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# Perspectives of renewable energy sources use in enhancement of environmental and energy security of belarus

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Summary. Interest in renewable energy sources (RESs) has been growing all over the world in recent years. The market for alternative energy resources is quickly growing in Western Europe and Asia. The development of renewable energy is caused by two major factors, one of which is the environmental policy requirements. Its importance increases from the legislative point of view and from the conditions accepted by the Convention on Climate in December 1997. The main concern is energy production capacity. The preference is given to production forms which can be created and developed quickly. The development of RESs in many cases is closely connected with the maintenance of energy safety of the country, influencing its sovereignty and independence.

Key words: renewable energy sources, alternative energy.

## INTRODUCTION

Energy safety problems in Belarus are mainly characterized by the fact that the Republic must buy up to 85% of energy resources. The basic domestic direction for maintaining energy safety includes a number of fundamental ways to prevent threats, thereby reducing the probability of their occurrence and easing the consequences. On the one hand, there are energy wasteful industrial and household sectors in the country; on the other hand, there are essential energy-saving reserves (including RES use), both in the energy and in other sectors of the national economy [4,6,12,15,19,11]. Nowadays, satisfaction of needs in fuel and energy resources (FERs) of Belarusian consumers, maintenance of efficient fuel-energy balance structure of the country, and the quest for additional energy sources have become the three main problems posed for the fuel and energy complex in the Republic (see "The program of increase in the use of local fuel types and alternative energy sources for 2003-2005 and up to 2010"). The involvement of RESs in the economic turnover serves as an energy-saving component which is directed to realization of legal, organizational, scientific, industrial, technical, and economic measures of effective utilization of energy resources.

The Republic of Belarus does not have sufficient amount of its own FERs to maintain national economy needs. National resources of available fossil fuels are few and they are depleted practically up to 80-90%. The country imports about 84% of the consumed FERs. Obsolete capital assets in energy, industry, agriculture and habitation are used up to 70-90% [13]. Therefore, as a result of low supply with its own energy sources (at the level of 15-18% from the general need) the problems of energy safety are the major components of the national and economic security for the country. The necessity for increasing energy safety is mainly caused by the need to quickly solve this problem, because, if the delivery of energy resources is restricted, the Republic can suffer a loss from gross domestic product (GDP) underproduction to the sum of $400-450 with the expectation of 1 ton of standard coal (TSC). It repeatedly exceeds the cost of FER import from any existing or new suppliers according to world prices. In case of emergency conditions in fuel systems or in the event of switching-off the heat supply systems during the winter period, the size of damage can be increased many times [10,19].

The most important branch of the economy in any developed country is power engineering. The moving forces and trends of its development reflect the processes of economical state and development of the country, geopolitical situations, and historical prospects. Realization of the measures taken by the government during 1995-2000 allowed a suspension in the decrease in production in the Republic. By the end of 1996, positive dynamics of main macroeconomic processes were achieved, year-to-year increases of GDP and consumer and industrial goods production were provided. Investment activity grew. We

succeeded in stabilizing the situation in the domestic consumer market as well as financial enterprises. From 2001 to 2005 GDP grew by more than 43%. In Europe, from 2000 to 2004 GDP increased on the average 1.7% a year, in the USA 2.8%, in Japan 1.9%, in Belarus this parameter reached 9.2% in 2005.

In 1990, the total FER gross consumption came to 54,965 million TSC, in 2000 it was only 34.5 million TSC, in 2005 (according to evaluation data) it was 36.8 million TSC (Fig. 1). The main reasons for the sharp decrease in energy resource consumption in Belarus during 1990-2000 was the decrease in industrial production, structural, changes in the energy sector of the national economy, as well as tough governmental policy on every possible economy of energy resources. At the same time, the composition of used fuel was changing. The consumption of heavy oil fuel (black fuel, mazut) was decreasing and the consumption of imported Russian gas was increasing. The average price of Russian gas reached about $50 per 1000 $m^3$ (2009) and it has constantly been increasing, approaching the world level.

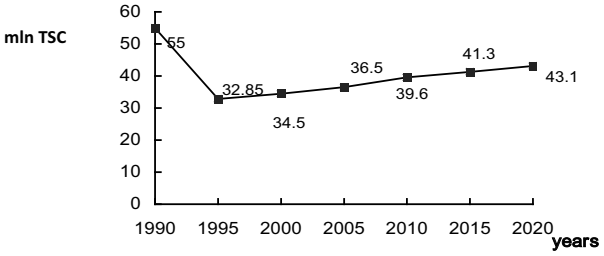


**Fig. I.** Time history of fuel and energy resources (FER) in Belarus (according to the data given by the Ministry of Statistics of Belarus and national energy development programs)

In the long-term outlook, the total FER gross consumption will grow. According to the formal forecast, by the year 2020, the size of total consumption will reach 43.1 million TSC, which is only 65- 70% of the consumption level that existed in 1990. In the future, the development of the national economy of the Republic should be followed by an increase of energy use efficiency, related to its consumption, development, and transportation. During 2001-2005, the GDP power consumption in the Republic decreased at a rate of 4.7-5.4% per year. In 2006-2010, average annual rates of energy consumption decrease were expected to be higher - 5.1-5.9% per year, and by 2020 they will decrease to 2.2-3.0% per year.

Nowadays, the problems facing power engineering specialists can be divided into two parts: application of new technologies using fossil fuel and development of alternative energy sources (wind and seasonal solar energy, biomass and waste).

## ANALYSIS AND PROSPECTS OF THE USE OF ALTERNATIVE AND RENEWABLE ENERGY SOURCES

### GENERAL CHARACTERISTIC OF THE PROBLEM

According to natural, geographic, and meteorological conditions in Belarus, alternative and renewable energy sources (RESs) can be the following: firewood and wood waste products, water resources, wind-driven potential, biogas from cattle-breeding waste, solar energy, phytomass, solid domestic waste, plant growing waste, and geothermal resources. There are several reasons why these energy sources should be widely used in the Republic. First of all, the work on the use of RESs will promote the development of our own technologies and equipment which can be exported in the future. Secondly, these sources, as a rule, are pollution free. This contributes to environmental security of Belarus. Thirdly,

**Table 1.** Economically expedient potential of the use of fire wood and wood waste products for heat and electric energy production

| Year | Firewood | | Wood waste products (million TSC) | Total (million TSC) |
|---|---|---|---|---|
| | million cubic meter | million TSC | | |
| 2003 | 4.18 | 1.11 | 0.28 | 1.39 |
| 2004 | 4.51 | 1.20 | 0.29 | 1.49 |
| 2005 | 5.36 | 1.43 | 0.31 | 1.74 |
| 2006 | 6.30 | 1.68 | 0.32 | 2.00 |
| 2007 | 7.29 | 0.33 | 2.27 | 2.27 |
| 2008 | 8.08 | 2.15 | 0.35 | 2.50 |
| 2009 | 8.95 | 2.38 | 0.36 | 2.74 |
| 2010 | 9.40 | 2.50 | 0.37 | 2.87 |
| 2011 | 9.88 | 2.63 | 0.39 | 3.02 |
| 2012 | 10.15 | 2.70 | 0.40 | 3.10 |

the development of such sources will raise energy safety of the state.

In order to cover the costs for the alternative energy sources, special attention should be paid to technical approaches using equipment produced in the Republic and with maximal use of local materials.

## FIREWOOD AND WOOD WASTE PRODUCTS

The Republic of Belarus has huge forest resources. The total area of the forest resources on 1 January 2001 was 9,248,000 ha, forest timber inventory - 1340 million cubic meters. Annual basic increase is 32.37 million cubic meters. A systematical and stable growth of forest resources can be predicted (up to 1.8 times in 2020) if a simultaneous improvement of age and stock forest structure takes place [18].

The centralized logging and firewood preparation in Belarus is carried out by enterprises of the Ministry of Forestry and by the Belarussian concern of wood-paper Industry. In 2003, the annual volume of firewood, sawing, and woodworking waste utilization as boiler stove fuel was 1.4 million TSC [Table 1] [19]. At present firewood fuel consumption for production of electric and heat energy by energy generative settings does not exceed 600,000 TSC per year.

The potential of the Republic to use wood as a fuel is estimated to be 3.5-3.7 million TSC per year, which is 2.5 times higher than in 2003. It should be pointed out that all the regions of Belarus own firewood recourses. On the whole in the Republic, the annual volume of firewood, sawing, and woodworking utilization was about 1.0-1.1 million TSC. Part of the firewood goes to population via self-stocking which is estimated at 0.3-0.4 million ISC.

Limited opportunities for Belarus to use wood as a fuel can be defined from the natural annual firewood increase. It is estimated at 25 million cubic meters or 6.6 million TSC per year including that for the contaminated areas of the Gomel region - 20,000 $m^3$ or 5300 TSC.

In order to use wood as a fuel in these regions it is necessary to work out and to apply new technologies and equipment for gasification and parallel decontamination. According to the planned double growth of firewood storage by 2015 and taking into account volume increases of wood waste products, sawing wastes and firewood processing, in 2005 the annual volume of firewood increased up to 1.6 million TSC.

International Sakharov Environmental University (ISEU) together with Austrian firm KOB developed a project on installation on the territory of Educational and Research Station Volma, Dzerzhinsk region, in 2006 of two modern heat-and-power engineering stations which will use raw wood bio-material. Heat-and-power engineering station PYROT with the capacity 250 kW (ground firewood) is shown in Fig. 2 (on the left side) [4,10].

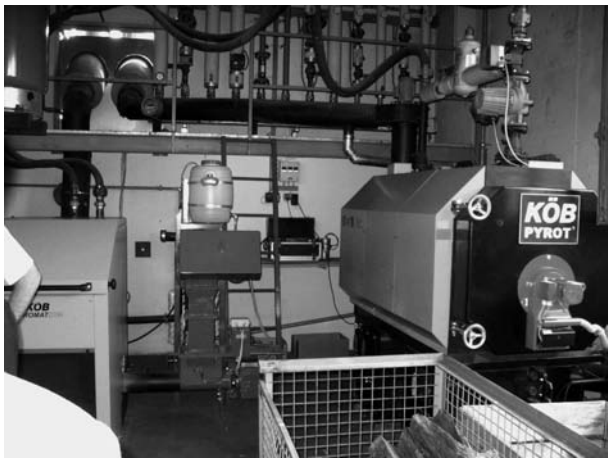


**Fig. 2.** Overview of heat -and-power engineering stations, KOB firm

Along with the use of wood waste products for heating purposes, it is worthwhile to provide economically grounded involvement of wood waste products of hydrolytic factories (lignine) into the fuel balance of the Republic. In the city of Rechitsa, Gomel region, a new industrial station using lignine has been put into operation. Lignine resources are about 1 million TSC per year, and an expedient volume of use is estimated to be 50,000 TSC per year. To solve the problem we need investment support, an application of the system of fixed prices, and a normative legal base modernization specified on tax preferences for enterprises producing electric and thermal energy from firewood.

## WATER POWER RESOURCES

The installed capacity of 20 hydroelectric power stations (HPSs) in Belarus was 10.9 MW on 1 January 2004. Due to water power resources about 28 million kWh of energy is produced annually. It is equivalent to the replacement of imported fuel at the rate of 7900 TSC. The potential capacity of all water channels in Belarus is 850 MW including technically accessible (520 MW) and economically expedient (250 MW) capacities [19].

The main directions of the development of small hydropower engineering in Belarus are the following: construction of new HPS, reconstruction, and restoration of existing UPS. The unit capacity of each hydropower unit will be in the range of 50- 5000 kW (Table 2), and the preference in that case will be given to quick mounted hydropower units of the capsular type.

Having the capacity of hydropower units from 50 to 150 kW it is possible to use asynchronous generators as the simplest and most reliable units in operation. As a rule, all the restored and newly constructed HPSs should work in parallel with power supply systems that will allow, in future, the simplification of circuit and constructive decisions.

Special attention in Belarus should be paid to the problems of cascade HPS construction on the rivers Sozh, Dnepr, and Pripyat because the possible scales of water flooding of the adjacent territories are limited by the zone contaminated with radionuclides.

## WIND-DRIVEN POTENTIAL

On the territory of Belarus there are 1840 sites for the installation of wind energy stations with a theoretical energy potential of 1600 MW and annual power generation of 6.5 billion kWh [19]. On 1 January 2005 the total capacity of installed wind energy stations was 1.1 MW and the replacement volume was 0400 TSC (Table 3). In fact, in 2005 in Belarus there were only three wing stations («Ecodom», Naroch-2, «Areola» Minsk-l) with the total capacity of 850 kW, and one rotor wind energy Station (Fig. 3) with the total capacity of 250 kW situated on the territory Educational and Research Station Volma, ISEU.

The development allowing the transformation of wind power into electric power by means of traditional wing wind energy stations used so far, in conditions of Belarus were economically unjustified. This fact was one of the reasons of the development of the rotor wind energy station (Fig. 3). However, modem technical development allows the creation of similar wing wind energy stations with a starting wind speed from 3 m/s and with rated operation speeds of 7-8 m/s. The cost of such stations is varying from $800 to $1200 for 1 kW of the established capacity. This makes such stations more attractive for use [20].

The Republic of Belarus is characterized by weak continental winds with the average speed of 4-6 m/s. Therefore, choosing the sites for the wind energy stations special tests and careful studies of FER on their application are required. In order to get an objective estimation about the reserve opportunity of full wind-driven potential, it is also required to complete a cycle of experimental research. The necessity of parallel work of wind energy stations with power supply system brings some complications into the general scheme and, thus, expenses for creation and operation of wind energy stations will increase considerably. At the same time, while calculating the expenses also the necessity of creation and maintenance of power reserve on other types of power stations should be taken into account. According to expert predictions, no more than 5% of the general potential

**Table 2.** Real and predicted volumes of the use of water and power resources for the electric energy production

| Year | Input capacity (MW) | Total installed HPS capacity | Increase of replacement volume (,000 TSC per year) | Power generation (million kWh_per year) | Total replacement volume (‘000 TSC) |
|---|---|---|---|---|---|
| 2005 | 0.76 | 11.94 | 0.97 | 34.9 | 9.77 |
| 2006 | 0.55 | 12.49 | 0.70 | 37.4 | 10.47 |
| 2007 | 18.37 | 30.86 | 23.50 | 121.3 | 33.97 |
| 2008 | 23.30 | 54.16 | 29.80 | 227.8 | 63.77 |
| 2009 | 20.80 | 74.96 | 26.60 | 322.8 | 90.37 |
| 2010 | 15.00 | 89.96 | 19.20 | 391.3 | 109.57 |
| 2011 | 0.29 | 90.25 | 0.40 | 392.8 | 109.97 |
| 2012 | 5.50 | 95.75 | 7.00 | 417.8 | 116.97 |

**Table 3.** Real and predicted volumes of the use of wind-driven potential for electric energy production

| Year | Total installed capacity of wind energy settings (MW) | Power generation (million kWh_per year) (TSC) | Total replacement volume (000 TSC) |
|---|---|---|---|
| 2005* | 1.2 | 2.15 | 0.60 |
| 2006 | 1.7 | 3.04 | 0.85 |
| 2007 | 2.2 | 3.94 | 1.10 |
| 2008 | 3.7 | 6.62 | 1.85 |
| 2009 | 3.7 | 6.62 | 1.85 |
| 2010 | 3.7 | 6.62 | 1.85 |
| 2011 | 5.2 | 9.31 | 2.61 |
| 2012 | 5.2 | 9.31 | 2.61 |

*Actual power for today

will be developed by the year 2005, i.e., 45 million kWh which is equivalent to 12,000 TSC.

**Fig. 3.** Overview of a rotor wind energy station, ISEU

One of the main directions of wind energy stations application will be their application for pump drive stations with low capacity (5-8 kW) and for water heating in the farming industry. These areas of application arc characterized by minimal requirements for electric energy quality that allows a simplification and sharp reduction in the price of wind energy stations.

### BIOGAS FROM LIVESTOCK WASTE

Tests results on biogas production from wastes of cattle-breeding complexes have proved that they are not economically competitive for only biogas production. The main reason is that it is possible to receive pollution-free and high-quality organic fertilizer without additional power expenses and as a result to reduce the power-consuming industry of mineral fertilizer production proportionally. The application of biogas allows us to improve environmental situation near the large-scale farms and cattle-breeding complexes, as well as on the areas under crops where livestock wastes arc spread nowadays, and in addition to receive high-quality biohumus fertilizers. Potential production of commodity biogas from cattle-breeding complexes is estimated to be 160 000 TSC per year, and by 2005 it will be no more than 15,000 TSC [19,2].

### GEOTHERMAL RESOURCES

In the Republic of Belarus, geothermal resources with the density of more than 2 TSC/m$^2$ and the temperature of 50°C at the depth of 1.4-1.8 km, and 90-100°C at the depth of 3.8-4.2 km are found in the Gomel and Brest regions [19]. However, high mineralization, low productivity of available wells, small number of wells and, on the whole, our poor knowledge of this resource will not allow the development of this RES for the next 10-15 years.

### SOLAR ENERGY

According to meteorological data, on average in Belarus there are 250 overcast, 85 rainy, and 30 clear days in a year. To satisfy electric power needs of Belarus in the volume of 45 billion kWh, 450 km$^2$ of heliostats are required. The price of heliostats is $450 per m$^2$, which is equal to $202.5 billion without the expenses for the exploitation of the synchronizers, building and construction works, cables, control systems, technical services, infrastructure, etc. The listed components will double the given sum.

Taking into account foreign experience and the experience gained from the building of a solar power station in the Crimea, specific capital investments and energy production costs are ten times higher using solar energy than using other sources. Technical progress in this area will promote the reduction of costs; however, in the case of Belarus, electric power production using solar energy will not be practical in the near future.

The main directions of solar energy utilization will be heliowater heaters and various heliostations for intensification and enhancement of drying processes as well as water heating in the farming industry [1,14].

In Belarus heliowater heaters with welded plastic collectors are worked out and prepared for large-scale manufacture. Therefore, the expensive heavy-metal pipes are not required for solar collectors, which makes their production more economical. Provided favorable conditions of economic and manufacturing facilities, the widest application of heliowater heaters in southern regions of the Republic can be expected.

At the same time it is expedient to develop in Belarus the following resources:

– Self-contained power supply with capacity starting from some watts up to 3-5 kW (home equipment, lightening, power supply of residential houses, lines of communication, etc.)
– Modular photoelectric stations for rural consumers with the capacity from 0.5 to 1 kW based on the elements modern generation

The development of such sources and stations needs a number of research efforts to create modern materials, to improve the quality of the existing materials (based on silicium), to reduce its price and, consequently, the price of the finished products.

In the favorable conditions of economic and manufacturing facilities a replacement of about 25,000 TSC per year of organic fuel with solar energy can be expected by 2020.

In the ISEU the solar water heating station («Doma», Austria) with the capacity of 1.0 kW and the photoelectric station («Fotovoltaik», Austria) have been used successfully for more than 5 years. They arc used for emergent lighting of the ground floor and as a training and visual appliance in the educational process (Fig. 4). In the near future it is planned to install also a photoelectric station with a capacity of 1.5 kW («Stromaufwaerts» Austrian firm) in the educational-hotel building of the University in Volma.

### DOMESTIC WASTE

The percentage of organic substances in domestic waste is about 40-75%. Domestic waste consists of 35-40% carbon, 50-88% combustible components, and 40-70% ash. The caloric value of domestic waste is 800-2000 kcal/g [19,8].

In world practice, power production from domestic waste can be realized in several ways such as burning, active and passive gasification. Gasification has the greatest potential in contrast to direct burning as the latter causes environmental problems. To solve these problems, an investment twice exceeding the cost of the burning stations would be needed.

In Belarus about 2.4 million tons of solid domestic waste is collected annually. They are dumped or directed to two waste reprocessing plants (in Minsk and Mogilev). Annually, the following amount of solid domestic waste is collected there (in thousand tons):

– Paper - 648.6.
– Food wastes-548.6.
– Glass-117.9.
– Metals - 82.5.
– Textile-70.8.
– Wood-54.2.
– Leather and rubber - 47.2.
– Plastic - 70.8 [19].

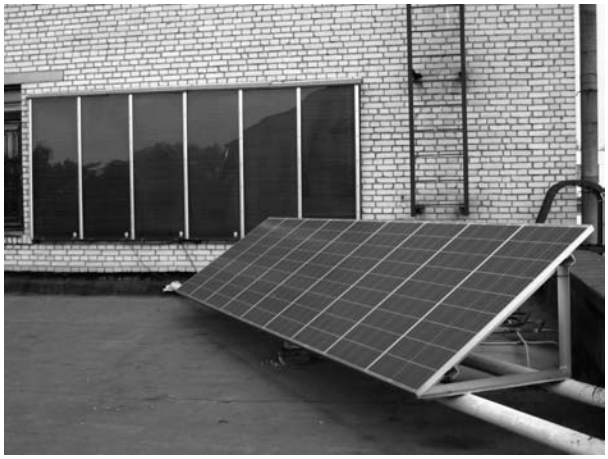

**Fig. 4.** Overview of solar water heating and photoelectric stations, ISEU

Potential energy of solid domestic waste collected in Belarus equals 470,000 TSC. In the case of biotreatment of these wastes with the purpose of gas production, the efficiency will not exceed 20-25%, which is equal to 100,000-120,000 TSC. Long-term stocks of solid domestic waste from all large cities should be taken into consideration due to the problems of its storage. It could be possible to get about 50,000 TSC from the processing of solid domestic waste into gas in the regional cities of Belarus, while in Minsk this number could be equal to 30,000 TSC. The efficiency of that direction should be estimated not only from the direct output of biogas, but also from the ecological component which is the basis in this problem. Certain characteristics of the effectiveness can be received on the basis of detailed design studies, creation, and operation of experimental-industrial area. By 2005, it can be possible to get up to 10,000 TSC.

### PHYTOMASS

As a raw material for liquid and gas fuel production, a periodically RES -phytomass of fast-growing plants and trees - can be used. In the climatic conditions of the Republic, a great number of plants in the amount of 10 t of dry substance which is equal to 5000 TSC are collected from 1 ha of power plantations. Using some additional agricultural methods the productivity of a hectare can be doubled. From this quality of phytomass it could be possible to get 5-7 t of liquid products equivalent to mineral oil. For raw material production the most appropriate would be the use of worked out peat deposits where no conditions for agricultural crops can be found. The area of such deposits in the Republic is about 180,000 ha, which can become a stable, pollution-free source of energy raw material in a volume up to 1.3 million TSC per year [4,16,11].

The use of rapeseed oil as an energy resource has great potential for the Republic of Belarus. The Republic has experience in rape cultivation; there are also some rapeseed-processing plants there. Taking into account the fact that rape does not accumulate radionuclides, its cultivation on the areas contaminated after the Chernobyl accident becomes particularly important. There is some experience gained in that direction. Thus, for example, in 2005 a diesel power station with the capacity of 300 kW (electric energy) and 400 kW (thermal energy) running on rapeseed oil was installed and put into operation by the Institute of Radiology, Otto Hugo Munich University together with ISEU. This station was put into operation in the milk-processing plant in Khoiniki within the framework of a humanitarian project – Fig. 5.

**Fig. 5.** Overview of diesel power station, working on rapeseed oil in Khoiniki

The lack of experience in the wide use of phytomass for energy production does not allow the estimation

of the expenses and future prices of the fuel. Special techniques, road infrastructure, reprocessing enterprises, etc, should be developed for this purpose. However, according to the integrated calculation the price adds up to $35 per TSC. According to the expert estimations by the year 2012, about 70,000-80,000 TSC can be received due to the use of phytomass for energy production [3,17,5].

### PLANT GROWING WASTE

The use of plant growing waste for energy production is considered to be a fundamentally new direction in energy savings. Practical experience of plant growing waste application as the energy earner has been acquired in Belgium and the Scandinavian countries, but not yet in Belarus. The total potential of plant growing waste is estimated to be about 1.46 million TSC per year (Table 4) [19]. The decisions on expedient volumes of burning plant growing waste for fuel production should be made by comparing certain economic needs. By the end of the predicted period this value is estimated at the level of 40,000-50,000 TSC.

**Table 4.** Real and predicted volumes of the biogas production, domestic waste, phytomass for electric and thermal energy production

| Energy resource (,000 TSC) | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|
| Biogas | 6.6 | 13.2 | 19.8 | 26.4 | 32.9 | 39.5 |
| Domestic wastes | 4.9 | 9.9 | 14.8 | 19.8 | 24.7 | 29.6 |
| Phytomass | 12.4 | 24.7 | 37.1 | 49.4 | 61.8 | 74.1 |
| Total | 23.9 | 47.8 | 70.7 | 95.6 | 119.4 | 143.2 |

From Table 4 it can be seen that due to all renewable and alternative energy sources, as well as thermal secondary power resources, mineral oil, oil gas and peat, the volume of local energy carriers is estimated as 6.75 million TSC per year.

## CONCLUSIONS

A working system on the development of the potential including educational programs for decision-making people and users of technologies should be carried out for the further development and application of alternative energy sources in Belarus. In spite of great efforts undertaken by the State Committee of Energy Efficiency and other authorities, alternative power is introduced in Belarus by a small number of pilot projects and technologies. The most successful projects are those using wood waste products for gasification with the subsequent burning and generating of thermal energy; also some small HPSs, four powerful industrial wind energy stations belonging to «Ecodom», «Areola», and ISEU; and one biogas station. Still, that is not enough. One of the low-cost ways to improve the present situation in wind-power engineering in modern economic conditions is to import second-hand wind energy stations with the capacity exceeding 100 kW. It is connected with the fact that in Europe wind energy stations with the capacity of 100-200 kW in the near future will be replaced by more powerful stations with the capacity from 600 kW up to 2.5 MW. The diagram given in Figure 6 describes the prospects of RESs and local fuel type development. A percentage of total consumption of FERs is given by nongovernmental organizations and State Committee of Energy Efficiency.

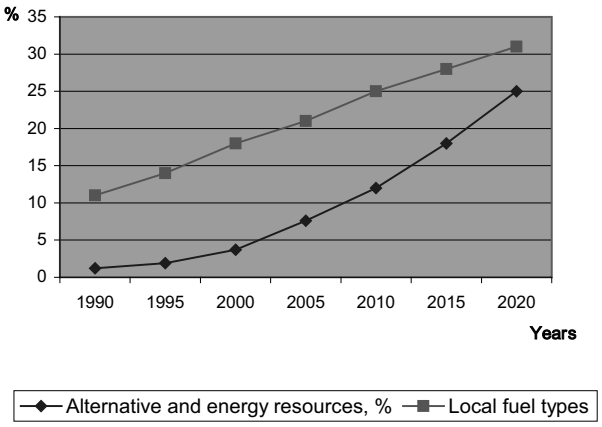


**Fig. 6.** Prospects of the development of alternative energy sources and local fuel types up to 2020 (ratio of total consumption FER, %)

On the whole, the described tendencies of the alternative and RESs development in the Republic of Belarus meet the same tendencies in Europe. The application of new technologies of biogas production from a renewable biomass - rapeseed oil for diesel engines and ethanol for carburetor engines - shows considerable promise for Belarus. Experience of some agricultural productions in the Grodno and Gomel regions has shown ecological expediency of the application of these technologies. It is very important to complete and update these technologies to the industrial level for local conditions and to introduce them into production by 2020. During this period the drastic cost increase for liquid mineral fuel is predicted with significant reduction of its natural resources.

The application of new technologies of biomass utilization (fast-growing wood, wood waste products) as boiler-stove fuel is also a very important question during the mentioned period. In Belarus production facilities for wide introduction of biomass gasification technologies already exist; also pilot projects on the development of these technologies have been carried out there with the support of UNDP and other international organizations. The development of these technologies will be especially important for cities and towns with wood-processing power and an advanced agrarian sector.

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## ПЕРСПЕКТИВЫ ИСПОЛЬЗОВАНИЯ ВОЗОБНОВЛЯЕМЫХ ИСТОЧНИКОВ ЭНЕРГИИ В ПОВЫШЕНИЯ ЭКОЛОГИЧЕСКОЙ И ЭНЕРГЕТИЧЕСКОЙ БЕЗОПАСНОСТИ БЕЛАРУСИ

Р е з ю м е . В последние годы интерес к возобновляемым источникам энергии (ВИЭ) растет во всем мире. Рынок альтернативных источников энергии быстро растет в Западной Европе и в Азии. Развитие возобновляемой энергии обусловлено двумя основными факторами, одним из которых являются экологические требования. Ее значение возрастает с законодательной точки зрения и в связи с этими условиями принята Конвенция по изменению климата в декабре 1997 года. Второе требование касается наращивания производства энергии. В соответствии с этим требованием предпочтение отдается производству форм энергии, которые могут быть созданы и быстро развивались. Развитие возобновляемых источников энергии во многих случаях тесно связана с энергетической безопасностью страны, влияющие на ее суверенитет и независимость.

К л ю ч е в ы е  с л о в а : возобновляемые источники энергии; альтернативные источники энергии, Беларусь.