

Ukraine: outlook to 2050

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At present Ukraine is developing as an independent state and defining its position in geopolitical system. Topical issue is Ukraine's integration into the world economy that will give advantages coming from participation in the world division of labour. Further development of international economic collaboration of Ukraine requires carrying out an energy policy coherent to the policy of leading world countries, first of all European Union. Discrepancy between energy policy and practical actions of Ukraine in this field may put us in discriminating position.

EU countries' goal is transition to sustainable development. In energy field they make great efforts to improve energy security, to increase the use of own renewable energy resources, to reduce negative influence of energetics upon environment. For the period till 2010 EU countries plan to raise the share of renewables up to 14.6% of the total primary energy consumption. Realisation of these plans and achieved big technological progress, particularly in wind energy and biomass utilisation, inspire them with more ambitious plans.

It is clear that to ensure sustainable development it is necessary to increase the efficiency of energy use with the transition to large-scale development of renewable energy. To estimate possibility for the transition to sustainable development in energy field, international organisation INFORSE (international network for sustainable energy) worked out scenarios for the development of energy sector in different European countries – "Vision 2050". The scenarios are based on data of the World scenario for the development of renewable energy.

Predicting further development of economy and energetics on the basis of modern and the most effective technologies, experts came to a conclusion about possibility to replace nuclear and fossil fuel (totally or partly depending on a region) by renewable energy sources (RES). For example, scenario worked out for Denmark demonstrates that transition to sustainable energy system will not exceed expenditures necessary for supporting traditional energetics, at least during the nearest 30 years. At the same time emission of CO₂ can be reduced by 70%.

Will Ukraine's energetics be able to develop in accordance with a similar scenario? Experts from Renewable Energy Agency carried out estimation of prospects for sustainable development of energy sector of Ukraine. For the analysis they used existing prognoses for the development of Ukraine's economy and data from the draft Energy strategy of Ukraine for the period till 2030. In contrast to provisions of the draft Energy strategy the experts assumed accelerated mastering technically available potential of RES. They also assumed that Ukraine's energetics would develop on technological and technical basis equal to the basis of EU countries.

The main indexes of Ukrainian economy development for the period till 2050

Strategy goal of Ukraine's economy development is the building of highly effective, highly technological developed state, which ensures adequate conditions and level of life for the population. There can be marked out three stages in the future development of Ukraine:

2001-2010 – the stage of structural reconstruction of economy;

2011-2020 – the stage of leading development of traditional branches and service;

2021-2030 – the stage of the beginning of transition to post-industrial society.

There are different scenarios for Ukraine's economy development - pessimistic, verisimilar and optimistic. Present investigation is based on the data [1] for pessimistic scenario.

Industry is the most important component of Ukraine's economy. Despite the crisis of 1990s its share in the economy remains considerable – more than 60% of gross revenue. In 2000 57% of industrial products was produced in power-consuming branches: energetics, metallurgy, chemical industry. Specific weight of machine building and metal processing products amounted only to 14.8%. Important issue is reconstruction of plants, and decrease of consumption of material and energy resources. According to existing prognosis even for pessimistic scenario the volume of industrial production (in comparable prices of year 1998) will be 1.4/1.8/2.2 times bigger as compared with year 2000 for years 2010/2020/2030 [1]. It can be assumed further growing 2.5/2.7 times for years 2040/2050. In industry specific consumption of heat and power during the period till 2050 will decrease by 30% and 50% correspondingly.

Agriculture provided about 12% of gross revenue in 2000. According to existing prognosis even for pessimistic scenario the volume of agricultural products (in comparable prices of year 1996) will be 1.5/1.9/2.3 times bigger as compared with year 2000 for years 2010/2020/2030 [1]. It can be assumed further growing 2.6/2.8 times for years 2040/2050. In agriculture specific consumption of heat and power during the period till 2050 will decrease by 40% and 50% correspondingly.

Construction provided about 6% of gross revenue in 2000. According to existing prognosis even for pessimistic scenario the volume of construction (in comparable prices of year 1998) will be 1.6/2.2/2.82 times bigger as compared with year 2000 for years 2010/2020/2030 [1]. It can be assumed further growing 3.1/3.3 times for years 2040/2050. In construction specific consumption of heat and power during the period till 2050 will decrease by 30% and 30% correspondingly.

To ensure development of industry and satisfy needs of population the physical volumes of transportation must be 1.25/1.6/2.57 times bigger as compared with 2000 for years 2010/2020/2030 even in accordance with pessimistic scenario of development [1]. It can be assumed further growing of transportation 3.0/4.2 times for years 2040/2050. It can be supposed that during the period till 2050 specific consumption of fuel by cars and buses will decrease by 40%, railway and aviation by 30% and water transport by 25%.

According to existing prognosis even for pessimistic scenario the volume of construction (in comparable prices of year 1998) will be 1.6/2.2/2.82 times bigger as compared with year 2000 for years 2010/2020/2030 [1]. It can be assumed further growing 3.1/3.3 times for years 2040/2050.

There is prognosis that the volume of housing and communal services construction (in comparable prices of year 1998) will be 1.6/2.2/3.1 times bigger as compared with 2000 in years 2010/2020/2030 [1]. It can be assumed further growing 3.5/4.3 times for years 2040/2050. In housing and communal services specific consumption of heat and power during the period till 2050 will decrease by 60% and 50% correspondingly.

In 1990 energy consumption of Ukraine was near 350 mill toe/year. Because of deep economic crisis current energy consumption decreased to 170 mill toe/year. According to existing prognosis it should be expected growth of energy demand with revival of economy.

Fossil energy resources of Ukraine

Explored reserves of **coal** in Ukraine amount to 52.6 milliard t that can satisfy demands of Ukraine for hundreds years. The main reserves of black coal are concentrated in the Donetsk and Lvov-Volyn' coalfields, brown coal – in Dnepropetrovsk oblast. From 1990 to 2000 annual

mining of coal dropped from 165 to 83 mill t [2]. It was because of economic crisis, structural reconstruction of the branch and competitiveness with relatively cheap natural gas from Russia. Potential productivity of currently existing mines makes 109 mill t/year and there is intention to rise coal consumption for energy generation. According to existing plans coal mining must be reached 110 mil t in year 2010, 117 mill t in 2020, and 120 mill t behind 2030 [1].

Explored reserves of **oil** and gas condensate in Ukraine amount to 222 mill t. For the most part they are small fields, which will not be able to cover demands of Ukraine. The maximal extraction of oil – 14.5 mill t – was achieved in 1972. From 1990 to 2000 oil extraction dropped from 5.2 to 3.8 mill t/year at the demand of about 35 mill t. It is planned in the future to stabilise oil extraction at a level of 5.2 mill t/year [3]. To our opinion it will be fulfilled due to high price of oil-derived products.

Explored reserves of **natural gas** in Ukraine are 1220 milliard m³. In 1970s a number of large fields of natural gas were worked. In 1975 natural gas extraction was 68 milliard m³. Remaining now gas reserves are dispersed over small fields, which cannot cover Ukraine's demands. In 2000 natural gas extraction was 18 milliard m³ at annual consumption of about 70 milliard m³. It is planned in the future to stabilise natural gas extraction at a level of about 31 milliard m³/year [3]. To our opinion it is not realistic because of high investments in small gas fields exploitation. We suppose that gas extraction will be at current level in foreseeable future. The situation with oil and natural gas in Ukraine clearly demonstrates possible exhaustion of fossil energy resources. Ukraine is one of the largest in the world importer of natural gas. There is task to decrease natural gas consumption in Ukraine.

There are on the territory of Ukraine big deposits of **uranium** ore, which are considered the great ones in the world. Availability of uranium ore permanently generates intention to create complete cycle for the extraction of uranium and processing of nuclear fuel in Ukraine.

From these data clear that resources of fossil fuel available in Ukraine cannot satisfy even current demand for energy. There are different scenario of energy supply in Ukraine. We would like to draw attention to possibilities in enlargement of renewable energy utilization in Ukraine, to show real resources and to avoid extremes in prediction of utilization of some types of renewables.

Renewable energy sources in Ukraine

Wind energy. Ukraine has favourable conditions for the development of wind energy. In many regions average annual wind velocity is 5-5.5 m/sec at a standardized height of 10 m above ground level.

It is considered that installed capacity of wind power plant (WPP) that can be achieved as a part of centralised energy system of Ukraine may come up to 16000 MW, and power generation may come up to 25-30 TWh/year. This figure is often accepted as a potential of wind power. The area necessary for the construction of such a WPP capacity is 2500-3000 km² that is quite real taking into account shoal of the Azov Sea and the Black Sea [1]. According to other estimations 7000 km² of Ukraine's territory can be used for the construction of WPP of 35000 MW total capacity. In present investigation it is accepted that WPP of 16000 MW total capacity can be potentially built in Ukraine. Accepted capacity factor is 30% (2630 hr/yr) that may be quite achieved in Ukraine's climatic conditions when using modern wind turbines [4]. With such assumptions the potential of wind energy is 42 TWh/year.

Currently total capacity of WPP is 50 MW_e. For the period till 2030 it is predicted the construction of WPP of 11290 MW total capacity with annual power generation of nearly 25 TWh/year. Prognosis for increasing capacity of WPP for the period till 2030 is accepted according to data [1] with slowing down rate in 2030-2050. Based on these prerequisites power generation by WPP may come to 42 TWh by 2050.

Solar energy. Period of sun shining at the territory of Ukraine is 1900-2400 hr/yr, and total average annual solar radiation varies from 1070 kWh/m² in northern part of Ukraine to 1400 kWh/m² in southern part.

Solar heat energy. Existing programmes for energy development envisages increasing use of solar energy mainly for local hot water supply in summer season. Potential of solar energy for heat production is estimated at about 32 TWh [1].

Climatic conditions of Ukraine allow also to use solar energy for the heating of buildings, creation of year-round centralised district heating systems with seasonal heat storage. Such technical solutions have been already realised in many countries located much more to the North than Ukraine. When using solar collectors (counting 3.9 m²/capita) [5] and 400 kWh annual heat production by 1 m² of solar collector, potential of solar energy for heat production is almost 75 TWh/year.

In present investigation rate for the installation of solar collectors for the period till 2030 is accepted in accordance with [1] with accelerating rate in 2030-2050. It may be assumed that by 2050 solar collectors will produce about 23 TWh_{th}/year.

Photovoltaic (PV). In Ukraine technical potential of solar energy for power production is estimated at about 16 TWh/yr [1] that makes up in average about 3.3 m² of PV batteries per capita with the production of about 100 kWh/m²/yr. Provided that a dwelling is equipped with modern and promising energy saving household appliances, indicated volume of power production could satisfy necessary household needs. It is assumed for year 2030 the PV-power generation makes 2 TWh/year, and that for 2050 makes 9 TWh/year.

The use of firewood and wood residues. In Ukraine forests cover only 15.6% of the territory, at that nearly half of them have environmental value. The country lacks for merchantable wood that is why timber is imported. The main forest areas are located in the Carpathians and Polissia (Forest Land) where more than 90% of wood is harvested. According to estimations [6, 7] wood potentially available for energy production makes up 1.6 mill m³/yr of felling residues, 2.1 mill m³/yr of wood processing waste, 3.8 mill m³/yr of firewood that in sum is equivalent to 16 TWh/yr.

In 2000 consumption of wood and wood waste for energy production amounted to about 5.8 TWh. According to prognosis [5] consumption of wood and wood waste for energy production will be about 13 TWh in 2030 and may achieve 16.3 TWh/year in 2040.

Further development of energy utilisation of wood can be also expected under reorganisation of forestry and intensive development of forestry. At present there are workable propositions aimed to raise productivity of Ukraine's forests to the level of neighbouring countries and achieve wood logging of 30 mill m³/yr and then 60 mill m³/yr without any harm to nature. So, prognosis on energy utilisation of wood in 2050 may be 25 TWh/yr.

The use of agriculture residues. Ukraine has good prospects to revive highly efficient agriculture, which is able to satisfy domestic needs in foodstuff and feedstock and also produce

products for export. The big part of the territory is steppe. It is characterised by low atmospheric precipitation, frequent draughts and other unfavourable phenomena. Due to that yields of the main crops are not stable. In accordance with estimations [6, 7] performed for unfavourable year 1999 potential yield of straw and stems may come to 35 mill t/year. Demand of agriculture is 13 mill t of straw a year, the surplus – about 20 mill t/yr that is equivalent to 82 TWh – can be used for other purposes including energy production.

In Ukraine some people have doubts as to possibility to use straw and stems for energy purposes. It can be explained by insufficient productivity of agriculture, big losses and burning of straw on fields, absence of stems storing.

Projects realized in Ukraine under support of European countries demonstrated technical possibility and economic expediency of straw application for energy production [7]. At present amount of straw used for energy production in Ukraine is equivalent only to 2 GWh/yr.

In accordance with the prognosis for the development of bioenergy in Ukraine [7] the use of straw and stems for energy purposes will be equivalent to 23 TWh in 2030. Further increase to 50 TWh/yr in 2050 may be assumed that will require up to 60% of technically available potential.

The use of biogas. According to estimations [6, 7] technical potential of biogas available for energy production consists of the biogas from manure (animal husbandry and poultry farming) – 2308 mill m³, the biogas from sewage sludge – 334 mill m³, and landfill gas – 2300 mill m³. In sum it is equivalent to 28.2 TWh.

Formerly in Ukraine biogas was widely produced at wastewater treatment plants, total volume of installed digesters was 162000 m³. Now biogas production in many cases is stopped because of bad technical condition of digesters, and because the state does not stimulate this activity. In 2000 the use of biogas was equivalent to 0.02 TWh.

A number of biogas plants for dung and manure processing are out of operation. Now in Dnepropetrovsk oblast a modern biogas plant is under construction that is supported by Dutch government. There was realized a demonstration project on the extraction and utilization of biogas on Lugansk landfill.

According to estimations [7] the use of landfill gas and biogas from sewage sludge will develop dynamically in the nearest years. After 2010 it is expected the increase in biogas production from animal husbandry waste. In 2030 total utilisation of biogas will amount to 10.2 TWh, and by 2050 it will achieve 17.4 TWh/yr.

Geothermal energy. Ukraine has a big potential of geothermal energy. According to official data of the Ministry of Ecology and Natural Resources reserves of thermal waters are 27.3 mill m³/day. Technical potential of geothermal resources is 97.7 TWh/yr. In 2000 geothermal energy utilisation amounted to 0.1 TWh. It is expected that total capacity of constructed geothermal district heating systems will be 9000 MW_{th} and that of geothermal power plants will be 400 MW_e in 2030. That will ensure production of 42 TWh, and in 2050 the production will come to 57 TWh [1].

Such degree of geothermal energy use seems to be too optimistic. Geothermal energy is renewable only in geological scale of time. Promising under geological conditions of Ukraine geo-circulating systems will exhaust aquifer resource during 20-30 years, and their renewing will take thousands of years. It means necessity to move geothermal energy extraction to other sites

every 20-30 years. In this investigation it is assumed that amount of utilized geothermal energy will be 8 TWh/year in 2030 and 14 TWh/year in 2050 that is equivalent to present use of geothermal energy in the whole Europe.

Hydro energy. Among all renewable energy sources hydro energy is known as technically proven technology for energy production. Seven large hydroelectric plants and one hydro accumulating plant of 3907 MW total capacity and 10-12 TWh average annual power generation were built on the Dnieper river.

The Dniestr hydroelectric plant of 702 MW capacity with 1 TWh average annual power generation was put into operation on Dniestr river in 1983. The Dniestr hydro power cascade will include the biggest in Europe Dniestr hydro accumulating plant of 2268 MW capacity and buffer hydroelectric plant. 50 small hydroelectric plants of about 100 MW total capacity with 0.25 TWh annual power production are exploited in Ukraine [8].

In Ukraine technically available potential of hydro energy is 81 TWh/yr. As for large hydroelectric plants and small hydro energy, total economically expedient unused potential is 17-19 TWh and up to 3.7 TWh correspondingly [1]. Then total economically expedient potential of hydro energy amounts to about 33 TWh/year.

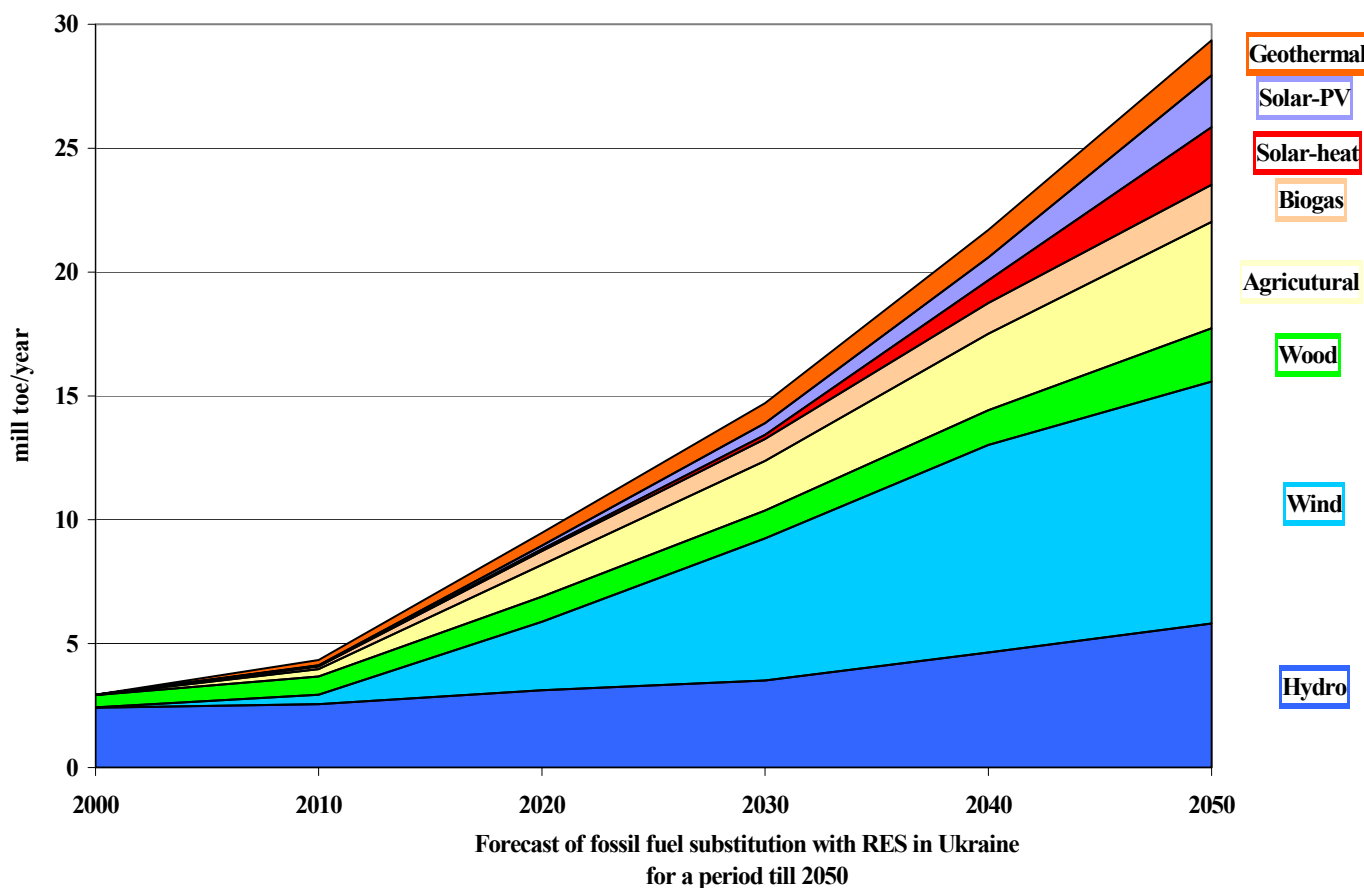
In Ukraine's conditions the development of hydro energy is real with the construction of hydroelectric plants of relatively high capacity (20-50 MW). Among priority measures is reconstruction of the hydroelectric plants of Dniepr cascade that will give 300 MW of additional capacity and increase in power production by 290 mill kWh.

Priority measure may be also the construction of hydroelectric plants on the section of the Tisa river from Burshtyn to Vilki of 220 MW total capacity.

Small hydro energy. Priority measure is considered the reconstruction of operating small hydroelectric plants and restoration of existing small hydroelectric plants, which are the most suitable for further exploitation. When constructing small hydroelectric plants priority will be given to plants, which protect neighbour territories from flood. There may be considered construction of small hydroelectric plants on existing water bodies, for energy utilisation in main canals, technical water supply systems and water drain.

In 2030 power production by hydroelectric plants may come to 15.1 TWh/yr [1]. Further increase in power production up to 25 TWh in 2050 may be expected.

It should be marked that value of individual RES also depends on the amount of fossil fuel that can be replaced by them. Power produced by hydroelectric plants, WPPs, PV units replaces almost three times bigger amount of fossil energy necessary for the generation of the same amount of power. In 2030 replacement of fossil fuel and nuclear energy by RES may be carried to 14 mill toe/year, and in 2050 - to 30 mill toe/year (see diagram).



Current power generation by nuclear power plants is about 80 TWh/year that is equivalent to the use of organic fuel in amount of 21 mill toe/year. Presented data shows that in the future it can be replaced by power production from renewables.

Ukraine's legislation on energy conservation and renewable energy

On the whole energy policy of Ukraine is directed at energy conservation and development of renewable energy utilisation.

In 1996 the Parliament of Ukraine (Verkhovna Rada) approved national energy program for the period till 2010. According to the program non-traditional and renewable energy will cover 10% of the total energy demand of the national economy in 2010. In 2000 topicality of this item of the program was confirmed in Recommendations of parliament session called "Energy policy of Ukraine".

In 1997 State Committee of Ukraine for Energy Conservation and National Academy of Sciences of Ukraine elaborated "The program of state support for the development of non-traditional and renewable energy and small hydro- and heat-power engineering as a component part of national energy program of Ukraine". According to the program 10% of the total energy and fuel consumption of Ukraine will be covered at the expense of non-traditional and renewable energy in 2010. The program consists of three stages: 1 stage – 1998-2000, 2 stage – 2001-2005, 3 stage – 2006-2010. The main task of the second stage is starting production of the equipment for the use of non-traditional and renewable energy and its implementation in Ukrainian regions.

Biomass and combustible gases (biogas, producer gas) which can be produced from biomass, are considered in the chapter “Non-traditional fuel”. Production of liquid fuels from biomass (fuel ethanol and bio-diesel fuel) is considered there too.

Governmental organisations responsible for RE issues in Ukraine are Ministry of Fuel and Energy and State Committee for Energy Conservation. Lately profile energy committee of Ukrainian Parliament has undertaken coordination in preparation of “Energy strategy of Ukraine for the period till 2030 and future perspective” including the section on RE.

A few Laws of Ukraine on renewable energy sources (RES) and co-generation have been recently developed/ accepted in Ukraine [9-11].

Law of Ukraine “On power energy” (October 10, 1997) with amendments (2000) envisages finance stimulus for wind power plant construction due to state budget expense. There are profitable tariffs for electricity generated at WPP. Really Ukrainian government gives such a support only for state owned wind power plants.

Now draft Law of Ukraine “*On corrective action to the Law of Ukraine “On power energy”*” has been developed and approved by the Cabinet of Ministers and has been submitted to the Verkhovna Rada (registration N 3504 from 16.05.2003). This draft Law was developed according the schedule of works on adaptation of Ukrainian legislation to legislation of EU. The subject of legislative regulation is improvement of relations on the power market, guaranty of power quality, in the sphere of construction of new generating capacities and free access to the power grids, stimulation of power production from renewable energy sources. Minister of Fuel and Power will present draft Law in Verkhovna Rada. According to this draft Law power supply companies must guarantee access to the power grids to small hydropower stations, and power stations producing power from renewable energy sources. New chapter IV “Stimulation of power production from renewable energy” is included in the draft Law. This stimulation includes:

- Purchase on the whole sale market of Ukraine power produced from RES;
- Guarantee access to the power grids for producers of power from RES;
- Installation of special tariff for the transportation of power from RES in the grids;
- Providing to RES power generating companies by subsidies, grants, tax, credit and other concessions.

The Law of Ukraine N 555-IV “*On alternative sources of energy*” was accepted by Verkhovna Rada on 20 February 2003. It is framework Law, which defines legislative, economic, ecological and organizational basis for the utilization of alternative sources of energy and promotion for their use in fuel-energy complex. According this Law term “alternative sources of energy” is equalized to “renewable energy sources”. This Law does not propose any financial stimuli and support mechanisms for producers and consumers of renewable energy sources. All financial stimuli and support mechanisms which where predicted in the first versions of the Law were excluded after some vetoes of the President of Ukraine in 2001 and 2002. First variant of this Law was registered in the Verkhovna Rada on 16.10.2000. That means that its acceptance took about 2.5 years with full excluding of financial stimuli and support mechanisms. In any case this Law has progressive significance such as indicated increase of renewable energy production and utilization as a main principle of State policy in this field.

The Law of Ukraine “*On combined heat and power production (co-generation) and utilization of dump energy potential*” (registration N 2583 of 08.05.2003) was accepted “in the first reading/ or as a base” by Verkhovna Rada on 23.05.2003. This Law regulates relations between

State, producers of power, which use co-generation technologies, dump energy potential of technological processes, and energy supply companies. This Law acts for qualified CHP plants, which started exploitation after 01.01.2003. It is proposed stimulation of construction and utilization of such CHP plants. National Commission on Regulation of Power Sector of Ukraine has to use profit norm of 22% for calculation and approval of sale tariffs for RES power. This figure is calculated from the condition that payback period for investments in such CHP plants will be less than 4.5 years. It is maximal payback period, which is still interesting for investors in Ukrainian conditions.

The “*Energy Strategy of Ukraine till 2030*” is under development by a group of Ukrainian energy experts on the decree of President of Ukraine. According to draft version targeted utilization of RES is 6.6 mtoe (4.7% of Primary Energy Consumption (PEC)) in 2010 and 21.8 mtoe (17% of PEC) in 2030.

Decree of President of Ukraine L. D. Kuchma “*On measures for the development of production of fuel from organic raw material*” of 26 September 2003 is also very important. The Decree envisages stimuli for the production of fuel ethanol, biodiesel and biogas.

Conclusion

Will Ukraine choose the way for sustainable development in energy sector? Draft “Energy strategy of Ukraine for the period till 2030 and further prospect” is being developed with big difficulties. Proposals for this document envisaged rather moderate use of RES, but a number of leading specialists do not want to take them into account properly. Nevertheless development of RES has legislative basis in Ukraine.

Enlarged use of RES would allow solving a number of existing problems connected with environmental pollution and global warming; it would also reduce danger of energy and economy crisis.

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