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Kyoto Protocol requirement and wind energy evolution in Lithuania

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From 2009 on, with the Ignalina Power Plant being closed, the annual power amount produced by it will be generated by the thermal power stations burning imported fossil fuel. For this reason emission of the fuel combustion products will increase considerably, and, affected by anthropogenic pollution, the ecological environmental situation in Lithuania will deteriorate correspondingly. Increased emission of sulphur and nitrogen oxides as well as solid particles will raise acid rain volumes, whereas additional emission of greenhouse gas will increase Lithuania's contribution to the global climate change with the negative influence on the ecological situation and health of the population in Lithuania.

Environmental condition can be improved by wider use of the renewable energy sources. For these purposes wind power having no harmful emissions is particularly suitable. Intended rapid wind power development should essentially decrease the common emissions of greenhouse gas and other contaminants and help ensure ecologically clean environment. It should lead to the more wide-ranging and combined improvement comprising economic, environmental safety, ecological, social, and political aspects.

Potential savings of fossil fuel – fuel oil or natural gas amounts – needed to generate the predicted wind power electricity quantity by thermal power plants have been calculated. Fuel savings would enable to prevent emissions of many anthropogenic pollutants into the environment. Avoided by introducing wind power, in 2010, greenhouse gas emissions calculated (using CO_2 equivalent) may reach 293,227 tons and might allow easier fulfilment of the requirements of the Kyoto Protocol. These amounts would completely match emission reduction norms presented in the 3rd and the 4th National Reports on the Climate Change Strategy and would decrease the planned reduction levels indicated in the National Energy Strategy (2007) by almost 8%. The economic gain, excluding fuel price, is taxes for pollutants: it would reach 1.1 million Lt in 2010 and 2.5 million Lt in 2020 (fuel oil) or 327 thousand Lt in 2010 and 715 thousand Lt in 2020 (natural gas). Lithuania's dependence on fuel imports would decrease, while the number of workplaces in the country would grow. Wind power development would reduce the negative anthropogenic influence exerted by pollutants on all the ecosystems.

Key words: wind power, fossil fuel, oil fuel, greenhouse gases, emissions, Kyoto Protocol

INTRODUCTION

Oil, coal and natural gas are the basis of the world energy. Energy sectors, industry, transport and other sectors consuming them emit large amounts of combustion products into the atmosphere. It is the atmosphere that is the most dynamic and the most pollution-exposed sphere through which all others – hydrosphere, lithosphere – are being polluted. However, with its physical and chemical properties severely changed under the action of pollutants this highly vulnerable human part of the ecosystem can be overtaken by catastrophic phenomena, which would manifest in all other parts of the ecosystem. Continuously growing amounts of emitted carbon dioxide, methane and nitrogen suboxide gases accumulate in the atmosphere and influence the global climate because of the so-called "greenhouse effect". Because of intensely rising concentration of these gases the climate changes may be much greater than the usual ones and can cause considerable temperature alterations. Some symptoms of such precarious alterations – the annual average temperature of the earth surface rises, arctic ice melts, sea level in the world rises, local and global climate change phenomena – are already noticeable.

Because of their chemical properties and all-round presence in the nature sulphur dioxide and nitrogen oxides are considered to be the main agents regulating the acidity of various ecosystem objects and are related to the consequences for the natural environment (Mylona, 1996). Precipitating to the earth surface, sulphur and nitrogen oxides, solid particles deform natural biological and chemical processes as well as various vital cycles in water, soil and forest ecosystems related to them. Although the stability of ecosystems is maintained by their buffer resources, the amounts of contaminants getting into them and accumulating in them determine the scale and characteristics of the damage.

Since 1990, Lithuania's environmental contamination with emissions by power and industry enterprises has been gradually decreasing. It was caused by industry reorganization, introduction of modern technologies and the energy sector structure. In Lithuania's primary energy resources balance of 2005, oil and oil products comprised 30.8%, natural gas – 28.4%, nuclear energy – 27.9% (Nacionalinė…, 2007). The existent primary energy balance structure, prior to the Ignalina PP shutdown, increasing contribution of local and renewable energy resources and the possibility to use various kinds of fuel in the greater part of power industry helps to ensure reliable energy supply with little environmental pollution.

After the closure of the Ignalina PP, thermal power plants using imported fossil fuel and releasing great amounts of various contaminants (sulphur, nitrogen, carbon oxides, solid particles and others) will become the main electric power producers. Significant increase of pollutants emitted to the atmosphere will have a great negative effect on both natural environment and people's health. The result of chemical pollution impact – acidification by sulphur and nitrogen oxides and gases causing green house effect, i. e. temperature rise – at the same time negatively influences all the ecosystems. Therefore, it is very important to introduce effective measures for the reduction of regional and global pollution. In addition, the Kyoto Protocol to the Convention on Climate Change of the United Nations (The Kyoto…, 1997) obliges to decrease greenhouse gas emission to prevent the global environmental pollution catastrophe. The assignment for Lithuania until 2012 is to reduce further greenhouse gas emissions by 8% in comparison with the amounts of 1990. The requirements of the Kyoto Protocol become a considerably complex task because of the forthcoming growth of contaminant emissions to the environment. Therefore, the necessity to use natural gas or other less environment polluting fuel as widely as possible instead of fuel oil in power industry was accentuated in all the versions of Lithuania's national energy strategy.

AIMS

With the Ignalina PP shut down, Lithuania will be confronted by the intensification of exploitation of the thermal power plants and by the growing consumption of fossil fuel. The unavoidable effect of this process is greater environmental pollution with all its negative consequences and increased contribution to the global climate change caused by the increasing greenhouse gas emissions. The negative effect of combustion gases on the environment and ecosystems was successfully investigated in detail by a large team of scientists while carrying out the state research programme Regional Development Sustainability in the Historical Perspective: Lithuania's Example (ECOSLIT, 1992–1997). As stated in the monograph by a group of authors (Lietuvos…, 1999) as well as in other publications, on the basis of investigation results it was established that pollutant amounts released into the environment and their concentrations produce the following effect: caused considerable reduction of growth of fir and pine trees (Kairiūkštis, 1998; 1999); have genotoxical effect on humans and animals (Lekevičius, 1998); caused immuno-suppression as a risk endogen factor for the formation of cancer and other illnesses (Tamošiūnas, 1999); polycyclic aromatic hydrocarbons, including benzopyrene, have the outstanding active mutagenic and cancerogenic effect on living organisms (Girgždys, 1999); support intensive anthropogenic eutrophization in most Lithuanian lakes (Gailiušis, 1999); lessen fish hatch quantities (Volskis, 1999). Hence, it is very important to decrease the use of fossil fuel and consequently avoid emissions of greenhouse gas and other pollutants into the atmosphere.

Wind power is favourable for the reduction of environmental pollution. The wind power plants working without greenhouse gas and other pollutant emissions can reduce negative influence on the above ecosystems, can maintain the environment ecologically less polluted and can make the implementation of the international protocols easier. Conventions and directives would also provide the possibility to join trade in CO_2 emissions, thus, improving the economic and ecological situation of the country. This energy development trend is motivated by rapidly changing global climate (global warming).

The aim of this work is to show, using the calculations carried out, that the wind power development in Lithuania, on the basis of the avoided combustion products emission into the atmosphere, will help considerably reduce the anthropogenic load of ecosystems, to preserve the cleaner and healthier environment, to implement the requirements of the Kyoto Protocol after the shutdown of the Ignalina PP more successfully, to improve the economic situation of the country and its energy sector and to lessen dependence upon fuel imports.

METHODS

The significance of wind power and its development for environmental condition due to the avoided environment pollution by greenhouse gas and other combustion products is being investigated in this work. According to the official wind power development forecasts and approved perspective plans it was calculated, how much conventional fossil fuel must be burned to generate the equivalent energy amount in the electric power plants and what amount of greenhouse gas and other contaminants (sulphur, nitrogen oxide, solid particles) would be released into the environment. These amounts of contaminants not emitted into the atmosphere will indicate what pollution of atmospheric air as well as loading of other ecosystems with chemical pollutants through it was avoided and how successfully the Kyoto Protocol requirements to reduce greenhouse gas emissions will be met. Fund savings resulting from import fuel amounts abandoned and payments for pollutant emission avoided will show the economic benefits of the wind power plants and reduced dependence on fuel imports for the state.

Emissions of greenhouse gases and other pollutants while burning fuel oil and natural gas were calculated according to the emission factors recommended (Organinio…, 1997).

Using CO_2 as the equivalent, greenhouse gas emission amounts were recalculated according to the global warming potential with a 100-year perspective chosen and compared with the greenhouse gas variation forecasts in the document directives.

RESULTS AND DISCUSSION

Analysis of wind power developments and forecasts

Intensification of wind power development is prompted by the intention to reduce pollutant amounts released by thermal power

plants after the shutdown of the Ignalina PP, taking into consideration the requirements by a series of important international protocols, conventions, directives and existent realities. Great wind power plants construction rates are planned: according to the wind power plants construction plan several wind power plant parks will be erected in Lithuania until 2010 having total nominal power of 180 MW (Vaičiukynas, 2005), and it is planned to produce more than 289 GWh electricity (Vėjo…, 2003). This value almost equals the electric energy amount produced by hydroelectric power plants. Forecasts of wind power industry development are presented in numerous publications (Katinas, 2006; Marčiukaitis, 2006), governmental documents, strategies and studies. Earlier values later are adjusted in accordance with the changes in both international and national situation. The irrevocable approach of shutting down the Ignalina PP requires more sober evaluation of the future situation of environmental protection, activities carried out and oversights, also assessment of decisions concerning real forecasts with greater responsibility. Lately, Lithuania's government in its decision of 2005 (Dėl Lietuvos…, 2005), National Energy Strategy (2007), specified earlier concrete wind power plant development directives until 2010 and specified the expected total power as well as the expected electric energy production quantities for these future power plants.

Wind power forecasts for 2020 indicate that total power of the wind power plants can reach 500 MW (Jankauskas, 2004), while electric energy production can reach 850 GWh (Danish…, 2003). These currently published data were used for the evaluation of activities of the wind power industry in 2020.

The decision concerning the data for 2015 was more difficult. In the long-term strategy of Lithuania's economical development (Ilgalaikė…, 2002) and other publications (Vilemas, 2002) for 2015, 22 thousand toe (232.6 GWh) of energy generated by wind power plants were predicted. However, in 2005, these predicted numbers were adjusted to improve precision (Dėl…, 2005) and already in 2008 the planned electrical energy production (259.6 GWh) exceeded the amounts forecasted for 2015. Therefore, proportional electricity generation growth in the wind power plants was conditionally assumed for the period of 2010–2020.

Wind power and its influence on pollutant emission reduction

Lithuania must carry out its commitments to the EU: until 2010, to increase the part of renewable energy sources in the general energy balance up to 12% and to increase the production of electric energy from renewable energy resources by up to 7% of the whole electric energy amount used in 2010 (Energy…, 1997; Directive…, 2001). Lithuania's electric energy amount received from renewable energy resources must increase twofold until 2010.

In 2005 and 2006, the electric energy quantities produced by wind power plants were considerably less than the predicted ones. Forecasts of the directives and documented tasks were not achieved. The generalised data according to the official sources and documents concerning the energy produced in wind power plants in 2005 and 2006 (Elektros…, 2007) and the predicted future electric energy amounts are presented in Table 1. While preparing the shutdown of the Ignalina PP, rapid development of the wind power industry is foreseen, and intense production of electric energy is planned. This growing wind power industry potential will provide for rejection of some amount of oil products or natural gas and, thus, for the reduction of fuel amount imported with all the advantages following.

Since, after the closure of the Ignalina PP, the main thermal power will be the Lithuanian Power Plant, let us assume that all the energy generated by the wind power plants is produced namely at this most important enterprise. In the periodicals (Lietuvos energetika, 1992) it is asserted that 343 grams of con-

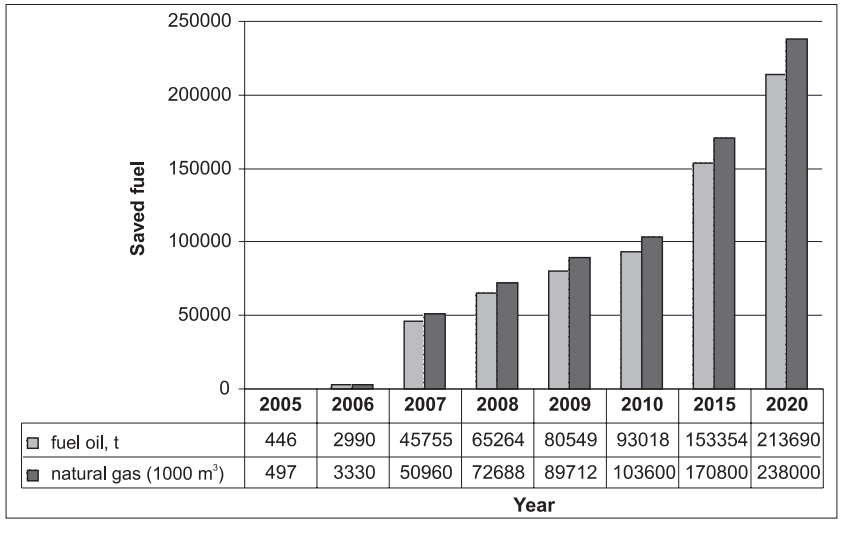

Fig. 1. Fuel saved using wind power plants (fuel oil or natural gas)

Table 1. **Electric energy amounts produced by wind power plants (in 2005 and 2006) and planned to be produced until 2020**

	Electric energy production in wind power plants (GWh)							
	Produced		Expected (planned) production					
Years	2005	2006	2007	2008	2009	2010	2015	2020
Electric energy production (GWh)	1.775*	11.891*	182	259.6	320.4	370	610	850
Power (MW)	0.85	54.94	82	132	173	200	350	500

* actual electric energy production does not match the prediction dated 2005 by the Government of the Republic of Lithuania.

ditional fuel must be used (carbon equivalent) in the Lithuanian Power Plant for the production of one kWh. Using this norm it is easy to determine fuel oil or natural gas quantities needed for the generation of electric energy produced by the wind power plants (Fig. 1).

Use of biomass instead of fuel oil provides positive environmental protection effect, as the registered quantities of the main compound causing greenhouse effect – carbon dioxide – decrease. During the process of burning biomass, CO_2 released is consumed for the formation of new biomass. However, emissions of methane, carbon monoxide and solid particles augment.

The wind power plants produce clean energy and release no gases or pollutants into the environment. For this reason, by burning fossil fuel amounts shown in Fig. 1, broad range of combustion product emissions can be avoided including emission of carbon dioxide (Fig. 2) as well as emissions of other gases to the environment directly causing greenhouse effect, namely, methane and nitrogen suboxide (Fig. 3).

As every gas from the set of greenhouse gases having direct effect brings different contribution into the global climate warming, their total quantity, calculated using CO_2 equivalent according to the global thermal potential, is presented in Table 2.

In the 3rd and 4th National Reports on climate changes (Lithuania's…, 2005) it was stated that greenhouse gas change (expressed using CO_2 equivalent) must amount to 0.235 Mt in 2005, 0.302 Mt in 2010, 0.379 Mt in 2015, and 0.451 Mt in 2020. It is forecasted in the National Energy Strategy (2007) that until 2010 in comparison with 2004, applying suitable utilization, due to the potential of energy saving, effective transformation and usage of renewable and local energy resources, emissions will

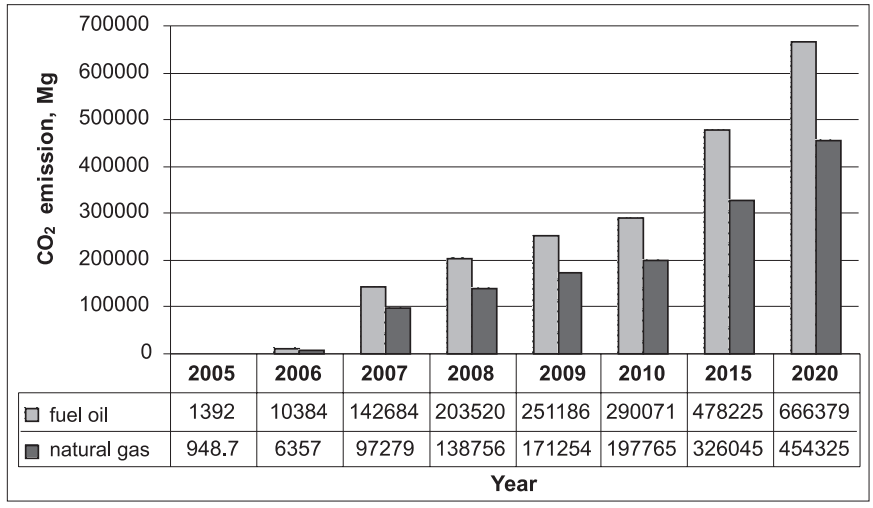

Fig. 2. Expected CO_2 emission by fuel (fuel oil or natural gas), if burnt in thermal power plants, saved using wind power plants

Table 2. **Greenhouse gas emission amounts expressed in CO_2 equivalent (fuel oil)**

Year	GHG	Emission, t	GWP (100 year)	Equivalent CO_2 emission, t/year	%
2005	CO_2	1392	1	1392	98.91
	CH_4	0.062	21	1.3	0.09
	N_2O	0.045	310	14	1
			Total GHG equivalent CO_2	1407.3	100
2010	CO_2	290071	1	290071	98.92
	CH_4	13.02	21	273	0.09
	N_2O	9.3	310	2883	0.99
			Total GHG equivalent CO_2	293227	100
2015	CO_2	478225	1	478225	98.92
	CH_4	21.46	21	451	0.09
	N_2O	15.33	310	4752	0.99
			Total GHG equivalent CO_2	483428	100
2020	CO_2	666379	1	666379	98.92
	CH_4	29.9	21	628	0.09
	N_2O	21.36	310	6622	0.99
			Total GHG equivalent CO_2	673629	100

decrease: CO_2 by about 32% (3.9 Mt) per year, SO_2 by 3% (1 kt) per year, NO_x by about 21% (10 kt) per year.

Greenhouse gases avoided because of the wind power development would greatly contribute to the easier achievement of the efficiency of implementing the requirements of the Kyoto Protocol. Greenhouse gas amounts presented in Table 3 using CO_2 equivalent would completely cover the aims of the activities of Lithuania's 3rd and 4th National Reports concerning climate change and those of the United Nations Framework Convention on Climate Change (UNFCCC) in implementing the national strategy. In addition, they would also create possibility for active participation in trading with greenhouse gas turnover pollution certificates in the EU trade system and in the world CO_2 markets.

The tasks of the National Energy Strategy to reduce general CO_2 emission will be also partly fulfilled, although on a lesser scale (up to 7.5%). In 1990, the energy sector released 37663 Gg of CO_2 into the atmosphere (Jaskelevičius, 1997). In case of closure of the Ignalina PP, without additional technological and technical solutions, pollutant emissions from the thermal power plants can exceed their levels of 1990 (Žukauskas, 1997). Due to the wind power, greenhouse gas emissions avoided in 2010, compared with the same gas emissions by the energy sector in 1990 and 2005, would constitute 0.78% and about 2.5%, correspondingly.

Sulphur dioxide quantities produced using fuel oil and natural gas are very different. Greater contaminant amounts are formed by burning fuel oil only. Natural gas is a much cleaner fuel and contributes to the environment pollution far less significantly as well. The difference is shown in Table 3.

Nitrogen oxides are of thermal origin. Their formation is influenced by the caloric value of the fuel used and conditions of the burning process. In case of fuel oil and natural gas relatively great amounts are formed (Fig. 4) causing many problems as emission

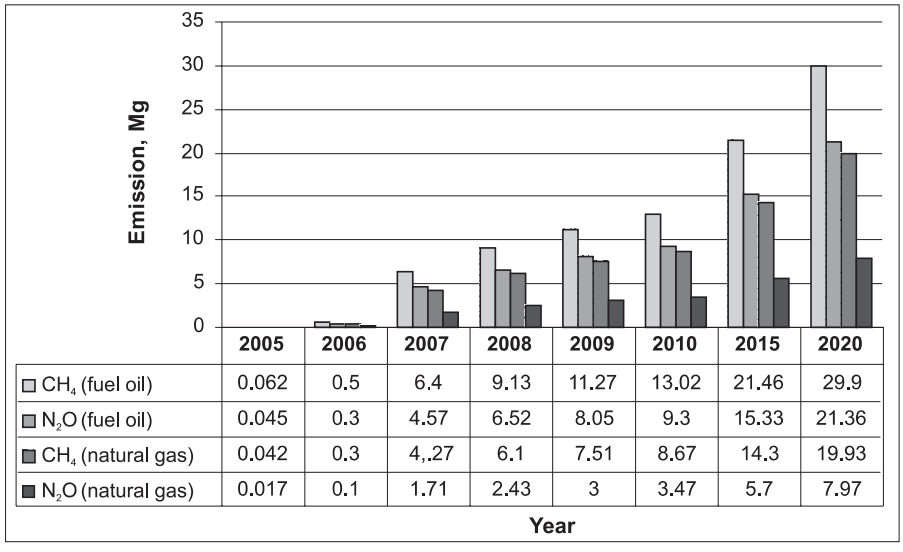

Fig. 3. Expected CH_4 and N_2O emissions by fuel (fuel oil and natural gas), if burnt in thermal power plants, saved using the wind power plants

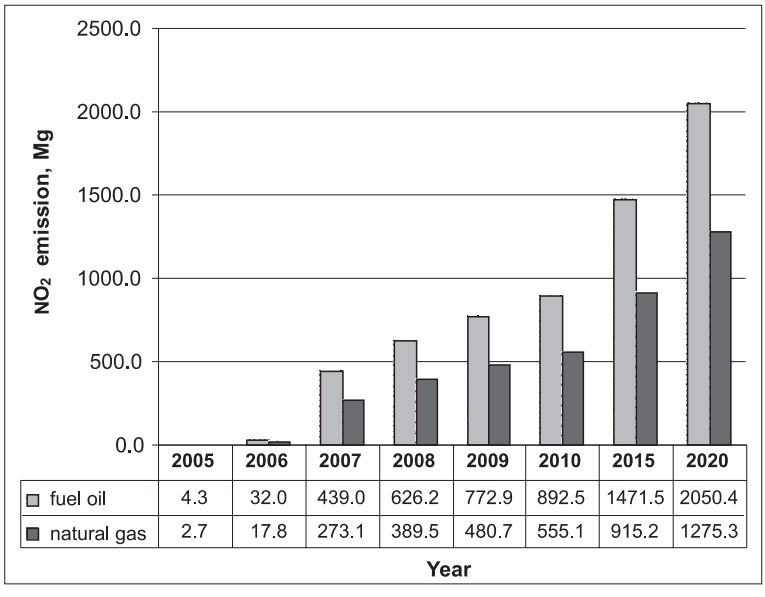

Fig. 4. Expected NO_x emission by fuel (fuel oil and natural gas), if burnt in thermal power plants, saved using the wind power plants

Table 3. **Sulphur dioxide emissions of planned production predicted for the wind power plants if using instead electric thermal power plants**

Years	2005	2006	2007	2008	2009	2010	2015	2020
SO_2 (fuel oil) Mg	8.7	65	892.7	1273.3	1571.5	1814.8	2992	4169.1
SO_2 (natural gas) Mg	0.005	0.03	0.51	0.73	0.9	1.04	1.7	2.4

Table 4. **Actual capital savings in 2005 and 2006, which would be accumulated in case of wind power development matching the predictions announced**

Fees for pollution, Lt (fuel oil)								
Years	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2015**	**2020**
SO_2	2708	20215	277627	395996	488743	564403	930503	1296603
NO_x	2512	18784	257711	367591	453681	523915	863747	1203585
SP	63	478	6462	9218	11377	13138	21660	30182
Total	5283	39477	541800	772805	953801	1101456	1815910	2530370
Fees for pollution, Lt (natural gas)								
SO_2	2	9	159	227	280	323	529	746
NO_x	1561	10449	160310	228631	282171	325861	537222	748601
SP	5	31	471	671	830	957	1582	2201
Total	1568	10489	160940	229529	283281	327141	539333	751548

of sulphur compounds can be reduced using purification equipment and by improving technology, while it is more difficult to control the increase of concentrations of nitrogen oxides.

It should be noted that, owing to the wind power industry, amounts of sulphur dioxide avoided help to match the national reports about climate change and the forecasts of the National Energy Strategy of the pollution reduction planned. Combined effect achieved owing to the wind power includes ensuring ecologically cleaner environment as well as economic, political and social benefits.

The economic benefit is based on fuel savings. Additional economic gain would be to avoid fees for pollutants emitted. Taking into account fees for every sort of pollutant released into the environment (Mokesčio…, 2003), additional economic benefit would amount to considerable sums (Table 4).

Economic and revenue growth has great influence on the application of new advanced technologies, efficient energy utilization and decrease in energy demand. The new project aims prepared by the Ministry of Environmental Protection of the Republic of Lithuania for the implementation of UNFCCC and the National Strategy comprise the following: reduction of the amounts of greenhouse gas by power enterprises; increase of the efficiency of energy use; decrease of energy consumption; increase of national power industry ability to adapt itself to climate change conditions. The predicted activities and expected results of their application in all the economy branches are also listed. Investment support will be sought to develop alternative energy resources (including wind power), to increase financial competitiveness of renewable energy resources, to lower the fee for pollution, to project and to construct alternative power plants, taking into account varying wind and solar energy resources, increasing wind velocity fluctuations and growing gustiness. The executive institution is the Ministry of Economics, while potential financing sources are state budget funds, national, international and EU funds as well as private funds.

Political aspect of the combined effect manifests itself so that dependence on fuel import and on difficulties associated with both internal and external conflicts among fuel exporting countries decreases.

Social effects result in the development of wind power engineering which will provide for new jobs, will contribute to the reduction of unemployment in suburban areas, as additional numbers of workers will be taken into service for wind power plants construction, maintenance and operation.

CONCLUSIONS

1. From 2010 on, after the Ignalina PP shutdown, nuclear energy used for power generation will be replaced by oil products, natural gas and by the growing potential of renewable energy sources. Use of imported fossil fuel to generate electric energy in thermal power plants will increase emissions of anthropological pollutants into the atmosphere resulting in negative influence on all the ecosystems.

2. Increasing flux of greenhouse gas and other pollutants emitted by the thermal power plants and anthropogenic environmental pollution can be effectively reduced by introducing wind power. According to forecasts for 2010, with the total power of 200 MW wind power installed and 370 GHz of electrical energy produced by them:

- ✓ greenhouse emission would decrease by 293,227 t (CO_2 equivalent, fuel oil) (in 2020, by 673,629 t);
- ✓ 1,815 t of SO_2; 893 t of NO_x; 71 t of solid particles (using fuel oil) or 1 t of SO_2; 555 t of NO_x; (using natural gas) (in 2020, 4,169 t of SO_2 and 2,050 t of $NO_{x,}$ correspondingly (using fuel oil) and 2.5 t of SO_2 and 1,275 t of NO_x (using natural gas) would be avoided;
- ✓ over 93,000 t of fuel oil or 103,600 thous. m^3 of natural gas (in 2020, 213,690 t and 238,000 thous. m^3 correspondingly) would be saved;
- ✓ owing to the wind power plants activities, pollutants avoided would help save over 1,1 million Lt for menacing fees for environmental pollution (fuel oil), and almost 327 thousand Lt (natural gas) (in 2020, 2.5 million Lt and 751 thousand Lt, respectively).

3. According to the forecasts, due to the development of wind power plants greenhouse gas, SO_2, NO_x emission quantities avoided in 2005–2020 match the emission reduction norms foreseen in the above Lithuania's 3rd and 4th National Reports concerning the climate change: for the year 2005 – 0.235 Mt, 2010 – 0.302 Mt, 2015 – 0.379 Mt, 2020 – 0.451 Mt. Annual emission reductions predicted by the National Energy Strategy in comparison with the 2004 annual emission reduction norms would constitute: 7.5% for CO_2, 181.5% for SO_2, and 9% for NO_x.

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KYOTO PROTOKOLO REIKALAVIMAI IR VĖJO ENERGETIKOS PLĖTRA LIETUVOJE

S a n t r a u k a

2009 m. uždarius Ignalinos AE, jos pagaminamą elektros energijos dalį generuos šiluminės elektrinės, degindamos importuojamą organinį kurą. Dėl to ženkliai padidės kuro degimo produktų išlakos ir dėl antropogeninės taršos pablogės Lietuvos aplinkos ekologinė situacija. Dėl pagausėjusių sieros ir azoto oksidų, kietųjų dalelių išlakų daugės rūgščių kritulių, papildomos šiltnamio efektą sukeliančių dujų emisijos didins Lietuvos indėlį į globalinį klimato atšilimą, o tai neigiamai atsilieps šalies ekologinei situacijai, gyventojų sveikatai.

Aplinkos kokybę galima pagerinti naudojant atsinaujinančius energijos šaltinius. Ypač tam tikslui praverstų vėjo energetika, nes vėjo elektrinės neturi kenksmingųjų išlakų. Numatoma sparti vėjo energetikos plėtra padėtų gerokai sumažinti bendruosius išskiriamų šiltnamio efektą sukeliančių dujų bei kitų teršalų kiekius, užtikrintų ekologiškai švaresnę aplinką. Būtų gaunamas kompleksinis efektas, apimantis ekonominį, aplinkosauginį, ekologinį, socialinį, politinį aspektus.

Apskaičiuoti galimo sutaupyti organinio kuro – mazuto arba gamtinių dujų – kiekiai, kurių prireiktų prognozuotai vėjo jėgainių elektros energijai gaminti šiluminėse elektrinėse. Sutaupytas kuras leistų išvengti daugelio antropogeninių teršalų emisijos į aplinką. Dėl vėjo energetikos išvengtos šiltnamio efektą sukeliančių dujų išlakos, perskaičiuotos CO_2 ekvivalentu, 2010 m. sudarytų 293227 t ir leistų lengviau atitikti Kyoto protokolo reikalavimus. Šie kiekiai visiškai atitiktų 3 ir 4 nacionalinių pranešimų dėl klimato kaitos strategijos nurodytus emisijų mažinimo skaičius ir beveik 8% sumažintų Nacionalinėje energetikos strategijoje (2007) numatytus jų mažinimo lygius. Ekonominį efektą be sutaupyto kuro sudarytų išvengti mokesčiai už teršalus: 1,1 mln. Lt 2010 m. ir 2,53 mln. Lt 2020 m. (mazuto atveju), arba 327 tūkst. Lt 2010 m. ir 751,5 tūkst. Lt 2020 m. (gamtinių dujų atveju). Sumažėtų šalies priklausomybė dėl kuro importo, padaugėtų darbo vietų. Dėl vėjo energetikos plėtros sumažėtų teršalų antropogeninis poveikis visoms ekosistemoms.

Raktažodžiai: vėjo energetika, organinis kuras, mazutas, šiltnamio efektą sukeliančios dujos, emisija, Kyoto protokolas