Assessment of the Regional Energy Efficiency Potential of the Housing Sector of Ukraine

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Abstract This article develops a methodological approach to the integrated assessment of potential opportunities for energy efficiency providing for the residential sector in the regional context. Regional comparison of energy efficiency potential is based on values that characterize technical, economic, and social components of energy efficiency in the residential sector. The regions are ranked according to the integrated values and clusters are formed according to the level of energy efficiency assessment, which characterizes the differentiation of regional effectiveness of organizational and economic supplying of energy efficiency in the residential sector. The results, attained during the estimation of potential opportunities of energy efficiency management give the possibility to assess not only the action efficacy of all government branches to implement energy-efficient technologies but also to identify opportunities to apply political instruments to support the practice of stable building, based on sustainable development principles.

Keywords Energy efficiency potential · Integral assessment · Ranking of regions by integrated rating score · Ensuring energy efficiency of the residential sector

1 Introduction

The issue of energy efficiency and the economic use of energy resources has been important for a long time for many countries around the world. More and more of them are trying to solve the energy efficiency problem by introducing the latest technologies. Ukraine is doing its best not to stand aside of those tendencies. The detected reserves of energy saving and energy efficiency of the residential sector of Ukraine's economy according to a recent evaluation by scientists and practitioners, vary from 50 to 70% of the current level of energy consumption.

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Therefore, there is a need to develop a methodological approach that would allow assessing the potential opportunities for energy efficiency of the residential sector in the regional context.

2 An Overview of Recent Research Sources and Publications

Scientific and methodological approaches to the energy efficiency of the residential sector of the economy are actively studied by scientists and practitioners all over the world, and their systematization of generalization allows identification of modern mechanisms and devices to improve organizational and economic guarantees of energy efficiency of the residential sector in Ukraine.

Among all the variety of extremely important problems of energy efficiency maintenance of residential sector in foreign countries the following should be included: scientific and methodological approaches to energy efficiency maintenance of the residential sector: assessment of energy poverty in low-income households, which includes climatic, building, socio-economic characteristics of the country (Spain) [1]; studying the difference in energy efficiency depending on the group of consumers and its type [2]; application of a nonlinear methodology and interdisciplinary approach to the study of energy consumption in households, in particular analysis of the covariance structure, to isolate direct and indirect consequences of household and housing characteristics for total annual domestic energy consumption (USA) [3]; study of the utility market potential, the role and tasks of its players, demand modeling and energy resources prices forecasting [4]; development of energy consumption management for efficient use of resources in terms of technical progress [5]; conceptual approaches to housing fund renovation and partial reconstruction in context of European energy policy, thermal modernization of housing fund, as well as combining energy efficiency issues with ecological, financial, social and cultural goals of housing management (Sweden) [6]; increasing energy efficiency in the non-profit housing sector (Netherlands) [7]; problems of effective energy applying and energy efficiency measures in the construction sector as a tool to reduce energy consumption and to improve local ecological sustainability (Malaysia) [8]; assessment of the impact of municipal construction structures and their actions in energy efficiency stable building and renovation field [9]; mechanisms to stimulate energy efficiency during the projecting and construction of residential and public buildings, including the availability of energy efficient housing for the population; impact of energy efficient measures in residential buildings on the cost of habitation (USA) [10]; problems of management innovation-oriented development the construction industry of Ukraine [11]; methodical approach to determining the minimum mediate costs for 1 m^2 of affordable housing at the level of Ukrainian regions [12].

3   Purpose of the Article

The main purpose of the paper is to develop and implement a methodological approach to estimating the regional potential of energy efficiency, which allows to apply comparative assessment of the performance of the management and economic allowance of energy efficiency and use of energy efficiency potential in the housing sector in Ukraine (including Donetsk and Luhansk regions), to rank the regions according to the integrated rating score.

4   Methodical Approach to Assessing the Regional Potential of the Residential Sector

Theoretical Aspects
The concept of potential in the modern economy is interpreted ambiguously, there are a lot of theoretical approaches to determining its essence and constitution. It is most frequently used in the study of market opportunities of economic entities, the formation and evaluation of current and future opportunities that ensure the effectiveness of activity and create circumstances for the development of a competitive environment. At the same time potential performs: as a set of available instruments and resources; includes sources, opportunities, tools, reserves, which could be involved in solving certain issues [13]; characteristics of available productive forces in any field [14]; present opportunities, resources, reserves, instruments, etc. [15, 16].

The potential of energy efficiency is identified by authors as a set of resources, possibilities, and tools, which can be used to reduce the cost of energy resources in residential buildings while ensuring the optimal level of comfort for the population.

The regional potential of energy efficiency characterizes local features of energy consumption and energy efficiency in regions, it should be considered as a set of resources, possibilities, and tools, which can be executed to decrease energy expenditures in residential buildings while ensuring the optimal level of comfort for the population.

The introduction of such a concept allows considering a methodological approach to the integrated assessment of potential opportunities for energy efficiency of the residential sector in a regional context as an important tool for improving the organizational and economic support of energy efficiency of the residential sector in the national economy.

Regional differentiation of organizational and economic support of energy efficiency of the residential sector in the national economy will indicate the effectiveness of energy efficiency management of buildings in Ukraine in the regional context. In this study, based on the available statistics of the State Statistics Service of Ukraine [17], the integrated rating of the regions according to their energy efficiency potential was calculated.

Regional comparison of energy efficiency potential is carried out on eight indicators: total area of housing area, in thousand m²; the current number of population in regions, in thousand people; disposable income of the population in regions of Ukraine, in million UAH; the number of buildings, equipped with units of commercial heat metering (residential) by regions, %; use of natural gas by regions, million m³; use of heat by regions, Gkal; electricity use, million kWh; the total amount of subsidies allocated to reimburse the cost of housing and communal services, thousand UAH.

The algorithm of rating assessment of energy efficiency potential is accomplished in three stages. The first stage is the calculation of the sum of the relative deviations of the indicators, which characterize certain activities of economic entities in the region, from the best values of these indicators by the formula:

$$S_j = \sum_{i=1}^{n} W_{ij}, \tag{1}$$

where $W_{ij} = \left(\frac{B_{ij} - B_{\min_i}}{B_{\max_i} - B_{\min_i}} \right)$ for stimulator indicators;

$W_{ij} = \left(\frac{B_{\max_i} - B_{ij}}{B_{\max_i} - B_{\min_i}} \right)$ for destimulator indicators;

S_j—rating evaluation of energy efficiency potential of the j-th region for each of the indicators;

B_{ij}—value i-th indicator of j-th region, $1 \leq i \leq n$;

$B_{\max_i}$, $B_{\min_i}$—a minimal and maximal value of indicators.

The second stage. Determining the arithmetic mean of the sum of the rating of the energy efficiency potential of the assessment region for each of the indicators according to the formula

$$S_{j_{avg}} = \frac{S_j}{n}, \tag{2}$$

$S_{j_{avg}}$—the arithmetic mean of the sum of energy efficiency potential ratings by n-th indicators;

n—the number of indicators on which the calculation is performed.

The third stage. Determination of the integrated rating score of the energy efficiency potential of the region using formula

$$S_{rj} = \sum \left(S_{j_{avg}} \cdot q_i \right), \tag{3}$$

where S_{rj}—integrated rating score of the energy efficiency potential of the j-th region;

q_i—the significance of i-th indicators group.

Region with the highest S_{rj} value has the biggest energy efficiency potential.

The Results

The regions are ranked according to the integrated indicator and clusters are formed according to assessment level of energy efficiency potential, which characterizes differentiation of regional effectiveness of organizational and economic support of energy efficiency in the housing sector of the national economy, the bigger the energy efficiency potential is, the lower energy efficiency considering the usage of energy resources is in the residential sector and the larger volume of energy resources can be saved, by increasing the effectiveness of organizational and economic support of energy efficiency in the residential sector of the national economy at the regional level (Fig. 1).

Dnipropetrovsk, Donetsk, Kharkiv, Odesa regions, and the city of Kyiv perform the highest energy efficiency potential.

The result of energy efficiency potential assessment of buildings allows evaluating not only the effectiveness of all branches of the government in the implementation of energy-efficient technologies but also to identify opportunities to introduce political instruments to support sustainable construction practice based on stable development principles.

This approach requires balancing all factors of sustainability—economic, energy, ecological and social.

Despite some positive changes in Ukraine's energy efficiency in general, the level of effectivity in regions of the country has changed in different ways, which requires taking in account certain regional specifics and, accordingly, setting adequate targets for regions to realize the potential, which would take into account national goals and regional specifics at the same time.

At the same time, it should be noted that, despite this, in Ukraine, a criteria base for energy efficiency assessment has not been defined yet, as well as methodical developments for its measurement and comparison (it is possible to adequately compare different countries and regions of the world in terms of energy efficiency, considering climatic, territorial, infrastructural and other features). In this case, the only, relatively universal and commensurate for international and regional comparisons of energy efficiency is the energy intensity of GDP taking into account purchasing power parity (PPS).

Scientific Novelty

A methodological approach to integrated assessment of regional energy efficiency potential has been developed, which characterizes the local features of energy consumption and energy efficiency of the regions of Ukraine, and can also be used to identify potential opportunities and priorities for energy efficiency management of buildings.

Practical Relevance

Firstly, the obtained results of the research allow making adjustments of energy-saving policy and strategies of social and economic development of the regions of
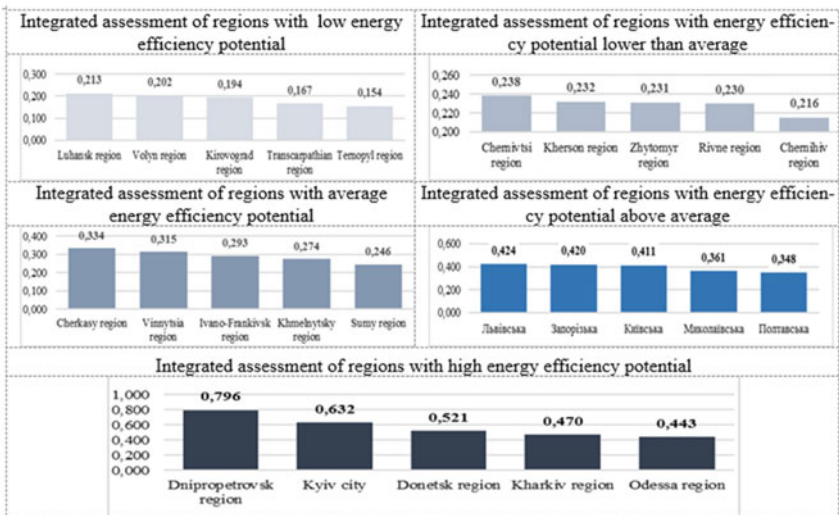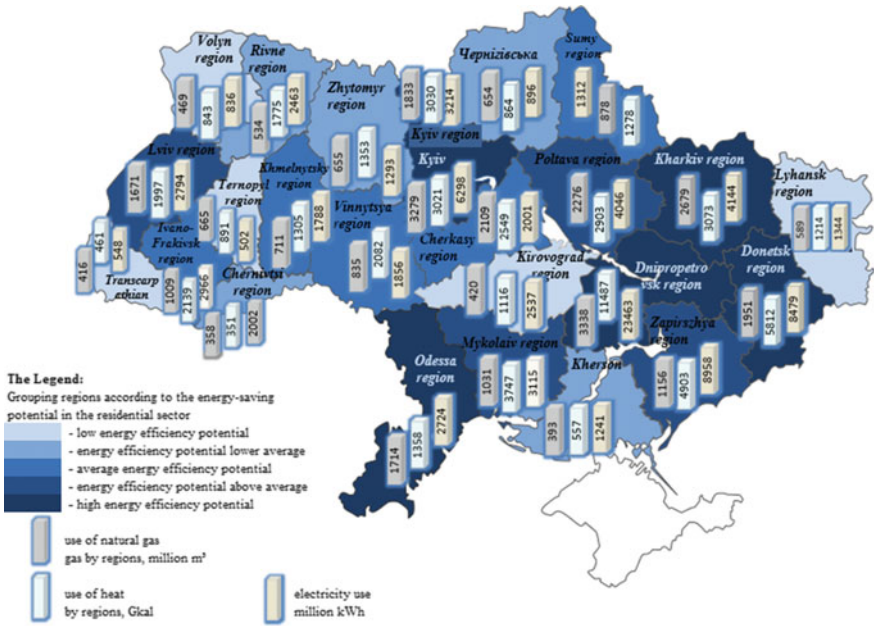
Fig. 1 Assessment of energy efficiency potential in the residential sector of Ukraine in the regional context, 2018 (developed by the author, data on the Autonomous Republic of Crimea are missing)

Ukraine on a systematic scientifically substantiated basis, as well as be taken into account in the development of relevant program documents. The practical use of the obtained results of the implementation of this approach makes it possible to determine the differentiation of regional effectiveness of organizational and economic support of energy efficiency of the residential sector in Ukraine.

5 Conclusion

The obtained results make it possible to optimize the content of regional and local strategies of sustainable energy development from a standpoint of energy efficiency, implementation of effective mechanisms to stimulate the population to introduce energy-saving technologies on a basis of the integrated approach, in terms of which along with creating the legislation, it is necessary to take into account the economic interests of housing owners and investors. This fundamental moment was understood in all developed countries of the world.

References

1. Sanchez CG, Gonzalez JN, Aja AH (2018) Energy poverty methodology based on minimal thermal habitability conditions for low income housing in Spain. Energy Build 169:127–140. https://doi.org/10.1016/j.enbuild.2018.03.038
2. Gillingham K, Palmer R (2013) Bridging the energy efficiency gap: policy insights from economic theory and empirical evidence. Rev Environ Econ Pol 8:18–38. https://doi.org/10.2139/ssrn.2206995
3. Estiri H (2015) The indirect role of households in shaping US residential energy demand patterns. Energy Pol 86:585–594. https://doi.org/10.1016/j.enpol.2015.08.008
4. Sioshansi FP (2016) Future of utilities – utilities of the future: how technological innovations in distributed energy resources will reshape the electric power sector, 1st edn. Academic Press, 492 p
5. Kayakutu G, Mercier-Laurent E (2016) Intelligence in energy, 1st edn. ISTE Press – Elsevier, 252 p
6. Femenias P, Mjornell K, Thuvander L (2018) Rethinking deep renovation: the perspective of rental housing in Sweden. Cleaner Prod 195:1457–1467
7. Filippidou F, Nieboer N, Visscher H (2017) Are we moving fast enough? The energy renovation rate of the Dutch non-profit housing using the national energy labelling database. Energy Policy 109:488–498. https://doi.org/10.1016/j.enpol.2017.07.025
8. Shaikh PH, Mohd NB, Nor SAA, Nallagownden P, Elamvazuthi I, Shaikh MS (2017) Building energy for sustainable development in Malaysia: a review. Renew Sustain Energy Rev 75:1392–1403. https://doi.org/10.1016/j.rser.2016.11.128
9. Hakkinen T, Rekola M, Ala-Juusela M, Ruuska A (2016) Role of municipal steering in sustainable building and refurbishment. Energy Procedia 96:650–661. https://doi.org/10.1016/j.egypro.2016.09.123
10. Im J, Seo Y, Cetin KS, Singh J (2017) Energy efficiency in U.S. residential rental housing: adoption rates and impact on rent. Appl Energy 205:1021–1033. https://doi.org/10.1016/j.apenergy.2017.08.047

11. Onyshchenko S, Yehorycheva S, Furmanchuk O, Maslii O (2019) Ukraine construction complex innovation-oriented development management. In: Proceedings of the 2nd international conference on building innovations, pp 687–700
12. Komelina OV, Shcherbinin LN, Shcherbinina SA, Ivanyuk BM (2019) Methodical approach to optimization of housing cost in the housing market of Ukraine. In: Proceedings of the 2nd international conference on building innovations, pp 609–616
13. Khomiakov VI, Bakum IV (2007) Upravlinnia potentsialom pidpryiemstva. Kondor, Kyiv
14. Busel V (2002) Velykyi tlumachnyi slovnyk suchasnoi ukrainskoi movy. Kyiv
15. Borisov AB (2003) Bolshoi ekonomichieskii slovar
16. Krasnokutska NS (2005) Potentsial pidpryiemstva: formuvannia ta otsinka: Navch. posib. Kyiv
17. Derzhavna sluzhba statystyky Ukrainy. http://www.ukrstat.gov.ua/. Accessed 11 Oct 2020