

ECONOMIC MODEL OF THE FORMATION OF A SMALL ALTERNATIVE ENERGY CLUSTER IN THE REGION

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Abstract. *The purpose* of this article is to analyze the domestic and foreign experience of forming a cluster structure and determine the possibilities and prospects of its use as a tool for increasing energy efficiency and establishing energy independence. Submission of proposals for the formation of an energy cluster in the Luhansk region under the name "Luhansk Energy Center". Determination of the features of the energy cluster, substantiation of its advantages and disadvantages, the structure and participants are proposed, the main types of activities are indicated, and proposals for the way of strategic development are provided. *Methodology.* Today, the formation of a cluster structure in Ukraine is a necessary condition for the activation of domestic production, increasing the efficiency of innovative development, achieving high indicators of economic growth, energy efficiency, energy security and energy independence. Information about the specifics of the development of countries and regions can help to understand the role of clusters, thereby creating a competitive advantage. *Results.* Clusters are the basis of an innovative economy and a form of economic activity, and their importance is growing, an example of which is the application of the concept of clusters in the development of renewable energy. Their multi-level structure makes it possible to conduct constant research, implement the most complex projects, including international ones, maintain business competitiveness and protect its interests. One of the main reasons for the urgency of the Ukrainian cluster is the globalization and restructuring of the economy, increasing competitiveness, access to foreign markets, partnership with investors and funds, investment attraction, etc. Cluster activity can depend on individual fields or a combination of several fields. *Practical implications.* As research shows, a big role in the activation of innovation belongs to renewable energy. Formation of new innovative centers of social economic development of the region should be carried out on the basis of cluster development of energy infrastructure tours according to the target function, namely energy recovery type provision. Most often, regional division in countries forms has existed historically for a long time, but it is not always takes into account all economic, technological, geographical physical features. Today there are new theoretical ones and practical knowledge, management mechanisms, with the help of which different fields are directed and combined technical and technological, economic and social overall progress. *Value/originality.* The main goal of the selected research is to determine the role of various institutions in the formation of the Luhansk energy cluster for the effective development of the region in the energy sector, as well as to confirm the possibility of using cluster systems in the context of ensuring an energy-efficient Ukrainian economy based on energy independence.

Key words: clusters, energy cluster, energy, renewable energy, energy efficiency, energy resources, small alternative energy (SAE).

JEL Classification: E21, L90, Q4

1. Introduction

Today, the formation of a cluster structure in Ukraine is a necessary condition for the activation of domestic production, increasing the efficiency of innovative development, achieving high indicators of economic growth, energy efficiency, energy

security and energy independence. Information about the specifics of the development of countries and regions can help to understand the role of clusters, thereby creating a competitive advantage.

Clusters establish a network of subjects of the state with a bedroom or a close one directly to

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development. An important mutual connection, which is manifested between subjects, is cooperation, so that it is close cooperation, as it gives the opportunity to make decisions and approaches to the full extent from various aspects for the galleys, which are clustered in different regions. The reformation of the problematic energy sector of the region and Ukraine as a whole is significantly improved in the form of clusters, the participants of which are not only the business gravity of the region, but also science, practices, communities, authorities and public organizations. Close cooperation clusters in the field of energy, it is not enough to help the subjects of the cluster to enter the out-of-the-way markets with the help of their own products, and invest money in the improvement of traditional energy sources and the possibility of alternatives and dynamic types of production.

2. Cluster development of small alternative energy in EU

As the experience of EU countries shows, cluster associations are one of the most effective forms of organizing energy-efficient processes, forms of regional development, in which not individual enterprises compete on the market, but whole complexes that reduce their costs thanks to joint technological cooperation of companies. Within the framework of the cluster structure, the tasks of increasing production volumes, full loading of production capacities are solved; implementation of material and energy saving measures, reduction of resource losses, improvement of energy efficiency and product quality; obsolete equipment, etc.

There are more than 51 energy clusters in the EU. At the same time, a trend towards more active development of the cluster approach in the field of energy efficiency and renewable energy sources has emerged. The creation of regional green energy clusters can contribute to the critical mass needed to act to lower these barriers to the wider use of renewable energy sources. In particular, within the framework of the "Green Energy Cluster" project, 4 new regional green energy clusters were created in cooperation with the existing EcoEnergy cluster in Upper Austria in the solar thermal energy and biomass sector (Beccali, Cellura, Mistretta, 2007; Kim, 2015; Milosavljević, Pavlović, Piršl, 2015)

Another cluster of Upper Austria Oekoenergie-Cluster (Oekoenergie-Cluster) can be included among the most famous in the field of RES – one of the most important energy clusters in Europe. The main goal of Oekoenergie-Cluster is to support enterprises working in the field of renewable energy and energy efficiency, to stimulate innovation and increase the competitiveness of these enterprises by means of investments in the development of production and exploitation of ecologically clean energy. Currently, this cluster includes more than 150 partner companies; the total number of employees is 6,300; turnover – 1.7 billion euros; more than 50% of manufactured products are exported; the coordinating organization of the cluster is O. O. Energi-esparverband. All companies included in the cluster are divided into two groups: working in the field of RES and working in the field of energy efficiency. Many companies are engaged in both types of activities.

One of the largest transnational clusters in the EU is the Belgian-Luxembourg cluster TWEED (Wallonia region), created in 2008. It is a cluster of technologies in the field of energy, environment and clean energy. To date, it includes 141 companies with a turnover of more than one billion euro.

The main goal of the TWEED cluster is to support investments in the production and operation of renewable energy through the implementation of the largest projects in this field. This cluster includes many companies specializing in the field of renewable energy. The entire industry is within their competence: alternative energy production, energy efficiency, energy saving, etc. The TWEED cluster keeps track of all exportable green technologies of Wallonia, elaborates them in order to make them even more competitive, and promotes these technologies abroad.

In this way, the enterprises of the cluster provide themselves with high competitiveness in world markets, and therefore, high competitiveness of this region in the world economy. It is the focus on exports of members of this cluster that forms the high competitiveness of the region in the field of RES. The coordinating organization of the TWEED cluster provides the following services to cluster members:

- implementation of measures proposed by the state to stimulate new projects;

- promoting cooperation by organizing relevant events, receptions, meetings, exhibitions, visits to partner companies, etc.;
- technical support and management of cluster projects;
- development of interaction with other clusters;
- information and communication support for the renewable energy sector in Wallonia.

Special attention is paid to wind energy in the Wallonia region. Currently, more than 200 wind turbines have been installed in Wallonia, located in 33 districts. They produce the amount of electricity used by 283,000 households.

A significant number of RES clusters exist in Denmark. One of them is the Hydrogen Innovation Research Center (HIRC) cluster, which was founded in 2004. Its goal is to promote the commercialization of technical research in the field of hydrogen technologies, support cooperation with universities, research institutes, educational institutions, public organizations, and especially with business community, both local and international. Today, HIRC is an active network consisting of approximately 100 research institutes, universities, and industrial companies in Denmark. The center closely cooperates with regional and municipal authorities. HIRC is committed to the advancement of hydrogen technologies, hydrogen products, and fuel cells. The main technological idea of the HIRC-hydrogen circuit is the conversion of wind energy using electrolysis into oxygen and hydrogen with the subsequent use of hydrogen in fuel cells that serve as a source of electricity.

It is interesting that the basis for the emergence of "hydrogen research" was the presence of a developed natural gas infrastructure in Denmark. In connection with the increase in the production of electricity by wind turbines, research has begun on the possibility of hydrogen production from the excess electricity produced by them and its distribution through the natural gas infrastructure. Hydrogen is transported to buildings, then it is transformed into heat and electricity in the fuel cells of the thermal power plants of these buildings, the by-product is water. Thus, hydrogen in this chain is an energy carrier obtained from the primary energy resource – wind energy. It is important to emphasize that even production waste: water obtained as a by-product does not pollute the environment! The HIRC cluster is focused on

energy saving due to the use of RES; reduction of pollution and CO₂ emissions into the atmosphere; creation of jobs in production and in research institutes. Cluster participants interact with the support of the KO, whose activities are as follows:

- information and communication support for scientific activity;
- strategic development;
- exchange of knowledge, establishment of contacts between research institutes and business, creation of a strong cooperative network, etc.

Since its establishment, HIRC has initiated numerous projects in the field of hydrogen technologies and has taken a direct part in their implementation. In our opinion, these projects are truly innovative:

1. "Hydrogen House" project. The goal of the project is to construct a house in which the hydrogen chain is fully functional. The first demonstration hydrogen house was located in Herning. The budget of the project will be 2.5 million Danish kroner. Designing began at the end of 2007. The project is exclusively of a demonstration nature and serves to familiarize the public with the possibilities of using hydrogen energy in the supply of buildings, attracting interest in hydrogen technologies.

2. The "hydrogen train" project. The project consists in the construction of a prototype of a train running on water. The program to study the possibilities of using hydrogen as fuel for trains was launched in 2005 and turned out to be quite successful. The International Hydrogen Train & Hydrail conference was held in Herning, attended by more than 50 countries, including the USA, Great Britain, Spain, Germany, Holland.

3. The "hydrogen demonstrator" project. With the support of the Danish Hydrogen Company Association (Danish Hydrogen Association), an exhibition hall was created where Danish owners and developers can share with visitors the results of their research, show the latest hydrogen products, and talk about the principles of creating and functioning of fuel cells.

4. The "H2PIA" project is a model of the future "hydrogen" society, in which people themselves produce and store energy for their needs with the help of hydrogen cells. "H2PIA" is a society of freedom, clean energy, creativity and innovation. With the help of hydrogen, it is possible to fully cover the energy needs of society.

Table 1

Energy consumption from renewable sources for 2018–2020

Indicators \ Year	2018	2019	2020
Total primary energy supply (thsd.toe)	93526	89259	86402
Hydroenergy	897	560	650
% of total	1,0	0,6	0,8
Energy of biofuels and wastes (thsd.toe)	3209	3349	4342
% of total	3,4	3,8	4,9
Wind and solar energy (thsd.toe)	197	426	794
% of total	0,2	0,5	0,9

Clean energy – because hydrogen is produced from renewable energy sources: sun and wind. The only byproduct of hydrogen production is pure water.

Creativity and innovation – because the creation of "H2PIA" is a close cooperation of the private and public sectors, as well as people working in various fields (technicians, architects, designers).

5. The "H2 HUB" project is a project to create hydrogen filling stations, promotes the spread of hydrogen use in the transport sector. The main goal is to bring hydrogen technologies to the market and create business opportunities for local companies. The project involves the testing of small cars with hydrogen engines, which will take place in several areas of Denmark in the near future.

The projects of the HIRC cluster seem quite fantastic, but perhaps at the beginning of the 21st century. many projects of various technical devices existing today looked just as fantastic. Let's emphasize that these projects are implemented precisely as a cluster, with the participation of scientific organizations, regional authorities and business.

A number of important lessons can be drawn from the experience of the functioning of European energy clusters that we have considered, which will contribute to the modernization of the regional economy of Ukraine. First of all, it is obvious that the authorities at the state and local levels should start active actions on the formation of clusters in the field of renewable energy, because at the regional level in Ukraine, an understanding of the need for these processes has already been formed.

3. Development of small alternative energy cluster in Ukraine

Alternative energy shows significant development in Ukraine, so in the period from 2008 to 2019, its share in the energy balance of Ukraine increased from 1.94% to 4.88% (Economic statistics on energy). However, since 2019, for some indicators, the fate of alternative energy has begun to decline (Table 1).

The forecast share of alternative energy in the energy balance of the country in 2030 should be 27.5%, while it will take second place after nuclear energy (Bilyavskij).

One of the most important advantages of the formation of production structures in alternative energy cluster-type – organizational and technological concentration not on individual industries, but on relationships between industries, industries, enterprises, and organizations. They contribute to the development of production and competition, simplification access to the latest technologies, risk distribution in various types of integrated activities, joint access to foreign markets, organization of scientific research and the process of training (retraining) specialists, reduction of transaction costs and achievement of other synergistic effects. An important distinguishing feature of the cluster is its innovative orientation. In view of this, many countries are increasingly actively using the cluster approach in the formation and regulation of their national innovation programs. The appearance of existing and potentially possible clusters in the economy of the region, as well as the provision of state support for their development is a necessary condition for further development of its economy in the medium and long term perspectives within the framework of the cluster approach,

there is a need to focus efforts on improvement work and assistance to individual enterprises, as well as establishing and strengthening relationships between suppliers and buyers, the population and producers, etc. The main function of the regional alternative energy cluster is maximum satisfaction of the needs of the population of the region. Other, no less important, functions of the energy cluster are:

- creation of a balanced region for the industrial processing sub-sector electricity supply market;
- maximum utilization of production capacities of all spheres of the region's energy cluster.

The criteria for evaluating regional cluster strategies in Ukraine should be the tools of cluster programs implemented within the framework of strategies, regional development goals and the state of environmental factors of clusters; efficiency, use of available resources within the framework of cluster programs, taking into account opportunity costs; effectiveness, or the contribution of cluster programs to the formation of economic, social and environmental results of the functioning of the regional economy in the short term; stability, or prolonged effect, which will take place after the completion of the cluster program; which will lead to the development and achievement of strategic goals in the long term.

The development in Ukraine of small alternative energy, based on the use of alternative energy sources, is due to the absolute limitation of energy resources, a significant distance from the consumer of energy from centralized networks, the need to improve the level and quality of life of the population of remote areas. The study showed that it is advisable to distinguish two types of cluster formations that differ in content and activities, namely:

1. Cluster formation, the main type of economic activity of which is the use of renewable energy sources, the development and implementation of environmental technologies (bioenergy and environmental cluster specializing in the development of renewable energy).

2. Cluster, which include enterprises of alternative energy.

In this regard, it is advisable to single out an independent SAE cluster that provides 100% of the capacity. If the SAE cluster functions as part of another cluster formation, then it can be defined as medium, providing up to 50% of the

power, small, providing up to 20% of the power, mini-cluster (emergency), providing up to 10% of the power, and a micro-cluster, providing up to 5% of power and satisfying mainly aesthetic needs. The use of the SAE ensures the formation of the comparative advantages of clusters and the territory of their location, which in the long run can be transformed into sustainable competitive advantages of the region, which ensures its investment attractiveness.

The creation of an SAE cluster in the regional socio-economic system involves the consistent implementation of the following stages:

- 1) assessment of the factor conditions for the development of small alternative energy in the region;
- 2) determination of the conditions of demand for the products of the SAE cluster;
- 3) prospective analysis of the state of related and supporting industries of the SAE;
- 4) determination of priority strategies, taking into account the structure of competitive relations in the energy sector of the region.

The application of the proposed algorithm makes it possible to clearly formulate a strategy for the development of the SAE cluster in the region, taking into account the characteristics of the latter, which will ensure an increase in the growth rate of indicators of the development of the socio-economic system.

Ensuring the achievement of strategic, tactical and operational goals for the development of the SAE regional cluster dictates the need to monitor its progressive dynamics using indicators characterizing the effect (net income, payback period) and efficiency (internal rate of return, return on investment) of the implementation of the project for the formation and development of the cluster.

It is expedient to reform the problematic energy sector of the region and Ukraine as a whole in the form of clusters, the participants of which are not only business players of the region, but also scientists, practitioners, communities, authorities and public organizations. Close cooperation of clusters in the field of energy will not only help cluster entities to enter foreign markets for the purpose of selling their products, but also to invest funds in the improvement of traditional energy sources and the possibility and dynamism of introducing alternative types of fuel.

The effectiveness of cluster activities is achieved by clarifying the roles of participants. Using the Polish experience of forming cluster associations, we consider the following roles in clusters to be optimal:

- Chairman of the Presidium of the cluster;
- Chairman of the Council of the cluster;
- Head of the entity coordinating the cluster;
- Cluster members (individuals, institutions).

Based on a study of the experience of cooperation of individuals and institutions in the field of energy and renewable energy, we propose to create a cluster "Luhansk Energy Center" with the following structure:

1. Chairman of the Council of the cluster – DBU "Luhansk Regional Center for Investments and Development".
2. Coordinator – NGO "Agency for Sustainable Development of the Luhansk Region".
3. LLC "Luhansk Energy Association".
4. PJSC "Donbasenergo".
5. Luhansk National University named after Taras Shevchenko.
6. Luhansk National Agrarian University.
7. Eastern Ukrainian National University named after Volodymyr Dal.
8. LOBO "Khors Community Foundation of Luhansk Region".
9. International company.

There are plans to sign a memorandum on the creation of a RES cluster and cooperation between all cluster participants.

All cluster participants will be involved at various stages in various areas of the Luhansk Energy Center in order to coordinate efforts to achieve maximum effect.

The functioning of such clusters has not only economic advantages, but also social priorities. We have analyzed and classified some of the benefits that are planned to be obtained from the activities of the Luhansk energy cluster, namely:

- joint efforts to provide a service to provide the population of institutions, enterprises, organizations with electric and thermal energy;
- protect common interests;
- informational support of project participants;
- joint provision of electricity and heat services to the population of institutions, enterprises, organizations;
- develop a plan for placing objects;

- creating market conditions, including choice, in energy markets by encouraging SMEs to produce energy;
- project participants enter foreign markets;
- business expansion;
- attraction of investment funds and attraction of funds;
- introduction of innovations in energy;
- social effect of project implementation (creation of jobs, lighting, budget at all levels);
- ecological effect;
- revival of the village;
- make maximum use of alternative heat and energy.

Among the key barriers that can affect the formation and effective functioning of energy clusters, we highlight:

- bureaucratic red tape;
- lack of awareness and lack of public acceptance of projects that can be implemented;
- monopoly dictates on the energy market of Ukraine;
- currency fluctuations;
- the investment environment is unattractive, etc.

3. Conclusions

Based on the conducted research, one of the urgent tasks of the development of Ukraine as a whole and its energy market in particular is the creation of cross-border and transnational clusters. To solve it, it is advisable to turn to the study and borrowing of the experience of the EU, which demonstrates an effective supranational system of measures aimed at stimulating clusters in various areas. To overcome the existing barriers to the creation of clusters in the general market of energy resources, it will be necessary to:

- to conduct further work on the harmonization of the conditions of economic activity;
- develop a coordinated, agreed cluster policy both at the national and supranational levels;
- to develop a legal framework regulating the creation and activity of clusters in the economy;
- coordinate international programs aimed at financing the most promising cluster projects based on public-private partnership;
- to stimulate the internalization of national clusters due to the permanent growth of their international cooperation, exchange of technologies, knowledge, etc.

A cluster approach to the organization of a common energy market will allow to obtain the necessary synergistic effect, which will increase the competitiveness of Ukraine on the world market, stimulate their transition to an innovative path of development due to the creation of new goods and technologies, and as a result, reduce the resource dependence of national economies on the export of energy carriers.

Based on the above, it can be concluded that currently innovative activity in the global electric power industry is accompanied by the formation of a multi-level innovation system, the purpose of which is to solve the increasingly complex tasks of innovative cluster development of the industry. The integration of domestic energy companies into this actively developing system is the most important condition for increasing the level of their technological development and ensuring competitiveness.

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Received on: 13th of October, 2022

Accepted on: 17th of November, 2022

Published on: 30th of November, 2022