

Optimal strategies for attracting private investment in energy efficiency projects at the household level

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ABSTRACT

In order to create a thriving clean energy industry, it is necessary to increase the number of households involved in energy efficiency. In addition, favorable conditions should be created to attract investment in innovation to create new energy-saving technologies. This also means expanding the use of existing environmentally friendly energy solutions, such as solar or wind energy development, which is particularly relevant for Ukraine, given the extensive damage to energy infrastructure caused by the fighting. When the cost-effectiveness of measures and guarantees of return on investment are insufficient for private investors or when measures that only indirectly contribute to energy efficiency are involved, financial support from the state is required, which should also be considered when developing approaches to ensuring the establishment of an effective system for investing in energy efficiency projects. Given the relevance of the topic under study, its goal is to identify the best ways to attract private investment in energy efficiency projects at the household level. To achieve this goal, the following tasks should be solved: to conduct a statistical analysis of the energy sector in Ukraine, to identify opportunities for financing energy efficiency projects in the residential sector, and to formulate recommendations for attracting resources to implement energy efficiency projects by households. The methodological basis of the study is statistical analysis and general scientific research methods. The study proves that co-financing, already being implemented in Ukraine under specific projects described in the paper, can become one of the main directions for developing energy efficiency projects. The strategies for supporting investment projects and raising funds to finance energy efficiency projects are also detailed and systematized. Possibilities of co-financing from various sources for projects in the main areas of energy saving are described in detail, which may be helpful primarily for households focused on implementing energy efficiency projects, either in terms of renewable energy production or improving the energy efficiency class of premises.

Keywords: energy efficiency, renewable energy, investment, co-financing, strategy, household, alternative energy

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1. Introduction

Ukraine's energy sector is one of the main components of the economy, its circulatory system. Against the backdrop of the significant destruction of the energy system due to hostilities in Ukraine, the role and importance of the energy sector is growing significantly. The development of industry, provision of services, organization of everyday life, and human health depend on the quantity and quality of energy supply. Thus, the energy sector is a direct guarantor of the vital activity of society and the stability of the economy [1]. At the current stage of development and recovery of Ukraine's economy, the industry faces new large-scale challenges, and to achieve them, it equally needs an inflow of capital and advanced, innovative technologies. The problem of investing in the country's energy sector, taking into account valuable Western experience, is urgent from both a theoretical and practical point of view, given that countries such as Ukraine, which have a large territory and significant potential for solar and wind energy production, also have significant opportunities to attract investment in this area, which need to be developed.

Investment policy in the energy sector is understood as a system of instruments, mechanisms, and measures that ensure the accumulation of sectoral and corporate investment resources and their efficient use [2-4]. Looking deeper, the mission of investment policy is to generate investment resources of a certain amount and use them economically feasible, justified, and transparently. For Ukraine, private investment in the energy sector is of particular importance, as decentralization of energy generation processes can solve the issue of energy capacity shortages caused by damage due to enemy shelling.

There are various forms of attracting investment funds in the energy sector: own investment funds, direct investment, issuance of additional shares (bonds), credit resources, budget financing, and leasing schemes for the use of energy equipment.

According to many scholars [5-7], improving energy efficiency is one of the most effective ways to achieve multiple economic, social, and environmental benefits and a central element in making significant progress towards achieving the Sustainable Development Goals.

One of the objectives of the global energy market is to double the global rate of energy efficiency improvement by 2030. Energy efficiency has been called the low-hanging fruit, a first-priority fuel, and a generator of numerous benefits for industry and the private sector. According to expert estimates [8-10], two-thirds of the world's energy efficiency potential remains untapped. In different sectors of the economy, the economically viable untapped energy efficiency potential is estimated as follows (for the period 2011-2035): in the electricity sector, it is almost 2,000 Mtoe; in the industrial and transport sectors, more than 4,000 Mtoe, and in the building sector, more than 5,000 Mtoe [11-13].

It is also widely recognized that significant progress is being made in energy efficiency. For example, in 2022, energy intensity improved globally by 1.8%, which is more than in 2021 (1.5%) and significantly higher than the annual rate of improvement observed in the previous decade (0.6%) [14]. A recent report on the Global Tracking System [15] states that progress in reducing the energy intensity of the global economy continues to accelerate: in 2022-2024, the average annual rate of improvement was 2.1%. However, the above figures are lower than the 2.6% improvement target set by the World Bank initiative [16]. To meet this target, significant investments are required. It is widely recognized that these investments will pay off both directly and from an economic point of view and by providing numerous benefits, such as improved quality of life, new jobs, better public health, climate change mitigation, etc. Moreover, the primary tool for improving the quality of energy development at the level of private households should be the attraction of private investment resources.

The development of energy-efficient technologies at the level of households deserves special attention since they can, due to the latest technologies, ensure the production of energy for their use and help the state in the formation of a new energy efficiency strategy, which is formed under the influence of the current state of the energy sector. Through incentive measures, households can ensure the development of an alternative energy

system and enable the state to focus on restoring the energy potential for industry, the social sphere, and those consumers who cannot ensure their energy autonomy.

2. Method

The study analyses the current state of Ukraine's energy sector and determines the degree of activity in implementing energy efficiency projects in the household sector. The analysis is based on time series analysis and statistical data analysis. In general, the data obtained indicate that at the current stage of development, Ukraine can be recognized as a country on the way to developing innovative energy-saving technologies and a green economy. In addition, the main problems accompanying the acquisition of investment funds for energy efficiency projects in the residential sector have been diagnosed.

In general, the study was implemented in two stages. In the first stage, we analyzed statistical materials on the development of renewable energy in Ukraine [14] to confirm the interest in energy efficiency projects. In the second stage of the study, attention was focused on the search for investment resources and strategies to attract and develop energy-saving technologies, as this area of innovative economic development is quite costly and requires a significant inflow of financial resources at the stage of post-war economic recovery in Ukraine. The main emphasis was placed on the energy supply for the residential sector and the opportunities for private household investors in the context of energy efficiency projects.

General scientific methods, particularly analysis, synthesis, generalization, systematization, induction, deduction, and graphical methods, were used to conduct the study. This set of general scientific methods, in combination with a unique method of comparative analysis of strategies for the development of private investment in energy efficiency projects, allowed to obtain a comprehensive result, which is determined by the main directions of further development of renewable energy in Ukraine and diagnostics of the leading financial risks of their implementation.

The focus on energy investment activity in the residential sector has allowed for a broad and unbiased view of the development of renewable energy technologies not only from the state but also from the private household sector, which, in the face of significant damage to energy and civil infrastructure, is becoming one of the most important players in restoring the energy system.

3. Results

Energy efficiency has become an essential criterion for adopting various projects in recent years. For households, in the context of energy shortages and high energy costs, energy efficiency is becoming a key factor when deciding whether to purchase a property or design a future building. Of course, developers and large businesses are also addressing energy efficiency issues. However, the main focus in ensuring energy efficiency in each household is still on the households themselves. Energy efficiency projects are not only focused on energy production but also on energy saving. In general, the energy-saving capacity of a building is the absence of significant heat losses during the cold season, as heating costs are the most significant article of annual household expenditures. Energy efficiency is characterized by reduced energy consumption for heating. These indicators are determined according to the energy consumption for heating a building in the cold season, regardless of the type of energy used. The following categories of buildings are distinguished [17-19]:

1. Passive. In such houses, the annual energy consumption for heating should be at most 15 kWh/m².
2. Active. Different levels of energy efficiency characterize such facilities. The main feature is increased comfort. Most often, such energy-efficient residential buildings have an automatic microclimate control system.
3. With low energy consumption. Such cottages consume from 16 to 35 kWh per year/m².
4. With a zero-energy balance. Such buildings' total energy consumption is zero, as renewable energy sources compensate for losses.
5. With a positive energy balance. Such buildings produce more energy than is consumed for heating.

For the Ukrainian economy, the main goal of using energy-saving technologies for a private house is to reduce heat and electricity consumption and maximize the number of passive buildings. Moreover, it is not just about winter but also about summer. When creating such a structure, a simple perimeter shape is used, conditions of complete airtightness are created, and "cold bridges" are excluded. The building is often orientated to the south, and warm and environmentally friendly materials are used for its decoration.

In international practice, dividing buildings into energy efficiency classes is customary. Depending on the energy efficiency factor, there are several classes of buildings. They are denoted by Latin letters:

A++ buildings consume 60% less energy than standard buildings.

The A+ category saves about 50-60% of energy.

Class A buildings are 40-50% energy efficient.

B+ buildings consume about 30-40% less than Class C.

B buildings provide resource savings of 15-30%.

Class C+ allows you to save 5-15% of heat.

Category C consumes 10-15% more heat and electricity.

Not all residential buildings in Ukraine have an energy efficiency class, although many construction companies' internal documents require an energy efficiency class of at least B.

Undoubtedly, the introduction and implementation of energy efficiency projects require significant investment and involve various investors. The government's efforts to create a favorable investment environment and stable and predictable business conditions will largely determine the effectiveness of attracting investment. The authorities have a range of methods at their disposal to support investment processes aimed at increasing the investment attractiveness of household projects (Table 1).

Table 1. Ways to support investment projects and raise funds to finance energy efficiency projects

Methods of supporting investment processes in the field of energy efficiency	Characteristics of the methods
Budget co-financing	Participation in investment projects with budgetary funds on a parity basis. Additional guarantees to the investor. Direct budget financing or co-financing is possible for both public and private sector facilities. Energy-saving measures in residential buildings reduce budget expenditures on benefits and subsidies. Energy saving in industry reduces budgetary expenditures on the development of municipal infrastructure.
Subsidies, preferential budgetary lending	Providing budgetary support for the implementation of investment projects on a repayable or non-repayable basis.
Local tax cuts, tax credits, tax deferrals	Improving the economic efficiency of households implementing investment projects in energy saving.
Providing sales volume guarantees	They are providing investors with business predictability. If energy-producing households have surplus energy, they can sell it to the state under the so-called "feed-in tariff," which involves receiving payment for the energy sold at a fixed rate. This mechanism not only stimulates the development of alternative energy at the household level but also creates opportunities for additional earnings for individuals active in this field.

Methods of supporting investment processes in the field of energy efficiency	Characteristics of the methods
Tariff support (setting tariffs at the required level)	When implementing projects falling under regulated activities, the tariff structure includes all necessary costs and the required rate of return on invested capital. Tariff support is implemented primarily for households by establishing a "feed-in tariff," which provides a guarantee of connection to the grid, a long-term contract to purchase all renewable electricity, and a premium to the cost of electricity produced by households.
Conclusion of concession agreements and long-term lease agreements	Private investors have long-term, predictable rules and conditions of business. In the process of developing green technologies at the household level, business representatives who manufacture, install and maintain solar and wind energy production systems can also be involved, accordingly, such business is also involved in the system of developing alternative energy for households.
Arranging project financing, special leasing and credit programs (regional, corporate, etc.)	Organizing financing/co-financing schemes for specific household investment projects also reduces the risks of private investors.
Introduction of a fee for connection to the utility infrastructure	Ensuring the rational use of developers' funds through their consolidation.
Information and analytical support	Additional information support helps to improve the validity of investment decision-making and reduces risks from unaccounted-for factors for investors in the residential sector.
Preferential conditions for the use of land resources and resources, the right to dispose of which is within the competence of local authorities	Creating additional incentives for investors to ensure the implementation of energy efficient projects. For example, the territorial community can allocate land plots on preferential terms for rent to those households that are focused on the implementation of energy-efficient projects and will show positive results of their activity in this area.
Development of infrastructure for investment projects	Reducing investment risks by diversifying investments and participating in infrastructure projects. For most households, the project to install an energy autonomy system or a solar panel system is very expensive, so there is a need to attract bank lending or investment funds, which also require regulation and protection through a system of legislative instruments and government support.
Organization of research and field testing of new equipment and technologies	Promoting the technological efficiency of investment projects and eliminating technological risks.

Source: Compiled by authors on the basis of [20-22]

The methods of supporting investment processes listed in Table 1 create an investment-attractive environment. However, the primary comprehensive tool for supporting and developing investment processes should be a system of strategic development of energy efficiency projects in the residential sector.

However, before developing such a system, it is worth analyzing the current state of the renewable energy sector in Ukraine. Statistics show that the active growth of renewable energy generation has risen since 2015. The dynamics of the growth of renewable energy capacities in Ukraine are shown in Fig. 1.

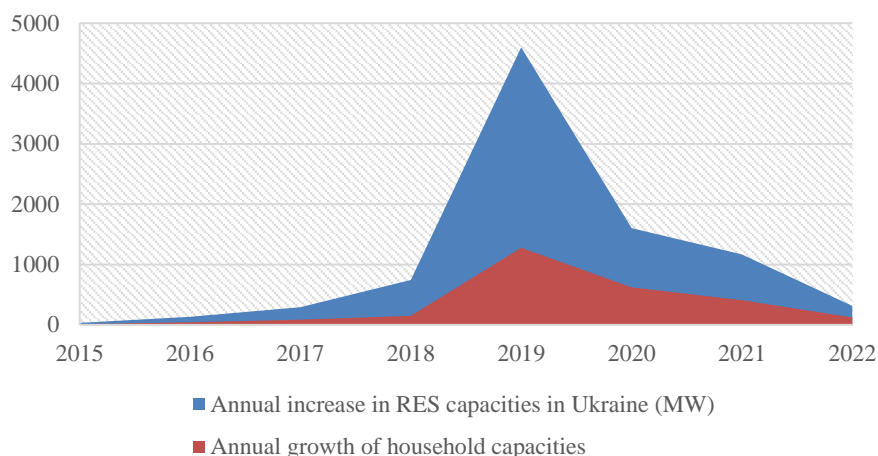


Figure 1. Dynamics of annual growth of renewable energy capacities in Ukraine, MW (Source: Compiled by authors based on [14])

Renewable energy production is based on wind and solar energy. However, since the beginning of the full-scale invasion of Ukraine, the industry has been losing a significant amount of money. According to [14], the industry lost almost 50% of its revenues during the year of the full-scale war. At the beginning of 2023, the level of payments rose to 91%, but in the following months, it began to fall again. Fig. 2. It is worth emphasizing that such dynamics are also characteristic of households that generate energy from alternative sources and sell it at a feed-in tariff.

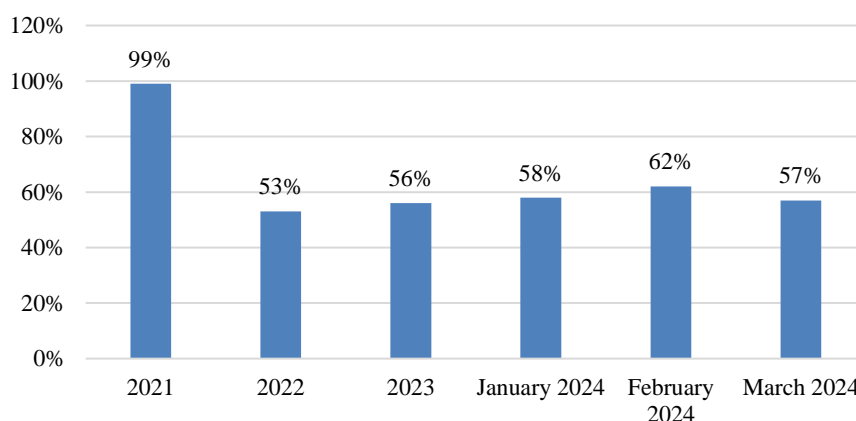


Figure 2. Status of payments for renewable energy sales (Source: Compiled by authors based on [14])

The main factors behind the low payment level are the insufficient transmission tariff for Ukrenergo, the low efficiency of the state's trade activity in energy purchases, the lack of sustainable exports, and price restrictions on the market. Accordingly, the potential low interest of households in implementing projects under such payment dynamics can be emphasized. In total, several directions for energy efficiency projects in private and residential apartment buildings were implemented in Ukraine between 2015 and 2022:

1. The "European Investment Bank provides funds for the Energy Efficiency of Public Buildings in Ukraine" program.
2. The project "Energise Your Business" is implemented with the support of the European Union under the EU4Business initiative, as well as with the support of Ukrgasbank (EUR 4 million) and Bank Lviv (EUR 3 million). The project concerns the business sector, but companies using funds within the project can provide services to households to improve their energy efficiency.
3. The Energy Efficiency in Municipalities project is being implemented at the regional level. The project directly concerns households, as it can provide them with stable access to energy resources without the

active involvement of the state. In addition, the project has social significance, forming the public's understanding of the importance of energy-efficient projects.

This is not an exhaustive list of projects; only the most ambitious ones are presented. However, it should be borne in mind that all projects and programs involve government participation and the provision of preferential financing, with the subsequent opportunity to obtain results from the implemented technologies and funds spent.

Statistical data on the amount of money households invest in energy efficiency projects is not publicly available, so we can only go by the data that, on average, 8 out of 12 territorial communities in Ukraine were active in implementing energy efficiency projects [23-25].

Such low activity of territorial communities, and as a result, households, emphasizes the importance of developing strategies for energy efficiency projects. Moreover, when developing such a system, it should be borne in mind that co-financing should be the main instrument for the effective implementation of these projects, i.e., the idea is that not only the household fully finance energy efficiency projects for itself but also has state support or the opportunity to attract more prominent investors. Opportunities for co-financing from various sources in the main areas of energy saving are presented in Table 2.

Table 2. Opportunities for co-financing from various sources in the main areas of residential energy saving, (Source: Compiled by authors based on [26-28])

Sources of funding	Results of implementation of energy saving projects			
	Improving the efficiency of existing energy supply systems in the settlement	Reducing the need for additional energy resources for energy recovery	Reduced energy consumption by existing customers	Meeting energy demand from renewable sources
Production programs of energy supply organizations	+			
Investment programs of energy supply organizations		+		+
Connection fee	+	+	+	+
Funds for building overhauls			+	
Consumer funds			+	+
Invoicing			+	
Sale of released capacity	+	+	+	+
Funds of developers (connection fee)	+	+	+	+
Investors	+	+	+	+
Budgetary allocations	+	+	+	+
Funds from international partners	+	+	+	+

Notes: «+» indicates the positive impact of one or another project with a certain source of financing on obtaining certain results of implementation of energy saving projects.

According to the comparison presented in Table 2, it is possible to state that the main system of strategic development of energy efficiency projects should be based on the search for co-financing of expensive projects. The development of co-financing projects should result in two main directions:

1. Increase in renewable energy consumption as a percentage (up to 50% by 2050).
2. Ensure thermal modernization of buildings in the volumes shown in Table 3.

Table 3. Expected results of thermal modernization of buildings by 2050

Name	Units of measurement	Residential buildings		Non-residential buildings	
		individual	communally owned houses	public	other non-residential
Buildings thermally modernized (fully or partially)	units.	3 088 352	97 916	15 784	74 192
Renovated building areas	million m ²	220.6	260.0	59.4	66.8
Annual natural gas (natural gas equivalent) savings*.	billion cubic meters	2.5 (8.37)	0.71 (2.36)	0.17 (0.58)	0.12 (0.40)
Annual heat energy savings	GWh	31 606	22 595	7 389	5 136
Annual electricity savings	GWh	247	453	1 062	1 105
Annual savings	million euros	1 022.2	939.2	580.3	397.9

* Annual savings of natural gas according to its share in heat generation (30%) (and the estimated amount of energy savings in natural gas equivalent)

Source: National energy and climate plan for the period up to 2030

It is essential to emphasize the need to combine both key areas, namely the growth of renewable energy generation and the improvement of energy efficiency in buildings, as only such a comprehensive combination can achieve efficient use of energy resources. Accordingly, the goals of the system of strategic development of energy efficiency projects are as follows [29-31]:

- formation of regional and sectoral energy programs that will contribute to ensuring the energy independence of households.
- ensuring a favorable investment climate in the industry to address reproduction tasks with a sufficient level of transparency to attract international investors.
- creating a field of investment strategies that provide uniform rules for the formation and use of investment resources by energy companies and private household suppliers of renewable energy.
- for the national energy system entities: revision of the current wholesale market pricing mechanism, change of the algorithm for setting the market price for residential electricity.
- for the entities of the sectoral investment subsystem: creation and constant updating of the regulatory framework for the activities of sectoral investment institutions and banks.
- implementation of corporate and sectoral mechanisms for the formation of investment resources, which can be implemented by purchasing energy from households at a "feed-in tariff" and using energy released due to greater energy autonomy of households.
- determining the functioning and status of households that are actively involved in implementing energy efficiency projects for their legal protection and further development of investment projects precisely within the framework of stimulating the private sector to increase energy efficiency.

These goals allow adaptation to environmental conditions and create a favorable climate for the development of energy projects of various kinds in the residential sector.

One of the reasons for the low efficiency of investment activity in the renewable energy field is the need for more logical interconnections between individual elements of the sectoral investment process. Today, the energy sector is using something other than an investment policy but rather an investment tactic that focuses on implementing current projects. It is necessary to change the very ideology of investment interaction between energy companies, households, and investors, prioritizing the use of own sources of investment financing and the use of state support in the case of global investment projects and only through the mechanism of public-private partnership and co-financing of investment activities.

3. Discussion

Energy-saving issues are attracting increasing attention from the scientific community, politicians, and practitioners, and there is a need to develop a unified view on how the most effective projects should be implemented in the energy efficiency field.

At the same time, researchers [32-34] emphasize that actions that an individual considers individual energy-saving activities implemented by him/her at the expense of his/her own or borrowed funds will not always be considered such by the state when providing budgetary or tax support measures.

For example, projects to install energy metering devices, conduct energy audits, implement energy management systems, and develop pre-investment documentation either precede the implementation of energy-saving measures or contribute to the rational use of energy resources [35-37]. Although such projects are considered priority areas for financing regional programs and often receive financial support from specialized investment sources, they are only indirectly related to energy efficiency improvement. As a result of their implementation, energy savings may not occur. We fully agree with this opinion and emphasize that only the state should regulate the issue of determining the significance of energy projects, if they are as transparent as possible and meet the primary goal.

Another example that can also be cited concerns projects aimed at constructing multi-apartment buildings and the purchase of climate control equipment for buildings and vehicles with high energy efficiency. The most frequent discussions are related to new construction projects or purchasing new equipment that does not replace existing equipment [38-40]. Often, investments in energy saving are equated with the costs of implementing an investment project in which the energy component is insignificant. As a rule, the priority tasks of such projects are to implement the main functions of the respective facilities: providing housing for the population, creating space for offices and production for the commercial sector, ensuring the necessary microclimate, etc.

In general, projects, including innovative ones, aim to organize the production of equipment and materials with high energy efficiency [41]. Their implementation does not lead to energy savings for the investor, although such equipment and materials can save energy for consumers. Accordingly, such projects can also be considered energy efficient.

Thus, even if we exclude the need for an expert assessment of the amount of funds raised for energy savings through the formation of a system of official statistical observation, criteria for evaluating the projects themselves are still needed, which is easiest to do based on determining the effectiveness of a particular project [42-44]. This reasonable opinion supports the idea of targeting investment funds to implement energy efficiency projects.

5. Conclusions

Based on the study's results, it is possible to state that in Ukraine, the system of financing energy efficiency projects will significantly impact the economic recovery in the near future, as the decentralization of the energy system today affects the population's comfort and ability to perform basic social and production functions.

Unfortunately, Ukraine is currently unable to fully comply with global trends and reach the level of renewable energy development typical of EU countries. However, the prerequisites for the development of energy efficiency projects are present, and such projects were successfully implemented before the full-scale invasion of Ukraine. It is also worth noting that Ukraine lacks financial resources to finance green projects. Hence, the issue of mobilizing the funds needed to invest in sustainable green technology projects is at the forefront.

An analysis of statistical data showed that the renewable energy market currently needs improvement, mainly due to active hostilities in the eastern and southern regions. The country needs government support for its development, primarily in the joint implementation of energy-saving investment projects. The study proved that implementing energy efficiency projects requires the joint participation of households, investors, international organizations, and the state to succeed.

According to the results obtained in the process of the research, the key directions of the development of the strategy for ensuring energy efficiency at the household level have been specified:

- Develop regional and sectoral energy plans that contribute to achieving household energy self-sufficiency.
- Ensuring a favorable investment climate for the renewable energy industry with sufficient transparency to attract international investors.
- Establishment of areas of investment strategies that provide uniform rules for the creation and utilization of investment resources by energy companies and private household suppliers of renewable energy.
- For organizations of the national energy system: reviewing the existing wholesale market pricing mechanism and modifying the market pricing algorithm for domestic electricity.
- For institutions of sectoral investment subsystems: establish and continuously update the regulatory framework for the activities of sectoral investment institutions and banks.
- Implement institutional and sectoral mechanisms for investment resource formation that can be implemented by purchasing energy from households at a 'fixed price' and using the energy released by households' energy self-sufficiency.
- Establishing the legal protection of households actively involved in implementing energy efficiency projects and defining their functions and status for further investment development.

Declaration of competing interest

The authors declare that they have no known financial or non-financial competing interests in any material discussed in this paper.

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