

**ЕКОНОМІКА ТА УПРАВЛІННЯ НАЦІОНАЛЬНИМ ГОСПОДАРСТВОМ.
МІЖНАРОДНІ ЕКОНОМІЧНІ ВІДНОСИНИ**

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Strategic approach to renewable energy development: EU experience

The article explores a strategic approach to the development of renewable energy sources in the EU. The main goals and principles in the energy sector are analyzed. The key indicators of the energy sector development are presented. The structure of EU energy resources and the structure of renewable energy sources are reviewed. The experience of the EU countries regarding the development of unconventional energy sources is summarized. The socio-economic implications of the large-scale use of renewable energy are listed. It is recommended to use the experience of the EU in Ukraine and to emphasize on this development strategy of the country, regions, energy industry and enterprises.

renewable energy sources, energy policy, energy indicators, sustainable development, socio-economical development

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Стратегический подход к развитию возобновляемой энергетики: опыт стран ЭС

В статье рассмотрен стратегический подход стран ЕС к развитию возобновляемых источников энергии. Выделены главные цели и принципы развития энергетической сферы. Изучены основные показатели развития энергетики. Проанализирована структура энергетических ресурсов ЕС и возобновляемых источников энергии. Обобщен опыт стран ЕС по развитию альтернативной энергетики. Перечислены социально-экономические преимущества от использования возобновляемых источников энергии. Рекомендуется использовать опыт ЕС в Украине и сделать акцент на этой стратегии развития страны, регионов, энергетического сектора и предприятий.

возобновляемые источники энергии, энергетическая политика, энергетические показатели, устойчивое развитие, социально-экономическое развитие

Statement of the problem. Energy supply is one of the most important components of the world political process, the main element of which is energy policy. Energy policy is an integral part of economic, energy and national security, which determines the conditions for the existence and development of the state. In the modern sense, the implementation of energy security is carried out subject to the achievement of a technically reliable, stable, cost-effective and environmentally safe supply of energy resources for key sectors of the economy (industrial, social, construction, transport), as well as creates the necessary conditions for the formation and implementation of national interests in the industry power engineering. One of the most dynamic examples of policy is energy policy in the EU. In this regard, the choice of the topic of research is relevant and timely.

Analysis of recent researches and publications. The energy strategies of the EU and the world, their influence on the development of renewable energy sources were studied by the following domestic scientists. In particular, L. Antonova [1] studied the guidelines of European energy policy, explored the evolution of renewable energy in Germany. The authors G. Geletukha [2], T. Zheleznaya [2], A. Prakhovnik [2] analyzed the energy strategy of the EU and some countries in the world, explored global warming issues. Renewable energy issues are reflected in the works of foreign authors such as Abbas Mardani [3], Ahmad Jusoh [3], Edmundas Kazimieras Zavadskas [3], Fausto Cavallaro [3], Zainab Khalifah [3], which

presented a systematic review of techniques and approaches in sustainable and renewable energy system problems. Nada Kh. M. A. Alrikabi [4] investigated the properties of renewable energy, environmental problems in non-renewable energy resources and analyzed existing available renewable resource in Iraq. However, these researchers in their scientific works did not reflect a comprehensive study of the current state of development of renewable energy compared to the planned indicators.

A comprehensive study of the strategic approach to the transition from traditional energy sources to alternative has not been paid enough attention to the authors in order to learn from experience and practical implementation of an effective set of measures to improve not only the energy sector in Ukraine, but also the development of its regions, individual enterprises and the country as a whole.

Statement of the objective is to explore effective tools and mechanisms for developing an EU strategic approach to the transition from traditional sources of energy to renewables.

The main material. The energy policy of the EU countries has gone through several stages of its development. The main milestones on this path were the Energy Charter, the Treaty to it and the Energy Union. At this stage of development, efforts are being made to build a common energy policy for the European Union. The energy policy of the EU is formed at two levels: national and integration. And the second level begins to prevail over the first. In the context of globalization of the world economy, there is also the influence of third countries on the economic policy of the EU. The main objectives of the energy policy of the EU countries are to ensure a reliable supply, including from abroad, with energy carriers at affordable prices and to reduce the burden on the environment.

Due to the fact that the energy sector is one of the main sources of greenhouse gas emissions that are associated with human activities, then the main reserves to reduce these emissions should be found and implemented in it. The European Union reaffirmed its official goal of reducing greenhouse gas emissions (decarbonization) in 2050 by 80-95% compared with 1990. On this basis, the European Commission developed the Energy Road Map until 2050 [5], which analyzed exactly how to achieve the goals set to reduce greenhouse gas emissions, while ensuring the reliability and competitiveness of energy supply systems. This will build on the established EU energy policy and the EU 2020 Strategy [6].

The roadmap does not replace national, regional and local efforts to modernize energy supply, but seeks to develop a long-term European technology neutral framework in which these policies will be more effective. It argues that a European approach to the energy challenge will increase security and solidarity and lower costs compared to parallel national schemes by providing a wider and flexible market for new products and services. For example, some stakeholders show potential cost savings of up to a quarter if there was a more European approach for efficient use of renewable energy [5; 4].

The EU's strategy for transition to a climate-neutral Europe by 2050 is not part of the legislation and represents a long-term vision of the European Commission with a detailed analysis of how the EU can fulfill its obligations under the Paris Agreement while benefiting from emission reductions and economic transformation. Development of the Strategy means the beginning of a large-scale discussion in the EU on this topic with the involvement of industry and civil society. This will establish the future directions of the EU energy and climate policy, the adoption and the direction of an ambitious strategy to the Secretariat of the UN Framework Convention on Climate Change. The Strategy modeled development directions for all sectors of the economy, from the implementation of specific technological solutions to demand side measures, such as promoting energy efficiency policies and a waste-free economy. According to the Strategy, all sectors of the economy, such as energy,

transport, buildings, industry have their own role in ensuring the transition to climate neutrality.

In this regard, the most important for the energy sector is to achieve the following goals:

- universal competitiveness of EU countries;
- development of alternative energy sources;
- reducing dependence on energy imports;
- approximation of the legislation of the EU member states in order to ensure the functioning of the energy market;
- development of trans-European energy infrastructures;
- geographic diversification of overseas supplies, ensuring their stability and security;
- introduction of energy-saving technologies and reducing the energy intensity in industrial production.

All EU governing bodies, with the European Commission playing a central role among them, are involved in the development and decision-making of energy policy. We will highlight the principles of the EU energy policy:

- non-discrimination principle – means ensuring transparency of the situation on the internal energy market, the possibility for consumers to receive information on the level of energy prices, as well as monitoring the supply and transit of energy resources of the EU community;
- the principle of taking into account the social factor. This rule is very important in energy policy, as it requires attention to the dependence of the level of unemployment in the energy sector on market conditions, as well as ensuring the safety of workers in the energy sector;
- the principle of not causing harm to the environment. This tenet means the need to take measures to protect the environment in the implementation of energy-saving activities.

We propose to analyze the changes that will occur in the main sectors of the economy. Energy sector operates mainly on fossil fuels. By 2050, more than 80% of the electricity in the EU will be generated using renewable energy sources, which implies a radical change by mid-century. The spread of renewable energy will entail a full-scale electrification of the energy system, including the use of energy in industry, buildings, and transport. Greenhouse gas emissions from industry can be reduced by switching to low and zero emissions technologies, introducing innovative processes and using carbon capture and storage technologies. Industry can improve resource efficiency and reduce emissions through reuse of products and energy, using waste-free economy approaches and merging sectors.

Conducting large-scale thermal renovation and other measures in the housing stock will reduce the use of energy for heating. The use of more efficient materials and devices, the distribution of «smart» building management systems, and changes in consumer behavior will help optimize energy consumption on the demand side. Further energy demand will be filled with renewable energy sources in the heat supply of residential buildings.

The transport sector also mainly uses fossil fuels. Achieving a significant reduction in emissions will require an integrated systems approach, ensuring change in behavior and consumer choice. This approach includes: achieving the overall efficiency of all vehicles and infrastructure with low and zero emissions; long-term transition to the use of alternative or zero emissions fuel for transport; improving the efficiency of the transport system through the use of digital technologies, «smart» pricing, with the subsequent transition to the use of more sustainable transport practices [7].

The table 1 presents indicators of energy use, electrification, power and emissions (development indicators). The data allows to compare current performance and planned.

After analyzing the data presented in the table, we see that, according to forecasts of Remap, it is planned to increase the share of electricity use in industry by + 21% in 2050 (as compared with the data of 2016); increase the share of electricity in the transport industry by + 30%; to increase the share of electric energy use in the buildings industry by + 22%. Also projected to increase the use of wind and solar energy. Growth of the planned indicators will lead to a significant reduction in carbon dioxide by -80%.

Table 1 - Key EU indicators

The name of indicators		2016	2030	2050
Energy use	TPES EJ/yr	63	54	45
	TFEC EJ/yr	44	38	29
RE shares	RE share in TFEC %	17%	30%	70%
	RE share in TPES %	16%	31%	71%
	RE share in power generation %	30%	55%	86%
Electrification	Share of electricity use in TFEC %	23%	30%	49%
	Share of electricity use in Industry %	33%	40%	54%
	Share of electricity use in Transport %	2%	7%	32%
	Share of electricity use in Buildings %	33%	42%	55%
Power capacity	Wind GW	154	319	621
	Solar PV GW	101	284	784
Emissions	Energy-related CO ₂ emissions Mt CO ₂ /yr	3050	1920	610
	Avoided emissions (vs Ref Case) Mt CO ₂ /yr	-	-711	-1337
	Reduction relative to 2016 %		-37%	-80%

Source: compiled by the authors [8; 7; 9].

Note that the Remap scenario includes the deployment of low-carbon technologies, based largely on renewable energy and energy efficiency, to generate a transformation of the global energy system that limits the rise in global temperature to well below 2 degrees Celsius above pre-industrial levels. The scenario is focused on energy-related carbon dioxide emissions, which make up around two-thirds of global greenhouse gas emissions.

Highlight the main prerequisites for the development of alternative energy:

Firstly, environmental reasons. Unlike fuel energy, renewable energy sources practically do not emit greenhouse gases, sulfur oxides and nitrogen.

Secondly, renewable energy sources are an inexhaustible source of energy in comparison with oil, gas, coal, etc.

Thirdly, dependence on energy imports. For example, low-income countries that import fossil fuels are very vulnerable to price increases, which negatively affect their balance of payments.

The energy available in the European Union comes from energy produced in the EU and from energy imported from third countries. In 2016, the EU produced around 46% of its own energy, while 54% was imported. The energy mix in the EU, meaning the range of energy sources available, was mainly made up by five different sources: petroleum products (including crude oil), natural gas, solid fuels, nuclear energy and renewable energy. In this connection, the analysis of the EU energy structure is relevant (Fig. 1).

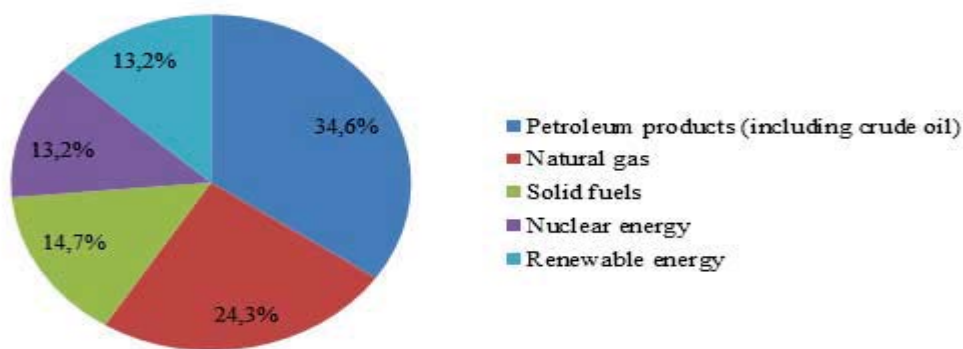


Figure 1 - EU energy balance, 2016

Source: compiled by the authors [9].

It is also important to analyze the structure of energy production in the EU (Fig. 2). Since this reflects the autonomy and independence of this union from energy imports.

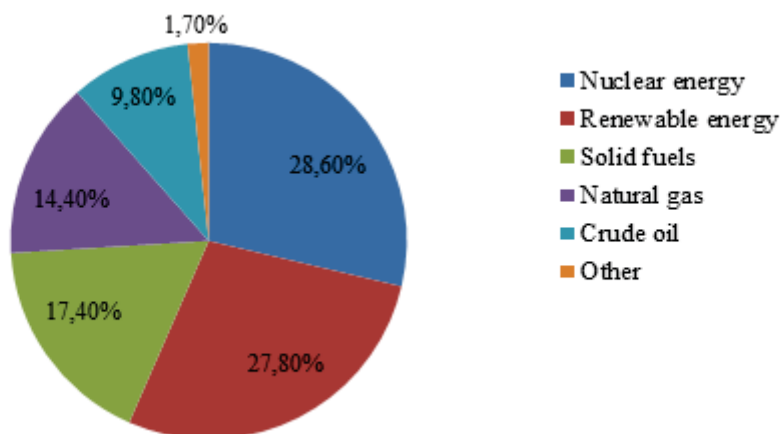


Figure 2 - Share of EU energy production by source, 2016

Source: compiled by the authors [9].

The production of energy in the EU is spread across a range of different energy sources: solid fuels (largely coal), natural gas, crude oil, nuclear energy and renewable energy (such as hydro, wind and solar energy). Nuclear energy (28,6% of total EU energy production) was the largest contributing source to energy production in the EU in 2016. Renewable energy (27,8%) was the second largest source, followed by solid fuels (17,4%), natural gas (14,4%) and crude oil (9,8%). However, the production of energy is very different from one Member State to another.

Renewable energy is energy that is generated by natural processes that are constantly replenished. This includes sunlight, geothermal heat, wind, tides, water, and various types of biomass. This energy cannot be exhausted and constantly updated [10]. Different countries use various sources of this energy. In this regard, it is important to analyze the structure of renewable energy sources in the EU (Fig. 3).

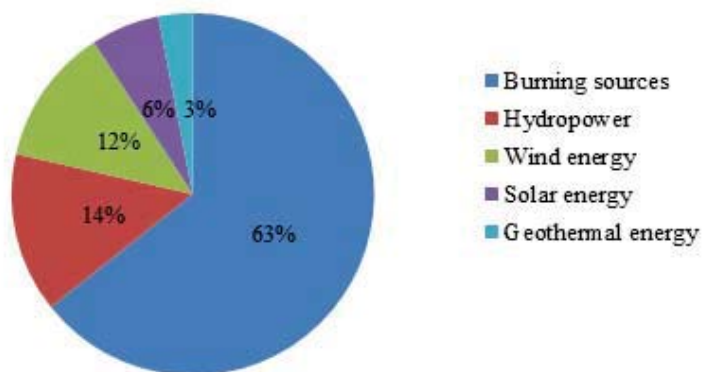


Figure 3 - The structure of renewable energy produced in EU in 2016

Source: compiled by the authors [9].

Worth noting that 63% of renewable energy produced in the EU comes from burning renewable sources (wood, biogas, bio gasoline and bio diesel); 14% of renewable energy produced in the EU comes from hydropower; 12% of renewable energy produced in the EU comes from wind energy; 6% of renewable energy produced in the EU comes from solar energy; 3% of renewable energy produced in the EU comes from geothermal energy – heat from the earth. The significance of nuclear energy is particularly high in France (80% of total national energy production), Belgium (75%) and Slovakia (62%). Renewable energy is the main source of energy produced in a number of Member States, with over 90% (of the energy produced within the country) in Malta, Latvia, Portugal, Cyprus and Lithuania. Solid fuels have the highest importance in Poland (78%), Estonia (67%), Greece and Czechia (both 59%), while natural gas is the main source of energy produced in the Netherlands (83%). Crude oil is the major source of energy produced in Denmark (47%) and the United Kingdom (41%).

To study the changes that have taken place with the energy resources of the EU countries, it is advisable to analyze their structure (Fig. 4).

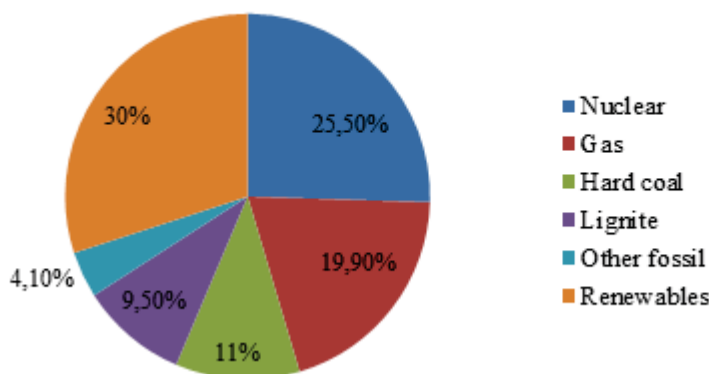


Figure 4 - EU energy resources in 2017

Source: compiled by the authors [11; 10].

The structure of energy resources in the EU in 2017 is as follows: the largest share is occupied by renewable energy sources (30%), which indicates that the EU policy on the development of alternative energy is developed. In second place among the resources is nuclear (25,5%); 19,9% – gas; 11% – coal; 9,5% – lignite; 4,1% – other fossil fuels. Analyze the structure of renewable energy in 2017 (Fig. 5).

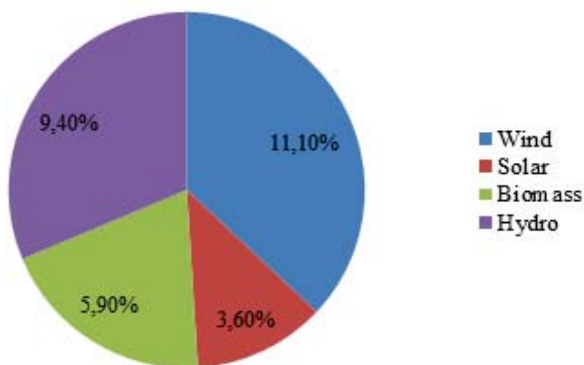


Figure 5 - The structure of renewable energy in EU, 2017

Source: compiled by the authors [11; 10].

The largest share in renewable energy is wind energy (11,10%); the share of hydropower was 9,40%; biomass – 5,90%; solar energy – 3,60%. We analyze what changes have occurred in the structure of renewable energy sources in 2018 (Fig. 6).

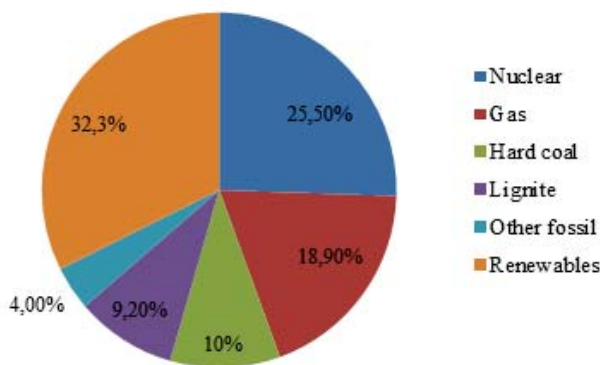


Figure 6 - The structure of EU energy resources in 2018

Source: compiled by the authors [11; 10].

In 2018, we see that the largest share of EU energy resources is occupied by renewable energy sources – 32,3%, which compared with 2017 increased by +2,3%. 25,5% is occupied by nuclear power engineering; 18,9% – gas; 10,0% – hard coal; 9,2% – lignite; 4% – others. Analyze how the EU renewable energy structure changed in 2018 (Fig. 7).

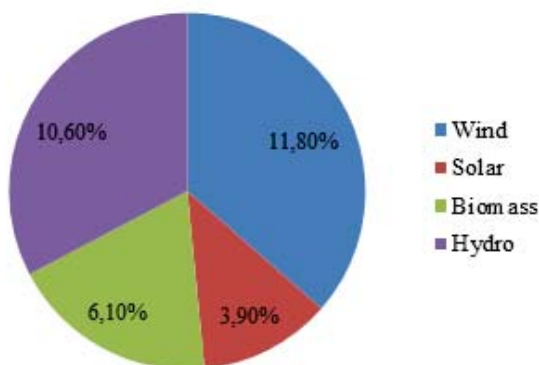


Figure 7 - The structure of EU renewable energy sources in 2018

Source: compiled by the authors [11; 10].

After analyzing the structure of renewable energy in 2018, we see a positive trend, which indicates an increase in the following indicators, compared with 2017: wind energy increased by +0,7%; solar energy increased by +0,3%; biomass – by +0,2%; hydropower – +1,2%. In 2018, renewables generated 32,3% of Europe’s electricity. A rise of +2,3% points, from 30,0% in 2017. Of that, half was from the recovery of hydro generation and half was from the structural rise in wind, solar and biomass generation. As of 2018, wind has the largest share in the renewables mix, contributing 12% of Europe’s electricity. Solar contributed 4%, less than biomass and a third of wind generation.

To follow the changes that occur with renewable energy sources, we will trace them in dynamics (Fig. 8).

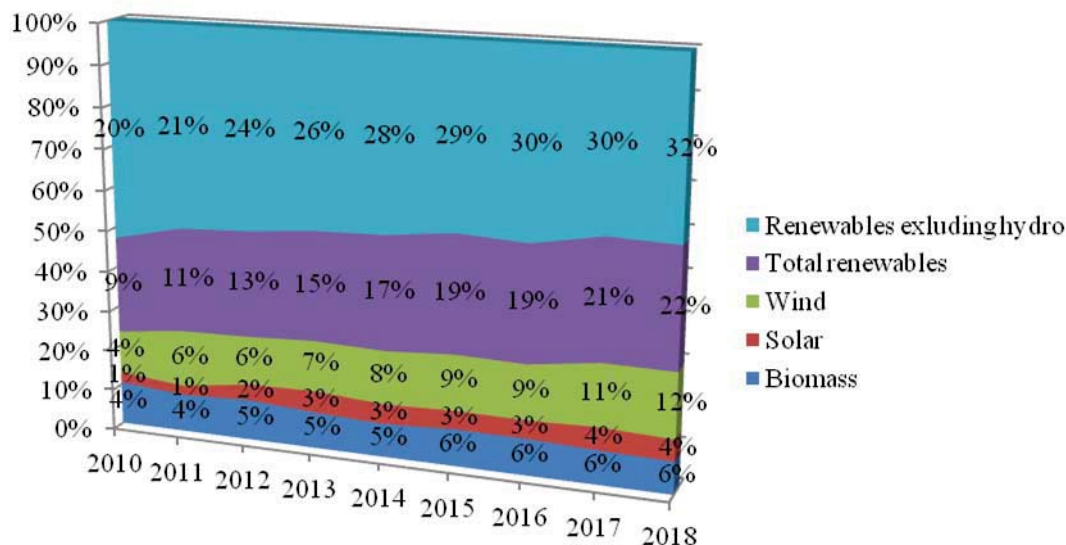


Figure 8 - EU-28 renewables share (as percentage of gross electricity production)

Source: compiled by the authors [11].

The data presented in Fig. 8 indicate a positive growth trend throughout the analyzed period, which is a confirmation of the effectiveness of the EU policy in the energy sector.

The use of renewable energy sources not only reduces carbon dioxide emissions into the environment, but also has huge social and economic effects. The socio-economic effects can be grouped into four categories: macroeconomic effects; distributional effects; energy system-related effects and additional effects (Table 2).

Table 2 - Socio-economic effects of large-scale renewable energy deployment

Macroeconomic Effects		Distributional Effects		Energy system-related effects		Additional effects	
Gross impact	Net impact	Positive	Negative	Positive	Negative	Benefits	Costs
Gross domestic product		Types of owners		Additional generation and balancing costs		Externalities	
Welfare		Regional distribution		Additional grid and transaction costs		Others	
Employment		Impacts across energy consumers and tax payers		Externalities			
Trade balance (including trade in energy products, domestic production and trade in equipment)							

Source: compiled by the authors [12].

Governments' drafted grandiose growth plans for solar in 2018. Governments began releasing draft «National Energy and Climate Plans» to 2030, which must be finalized by the end of 2019. Many gave explicit reference to their solar ambitions; more are expected:

- France plans 45 GW by 2030: France announced an aggressive expansion of wind and solar capacity to 2030, as well as slowing the rate of nuclear closures. Solar capacity in France was 8 GW in 2017;

- Italy plans 50 GW by 2030: Italy announced their draft National Integrated Plan for Climate and Energy 2030, which plans to increase solar capacity to 50 GW in 2030, from 19 GW in 2017;

- Spain plans up to 77 GW by 2030: Spain released scenarios for solar, with up to 77 GW by 2030, up from only 6 GW in 2017. Later in November, the Spanish Government went a step further and begins drafting legislation to make 100% of electricity renewable by 2050;

- Germany committed to contract 4 GW per year of solar in 2019, 2020 and 2021. Critically, Germany raised its target for renewable electricity in 2030 to 65%, compared to 38% in 2018;

Portugal proposed a stepping stone of 80% clean electricity by 2030, on the way to 100% by 2050 [11, 17].

So, the effect of the development in renewable energy has not only macroeconomic and regional importance, but also affects every person. In addition, renewable energy sources expand the possibilities of energy supply and help to improve the economic and social prospects of rural and remote areas. Renewable energy sources are considered as a tool to ensure sustainable, safe and flexible energy supply in a constantly changing climate and political conditions. In this regard, the development and spread of renewable energy technologies is taking place not only in the EU, but also outside it.

Conclusions and prospects for further researches. The EU energy policy is one of the most dynamic, consistent and flexible, as its energy sector development program allows making fundamental conclusions in the long run and making important strategic decisions. The EU considers the energy of the sun, wind, water, biomass and geothermal energy as renewable energy sources. According to the plans of the European Commission, in 2050, electricity should provide more than half of all energy consumption (at least twice as much as now). Citizens of European countries will not only drive electric cars, but also partially heat their homes with electricity, 80% of which will be produced from renewable energy sources at 15% at nuclear power plants. Governments' drafted grandiose growth plans for solar in 2018. The increase in the production of renewable energy will not only reduce carbon dioxide emissions into the atmosphere, but also increase employment and increase the level of welfare of the population. In addition, renewable energy sources expand the possibilities of energy supply and help to improve the economic and social prospects of rural and remote areas. Renewable energy sources are considered as a tool to ensure sustainable, safe and flexible energy supply in a constantly changing climate and political conditions. In this regard, the development and spread of renewable energy technologies is taking place not only in the EU, but also outside it. The experience of countries in the energy sector of the EU needs to be used in Ukraine and to emphasize on this strategy of development in our country, its regions, the energy industry and enterprises.

To move Ukraine to a path of sustainable socio-economic and environmental development, the prospects for further research should be focused on the development of alternative energy in Ukraine, not only in the energy sector, but also in industrial enterprises, which will not only create new jobs, but also attract investment and improve image of the country in the international market.

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Стратегічний підхід до розвитку відновлювальної енергетики: досвід країн ЄС

У статті досліджено досвід країн ЄС, заснований на використанні стратегічного підходу до розвитку відновлювальної енергетики. Зазначено, що політика ЄС формується на двох рівнях: національному та інтеграційному, однак в умовах глобалізації світової економіки відбувається також вплив третіх країн. Головними цілями політики ЄС у енергетичній сфері є забезпечення надійного постачання енергоносіїв за доступними цінами, зменшення навантаження на навколишнє середовище завдяки розвитку відновлювальних джерел енергії. Зазначено головні передумови розвитку альтернативної енергетики: екологічні причини, залежність від імпорту енергії, а також її невичерпність, порівняно з нафтою, газом, вугіллям тощо.

Обґрунтовано, що Стратегія моделює напрями розвитку для всіх галузей економіки, починаючи від впровадження конкретних технологічних рішень, вимагаючи побічних заходів, таких як сприяння політиці енергоефективності та безвідходної економіки. Відповідно до Стратегії, усі галузі економіки, такі як енергетика, транспорт, будівництво, промисловість, відіграють свою роль у забезпеченні переходу до кліматичного нейтралітету. У зв'язку з цим, найважливішим для енергетичного сектору є досягнення наступних цілей: загальна конкурентоспроможність країн ЄС; розвиток альтернативних джерел енергії; зменшення залежності від імпорту енергоносіїв; наближення законодавства країн-членів ЄС з метою забезпечення функціонування енергетичного ринку; розвиток транс'європейської енергетичної інфраструктури; географічна диверсифікація закордонних поставок, забезпечення їх стабільності та безпеки; впровадження енергозберігаючих технологій та зниження енергоємності у промисловому виробництві.

Усі органи управління ЄС беруть участь у розробці та прийнятті рішень в енергетичній політиці. У статті виділено головні принципи енергетичної політики ЄС: принцип недискримінації - означає забезпечення прозорості ситуації на внутрішньому енергетичному ринку, можливість отримання споживачами інформації про рівень цін на енергоносії, а також моніторинг постачання та транзиту енергоресурсів спільноти ЄС; принцип врахування соціального чинника. Це правило є дуже важливим в енергетичній політиці, оскільки вимагає уваги до залежності рівня безробіття в енергетиці від ринкових умов, а також забезпечення безпеки працівників енергетичного сектору; принцип не заподіяння шкоди навколишньому середовищу.

Проаналізовано структуру енергетичного балансу ЄС та виявлено, що найбільшу питому вагу займають саме відновлювальні джерела енергії, використання яких збільшується з кожним роком, що свідчить про ефективність політики країн ЄС в енергетичній галузі. Відзначено, що ефект від розвитку відновлюваної енергетики має не лише макроекономічне та регіональне значення, але й впливає на кожну людину. Відновлювані джерела енергії розглядаються як інструмент для забезпечення стійкого, безпечного та гнучкого постачання енергії в умовах постійно мінливих кліматичних та політичних умов. У зв'язку з цим розвиток і поширення технологій відновлюваної енергії відбувається не тільки в ЄС, але і поза його межами.

Стратегічний підхід до розвитку альтернативної енергетики потрібно використовувати в Україні та робити акцент на цій стратегії у регіонах, енергетичній галузі, промислових підприємствах. Адже саме завдяки цьому можливо перейти на шлях сталого соціально-економічного та екологічного розвитку, що сприятиме не лише створенню нових робочих місць, покращенню екологічної ситуації, залученню інвестицій та поліпшенню іміджу країни на міжнародному ринку.

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