STRATEGIC PRIORITIES FOR THE DEVELOPMENT OF THE USE OF RENEWABLE ENERGY SOURCES

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Introduction

Given the increasing exhaustion of traditional energy resources and the aggravation of global contradictions in economic development, one of the main national strategic objectives is to ensure energy security. This problem can be solved, first of all, through the diversification of energy resources, optimization of the model for energy consumption and implementation of energy-efficient technologies based on renewable energy sources. Over the last decade, renewable energy has not just become a mere tool for realizing the idea of low carbon society. It can be an economically viable alternative to fossil fuels. Between 2006 and 2016, the global consumption of renewable energy increased from 93.2 to 419.6 million tonnes or by 4.5 times. In 2015, the total global annual capacity growth of renewable energy exceeded that of traditional generation, which emphasizes the competitiveness of renewable energy production [1; 2].

Typology of knowledge

Nowadays, renewable energy is rapidly spreading, replacing traditional and environmentally unfriendly energy sources. Renewable energy is based on the use of solar, water, wind and natural heat. In EU legislation, the definition of renewable energy sources was introduced in 2009 in Directive 2009/28/EC [3] on the promotion of electricity produced from renewable sources in the internal electricity market. The term “renewables energy sources” should be understood as nonfossil energy sources (wind, solar, geothermal energy, waves and tides, hydropower, biomass, organic waste gas, waste gas and biogas) [4]. The most thorough definition of the term “renewable energy” was published in 2002 by the International Energy Agency (IEA). According to its classification, renewable energy sources include:

1) combustible renewables and biomass waste, namely solid biomass and animal products (biological mass, including any plant material used directly as fuel or converted to other forms before burning (wood, vegetable and animal waste; charcoal derived from solid biomass); gas or liquid from biomass produced in the process of anaerobic fermentation of biomass and solid waste and burned for electricity or heat generation; municipal waste, namely waste from residential, commercial and public sectors that are burned to generate heat and electricity; industrial waste, namely solid and liquid materials that are burned to generate heat and electricity at specialized enterprises;

2) hydropower, that is a potential or kinetic energy of water converted to electrical energy by large and small hydropower plants;

3) geothermal energy, that is thermal energy coming from the bowels of the Earth, usually in the form of hot steam or water; it is used for electricity generation or directly as a heat source for heat supply systems, agriculture needs, etc .;

4) solar energy, that is the radiation of the sun used as thermal and electrical energy;

5) wind energy, that is kinetic wind energy used to generate electricity in wind turbines;

6) tidal, wave and ocean energy, that is the mechanical energy of tidal flows or waves used to generate electricity [5–7].

The world community has discovered the most promising way to address the issue of energy supply. It is to use renewable energy sources that are characterized by an inexhaustible resource potential and environmental friendliness. One of the major events contributing to the development of renewable energy is the 2015 United Nations Climate Change Conference in Paris. Indeed, 195 countries have signed a historic agreement on a global climate change issue and pledged to double investment in the study of clean energy over the next five years. The Paris Agreement entered into force on November 4, 2016. Its main mission is to limit warming to 1.5 ^{0}C. The main objective of the Paris Agreement is to increase the capacity of the participating countries to deal with the effects of climate change. To

achieve these ambitious goals, they have envisaged certain flexible opportunities for funding, technology transfer and strengthening of institutions that can be applied to countries with different levels of economic development [1]. It must be noted that Ukraine was one of the first to accede to the Paris Agreement and submit its proposals on the intended nationally determined contributions. An important practical step towards its implementation, as well as a step towards the implementation of European environmental standards, is the approval by the Government of Ukraine of a National Emission Reduction Plan for Large Combustion Plants in November 2017, whose implementation is aimed at the gradual and substantial reduction of emissions from thermal generation. In September 2015, Ukraine informed the UNFCCC Secretariat of its goal of not exceeding 60% of the 1990 greenhouse gas emissions level in 2030. The Paris Agreement calls on countries to periodically review their commitments to reduce their greenhouse gas emissions and introduce a cyclical mechanism for updating the parties' targets. Thus, each party is required to report (submit to the UNFCCC Secretariat) every five years, starting in 2020, the replacement of the intended nationally determined contributions, which were recorded in 2015 [8].

An effective mechanism used by the EU to stimulate the development of renewable, alternative energy sources are national strategies, programmes and plans. The issues of energy efficiency and energy security in Ukraine are dealt with by the State Agency for Energy Efficiency and Energy Conservation (State Energy Efficiency), Association for Energy Efficiency and Energy Conservation. Some issues are covered by the Bioenergy Association of Ukraine and the Institute for Renewable Energy of the National Academy of Sciences of Ukraine. Globally, the analysis of energy efficiency is conducted by the IEA, Enerdata, Bloomberg, British Petroleum; about the use of renewable energy – by the Renewable Energy Policy Network for the 21st century (REN 21), etc.

The development of renewable energy has necessitated a clear regulation of the economic, legal and organizational aspects of the use of renewable energy. Therefore, in 2003, the Law of Ukraine "On Alternative Energy Sources" was

adopted. It defines the term as follows: “alternative energy sources – renewable energy sources, which include solar, wind, geothermal, wave and tidal energy, hydropower, biomass energy, organic waste gas, sewage treatment plants, biogas and secondary energy resources, namely blast furnace and coke oven gases, coal bed methane, conversion of the waste energy potential of technological processes”. Thus, in line with the Ukrainian law, “alternative energy” is a slightly broader concept than “renewable energy” since it targets not only clean renewables but also secondary energy resources. It must be noted that today the state is encouraging the use of renewable energy to replace traditional energy resources, in particular, imported natural gas and oil. To clearly understand the distinction between alternative and renewable energy, one must bear in mind that there is still no single approach to defining these categories. Also, the concepts of “non-traditional” and “renewable” sources of energy are quite often used in the scientific literature. Therefore, it is important to interpret these categories. Theoretical approaches of different scholars and researchers to defining the concept of alternative energy sources are presented in Table 1.

According to international law, there are several types of alternative energy sources, namely renewable, new, non-traditional ones, etc. The ECOSOC Resolution of 1956 is the first international act in this field that divides all energy sources into traditional and new ones. In turn, EU countries use the terms “alternative sources” and “renewable energy sources”. The Ukrainian legislation accepts the term “alternative energy sources”. This term is quite appropriate as today and later in the future, the energy from these sources will be used along with (alternatively) coal, oil and gas.

There is currently no clear understanding as to what to refer to alternative sources. In the EU, alternative sources first included the liquefaction and gasification of solid fuels, exploitation of geothermal fields, as well as the use of solar energy (Regulation (EEC) No 2039/82 as regards the granting of financial support to projects to exploit alternative energy sources).

Table 1

Approaches to defining such concepts as "alternative energy sources" and "renewable energy sources"

Author/source	Definition
1	2
The law of Ukraine "On Alternative Energy Sources"	Renewable energy sources which include solar, wind, geothermal, wave and tidal energy, hydropower, biomass energy, organic waste gas, sewage gas, biogas. Secondary energy sources include blast furnace and coke coal gas, coal bed methane, conversion of the waste energy potential of technological processes.
H. Pivniak	Sources based on permanent or temporary natural processes, as well as the life cycle of flora and fauna and life activity of individuals.
Yu. Sibikin, M. Sibikin	Energy sources that are inexhaustible, environmentally friendly and do not alter the energy balance of the Earth.
Ye. Shkuridin	Renewable, permanent or temporary energy sources that are an alternative (substitute) to relevant traditional (non-renewable) energy sources.
J. Twidell, A. Weir	Sources based on energy flow in the environment that are not the result of purposeful human activity.
O. Bělohlávek	Sources or means of production other than the burning of fossil fuels.
I. Pidhirnyi	Ways, devices or other methods for obtaining energy from the energy of renewable or practically inexhaustible natural resources and phenomena which can replace a traditional energy source operating on oil, gas or coal.
S. Naraievskyi	Input elements of the energy system that are transformed into secondary energy (electrical, thermal, mechanical) through the use of alternative conversion technologies.
M. Syrotiuk	Renewable energy sources in the geographic environment of the Earth are solar, wind, geothermal energy, as well as bioenergy and river hydropower. They are practically inexhaustible and environmentally friendly.
V. Baranovska, S. Berzina, O. Bohdan, O. Voznyi	Renewable energy sources exist permanently or temporarily as energy streaming from the sun, wind, Earth heat, wave and ocean energy, river hydropower, biomass.
O. Borodina	Alternative energy sources are renewable sources including energy from solar radiation, wind, seas, rivers, biomass, Earth heat. Secondary energy resources exist permanently or temporarily.
A. Shevtsov, M. Zemlianyi, T. Riauzova	Non-traditional and renewable energy sources include hydroelectric power plants (large, average and small), geothermal, solar, photovoltaic, thermal, tidal, ocean and wind energy, solid biomass, biomass gases, liquid biofuels and municipal renewals, which the IEA defines as renewable energy sources.

1	2
O. Melnykova, A. Prakhovnyk, Dag Arne Hoystad, Ye. Inshenkov, V. Deshko, A. Konechenkov	Renewable energy sources are those that are constantly renewed in nature (solar radiation, biomass, river and ocean waters, geysers, etc.) and exist based on the permanent or temporary flows of energy, namely solar radiation (biomass, solar, wind and wave energy); the gravitational interaction between the sun, the moon and the Earth (which results in sea tides); thermal energy of the Earth's core, as well as chemical reactions and radioactive decay in its bowels (geothermal energy of geysers).
L. Klymenko, S. Soloviov, G. Nord	Self-renewable energy sources include energy from sunlight, wind, geothermal, tides, etc.
A. Prokip	Renewable energy resources are resources that are constantly generated naturally or anthropogenically.

Eventually, they started to separate the legal regulation of the generation, transportation, exploitation and consumption of electricity from renewable sources from renewable transport fuels.

Under the Directive 2001/77/EC of the European Parliament and of the Council of 27 September 2001 on the promotion of electricity produced from renewable energy sources in the internal electricity market [9], they include wind, the sun, waves and other hydropower sources, geothermal energy sources. etc.

The Directive 2009/28/EC [2] considers renewable energy sources as a whole and indicates that energy from renewable non-fossil sources includes wind, solar, aerothermal, geothermal and ocean energy, hydropower, biomass, organic gas, purified gas sewage and biogas. It is noted that aerothermal energy is obtained in the form of heat in the atmospheric air, geothermal energy – in the form of heat from the surface of the earth, hydrothermal energy – in the form of heat of surface waters, biomass – biological share of production, waste and residues of biological origin from agriculture, including plant and animal substances, forestry and related industries, fisheries and aquaculture, as well as biological part of industrial and household waste [10; 11].

According to the Statute of the International Renewable Energy Agency (IRENA), the term "renewable energy" encompasses all forms of energy continuously produced by all renewable sources such as bioenergy, geothermal

energy, hydropower, ocean energy, including tidal, wave and thermal energy, solar energy, wind energy. Consequently, the IEA singles out the following types of renewable sources: biomass energy, geothermal energy, hydropower, ocean energy, solar energy, wind energy.

According to Art. 1 of the Law of Ukraine "On Alternative Energy Sources", alternative energy sources are recognized as renewable energy sources, which include solar, wind, geothermal, wave and tidal energy, hydropower, biomass energy, organic waste gas, sewage gas, biogas. In turn, secondary energy resources include blast furnace and coke oven gases, coal bed methane, conversion of the waste energy potential of technological processes.

The study of "REMAP 2030. Renewable Energy Prospects for Ukraine", published in April 2015 by the IRENA, proves that Ukraine has significant potential for renewable energy, which is more than 98.0 million tonnes of fuel equivalent per year (see Table 2).

Table 2

The technically achievable potential of energy generation from renewable energy sources and alternative fuels

Areas for utilizing renewable energy sources	The technically achievable potential of energy generation, million tonnes of fuel equivalent per year
1. Wind energy	28.0
2. Solar energy, including	6.0
2.1) electricity	2.0
2.2) thermal energy	4.0
3. Small hydropower	3.0
4. Bioenergy, including	31.0
4.1) electricity	10.3
4.2) thermal energy	20.7
5. Geothermal heat energy	12.0
6. Environmental energy (heat pumps)	18.0
Total replacement of traditional fuel energy sources	98.0

Given its large potential of renewable energy sources estimated at 98 million tonnes, Ukraine currently uses it by only 5%. Only 11% of final consumption in

Ukraine is to be generated from renewable energy sources under the provisions of ESU-2035 (The Energy Strategy of Ukraine until 2035), the obligations to the Energy Community and the objectives of the National Renewable Energy Action Plan until 2020.

However, this was a political task rather than an objective assessment of realistic investment opportunities. Thus, the likelihood of its implementation is rather low. It must be noted that between 2007 and 2017 there was a gradual increase in installed capacity of renewable energy sources in Ukraine. However, the difficult economic situation in the country did not contribute to the achievement of the goals adopted in the National Renewable Energy Action Plan, which aims to achieve 11% share of renewable energy sources in energy consumption (see Table 3).

Table 3

Energy consumption based on renewable energy sources (between 2007 and 2017)

Year									
2007	2008	2009	2010	2011	2012	2013	2014	2015	2017
1. Total primary energy supply, thousand tonnes oil equivalent									
139330	134562	114420	132308	126438	122488	115940	105683	90090	91658
2. Hydropower, thousand tonnes oil equivalent									
872	990	1026	1131	941	901	1187	729	464	660
3. Total percentage, %									
0.6	0.7	0.9	0.9	0.7	0.7	1.0	0.7	0.5	0.7
4. Biofuel energy and waste, thousand tonnes oil equivalent									
1508	1610	1433	1476	1563	1522	1875	1934	2102	2832
5. Total percentage, %									
1.1	1.2	1.3	1.1	1.2	1.2	1.6	1.8	2.3	3.1
6. Wind and solar energy, thousand tonnes oil equivalent									
4	4	4	4	10	53	104	134	134	124
7. Total percentage, %									
0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1
Total energy from renewable energy sources									
8. Total energy supply from renewable sources, thousand tonnes oil equivalent									
2384	2604	2463	2611	2514	2476	3166	2797	2700	3616
9. Share of energy supply from renewable sources, %									
1.7	1.9	2.2	2.0	2.0	2.0	2.7	2.6	3.0	3.9

As of year-end 2017, 1.117 MW capacity of renewable energy sources was installed, producing about 1% of the total electricity generated. Wind and solar power plants account for the largest share of renewable energy sources in Ukraine, generating 925 GWh and 492 GWh of electricity in 2017, respectively.

Summary

Therefore, the main ways for developing renewable energy sources can be the following: to implement a stable and anticipated policy for stimulating the construction of solar power stations and wind farms; to conduct international communication campaigns to encourage the entry of foreign strategic and financial investors into the renewable energy market of Ukraine; to construct and force in application renewable energy sources of 5 GW capacity; to increase the use of biomass in the generation of electricity and heat.

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