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RENEWABLE ENERGY AND ENERGY EFFICIENCY AS MAIN COMPONENTS OF ENERGY SECURITY

Energy security. The security of energy supply, particularly electricity becomes more and more critical issue. The interruption of electricity supply can incur significant financial losses and create havoc in cities and urban centers. Energy security is a shared issue not only for importing of energy resources countries but for exporting ones as well. The new threats to energy security have appeared in recent years: unpredictable fluctuation of energy carriers prices, disruption of trade due to policy of transit countries, reduction in strategic reserves, large scale disruptions of electricity supply and deregulation of energy systems in some countries, reduction of investments to energy sector as a result of financial crisis.

Energy security implies the availability of energy, in its different forms and at all times, to users in sufficient quantities and at reasonable prices during normal period as well as in required quantities for overcoming consequences of environmental and technical emergencies. Additionally involves *prevention of serious accidents in energy system itself.*

Energy security should be considered at many levels: global, regional (e. g. EC, CIS, Balcans countries), national (country), local.

At the national level there are the following main threats to energy security:

Internal

– shortage of domestic fuel and power resources;

– high energy intensity of economy;

– lack of adequate country (or regional) strategic reserves to cater for any transient interruption, shortage or unpredictable high demand;

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– ageing of energy equipment and systems;
– in appropriable energy prices;
– non-payment for energy delivery;
– Not adequately dealing with environmental challenges.

External

– notability to draw on foreign energy resources that can freely imported through port, other transport means and cross-boundary energy grids (pipelines and electricity networks);
– low diversification of energy export:
  – by countries;
  – by types of fuel;
– interruptions of energy trade and supply;
– shortcoming and gaps in energy treaties, charters and trade agreements;
– lack of foreign investments.

Energy security is a major issue for Republic of Belarus because domestic fuel and power resources only cover 15% of national needs. Therefore the Concept of the Energy Security of the Republic of Belarus was developed by National Academy of Sciences of Belarus, Ministry of Energy, Ministry of Economic, Department of Energy Efficiency etc. If was approved by President of the Republic of Belarus in September 2007.

Generally there are following four main trends of enhancing of energy security:

1. Increasing of the share of domestic fuel and power resources (energy independency);
2. Alternatives for fuel and power supply (diversification);
3. Upgrading of reliability of energy system;
4. Improving of energy efficiency (energy saving).

The Concept aims to increase energy production from internal sources and decrease the energy intensity of the economy. The current goal is to achieve up to 25% of total energy consumption by means of domestic resources including renewables.

As a mechanism of realization of the Concept the National Program on Domestic and Renewable Energy Sources Development during 2011-2015 and Republican Program on Energy Saving during 2011-2015 were adopted by Government of the Republic of Belarus in May 2011 and December 2010 respectively.

Renewable energy contributes in directions 1 and 2 of energy security enhancing.

Renewable energy is developing by unprecedented pace in recent years. Grid-connected solar PV has grown by an average of 60% every year for the past dec-

ade. During from 2005 to 2009 wind power capacity grew an average of 27%, solar hot water by 19% and ethanol production by 20% annually.

Along with recognized leaders such as Germany, U. S., Denmark, Sweden in the field of renewable energy in recent years China, India, Brazil are beginning to play an important role, notable efforts was made by Argentina, Costa Rica, Egypt, Indonesia, Columbia and other. In 2009 China produced 40% of the world's solar PV supply, 30% wind turbines and 77% of the world's solar hot water collectors.

The main reasons for increased interest in renewable energy sources (RES) in both developed and developing countries are following:

– running out of conventional fuel resources;
– eliminating the threat of climate change;
– energy security.

As in others high-tech areas development of renewable energy requires joint efforts and cooperation of various countries, exchange of experiences, knowledge and technology, training of producers and end-users of renewable energy installations. The work of international organizations in this area is of great importance. At various times the following internationals organizations have been created:

– European Renewable Energies Federation (EREF);
– European Renewable Energy Council (EREC);
– Global Wind Energy Council (GWEC);
– Greenpeace;
– International Clean Energy Consortium (OCEC);
– International Hydropower Association;
– Renewable energy and Energy Efficiency Partnership (REEEP);
– World Wind Energy Association (WWEA).

Finally in 2009 the established was International Renewable Energy Agency (IRENA). To date 48 countries and the European Union signed the Charter of the Agency and 50 countries have ratified it. On April 2011 the Assembly of the IRENA held its first inaugural session.

Session of the Assembly of the IRENA reaffirmed, that problem of the use of RES is relevant for both rich and poor in fuel and energy resources countries. The latter category includes the Republic of Belarus.

Renewable energy in Belarus. As it is known renewable energy is defined by following categories of potential:

– theoretical;
– technical;
– economic or environmental.

In the Tab. 1 these potentials are presented for Belarus.

Table 1. Potential of Renewable Energy in Belarus

Source	Theoretical	Technical	Economic or Environmental
Hydro, TWh	1.7	1.0	0.6
Wind, TWh	Not ass.	2.8	Not ass.
Solar, TWh	11.2	1.2	Not ass.
Fire Wood, Mtoe/y	2.9	2.9	2.2
Biogas, Mtoe/y	Not ass.	0.27	Not ass.
Municipal Waste, Mtoe/y	0.33	0.07	Not ass.

Wind. The average annual wind velocity in Belarus is less than 4 m/s and in majority of sites it changes from 3 to 4 m/s. Nevertheless 1840 „windy sites" in the country have been found theoretically with average wind speed of 5.5-6.5 m/s near the ground and 6.5-7.5 m/s at the height of 40 m.

Taking into account the moderate wind conditions in Belarus the new type of wind turbine has been developed on the basic of Magnus effect. It was equipped with rotating cylinders instead of conventional blades. The efficiency of this turbine has been demonstrated during testing of pilot unit with capacity of 100 kW. At present the second unit with capacity of 250 kW is under operation not far from Minsk city (Fig. 1).

Figure 1. Picture of rotary wind turbine with capacity of 250 kW

Figure 2. Module wind turbine unit
with total capacity of 52.5 kW

This wind turbine was designed and manufactured by enterprise „AEROLLA" which was founded in Belarus about ten years ago. Except rotary the conventional module wind turbine unit with capacity of 10 kW each was developed (Fig. 2). It is expected that cost of this type of turbine in Belarus will be 500-550 EURO/kW without tower and 600-700 EURO/kW together with tower.

Hydro. At present in Belarus there are 41 small hydro power plants (HPP) with total capacity of 16.1 MW and annual generation about of 48.6 GW·h of electricity (0.13% of total consumption in the country only). It is estimated that theoretical hydro power potential is about 850 MW, of which 520 MW are technically feasible and 250 MW are economically suitable. The design of construction of two middle-scale HPP cascades is developed: 4 plants with total capacity of 132 MW on West Dvina river and 2 plants (37 MW) on Neman river. The construction of

33 new HPP with total capacity of 102.1 MW is envisaged by National Program including:

– 4 units with capacity above 10 MW each;
– 9 units with capacity from 100 kW to 10 MW;
– 20 units with capacity less than 100 kW.

Solar. There are only 1815 sunshine hours in average per year at the latitude of Minsk, the capital of Belarus. The average energy density of solar radiation is 32 W/m² taking into account cloudy and night time. Therefore the typical solar energy implementation in the country is domestic hot water system. In order to estimate the efficiency of the system under different meteo conditions a demonstration scale collector was constructed (Fig. 3). It consist of 30 panels with total surface of 24 m² which were installed at the angle of 30° to horizon (South-South-East orientation). The average period of operation of such unit in Belarus is approximately 6 months (from the middle of April to the middle of October).

Figure 3. Experimental module of solar heating system

It was investigated that the average heat flow during a season varied from 1 to 2 J/m² and water temperature reached 65 °C. In 2010 the solar heater with capacity of 120 kW have been commissioned in Soligorsk. The construction of 41 solar heating units on the Belarus Railway is planning according to the National Program.

Figure 4. Boiler with capacity of 1.2 MW

At present PV solar cells with efficiency from 13 to 15% and cost from 3 to 3.5 US$/W are manufactured in Belarus. They are mainly used for electrical herd systems and local supply of cottages and small farms with electricity. The annual production is about 300 kW. The potential of 1 ktoe per year is prognosis level of utilization of solar energy for the nearest future.

Geothermal energy. Two regions with density of geothermal energy from 115 to 175 GJ/m^2 and water temperature of 50 °C at the depth 1.4-1.8 km and 90-100 °C at the depth 3.8-4.2 km are found. At present estimation of total geothermal potential in Belarus is being made. It is supposed that activity in this direction shall be carried out in the framework of research and development during 2011 – 2015.

Biomass. Wood fuel is the most significant renewable energy resource in Belarus. The annual accretion of timber biomass is assessed to reach 32 mill. m^3, from which 10-12 mill m^3 are harvested. At present only 4.3 mill. m^3 firewood is used by households and 0.9 mill m^3 wood industry waste is burned in municipal boilers. New designs of boilers with capacity from 0.25 to 1.5 MW and efficiency up to 82% are developed for using of wood waste (Fig. 4).

According to the Concept the use of wood biomass as a fuel has to increase to 11 mill m^3 in 2020. Seven small CHP power plants from 1.2 to 3.7 MW with use wood chips as a fuel were constructed during recent years. In Belarus there are almost 270 thousand hectares of soil which have been excluded from economic

turnover due to high level of radioactive contamination after Chernobyl NPP accident. The technology of utilization of contaminated biomass has been developed by the Institute of Power Engineering Problems (Sosny-Minsk, Belarus) and Sandia National Laboratories (Livermore, USA). The most attractive option could be the fast rotation coppice technologies that can provide not only additional biofuel but certain removal of radioactive source term from contaminated soil.

The investigation of biomass production through short rotation crops was set up by Institute of Power Engineering Problems (at present Joint Institute of Power and Nuclear Research) in co-operation with RISO National Laboratory (Denmark) and SCK-CEN (Belgium). It was received that 5.1 tons dry matter can be harvested annually on sand soil and 10.5 tons on peat soil.

The Concept envisages the following grows of renewable resources:

– wood biomass as a fuel…… from 1 to 2.2 Mtoe/y;

– Wind PP…… from 0.85 to 5.2 MW;

– Hydro PP…… from 9 to 200 MW.

EnergyEfficiency. Tab. 2 compares the development of the primary energy-GDP intensity of Belarus with other selected countries. Over the past decade, Belarus has made good progress in reducing its energy intensity compared to the many former Soviet Union countries. Energy efficiency has been a top priority for the Belarus Government since the mid-1990 s and by now has brought tangible results.

Since 1992, the primary energy-GDP intensity has fallen steadily at an average rate of 5.3% per year. However, the 2005 intensity of 16.2 GJ per $1 000 at year 2000 purchasing power parity (2000 ppp) – equivalent to 0.385 toe per $1 000 (2000 ppp) – is still more than double the intensity found in many of its neighboring Western European countries.

The combined impact of the following administrative and market measures allowed Belarus to reduce energy intensity:

– the passage and enforcement of energy efficiency legislation;

– the establishment of the Committee on Energy Efficiency, which is empowered by an effective mandate to promote energy efficiency and monitor compliance with energy efficiency targets by sectors and regions;

– an increase in energy tariffs and cash collections;

– the availability of budget funds to catalyze energy efficiency investments;

– the establishment of energy efficiency targets for sectors and regions along with administrative and financial sanctions against economic agents and leadership that fail to meet the targets;

– fiscal and staff incentives for enterprises implementing energy efficiency projects; and

– a public awareness campaign.

Table 2. Energy efficiency and economical indicators for 2008 (IEA)

Country	TPES/ pop. (toe/ capita)	Elec. cons./ pop. (kWh/ capita)	TPES/GDP (toe/th USD 2000 y)	TPES/GDP (PPP) (toe/th USD 2000 y)	GDP (PPP)/ pop. (th USD 2000 y /capita)
World	1.83	2782	0.3	0/19	9.55
OECD	4.56	8486	0.18	0.16	27.62
Former Soviet Union	3.65	4660	1.59	0.4	9.00
Austria	3.99	8218	0.15	0.12	32.70
Belarus	**2.91**	**3427**	**1.17**	**0.31**	**9.37**
Czech Republic	4.28	6461	0.56	0.21	20.61
Denmark	3.46	6462	0.11	0.11	31.09
Estonia	4.03	6346	0.57	0.24	16.81
Finland	6.64	16351	0.23	0.21	31.56
Germany	4.08	7148	0.16	0.14	28.64
Latvia	1.98	3087	0.33	0.14	14.55
Lithuania	2.73	3557	0.46	0.17	16.01
Norway	6.22	24868	0.15	0.15	40.61
Poland	2.57	3733	0.41	0.17	14.70
Sweden	5.36	14811	0.17	0.17	32.19
Ukraine	2.94	3534	2.55	0.4	7.34
Serbia	2.18	4284	1.16	0.31	6.95
Albania	0.66	1373	0.37	0.12	5.56
Croatia	2.05	3878	0.21	0.1	15.15
Bosnia and Herzegovina	1.59	2467	0.71	0.17	9.10

It was estimated the total energy saving potential in direction 4 up to 2020 consists of 6700 Mtoe, *i. e.* about 30 % of present annual primary energy consumption. According to the Concept it is planning to reduce energy intensity of GDP up to:

2010 by 31 %

2015 by 50 %

2020 by 60 %

in comparison with 2005.

Re-use of waste heat is one of the most effective options energy-saving policy. In Belarus the total theoretical potential waste heat achieves 75 PJ/y (Tab. 3), technically feasible – 41 PJ/y, but utilization in year 2003 – 13 PJ.

Table 3. The theoretical waste heat potential in Belarus (PJ/y)

Chemical and petrochemical industry	46.5
Power district heat generation	11.4
Industry of building materials	7.4
Machinery and metallurgy	4.1
Others	5.6

More then 30 heat exchangers for production of steam and hot water by utilization of waste heat was developed in the Joint Institute of Power and Nuclear Research – Sosny. One of them is showed on the Figure 5.

Figure 5. Picture of the salvage heat exchanger with output of 10 t/h of steam