Regional Trajectories of Household Energy Efficiency: Modeling for Policy Decision-Making in Post-War Ukraine[1]

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Abstract. *The article offers a methodological framework for the comprehensive assessment of regional convergence and divergence processes in household energy efficiency based on multifactor modeling. The purpose of developing this model is to support the adoption of substantiated managerial decisions that will contribute to the formation of a fair and effective energy transition policy in post-war Ukraine. The model is based on the adapted Cobb-Douglas function, which takes into account a wide range of factors (socio-economic, behavioral, climatic, technical, and others) that directly influence energy consumption levels in the residential sector. The proposed approach enables not only the identification of key determinants of household energy efficiency across different regions but also the detection of common dynamic patterns (attractors) that outline regional development trajectories, considering the potential for convergence as well as the risks of divergence in energy efficiency levels among regions. The practical significance of the model lies in its application for simulating various policy scenarios and corresponding managerial decisions. This facilitates the planning and evaluation of the effectiveness of targeted subsidy programs for energy efficiency measures for households and communal enterprises, the development of comprehensive energy modernization plans for the housing stock, and the assessment of the*

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impact of climate change on energy consumption in the residential sector. Additionally, the model supports substantiating the feasibility of creating educational programs on energy saving and the rational use of resources for households. The results of the simulation analysis within the model have enabled the formulation of scientifically grounded recommendations to improve the efficiency and fairness of resource allocation in the household energy supply sector. This, in turn, will contribute to the adoption of strategically balanced and adaptive decisions at the regional level, ensuring a sustainable and equitable energy transition for Ukraine in the post-war period.

Keywords: *divergence, household, energy transition, energy efficiency, convergence, modeling, decision-making, regional policy, simulation analysis, Ukraine.*

JEL Classification: *D10, O13, C50*

1 Introduction

In today's wartime environment, improving household energy efficiency is of particular importance as a factor of energy security, regional resilience and socio-economic stability. Reducing energy consumption, implementing energy-efficient solutions and developing decentralized power sources have become not only an element of environmental policy, but also an urgent need for survival and adaptation in the face of constant threats to energy infrastructure. In these circumstances, it is particularly relevant to study the patterns of spatial development of energy efficiency in the household sector to make substantiated managerial decisions.

Economic theory suggests that less developed regions may exhibit higher growth rates by leveraging the accumulated experience, technologies, and institutional practices of more advanced areas. This concept, known as the convergence effect, takes on renewed relevance in the context of the energy transition and national reconstruction. Applied to household energy efficiency, it implies that regions with lower levels of technology adoption can catch up with others through targeted policies, investment support, and the exchange of best practices.

In recent years, Ukraine has witnessed the active implementation of energy efficiency measures in the private sector, including building insulation, the installation of energy-saving windows, and energy-efficient equipment. These efforts have been largely driven by national and local authorities through a range of support programs (Green Economy Financing Facilities, 2020). At the same time, the renewable energy sector has been expanding with a notable increase in the number of private home solar power plants, whose installation has become economically attractive due to the feed-in tariff mechanism (Kurbatova, Spivakovskyy, Sotnyk, Hyrchenko, 2021; Kurbatova, Sotnyk, Prokopenko, Bashynska, Pysmenna, 2023). These trends demonstrate the significant potential of households to contribute to the emergence of a new decentralized model of energy consumption and underscore the importance of examining regional disparities in energy efficiency. This gives rise to several critical questions: Are regions converging in terms of energy efficiency development in the private household sector, or are inequalities deepening? Is a unified national trajectory of energy transformation taking shape, or are regions progressing at different speeds, reflecting disparities in access to resources, political commitment, or local initiatives? Addressing these questions amidst the ongoing challenges facing Ukraine's energy infrastructure is crucial for strengthening the overall energy resilience of the country and its regions. For this reason, the study of the spatial aspects of household energy efficiency development is both highly relevant and strategically important.

2 Analysis of Recent Publications

Traditionally, the concepts of regional convergence and divergence have been associated with the analysis of economic development, household income, productivity, and other macroeconomic indicators (Berkowitz, 2022; Nayak, Sahoo, 2022). In this context, convergence refers to the tendency for regional disparities in specific indicators to diminish over time, while divergence, on the contrary, indicates a widening of such differences. Beta-convergence describes a negative relationship between the initial level of an indicator and its subsequent growth rate, implying a reduction in disparities. Sigma-convergence, meanwhile, captures changes in the dispersion of indicators across regions over time.

In recent years, there has been growing interest in examining convergence not only in macroeconomic indicators but also in environmental and energy-related metrics. A significant body of research has focused on analyzing convergence processes in energy consumption and energy efficiency, which are considered key components of sustainable development. Several scholars (Cornille, Fankhauser, 2006; Lee, Park, 2022) have investigated whether countries or regions are converging in terms of energy efficiency, and, if so, which factors drive these processes. Particular attention has been paid to the role of national and international policies, especially within the European Union, as potential catalysts for convergence or, conversely, as factors contributing to divergence (Holz, Förster, 2020; Boßmann, Samadi, 2018).

Studies indicate that the processes of convergence or divergence in regional energy efficiency indicators are influenced by a range of factors, including economic development, the level of investment in technology, government policy, climatic conditions, household structure, and patterns of energy consumption (Lin, Ouyang, 2021; Zhao, Fan, Wei, 2019). When modeling energy efficiency in private households, the following factors are most commonly considered: 1) economic indicators – such as income levels, employment rates, and energy prices (Wang, Li, Chen, 2018); 2) technological innovations – the availability and diffusion of modern energy-saving technologies (Zhang, Zhou, 2020); 3) demographic characteristics – including the number of household members and their age distribution (Sun, Yang, Li, 2019); 4) climatic conditions – such as average temperatures and the presence of heating or cooling seasons (Liu, Wang, Huang, 2021); 5) political and institutional factors – including the existence of energy-saving legislation, support programs, and subsidies (Apergis, Payne, 2017), etc. Therefore, effective modeling of energy efficiency convergence processes in the private household sector requires a comprehensive consideration of these interrelated factors.

Despite the growing body of research on regional convergence and divergence in energy efficiency, several important issues remain insufficiently explored. In particular, limited attention has been given to identifying a "single attractor", i.e., a stable state toward which regions might converge in this domain. Moreover, there is a lack of an integrated framework that brings together economic, technological, social, and climatic factors into a unified model, which could provide a more comprehensive understanding of the drivers behind convergence and divergence processes. The adoption of such integrative approaches is crucial for the development of adaptive policies aimed at improving the decision-making and the governance of energy efficiency processes at the regional level.

Taking into account the above, the aim of this study is to develop methodological foundations for assessing the regional convergence and divergence of the energy efficiency processes in Ukrainian households through multifactor modeling. It will support informed management decisions on the formation of a just and effective energy transition policy for Ukraine in the post-war period. Special emphasis is placed on identifying common patterns in the dynamics of implementing energy-efficient solutions (represented as so-called attractors) and on mapping regional development trajectories. In addition, the study provides policy recommendations based on simulation analysis to improve energy transition strategies, with a focus on enhancing both the efficiency and equity of resource allocation in the post-war period.

3 Main Research Results

This study focuses on the analysis of interregional convergence in socio-economic indicators, which constitutes a key component in the development of effective regional policy. One of the approaches to quantitatively assessing such processes involves the use of econometric models based on production functions. As suggested by World Bank researchers Lall and Yilmaz (2021), interregional convergence of economic indicators can be evaluated using a modified Cobb–Douglas production function:

$$\ln(y_{it}) = a_0 + b_1 \ln(y_{i,t-1}) + c_k Z_{kit-1} + \\ + d_i D_i + e_i T_i + \varepsilon_i , \qquad (1)$$

where $ln\ (y_{it})$ – the natural logarithm of per capita income in region i in year t;

$ln\ (y_{i,t-1})$ – the natural logarithm of per capita income in region i in the year preceding t;

Z_{kit-1} – a vector of k additional regional characteristics (e.g., investment policy, intellectual capital, health capital, etc.) in region i in the year preceding t;

D_i – a vector of regional dummy variables for region i;

T_i – a vector of time dummy variables for region i;

a_0, b_1, c_k, d_i, e_i – estimated coefficients measuring the influence of the respective indicators;

ε_i – the standard error term of the regression.

To analyze energy efficiency and evaluate potential trends of convergence or divergence across regions, it is appropriate to adapt the approach presented in model (1), to the specifics of energy-related indicators. The first step is to define a dependent variable for the new model that accurately reflects the level of energy efficiency at the micro level. In this study, we propose measuring household energy efficiency (EEH_{it}) as the ratio of the annual amount of energy consumed to both the area of the residential building and the number of household members:

$$EEH_{it} = \frac{EC_{it}}{HS_{it} * SH_{it}}, \quad (2)$$

where EC_{it} – the amount of energy consumed by household i in year t, measured in kilowatt-hours (kWh);

HS_{it} – the floor area of household i in year t, measured in square meters (m²);

SH_{it} – the number of members of household i in year t.

The lower the amount of energy consumed per unit of floor area and per household member, without compromising the quality of life, the more energy efficient the household is considered to be.

By adapting model (1) to the context of energy economics, where the dependent variable represents energy efficiency in the private household sector, the model can be reformulated as follows:

$$\begin{aligned} Ln\left(EEH_{it}\right) &= \beta_0 + +\beta_1 \ln(EEH_{it-1}) + c_1 E_{it} + \\ &+ c_2 ES_{it} + c_3 CAP_{it} + c_4 TR_{it} + c_5 AGE_{it} + \\ &+ c_6 TEMPW_{it} + c_7 TEMPS_{it} + c_8 FH_{it} + \\ &+ c_9 BA_{it} + + c_9 I_{it} + c_{10} O_{it} + \varepsilon, \end{aligned} \quad (3)$$

where $Ln(EEH_{it})$, $ln(EEH_{it-1})$ – natural logarithms of the energy efficiency indicators of the private household i in year t and in the preceding year (t–1);

E_{it} – level of education (in years) of the head of the private household i in year t;

ES_{it} – composite indicator reflecting the energy characteristics (energy performance) of the building of the private household i in year t (e.g., presence of insulation in enclosing structures, energy-saving windows, energy-efficient ventilation systems, extent of natural lighting use, etc.);

CAP_{it} – composite indicator of the energy consumption profile of the private household i in year t (e.g., average annual energy consumption, load variation over time, etc.);

TR_{it} – energy tariff per unit for the private household i in year t;

AGE_{it} – average age of all members of the private household i in year t;

$TEMPW_{it}$, $TEMPS_{it}$ – average ambient temperature in the area of the private household i in year t, during the heating season and outside of it;

FH_{it} – binary variable indicating the type of housing of the private household i in year t (1 – apartment; 0 – private house);

BA_{it} – a variable reflecting the knowledge, beliefs, attitudes, and behavioral practices of respondents (members of the private household i) regarding the impact of energy efficiency on environmental quality in year t;

I_{it} – the average annual income of the private household i in year t;

O_{it} – the employment sector of the household i (determined by the household head) in year t;

$\beta_0, \beta_1, c_1 \ldots c_{10}$ – estimated coefficients measuring the effects of the respective variables;

ε – the standard error term of the regression.

The selection of variables for the proposed model was based on a review of contemporary scientific literature, which demonstrates that household decisions regarding investments in energy efficiency projects are largely influenced by socio-economic, demographic, behavioral, and climatic factors.

For instance, the education level of the head of the household has a significant impact on the perception of new technologies and decisions related to energy efficiency investments. More educated individuals typically have a better understanding of the benefits of implementing energy-saving technologies and are more likely to make informed assessments of the long-term advantages of such investments (Mills, Schleich, 2012; Baidoo, Danquah, Nunoo and et al., 2024).

The structural characteristics of a building that determine its energy efficiency directly influence the amount of energy it consumes. These features include the use of energy-efficient windows and ventilation systems, the effectiveness of natural lighting, the presence of automated systems for monitoring and managing energy consumption, and others. Research findings (Das, Paul, 2015) indicate that window size, room layout, and wall insulation significantly impact both natural lighting and levels of heat and energy consumption. The authors (Nazeriye, Haeri, Haghighat, 2021) argue that only newly constructed buildings in the United States comply with modern energy-saving standards, whereas such features are generally absent in older buildings, which often require retrofitting or modernization.

Another important factor is the energy consumption profile of a particular household. Unlike static indicators, accounting for fluctuations in energy use caused by residents' presence in the dwelling allows for a more accurate assessment of the potential for improving energy efficiency (Le, Gangwei, Weijun, 2023). Therefore, it is advisable to consider not only the total amount of energy consumed but also the variability of consumer behavior. This is supported by research (Sun, Wang, Li, 2022) indicating that individual patterns of energy use in private households significantly influence the effectiveness of energy-saving measures.

A further key factor is the price of energy, which can motivate households to save by switching to cheaper energy sources where available, or by investing in energy-efficient technologies (Alberini, Filippini, 2011). Moreover, the time-zone differentiation of electricity tariffs may influence consumer behavior by encouraging households to shift their electricity consumption to off-peak periods when the price per kilowatt-hour is lower. Such practices not only help to reduce household expenditures but also contribute to lowering the load on the power grid during peak hours, which is essential for ensuring grid stability and optimizing system-level energy costs (Reguant, 2024; Octopus Energy, 2018).

The age of household members significantly influences their energy use behavior. Younger individuals are more likely to reside in temporary or rented accommodation, where investment in energy efficiency tends to be lower and energy conservation is not typically prioritized. Such a lifestyle is often associated with less efficient energy use, which poses challenges for the adoption of energy-efficient solutions. In contrast, older household members tend to place greater emphasis on economical energy consumption, which positively contributes to the overall level of household energy efficiency (Wilson, Dowlatabadi, 2007; Sunikka-Blank, Galvin, 2012; Bröchner, Brandt, 2011).

Climatic factors have a substantial impact on energy consumption, as extreme temperatures significantly increase the load on building heating and cooling systems. The influence of outdoor temperatures on energy use has been confirmed in research (Catalina, Iordache, Caracaleanu, 2013) that highlights the critical importance of thermal insulation in both cold and hot climates. Similar conclusions have been drawn in research (Santamouris, 2016) emphasizing the role of adaptive insulation technologies in enhancing the energy efficiency of residential buildings across various climatic zones. Furthermore, in research (Rehman, Mourshed, Rezgui, 2019) it is argued that seasonal temperature fluctuations have a considerable effect on household energy consumption patterns, particularly regarding heating and cooling demands in individual residential buildings.

The type of housing also influences a household's level of energy efficiency. Typically, apartments exhibit higher energy efficiency than private residential buildings. This can be attributed to the presence of shared walls with adjacent units, which reduces heat loss, as well as the fact that apartments are often equipped with more modern heating and energy-saving systems (Mlecnik, 2010; Pérez-Lombard, Ortiz, Pout, 2008)In contrast, private residential buildings tend to have a larger surface area of external walls, resulting in greater heat loss, and they typically feature fewer energy efficiency improvements due to the higher cost of implementation. These characteristics highlight the need for more comprehensive and economically viable solutions to improve energy efficiency in such dwellings.

A conscious attitude toward the environment and individuals' environmental habits significantly influence decision-making regarding investments in energy efficiency measures. According to the OECD methodology (OECD, 2014) households can be divided into three main groups based on their environmental beliefs and motivations: 1) altruists – individuals who deliberately seek to change their lifestyles and are willing to make sacrifices to address environmental issues; 2) sceptics – those who question the seriousness of environmental problems and are generally reluctant to take action; 3) green growth supporters – individuals who acknowledge environmental challenges and view technological innovation as the primary means of overcoming them. This classification helps to better understand the motivational factors driving household behavior in the field of energy efficiency and supports the development of targeted policies tailored to the characteristics of different population groups. A similar approach has been adopted by other researchers (Steg, Vlek, 2009; Whitmarsh, O'Neill, Lorenzoni, 2011), who emphasize the role of environmental attitudes in shaping household behavior. These attitudes directly influence the motivation to invest in energy-efficient solutions, modify consumption habits, and engage in sustainable energy initiatives.

Household income is one of the key economic factors that significantly influences energy efficiency levels. Higher-income households typically have more financial resources to invest in energy-efficient technologies (Ramos, Rodrigues, Silva, Almeida, 2016), which enables them to reduce energy expenditures over the long term. Conversely, low-income households often lack the financial capacity to implement such measures, even if they are aware of their benefits (Allcott, Greenstone, 2012). However, at higher income levels, motivation to save energy may decrease, as the relative cost of energy becomes negligible, and households may be less inclined to make additional efforts to adopt energy-efficient solutions. For low-income households, immediate survival often takes precedence over evaluating the long-term benefits of energy-saving investments. These contradictory trends underscore the need for targeted subsidy programs, as well as informational and financial support mechanisms for low- and middle-income households. Such interventions can substantially improve both the capacity and motivation of these households to invest in energy-efficient technologies (International Energy Agency, 2020).

The employment sector of a household, which reflects the type of economic activity of the primary breadwinner (head) or the main economically active member, is a significant factor influencing energy efficiency. It affects income levels, employment stability, access to social protection, vocational education, opportunities to participate in national or international energy efficiency support programs, and the household's environmental awareness. This variable can shape both investment decisions in energy-efficient technologies and behavioral patterns in energy consumption. For instance, households where the head is employed in the public sector (e.g., education, healthcare, or civil service) may have greater trust in formal government support programs and enjoy relatively stable income. However, they may simultaneously face limited financial resources for making substantial upfront investments. Conversely, households in which the head is employed in the private sector or engaged in entrepreneurial activity are more likely to prioritize the economic viability of investments in energy efficiency measures and to make active use of self-financing tools or alternative sources of funding, such as loans, leasing, or crowdfunding. Employment in agriculture is typically associated with a higher degree of energy autonomy (e.g., access to biomass, availability of land for solar power installations), but is also characterized by lower average income, income seasonality, and limited access to banking instruments and digital services. Self-employment or non-standard forms of employment may offer greater flexibility in the use of time and financial resources, yet they are also marked by income volatility and a lack of long-term financial security, which can hinder the adoption of capital-intensive energy-efficient technologies.

Thus, the proposed model, adapted to analyze energy efficiency levels in the private household sector, incorporates a broad spectrum of socio-economic, demographic, behavioral, and climatic factors. It enables a comprehensive examination of both objective characteristics, such as housing type, energy tariffs, household income, and the building's energy profile, and subjective dimensions, including environmental attitudes, behavioral practices, and educational attainment, all of which influence household energy efficiency.

Applying the simulation analysis, a number of policy recommendations can be proposed to enhance household energy efficiency and to make informed management decisions. Given the influence of the aforementioned factors, the following aspects should be considered in the development of relevant energy efficiency policies:

Education level of the household head. If the estimated coefficient is statistically significant and positive, indicating that higher education levels are associated with more energy-efficient behavior, it is advisable to strengthen information and awareness-raising campaigns focused on the promotion of energy-saving technologies and available support schemes in the residential sector. Special emphasis should be placed on outreach at the community level, particularly in regions where the average level of basic education falls below the national benchmark.

Energy performance of housing. If the coefficient is statistically significant and positive, suggesting that insulation, efficient ventilation, and other energy-saving measures enhance household energy efficiency, there is a clear rationale for scaling up energy modernization support programs at both national and local levels. Special attention should be given to simplifying access for private households to such programs, as well as introducing dedicated support mechanisms for homeowners' associations, particularly in multi-apartment buildings.

Energy consumption profile. If the coefficient is statistically significant and negative, indicating that higher consumption levels are associated with lower energy efficiency, it is recommended to foster the development of a digital infrastructure that enables households to monitor and manage their energy usage. This may include the widespread deployment of smart meters, mobile applications for real-time energy consumption tracking, and interactive data visualization tools. In large urban centers with high average energy consumption (e.g., Kyiv, Kharkiv, Dnipro, Lviv), special emphasis should be placed on incentivizing voluntary demand-side responses during peak hours through demand management schemes and time-based pricing mechanisms.

Energy tariffs. If the impact of this variable is statistically significant and positive, suggesting that higher tariffs encourage more energy-conscious consumption, tariff policy can serve as an effective economic lever for influencing consumer behavior. However, it is essential to complement such measures with targeted support for socially vulnerable population groups, particularly through well-designed subsidy schemes or other compensation mechanisms aimed at mitigating the regressive effects of price increases.

Age of household members. If the indicator is statistically significant and positive, indicating that older residents tend to exhibit more energy-saving behavior, public policy should incorporate targeted educational and motivational initiatives for younger populations. It is advisable to implement pilot projects in student dormitories and rental housing to instill energy-saving habits from an early age.

Climatic factors. If lower temperatures during the heating season negatively affect energy efficiency, it is advisable to implement territorially differentiated policies. For example, stricter thermal insulation standards can be introduced for buildings located in northern and mountainous regions. Furthermore, it is recommended to promote the adoption of individual heating systems powered by renewable energy sources, such as biomass and heat pumps, particularly in rural areas.

Housing type. If private houses demonstrate lower levels of energy efficiency compared to multi-apartment buildings, government policy should prioritize support for the private housing sector. This may include simplifying energy audit procedures and introducing comprehensive financing programs for building energy modernization.

Environmental beliefs and behavioral habits. If the influence of these factors proves to be statistically significant and positive, it is recommended to initiate community-level communication campaigns aimed at promoting energy-efficient behavior. These campaigns should emphasize real-life success stories tailored to the needs and values of various target groups. To maximize the effectiveness of behavioral interventions, the OECD framework can be applied, which categorizes individuals into typical segments (altruists, sceptics, and pragmatists) and prescribes differentiated strategies based on the behavioral profile of each group.

Income level. If this variable has a statistically significant and positive effect, it is advisable to identify the income threshold beyond which interest in adopting energy efficiency measures tends to decline. Based on this insight, government support should be primarily directed toward low- and middle-income households. Effective policy instruments may include preferential loans, tax rebates, or other forms of financial incentives.

Employment sector. If the employment sector has a statistically significant effect on energy-efficient behavior, this suggests the existence of sectoral or occupational differences. In such cases, it is advisable to develop targeted support policies for specific sectors of the economy, taking into account the nature of employment, levels of awareness, and access to relevant resources.

Based on the developed model and the results of the simulation analysis, two main trajectories of regional development in the area of energy efficiency can be identified. The first trajectory includes regions that demonstrate a tendency to converge with average or leading energy efficiency indicators and exhibit the presence of an attractor. For these regions, efforts should focus on ensuring sustained progress by strengthening institutional capacity, enhancing existing programs, and expanding communication initiatives. The second trajectory concerns regions characterized by lagging performance or unstable dynamics. In such cases, sectoral energy policy should prioritize balanced and corrective support. This includes the development of targeted assistance programs, the promotion of local energy cooperatives, and the provision of simplified access to financing, particularly in regions affected by destruction resulting from hostilities.

Although the study of energy efficiency processes in Ukraine is highly relevant in the context of the full-scale war, the practical application of the proposed model faces several challenges. First, access to a substantial portion of official statistical data is currently severely restricted. Second, the ongoing hostilities have caused extensive damage to energy infrastructure, resulting in significant changes to the structure of energy supply, including in the residential sector. The instability of electricity provision, due to both scheduled and emergency outages, makes it difficult to conduct accurate assessments of energy efficiency, as actual consumption does not always reflect the real energy needs of households. Third, both internal and external migration have significantly altered household structures, further complicating the analysis of typical behavioral patterns in household energy use.

If access to statistical data is restored in the post-war period, the proposed model holds significant potential for broad application within regional and national policies aimed at the rational use of energy resources. Specifically, the model has practical value for the design of targeted subsidy programs. By incorporating factors such as income level and housing type, it enables the development of support mechanisms for energy-efficient solutions tailored to the most vulnerable segments of the population. Moreover, the model can be employed to assess the potential impact of climate change. Through the inclusion of temperature-related variables, it facilitates the simulation of energy consumption scenarios under conditions of global warming or adverse weather events. The model can also serve as a tool for planning the energy modernization of residential housing, particularly in identifying priority building types that require insulation, energy audits, and other upgrades. Additionally, it allows for the identification of household groups with low levels of environmental motivation or awareness, for whom targeted educational initiatives would be appropriate.

4 Conclusions

Enhancing energy efficiency in the household sector remains one of the key priorities of Ukraine's energy policy, particularly in light of rising energy prices and the urgent need to reduce the country's energy dependence. For effective decision-making in this area, it is essential to apply approaches that account for the diverse factors influencing the structure and volume of household energy consumption. This study presents a model that enables a comprehensive assessment of energy efficiency in the household sector, as well as the identification of patterns of convergence or divergence across regions. The model incorporates a wide array of factors, allowing not only the identification of the most influential determinants of household energy efficiency but also the adaptation of national and regional policies to specific behavioral patterns, housing characteristics, climatic conditions, and the economic potential of different regions. Although the use of this model is highly relevant, its current application is constrained by limited access to statistical data and the broader challenges imposed by martial law. Nevertheless, its implementation in the post-war period may serve as a foundation for refining national energy policy, guided by principles of regional balance and prioritization of decentralized energy production.

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