LIB MOD Zentrum Liberale Moderne

IMPROVING ENERGY EFFICIENCY IN UKRAINE

Basic principles and priority steps

by Vadym Lytvyn

LibMod Policy Paper

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EXECUTIVE SUMMARY

1. Ukraine's energy efficiency standards for new and newly renovated buildings are in line with those of the European Union. However, there are hardly any incentives for the improvement of the energy efficiency of older buildings. The explanation for the limited energy efficiency of residential buildings and the small number of green heating projects for self-consumption lies in the low tariffs in the energy sector and the need to compensate energy suppliers for the difference in tariffs, which incentivises consuming rather the saving.

2. Before large-scale, expensive projects, such as building insulation and large-scale solar generation projects, are implemented, steps should be taken to ensure that existing systems are functioning as they should. This includes the regulation of district heating, pipeline insulation and the implementation of proven, relatively inexpensive solutions for replacing fossil fuels – for example, solar generation of electricity to fulfil buildings' needs, heat pumps to partially cover heat supply needs and solid fuel boilers and co-generation plants in district heating systems. Such projects are usually quick to pay off, especially if funds for tariffs subsidies are distributed (instead of encouraging overconsumption).

3. These initiatives increase energy supply reliability, which is especially important given the constant threat of Russian shelling of infrastructure, and they will be effective in ensuring a green transition in peacetime. Measures accompanying the implementation of the basic principles of energy efficiency will create institutional capacity and contribute to experience and the training of specialists for larger-scale projects involving investment from international financial institutions.

4. In the next three to five years, attention should be focused on the installation of heat consumption regulation systems for entire buildings, such as individual heating points, and on the partial modernization of intra-building networks – insulation and balancing – to reduce the need for heat energy. Priority measures should include equipping apartment buildings and single-family homes with solar panels with hybrid inverters able to partially cover their electricity consumption needs, including electricity for hot water, and the use of heat pumps to supply hot water in apartment buildings.

5. The successful implementation of these measures requires the prior establishment of effective energy management systems and project teams in communities, in institutions of state, municipal government and in large businesses that can ensure effective preparation for and support of the relevant projects, and are able to monitor energy consumption and project impact factors before and after implementation, as well as verify the efficient equipment operation to ensure savings and return on investment.

INTRODUCTION

This policy paper describes the primary areas for improvements in energy efficiency and the use of renewable energy sources in Ukraine. The focus is on projects that can be implemented in the short term and that will create conditions favourable for the launch of a larger-scale green transformation. The paper recommends measures that would reduce energy consumption and result in the replacement of five to 10 percent of fossil fuel use, provided the projects are self-sustaining within three to eight years and can be implemented within the next three to five years.

Implementation of the proposed projects should result in the creation of the conditions necessary to improve the energy efficiency project management for state and local authorities, energy resource end-users and energy supply companies.

Special attention is paid to obstacles to the implementation of energy efficiency measures and to recommended measures aimed at overcoming these obstacles, both within the existing regulatory framework and within an improved regulatory system, are proposed in the form of recommendations.

The policy paper sets out information on the current situation regarding the energy efficiency of residential and public buildings, private industry and heating systems in general. It also identifies the preliminary potential for reducing energy losses in each sector, considering the experience of established projects and best European practices.

The policy paper presents a cross-sectoral analysis of projects aimed at improving efficiency and replacing traditional energy sources with renewables to ensure sustainable functioning of Ukraine's energy systems.

1. BRIEF DESCRIPTION OF ENERGY EFFICIENCY IN INDIVIDUAL SECTORS

While energy efficiency has long been a focus of policy discussions, few large-scale energy conservation projects have been implemented thus far. There are many objective and subjective reasons for this situation, including low energy tariffs, which disincentivize energy conservation on the part of residential consumers; a relatively small percentage of production costs represented by energy across various industries; a lack of funding for energy conservation projects in the public sector; and insufficient government support.

1.1. Multi-residential buildings

Technical condition

Multi-residential buildings play a large role in Ukraine's energy balance, and they harbour great potential for reducing energy costs. This sector is associated with significant consumption of energy for heating and hot water. Energy consumption in the sector now amounts to about 160-250 kWh/sqm[1] current standards define ~~7~~0-90 kWh/sqm[2] as an acceptable norm. Most buildings connected to district heating are not equipped with a system to regulate heat consumption. However, in view of the current trend towards the transition of individual apartments to individual heating in a quite chaotic manner, such systems may not necessarily be a reliable one-fit-all solution.

The heat-transfer resistance of the envelopes of multi-residential buildings is two to four times lower than is prescribed by modern standards. The engineering systems of most apartment buildings are worn out, and the pipeline insulation is either non-existent, or of poor quality.

The populist tariff policy resulted in a significant number of consumers switching from district heating to individual apartment boilers and electric water heaters, thereby reducing the efficiency of the former. This can be attributed to the sale of natural gas and electricity to retail consumers at prices well below market prices, which made district heating companies uncompetitive, as they purchased their energy resources at a much higher cost.

Organizational aspects

Only about 20% of the co-owners of multi-residential buildings have switched to self-management and created condominiums. This transformation creates the preconditions for implementation of energy efficiency projects, including co-financing. For buildings still under cooperative ownership, the lack of ways to accumulate funds and ensure effective equipment management significantly hampers the effective implementation of energy conservation projects.

The cost of energy resources for building residents lies between one half and one fourth of the market price, which discourages the residential consumers from implementing energy efficiency measures or the use of alternative energy sources. The state should be interested in co-financing such measures, as this would reduce budget expenditures to compensate for the difference in tariffs. Thermal energy suppliers have no interest in consumer-side reductions of energy consumption. Thus, a lack of proper regulation leads to overconsumption of energy.

The overall potential for the reduction of energy consumption in multi-residential buildings is estimated at 10-20%. This is the level of savings that could be achieved through the implementation of relatively inexpensive measures with a payback period of about three years. Comprehensive thermal renovation projects would be likely to yield energy savings at a level of about 50–60%.

The advantage of renewable energy can be utilized by those district heating systems that use alternative fuels. To a lesser extent, the share of alternative energy sources could be

1 Association of Energy Auditors of Ukraine. https://aea. org.ua/
2 Association of Energy Auditors of Ukraine. https://aea. org.ua/

increased by installing rooftop solar panels and heat pumps, mainly for hot water supplies. In addition, multi-residential buildings can become effective tools in regulating power supply schedule through accumulating energy in hot water supply systems.

The cost of energy resources for building residents lies between one half and one fourth of the market price, which discourages the residential consumers from implementing energy efficiency measures or the use of alternative energy sources.

Key areas for improving energy efficiency in multi-residential buildings are as follows:

Area 1: Regulating thermal energy consumption

- Quick paybacks might be achieved by regulating thermal energy consumption at the level of the apartment building and insulating and renovating in-house heating pipelines, which will result in a significant reduction of gas consumption, specifically, of 0.8–1 billion cubic meters per year;

Estimated funding requirements: EUR 1.5–3 billion, EUR 100–200 million of which would need to be a priority budget allocation for the first two-year period.

The project payback period is estimated at between three to seven years.

Area 2: Equipping houses with solar panels and storage

- Equipping multi-residential buildings and private owned housing with solar panels with hybrid inverters that will partially cover their energy needs, including energy for hot water systems;
- Making power storage devices available might have a positive impact on the reliability of power supply to critical consumers in the building during blackouts; this might contribute to balancing the power supply system.

Estimated funding requirements: EUR 0.5–1 billion (which will allow the installation of about 10,000 thousand rooftop solar stations with storage systems), EUR 100 million of which would need to be allocated to projects in multi-residential buildings, where proactive owners decide in favour of implementation.

The project payback period is 7 to 15 years.

Area 3: Installation of heat pumps

- There is a potential for switching to the use of heat pumps for the hot water supply in multi-residential buildings, which would make it possible to replace 0.3–0.7 billion cubic meters of natural gas consumption per year;
- Heat pumps coupled with storage tanks would be able to smooth out peaks in the power supply system, as well as complement solar panels.

Estimated funding requirements: EUR 100–300 million (for approx. 2000 units), EUR 10 to 20 million of which would be a priority allocation.

The project payback period is between five and ten years.

1.2. Private residential buildings

Most privately owned homes in Ukraine do not meet modern energy efficiency standards and require thermal modernization. Moreover, the tariff policy, which considers natural gas to be the main fuel used, fails to encourage energy saving on the consumer side. This suggests a significant potential for the reduction of energy consumption, which could be cut in half, and replacing fossil energy sources.

Technical condition

The energy consumption level of most single-family houses is of 200 kWh/square meter.[3] The main sources of energy are natural gas for heating and to some extent for the hot water supply, and electricity from the grid. There is a great potential for switching to alternative fuels, and in particular to biomass, such as pellets, briquettes,

3 https://aea.org.ua/

and firewood, however, the low price of gas paid by households will continue to make such a switch economically unfeasible in the absence of additional incentives. As a rule, private householders are able to adjust heating to reflect their actual needs, although in most cases this is done manually, without the use of an automation system. In addition, significant potential for the use of renewables, including solar energy, heat pumps, and solid fuel boilers can be identified.

Private homeowners can make a significant contribution to energy efficiency through replacing natural gas with renewable energy sources, primarily by using biofuels and heat pumps. Furthermore, they may contribute to improving power system reliability through distributed generation and solar generation mainly for their own households' needs.

Organizational aspects

Low tariffs for natural gas and electricity make the implementation of most energy conservation projects or a switch to alternative energy sources uneconomical. This is true both for high-income individuals living in large houses and for less wealthy homeowners, who may receive a subsidy in addition to paying low rates for electricity. Currently, there are no government programs for co-financing energy conservation measures for single-family homeowners, despite the fact that the single-family homeowners have proven to be well suited for participation in such programs, as the most recent experience with the Warm Loans[4] co-financing program has shown. At present, this program is unavailable.

Private homeowners are more flexible when it comes to implementing energy conservation projects, as unlike multi-residential building co-owners, they do not need to coordinate their efforts among their neighbours. In connection with the need to have a backup power source available, the number of solar systems and solid fuel boilers installed at private households has increased over the past year, despite their low economic impact.

Private homeowners can make a significant contribution to energy efficiency through replacing natural gas with renewable energy sources, primarily by using biofuels and heat pumps. Furthermore, they may contribute to improving power system reliability through distributed generation and solar generation mainly for their own households' needs. However, this requires additional incentives and signals from the state, either in the form of raising electricity tariffs or co-financing measures that will reduce budget expenditures to compensate for the "difference in tariffs."

1.3. Public buildings

Under national and European energy efficiency guidelines, state-owned public buildings should be exemplary in terms of energy efficiency.[5] However, the vast majority of public buildings, both state-owned and municipally owned, fall well short of the current energy efficiency standards.

Technical condition

Public buildings have specific energy consumption at the level of about 150 kWh/sqm.[6] The main sources of energy are natural gas, which is used in individual boiler houses or district heating systems, both for heating and, to some extent, for the hot water supply, and electricity from the grid. In some cases, budget shortfalls lead to a reduction in energy consumption associated with a deterioration in indoor climate parameters, such as lower temperature and air circulation. In most cases, public buildings do not have automatic weather compensation systems and/or

4 Warm Loans Efficacy: Study Results | State Agency on Energy Efficiency and Energy Saving of Ukraine (saee.gov.ua) Over six years, 850 thousand Ukrainian families have resorted to "Warm Loans" | Ekonomichna Pravda (epravda.com.ua)

5 On Energy Efficiency... | Law Number 2118-VIII as of 22.06.2017. rada.gov.ua. Directive 2010/31/EU of the European Parliament and the Council as of 19 May 2010 on energy performance of buildings. europa.eu

6 https://aea.org.ua/

hourly heating monitoring. The building envelope heat-transfer resistance is significantly lower than is prescribed by modern standards.

Organizational aspects

Market-based energy tariffs make the implementation of a significant number of energy conservation projects economically feasible. However, the budget deficit may hinder the implementation of large-scale programs. Financing can be secured through available credit lines from international financial institutions under municipal guarantees. However, in some cases the limits on such credit lines are low, due to constraint development budgets. In addition, procedures for obtaining funding from microfinance organizations are usually time-consuming.

A few municipalities have already established energy management systems including energy consumption monitoring. This is a key to both improving efficiency through organizational and cost-free measures and attracting additional investments in the form of grants and loans State-owned institutions typically lack energy management systems, the implementation of which did not begin until 2022-2023, after the Law of Ukraine "On Energy Efficiency" was adopted.[7] Yet, state-owned buildings have much greater potential when it comes to improving energy efficiency than do municipally owned buildings, since the latter are more likely to fall subject to energy budget constraints.

Public buildings should become energy efficiency benchmarks and a key focus for the government actions in the near future, especially since they are relatively few in number. The first step should be to introduce an energy management system in all state-owned and municipally-owned buildings, such as administrative buildings of government agencies; state and municipal enterprises; state departments; buildings of educational institutions – from kindergartens to university campuses– healthcare establishments, and more. Technical measures should initially include quick-impact projects, such as the installation of weather compensation systems, automatic monitoring systems for energy consumption and microclimate parameters and partial modernization of heating systems. They should also include comprehensive renovation measures, such as thermal insulation, reconstruction of ventilation and heating systems, and the implementation of alternative energy sources.

The generation facilities and heating networks are in poor condition in most of the Ukrainian cities that have retained district heating. Losses in the networks can reach as high as 20 to 25%

1.4. Heat supply systems

Technical condition

The generation facilities and heating networks are in poor condition in most of the Ukrainian cities that have retained district heating. Losses in the networks can reach as high as 20 to 25%, resulting in further deterioration of the networks and, in some cases, poor service quality.

Most of the buildings connected to district heating are not equipped with individual weather compensation systems, which results in energy overruns. The main fuel for generation facilities is natural gas, and due to its subsidized price, there is no economic motivation for a transition to alternative fuels, such as wood chips and pellets burnt to power boilers and co-generation units. Very few co-generation units are used to produce thermal energy. Those that are in use are mainly combined heat and power plants in large cities such as Kyiv and Kharkiv. The lack of own generation at thermal energy supply facilities has necessitated the installation of additional diesel generators to power boiler houses.

7 https://zakon.rada.gov.ua/laws/show/1818-20#Text

Most cities do not have a centralized hot water supply system, as such a system would be unable to compete with cheaper hot water from electric boilers. This is due to the subsidized tariffs for households, which create no incentive for energy savings. However, if electricity were priced at market prices, a centralized hot water supply could be significantly cheaper. Organizational aspects

Subsidized tariffs and moratoriums on tariff hikes for households represent a drain on working capital from thermal energy suppliers, most of which are municipal companies. That being said, municipal heating companies, which have the greatest institutional capacity to implement such measures, are not interested in consumer-side savings. Since most thermal energy suppliers are municipally owned companies, there is a good opportunity here for obtaining relatively inexpensive loans from international financial institutions under municipal guarantees.

The power supply system has been heavily damaged by shelling, resulting in generation and transmission capacity deficits. Moreover, the system lacks sufficient shunting capacity to respond to fluctuations in the power demand.

Given the country's energy balance and its monthly distribution, the district heating sector is one that will allow for a significant integration of alternative energy sources. The focus here should be on biofuel-fired boilers, co-generation plants, and heat storage to accumulate surplus green power generation for hot water supply and to level out electricity consumption in order to minimize the use of coal-fired power plants as shunting capacities. Thermal energy suppliers can play a special role in improving energy efficiency, provided they are incentivized to reduce energy use on the consumer side, for example, through energy service contracts. And, of course, they can also play an important role in improving generation and distribution efficiency by replacing or insulating heating networks and modernizing boiler houses.

Cost-effective district heating projects

- **Replacement of natural gas with biofuels**

Natural gas could be replaced with biofuels to reduce gas consumption by 1–1.5 billion cubic meters per year. This potential for natural gas replacement is currently not utilized due to the existing tariff policy. The amount of funding required for the conversion of systems is estimated at EUR 1–1.5 billion, EUR 100-150 million of which would need to be a priority allocation. The project payback period is estimated at between seven and ten years if tariffs were determined by the market.

- **Improving energy efficiency on the consumer side**

Energy efficiency could be improved by modernizing heat supply sources and ensuring that they operate in conjunction with demand-side management systems. This will involve modernizing boiler and pump control systems, as well as the participation of heat supply companies in improving energy efficiency on the consumer side. The project payback period is estimated at between one and five years.

1.5. Power supply systems

In Ukraine, nuclear power plants are the biggest suppliers of electricity - up to 50% of the total volume - followed by coal-fired thermal power plants. Hydropower plants are used mainly as shunting capacities that can quickly increase electricity production during peak hours, but they do not provide sufficient capacity to cover this need. Due to the lack of efficient shunting capacities, coal-fired power units are also used to cover peak demand, which negatively affects environmental performance.

In recent years, the share of solar generation in electricity generation has increased significantly. However, unstable generation in the summer season and shortage of energy storage equipment results in a poor utilization of green

energy. Moreover, energy system operators may even resort to switching off individual solar power plants in the summer months, to balance the power system.

Russian missiles and drones have caused significant damage to power generation and distribution facilities in Ukraine. As a result of targeted attacks by Russian forces on the electricity transmission infrastructure, as of June 30, 2023, about 43% of power lines and about 50% of substations had been destroyed or damaged. Some of the substations were attacked more than once. In total, there have been 250 attacks on Ukrenergo substations.[8] Significant damage has been inflicted on every single type of generation unit. Every single thermal power plant has been attacked, damaged or occupied, and 100 percent of large hydroelectric power plants have been attacked, damaged or destroyed. In the renewable energy segment, wind power has suffered the most, as 80% of Ukraine's wind capacity is in the occupied territories.

Technical condition

The power supply system has been heavily damaged by shelling, resulting in generation and transmission capacity deficits. Moreover, the system lacks sufficient shunting capacity to respond to fluctuations in the power demand.

Ukraine's system is synchronized with the European system (ENTSO-E), which allows it to sell surplus generation and buy electricity on the European market within certain limits.

After the green tariff expires and with the introduction of the net billing system, the focus of energy efficiency measures in the electricity supply system should be on the use of solar installations for self-consumption, given the low cost of electricity on the market in the summer during the hours of maximum solar generation.

Organizational aspects

Electricity for the households use costs only about one-third of what it would at the market price, which creates an additional burden on the state budget and the state-owned electricity generating enterprises, Energoatom and Hydroenergo.

Currently, it is extremely difficult to connect small generating units to the grid and sell surplus energy to consumers. All in all, this precludes the development of distributed generation and small co-generation units. The low tariff rates give households no incentive to install solar power plants to produce energy for their own consumption. Most solar panels installed on privately-owned buildings were installed with the intent of selling electricity to the grid at a green tariff.

The key focus of energy conservation projects is to create the distributed power generation facilities, such as small gas-fired and biofuel-fired co-generation plants and solar power plants and power storage facilities that will ensure the energy supply to multi-residential and public buildings. Of course, another focus of energy sector projects is to restore damaged networks and generation units. Implementation of the projects described above would allow the reduction of power flows and load on networks, while increasing the reliability of electricity supply to consumers. Another area for development is to create shunting capacities, such as gas turbine and steam-gas power plants and industrial storage systems, to balance the peaks in the energy system and increase the efficiency of the use of variable renewable energy sources (from solar and wind generation facilities).

1.6. Industry and commerce

Industrial and commercial enterprises, long exposed to the burden of high tariffs, have begun to implement measures to improve energy efficiency. Typically, the relatively low share represented by energy in the production cost structure across many industries (up to 3%), has hindered the widespread implementation of energy conservation projects, as that businesses did not pay much attention to this cost component. However, over the past year and a half, a significant increase in energy costs, not only natural gas and solid fuels, but also electricity, has compelled many companies to take a more proactive approach to ensuring

8 2023_06_30_UA_sectoral_evaluation_and_damage_assessment_Version_XI__final.pdf (energycharter.org)

their energy efficiency. In addition, frequent blackouts resulting from the Russian attacks on the energy infrastructure have created a need to establish back up energy supply systems.

Many, very diverse energy efficiency projects are possible in this sector, depending on the specifics of individual industries. Therefore, the main driver should be the availability of affordable loans for the implementation of clean energy generation projects and energy consumption reduction.

1.7. Cross-sectoral interaction

One can expect the greatest effect from the efforts of Ukrainian economic operators to reduce their carbon footprint to appear at the points of intersection of various sectors. Should various projects combine efforts of multiple partners and consider areas for mutual development, that may result in greater synergies. In particular:

- Given their significant year-round demand for hot water and the need to ensure simple and cheap ways to acquire and store it, residential buildings could potentially become a kind of consumer which balance the power system through consumption of surplus renewable energy generation. In this way providing the self-regulation of the system.
- Excess heat from industrial enterprises represents a potential source of thermal energy supply.
- Co-generation units at the boiler houses of district heating systems could contribute more effectively to the power system than large coal-fired power plants, as they former operate at high efficiency through heat recovery.
- The simultaneous introduction of automation systems both at thermal energy generating plants and in the buildings they supply would significantly reduce gas consumption for heating and hot water supply as well as the electricity needed to pump coolant.
- Reducing the need for thermal energy on the consumer side would reduce the cost of generation projects as it would reduce the amount of capacity required.

2. DESCRIPTION OF POWER CONSERVATION PROJECTS AND WAYS TO REPLACE FOSSIL FUEL

Based on an analysis of previous studies and energy audits[9], we identified a number of priority projects that could be described using the following criteria:

- Affordable implementation cost
- Easy scaling
- Payback period of no more than five to seven years, attractive loan conditions
- Further integration with larger-scale modernization projects
- Possibility of obtaining tangible savings or increasing energy security by replacing energy resources.

During a further analysis, we established that the cost of energy is market-based. It is worth mentioning that the cost difference between the energy purchased under “preferential” and real tariffs still ends up being paid, if not directly, then through taxes or the deficit of state and local budgets.

9 https://www.oporaua.org/zhitlo/proekti-rishen-organiv-mistsevogo-samovriaduvannia-dlia-stimuliuvannia-vprovadzhennia-energoefektivnikh-zakhodiv-u-zhitlovikh-bagatokvartirnikh-budinkakh-v-iakikh-stvoreno-osbb-24592

https://www.oporaua.org/zhitlo/analiz-tekhnichnikh-rishen-z-vikoristannia-chistikh-dzherel-energiyi-v-bagatokvartirnikh-budivliakh-24588

https://www.oporaua.org/zhitlo/skilki-koshtuiut-deshevi-elektroenergiia-ta-gaz-dlia-naselennia-ta-iak-zmenshiti-tsi-vitrati-24742

https://www.oporaua.org/zhitlo/finansovi-pokazniki-proektiv-z-pidvishchennia-efektivnosti-energospozhivannia-ta-vikoristannia-vidnovliuvanikh-dzherel-dlia-zhitlovogo-bagatokvartirnogo-sektoru-ta-rekomendatsiyi-shchodo-programi-yikh-stimuliuvannia-24755

1. Installation of weather compensation systems in buildings (at the individual heating point).

   Cost per building: UAH 1–2 million (approx. EUR 23.500 – 47.000)

   Payback period: between three and five years.

   Sectors: multi-residential buildings, public buildings.

   Must consider: ability to provide quality service and motivation to determine the optimal configuration.

2. Thermal insulation and/or repair of pipelines and individual parts of heating and hot water supply systems.

   Cost per building: UAH 0.2–2 million. (approx. EUR 4.700-47.000)

   Payback period: one to two years.

   Sectors: residential apartment buildings; public buildings; district heating systems.

   Must consider: ability to ensure durability of insulation materials.

3. Equipping boiler houses with combustion automation systems, weather compensators, control of pumps, fans and smoke exhausters.

   Cost per boiler house: starting from UAH 0.5 million. (approx.. EUR 11.700)

   Payback period: 0.2–2 years.

   Sectors: district heating; water supply and sewage systems.

   Must ensure: ability to ensure qualified maintenance; availability of trained personnel.

4. Installation of co-generation units at gas boilers.

   Cost per boiler house: starting from UAH 10 million. (approx. EUR 230.000)

   Payback period: between three and seven years.

   Sectors: district heating systems; public buildings such as hospitals.

   Must consider: the actual need for electricity and additional components, such as frequency regulators, to allow operation in an "island mode" without external power supply.

5. Installation of biomass boilers and co-generation units.

   Cost per boiler house: starting from UAH 10 million. (approx. EUR 230.000)

   Payback period: between five and seven years.

   Sectors: centralized thermal energy supply systems; complexes of buildings and individual public buildings.

   Must consider: high probability of thermal energy consumption reduction in the future due to thermal modernization on the consumer side.

6. Installation of rooftop solar power plants with hybrid inverters and power storage units.

   Cost per building: starting from UAH 0.5 million. (approx.. EUR 11.700)

   Payback period: between six and seven years.

   Sectors: residential and public buildings; district heating systems; water utilities and industrial enterprises.

   Must consider: selection of equipment based on building's own energy consumption in the summer season (installation not recommended at the buildings of such institutions as educational institutions as they do not operate during long summer holidays).

7. Installation of heat accumulators for hot water supply and heating, as well as air conditioning, to use cheap electricity during periods of excess generation or its shortage at night.

   Cost per building: starting from UAH 0.5 million. (approx.. EUR 11.700)

   Must consider: the possibility of combining such thermal energy accumulators with heat pumps, which will further increase the efficiency of electricity use.

3. ORGANIZATIONAL ASPECTS AND MEASURES TO INCENTIVIZE PROJECT IMPLEMENTATION

There are a few obstacles to the implementation of energy conservation and fossil fuel replacement projects, with respect to both financing and project organization. Some projects may have quite long payback periods and would thus not appear sufficiently attractive to investors. Procedures for approving and reviewing projects, obtaining construction permits, connecting to the grid, and acquiring technical specifications appear quite complicated at present, and there is a lack of experience in implementing large-scale projects, including in the coordination of stakeholders. Another obstacle arises from the need of co-owners of multi-residential building to coordinate energy conservation projects and grant collective approvals. In addition to it, energy suppliers lack motivation to encourage consumers to save energy.

Increasing economic attractiveness of energy conservation projects by offering subsidies from the state or local budgets

This point concerns measures aimed at reducing the consumption of subsidized energy (through energy savings or replacement with other energy resources). This applies to natural gas, thermal energy produced by gas-fired heat plants and electricity for household needs. The investor's share of the total benefits arising from the implementation these types of projects ranges from one half to one quarter; most of the benefits are indirect benefits that the state receives (because the measures reduce its expenditure in subsidies and the amount paid to reimburse the difference in tariffs). However, this means that the investor's payback period is two to four times longer than it would be if the energy savings related to energy purchased at full cost. Thus, the state has a direct interest in co-financing these types of energy efficiency measures, as they will result in the reduction of the state's expenditures to cover the difference in tariffs. And this benefit is all the greater since these expenditures are often financed by borrowed funds.

Possible forms of support:

- Providing grants to ensure partial reimbursement of investors' expenses for energy efficiency measures (similar to Energy Efficiency Fund);
- Refunding the loan principal or interest for the implementation of energy efficiency measures (similar to Warm Loans Program);
- Compensation to producers of energy from renewable sources, primarily solid fuel-fired boilers and co-generation units, for part of the fuel costs in proportion to the energy supplied that will put them on equal footing with producers of thermal energy at gas-fired heat plants. This will cost the state less than does compensating for the difference between the market price of natural gas and the price of natural gas paid by households.

The above-mentioned measures are to be considered necessary until the cost of energy for the population is brought to the level of market prices.

Simplification of project approval procedures

Several changes have already been introduced to facilitate the implementation of energy efficiency measures. There is no need to obtain technical specifications for the installation of weather compensators, and it is possible to obtain construction permits for a number of energy conservation projects in residential and public buildings without having to go through a comprehensive examination. However, obtaining approval is still a complicated process for certain energy conservation interventions, such as installation of co-generation plants and solar power plants with the possibility of selling thermal energy and electricity to the grid. The approval process can take more than a year, resulting in significant costs and a lack of savings during this period, as a review of Energy Efficiency Fund projects and measures to upgrade boiler houses clearly shows.

The solution should be to expand the list of works that can be performed under simplified procedures and develop standardized design solutions.

Factors hindering the implementation of large-scale projects

In Ukraine, many projects move very slowly, even when funding is available. There are several reasons for this. First, only few Ukrainian companies and professionals are able to implement energy conservation projects really well, so as to meet a pre-set target for energy consumption reduction. Instead, most companies focus on just performing construction work. Secondly, the requirements for projects in this sector are usually too high. This precludes newly established Ukrainian companies from participating in tenders, and consequently, from gaining experience and/or increasing financial turnover. European companies, for their part, may not be interested in such volumes.

There are some difficulties with project implementation: instead of gradually taking on projects of greater and greater complexity, Ukrainian companies tend to start tackling overly complicated projects right from the start. Moreover, after a project's completion, no efforts are made to ensure result monitoring. Yet, project results should be monitored over a period of at least five years after a project's commissioning. When such monitoring is performed, the results are usually published in open sources, presenting statistics of actual energy savings or new volumes of power generation. Other best practices include publication of documents and/or document templates developed in connection with project implementation, such as tender and project documentation, reports, and more.

As in all other areas, Ukraine also suffers from a shortage of staff and a lack of capacity. Other obstacles include the lack of sufficient training based on case studies for project managers and lack of experience gained with previously implemented projects. Low wages are another issue in municipalities and government agencies.

The following solutions can partially offset these shortcomings:

- Establish project offices and recruit well-paid project teams employed at municipal or state-owned enterprises; their job will be to prepare, implement and further monitor project effectiveness;
- Include the installation of automated energy monitoring systems as a mandatory requirement for these projects and require the project beneficiaries to publish this information in the public domain;
- Conduct periodic training events with the involvement of representatives of project teams to share lessons learned;
- Implement small pilot projects at the initial stage, to allow newly established enterprises to gain experience and build capacity so that they can participate in larger projects in the future.

Simplification of procedures to coordinate project implementation with multi-residential building co-owners

Given the importance of the sector and, in some cases, the actual blocking of the implementation of certain measures due to the impossibility of obtaining the consent of the majority of co-owners (due to the complexity of conducting surveys and recording their results) for buildings where no condominiums have been created, it is necessary to amend the regulatory framework to allow for the implementation of certain measures (such as partial modernisation of engineering networks in buildings) without obtaining the consent of co-owners.

Since apartment owners become the actual beneficiaries of the energy conservation projects that are implemented, especially considering that they have direct contracts with thermal energy supply companies, it is necessary to develop a procedure to return part of the savings to the investor (managing company, the thermal energy supplier or a private investor).

Creating incentives for energy suppliers to save energy on the consumer side

This applies first and foremost to thermal energy suppliers. Fuel accounts for 70 to 80% of the cost of their product (thermal energy), and therefore, if the savings are distributed between the consumer and the supplier so that

each of them gets approximately 50% of them, thermal energy suppliers derive a greater return from selling "savings" than from selling energy. Energy service contracts are one instrument that can be used to distribute the savings.

This approach is very important. One reason is that the thermal energy suppliers are best positioned to manage weather compensation systems on the consumer side, since they have personnel, access to equipment, and information on actual energy consumption. The other reason the conflict of interest that arises from the energy supplier's desire to sell more to make more money.

4. RECOMMENDATIONS ON IMPROVING INSTITUTIONAL CAPACITY TO IMPLEMENT PROJECTS

Energy conservation projects should be based on a energy management system. This is especially relevant for buildings that consume a significant amount of energy and are financed from state or local budgets. However, the energy consumption of these buildings is not analysed or optimized in any way in most cases.

The Law of Ukraine "On Energy Efficiency" obliges all budgetary institutions and authorities to establish energy management systems. This can be done either within the organizational structure or through outsourcing.

The experience of implementing energy management systems in municipalities has been very positive and has demonstrated excellent results. The main functions of energy management systems should be to ensure continuous collection and analysis of energy consumption data to detect deviations. The optimal way of doing this is to use automated energy monitoring systems to inform decision-making. Energy managers should develop energy efficiency projects, perform energy audits, draw up applications for funding, and perform feasibility studies. They should monitor the implementation of energy conservation projects, and ensure energy efficient operations throughout the project lifetime, even after the project commissioning. This should guarantee that the actual savings achieved are recorded using automated energy monitoring systems.

In view of the Law and supporting regulations already adopted, the following tasks need to be addressed:

1. Ensure adequate funding for the energy management system (salaries, technical equipment). Sources of funding can include actual energy savings. This will help reduce staff turnover and ensure that "institutional memory" is preserved.
2. Political support of energy management units by the organization management, which will make it possible for the units to record cases of cost overruns, but also make it possible to eliminate them effectively by involving other departments, such as maintenance and construction departments, in the project implementation process.
3. Implement pilot projects to demonstrate the effectiveness of systems and best practices for training energy managers across different institutions.

It is also worth pointing out the drawbacks associated with assigning energy efficiency monitoring tasks to specialists in other areas and departments, i.e., outside professional energy management units. In such cases, the duties of energy managers are performed as the last priority, which is inefficient, especially in the absence of a system of incentives tied to the savings achieved.

In the case of energy management in buildings, it is crucial not only to monitor energy consumption, but also to ensure compliance with microclimate parameters. Moreover, it is important to bear in mind that energy savings should not be achieved at the cost of poorer conditions for staff and visitors in public buildings and those living in residential building.

5. WHAT'S NEXT?

Should efforts be made to build capacity in both municipalities and central authorities to develop and implement relatively simple, quick-payback measures, this will ensure that they are better positioned to implement larger-scale energy conservation projects in the future.

The implementation of energy conservation projects in the residential sector will help ease the burden that the inevitable increases in energy tariffs will place on households

The implementation of energy conservation projects in the residential sector will help ease the burden that the inevitable increases in energy tariffs will place on households.

The approaches and solutions proposed here will help prevent the further deterioration of the utilities sector; significantly improve the reliability and efficiency of energy supply and create a foundation for the further development of a more efficient and environmentally friendly energy supply system. Moreover, the suggestions provided in this paper could help eliminate key institutional barriers and prepare the sectors for major investments.

Steps to improve energy efficiency in different sectors are set out below.

For buildings:

- Undertake integrated thermal rehabilitation to achieve an energy consumption reduction of 50% or more;
- Increase the number of buildings with close to zero energy consumption;

For thermal energy suppliers:

- Convert the existing systems into highly efficient thermal energy supply systems; promote renewable energy sources; ensure higher reliability and controllability; expand the list of services provided and bring back the service of hot water supply;
- Upgrade thermal energy supply networks and promote co-generation plants, including biofuel-fired heat plants.

For the electricity supply sector:

- Transition to smart grids and promote decentralized generation systems;
- Ensure that prosumers are able to sell energy to neighbours directly, rather than through energy companies.

For industrial enterprises:

- Increase business competitiveness through the implementation of energy-efficient solutions;
- Reduce the cost of energy resources by eliminating cross-subsidization;
- Improve reliability of energy supply.

The implementation of the proposed solutions will enable the energy market participants to work out organizational approaches and prepare relevant amendments to legislation and regulations in preparation for the next stage of energy conservation, decarbonization and reduction of Ukraine's carbon footprint.

CONCLUSIONS

1. Ukraine has a significant potential to reduce energy consumption and fossil fuel use through relatively inexpensive and quick-payback measures, achieving energy savings of up to 10-20% in the building and heating sectors.
2. Given that most of this potential is associated with residential buildings, the implementation of a significant number of measures both in buildings and at energy suppliers could be funded by reallocating funds currently spent on subsidies and the "tariff difference" compensation. In this case, minimal external investment will be required.
3. Implementation of the proposed measures in the next three to five years would significantly increase institutional capacity, thus, resulting in the emergence of more qualified contractors on the market, which will help to prepare for the next step – the implementation of large-scale projects in the buildings and in the power generation sector. To implement such projects, funds from international financial institutions will be involved.
4. It is crucial to ensure that projects do not end at the implementation stage. Instead, projects should continue during a post-commissioning monitor phase of at least five to ten years, to track the project impact. This will enable both the retention of project teams and the institutionalisation of the experience gained.
5. It is also essential to channel limited organizational resources to the projects that have the potential to delivering the greatest return, rather than disseminating resources over a diverse range of projects. The focus should also be on building organizational capacity to perform more and more complex projects.
6. This approach will enable those carrying out projects to achieve self-sustainability, as they will begin to benefit from savings and energy cost reductions from the early stages of project implementation. This will help to significantly expand the market for both Ukrainian project executors and other European equipment suppliers.

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