Energy security components of agglomerations

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Abstract.

This work is devoted to the development of energy security components within the mountainous agglomeration space. Concepts and approaches to the definition of energy security in the country and agglomerations in the mountains are considered. In this paper, the concepts of agglomeration, energy security and its components were revealed, energy safety we compared these concepts and derived theoretical and practical differences. Most of the research was devoted to the development of the methodology for calculating the energy security index for the country and agglomerations which are situated on the mountainous terrain, a comparison of the two approaches. The methodological principles of division of its components are improved. Our results clearly demonstrate that in order to effectively ensure the energy security of agglomerations, it is necessary to strive to achieve the highest index indicators for its various components.

Keywords.

Energy security, Agglomeration, Urban - rural area, Energy Components, Sustainable development.

1. Introduction.

This work is designed to answer questions related to energy security, namely the energy security of remote places in the mountains. It is important to highlight the main components of energy security for sinter formations. The formation of energy security components makes it possible to analyze individual territories and implement changes in the legal framework, regulate the energy system, establish connections. Experience shows that security is important both for the functioning of the economic space of the state and for the existence of man as an individual. From the point of view of human existence and needs, security is one of the needs. The understanding of security is based on the rules of its solution as an anthropogenic problem, with which theorists link the existence and development of man as a social being. Security is a complex and significant element of the functioning of the economic space and society as a whole.

The priority role of energy security is determined by the fact that it characterizes the ability of the national economy to expand reproduction and structural improvement.

Energy security is an indicator of economic independence and potential. Different approaches are different from the definition, but in our work we focus on the definition given in the legislation of Ukraine. Energy security is a set of potentials of various components of the state (resource, energy, technological, technical, environmental, economic, scientific, organizational and managerial), which are aimed at meeting its fuel and energy needs and are reflected in the policy of protection of national interests in energy, reduction of dependence on energy imports and development of own production and production of energy products. [1] Prospects for the priority development of agglomerations as a spatial form of localization of settlements are determined by the fact that, first, they are the core of the settlement system in the region, its supporting framework; secondly, agglomerations play the role of drivers of economic growth and areas with high economic potential, interaction between settlements, which causes a synergistic effect that will affect the sustainable development and the level of its logistics. [3] In addition to the above, we propose to consider agglomeration space in a non-classical definition, which urban agglomeration (hereinafter abbreviated "agglomeration") is a special form of settlement, which should be understood as a territorial formation arising on the basis of a large city (or several compactly located cities - conurbation) and creates a significant zone of urbanization, absorbing adjacent settlements; is characterized by a high degree of territorial concentration of various industries, especially industry, infrastructure facilities, research schools, as well as a significant population has a decisive transformative impact on the environment, changing the economic structure of the territory and social aspects of life; has a high level of economic complexity and territorial integration of its elements. [4]

2. Review of Literature.

Research on the issue of formation and the development of agglomerations, much attention was paid by domestic and foreign scientists. In particular, G. Lappo, Y. Pityurenko, Y. Pivovarova, A. Stepanenko, Y. Bilokonya, D. Bogorad, M. Gabrel, M. Dyomin, Y. Dekhtyarenko, O. Topchieva, G. Filvarova. Among international organizations and companies, the BSEC, Mckinsey and The Economist Intelligence Unit are studying this issue. In addition, Ukrainian scientists from the Public Institution "Institute of Environmental Economics and Sustainable Development of the National Academy of Sciences of Ukraine" pay much attention to the study of energy, economic and environmental security of agglomeration and urban-rural areas.

The importance of the problem of energy security policy is based on the general social significance of energy, which consists of four main aspects of its use by the socio-economic system [5]:

(1) functioning, i.e., ensuring basic human needs and energy supply of economic activity;
(2) maintaining the existing level of infrastructure of modern society;
(3) use of energy to ensure population growth, capital, and consumption;
(4) ensuring the dynamics of changes in economic infrastructure, technical progress, and productivity growth.

In our work, we start from the basic concept of energy security and put it on the energy security of entities of our country. Because these concepts are equally valid at the national level and at the local level.

The conceptual apparatus of energy security is based on the concepts of national security and reliability [6]. For exa|mple, Benjamin Sovacool [7] points out that energy security consists of the interconnected factors including availability, affordability, efficiency, sustainability, and proper governance. Moreover, Sovacool and colleagues come to an agreement on the fact that conceptualizing and measuring energy security is a complex topic that might be very country-dependent and tied to local culture and habits which makes it very complex and robust for studying and calling for local comprehensive case studies that would allow shedding somewhere more light on its nature and scope [8].

From the standpoint of the national security concept, energy security expresses its energy aspects and reflects the contribution of energy to its security [9]. With regard to the above, Kiriyama and Kajikawa [10] or Umbach [11] present a multilayered analysis of energy security research and the energy supply process as well as draw implications for global energy security. Moreover, there are various methodologies of energy security [12] as well as a plethora of methods, indicators, and measures often used in the research literature [13]. Smart grids or nuclear energy security are of a special interest [14]. In addition, system dynamics approach is often involved for assessing the whole complexity of these issues.

In general, most articles on energy security introduce their wording of the term "energy security". For example, energy security is defined by the World Energy Council as " . . . the confidence that energy will be available and in the quantity and quality required by economic conditions . . . " [15]. International Energy Agency formulates energy security as " . . . continuous physical availability of resources at a price that is acceptable in terms of environmental compliance . . . " [16]. However, all scientists agree that energy security is a dynamic phenomenon. Thus, there are longterm and short-term energy security's aspects. The first is mostly about the economic aspects of timely energy supply and environmental safety. The second is oriented on the prompt adaptation of the energy system to sudden threats or changes in the energy balance [16].

Based on the above, the following definition of energy security in the system of modern geoeconomic threats can be given: Energy security is the state's ability to ensure efficient use of its fuel and energy, to optimize diversification of sources and resources to ensure the livelihood of the population and volatility of prices for fuel and energy resources or to create conditions for rapid adaptation of the national economy to new prices for these resources [16].

Inherently, energy security is part of the economic security that characterizes the security of economic relations [14]. It is realized through economic mechanisms and allocated to a separate category because of the determining influence of energy on the national economy development (Figure 1).

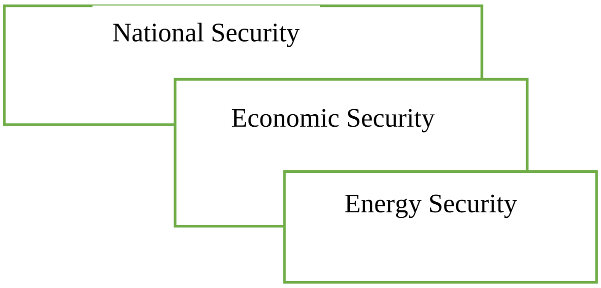

Figure 1. Energy security within the structure of state national security.

In terms of reliability, we view energy security as the continuity of electricity supply. At the same time, if reliability is a characteristic of the energy system of a territorial entity, then energy security characterizes the condition of a territorial entity, achieved by the continuous power supply.

Safety is the key category in the conceptual apparatus of energy security. It represents a condition achieved by ensuring the following three objectives:

- deficit-free resource supply for territorial entities;
- economic affordability of energy products for local consumers; and
- availability of technologies that allow to manage the reliable and efficient operation of the
- territorial energy system in the presence of existing environmental constraints [19].

Hence, Hoffmann [20] or McPherson and Tahseen [21] show how energy security can be characterized by the categories such as resource sufficiency, economic affordability, as well as technological allow ability. Moreover, it has been proposed to clarify the concept of energy security based on the following considerations: First, the widespread use of market-based energy management mechanisms by the state resulted in privatization and transfer of a large part of the business assets of power systems to private owners [22].

In order to make sure that the stable operation of the industry is reached, these mechanisms require assurance of economic efficiency of energy production and formation of profit margins that allow energy enterprises to implement the technological modernization and innovative development programs [23].

Second, the economic affordability of energy resources and products becomes the upper limiting threshold for resource sufficiency and technological efficiency reflecting the amount of available energy resources, the economy of their production processes and the transformation into energy products [24]. It also becomes obvious that in the sector of energy, the economic limit in market conditions is reached earlier than the resource and technological limits.

Therefore, we propose the characterization of energy security at the territorial level as a condition of protection of the territorial unit of the country from threats to reliable fuel and energy supply achieved by ensuring the functioning of its energy system in market conditions in accordance with the principles of consumer affordability of energy products and economic profitability of its production.

This clarification of what the energy security is, allows us to consider the economic and managerial problems of its provision more comprehensively. These problems represent the key issues in the context of the ongoing globalization and liberalization of energy market.

3. Methodology.

Lack of energy resources can be a problem for remote cities, towns and villages, especially those located in the mountains. It is because of the peculiarity of the location of such settlements that it is logical to create agglomerations around the most developed city. Modern agglomerations are formed on the principle of common natural resource potential, specialization of the economy and economic relations. The main principle of their allocation is the level of economic development and development, the ratio between the most important resources and the degree of their use. The big city is inextricably linked with other parts of the urban space by the social division of labor.

There are many works devoted to the study of energy security, identification of its components and calculation of indices. Therefore, in this paper we try to contribute to the idea of energy security and its components, we also review the existing components within the agglomeration space. We have revised the existing energy security indicators; this allows us to streamline according to their emphasis. Since we consider agglomerations that are mostly located in mountainous areas, an analysis of global agglomerations and agglomerations of Ukraine was conducted and identified those that have the potential for development.

4. Results.

Given that energy security is a basic need, an important task of every state, enterprise and individual households, we offer it consider the relationship of the following components:

- development of fuel and energy complex;
- meeting the needs of the economy and the population in energy resources, taking into account environmental aspects;
- protection of national interests.

In the context of each of these components, we highlight the criteria that are subject to quantification and make it possible to determine the type of current level of energy security and its potential (Fig. 2)

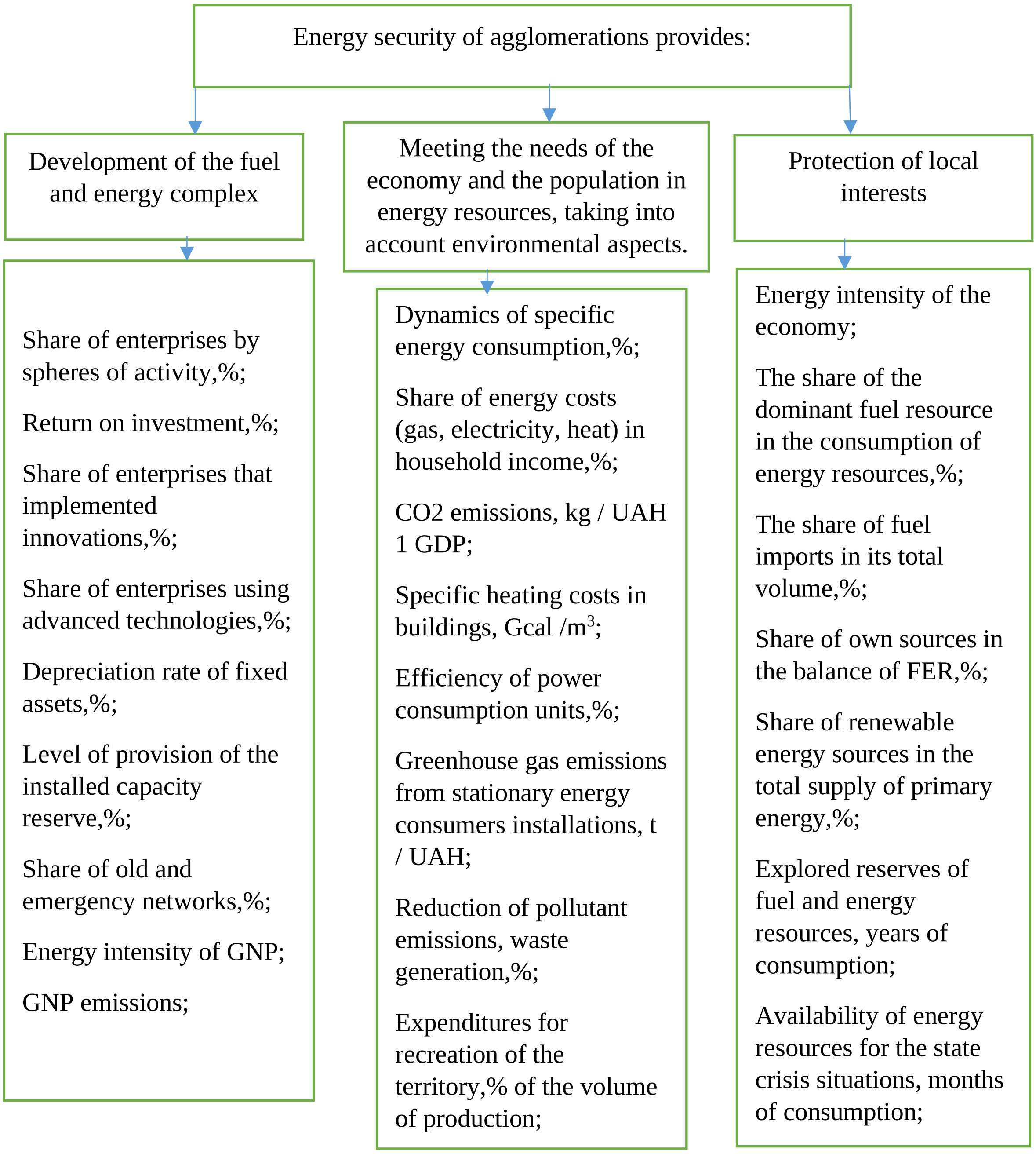

Figure 2. Criteria for assessing the energy security of agglomeration space.[25]

The energy supply issue consists of three stages – “secure resources” “secure a reliable domestic supply chain” and “manage demand.” A generally conceivable resource-securing method is to develop or acquire resources at home or abroad and transport them to the domestic market. Therefore, the “development of domestic resources,” “acquisition of overseas resources” and “transportation risk management” are deemed major items constituting the first stage of the supply chain. The “reliability of the energy supply” and “construction of supply infrastructure” are required to “secure a reliable domestic supply chain” and are deemed major items for this stage. “Energy efficiency” is cited as a major item indicating that something is being done to “manage demand.” On top of these factors, “preparedness for supply disruptions” has also to be seen as a major component of energy security.

Environmental sustainability has been added to the factors comprising the energy security issue, in light of heightened awareness of global environmental concerns. Most greenhouse gas emissions are produced by energy sources, and so it goes without saying that an important factor to ponder when thinking about energy issues is consideration for the environment, including climate change issues. If any of these factors is dropped, it may be structurally difficult for the supply chain to maintain a stable state of energy security [6].

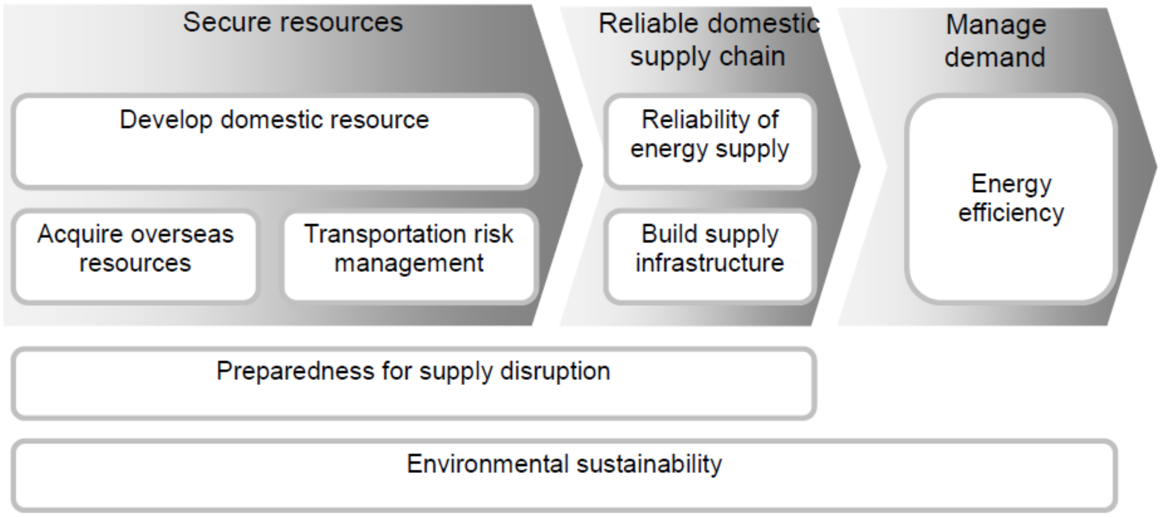

Figure 3. Components of energy security.

The most common methods of calculating energy security. Special emphasis should be placed on the paradigm shift in energy security in recent years, which is associated with the transition to alternative energy sources and ensuring the greening of energy security.

Thus, attempts to define the essence of the concept of “energy security” were not systematic and were marked by a variety of approaches (i.e., [26]) and some with insufficient justification. The same applies to methods of calculating energy security. In particular, the most common of them are:

- International energy security risk index-analysis of the methodological settings [27];
- Index of U.S. energy security risk [28];
- World energy outlook 2020 [29].

4.1. Energy Security Indicators

4.1.1 Energy Security Price Index (ESPI)

Different approaches are also characterized by attempts to develop analytical tools for assessing the level of threats and the state of energy security, but they do not make it possible to clearly define the subject field of energy security and define the scope of its concept.

The energy security price index (ESPI) developed by Lefèvre [30] is based on a political risk assessment of energy exporters and the market share of energy exporting countries in the global export potential for each fuel. The resulting (global) price risk for each fossil fuel *f* is expressed in a single index, the so-called ESMC*pol-f* (energy security market concentration index amended by a political risk rating). These fuel-specific indices are then multiplied by the share of each fuel in the examined country’s total primary
energy supply and added up to obtain one single number:

$$ESPI = \sum_f \frac{E_f}{TPES} ESMC_{pol-f} \text{ with } ESMC_{pol-f} = \sum_c r_c \quad {}^{2}_{cf} , \qquad (1)$$

where $\frac{E_f}{TPES}$ is the share of fuel *f* in total primary energy supply in the observed country, ωcf denotes the share of export country *c*'s net export potential in global export potential of fuel *f* (in percentage points) and *rc* is the political risk rating of export country *c* ranging from 1 (low risk) to 3 (high risk). The risk rating scales up Herfindahl's concentration index whenever countries are perceived as politically unstable: ESMCpol-f is large when few high-risk exporters dominate the world market (the maximum of ESMCpol-f is 30000 points). Note that ESMCpol-f is independent of the country for which the energy security index is calculated since ωcf only considers export potentials in a truly globalized market. The fuel-specific concentration indices ESMCpol-f are then weighted by the share of each fuel in total primary energy supply of the country under consideration in order to obtain the aggregate ESPI indicator.

4.1.2 Energy Security Import Index (ESMI)

Another common indicator for energy security is a region's share of net energy imports in its total energy consumption. Since imports defy the control of a country, they are potentially insecure in times of crises. For the calculation of the energy security import index (ESMI), we add up the shares of (positive) net imports across the fossil fuels f (coal, natural gas and oil) in total primary energy supply:

$$ESMI = \sum_f \frac{M_f - X_f}{TPES} \times 100 \text{ for all } f \text{ where } M_f > X_f \text{.} \qquad (2)$$

The indicator ranges between 0 (no net imports of fossil fuels) and 100 (complete import dependency).

4.1.3 Energy Intensity (EI)

The energy intensity of an economy is a demand-side indicator which measures the ratio of total primary energy supply over GDP:

$$EI = \frac{TPES}{GDP}. \qquad (3)$$

4.1.4 Composite Energy Security Index (ESI)

The three indicators – ESPI, ESMI, and EI – can be combined towards a composite energy security index (ESI) capturing three different energy security aspects: the price risks to specific fuels, the import dependency on specific fuels, and the importance of energy in the economy:

$$ESI = \sum_f \frac{M_f - X_f}{GDP} ESMC_{pol-f} \text{ for all } f \text{ where } M_f > X_f \qquad (4)$$

The ESI indicator thus represents an aggregation of the fuel-specific energy security market concentrations (including political risks) weighted by the shares of (positive) net imports of the respective fuels in GDP

Conclusion.

In this study, we have made an overview of the criteria for assessing the energy security of the agglomeration area that we apply to the area, including located in mountainous areas, for Ukraine it may be Chernivtsi agglomeration, which has the largest electricity use among mountain agglomerations in Ukraine, but the smallest among their total. Given the dependence of local energy security and national, we focus on the economic strengthening of areas with complex geopolitical location. Therefore, based on the indices and components of energy security presented in this paper, we propose to conduct a detailed analysis of specific mountain agglomerations, those that are developed and those that have great potential.

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