Ministry of Education and Science of Ukraine

ODESSA NATIONAL ACADEMY OF FOOD TECHNOLOGIES

International Competition of Student Scientific Works

BLACK SEA SCIENCE 2021

PROCEEDINGS

ODESSA, ONAFT 2021

Ministry of Education and Science of Ukraine

Odessa National Academy of Food Technologies

International Competition of Student Scientific Works

BLACK SEA SCIENCE 2021

Proceedings

Odessa, ONAFT 2021

UDC 001.8(063)

Recommended for print by the Academic Council of
Odessa National Academy of Food Technologies
on April 6, 2021, Protocol No. 13

Black Sea Science 2021: Proceedings of the International Competition of Student Scientific Works / Odessa National Academy of Food Technologies; B. Iegorov, M. Mardar (editors-in-chief.) [*et al.*]. – Odessa: ONAFT, 2021. – 731 p.

Proceedings of International Competition of Student Scientific Works «Black Sea Science 2021» contain the works of winners of the competition.

The author of the work is responsible for the accuracy of the information.

Organizing committee:

Prof. Bogdan Iegorov, D.Sc., Rector of Odessa National Academy of Food Technologies, Head of the Committee

Prof. Maryna Mardar, D.Sc., Vice-Rector for Scientific and Pedagogical Work and International Relations of Odessa National Academy of Food Technologies, Deputy Head of the Committee

Prof. Stefan Dragoev, D.Sc., Vice-Rector for Scientific Work and Business Partnerships of University of Food Technologies (Bulgaria)

Prof. Baurzhan Nurakhmetov, D.Sc., First Vice-Rector of Almaty Technological University (Kazakhstan)

Prof. Mircea Bernic, Dr. habil., Vice-Rector for Scientific Work of Technical University of Moldova (Moldova)

Prof. Jacek Wrobel, Dr. habil., Rector of West Pomeranian University of Technology (Poland)

Prof. Michael Zinigrad, D.Sc., Rector of Ariel University (Israel)

Dr. Mei Lehe, Ph.D., Vice-President of Ningbo Institute of Technology, Zhejiang University (China)

Prof. Plamen Kangalov, Ph.D., Vice-Rector for Academic Affairs of "Angel Kanchev" University of Ruse (Bulgaria)

Dr. Alexander Sychev, Ph.D., Assoc. Professor of Sukhoi State Technical University of Gomel (Belarus)

Dr. Hanna Lilishentseva, Ph.D., Assoc. Professor, Head of the Department of Merchandise of Foodstuff of Belarus State Economic University (Belarus)

Prof. Heinz Leuenberger, Ph.D., Professor of the Institute of Ecopreneurship of University of Applied Sciences and Arts (Switzerland)

Prof. Edward Pospiech, Dr. habil., Professor of the Institute of Meat Technology of Poznan University of Life Sciences (Poland)

Prof. Lali Elanidze, Ph.D., Professor of the Faculty of Agrarian Sciences of Iakob Gogebashvili Telavi State University (Georgia)

Dr. V. Kozhevnikova, Ph.D., Senior Lecturer of the Department of Hotel and Catering Business of Odessa National Academy of Food Technologies, Secretary of the Committee

4. POWER ENGINEERING AND ENERGY EFFICIENCY

A RESULT-ORIENTED FRAMEWORK TO SUPPORT THE LOW-CARBON TRANSFORMATION OF ENERGY SERVICES MARKET

Author: Maria Yevtukhova
Advisors: Valeriy Deshko
Oleksandr Kovalko
National Technical University "KPI" (Ukraine)

Abstract. *Today, the scope of energy services markets (ESMs) has expanded worldwide and covered almost all areas of production and consumption of goods and services for both industrial and public appointments, as well as households, mainly due to energy efficiency and renewable energy sources. At the same time, the incompleteness of theoretically grounded bases significantly reduces the pace of these markets development. The purpose of this study is to present the framework for the determination of directions and construct a model of structural organization and functional interaction of the ESMs participants. Such approach allows, by combining resources, capabilities and information, to expand the scope and improve the efficiency and productivity of energy services. A new structure-function model of ESMs participants' interaction has been developed. In addition, a new organizational mechanism is proposed to support the efficient functioning of the ESMs in the form of a cycle of continuous improvement of the energy services results. The practical significance of the study is to create a conceptual framework for the organization and functioning of ESMs, which allows to systemically assess the new opportunities for such markets in both developed and developing countries.*

Keywords: *energy services, market structure, mechanism of continuous improvement.*

I. INTRODUCTION

Pollutions from the burning of fossil fuels-and-energy resources are largely responsible for the dramatic changes in the behavior of the global ecosystem. They are increasingly affecting the socio-economic situation and human health. These, and especially recent events COVID-19 coronavirus pandemic, point to the urgent need to create and without delay to implement of a new methodological framework for large-scale realization of measures to improve energy efficiency (EE) and the use of renewable energy sources (RES). This study considers the implementation of such a framework based on the methodological provisions of the business concept of "energy services market", the principles of the formation and functioning of which we determine by comparison with similar principles of an ecosystem, where stable equilibrium is achieved due to the balanced interaction of its components (elements) with environment. Therefore, when choosing a solution to the problem of pollutions from business activities, we should clearly understand that the natural reserves required for the functioning of business would be short-lived if these reserves were not renewed through a balanced exchange of energy and resources between the elements of eco- and business systems.

Business systems are complex; therefore, within the proposed framework we will consider them in a generalized form, which, however, should cover all the main market participants. Among them are manufacturers, suppliers, distributors and consumers, state and local authorities, regulators, etc., which are directly or indirectly involved in the creation (production, supply, use) and disposal of the products, goods or services.

The field of energy services covers all major branches of the global economy, where fuel and energy resources are used intensively. Primarily, these are energy, industry, transport, housing and communal sectors, agriculture etc. Since the beginning of the third millennium, global energy services markets are rapidly developing in two priority fields. These are EE and RES, where energy efficiency is considered as “a special type of fuel”. According to the International Renewable Energy Agency, the cumulative investment in EE and RES in the world for 2016-2050 under different scenarios will be $(29.0-37.0) trillion and $(13.0-27.0) trillion, respectively.

Energy service companies (ESCOs) are some of the most efficient and most commonly used energy service providers that meet these challenges in practice around the world. Thanks to their joint efforts with national and local authorities, energy services markets are actively developing in the vast majority of countries, demonstrating high growth rates. However, despite their significant efforts, including those associated with the public and business, the volume of environmental pollution is constantly increasing in the world, and this is a global problem for our planet.

Our study shows a huge number of publications, including scientific ones, devoted to the formation and development of ESMs at the national and local levels, but the structural and organization schemes of these markets are still unresolved and, no less important, there are still no formalized models and mechanisms of their operation.

In general, this requires a comprehensive development of theoretical and methodological foundations to support the low-carbon transition and improve the efficiency of energy services markets, and, as an initial step, it is necessary to develop a conceptual result-oriented framework for realization such support.

II. LITERATURE ANALYSIS

2.1. Legal framework

The availability of an appropriate legal framework is a determining factor in the success of the transition to a low-carbon economy, the main strategic goals of which are determined as EE and RES. To succeed in this, a branched network of federal and local energy-saving agencies, as well as the programs for financing and promoting EE and RES technologies have been developed and implemented in the USA. A special fund for investing in energy services activities have been established in accordance with the Federal Energy Policy Act of 1992. The necessary financial resources for the implementation of these programs set the tasks for increasing the internal production of traditional energy resources, the paces of gradual reduction of the country's dependence on import of oil, measures to ensure national energy security have been allocated among others under the Energy Policy Act of 2005. Objectives to increase production of environmentally friendly renewable fuels, to growth the efficiency of products, buildings, and vehicles, facilitate greenhouse gas collection and storage options, improve the energy performance of the Government, and increase the US energy security, achievement of which underpin by appropriate finding, have been adopted by Energy Independence and Security Act of 2007. For example, a 30 % tax benefit applies to equipment manufacturers using the latest state-of-the-art technologies. The National Action Plan for Energy Efficiency of 2005 represents a private-public initiative to create a sustainable, aggressive national commitment to EE through the collaborative efforts of gas and electric utilities, utility regulators, and other partner organizations. The American Recovery and Reinvestment Act, designed for 10 years, regulates a number of preferential mechanisms for economic incentives to save energy and increase EE. The program of its implementation provides US$787 billion to implement ESs projects. In total, 34 new or updated standards concerning EE and RES have been introduced in the USA since 2009.

As for European Union, EE and RES services are the key driver in attracting investment in energy infrastructure transformation in order to achieve the Union's headline targets on EE of at least 32.5 %. For this, a package of EE and RES measures that include policy, energy savings obligation, methods and principles for calculating their impact, rules for metering gas, electricity, heating and cooling, domestic hot water parameters were developed. In this context, measures, encompassing policies and individual actions that provide verifiable end-user energy savings, enfold responsibilities of each participating party, including public authority, and ensure monitoring of the results, have been stipulated. It was pointed out that economic analysis of these measures must take into account all relevant costs and energy savings due to increased flexibility in the supply, transportation and use of energy resources, including the optimization of operation, avoided costs and saving from reduced investment in infrastructure. In total, EU framework in regulating EE and RES sphere covers tens binding directives for EU member states, over 340 standards of International Electrotechnical Commission, more than 110 standards of International Organization for Standardization (ISO) and 300 European Standards EN [1–3].

A comparative analysis of legal and regulatory frameworks in developed countries aimed at stimulating ESs improvement can be found in [4, 5]. It is noted that the growth of the ESs market provides a number of significant benefits for the sustainable economic growth of countries, reducing dependence on energy imports, increasing incomes and employment, improving the profitability and competitiveness of produced goods and services, developing the knowledge-intensive industries. Among the actively used tools are multi-level structures of ESMs management, national, local and sectoral target-oriented programs, national standards, certification programs, as well as government subsidies and grants, tax benefits, and preferential lending.

With regard to the development of the ESMs in developing countries, Ukraine is a typical example [3]. The Energy Saving Law of 1994 can be identified as a key starting point. As separate clauses of this Law are considered: topics of the ESMs contract, sources of ESMs financing, including the State Energy Saving Fund, clients' own and borrowed funds, state and local budgets. Instruments for stimulation of energy saving have been identified by giving tax privileges, priority crediting of ESMs measures, setting of high rates of depreciation of energy saving fixed assets, targeted state and other subsidies and irrevocable allocation, standardization, establishing a set of mandatory norms, rules and requirements. The main practical steps in the formation of the ESMs in Ukraine are the creation of 10 small private ESCOs under the US technical assistance, as well as creation of Ukrainian ESCO (UkrESCO) under the EBRD credit of US$20 million in 1998. The next decisive points are the Law of Ukraine "On Introduction of New Investment Opportunities, Guaranteeing the Rights and Legal Interests of Entrepreneurs for Large-Scale Energy Modernization" of 2015 and the "Energy Strategy of Ukraine till 2035: Safety, Energy Efficiency, Competitiveness" of 2017. The Law of 2015 defines the concept of energy services and energy service agreement, basic conditions to regulate the relationship between the clients and ESCOs, as well as mechanisms for tendering and securing payments for investors. Among the main objectives of the Energy Strategy in the EE sphere are considered: the elimination of cost-based methodology of tariff formation, improving the framework for regulating energy markets, enhancing their competitiveness, marking household goods by energy indicators, conducting energy audits at enterprises and in buildings, expanding energy efficient transport, using the ESCOs contracts in the public and housing sectors, creating instruments of state financial and technical support (with foreign partners) to implement ESMs measures. With regard to RES, a steady expansion of the use of all types of renewable energy is envisaged. Thus, by 2025, the Strategy plans to increase their share to 12% of total primary energy supply and to at least 25% by 2035.

2.2. Energy services

Over past few decades, the global economy is increasingly transforming from a manufacturing (product) economy to a service economy [6–8]. Among the models (mechanisms) of transformation, the most common are models based on the concepts of Service-Dominant Logic [9] and Product-Service Systems [10, 11]. The activity of economic entities of all forms of ownership and functional purpose has significantly intensified in the energy services (ESs) markets due to the significant growth of the role of energy efficiency and renewable energy sources in the low-carbon restructuring of the modern economy [12–15]. It is important that in addition to energy service companies (ESCOs), other economic entities are actively involved in this activity, first of all, manufacturers of EE and RES equipment and materials, suppliers of primary fuel and energy resources, utilities, investors, representatives of trading platforms, state and local authorities and regulators [5, 16].

Up-to-date energy services consist of professional business (commercial) activities, including scientific and technical, as well as management and consulting services. The specifics of energy services are defined in EU legislation as "the physical benefit, utility or good derived from a combination of energy with energy efficient technology and/or with action, which may include the operations, maintenance and control necessary to deliver the service, which is delivered on the basis of a contract, and in normal circumstances has proven to lead to verifiable and measurable or estimable energy efficiency improvement and/or primary energy savings" [17–19].

The category of energy services by its purpose covers the activities, mechanisms and resources needed to improve the efficiency (productivity, quality, etc.) of production, transmission, distribution, supply and final consumption of energy. So when we talk about efficiency, we have to classify this type of service as energy performance services or energy-related services [19–20]. These services provide additional added value (profitability, benefit, usefulness, etc.) by combining energy with energy efficient technology and / or operation, including maintenance and control procedures required to provide services [18, 21–23]. More detailed information about features of energy services can be found in the works [24–26].

A significant impetus for the implementation of energy services is the use of smart technologies that allow on a fundamentally new platform to integrate the capabilities of products, goods and services for further use to meet the end needs of consumers. Such integration of smart goods and services allows implementing their new properties when using services by consumers through, for example, smart measurement, verification and adjustment in real time [27].

2.3. Energy services companies

Energy Services Companies (ESCOs) are one of the most efficient and widespread types of commercial organizations that provide energy-oriented services, including the implementation of measures (investment projects) for energy efficiency and renewable energy. Therefore, the task of combining and strengthening the efforts of ESCOs aimed at overcoming the problems of environmental pollution and improving the efficiency of natural resources use is more relevant today than ever before [7, 28–30].

ESCOs operate on the basis of energy service contracts, providing a wide range of energy services that cover technical, economic, financial and legal aspects of design, engineering, installation, commissioning, monitoring and verification of the results achieved from the implementation of innovative projects in the area of energy efficiency and energy infrastructure improvement [29–33].

Fundamental differences of energy services provided be ESCOs are:

(1) The energy service contractor (ESCO) shall guarantee that the savings of fuel, energy and other material and technical resources, stipulated in energy service contract and received a result of implementation of turnkey energy service project, will exceed the payments to cover project costs for the payback period;

(2) The energy service contractor invests its own funds (in whole or in part) in the implementation of energy service projects. If the savings guaranteed by him do not materialize, the difference is compensated at the expense of the contractor.

Other types of funding for ESCO projects may include such as "funds, subsidies, tax rebates, loans, third-party financing, energy performance contracting, guarantee of energy savings contracts, energy outsourcing and other related contracts that are made available to the market place by public or private bodies in order to cover partly or totally the initial project cost for implementing energy efficiency improvement measures" [17–18].

Varieties of ESCO energy service contracts are discussed in detail in numerous publications, for example in [33–37], where the following main models are among the most common: Energy Performance Contracting (EPC), Energy Supply Contracting (ESC), Chauffage and Full Management Contracting (FMC). It is noted that most of these contracts used in practice are mixed. The most widespread is the Energy Performance Contract (EPC), which sets out the ESCO's obligations to increase the productivity (efficiency) of energy service outcomes, which under this contract may cover both the supply side and the final energy consumption side. The customer in accordance with the achieved level of energy efficiency pays ESCO costs agreed under this contract [8].

The main components of energy service contracts in conjunction with the scheme of causal chains of ESCO interaction with the customer and other project participants (subcontractors, financial institutions and support funds, etc.) are presented in detail in the paper [19]. It should be added here that the complexity of implementing ESCO projects significantly slows down their financing, mainly due to the need to ensure a guaranteed level of energy saving in an uncertain business environment.

The results of a comparative analysis of the properties of energy services projects under ESCO contracts with other type of services considered within the framework of the service-dominant logic and product-service systems show that they have many common features [25, 26, 38, and 39]. Their integrated use allows realizing the synergy of system interaction of these services, aimed at expanding the scope of their use and increasing the amount of systemically created added value. This, of course, requires the improvement of the conceptual provisions of energy services, which will provide more favorable conditions for result-oriented framework to support the low-carbon transition by the way of ensuring mutually beneficial interaction between ESCOs and other market participants, in particular with customers and final consumers of goods and services.

2.4. Estimation of energy services markets in the world and Ukraine

Potential and development trends of energy services markets is largely determined by the size and growth rate of energy markets, as well as investments involved in their development. Analysis shows that, the consumption of fuel and energy resources in the world is constantly growing and is projected to grow until 2050. Thus, in 2040, compared to 2016, world oil consumption may increase by 10.3%, natural gas – by 31.9%, coal consumption will not change, nuclear energy production will increase by 35.1%, hydropower – by 26.7% and energy from other RES – by 80.1% [40]. The global crises certainly have a significant impact on the growth rates. So, the IEA expects global CO_2 emissions to decline by 8% in 2020 compared to 2019 through COVID-19 pandemic [41].

It is important for us that the proportions of the growth rates of the markets generally remain unchanged until 2050, demonstrating the outstripping growth of RES. In this vein, the transition to low carbon technologies opens up many new investment opportunities that can support the development of energy services market, such as investments in energy efficiency, smart grids, building retrofits, and so on, as the cost of renewables and other green technologies has dropped sharply. For example, solar photovoltaics (PV) prices fell 90% between 2009 and 2018 and battery prices by 85% between 2010 and 2018 [42]. At the same time, global investments in clean energy increased 1.33 times over this period – to US$ 322.5 billion in 2018.

The significantly faster development of energy services markets is driven by a number of additional factors, primarily significant changes in the complexity of technologies, which require special techniques, equipment and knowledge from energy service providers to solve problems of both clean energy project development and commissioning. Among the main ones, they need to overcome the following obstacles: unsupported legal framework, incentive sharing dilemma, lack of best practices as well as standards, complex and lengthy procurement and time frames, resistance to outsourcing, etc [4, 43, 44].

The analysis of the activities of Ukrainian ESCOs in the energy services market shows that the percentage of able to fulfill energy service contracts in 2018 - 2022 at lending rates 20-25%, 15-20%, 10-15% and 5-10% per annum in the national currency amount to 0%, 7%, 36% and 57%, respectively. That is, ESCOs, which can be borrowed from Ukrainian banks for more than a year, practically do not exist today. In addition, the percentage of ESCOs agreeing to enter into energy service contracts with a payback period of projects > 10, 5-10, 3-5 and < 3 years are, respectively, 17%, 21%, 25% and 37%. At the same time, 29% of Ukrainian ESCOs are stated their intention to use exclusively their own funds, 30% of them – attracted loans from domestic banks, and 41% – from foreign investors [45–47].

For comparison, the dominant form of financing energy service projects for EU countries is customers' own funds (52%), 26% of respondents use the services of banks and other borrowers, and by ESCO services - an average of 5%. And this is in wealthy European countries with developed economies and credit resources at 2-4% per annum [4, 43].

III. OBJECT, SUBJECT, AND METHODS OF RESEARCH

The object of research is the processes of organizing the energy services market as a complex technological system aimed at improving energy efficiency, attracting renewable energy sources and reducing CO_2 emissions.

The subject of research is the methods and models of structural organization and functional interaction of elements (participants) of realistic and evaluable energy services market.

Methods of research: The methods of complex analysis of large systems, conceptual logic and black box that are used in determining the directions of development and construction of the model of structural organization of the energy services market, as well as elements of set theory and energy management method – to formalize the functional interaction of elements (participants) the market.

The goal of the research is to determine the directions of development and construct a model of structural organization and functional interaction of participants of the energy services market, which determine (highlight) the main components (segments) of the market and their interaction with other (complementary) markets, primarily organized by energy and manufacturing companies.

Realization of the set purpose demands the solution of the following tasks.

Carrying out a systemically coordinated analysis of literature sources, covering:

- the legal framework for the organizing the energy services markets,
- clarifying the terminology of energy and energy-related services,

- analyzing the activities of energy service companies (ESCOs), and
- assessing the development of the markets in the world and in Ukraine;

Conducting research on:

- identifying the stages that form the cycle of continuous improvement of energy services results,
- developing a structural and functional model of the ess market,
- formulating conceptual provisions for the development of the ess market,
- conducting a comparative analysis of ESCOs in developed and developing markets (on example of Ukraine).

IV. RESULTS

4.1. The cycle of continuous improvement of energy services results

To succeed in the implementation of energy services, we need to organize the energy services management cycle based on the Deming closed-loop model: a plan-do-check-act, which activates the process of continuous improvement of results [48–49]. The proposed energy services cycle includes the following main components, represented in Fig.1. Among them the key are: conducting marketing for the selection and evaluation of clients, providing the preliminary and investment audits, as well as comprehensive financial and legal expertise of clients, necessary for fulfillment of guarantee and post-guarantee obligations up to the transfer of rights to clients.

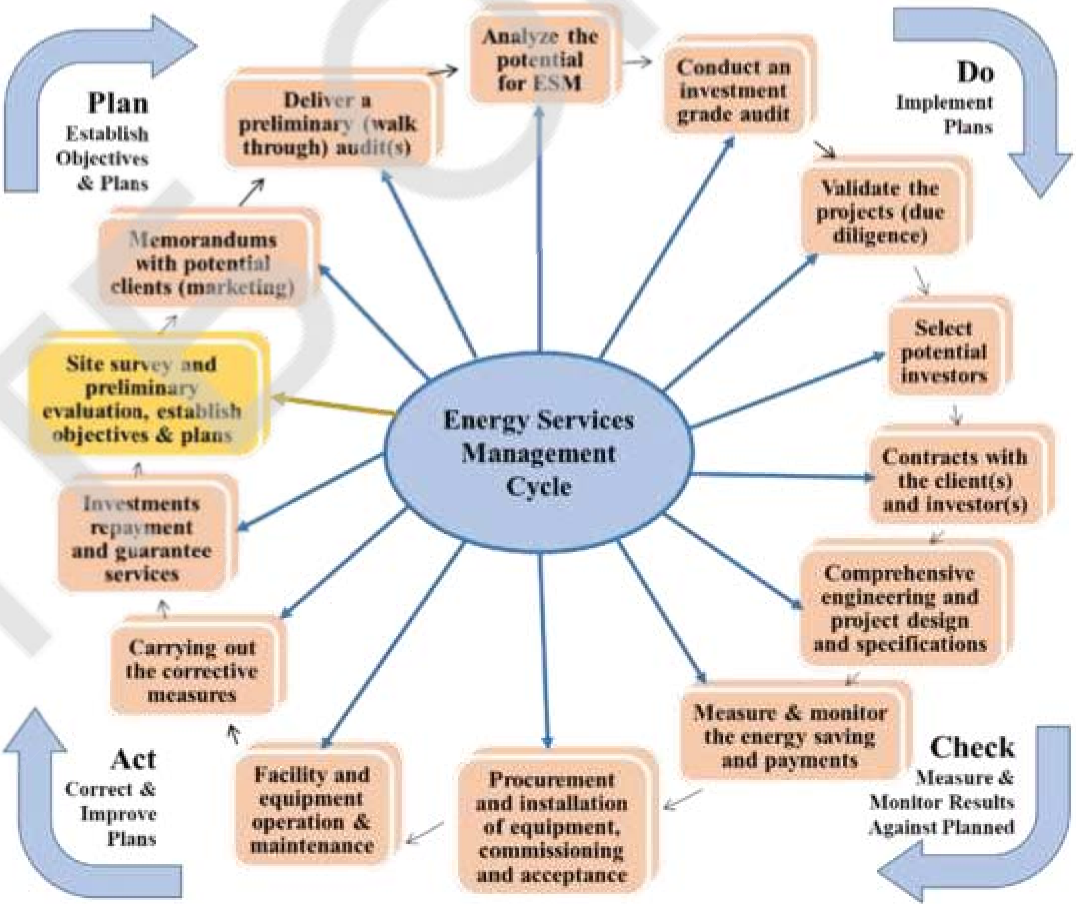

Fig. 1. Deming closed-loop for the implementation of energy services projects

It should also be noted that the implementation of energy services projects today requires the involvement of cloud (virtual) technologies for monitoring, control and optimization of parameters and modes of operation of technological equipment [50]. The use of virtual technologies for providing services allows participants of energy services projects to use hardware and software, tools and methodologies that are not available for the technical possibilities of their own technological and computing base, not to spend significant funds on licensed software and not to monitor updates. However, of course, there are disadvantages to using virtual technology services. Thus, the storage of user data and their cybersecurity is usually provided by a third-party organization – a cloud technology provider, the user does not have the actual ability to upgrade software, and access to "cloud" services requires a constant connection to the Internet.

4.2. Structure-function model of the energy services market

The specifics of energy services market in this paper is reflected in the form of a conceptual model, the structural and functional elements of which are linked by the flows of energy, information, other resources (materials, equipment, etc.) used or affect the effectiveness of each element and the market as a whole. Such vision allows us break down the difficult to analyze problem into workable sub-blocks (elements).

The proposed structure-function model, where the main participants in the energy services market and their relationships, formalized on the basis of set theory, is presented in Fig.2.

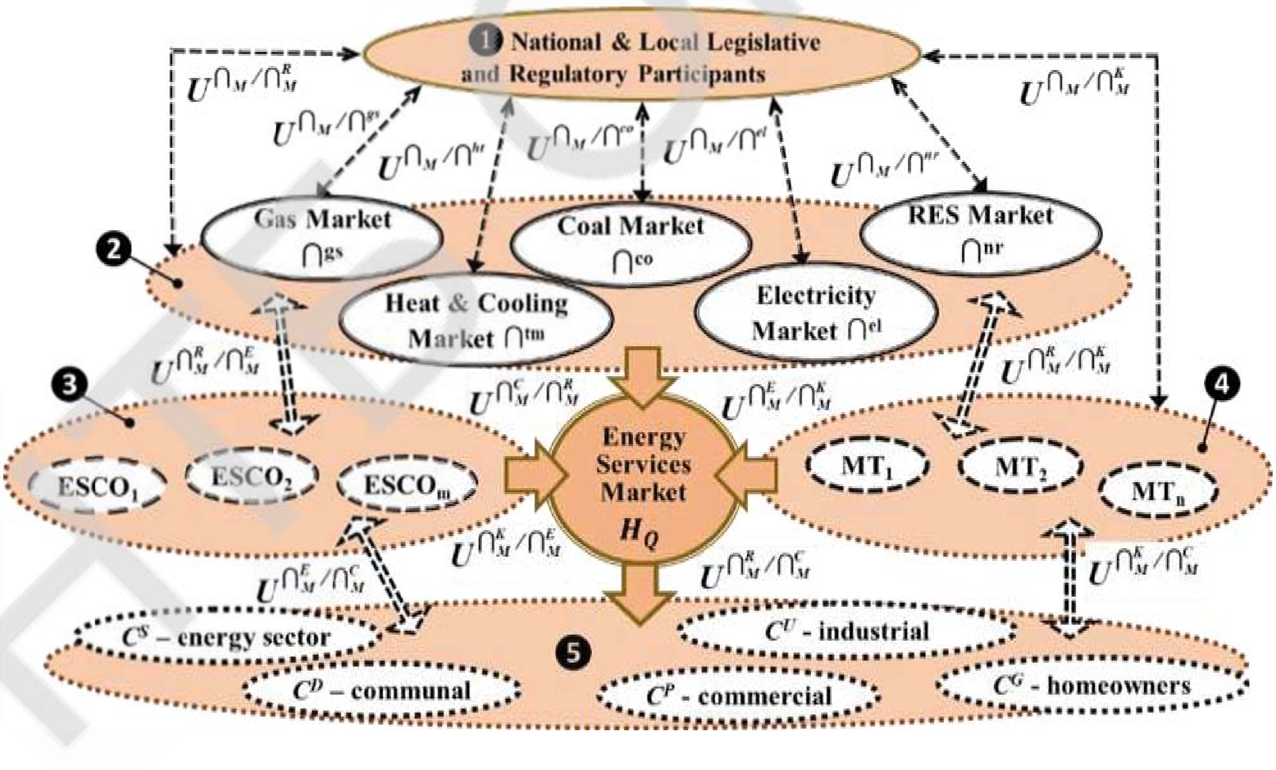

Fig. 2. Structure-function model of the energy services market organization

Among the participants of the energy services market are representatives of [3]:

- State and local governments and regulators, investors, trading platforms, etc.;
- Primary energy resources markets (natural gas, coal, biomass, portable water,

wind, and solar radiation, etc.) And secondary energy resources markets (which operate with resources that have been converted or stored, for example electricity, heating and cooling);

- Providers of energy services (ESCOs);
- Manufacturers of energy-efficient and RES equipment and materials (MT); and
- Consumers of services from different sphere of their business activity, which are the principal participants of the Low-Carbon transition under the proposed framework.

ESCOs play a leading role in organizing the interaction of participants by implementing the energy services projects (see details in [3, 50]).

To formalize the interactions in such multipart system of the market participants, we propose using the mathematical sign (∩) of intersection of sets in families, which allows reflecting correctly the scale and complexity of such interactions. In such a way, the ordered sets of designations $\cap_M$,$\cap_M^R$,$\cap_M^E$,$\cap_M^K$,$\cap_M^C$ correspond to the numbering of participants (1), (2), (3), (4), (5), shown in Fig. 2. Likewise, the use of the "U" forms with indices denotes direct and feedback links between different participants of the market. For example, $U^{\cap_M^R/\cap_M^E}$ denotes links between participants (2) and (3) in the form of mappings of ordered sets of input variables into sets of output variables (in our case these are $\cap_M^R$ and $\cap_M^E$).

4.3. Conceptual provisions of energy services market development

Among the main measures to ensure the result-oriented development of the ESs market, first of all, should be:

- Strengthen the legislative and regulatory framework through gradual harmonization with the EU's energy acquis;
- Implement an integrated approach to the national and local energy security through diversification of resources;
- Increase the share of renewable energy, cogeneration, low-potential sources and waste energy potential;
- Ensure the quality and availability of energy services, making them reliable, secure and affordable for consumers;
- Reduce the ecological impact of energy systems on the environment;
- Attract investments from international financial institutions and private investors;
- Strengthen and maintain the financial viability of energy services providers;
- Implement information and measurement systems for energy management;
- Reduce energy losses during transformation and transportation processes.

Particular attention needs to be paid to solving the problem of attracting investment in energy service projects in Ukraine, the successful solution of which mainly depends on the coordinated efforts of the government, regulators and businesses.

4.4. Specifics of ESs market in Ukraine

The existing experience of building energy services markets in developed countries can be used in Ukraine only partially and only to select strategic directions for their development, while the practical content of their implementation mechanisms requires restructuring of existing mechanisms taking into account fundamentally different economic and social conditions in Ukraine.

Among the main risks of formation and functioning of the energy services market in Ukraine, it is necessary to note the following:

Policy: There is a lack of policy measures to provide a favorable basis, requirements or incentives for energy service market participants to provide and/or purchase energy services, as well as to take other measures to improve energy efficiency and implement RES;

Institutional: high dependence on state and local governments support, fears of customers and contractors of energy services that state programs to support energy efficiency will not be implemented (dependence on subsidies);

Financial: medium- and long-term cost planning remains in short supply and is exacerbated by weak discipline in the private and, in particular, the public sector in return on EE and RES investments;

Investment: weak demand for investment in energy services due to the instability of the economic situation in Ukraine, high interest rates of Ukrainian banks and low energy prices compared to prices for energy efficient equipment and materials;

Executive: the tendency to reduce outsourcing and increase customers' own capabilities due to high operating costs of energy service providers;

Environmental: lack of an integrated approach to energy efficiency, which leads to systematic violations of sanitary norms and environmental requirements;

Information: lack of information and awareness of officials and business representatives about the real benefits of energy service, lack of trust in its performers and their level of qualification.

V. CONCLUSIONS

1. Energy service is a fundamental instrument for putting energy efficiency and renewable energy technologies into practice the worldwide. Energy services are particularly important for the well-being of any entity and community, as adequate heating, cooling, lighting and other energy and non-energy uses are essential services that guarantee a decent standard of living and health for people.

2. The proposed result-oriented framework for identifying the main components and stages of sustainable development of the ESs market is aimed at solving the complex tasks of low-carbon transition by systemically overcoming political, institutional, financial, economic, environmental and information barriers based on the synergy of ESs market incentives and management.

3. The main strategic direction of development becomes the creation of a smart network of coordinated actions of ESs market participants, which is focused not on the procedures of purchase and sale of goods (products), but on the provision of energy-related services to meet the needs of consumers. Such services, when based on the systemic implementation of EE and RES measures and the closed cycle of energy management, as a powerful tool to manage this process, are becoming a fundamental unifying factor in realizing the benefits of energy services.

4. The transition to low-carbon production requires adapting existing ESs market legislation and regulations and changing the existing roles of market participants, making them transparent and fair, and unlocking many new opportunities for all customer groups – industrial, commercial, households, etc. Active involvement of state and local authorities and regulators creates new opportunities to increase using the EE and RES technologies.

5. The fundamentally different economic and social conditions for the functioning of energy services markets in developed and developing countries, as example in Ukraine, require special research when someone is going to transfer their rules and technologies from one country to another.

6. In general, the analysis conducted in this paper indicates the urgent need to develop mathematical models and perform numerical calculations to determine the optimal structure and parameters of the energy-related services market, which is a priority for further research.

VI. REFERENCES

1. EU. (2018). Directive EU 2018/2002 amending Directive 2012/27/EU on energy efficiency. Official Journal of the European Union, No. L 328, 210-230. ISSN 1977-0677.

2. EU Commission. (2019). Energy Efficiency Progress Report: 2018 assessment of the progress made by Members States towards the national energy efficiency targets for 2020 and towards the implementation of the Energy Efficiency Directive as required by Art. 24(3) of the Energy Efficiency Directive 2012/27/EU. Brussels: EU Commission.

3. Deshko V. I., Kovalko O. M., Novoseltsev O. V., Yevtukhova M. Y. (2020). Energy Services Market: Conceptual Framework and Mechanism of Forming. International Journal of Civil, Mechanical and Energy Science, Vol-6, Issue-6, 48-55. ISSN: 2455-5304, https://dx.doi.org/10.22161/ijcmes.66.4.

4. Grazer Energy Agency. (2016). Report on the European EPC Market. Graz: Grazer Energieagentur GmbH. http://www.grazer-ea.at.

5. Szomolanyiova J., Keegan N. (2018). European Report on the Energy Efficiency Services Market and Quality. Vienna: QualitEE.

6. Alatorre Frenk C., Backhaus M., Bauer N., et al. (2017). Perspectives for the energy transition: Investment needs for a low-carbon energy system. Berlin: IEA & IRENA Publications.

7. Ritchie J., Lane K., Sung J, et al. (2019). Energy efficiency 2018: Analysis and outlooks to 2040. Paris: IEA Publications.

8. Novoseltsev O., Kovalko O., Evtukhova T. (2013). Cross-border cooperation of energy service companies as a factor enhancing energy and economic safety. Energy Efficiency Improvement of Geotechnical Systems. London: Taylor & Francis Group. CRC Press.

9. Lusch R. F., Nambisan S. (2015). Service Innovation: A Service-Dominant Logic Perspective. MIS Quarterly, Vol. 39, No. 1, 155-175.

10. Tukker, A. (2015). Product services for a resource-efficient and circular economy – a review. Journal of Cleaner Production, Vol.97, 76-91.

11. Haase R. P., Pigosso D. C. A., McAloone T. C. (2017). Product/Service-System Origins and Trajectories: A Systematic Literature Review of PSS Definitions and their Characteristics. Procedia CIRP 64, 157 – 162.

12. IEA & IRENA. (2017). Perspectives for the Energy Transition: Investment Needs for a Low-Carbon Energy System. Berlin: IEA & IRENA Publications. www.irena.org/remap.

13. IEA. (2019). Energy Efficiency 2018: Analysis and Outlooks to 2040. Paris: IEA Publications. https://www.iea.org/reports/energy-efficiency-2018.

14. IRENA. (2019). Global energy transformation: A roadmap to 2050. Abu Dhabi: IRENA. www.irena.org/remap.

15. China Council. (2019). Energy Efficiency China 2018. Beijing: China Council for an Energy Efficient Economy. https://www.energycharter.org/fileadmin/DocumentsMedia/EERR/EER-China_ENG.pdf.

16. Grazer Energieagentur. (2016). Report on the European EPC Market. Graz: Grazer Energieagentur GmbH. www.guarantee-project.eu.

17. EU. (2006). Directive 2006/32/EU of the European Parliament and of the Council of 5 April 2006 on Energy end-use efficiency and energy services. Official Journal of the European Union, L 114, 64–85.

18. EU. (2012). Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on Energy efficiency. Official Journal of the European Union, L 315, 1–56.

19. Eutukhova T., Kovalko O., Novoseltsev O., Woodroof E. (2020). Energy Services: A Proposed Framework to Improve Results. Energy Engineering, Vol.117, No.3, 99-110.

20. World Trade Organization. (1998). Energy Services. Background note by the Secretariat. Geneva: World Trade Organization, No. S/C/W/52. www.wto.org.

21. International Organization for Standardization. (2017). Energy services – Guidelines for the assessment and improvement of the energy service to users (ISO 50007:2017). ISO/TC 301.

22. European Committee for Standardization. (2010). Energy efficiency services – Definitions and requirements (EN 15900:2010). Beuth Verlag GmbH.

23. Larsen P. H., Goldman C. A., Satchwell A. (2012). Evolution of the U.S. energy service company industry: market size and project performance from 1990–2008. Energy Policy, Vol. 50, 802–820.

24. Sorrell, S. (2007). The economics of energy service contracts. Energy Policy, 35(10), 507-521.

25. Benedetti M., Cesarotti V., Holgado M., Introna V., Macchi M. (2015). A proposal for Energy Services' classification including a Product Service Systems perspective. Procedia CIRP, 30, 251 – 256.

26. Nolden C., Sorrell S., Polzin F. (2016). Catalysing the energy service market: The role of intermediaries. Energy Policy, 98, 420–430.

27. Valencia A., Mugge R., Schoormans J. P. L., Schifferstein H. N. J. (2015). The Design of Smart Product-Service Systems (PSSs): An Exploration of Design Characteristics. International Journal of Design, Vol. 9(1), 13-28.

28. Yan L., Keay-Bright S., Antonenko O. (2019). Energy efficiency China. Brussels: Energy Charter Secretariat.

29. Stuart E., Larsen P. H., Carvallo J. P., Goldman C. A., Gilligan D. (2016). U.S. energy service company (ESCO) industry: Recent market trends. Ernest: Orlando Lawrence Berkeley National Laboratory.

30. Boza-Kiss B., Bertoldi P., Economidou M. (2017). Energy service companies in the EU - Status review and recommendations for further market development with a focus on energy performance contracting. Luxembourg: Publications Office of the European Union.

31. Hansen S. J., Bertoldi P., Langlois P. (2009). ESCOs around the world: Lessons learned in 49 countries. Washington: The Fairmont Press.

32. Woodroof E. A., Thumann A. (2012). How to finance energy management projects: Solving the "Lack of capital problem". Washington: Fairmont Press.

33. Hofer K., Limaye D., Singh J. (2016). Fostering the Development of ESCO Markets for Energy Efficiency. Washington: World Bank.

34. Kim J.-I., Jain N., Lee H., Nieto M. T., Husband D. et al. (2015). Business models to realize the potential of renewable energy and energy efficiency in the Greater Mekong Subregion. Manila: Asian Development Bank.

35. International Finance Corporation. (2011). IFC energy service company market analysis. Quebec: Econoler. https://www.yumpu.com/en/document/read/4636985/ifc-energy-service-company-market-analysis.

36. Carbonara N., Pellegrino R. (2018). Public-private partnerships for energy efficiency

projects: A win-win model to choose the energy performance contracting structure. Journal of Cleaner Production, Vol.170, 1064-1075.

37. Il′chuk M., Reminska O., Shapovalenko V., Kyrychok O. (2015). Energy Service Contracts: opportunities and prospects in Ukraine. Bonn: Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH.

38. Mourtzis D., Boli N., Alexopoulos K., Rozycki D. (2018). A framework of Energy Services: from traditional contracts to Product-Service System (PSS). Procedia CIRP, 69, 746 – 751.

39. Nolden C., Sorrell S. (2016). The UK market for energy service contracts in 2014–2015, Energy Efficiency, 9, 1405–1420.

40. British Petroleum. (2018). BP Energy Outlook. London: British Petroleum. http://www.bp.com/energyoutlook.

41. IEA. (2020). Global Energy Review 2020. The impacts of the Covid-19 crisis on global energy demand and CO2 emissions. Paris: IEA. https://www.iea.org/reports/global-energy-review-2020.

42. Bloomberg. (2020). Clean Energy Investment Trends 2020. Stockholm: Bloomberg Finance L.P. Ltd. https://webstore.iea.org.

43. Boza-Kiss B., Toleikyté A., Bertoldi P. (2019). Energy Service Market in the EU - Status review and recommendations 2019. Luxembourg: European Commission. ISBN 978-92-76-13093-2, doi:10.2760/768, JRC118815.

44. EU Commission. (2017). Energy Efficiency Progress Report: 2017 assessment of the progress made by Members States towards the national energy efficiency targets for 2020 and towards the implementation of the Energy Efficiency Directive as required by Art. 24(3) of the Energy Efficiency Directive 2012/27/EU. Brussels: EU Commission.

45. UNDP-GEF Project. (2017). Removing Barriers to increase investment in Energy Efficiency in Public Buildings in Ukraine through the ESCO modality in Small and Medium Sized Cities. Kyiv: UNDP in Ukraine.

46. OECD. (2018). Enhancing Competitiveness in Ukraine through a Sustainable Framework for Energy Service Companies (ESCOs). Kyiv: OECD.

47. Kovalko O., Novoseltsev O. (2018). Analysis of the State and Development Trends of Energy Service Market in Ukraine. Proc. of XIX International Scientific and Practical Conference “Renewable Energy and Energy Efficiency in the 21st Century”, Kyiv, September 26-28. Kyiv: Interservice, 31-34.

48. International Organization for Standardization. (2018). Energy Management Systems. Requirement with Guidance for Use (ISO 50001:2018), Geneva, ISO Central Secretariat.

49. Cosenza E., Devetta M., Rosa M., Zogla L., Barisa A., etc. (2018). Energy Management System (EnMS) Guidebook for Local Authorities. Freiburg: Local Governments for Sustainability.

50. Chupryna L., Kovalko O., Novoseltsev O., and Woodroof E. (2020). Virtual Organization of Energy Management: Service-Oriented Framework to Improve Results. International Journal of Energy Management, Vol.2, No. 6, 47-63. ISSN: 2643-6779 (Print), ISSN: 2643-6787 (Online).