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COST-EFFICIENT AND GREEN: TRANSFORMING HOUSEHOLD HEATING IN UKRAINE FOR A SUSTAINABLE FUTURE

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Heating costs present a significant portion of household expenditures in Ukraine, exacerbating energy poverty, particularly in wartime conditions. Moreover, the residential sector consumes approximately 40% of the country's power resources, with the majority being allocated to heating processes. Given the low energy efficiency of residential buildings, the relatively long heating season of 5-6 months, and the predominant use of fossil fuels in private heating systems, the potential for decarbonizing Ukrainian households' heating processes is significant [2; 3]. From this perspective, a pressing task is to research and develop cost-optimal and environmentally friendly strategies for residential heating systems to promote sustainable development and enhance energy efficiency in the sector.

To determine cost-optimal household heating strategies, we evaluated the total operating costs of a private home heating system using a typical Ukrainian household located in Sumy, in the northeast of Ukraine. This region experiences the lowest ambient air temperatures during the coldest five-day period within the heating season in the country. We considered a private house with autonomous heating, covering an area of 120 m² and having a heat load of 8.4 kW. We explored the possibilities of heating using various energy carriers, including natural gas (a gas boiler), coal, firewood, wood pellets, wood briquettes (a solid fuel boiler) and electricity (a heat pump and an electric boiler). We assumed that application of every energy carrier does not require essential modernization of the heating system. In our assessment, we factored in the running costs of different energy carriers for heating, as well as expenses related to purchasing, transportation, installation, and maintenance of equipment, electricity supply connection fees, and additional fixed costs for powering the equipment. Additionally, we considered the influence of climatic zones and their ambient air temperature fluctuations during a heating season, multi-zone electricity tariffs, and the potential for heating automation when determining heating options.

The calculations conducted revealed that the most cost-effective option, aimed at minimizing total household expenses, is utilizing firewood for heating throughout the entire heating season, primarily due to the affordability of this resource. The second most economical choice (with costs 47% higher) is natural gas, attributed to the preferential pricing for this power source offered to the population in Ukraine. Conversely, the most expensive heating option, surpassing the costs of firewood usage by 3.3 times, is the utilization of wood pellets, primarily due to their higher purchase price and equipment costs (wood pellet boilers). Comparatively, expenses are lower for employing electricity (-6% for

electric boilers and -8% for heat pumps) and coal (-7%). The elevated expenditures for these energy sources stem from factors such as high coal and electricity prices (for electric boilers) and equipment costs (for heat pumps).

Consequently, under prevailing market conditions, the cost-optimal strategies for households in the northeastern region of Ukraine involve giving preference to firewood heating or natural gas (particularly favored for its potential automation of the heating process). In instances where there are constraints on gas supply, alternative albeit pricier options include electricity or coal. As a result, the existing state policy regarding power supply for the private residential sector incentivizes maximum utilization of firewood and natural gas by the population for heating purposes. Given that firewood is a renewable resource, its household use does not result in additional CO₂ emissions. However, the inability to automate the heating process at affordable investment costs while using firewood often leads homes to favor natural gas, despite its limited domestic reserves in Ukraine. This cost disparity slows down the decarbonization processes within the residential sector.

Continuing the current state policy will maintain a heavy reliance of the residential sector on natural gas for heating, while also leading to an increased use of firewood due to declining incomes among Ukrainians. However, amidst the ongoing war, centralized gas networks frequently become targets for shelling, heightening the security risks associated with gas supply for households. Hence, expediting the transition to renewable energy sources that offer full autonomy for home heating systems and contribute to the decarbonization of the residential sector is imperative. Achieving this goal will necessitate significant changes in economic policy within the sector.

Given the high cost of pellet boilers, which are domestically manufactured in Ukraine using imported components, it is advisable to provide state economic support to local boiler equipment manufacturers. Additionally, introducing partial reimbursement schemes for households adopting pellet boilers, akin to the pre-war “warm credit” program [1], combined with compensations at both state and local levels, is recommended. To overcome financial barriers, an important aspect of policy should involve implementing subsidies for low-income households that utilize wood pellets and briquettes for heating.

Considering the current high expenses associated with heat pump systems, it is pertinent to renew and expand state investment support for such initiatives through partial compensation mechanisms for heat pump installation costs. Since electricity is essential for operating heat pumps, developing of distributed electricity generation, including regional grids of small-scale power plants utilizing green energy sources, is necessary. Addressing the escalating electricity demand for heating purposes requires the concurrent development of industrial wind power generation and household thermal energy storage systems. Hence, partial state compensations for procuring and installing these technologies are essential.

A crucial step to promote heat pumps in Ukraine is to maintain a two-rate electricity tariff for homes, effectively reducing their current electricity expenses for heating and incentivizing the adoption of green energy technologies. Conversely, it is imperative to reassess the state-subsidized gas prices for the population, elevating them to economically justified levels to remove gas from the roster of the most cost-effective energy sources for heating private residences. However, considering the prevalent energy poverty among a significant portion of Ukrainian households, exacerbated by the ongoing conflict, any increase in gas prices should be accompanied by state economic support schemes for the utilization of green energy technologies in heating. Given that certain types of energy-efficient heating equipment or their components, such as heat pumps, are not domestically manufactured or lack domestic counterparts in Ukraine, introducing customs privileges to incentivize the import of such products is advisable.

While the conducted research provides essential insights for refining energy policy in the residential heating sector, it does have certain limitations. The latter are associated with the potential opportunities for the combined use of various types of energy carriers in household heating systems. Therefore, conducting further research to broaden the spectrum of utilized energy carriers is needed. Additionally, promising avenues for research include the integration of domestic solar and wind energy systems for generating green electricity and their utilization for heating purposes, modernization of residential buildings based on the principle of zero energy consumption, etc.

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