 1 t of CH_4 = 21 t of CO_2 equivalent.

If natural gas (m^3) was used for heating, its volume should be converted into tons using the formula:

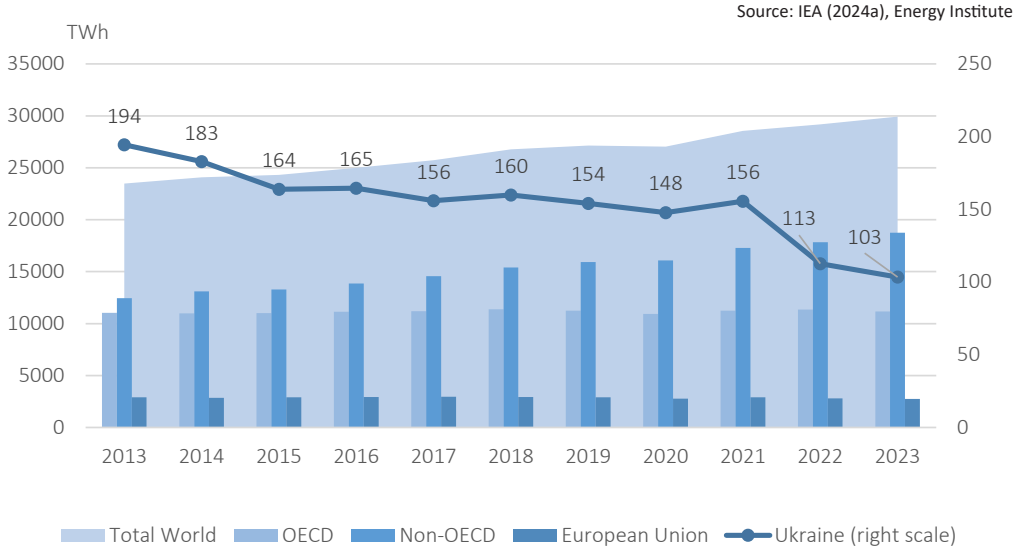
$$Q = Q' \cdot r \cdot 10^{-3}, \quad (3)$$

where Q – volume of gas, tons; Q' – volume of gas consumed, m^3; R – density of natural gas under normal conditions, kg/m^3; r = 0.723 kg/m^3.

3. RESULTS AND DISCUSSION

In modern conditions, the electric power sector plays a leading role in ensuring the sustainable development of most countries' economies. In 2023, global electricity production increased by 2.5% compared to 2022, reaching a record level of 29,925 TWh (Figure 2). Steady growth in electricity demand amid growing economic activity was observed in India,

Source: IEA (2024a), Energy Institute (2024) data.



Note: A terawatt-hour (TWh) is a unit of energy equal to outputting one trillion watts for one hour.

Figure 2. Electricity generation in 2013–2023

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Source: IEA (2024a), Energy Institute (2024) data.

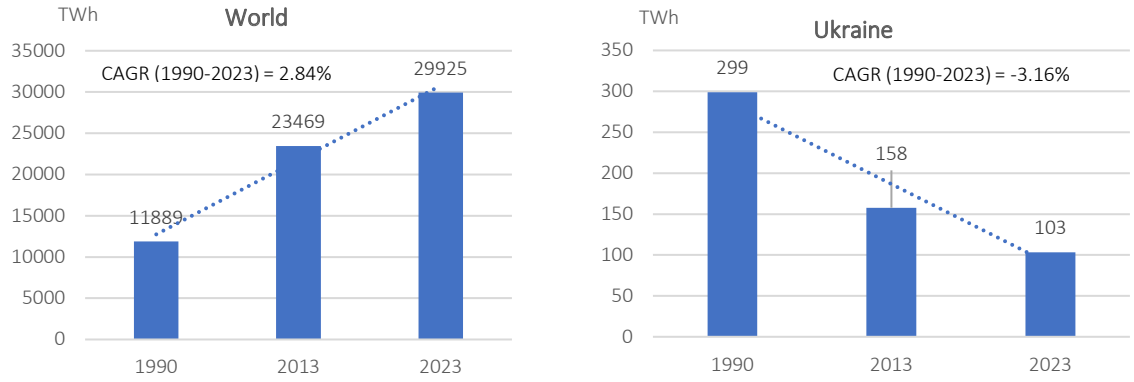

Figure 3. Electricity generation in the world and Ukraine in 1990–2023

China, and Northeast Asian countries, while the EU and other advanced economies saw a decline in demand due to slower production and rising inflation. Global electricity demand is expected to grow by 3.4% annually, with the share of electricity in final energy consumption approaching 30% in 2030, compared to 18% in 2023 (IEA, 2024b).

Over the period 1990–2023, global electricity production increased more than 2.5 times, with a compound annual growth rate (CAGR) of 2.84%. Unfortunately, the negative trend in Ukraine is insignificant. The instability of the economic and political situation in Ukraine after the collapse of the USSR, structural changes in the economy, ineffective public administration, and military actions with large-scale destruction worsened the situation in the energy sector, increased the country's energy dependence, and limited the provision of energy services to consumers. From 1990–2023, annual electricity production in Ukraine decreased by 2.9 times – from 298.8 to 103.4 TWh, equivalent to an annual reduction of 3.16% (Figure 3).

The war in Ukraine has resulted in widespread destruction of energy infrastructure, limiting access to reliable electricity for the majority of the population and exacerbating energy poverty. According to the World Bank's estimates, by the end of 2023, the total needs for restoring and reconstructing the economy were estimated at almost USD 486 billion (or 440 billion euros), which was approximately 2.8 times higher than Ukraine's estimated nominal GDP for 2023, and continue to grow. According to the World Bank report (RDNA3), losses and needs in Ukraine's energy and fuel resource extraction sector are estimated at USD 54.0 billion and USD 47.1 billion, respectively (World Bank, 2023).

Increasing sustainable consumer access to energy services must be based on sustainable development

Table 1. Global carbon dioxide (CO_2) emissions by sector, %

Source: IEA (2024a) data.

Sector	Ukraine		EU (27)		World	
	1990	2021	1990	2021	1990	2021
Electricity and heat producers	48.37	46.53	38.02	31.21	37.21	**43.62**
Industry	28.32	21.16	19.20	14.71	19.26	18.89
Transport	7.97	15.97	18.45	29.66	22.48	22.73
Residential	7.56	9.63	12.26	11.77	8.96	5.93
Other energy industries	3.50	1.80	4.32	5.08	4.74	4.71
Agriculture/forestry	3.15	2.29	2.23	2.33	1.93	1.20
Commercial and public services	0.41	2.62	4.97	4.84	3.69	2.38
Fishing	0.00	0.00	0.12	0.16	0.09	0.06
Final consumption not elsewhere specified	0.71	0.00	0.43	0.23	1.63	0.48
Total	100.00	100.00	100.00	100.00	100.00	100.00

and the transition to cleaner energy production and consumption, as the electricity sector remains a major source of greenhouse gas emissions. During 1990–2021, the share of CO_2 emissions from heat and electricity production in the world increased from 37.2% to 43.6%; in Ukraine during this period, this share was significant and reached 46-48% (Table 1).

Energy poverty is directly related to poverty, vulnerable households, and energy security. Therefore, when analyzing this problem, different indicators are used based on the scale of the problem and monitoring features. The development of national energy poverty criteria should consider economic, social, natural-climatic, and other conditions. That is why Ukraine needs to organize the collection and monitoring of energy poverty data at both the state and local levels.

To organize data collection at the local level, attention should be paid to the recommendations of the European Commission on energy poverty assessment. Thus, EC (2020) pays special attention to the following areas:

- poverty level (the proportion of the population living at risk of poverty (below 60% of the national average));
- inability to provide the required level of heat in the house;
- arrears in payment of utility bills;
- expenses for electricity, gas, and other types of fuel.

As Table 2 shows, the inability to maintain a suitable temperature in the house was particularly high in Eastern, Central, and Southern Europe; Bulgaria, Spain, Portugal, and Greece showed the highest values of these indicators.

The number of EU citizens suffering from energy poverty and unable to keep their homes at an adequate temperature was 6.9% in 2019, 9.3% in 2022, and 10.6% in 2023 (EU, 2023). Expenditures on electricity, gas, and other fuels in household expenditures reach 9-10% in Bulgaria, Poland, Slovakia, and the Czech Republic. In most European countries, the average energy burden – the share of income spent on energy services – is almost twice as high for the poorest 20% of households as for the richest 20% (Lausberg & Croon, 2023). For comparison, in Ukraine, the share of the population unable to afford adequate home heating increased

Table 2. Energy poverty assessment in EU countries in 2023 and Ukraine*

Source: EU (2024) and the State Statistics Service of Ukraine (2024) data.

Country	Inability to keep home adequately warm, % of the total population	Arrears on utility bills, % of total population	Population living in residential premises with leaks, dampness, and rot, %	Expenditure on electricity, gas, and other fuels, % of total household expenditure
European Union – 27 countries (from 2020)	10.6	6.9	15.5	n.a.
Euro area – 20 countries (from 2023)	11.3	6.9	18.0	n.a.
Austria	3.9	5.5	10.5	4.1
Belgium	6.0	3.7	14.5	4.5
Bulgaria	20.7	17.8	8.4	9.2
Croatia	6.2	11.6	5.6	7.4
Cyprus	16.9	9.0	31.6	3.7
The Czech Republic	6.1	1.9	8.5	10.3
Denmark	6.9	4.7	15.0	6.3
Estonia	4.1	4.6	10.5	5.6
France	12.1	7.5	21.1	4.3
Germany	8.2	5.4	16.0	5.2
Greece	19.2	32.9	13.5	6.4
Hungary	7.2	7.3	12.6	6.5
Ireland	7.2	7.6	n.a.	n.a.
Italy	9.5	4.1	17.1	4.8
Latvia	6.6	7.0	18.8	7.1

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Table 2 (cont.). Energy poverty assessment in EU countries in 2023 and Ukraine*

Country	Inability to keep home adequately warm, % of the total population	Arrears on utility bills, % of total population	Population living in residential premises with leaks, dampness, and rot, %	Expenditure on electricity, gas, and other fuels, % of total household expenditure
Lithuania	20.0	6.5	8.6	8.0
Luxembourg	2.1	4.8	18.0	2.6
Malta	6.8	4.9	7.2	2.8
The Netherlands	6.9	1.1	14.9	4.0
Poland	4.7	4.0	5.7	9.1
Portugal	20.8	3.8	29.0	n.a.
Romania	12.5	13.6	7.5	n.a.
Slovenia	3.6	6.6	18.5	6.6
Slovakia	8.1	7.2	5.8	10.5
Spain	20.8	9.6	23.0	4.3
Finland	2.6	7.4	5.3	3.8
Sweden	5.9	3.3	4.8	n.a.
Ukraine, whole	17.2	15.4	n.a.	15.2
rural	26.4	18.3	n.a.	n.a.
urban	12.6	13.9	n.a.	n.a.

Note: * For Ukraine, the latest data for 2021 are provided.

from 9.2 to 15.2% from 2010–2021 (The State Statistics Service of Ukraine, 2024).

In 2023, 15.5% of the EU population lived in dwellings with leaks, dampness, and rot, and 18% in the Eurozone. The Renovation Wave initiative within the European Green Deal targets the renovation of private and public buildings, and the Social Climate Fund includes energy-poor households among its main beneficiaries.

In Ukraine, forming a database for analyzing energy poverty in the context of economic crisis and war is difficult. However, given the severity of this problem, developing a monitoring program is highly relevant.

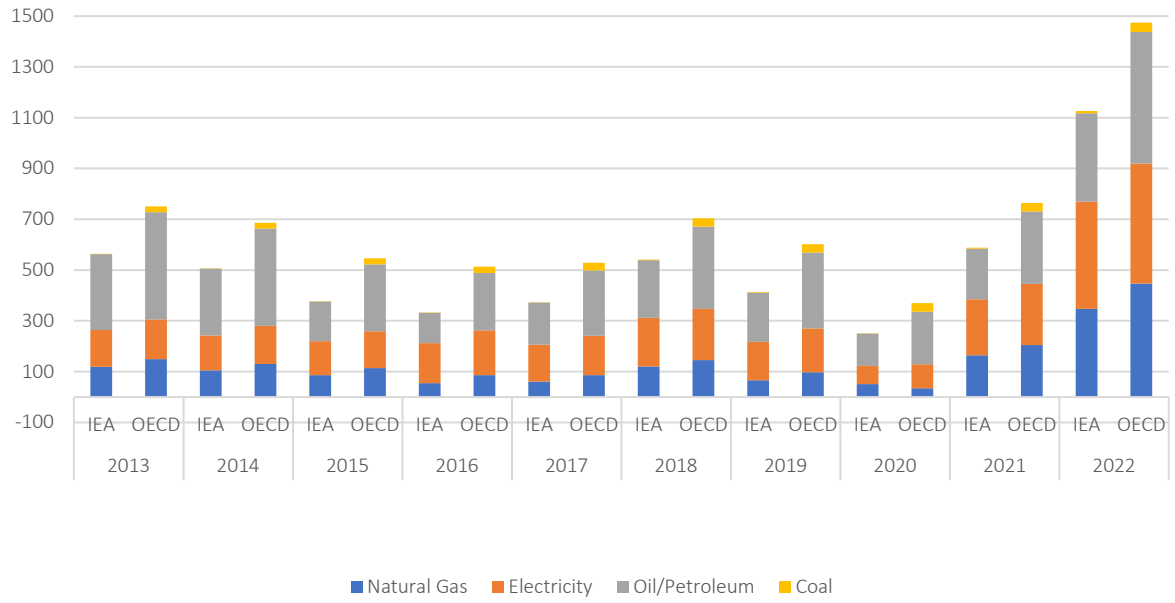
An important tool of state support used to help vulnerable groups of the population is energy subsidies for electricity and gas. According to IMF approaches, energy subsidies are divided into subsidies for consumers and producers. Consumer subsidies arise when prices paid by consumers and households (for final consumption) are below the supply cost, including transportation costs. Production subsidies arise when prices exceed this level (Clements et al., 2013).

World Bank documents use a broader term – fossil fuel subsidies. These are deliberate government policies directed at fossil fuels, electricity, or heat produced from fossil fuels, and they have the following effects: reducing the cost of purchased energy; reducing the cost of producing or delivering fuel, electricity, or heat; and increasing the revenues of resource owners or suppliers of fuel, electricity, or heat (Kojima & Koplow, 2015).

Different approaches are taken to disclosing the content of state support for the production and consumption of fossil fuels. Thus, according to the OECD definition, fossil fuel support includes both direct budget transfers and tax expenditures that provide a benefit or advantage to the production or consumption of fossil fuels compared to alternatives. Since 2019, the OECD has proposed using the inventory approach to assess and monitor the Sustainable Development Goal Indicator 12.C.1 (OECD, 2015b, 2023). This approach estimates the fiscal value of government support as all direct budget transfers and tax incentives to obtain benefits and preferences for fossil fuel production and consumption. Based on this approach, the OECD identifies, documents, and values around 800 different fossil fuel support measures in the OECD and selected partner countries (OECD, 2015b).

Subsidies are seen as distorting market prices, increasing budget deficits in many fragile economies, and generally limiting funding for clean energy initiatives. However, many governments continue

Source: OECD (2023) and IEA (2024a) data.



Note: The fiscal cost of support measures for the production and consumption of fossil fuels (82 economies (OECD countries and selected economies)).

Figure 4. Cost of government support for fossil fuel production and consumption measures according to OECD and IEA approaches, USD billion

to use these subsidies in the domestic market to cushion the negative impact of price shocks on the economy, particularly vulnerable segments of the population.

An assessment of the cost of government support for fossil fuel production and consumption measures worldwide using the OECD and IEA approaches shows that it has increased significantly in recent years (Figure 4).

Thus, according to the OECD methodological approaches, in 2022, fiscal spending on government support for fossil fuels doubled compared to 2021 and reached a record level of USD 1,483.3 billion, compared to USD 769 billion in 2021 (Figure 4). In 2022, 81% of this spending was directed toward supporting consumers (both households and businesses), 16% toward supporting producers, and 3% toward supporting the provision of general services (support that is not directly related to consumers or producers) (OECD, 2023).

An analysis of the dynamics of government spending on fossil fuel support based on the IEA approach also shows a rapid increase in their value in 2022 compared to 2021 – from USD 587.5 to USD 1,126 billion. Compared to 2020, these expenses increased fivefold (Figure 4).

It should be noted that the results of assessing the cost of government support measures for the extraction and consumption of fossil fuels according to the OECD and IEA approaches differ (Figure 4). The IEA focuses on fossil fuel subsidies that are associated with any government action "that affects primarily the energy sector and results in a reduction in the cost of energy production, an increase in the price received by energy producers, or a reduction in the price paid by energy consumers" (UNEP, 2019). This approach is, therefore, narrower than that used by the OECD.

The results of the subsidy structure analysis reflect the desire of governments in most countries around the world to support the decarbonization of the economy by eliminating coal subsidies (UNEP, 2024). Thus, coal subsidies account for only 0.8% of the global fossil fuel subsidy portfolio, or USD 9.1 billion; oil and natural gas account for 30.8% each, or USD 347.5 and USD 347.4 billion, respectively. Electricity subsidies amount to USD 422.7 billion, or 37.5% of the total volume (Figure 5).

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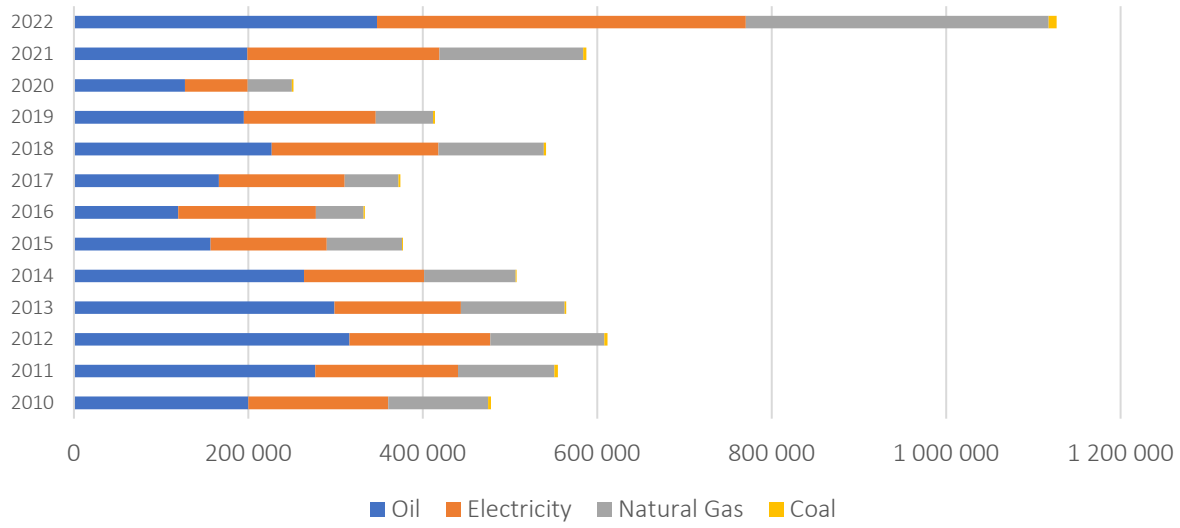

Note: The data provided include the cost of the fossil fuel subsidy used by end users or as a resource for electricity generation.

Figure 5. Global value of fossil fuel subsidies in 2022, real 2022 USD billion

The Russian Federation spent the most fossil fuel subsidies in 2022 – USD 160.86 billion, Iran – USD 126.96 billion, and China – USD 103.55 billion. The cost of subsidies per person is a more accurate indicator of the possibilities of state support for consumers. The value of this indicator is highest in countries that import fossil fuels (Kuwait, the UAE, Qatar, Saudi Arabia, Turkmenistan, etc.), where the cost of subsidies per person reaches 2-5 thousand US dollars (Table 3).

Fossil fuel subsidies are significant in Iran, Venezuela, Uzbekistan, and Algeria, amounting to 22-36% of GDP. However, the effects of subsidies on the economies of exporting and importing countries are different. Thus, for energy-importing countries, introducing fuel subsidies to reduce the end-use price on the domestic market leads to increased budget expenditures. For energy-exporting countries, subsidies do not directly impact the budget but act as part of the

Table 3. Fossil-fuel subsidies in selected countries in 2022

Source: IEA (2024a) data.

Country	Subsidy per capita (USD/person)	Total subsidies		Value of fossil-fuel subsidies by fuel, USD billion			
		real billion USD	as a share of GDP, %	Oil	Gas	Coal	Electricity
Kuwait	4,939.37	21.08	11.42	3.74	6.20	0	11.14
The United Arab Emirates	3,922.60	37.03	7.30	4.90	20.21	0	11.92
Qatar	3,762.49	10.14	4.50	1.43	3.80	0	4.91
Turkmenistan	2,385.49	15.34	19.67	2.35	10.21	0	2.78
Saudi Arabia	2,113.36	76.94	6.94	35.08	16.56	0	25.30
Kazakhstan	1,794.37	34.45	15.26	9.64	7.60	3.43	13.78
Libya	1,784.14	12.15	27.58	8.70	0.36	0	3.09
Iran	1,433.77	126.96	36.05	52.19	45.25	0	29.52
Russia	1,124.37	160.86	7.26	0	97.81	0	63.05
Algeria	1,109.99	49.84	25.51	15.97	19.52	0	14.35
Azerbaijan	1,103.90	11.24	16.08	1.90	5.01	0	4.33
Hungary	751.50	4.93	4.45	0	3.56	0.001	1.37
Uzbekistan	640.38	22.72	28.25	1.68	15.31	0	5.73
Egypt	596.56	66.21	13.93	25.44	9.29	0	31.48
Iraq	491.52	21.87	8.09	13.90	1.15	0	6.82
Ukraine	490.85	19.61	12.94	0	9.20	0	**10.41**

Table 3 (cont.). Fossil-fuel subsidies in selected countries in 2022

Country	Subsidy per capita (USD/person)	Total subsidies		Value of fossil-fuel subsidies by fuel, USD billion			
		real billion USD	as a share of GDP, %	Oil	Gas	Coal	Electricity
Poland	468.93	2.97	2.71	0.017	2.95	0	0
Venezuela	453.10	12.82	21.61	5.36	1.28	0	6.18
Argentina	438.95	20.21	3.20	8.52	7.54	0	4.14
Croatia	418.43	0.66	2.28	0	0.66	0.001	0
The Slovak Republic	278.37	1.06	1.38	0	1.04	0.022	0
Austria	232.18	1.17	0.44	0.007	1.16	0	0
The United Kingdom	217.77	5.98	0.48	0.096	5.88	0.0002	0
France	173.52	6.57	0.42	0.017	6.55	0	0
China	73.32	103.55	0.57	28.92	20.02	0	54.61
India	19.78	55.62	0.83	33.87	2.49	0	19.26

lost rent from selling energy resources on the foreign market at higher prices.

In Ukraine, in 2022, the total volume of fossil fuel subsidies, including those used as a resource for electricity generation, amounted to USD 19.61 billion, which is almost 13% of GDP (Table 4). Compared to 2021, this amount has almost doubled – from USD 9.66 to 19.61 billion. Analyzing the situation in Ukraine, it should be noted that the subsidy structure was dominated by subsidies for electricity, the share of which in the total volume increased from 23.9% in 2021 to 53.1% in 2022 (Table 4).

It should be noted that the amount of fossil fuel subsidies per capita in Ukraine is 7.5 times higher than the general subsistence minimum in effect in 2022.

Refusal of state support for vulnerable population groups – electricity consumers – contradicts the direction of Sustainable Development Goal 7: Affordable, Reliable, Sustainable, and Modern Energy for All. The imbalance in fuel supplies not only increases price risks but also negatively affects the direction of actions to support the transition to green energy. However, a significant increase in the total cost of subsidies creates an additional burden on the state budget and leads to the government's more active use of other methods to protect the population. In addition, subsidizing energy bills for low-income households does not always encourage households to improve the energy efficiency of their buildings.

It is advisable to focus on implementing long-term measures to solve the energy system's systemic problems and overcome energy poverty in Ukraine. One promising area is the transition to distributed generation and strengthening measures to improve energy efficiency at the local level.

In the context of a deficit of public funding to support vulnerable groups of the population and restore social infrastructure based on energy sustainability, private investment is increasingly being attracted in Ukraine through:

- conclusion of performance contracts – agreements between building owners and a private energy service company (Energy Services Company (ESCO)) (OECD, 2015a). These contracts are widely used in foreign practice by

Table 4. Fossil-fuel subsidies in Ukraine in 2010–2022

Source: IEA (2024a) data.

Value	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Electricity	6.82	6.23	4.67	4.73	6.00	6.96	5.64	4.45	5.08	3.03	2.65	7.35	10.41
Gas	9.67	12.19	11.18	8.69	7.75	4.33	–	–	1.18	–	–	2.31	9.20
Total	16.48	18.42	15.85	13.42	13.74	11.30	5.64	4.45	6.26	3.03	2.65	9.66	19.61

Note: The data provided include the value of gas subsidies for end-use and subsidies for fuel used as a resource for electricity generation.

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local authorities to improve energy efficiency. When using such schemes, the amount of payments to the contractor depends on the actual energy savings and, accordingly, reduces household expenses;

- implementation of projects to improve energy efficiency using funds from residents of multi-storey buildings in which associations of co-owners of multi-apartment buildings have been created. These are voluntary associations of residents of buildings for proper maintenance of the building and adjacent territory, which are analogous to homeowner associations (HOAs) and property owner associations (POAs).

In Ukraine, the EnergoDim program was introduced to support the financing of energy-efficient measures in housing construction through the established Energy Efficiency Fund. This fund also implements programs such as Restore the Home, which provides grant support for repairing private residential premises and improving the comfort of housing for citizens with reduced mobility, and Green House, which aims to expand the use of renewable energy sources in residential construction.

The EnergoDim program is implemented in cooperation with IFC and GIZ. It is financed by the Energy Efficiency Fund, which is formed at the expense of the State Budget of Ukraine and contributions from the European Union and the Government of Germany. The program is designed for voluntary associations of building residents to properly maintain the house and surrounding area.

Building co-owners can apply for participation in the EnergoDim program through partner bank branches. Participation in the program allows co-owners of housing to receive reimbursement of up to 70% of the costs of developing and examining design documentation, conducting a preliminary energy audit, technical and author's supervision services, energy efficiency certification after the project is implemented, and inspection of the engineering systems of the building in which energy modernization measures have been carried out (Energy Efficiency Fund, 2024; Verkhovna Rada of Ukraine, 2017). Table 5 presents the main results of projects implemented in Ukraine with the support of the Energy Efficiency Fund.

Table 5. Main results of the implementation of energy saving and energy efficiency projects with the support of the Energy Efficiency Fund in Ukraine

Source: Energy Efficiency Fund (2024) data.

Indicator	Value as of August 16, 2024
Number of applications submitted for participation in projects	963
Number of approved applications:	–
• for participation	650
• for project approval	518
Number of completed projects	175
Number of projects in progress	475
Number of households in completed projects, units	16312
Declared cost of all projects, UAH million	6,656.083
Actual cost of completed projects, UAH million	1018.708
Actual cost of partially completed projects, UAH million	3,190.358
Amount of grant funding paid, UAH million	1,462.205
• including reimbursement of expenses for:	–
• preliminary energy audit;	9.335
• design documentation and its examination	56.209
Construction work on the implementation of measures to improve energy efficiency	1141.063
Declared annual cost savings from project implementation, UAH million	416.806
Declared annual energy savings from the implementation of projects. thousand kWh per year	308,076.96
Declared annual reduction of CO_2 emissions, thousand tons per year	83.54
Average level of declared energy savings from project implementation, %	31.27
Energy savings (total accumulated value after completion of projects), thousand kW	156,150.837
Reduction of CO_2 emissions (total accumulated value after completion of projects), thousand tons	43.926

Energy modernization projects for buildings based on the Build Back Better principle reduce energy costs and increase housing energy efficiency. However, the reduction of CO_2 emissions is significantly lower than stated, necessitating better environmental auditing of projects and a more accurate assessment of the overall costs and benefits. Housing energy retrofit projects should focus on using efficient technologies, and therefore, the results of decarbonization should be assessed more accurately.

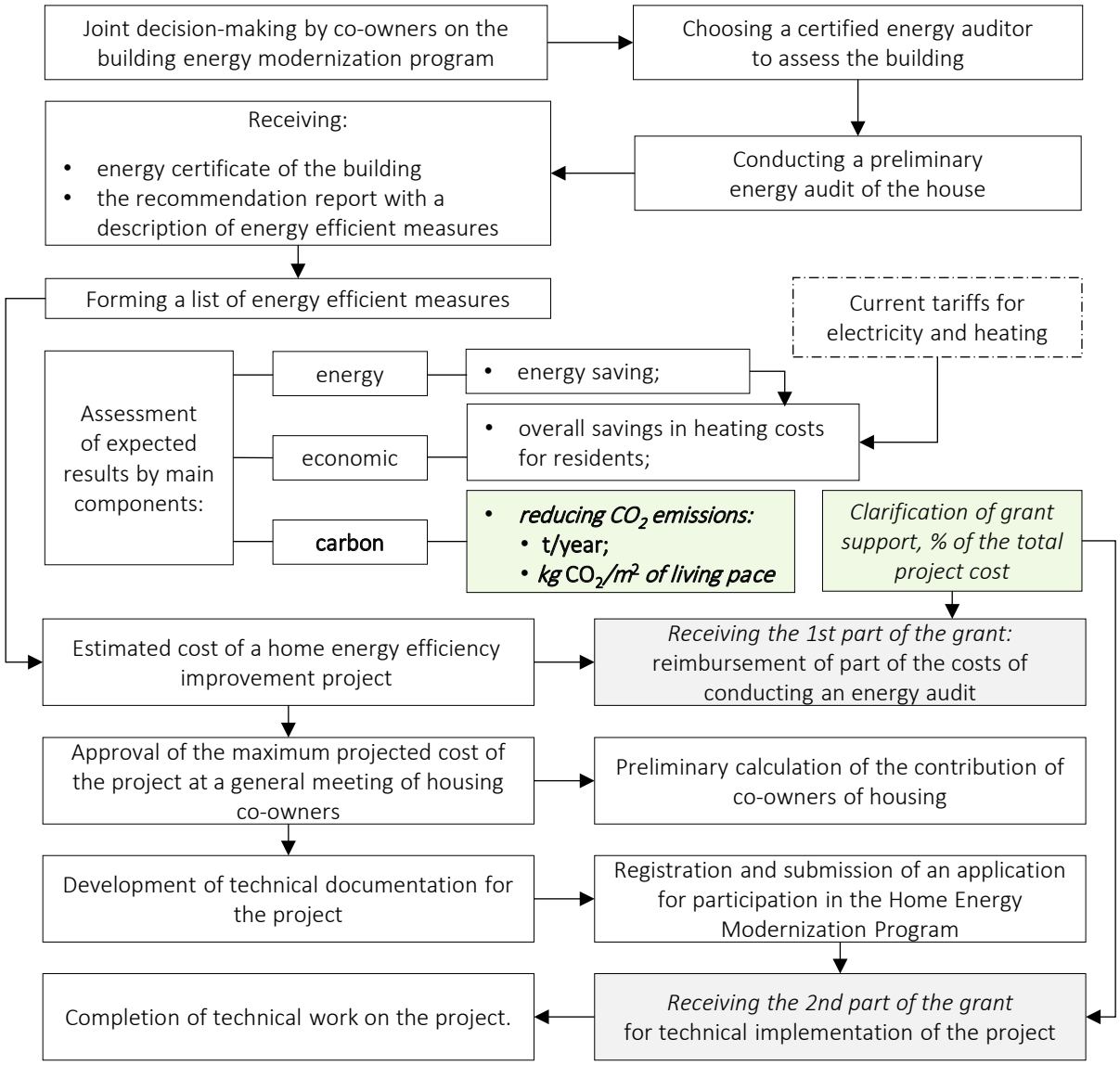

Figure 6. Scheme of grant support for energy modernization projects in residential buildings

Along with assessing cost savings and energy conservation, paying more attention to evaluating the project's carbon reduction would be appropriate. Figure 6 presents an evaluation of the results of implementing energy modernization projects for buildings at the application pre-selection stage.

For this purpose, a criterion such as reducing CO_2 emissions per unit of living space is proposed. This indicator is attractive because it does not contain a cost component, which neutralizes the influence of the price factor when forming the project estimate. The proposed approach's results are demonstrated using the example of two successful projects implemented in Ukraine within the framework of the energy modernization program for multi-story buildings (Table 6).

As the results of the comparative analysis of implementing the two projects show (Table 6), the second project's assessment exceeds the first assessment by almost four times. In both options, according to the energy audit results, the reduction in energy consumption is the same – 38.6% and 38.9% – but the carbon efficiency of the projects differs significantly. Thus, implementing Project 2 reduces CO_2 emissions per unit of heated area by 4.437 kg CO_2 per m^2 compared to 9.007 kg CO_2 per m^2 for Project 1. The effectiveness of measures to reduce CO_2 emissions for Project 2 is almost 2.8 times lower than for Project 1.

To prevent the use of low-efficiency technologies in the thermal modernization of housing and the

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Table 6. Ecological and economic efficiency of energy modernization projects for buildings

Indicators	Project 1	Project 2	Project 2 (adjusted)
Project cost, USD thousands	155.865	557.834	557.834
Living (heated) area, thousand m^2	17.431	45.033	45.033
Average cost of works per unit of living space, USD per m^2	8.94	12.39	12.39
Predicted reduction in energy consumption based on energy audit results, %	38.6	38.9	38.9
Annual heating savings, USD thousands per year	13.169	23.596	23.596
Annual CO_2 reduction			
• tons per hour	157.0	199.8	199.8
• kg CO_2 per m^2 of living space	9.007	4.437	**4.437**
Efficiency of measures to reduce emissions. kg CO_2/USD	1.01	0.36	0.36
Energy Efficiency Fund Grant			
• % of the total cost	70.0	70.0	*34.5* ↓
• USD thousand	109.105	390.484	**192.349** ↓
Contribution of co-owners, USD thousand	46.760	167.350	365.485 ↑

unjustified increase in the estimate during the construction works, a correction factor to consider the carbon effect has been proposed for use when selecting projects for grant assistance (Table 6). The coefficient value depends on the reduction of CO_2 emissions per m^2 of heated area, which allows for the establishment of financial support for selected solutions for building energy modernization based on the carbon component of the design solution. Using such an approach requires tightening energy audit requirements and preventing greenwashing.

The benefits of sustainable housing reconstruction at the local level include improving citizens' quality of life, increasing the energy efficiency of housing stock, reducing energy costs, and gradually overcoming energy poverty.

CONCLUSION

The paper examines efforts to alleviate energy poverty in Ukraine by providing energy subsidies and financing programs to improve building energy efficiency through the Energy Efficiency Fund. The study compares energy poverty indicators in the EU countries and Ukraine. The values of energy poverty indicators vary across EU countries and Ukraine due to differences in energy consumption volumes and characteristics, inability to maintain the required level of household heating, levels of expenses for electricity, gas, and other fuels, and arrears in utility bill payments. In Ukraine, energy poverty is exacerbated by the war and the destruction of energy capacities, low population incomes, high energy costs, and low energy efficiency of housing.

In these conditions, state support for vulnerable population groups is based on providing energy subsidies. The study focuses on approaches to assessing government support for measures of fossil fuel consumption according to OECD and IEA methodologies. Long-term measures of state support for the population based on energy subsidies create an additional burden on the state budget and have a high fiscal cost in Ukraine.

Promising areas for overcoming energy poverty in Ukraine are strengthening measures to improve energy efficiency locally. The results of the implementation of energy efficiency projects with the support of the Energy Efficiency Fund in Ukraine are demonstrated.

The application of the cost-benefit analysis method will enable a more accurate assessment of the climate impacts of project implementation. The study proposes introducing an additional criterion for carbon assessment – a reduction in CO_2 emissions per square meter of living or heated area – when considering the allocation of financial (grant) support for building energy modernization projects.

Organizing energy poverty monitoring in Ukraine requires a thorough study of the guidelines, approaches, and tools for application. The issue of collecting data to monitor energy poverty in Ukraine, amid increased internal and external migration due to the war, remains controversial. Particular attention should be paid to organizing data collection on the availability of energy services to objectively study the state of households suffering from energy poverty. At the local level, this information can be used to implement programs to modernize buildings' energy efficiency. In addition, due to a lack of funding and economic and political instability, the expansion of energy modernization programs for social infrastructure in Ukraine is slowing down.

AUTHOR CONTRIBUTIONS

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Methodology: Svitlana Naumenkova, Ievgen Tishchenko, Volodymyr Mishchenko, Svitlana Mishchenko.
Project administration: Svitlana Naumenkova.
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REFERENCES

1. Araújo, C., Almeida, M., Bragança, L., & Barbosa, J. (2016). Cost-benefit analysis method for building solutions. *Applied Energy, 173,* 124-133. https://doi.org/10.1016/j.apenergy.2016.04.005
2. Bartiaux, F., Maretti, M., Cartone, A., Biermann, P., & Krasteva, V. (2019). Sustainable energy transitions and social inequalities in energy access: A relational comparison of capabilities in three European countries. *Global Transitions, 1,* 226-240. https://doi.org/10.1016/j.glt.2019.11.002
3. Boardman, B. (1991). *Fuel poverty: From cold homes to affordable warmth*. Belhaven Press.
4. Clements, B., Coady, D., Fabrizio, S., Gupta, S., Alleyne, T. S. C., & Sdralevich, C. A. (2013). *Energy subsidy reform. Lesson and implications.* International Monetary Fund. https://doi.org/10.5089/9781475558111.071
5. Council of the European Union. (2021). *Fit for 55 Package. Overview of progress of the "Fit for 55" package of legislative proposals.* Brussels: Council of the European Union. Retrieved from https://data.consilium.europa.eu/doc/document/ST-13977-2021-INIT/en/pdf
6. Council of the European Union. (2023). *Proposal for a Directive of the European Parliament and of the Council on Energy Efficiency (recast).* Brussels: Council of the European Union. Retrieved from https://data.consilium.europa.eu/doc/document/ST-7446-2023-INIT/en/pdf
7. Croon, T., Hoekstra, J., & Dubois, U. (2024). Energy poverty alleviation by social housing providers: A qualitative investigation of targeted interventions in France, England, and the Netherlands. *Energy Policy, 192*, Article 114247. https://doi.org/10.1016/j.enpol.2024.114247
8. Energy Efficiency Fund (EEF). (2024). *"Energodim" Program: Status of projects*. Retrieved from https://eefund.org.ua/en/energodim-2/
9. Energy Institute. (2024). *Statistical Review of World Energy 2024.* Retrieved from https://www.energyinst.org/statistical-review

http://dx.doi.org/10.21511/ee.15(2).2024.14

10. EU. (2023). *Energy poverty in the EU.* Retrieved from https://www.europarl.europa.eu/RegData/etudes/BRIE/2022/733583/EPRS_BRI(2022)733583_EN.pdf

11. EU. (2024). *Eurostat. Database.* Retrieved from https://ec.europa.eu/eurostat/en/

12. European Commission (EC). (2014). *Guide to Cost-Benefit Analysis of Investment Projects for Cohesion Policy 2014–2020.* Retrieved from https://ec.europa.eu/regional_policy/en/information/publications/guides/2014/guide-to-cost-benefit-analysis-of-investment-projects-for-cohesion-policy-2014-2020

13. European Commission (EC). (2017). *Communication from the Commission to the European Parliament, the Council, the European and Social Committee and the Committee of the Regions. Establishing a European Pillar of Social Rights.* Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52017SC0201

14. European Commission (EC). (2019). *Communication from the Commission. The European Green Deal.* Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2019%3A640%3AFIN

15. European Commission (EC). (2020). *Commission Recommendation (EU) 2020/1563 of 14 October 2020 on energy poverty.* Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32020H1563

16. European Commission (EC). (2024). *Energy poverty.* Retrieved from https://energy.ec.europa.eu/topics/markets-and-consumers/energy-consumers-and-prosumers/energy-poverty_en

17. IEA. (2020). *Ukraine Energy Profile.* Retrieved from https://www.iea.org/reports/ukraine-energy-profile

18. IEA. (2024a). *IEA Data and Statistics.* Retrieved from https://www.iea.org/data-and-statistics

19. IEA. (2024b). *Electricity 2024. Analysis and forecast to 2026.* Retrieved from https://iea.blob.core.windows.net/assets/18f3ed24-4b26-4c83-a3d2-8a1be51c8cc8/Electricity2024-Analysisandforecastto2026.pdf

20. IRENA. (2020). *Renewable energy prospects for Central and South-Eastern Europe energy connectivity.* International Renewable Energy Agency, Abu Dhabi. Retrieved from https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2020/Oct/IRENA_REmap_CESEC_2020.pdf

21. IRENA. (2024). *Key Enablers to Triple Renewables by 2030: Policy and Regulations.* Retrieved from https://www.irena.org/News/articles/2024/Jul/Key-Enablers-to-Triple-Renewables-by-2030-Policy-and-Regulations

22. Kashour, M., & Jaber, M. (2024). Revisiting energy poverty measurement for the European Union. *Energy Research & Social Science, 109,* Article 103420. https://doi.org/10.1016/j.erss.2024.103420

23. Kocheshkova, I. (2019). Energy poverty in EU countries and Ukraine. *Visnyk Ekonomichnoi Nauky Ukrainy, 2*(37), 48-55. https://doi.org/10.37405/1729-7206.2019.2(37).48-55

24. Koďousková, H., & Lehotský, L. (2021). Energy poverty in the Czech Republic: Individual responsibility or structural issue? *Energy Research & Social Science, 72,* Article 101877. https://doi.org/10.1016/j.erss.2020.101877

25. Kojima, M., & Koplow, D. (2015). *Fossil fuel subsidies approaches and valuation* (Policy Research Working Paper No. 7220). Energy and Extractives Global Practice Group. Retrieved from https://documents1.worldbank.org/curated/en/961661467990086330/text/WPS7220.txt

26. Kyprianou, I., Serghides, D., Varo, A., Gouveia, J., Kopeva, D., & Murauskaite, L. (2019). Energy poverty policies and measures in 5 EU countries: A comparative study. *Energy and Buildings, 196,* 46-60. https://doi.org/10.1016/j.enbuild.2019.05.003

27. Lausberg, P., & Croon, T. (2023, January 19). *Europe must fight energy poverty more effectively.* European Policy Centre. Retrieved from https://www.epc.eu/en/publications/-Europe-must-fight-energy-poverty-more-effectively~4da8dc

28. Legendre, B., & Ricci, O. (2015). Measuring fuel poverty in France: Which households are the most fuel vulnerable? *Energy Economics, 49,* 620-628. https://doi.org/10.1016/j.eneco.2015.01.022

29. Li, K., Lloyd, B., Liang, X.-J., & Wei, Y-M. (2014). Energy poor or fuel poor: What are the differences? *Energy Policy, 68,* 476-481. https://doi.org/10.1016/j.enpol.2013.11.012

30. Liu, Y., Liu, T., Ye, S., & Liu, Y. (2018). Cost-benefit analysis for Energy Efficiency Retrofit of existing buildings: A case study in China. *Journal of Cleaner Production, 177,* 493-506. https://doi.org/10.1016/j.jclepro.2017.12.225

31. Mihic, M., Petrovic, D., Vuckovic, A., Obradovic, V., & Djurovic, D. (2012). Application and importance of cost-benefit analysis in energy efficiency projects implemented in public buildings: The case of Serbia. *Thermal Science, 16*(3), 915-929. https://doi.org/10.2298/TSCI110911090M

32. Ministry of Energy of Ukraine (MEU). (2022). *Enerhetychna stratehiya [Energy strategy].* (In Ukrainian). Retrieved from https://www.mev.gov.ua/reforma/enerhetychna-stratehiya

33. Mishchenko, V., Naumenkova, S., & Shapoval, O. (2016). Consumer loans securitization. *Actual Problems of Economics*, *186*(12), 311-321. Retrieved from https://www.proquest.com/openview/7c1fa4eafa3430721aa0bc39e5c91029/1

34. Moore, R. (2012). Definitions of fuel poverty: Implications for policy. *Energy Policy, 49,* 19-26. https://doi.org/10.1016/j.enpol.2012.01.057

35. Mulder, P., Dalla Longa, F., & Straver, K. (2023). Energy poverty in the Netherlands at the national and local level: A multi-dimen-

sional spatial analysis. *Energy Research & Social Science, 96,* Article 102892. https://doi.org/10.1016/j.erss.2022.102892

36. Murray, A., & Mills, B. (2014). The impact of low-income home energy assistance program participation on household energy insecurity. *Contemporary Economic Policy, 32*(4), 811-825. https://doi.org/10.1111/coep.12050

37. National Recovery Council. (2022). *Ukraine's National Recovery Plan*. Retrieved from https://recovery.gov.ua/en

38. Naumenkova, S., Mishchenko, V., & Mishchenko, S. (2022). Key energy indicators for sustainable development goals in Ukraine. *Problems and Perspectives in Management, 20*(1), 379-395. http://dx.doi.org/10.21511/ppm.20(1).2022.31

39. Naumenkova, S., Mishchenko, V., Chugunov, I., & Mishchenko, S. (2023). Debt-for-nature or climate swaps in public finance management. *Problems and Perspectives in Management, 21*(3), 698-713. http://dx.doi.org/10.21511/ppm.21(3).2023.54

40. Nussbaumer, P., Bazilian, M., & Modi, V. (2012). Measuring energy poverty: Focusing on what matters. *Renewable and Sustainable Energy Reviews, 16*(1), 231-243. https://doi.org/10.1016/j.rser.2011.07.150

41. OECD. (2015a). *Enhancing competitiveness in Ukraine through a sustainable framework for energy service companies (ESCOs).* Retrieved from https://web-archive.oecd.org/2015-12-14/381027%20-Framework_ESCO_Ukraine_ENG.pdf

42. OECD. (2015b). *OECD companion to the inventory of support measures for fossil fuels 2015.* https://doi.org/10.1787/9789264239616-en

43. OECD. (2018). *Cost-benefit analysis and the environment: Further developments and policy use.* http://dx.doi.org/10.1787/9789264085169-en

44. OECD. (2023). *OECD inventory of support measures for fossil fuels 2023.* https://doi.org/10.1787/87dc4a55-en

45. Sareen, S., Thomson, H., Herrero, S., Gouveia, J., Lippert, I., & Lis, A. (2020). European energy poverty metrics: Scales, prospects and limits. *Global Transitions, 2,* 26-36. https://doi.org/10.1016/j.glt.2020.01.003

46. Siller, T., Kost, M., & Imboden, D. (2007). Long-term energy savings and greenhouse gas emission reductions in the Swiss residential sector. *Energy Policy, 35*(1), 529-539. https://doi.org/10.1016/j.enpol.2005.12.021

47. The State Statistics Service of Ukraine. (2024). *Statistical Information*. Retrieved from https://www.ukrstat.gov.ua/

48. UN. (2015a). *Paris Agreement.* Retrieved from https://unfccc.int/sites/default/files/english_paris_agreement.pdf

49. UN. (2021a). *Global roadmap for accelerated SDG7 action in support of the 2030 Agenda for Sustainable Development and the Paris Agreement on Climate Change*. Retrieved from https://www.un.org/sites/un2.un.org/files/2021/11/hlde_outcome_-_sdg7_global_roadmap.pdf

50. UNEP. (2019). *Measuring fossil fuel subsidies in the context of the sustainable development goals.* Retrieved from https://wedocs.unep.org/bitstream/handle/20.500.11822/28111/FossilFuel.pdf

51. UNEP. (2024). *SDG 12 HUB. Target 12.c. Fossil Fuel Subsidies.* Retrieved from https://sdg12hub.org/sdg-12-hub/see-progress-on-sdg-12-by-target/12c-fossil-fuel-subsidies

52. Verkhovna Rada of Ukraine. (2015). *Zakon Ukrainy on enerhetychnu efektyvnist [Law of Ukraine on energy efficiency].* (In Ukrainian). Retrieved from https://zakon.rada.gov.ua/laws/show/1818-20#Text

53. Verkhovna Rada of Ukraine. (2017). *Zakon Ukrayiny "Pro yenergetichnu yefektivnist budivel" [Law of Ukraine "On the energy efficiency of buildings"].* (In Ukrainian). Retrieved from https://zakon.rada.gov.ua/laws/show/2118-19#Text

54. Walker, G., & Day, R. (2012). Fuel poverty as injustice: Integrating distribution, recognition and procedure in the struggle for affordable warmth. *Energy Policy, 49,* 69-75. https://doi.org/10.1016/j.enpol.2012.01.044

55. World Bank. (2023). *Ukraine – Third rapid damage and needs assessment (RDNA3): February 2022 – December 2023.* Retrieved from https://documents1.worldbank.org/curated/en/099021324115085807/pdf/P1801741bea12c012189ca16d95d8c2556a.pdf

56. Zhuravka, F., Chorna, S., Petrushenko, Y., Alwasiak, S., Kubakh, T., Mordan Y., & Soss, J. (2024). Financial security of Ukraine under martial law: Impact of macroeconomic determinants. *Public and Municipal Finance, 13*(2), 1-3. https://doi.org/10.21511/pmf.13(2).2024.01

http://dx.doi.org/10.21511/ee.15(2).2024.14