Management of Innovative Energy Efficient Technologies in the Conditions of Sustainable Development

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ABSTRACT

Irreversible depletion of the world's hydrocarbon reserves, rising energy prices, environmental pollution problems – all this is forcing most developed countries to set their own energy strategies aimed at developing alternative energy. Thus, there is need to develop theoretical principles and practical recommendations for the formation of the concept of energy saving technology management in view of compliance with the conceptual principles of sustainable development, namely focusing on carbon-free energy technologies. The analysis and prospects of development of the state's energy platform on the basis of postulates of sustainable development are carried out. It is proved that the introduction of models for the development of energy efficient technologies "Energy Efficiency +" and "New Paradigm - Power Market" will allow Ukraine to make a technological breakthrough. The scientific and methodological approach to improving the management system of energy resources distribution in accordance with the requirements of alpha stakeholders, especially industrial enterprises, according to certain parameters at the stage of Industry 4.0 in the conditions of communication environment constraints energy saving.

***Keywords**: sustainable development, energy efficient technologies, alternative energy, stakeholders.*

Introduction

It is proved that innovations in the energy field are priority for sustainable development at all levels of the economy. It is determined that the European Union is the initiator of the formation and implementation of innovative strategies for sustainable development, especially environmental responsibility. Environmental responsibility of companies and countries is aimed at sustainable management of natural resources, development of safe technologies in the energy sector, increasing the use of renewable energy sources and clean energy, nuclear and energy security.

Implementation of new engineering and design solutions in energy supply systems, which provide for the integrated use of energy from renewable sources, will solve an important economic and scientific-technical problem of reducing the consumption of traditional fuel and energy resources for Ukraine.

Optimization of existing energy systems will lead to a gradual increase in efficiency without significant investments in innovative technologies for energy production, transmission and distribution. Modernization of existing energy systems to the intellectual level involves the creation of a fully integrated system – from production, transmission to distribution and consumption of electricity and the introduction of new metering systems by individual consumers (Dileep 2020).

However, a set of issues related to determining the domestic specifics of the introduction of a modern model of energy-saving technologies, including the use of renewable energy sources, among economic agents needs in-depth analysis and methodological clarification. It is becoming increasingly difficult for energy companies to determine which set of communication tools is effective to build lasting relationships in the marketplace and achieve optimal impact on the consumer (Kappagantu and Daniel 2018).

The aim of the article is systematic study, critical assessment of theoretical principles and current practices of managing the implementation of energy-saving technologies, given the use of renewable energy conversion technologies to ensure sustainable development.

Methods

Theoretical and methodological basis of the article are modern theories, concepts, hypotheses. The following general and specific methods are used to ensure the reliability of the results and conclusions: dialectical, epistemological and logical, including terminological analysis – to study the conceptual and categorical apparatus and clarify the basics of management decisions; induction, deduction, scientific abstraction and generalization – to substantiate economic categories and definitions; monographic and comparative – to systematize scientific approaches to the specification of the theoretical foundations of expanding the methodological basis of management; methods of abstract-logical method – for the development of theoretical and methodological generalizations and formulation of conclusions based on research results.

Results

The results of the introduction of renewable energy technologies (i.e. solar energy, environmental heat, groundwater heat, etc.) are improving the environment, ensuring sustainable development of Ukraine, reducing risks from external energy supply, increasing the autonomy of energy supply to consumers. The prospects of this area are due to the fact that its results are relevant for several related fields of science: construction, industrial heating, agriculture, ecology. Only by taking into account the technical, technological, environmental and other aspects can the economic and scientific-technical problem of reducing the consumption of traditional fuel and energy resources be solved.

In modern conditions, the problem of rational use of energy resources is becoming increasingly important at all hierarchical levels: consumer (nanolevel); enterprises (microlevel); countries (macrolevel); world (megalevel). There is no doubt that the sustainable socio-economic development of any country largely depends on the growth of energy efficiency of the national economy.

Energy saving is a key factor in improving energy efficiency, economic efficiency and economic security of business, which is a necessary factor in sustainable development of society.

New 4th investment cycle is being launched today in the global energy sector, in which the following global trends will operate according to the International Energy Agency (IEA).

Components of the driver activation of the development model "Energy efficiency +" in the medium term: the dominance of centralized energy; development of threegeneration; development of dispersed generation; economically justified innovations; development of intelligent energy models in individual clusters (Smart Grid 1.0) (Gunduz and Das 2020).

Today, a new energy civilization has been formed and continues to develop in the leading countries, the main features of which are: energy efficiency; intelligent energy systems built according to the Smart Grid concept; decentralization of energy; new energy sources, etc.

The development of energy of the 4th investment cycle is implemented within the framework of such models (Fig. 1).

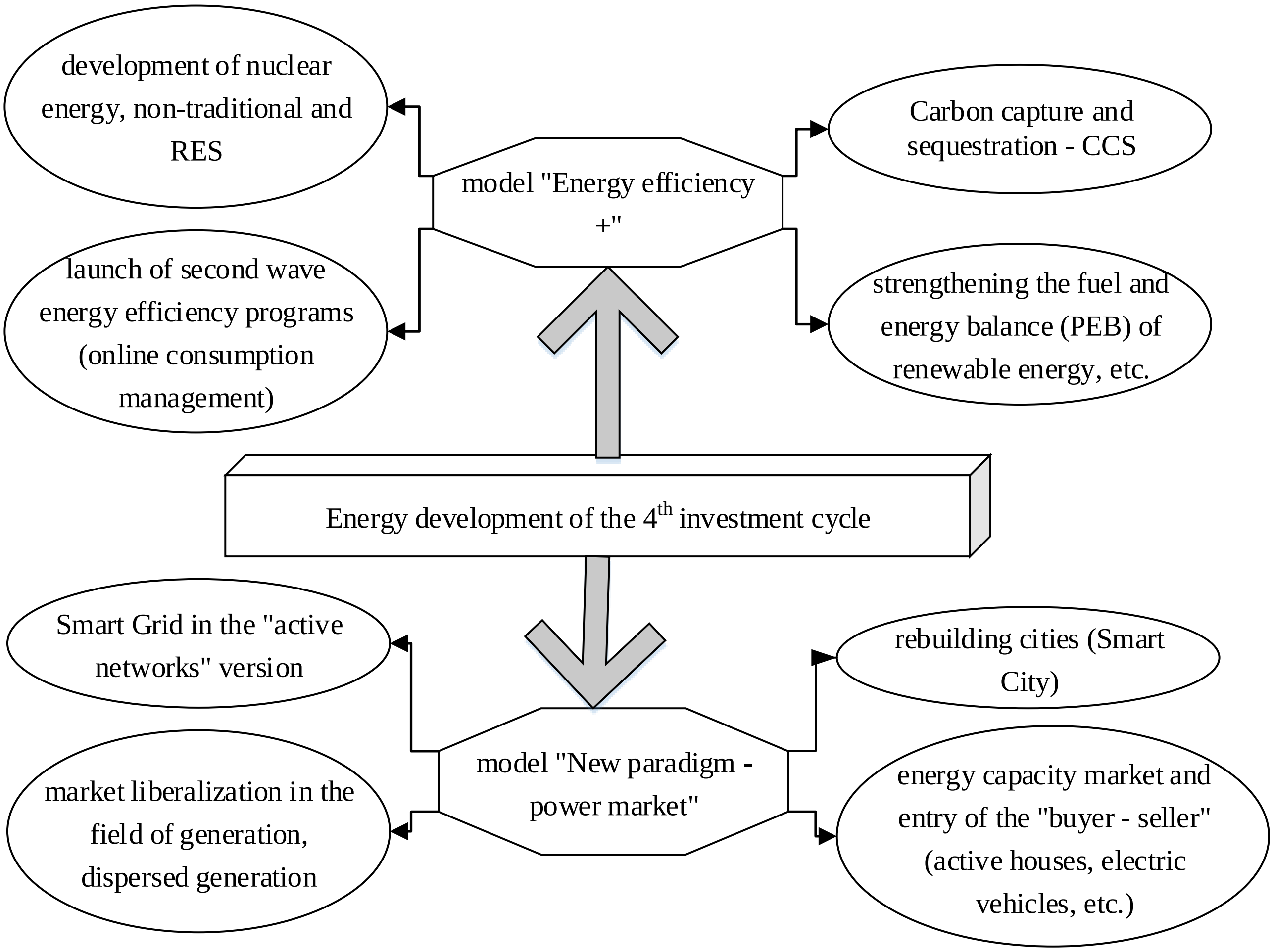

Fig. 1. Architectonics of formation of models of energy development of the 4th investment cycle

Source: Hilorme (2020)

Issues of energy savings due to rising energy prices, shortages, the need to import energy resources, their irrational consumption remain in the spotlight at the present stage of development of society. The negative factor is the high energy intensity of the Ukrainian economic system.

This especially concerns economy sectors, such as metallurgy, chemical industry, coal mining, technical equipment of communication devices of the housing and communal services sector, etc. Energy consumption of industrial companies does not meet the conditions of an energy efficient society (Kim and Huh 2018).

High costs of fuel and energy resources limit the competitiveness of national production, particularly in conditions of external energy dependence. A significant part of energy consumption does not allow companies to obtain the necessary values of profit, slows down development. As a result, the high share of expenditures on fuel and energy resources in the production costs of companies does not increase the competitiveness of national products.

Fuel and energy resources of own production are not enough to meet the needs of industry and households in Ukraine, which requires the import of energy at a fairly high price. Assessing the prospects for energy development in Ukraine, it should be noted that it is advisable to introduce renewable energy sources as an alternative to outdated resource-intensive technologies for sustainable development.

Due to the depletion of non-renewable energy sources, their high cost and low efficiency in use, the harmful effects on the environment in the world are increasingly used by alternative and renewable energy sources. For the last years there has been a growing trend in the share of energy supply from renewable sources in Ukraine, which leads to the active development of technologies for the construction of devices for their conversion into heat and electricity. The implementation of such energy generation technologies contributes to the active development of the entire field of energy saving and energy efficiency.

Recently, technologies, technical solutions and equipment for active energy saving that use soil heat and solar energy, environmental heat, etc., ventilation systems that utilize waste heat and other secondary energy resources have come to the fore. In this direction the greatest potential for creating efficient energy-saving technologies and devices for the energy sector is concentrated. However, the mechanical connection of traditional architectural elements, such as solar panels, photovoltaic batteries, etc., which are already widely used in the world and are designed to use renewable energy sources, leads to insufficient implementation of the functionality of energy systems. Currently, a promising area of energy saving is a comprehensive simultaneous regulated production, conversion, redistribution and accumulation of energy (Ghasempour 2019).

A brilliant example of the technical implementation of such opportunities is the use of energy-active fences (EAF) (Nakashydze et. al 2019). This technical approach makes it possible to ensure a significant reduction in the energy intensity of the energy received and the stability of its generation. An important aspect of this approach is that it comprehensively takes into account: the impact of energy-intensive fencing and the peculiarities of their location on the architectural form of the building; thermal energy influence of natural climatic conditions on the shape, size and thermal balance of objects; the effect of heat load on the air conditioning system.

In this technical solution, the increase in energy efficiency is due to the fact that in the construction of energy-active fences it is important to analyze the climatic features. This is necessary to determine the possibility of meeting the energy needs of the facility through solar energy and the choice of appropriate orientation of energy-active fences (Tonkoshkur et. al 2021).

Also at increase of energy efficiency in this case the choice of a material from which constructive elements of an energy-active fence are made plays an essential role. The energy-absorbing panel of the energy-active fence must be made of materials whose mechanical, thermal and chemical properties meet the functional and operational requirements.

Liquid coolant in the energy supply system can be used as a working fluid during the operation of the energy-active fence. In this case, the energy-absorbing panel must be designed for pressure that corresponds to the allowable operating pressure in the solar circuit of the power supply system, and maintain strength and tightness in hydraulic tests at a pressure equal to twice the worker. In order to increase the energy saving level, the pipelines should be designed to ensure guaranteed filling with coolant without the formation of air cavities.

The level of energy efficiency is also conditioned by the fact that the outer translucent layer of thermal insulation of the energy-active fence is a single or multilayer glass or polymer coating. Therefore, it is important to have resistance to atmospheric and operational influences. The main criteria when choosing materials for the outer layer of multilayer translucent insulation of energy-active fence are: preservation of properties in the temperature range from minus 45 ^{0}C to plus 100 ^{0}C, and the inner layer – from minus 45 ^{0}C to plus 150 ^{0}C; the service life of translucent insulation must be at least 10 years (Chen et.al 2021).

In the technical solution of the energy generating device, the level of energy efficiency is determined by the design features of energy-active fence – the presence of the layer that prevents atmospheric moisture from entering the structure and protects from moisture condensing on its inner surface.

The increase in the level of energy efficiency of this technical solution is due to the fact that it is advisable to use the thermal energy of ventilation discharges in energy supply systems. To do this, the design of energy-efficient fencing provides for the installation of ventilated air layers. At the same time, the channels of the air coolant should be rationally located between the energy-absorbing and decorative-protective layers. Ducts must have cut-off elements that allow them to be forcibly closed with a height of not less than the height of the floor, but not more than 6 m. The minimum cross-sectional size of such ducts must be at least 40 mm. It is advisable to cover one of the surfaces of the layer with aluminum foil or a coating with similar reflective properties to reduce heat loss due to re-radiation.

It is important that energy efficiency is increased due to the fact that in this technical solution it is possible to regulate the amount of absorbed solar energy. The air pumped by the ventilation duct washes the heat-receiving elements and heats up. Next, the air heated in this way enters the heat exchanger type "air – liquid" heat pump. To create a large area on the facade of the heat-absorbing surface, collector-air duct is used, which allows to connect separate modules of energy-active fences in parallel or in series.

Technically, the process of increasing energy efficiency proceeds to the fact that thermal insulation with a moisture-proof energy-reflecting layer and translucent thermal insulation form a ventilation duct. In the duct there is a heat-receiving element which is executed in the form of rotary blinds. On the one hand, the blinds have a surface that reflects sunlight well, on the other – a surface that absorbs it well.

There is also a version of energy-active fence, which is mounted directly on the insulated frame of the roof or facade when organizing the energy supply system. There is an increase in energy efficiency because in this embodiment, the design of air ducts and collectors of liquid circuit, supply/discharge. The energy supply system includes a heat pump and a seasonal heat accumulator, which uses energy from alternative sources – solar energy, soil and air heat (including ventilation emissions). In a complex with the heat pump of an energy-active fence allows to receive heat from air and in the absence of the sun (night, clouds), carrying out at the same time function of the chiller heat exchanger (Borowski 2021).

The effects of energy saving can be significantly enhanced if we implement integrated systems in the implementation of energy supply systems. Such systems should include energy-active fences that convert energy from alternative sources such as solar radiation, ambient heat, ventilation air heat, and so on. Energy-active fence is a building structure that performs the functions inherent in heating, hot water, and power supply systems, providing conversion, generation, and redistribution and storage of energy.

The effect of the implementation of integrated energy supply systems with energy-active fences is associated with the possibility of significantly reducing the number of fuel bases, restructuring the fuel supply infrastructure, transport network and energy distribution.

In the considered energy supply systems it is proposed to use not only energy-active fences, but also heat pumps, ground heat accumulators and energy from alternative sources, such as solar energy, geothermal energy, bioenergy, etc. The implementation of the presented technical solutions will lead to a significant financial cost to a significant effect of energy saving, will improve the environment, reduce dependence on the use of organic energy. The above approach to the construction and design options for energy-active fences can be used to improve the energy efficiency of buildings. They do not reflect all the possible variety of technical solutions. The advantages of using innovative energy supply systems with energy-active fences are demonstrated by the example of a 9-floor typical building. Preliminary calculations show that passive thermal modernization of the building will reduce heat loss in the cold season by an average 1.5 times. But thermal modernization with the use of energy-active fences as alternative source that uses energy, can reduce energy consumption by an average of 3.5 times during the cold season.

In the warm period of the year, the use of innovative energy supply system with energy-active fences can reduce the load on the air conditioning system by 3 times, and energy from renewable sources can be used to replace energy consumption for hot water, and its excess – for storage in seasonal heating. This allows us to talk about the payback of such systems in 5-7 years. "Progressive results" means focusing on samples (countries, companies) with the highest energy efficiency. This is possible by comparing these indicators with estimates of the best and most advanced technologies (Best-in-Class) in the research area based on determining the distance between the research result and the efficiency limit.

Thus, the following energy efficiency categories can be identified based on the Best-in-Class methodology and the attributive approach in order to realize the potential (Fig. 2).

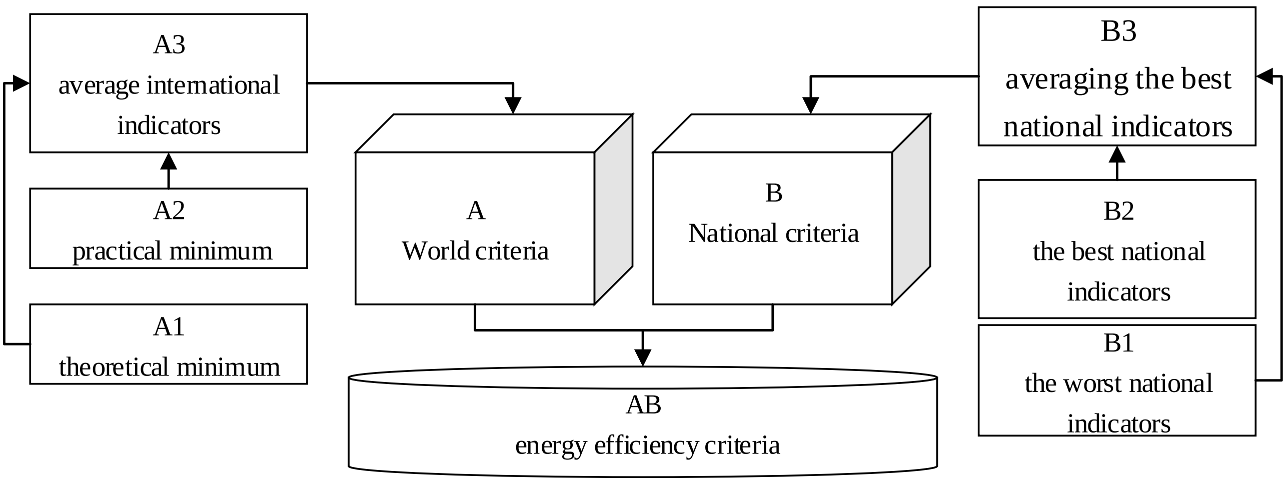

Fig. 2. Defining energy efficiency criteria based on the Best-in-Class methodology in order to realize the potential

Source: Hilorme (2020)

AB as a set of energy efficiency criteria is a general set of global criteria *(A)* and national *(B)*: $AB = A \Delta B$. It should be noted that in order to ensure the competitiveness of national enterprises in world markets on the basis of energy saving, national criteria should be closer to the world: the covariate functor reflects the function $f : B \rightarrow A$. Each block of subsets *A* and *B* is a boulevard of local indicators: respectively, $2^A = \{A1, A2\}$; $2^B = \{B1, B2\}$. A subset of the second type with respect to the induction assumption, 2^A or 2^B, a subset of the first type defines a subset of this type obtained from some single subset of the second type by adding an element a_0, therefore: $2^A = A1 \cup A2$ та $A1 \cap A2 = \otimes$.

Each of the minima is a minimum criterion of energy efficiency. Thus, if we define the criteria of technological equipment as a technological basis for energy efficiency of the enterprise, we can characterize this minimum: *A1* "Theoretical minimum" is the specific energy consumption required to perform certain work or conversion of materials in accordance with the laws of electromechanics and thermodynamics; *A2* "Practical minimum" – the best in the world practice of specific energy consumption when using on a commercial basis technologies that have a certain efficiency.

Of all the technically feasible energy efficiency measures, only few are economically efficient and economically attractive over a period of time. To determine the best way to achieve savings from investing in energy efficiency projects, it is important to distinguish economically reasonable and financially attractive projects. The difference between economically reasonable investments and financially attractive investments is explained by the different discount rates between public and private investments, the indirect impact of energy savings and the impact of external factors. Decomposition analysis can be used to study the influence of factors influencing the energy intensity of GDP (Table 1). This method recommends that the International Energy Agency (IEA) be involved in the practice of enterprises (Al-Turjman and Abujubbeh 2019).

Table 1. Logical and structural model of the influence of factors that cause changes in the volume of final energy consumption

Level	Factors	Economic sector		
		Industry	Household	Transport
1	"Activity"	added value of the total output of goods (value-added output)	number of people	passenger traffic or cargo transportation volume

2	"Structure"	share of output of different types of products	number of square meters per person	passenger traffic or cargo transportation volume
3	"Efficiency"	the amount of energy used per unit of activity in each of the final energy consumption sectors		

Source: Hilorme (2020)

The considered decomposition analysis is used for in-depth analysis of energy efficiency and requires additional initial data. In order to overcome this shortcoming of the considered methodology, it is necessary to determine the aggregate energy efficiency, which consists of individual indicators: energy intensity, electricity intensity and fuel intensity of GDP (Nakashidze et. al 2020).

The indicator of energy intensity of GDP reflects the trends of economic development at the macro level from the standpoint of energy consumption with the definition of the appropriate type of economic activity: intensive (energy saving) or extensive (energy consuming). Energy efficient societies can successfully solve the problem of efficient provision of energy resources for the socio-economic development of the country. At the same time, appropriate measures are used in the state regulatory policy in order to increase the influence of energy stimulating factors on the vector of social development based on the optimization of energy consumption (Dranka and Ferreira 2020).

In the 21st century, the problem of increasing the efficient use of energy resources can be solved only by introducing the latest energy-efficient technologies and equipment that meet the appropriate level of scientific and technological progress. Unfortunately, only some sectors of the economy are gradually entering the era of Industry 4.0 in Ukraine. At the same time, developed countries have begun to discuss the peculiarities of the entry of national economies already in Industry 5.0. Today, business efforts should be focused on innovative development, especially in overcoming technical and technological backwardness. According to the attributive approach, innovative change of the system is possible only with radical changes in its functional properties (attributes) (Żywiołek et.al 2022). In the table Table 2 shows the comparative characteristics of the change in the attributes of energy systems in accordance with the technological structures of Industry 3.0 and Industry 4.0.

Table 2. Comparative characteristics of the attributes of energy systems in accordance with the technological structures of Industry 3.0 and Industry 4.0

Systems attributive feature	Technological way	
	Industry 3.0	Industry 4.0
Price level information for the final consumer	Unavailable or too late	Displayed in real time
Power flow control	Limited	General management
System generation	Centralized	Distributed
Equipment inspection	In place	Remote monitoring
Communication between elements	One-sided or complete absence	Bilateral
Topology	Radial prevails	Network prevails
Reaction	On the consequences of the accident	Anticipation and prevention (prevention) of accidents
Duration of work	Until complete failure (breakdown)	Continuous monitoring, self-diagnosis
Restore network operation	Manual	Automatic
The level of system accidents	High	Low
Disconnection from the network	Manual, fixed	Adaptive

Source: Hilorme (2020)

Analysis of changes in the attributes of the energy system, built on the principles of Industry 4.0, has significant advantages: controllability, economy and efficiency. This will significantly increase energy efficiency and provide the expected benefits for all stakeholders. The implementation of key requirements based on a basic approach can be guaranteed by combining traditional development with the creation of new attributes of its key element, the energy system.

A necessary condition for the development of "Smart Grid" is the formation of a strategic vision of tasks that must meet the requirements of stakeholders. The following stakeholder groups can be distinguished: companies, end users and the state (Fig. 3).

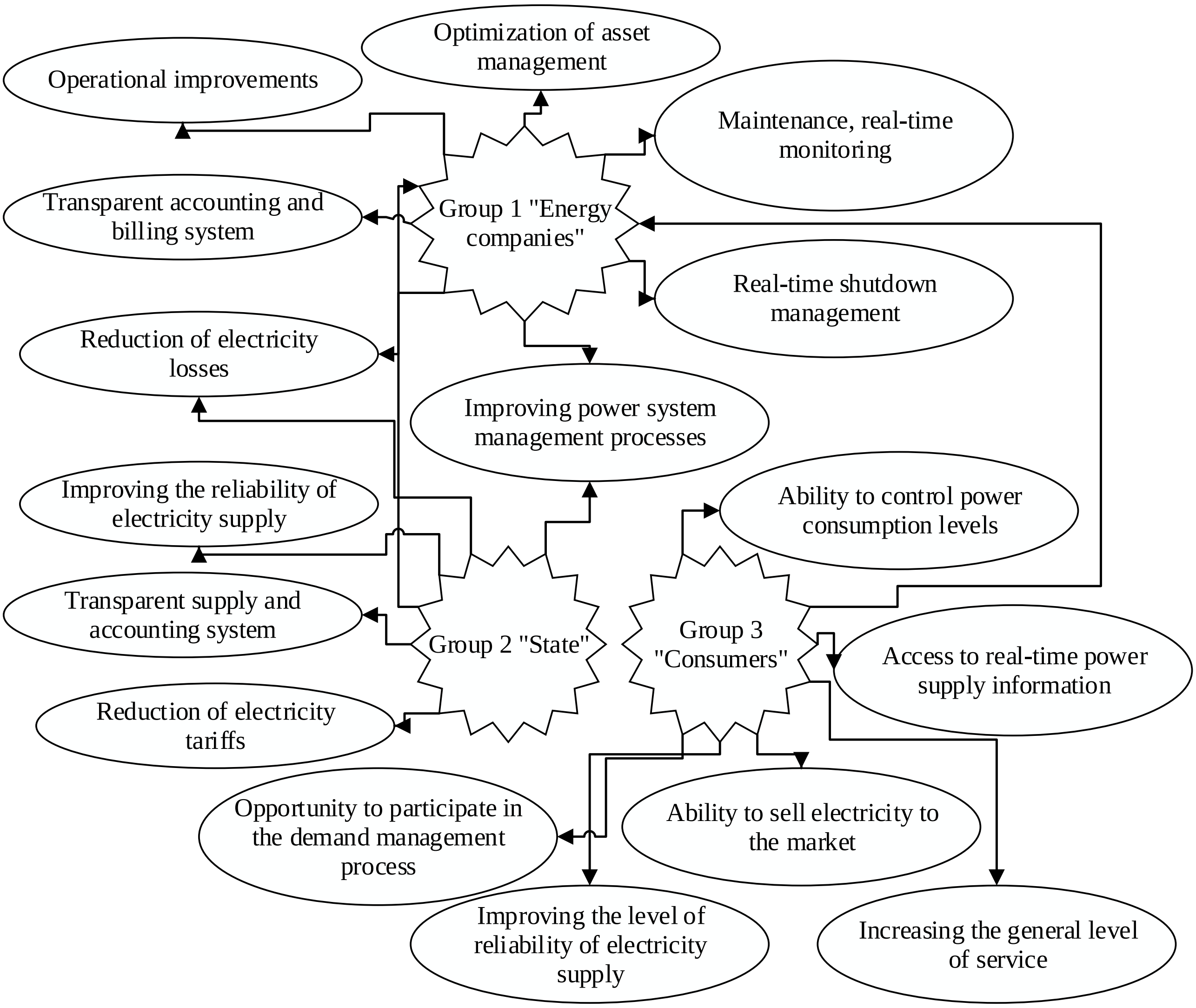

Fig. 3. Requirements of 3 groups of stakeholders (energy companies, state, population) for the implementation of the concept of "Smart Grid" in energy

Source: Hilorme (2020)

Of course, these groups can be supplemented by other stakeholders, such as investors. For each country, stakeholders have an individual character, which is determined by the factors of the national economy.

Thus, for Ukraine, Group 1 "Energy Companies" includes stakeholders: wholesale sellers of electricity, capacity; retailers of energy services; transmission companies; distribution network companies.

Group 2 "State" includes the following stakeholders: government regulators; wholesale electricity market operator; reliability regulators. Group 2 "Consumers" includes the following stakeholders: enterprises, institutions, organizations; people.

It is necessary to note the following features of the requirements of the considered groups of stakeholders. Firstly, group 2 "Government" and group 3 "Consumers" in addition to the requirements for the state of the country's energy system have the corresponding requirements/expected effects to group 1 "Energy companies".

This is due to the fact that energy companies provide energy services to other groups of stakeholders. Secondly, Group 1 and Group 2 have the following common requirements/expected effects: reduction of electricity losses and improvement of energy management processes.

The reduction of electricity losses forms the expected profits of energy companies, and for the state this parameter allows to build an energy-efficient society. And the improvement of energy management processes satisfies the condition for the development of energy systems from the standpoint of these groups of stakeholders. Thirdly, the requirement "Opportunity to sell electricity on the market" applies only to the population as a subgroup of final consumers.

The formation of an energy-efficient society makes it possible to solve the problem of efficient energy supply successfully at all levels of the economy: national - promotes socio-economic development of society; microlevels – contributes to the successful innovative development of business. Therefore, it is necessary to develop appropriate Energy Efficiency Standards at each level, which will allow to identify landmarks and vectors of development based on the concept of resource conservation, in particular, energy conservation. Thus, the development of Energy Efficiency Standards of Ukrainian society will help determine the impact of relevant factors (especially energy costs) on GDP and achieve a high quality of life (life, work, leisure, etc.).

Appropriate measures can be applied to manage the process of achieving energy efficiency. Six groups were separated: financial renewal; pricing mechanisms; financial measures and tax incentives; commercial development and capacity building; technological development; mechanisms of regulation and control.

The potential for improving energy efficiency should be considered as a promising market that should stimulate Ukraine's technological development in the field of energy saving and energy efficiency. The presence of significant energy-saving potential in Ukrainian economy is an opportunity for modernization and development of innovations. At the same time, it is important to avoid attracting outdated foreign energy-saving technologies to the Ukrainian market.

Increased energy consumption because of increased energy efficiency is Jevons' paradox. Reducing resource efficiency reduces the cost of a resource and increases its demand and consumption by measuring its usefulness (Sun et.al 2021). Jevons' paradox is the claim that technological advances can increase energy consumption by increasing resource efficiency.

The opposite effect is determined as a percentage of the energy consumption decrease, which is projected to be lost with increasing energy consumption. The Jevons' paradox arises when the adverse effect reaches a value of more than 100% and exaggerates the initial savings by increasing efficiency. At the macrolevel, technological advances that improve energy efficiency tend to increase overall energy consumption. Therefore, energy consumption can be reduced with or without energy efficiency, and energy consumption can increase simultaneously with energy efficiency.

The implementation of energy efficient technologies does not always lead to reduction in energy consumption because of the opposite effect. The relative reduction of energy prices by increasing energy efficiency stimulates an increase in energy consumption (direct adverse effect).

Energy saving measures will reduce the amount of energy used per unit of products, works and services and increase energy consumption. However, scientists believe that at the microlevel, the increase in energy consumption because of adverse effects is less due to the initial decline in energy consumption caused by the introduction of energy efficient technologies. At the corporate level, increasing energy efficiency leads to a reduction in overall energy consumption, even if we take into account the purchase of additional energy resources from the released funds, the opposite effect is 100%.

However, more detailed studies of energy efficiency processes show that the adverse effects of energy efficiency measures occur at both the macro and micro levels. Cheap energy resources and reduced energy consumption do not hinder or stimulate the increase in overall energy consumption.

But even with the adverse effects of energy efficiency, there are many benefits for the company, especially in terms of technological and economic development. It should be noted that the opposite effect is not evidence of energy shortcomings, and the Jevons' paradox does not lead to futile efforts to save energy.

Small increase in energy efficiency does not allow business to increase energy consumption. Only in the presence of high energy efficiency energy consumption can be significantly increased. Therefore, we can assume that the greater the adverse effect, the more justified is the reduction of specific energy consumption, i.e increase energy efficiency. The presence of adverse effects on the activities of economic agents is an indicator of energy savings. A higher level of adverse effects is possible only if energy efficiency is improved, production is expanded, and the corporation is improved.

Improving energy efficiency can lead to significant benefits for business: development, increased end results and increased competitiveness.

The energy efficiency increase at the present stage of STP is mainly the result of the implementation of innovative energy saving technologies, particularly, the use of alternative energy sources. At the same time, in the presence of energy saving, the total consumption of energy resources may decrease, but sometimes increase due to the opposite effect.

In order to reduce energy imports and the environmental impact on the country, companies need to reduce energy consumption and the share of non-renewable energy consumption. Companies should be able to carry out the planned volumes of their activities with the least possible use of energy resources. In these conditions, the question of the need to avoid the opposite effect – the consumption of energy resources depending on changes in production. When analyzing the transformation of scientific approaches to determining the content of energy saving and energy efficiency in enterprises at the four stages of development of the concept of energy saving, certain features of enterprise development are separated taking into account this concept. It is necessary to consider in more detail the development of the energy platform as a basis for enterprise management based on the concept of energy saving. At the same time take into account the trends of the current stage of development of energy efficient societies, especially the concept of "Smart Grid".

Conclusions

Four stages of formation of the energy saving concept as a global trend in the historical concept are identified. The architectonics of formation of models of energy development of the fourth investment cycle as interrelation of two models of development of energy efficient technologies is defined: "Energy efficiency +" and "New paradigm - power market".

The directions of implementation of these models as ensuring sustainable socio-economic development at all hierarchical levels of the economy are clarified: consumer (nanolevel); enterprises (microlevel); countries (macrolevel); world (megalevel). It is proved that the components of activating the driver of the development model of "Energy Efficiency +" are: the dominance of centralized energy; development of trigeneration; development of dispersed generation; economically justified innovations; development of intelligent energy models in individual clusters (Smart Grid 1.0).

An understanding of the energy efficiency criterion based on the Best-in-Class methodology and the attributive approach in order to realize the potential is offered. Based on decomposition analysis, a logical-structural model of the impact of factors causing changes in final energy consumption in three sectors of the national economy (industry, household, transport), and identified hierarchical levels of three factors: activity, structure, efficiency. It is established that the aggregate energy efficiency indicator consists of individual indicators: energy intensity, electricity intensity and fuel intensity of GDP.

The driving forces of energy efficient society development are systematized as a set of four categories: economic development and competitiveness; energy security; climate change; public health. This made it possible to develop a system of energy efficiency policy measures (financial renewal, financial measures and tax incentives, technological development, commercial development and capacity building, regulatory and control mechanisms) and their respective implementation tools. The defined methods of energy saving and energy efficiency assessment, scientific paradoxes, postulates and plots allowed to build a semantic system of transformation of scientific approaches to determining the content of energy saving and energy efficiency.

Prospects for further research are to determine the effectiveness of Smart Grid 1.0 technology in the implementation of projects on energy-saving technologies based on renewable energy sources.

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