

NEW CHANGES IN THE LITHUANIAN ENERGY SECTOR

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Abstract. One of the most important strategic goals in Lithuania is implementation of sustainable development provisions. Taking into consideration closure of Ignalina Nuclear Power Plant implementation of this aim depends very much on development of the Lithuanian energy sector. This paper presents some findings from the analysis of the Lithuanian energy policy and the energy sector development, in particular taking into consideration the role of energy efficiency, renewable energy sources and nuclear energy. The paper focuses on changes in primary energy balance and in deployment of renewable energy sources over the period 2010–2020. The paper also presents analysis of changes in electricity generation taking focus on factors stimulating construction of new regional nuclear power plant in Lithuania and factors limiting its attractiveness.

Keywords: Energy sector, sustainable development, nuclear energy, energy intensity, renewable energy.

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1. Introduction

Environmental protection encompasses many aspects of rational and safe use of natural resources, including legal, biological, technological and economic measures. Environmental policy is one of the most dynamic of the European Union (EU) policies in particular taking into consideration concerns related with climate mitigation. It is influenced by many activities in various sectors of the economy since the role of environmental quality and human health is very important factor affecting the development of national, regional and global policies.

Activities in the energy sector, mining, manufacturing, transport sector and other industrial sectors are associated with environmental pollution, usage of limited natural resources, and therefore poses certain danger to the environment and human health. Policies

leading to sustainable development create favourable conditions for achieving the welfare for future generations. Principles of sustainable development should be integrated into all activities based on the common understanding of environmental requirements, responsibilities and mechanisms of appropriate legislative determination in all the EU-27 countries.

The main principles for sustainable development were laid down at the United Nations conference on environment and development in Rio de Janeiro in 1992. It was agreed that “in order to achieve sustainable development, environmental protection shall constitute an integral part of the development process and cannot be considered in isolation from it” (The United Nations... 1992). Thus, sustainable development has been validated as a major ideology of long-term social development in many countries.

Lithuania being in transition from centrally planned to a free market economy since early 1990s has had an ambitious plan to become a member of the EU and to integrate into democratic international organisations, as well as to approach gradually to an average of leaving standards in developed European countries. At the same time Lithuania was ready for active cooperation with developed countries in the field of environmental protection. In 1992, the Lithuanian Environmental Protection Programme, covering the most important environmental problems including means and order of their solution, was prepared. In 1996, the National Environmental Protection Strategy was prepared and approved by the Lithuanian Parliament (National Environment Protection Strategy 1996). The Strategy included provisions related to the key environmental problems for that time and for the period of its implementation, the main priorities and objectives, principles of environmental policy, processes of the country's integration into the EU structures, as well as means for implementation of the Strategy. Most of the Strategy provisions and planned measures were successfully implemented.

New activities in the area of the country's sustainable development were stimulated by an aspiration to take part and to prepare the Lithuanian report for the Summit Meeting in Johannesburg in 1992. Taking into consideration the Plan for Implementation of this World Summit outcome, in 2003, the National Strategy for Sustainable Development was prepared and approved by the Lithuanian Government (National Strategy for Sustainable Development 2003). Sustainable development is treated in the Strategy as a compromise between environmental, economic and social goals of society, allowing reaching the commonweal for the society and for future generations, without exceeding limits of negative impact on environment. In 2009, taking considerable changes in the national economy and the energy sector the updated National Strategy for Sustainable Development was prepared and approved by the Lithuanian Government (Updated National Strategy for Sustainable Development 2009).

Efforts for sustainable development of the energy sector are clearly declared in the National Energy Strategy (Lithuanian Energy Institute 2003, 2008; The Government of Lithuania 2010). Provisions in these documents confirm that Lithuania will comply with the obligations in the energy sector assumed under international environmental conventions and

will implement the requirements set in the EU environmental directives. One of the most important priorities of the Lithuanian energy policy is to contribute into initiatives and attempts of the EU directed to reduction of greenhouse gas emissions and mitigation of climate change in the world.

The aim of this paper is to set out some findings from analysis of the Lithuanian energy policy and the energy sector development, in particular taking into consideration the role of energy efficiency and deployment of renewable energy sources. The paper also presents analysis of changes in electricity generation especially taking focus on factors stimulating construction of new regional nuclear power plant in Lithuania and factors limiting its attractiveness.

2. Impact of the Lithuanian energy sector on environment

Total emissions of the main pollutants (CO, NO_x, SO₂, non-methane volatile organic compounds and particulate matter) from all stationary and mobile sources of pollution in Lithuania during the period 1990–2000 decreased more than 2.5 times, from 1.1 to 0.45 million tons. The emissions from stationary sources of pollution in Lithuania decreased more than 4 times. This reduction was stipulated by the decline of activities in manufacturing, more efficient use of energy resources by end users and the introduction of measures reducing pollution (Statistics Lithuania 2009 b).

Reduction of total air pollutants was caused by significant reduction of carbon monoxide. One can see also a tendency of reduction in the total volume of sulphur dioxide and particulate matter. Only volumes of nitrogen oxides and volatile organic compounds were increasing during this period. In 2010, the major contribution into air pollution was from the energy sector (67 % of SO₂, 65 % of particulate matter and 52 % of CO), transport sector (68 % of NO_x and 45 % of CO) and manufacturing (65 % of volatile organic compounds). Implementation of measures directed to reduction of SO₂ and NO_x emitted into atmosphere by implementing the national emission reduction and ambient air quality improvement programmes is required (Baublys *et al.* 2011).

Currently more and more concerns are related with reduction of greenhouse gas emissions. In many

countries major sources of greenhouse gas emissions are: the sector of electricity and heat generation, fuel combustion in branches of economy, oil refining and emissions from other activities in the energy sector. Specific feature of the Lithuanian energy sector is that more than 70 % of electricity in 1990–2009 was generated by Ignalina Nuclear Power Plant (NPP). Therefore contribution of energy transformation sector into balance of greenhouse emissions so far was rather low. As one can see from Figure 1, total amount of energy-related greenhouse gases emissions

in 2000 was by 3 times lower than in 1990 (United Nations Framework...2012) owing to significant reductions of electricity and district heat generation using fossil fuels and during this period even larger (by 5.3 times) reduction of emissions was from fuel combustion in manufacturing, construction, agriculture, household and services sector. Reduction of greenhouse emissions in the transport sector which remains important source of air pollution (Ambrzevičius, Baublys 2001) during the period 1990–2000 was comparatively low (by 1.8 times).

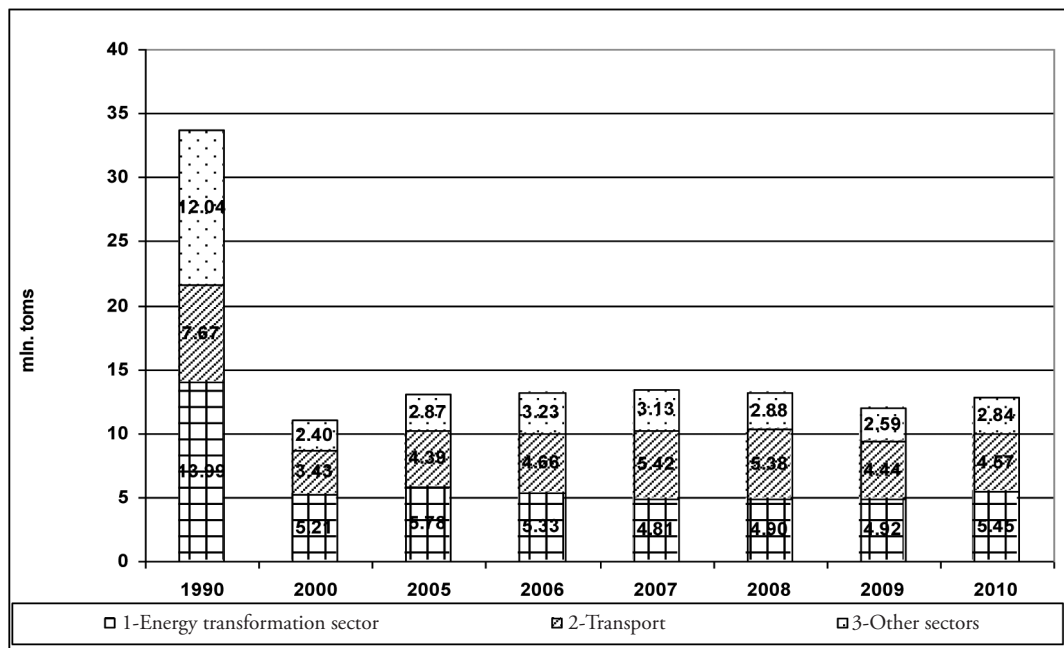


Fig.1. Emissions of greenhouse gases caused by fuel combustion: 1 – Energy transformation sector; 2 – Transport; 3 – Other sectors

Source: United Nations Framework Convention on Climate Change (2012)

In principle energy-related greenhouse gas emissions should reflect the trend of total primary energy consumption in the country. However, due to dominant position of Ignalina NPP in the electricity generation greenhouse gas emissions from the energy transformation sector during the period 2000–2008 did not increase. And vice versa significant increase (by 1.8 times) of emissions during this period from the transport sector was caused by fast growth of activities in this sector.

The changes of total greenhouse gas emissions over the period 1990–2010 are given in Table 1 (United Nations Framework... 2012). In 2000, total emissions decreased to 39 % from the base year (1990) level, but during the period 2000–2008 greenhouse

gas emissions increased by 25 % due to growing activities in various sectors. In 2009, as a result of economic recession greenhouse gas emissions decreased to 41.4 %, but in 2010 increased again to 43.1 % from the 1990 level. In 2010, the share of energy-related activities in the balance of greenhouse gas emissions was 59.7 %, share of agriculture – 24.0 %, industrial processes – 10.5 %, and share of solid waste disposal, waste incineration, etc. – 5.8 %.

Table 1. Greenhouse gas emissions in Lithuania, million tons

	1990	2000	2005	2006	2007	2008	2009	2010
Energy-related emissions	33.70	11.04	13.04	13.21	13.36	13.15	11.95	12.85
Energy transformation sector	13.99	5.21	5.78	5.33	4.81	4.90	4.92	5.45
Transport sector	7.67	3.43	4.39	4.66	5.42	5.38	4.44	4.57
Other sectors	12.04	2.40	2.87	3.23	3.13	2.88	2.59	2.84
Industrial processes	4.30	3.03	4.10	4.36	6.16	5.50	2.30	2.25
Agriculture	10.57	4.68	5.26	5.25	5.41	5.16	5.15	5.16
Waste and solvents	1.36	1.40	1.38	1.32	1.30	1.27	1.27	1.25
Total	49.93	20.14	23.78	24.14	26.23	25.08	20.67	21.52

Source: United Nations Framework Convention on Climate Change (2012)

Lithuania has ratified the Kyoto Protocol with commitment to reduce greenhouse gas emissions from the

1990 level by 8 % during the period 2008–2012. Currently Lithuania has no problems to comply with this obligation. But in a future amount of emissions will grow owing to closure of Ignalina NPP and increased consumption of fossil fuels for electricity generation as well due to increase of fuel combustion in other sectors of the economy caused by expected economic growth. Therefore provisions of sustainable development in the energy sector could be implemented by increasing energy efficiency, fast deployment of renewable energy sources and possibly construction of new nuclear power plant. Activities directed to reduction of greenhouse gases emissions in non energy-related activities could be based under implementation of modern technologies in manufacturing, improvement in waste management, etc.

3. Primary energy supply

The Lithuanian energy sector constructed through 1990 was oriented towards large, but inefficient energy consumption, as well as towards considerable exports of electricity from Ignalina Nuclear Power Plant (Ignalina NPP) and refined oil products from Māžeikiai Oil Refinery. Important features of the energy sector are very high dependence on primary

energy supply from one country (Lithuania depends on Russia for 100 % of its natural gas, for more than 90 % of its crude oil and almost 100 % of coal requirements), from one side, and still existing excess in electricity generating capacities as well as in the oil refining capacity exceeding by three times the country's internal demand, from another side.

Since 1990 due to significant reduction of economic activities, structural changes, reduced export of electricity and other factors primary energy demand was decreasing and in 2000 total primary energy supply was by 2.2 less than in 1990. But the period 2000–2008 could be characterized by stable and fast economic growth – GDP was increasing on average by 7.4 % per year. In 2009, GDP decreased by 14.8 %. Currently the country's economy is recovering – GDP increased by 1.5 % in 2010 and by 5.9% in 2011. The development of the total primary energy consumption was stipulated by this economic growth but with certain fluctuations owing to changes in export of electricity to neighbouring countries during the period 2000–2008, and in particular due to closure of Ignalina NPP at the end of 2009. These changes in thousand tons of oil equivalents are shown in Table 2 and Figure 2.

Table 2. Primary energy consumption in Lithuania

Year	Electricity import/export	Indigenous resources	Coal	Nuclear	Oil and oil products	Natural gas	Total
	Thousand toe						
2000	-114.9	816.6	88.5	2193.9	2168.7	2064.3	7217.1
2001	-341.0	850.3	79.2	2961.0	2574.2	2146.7	8270.4
2002	-557.9	943.8	135.5	3685.5	2472.7	2170.4	8850.0
2003	-647.6	987.4	173.6	4035.0	2348.1	2354.3	9250.8
2004	-618.8	1013.1	169.3	3935.5	2540.9	2348.4	9388.4
2005	-255.1	1063.4	187.6	2694.0	2691.9	2476.9	8858.7
2006	-36.8	1118.3	260.7	2254.5	2690.2	2454.5	8741.4
2007	-118.0	1194.8	253.6	2562.4	2727.5	2892.1	9512.4
2008	-82.3	1231.2	219.4	2578.3	2955.7	2596.0	9498.3
2009	-252.1	1276.3	169.4	2828.2	2495.7	2181.6	8699.1
2010	515.1	1284.9	209.6	0	2552.4	2492.0	7054.0
2011	579.5	1314.1	232.2	0	2445.4	2718.8	7290.0

Year	Electricity import	Indigenous resources	Coal	Nuclear	Oil and oil products	Natural gas
	%					
2000		11.3	1.2	28.8	30.1	28.6
2001		10.3	1.0	31.7	31.0	26.0
2002		10.7	1.5	35.3	28.0	24.5
2003		10.7	1.9	36.6	25.4	25.4
2004		10.8	1.8	35.3	27.1	25.0
2005		12.0	2.1	27.5	30.4	28.0
2006		12.8	3.0	25.4	30.8	28.0
2007		12.6	2.7	25.7	28.7	30.3
2008		13.0	2.3	26.3	31.1	27.3
2009		14.7	1.9	29.6	28.7	25.1
2010	7.3	18.2	3.0		36.2	35.3
2011	7.9	18.0	3.2		33.5	37.3

Source: Statistics Lithuania 2004, 2006, 2007, 2008, 2009 a, 2010, 2012; Baublys *et al.* (2011)

During the period 2000–2009 the share of the nuclear – the cheapest imported fuel – was very high and fluctuated about 31 % with the lowest value of 25.4 % in 2006, and the highest value of 36.6 % in 2003. The role of nuclear fuel was very important because being comparatively cheap nuclear fuel helped to relieve certain burden of balance of payments and therefore soften social problems during transition period. Nuclear fuel helped also to increase the security of the primary energy supply, especially in the power sector. The share of nuclear energy in the primary energy balance in the year 2009 (year of the final closure of Ignalina NPP) was 29.6 %.

Oil and oil products were the most important fuels in Lithuania over several decades. However, since 1990 their role was decreasing owing to significant reduced use of heavy oil products for production of electricity and district heat. During the period 2003–2008 contribution of oil products into the primary energy balance was increasing due to fast growth in consumption of motor fuel, and in 2008 it was equal to 31.1 %. However, in 2009, due to significant reduction of motor fuel consumption, share of oil products decreased to 28.7 % and increased again to 36.2% in 2010.

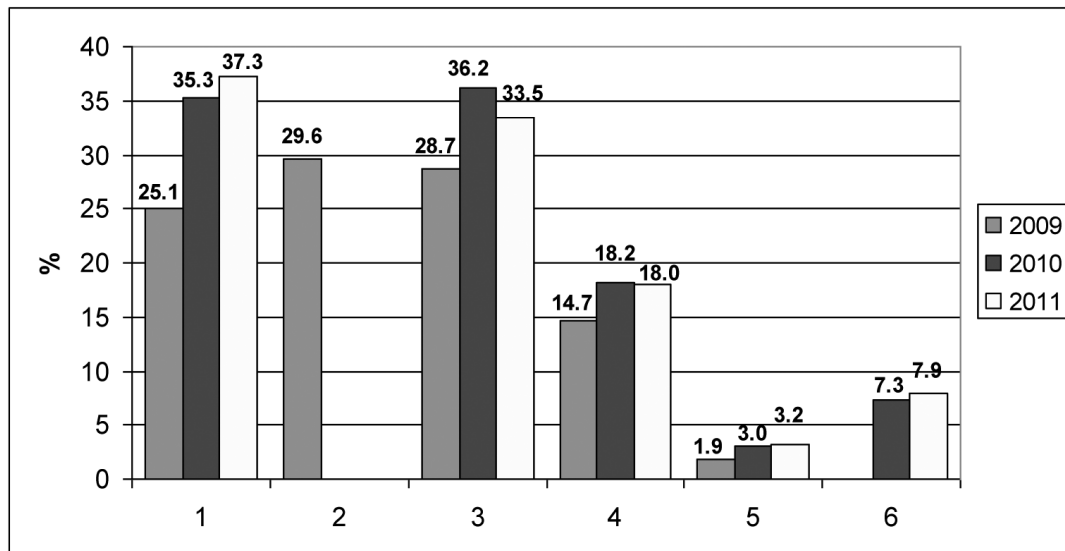


Fig.2. Primary energy consumption in Lithuania: 1 – Natural gas; 2 – Nuclear energy; 3 – Oil products; 4 – Indigenous resources; 5 – Coal; 6 – Electricity import

Source: Statistics Lithuania 2004, 2006, 2007, 2008, 2009 a, 2010, 2012; Baublys *et al.* (2011)

At present natural gas is one of the most important fuels in the Lithuanian primary energy balance. The share of natural gas, the most attractive fuel in a long-term perspective, was about 25 % over the period 1990–2008. During the two years (2008 and 2009) period total consumption of natural gas was decreasing mostly owing to reduction of its non-energy use – in 2009, consumption of gas for production of mineral fertilizers was by 1.6 times less than in 2008 and by 1.9 times less than in 2007. Due to this reason the share of natural gas in the balance of total primary energy decreased from 30.4 % in 2007 to 27.3 % in 2008 and to 25.1 % in 2009. Owing to closure of Ignalina NPP the share of natural gas increased to 35.3 % in 2010 and to 37.3 % in 2011.

The role of coal was continuously decreasing – from 4.8 % in 1990 to 1.0 % in 2001. During the period 2002–2007 the share of coal in the primary energy balance was increasing and in 2007 reached 2.7 %, but in 2009 its contribution decreased again to 1.9 %. In 2011 the share of coal accounted to d 3.2 %.

4. Role of renewable energy sources

Primary energy resources in Lithuania are rather scarce. Currently the following indigenous resources are used for energy requirements: local oil, peat, wood, geothermal and hydro energy, as well as energy from chemical processes. In 2011, the share of all indigenous resources in the country's primary energy

balance was 19.6 %. Major share of extracted local oil is exported and its production since 2001 is decreasing. Peat-bogs are comparatively small and peat is used mostly in agriculture and in particular for horticultural needs. Certain contribution into balance of indigenous resources is originated from energy of chemical processes. This energy corresponds to the content of the thermal energy gained in the chemical processes (production of fertilizers), which is transferred into hot water and steam.

As it is shown in Figure 3, contribution of renewable energy sources (due to limited indigenous resources) is rather significant and since 2001 they are playing more and more important role. In 2011, the share of renewable sources in the balance of indigenous energy resources increased to 73.9 %. Currently wood (including wood waste, boughs, wood chips, pellets, sawdust and waste from agriculture) is the main renewable energy source. The contribution of hydro energy in absolute value is fluctuating depending on climatic conditions with comparatively small changes, and since 2006 contribution of bio-fuels, used as a motor fuel for the road transport, as well as of wind energy is increasing.

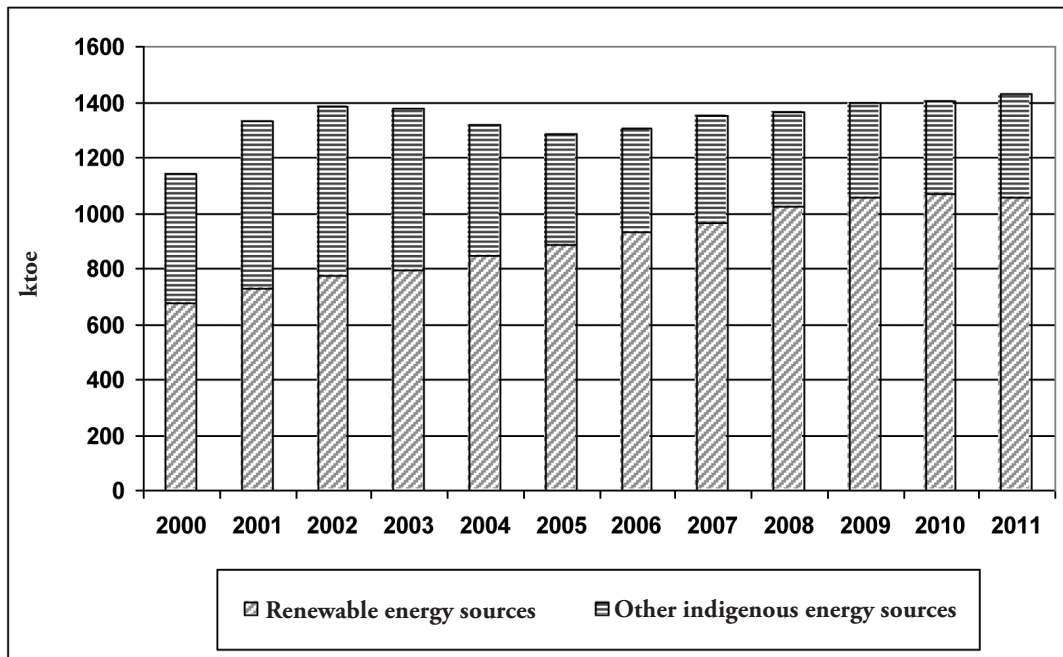


Fig.3. Consumption of indigenous and renewable energy sources

Source: Statistics Lithuania 2004, 2006, 2007, 2008, 2009 a, 2010, 2012; Miškinis *et al.* (2011)

Contribution of renewable energy sources could be illustrated by several indicators. The most aggregated are the following: 1) share of renewable energy in the country's primary energy balance, 2) share of green electricity in the gross electricity consumption, 3) share of renewable energy resources from the gross final con-

sumption. As one can see from Figure 4, the share of renewable energy in the primary energy balance is growing but with some fluctuations which are caused mostly by different volumes of electricity exported to neighbouring countries and by corresponding consumption of nuclear energy.

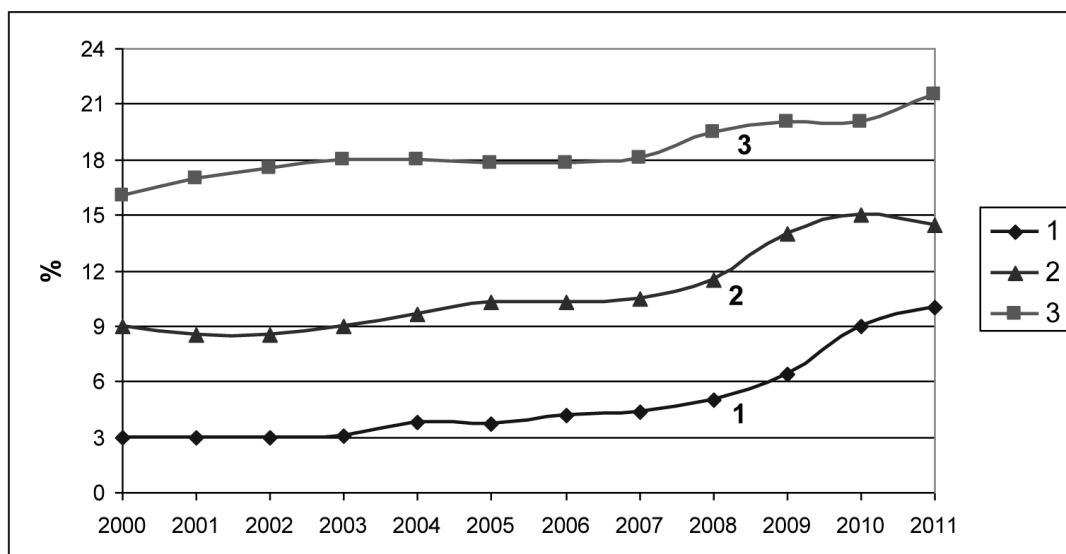


Fig.4. Changes in contribution from renewable energy sources in Lithuania: 1 – share of RES from gross electricity consumption; 2 – share of RES from total primary energy consumption; 3 – share of RES from gross final energy consumption

Source: Statistics Lithuania 2004, 2006, 2007, 2008, 2009 a, 2010, 2012

In 2010, owing to significant reduction of the total primary energy consumption this indicator was the highest during last twenty years – 15.1 %. Fluctuations of the share of green electricity are related to changes in the gross electricity consumption and also in volumes of its generation by hydro power plants. The largest contribution of green electricity into balance of electricity consumed for all country's internal needs was in 2011 with 9.6 %. The share of electricity from renewable energy sources will increase faster in a near future as a result of planned construction of new wind power plants.

At present the main aggregated indicator, used in the EU-27 countries, is the share of renewable energy sources in the gross final consumption. In 2004, the value of this indicator was equal to 17.3 %, but it increased till 19.9 % in 2010 and to 20.4 % in 2011 owing to reduction of the gross final energy consumption.

Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources provides mandatory national targets for each the EU-27 country, which are consistent with a target of at least a 20 % share of energy from renewable sources in the Community's gross final consumption of energy in 2020 (The European Parliament 2009) The national overall target for the share from renewable energy sources in the Lithuanian gross final consumption in 2020 is not less than 23 %. To achieve this target the Lithuanian Government adopted a National Strategy for Deployment of Renewable Energy Sources (2010), setting out the electricity and heat production from renewable energy sources as well as production and consumption of biofuels in the transport sector, covering the period 2010–2020. The objectives set out in this Strategy could be described by the indicators presented in Table 3.

Table 3. Indicators of renewable energy consumption

	2015	2020
Biomass for production of district heat, ktoe	418	539
Heat produced from geothermal energy, ktoe	4	5
Heat from solar energy, ktoe	5	9
Direct use of biomass in branches of the economy, ktoe	461	484
Renewable energy from heat pumps, ktoe	6	14
Total renewable sources in heating and cooling, ktoe	894	1051
Biofuels in the transport sector, ktne	111	169
Electricity from hydro power plants, GWh	446	470
Electricity from wind power plants, GWh	924	1250
Electricity from solar power plants, GWh	13	15
Electricity from power plants using biomass, GWh	761	1223
Gross electricity generation from renewable sources, GWh	2120	2945

Source: National Strategy for Deployment of Renewable Energy Sources (2010)

Based on comprehensive analysis, performed at Lithuanian Energy Institute applying the optimisation MESSAGE model, the reasonable share from renewable sources in the gross final consumption in 2020 should reach at least 21 % (Galinis *et al.* 2010; Miškinis *et al.* 2011). This target could be achievable for Lithuania without any support schemes in a case when the functioning of the energy sector is based on free market principles. A key factor promoting the wider use of energy from renewable sources is the external costs when using fossil fuels. These costs could be partly assessed for energy facili-

ties as a charge for CO₂ emissions. Taking into consideration the impact of these charges, the volume of consumption of renewable energy sources over the next decade should increase by 1.8–2 times. In this case the share of energy from renewable sources in the gross final consumption in Lithuania would reach 26–29 % in 2020. The higher value is expected in a case of low prices for renewable energy sources, the lower – in the case of high prices for renewable energy sources. A significant contribution is expected in these scenarios from electricity generation using renewable energy sources – reasonable target for ratio

of the green electricity to gross electricity consumption is 27–31 % in 2020. Very high potential for wider use of energy from renewable sources is related with modernization of the district heating systems and changes in their fuel balance. So far natural gas is dominating in the fuel balance of this sector with a 19 % share of biomass. Based on the performed analysis, the rational share of biomass in this sector is expected to increase up to 53–62 % over decade.

5. Alterations in energy efficiency

Inefficient use of energy is one of the legacies of central planning in all countries of Central and Eastern European countries. Therefore policy for increasing energy efficiency since 1990 was and remains as one of the most important strategic objectives in Lithuania. The most popular indicators of energy efficiency used in various publications are: primary energy intensity and final energy intensity. The first one, measured as the gross primary energy consumption

per unit of GDP, is used for comparison of overall energy efficiency in various countries. Another one, measured as total final energy consumption per unit of GDP, is applied for comparison of how efficiently final energy is used by the end users.

Since 1995, primary energy consumed per unit of GDP at constant prices, has been decreasing in Lithuania by 5.4 % per annum. In 2011, this indicator was by 2.4 times lower than in 1995 (Figure 5). Final energy intensity was decreasing on average by 4.2 % per year and decreased during the period 1995–2011 by 2.0 times. In 2009, inelastic behaviour of energy consumers was confirmed – GDP decreased by 14.8 %, but the primary energy consumption decreased by 8.4 % and the final energy consumption – by 9.5 %. Owing to larger reduction of GDP than energy consumption, in 2009, primary energy intensity in Lithuania was by 7.6 %, and final energy intensity by 6.3 % higher than in 2008.

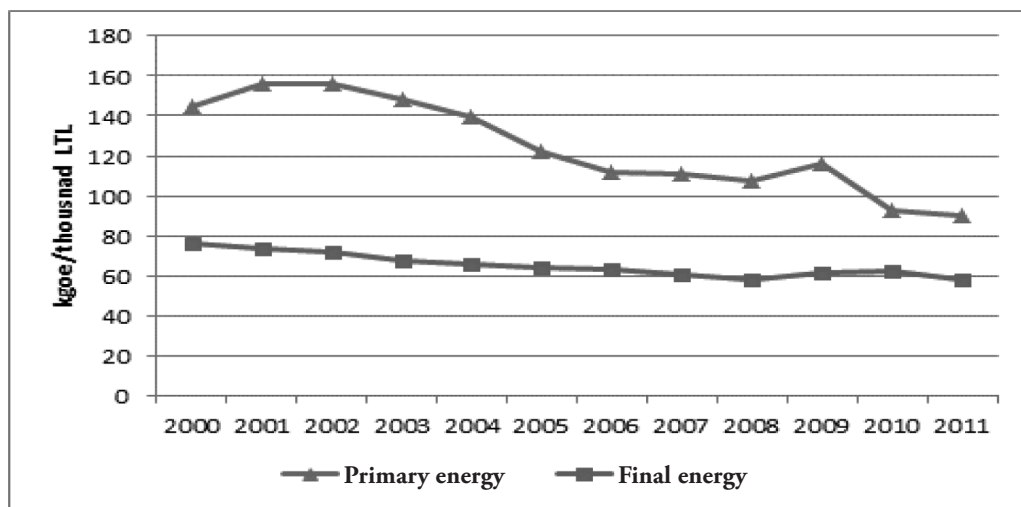


Fig.5. Changes of energy intensity indicators in Lithuania

Source: Statistics Lithuania 2004, 2006, 2007, 2008, 2009 a, 2010, 2012

To compare overall energy efficiency in Lithuania and other countries, the ratio between the gross inland consumption (total primary energy supply) and the GDP could be applied. Currently in the Eurostat-database GDP figures are taken at chain linked volumes with reference year 2005 and applying exchange rates between national currencies and common currency (Euro). Based on these GDP indicators, primary energy intensity in 2010 in Finland was by 1.5 times, in Lithuania by 2.0 times, in Poland by 2.2 times, in Czech Republic by 2.5 times, in Roma-

nia by 2.6 times, in Bulgaria by 4.4 times higher than in the EU-27 (Eurostat 2012). One can see similar differences of the primary energy intensity indicators in developed European countries and countries with transition economies from Central and Eastern Europe based on data presented in publications of the International Energy Agency (2010 a, b; 2012 a, b) in a case when GDP from national currencies are transferred into US dollars (2005) applying exchange rates (Table 4). Based on analysis of these indicators, a conclusion about possibility of reducing

the primary energy intensity in the former Eastern Block by several times would be possible. However, such a conclusion is not correct because the real possibility for reduction of the relative primary energy consumption per unit of GDP is much lower (Miškinis *et al.* 2006). High energy intensity in the former centrally planned economies is determined first of all by the very low level of GDP in these countries. To

have more correct comparison of differences in energy efficiency in developed Western countries and developing countries from the former Eastern Block, GDP should be adjusted by indicators of Purchasing Power Parities (PPP). This principle is used as the most reasonable for comparison of economic development level in the EU-27 countries.

Table 4. Energy intensity indicators in 2008, 2010

	Primary energy intensity, kgoe/000 Euro [Eurostat]		Primary energy intensity, kgoe/000 USD2005 [IEA]				Final energy intensity, kgoe/000 USD2005 [IEA]			
	2008	2010	Exchange rates		PPP		Exchange rates		PPP	
			2008	2010	2008	2010	2008	2010	2008	2010
EU-27	152	152	119	119	123	123	83	83	86	86
Germany	142	142	112	111	121	120	79	77	85	83
France	151	152	120	119	137	136	74	74	85	85
Finland	209	225	164	177	199	216	121	130	148	158
Estonia	460	546	345	401	215	250	201	209	126	131
Latvia	301	363	236	284	126	152	220	272	117	145
Lithuania	366	311	300	258	161	138	161	201	86	107
Czech Republic	371	375	296	297	177	177	179	182	107	109
Slovak Republic	378	371	302	297	166	163	195	190	107	105
Bulgaria	717	671	569	542	216	206	305	276	116	105

Source: International Energy Agency (2010 a, b; 2012 a, b)

Application of primary energy intensity indicators gives a possibility to compare overall energy efficiency in various countries. However, the primary energy consumption, necessary to meet requirement of energy consumers in each country, depends very much on the structure of electricity generating capacities, the role of the energy sector for the country's economy, volumes of the primary energy consumption for non-energy purposes, etc. In addition it is important to note that changes in the energy transformation are going comparatively slowly. Energy efficiency in Lithuania (similarly as in other Central and Eastern European countries) has been increasing since beginning of the transition period first of all on the consumer side due to significant structural changes in the national economy and implementation of appropriate energy saving measures. Therefore indicators of the final energy intensity reflect better current status and changes in energy efficiency. Thus, these indicators are more suitable for comparison of energy efficiency in various countries and assessment of energy saving potential.

Based on preliminary expert assessment, The primary energy intensity in Lithuania in 2010 was lower by 20.1 % compare with 2009 owing to significant changes in the gross primary energy consumption. One can expect continued reduction of energy intensity during the period 2010–2020. Taking into consideration still existing energy saving potential, in 2020, the primary energy intensity in Lithuania could be reduced by 20 % and the final energy intensity by 25 %.

6. Changes in the Lithuanian power system

The most important changes in the Lithuanian energy sector in 2009 were related to the final closure of Ignalina NPP, especially taking into consideration its very high contribution into the country's primary energy balance and in particular into electricity generation. Even after closure of Unit 1 at the end of 2004 this power plant was dominating in the electricity market – its share in the balance of gross electricity generation in 2009 was almost 71 %. Global economic recession and closure of this power plant

were factors that have had painful influence not only on the energy sector, but also on the national economy, energy security in Lithuania and even in the Baltic region, competitiveness of the country's manufacturing on the international markets, social needs of population and increase on greenhouse emissions. Reduction of electricity demand stipulated by significant decrease of activities in branches of the economy was only the factor mitigating the problem of decommissioned capacities.

According principles of the international statistics it is considered that nuclear fuel used for electricity generation is a domestic energy source independently where its supply is coming from. Although nuclear fuel was imported from Russia, dependence of Lithuania on energy import was decreasing from 70 % in 1990 to 41.9 % in 2003 due to growing contribution of all indigenous energy resources and nuclear fuel into the country's energy balance. In 2009, dependence on energy import increased again until 50.7 %. Based on preliminary assessment, since 2010, this dependence owing to closure of Unit 2 at Ignalina NP, increased up to 80 % because nuclear fuel used for electricity generation is substituted partly by imported fossil fuels and partly by electricity import from neighbouring countries. This dependence on energy import was very strong factor when justifying necessity to construct a new nuclear power plant in the updated National Energy Strategy (Ministry of Energy of the Republic of Lithuania 2012).

Ignalina NPP was in operation for more than two decades without any accidents, supplying least cost electricity without any interruptions. This power plant was even as one of the main pillars of economic independence. These factors were important to form positive public opinion and attitude of the major political parties about nuclear option. In addition many factors stipulating construction of new regional nuclear power plant in Lithuanian are the following (Miskinis *et al.* 2009):

- Prevalence of import of primary energy resources from Russia, dependence of Lithuania's gas supply and power systems on Russia's energy systems as well as absence of interconnections with Western European energy systems;
- The decommissioning of Ignalina NPP has had a considerable effect on the structure of electricity generation sources, primary energy balance and electricity production price;

- The strict environmental requirements set forth to energy enterprises, including restrictions on CO₂ emissions;
- Rapid and significant increase of natural gas prices, which depend on a monopolistic supplier, and their instability at the international energy markets;
- Potential interruptions in supply of natural gas, crude oil and petroleum products or in their transit, etc.

Fast development of nuclear power in 1970 and 1980s in many countries was crucially influenced by accident on 26th April 1986 at Chernobyl Nuclear Power Plant when Unit 4 went out of control and exploded. This well-known nuclear accident of catastrophic proportions was also serious political and moral disaster. However, during last few years nuclear revival is again on the agenda in various regions.

On August 2010, 441 nuclear reactors totalling 374.6 GW were operating in 30 countries. In 2008, contribution from nuclear power plants in the total production of electricity in the world was 13.5 % and in the EU-27 – 27.8 %. At the end of 2010 new 65 nuclear reactors were under construction, including 26 units in China, 11 in Russia, 6 in India, 5 in South Korea, etc. However, many of the nuclear reactors listed by the IAEA as "under construction" have encountered construction delays due to political changes, shortage of finance, changes in designs, etc. Nevertheless this nuclear revival is factor supporting construction of nuclear power plant in Lithuania.

Nuclear option could be very attractive alternative for diversification of primary energy sources in the Baltic region and also because nuclear power plant requires importing not much uranium compare to amount of coal, heavy fuel oil or natural gas necessary for production of the same volume of electricity.

Due to global economic recession electricity consumption decreased in all sectors of the Lithuanian economy and total final consumption in 2009 was by 7.4 % less than in 2008. Similar reduction of electricity consumed by end-users in 2009 was in other Baltic States – in Estonia final electricity consumption decreased by 6.4 % and in Latvia by 7.9 % (Statistics Estonia 2012; Statistics Latvia 2012). Total final electricity consumption in the Baltic States decreased in 2009 by 1.73 TWh. In 2011, total final electricity consumption in the region increased again by 0.44 TWh compared with the 2009 level. Never-

theless slow growth of electricity demand in the Baltic States during the last two years can have impact on planned commissioning time of new power generation capacities.

To have consistent comparison with the forecast of electricity demand presented in (Deksnyš *et al.* 2007), the same methodology and the same assumptions about economic development and factors stipulating electricity demand growth in Lithuania were applied for the current forecast which is shown in Figure 6. Based on the comparison of previous and current forecast one can assess that net electricity generation in

2020 required to meet demand of final consumers in Lithuania will be by about 2 TWh less than expected in 2007. This lower demand is caused only by impact of the economic recession on electricity consumption in 2009–2010 in Lithuania. Taking into consideration similar reduction of electricity consumption in other Baltic States commissioning of new unit at nuclear power plant, earlier planned in 2020, could be postponed for some 5 years. Other reason for some delay could be expected growth of electricity generation using renewable energy sources and in particular construction of new CHP using biomass.

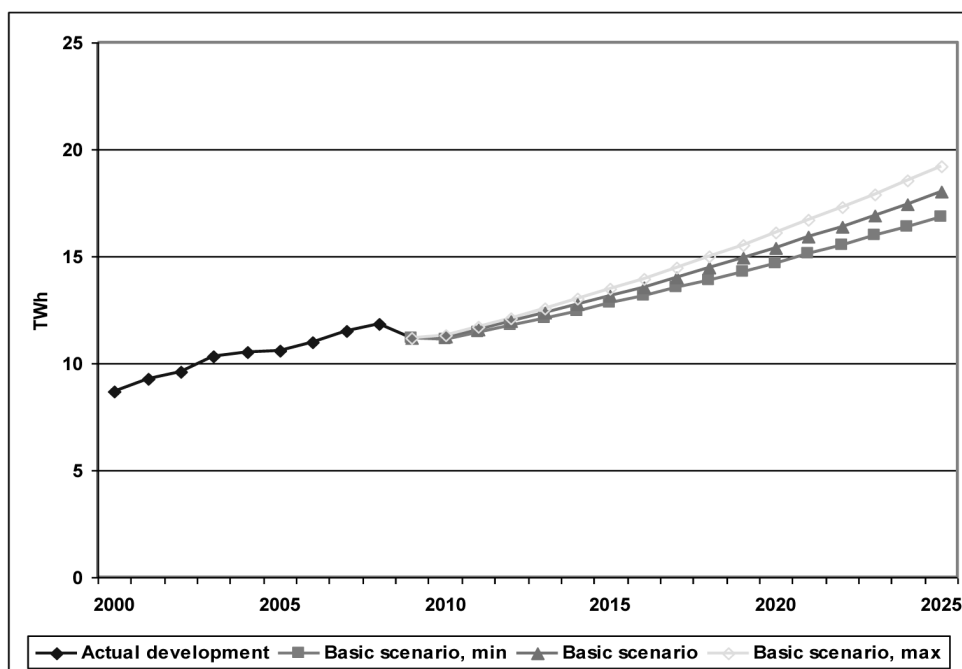


Fig.6. Forecast of net electricity production in Lithuania

Source: Deksnyš *et al.* (2007)

No doubts that construction of new nuclear power plant is an important means increasing energy security in the Baltic region and contributing into programmes of climate change mitigation. However, there are many factors that can reduce attractiveness of nuclear option: slow pace of negotiations with strategic investor; high construction cost of a modern western-type nuclear power plant; absence of experience in private and public partnership for the case of so large project; lack of highly experienced human resources necessary for construction of such power plant; risk due to failure of project management; lack of experience necessary for preparation qualitative agreements with the strategic investor and project partners, uncertainty of competitiveness of

the new nuclear power plant in the Nordic electricity market and market of Central and Eastern Europe as well other relevant markets. In-dept assessment of all these factors is required in particular taking into consideration current negative public opinion in Lithuania (based on results of consultative referendum).

Taking into consideration necessity to reduce dependence on energy import, economic and technical factors and in particular factor of energy security as well as environmental requirements, strategic goals in the energy sector such construction of new regional nuclear power plant, integration of the common Baltic electricity market into market of Scandinavian countries, construction of interconnections

with Poland and Sweden, etc. should be based on comprehensive analysis of the energy sector development and consolidated decisions of Estonia, Latvia and Lithuania.

Conclusions

Important features of the Lithuanian energy sector are the following: high dependence on primary energy supply from Russian Federation caused by closure of Ignalina NPP; absence of interconnections with Western energy systems; growing contribution of renewable energy sources; largely developed district heating systems.

To ensure sustainable development of the national economy the most important measures are the following: fast deployment of renewable energy sources and in particular significant increase of the share of renewable energy sources in the district heat and electricity generation; continued reduction of energy intensity; construction of LNG terminal; construction of interconnections Lithuania-Poland and Lithuania-Sweden, and possibly construction of new regional nuclear power plant.

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