IMPACT OF CO_2 TRADE ON ELECTRICITY PRODUCERS DEPENDING ON THE USE OF DIFFERENT ENERGY SOURCES IN ESTONIA

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Abstract

The aim of this paper is to identify the main circumstances related to the Estonian energy sector and economy and the facts which are important for development of the research conducted by the author and for clarification of the main viewpoints. The paper provides the principal facts on the first (2005-2007) and second (2008-2012) period of CO_2 (carbon dioxide) trade in Estonia; describes electricity production in Estonia on the basis of the electricity development plan effective in the reference year 2007 and proceeding from that – calculations of CO_2 emissions by kind of fuel used. The paper will touch upon the main legislative provisions concerning renewable energy support, which essentially influence the development of renewable energy generation and indirectly the CO_2 trade. Analogously with the reference year 2007 methods of calculation, CO_2 emissions have been calculated for 2020. The electricity production prognosis for the year 2020 is based on the interpretation of the electricity sector development plan. Computation according to the CO_2 calculation methodology shows that the CO_2 emission amount will be ca 5.7 Mt (million tonnes) in 2020. In 2020 compared to 2007, the domestic consumption of electricity is estimated to grow: in 2007 the domestic consumption of electricity was ca 8200 GWh, in 2020 it is estimated to be ca 10480 GWh, i.e. the growth is ca 22%. Decrease in the emission amount of CO_2 will be gained due to the expected use of different energy sources, compared to those used in 2007, in the designed power plants based on renewable energy sources or gas. The share of oil shale-based energy production will decrease from 83% to 44% resulting in a further reduction of CO_2 emissions from 12 Mt to 4 Mt. In view of the fact that, during consumption, the CO_2 emissions comprise nearly 60% of the gross consumption of electricity production, the research reveals that raising consumer awareness of the use of various energy saving equipment and the promotion of economical lifestyle involve a remarkable potential for reducing the amount of CO_2 emission. To ensure competitiveness of electricity producers in the free market conditions, influenced by CO_2 emission allowance trading, construction of the power plants in compliance with national regulations must be ensured with the help of support schemes, state aid, tax policies and legislative measures. Since the quota trade rules which will apply after the year 2012 are not distinctly clear yet, thus this topic will be developed further in the articles to come.

Keywords: CO_2 trade, energy sources, electricity production, Estonia

JEL Classification: Q410

Introduction

Estonia has, together with other countries across the world, opted for a sustainable path of development where national welfare growth is based on the achievement of balance between the economical use of natural resources and the environment.

The European Union (EU) Directive 2003/87/EC of 13 October 2003 has established a scheme for greenhouse gas (GHG) emission allowance trading with the purpose to:

- Induce society to use resources more effectively and encourage innovations;
- Increase awareness of CO_2 (carbon dioxide) damage from fossil fuel combustion and their cost to society;
- Improve fulfilment of the obligations taken under the Kyoto Protocol for reducing greenhouse gas emissions.

CO_2 quota trade is a symbiosis of power engineering and financial world, which is important for all energy producers and other industries involved in the quota trade. Via energy prices, the CO_2 trade experts influence all enterprises which consume energy. This paper is one of the series prepared in the framework of the research "Impact of Greenhouse Gas Emission Allowance Trading on the Estonian Energy Sector".

The main objectives of the research are:

- To describe the institutions involved in emission allowance trading, emissions trading registry, distribution and certification of emission quotas, and to identify the general economic mechanisms of the scheme and possible effects.
- To evaluate the impact of emissions trading on the economic performance of energy enterprises and their investments.
- Energy enterprises' strategy for emissions trading (marginal cost curve, price of pollution quotas, organisation of emissions trading in practice, conducting of transactions, risk management).
- Trading in pollution quotas (quota market, price).
- To investigate the economic impact of the emissions trading international market on the energy sector.
- To examine the impacts of emissions trading via energy enterprises on the energy sector as a whole (utilisation of renewable energy, implementation of new combustion technologies).
- To study the economic impact of other flexible mechanisms laid down in the Kyoto Protocol (joint implementation, clean development mechanism) on emissions trading and energy sector.

The purpose of this paper is to identify the main circumstances related to the Estonian energy sector and economy and facts which are important for development of the research conducted by the author − *Impact of Greenhouse Gas Emission Allowance Trading on the Estonian Energy Sector,* and for clarification of the main viewpoints. The author of this study analyses the CO_2 air emissions from electricity generation on the basis of different fuel usage in the power production of Estonia by applying a simple determination method intended for calculation of the carbon dioxide emissions into the ambient air. According to common knowledge, this analysis is novel for Estonia and such calculations have so far not been made for Estonia. Consequently, this gives a good opportunity for respective studies at the national level.

The main objectives of the paper are:

- To provide the principal facts on the first (2005-2007) and second (2008-2012) period of CO_2 (carbon dioxide) trade in Estonia.
- To describe electricity production in Estonia on the basis of the electricity development plan effective in the reference year 2007 and calculations of CO_2 emissions by kind of fuel.
- Touch upon the main legislative provisions concerning renewable energy support, which essentially influence the development of renewable energy generation and indirectly the CO_2 trade.
- To calculate CO_2 emissions for 2020 analogously with the reference year 2007 methods of calculation.
- To forecast electricity production for the year 2020 based on the interpretation of the electricity sector development plan.

Impacts of the European Union climate and energy package (will come into force in 2013) on the energy sector require further in-depth analysis and will not be discussed in this paper.

This paper seeks to identify the major energy sector and economy related circumstances and facts in Estonia that are important for further development and clarification of the research.

The EU GHG emissions trading scheme 2005-2007

The first period of trading lasted from 2005 to 2007 (introduction) when the **CO_2 quota** (this analysis deals with the impact of CO_2 trade only) trading was mainly conducted only between EU Member States.

The GHG emissions quota trading scheme 2005-2007 was like a training stage. Their utility was limited as banking was missing between the first and second stages, and units were overpriced. Overpricing of the units led to that their price approached zero by the end of the period (Figure 1) because of a change in the demand-to-supply ratio as a result of active marketing activity of the industrial sector.

Figure 1. CO_2 trading opportunities for EGL (Elektrizitäts-Gesellschaft Laufenburg). (EGL 2008)

Figure 1 depicts the EUA (European Union Allowances) price fluctuations from December 2004 till April 2008. Sharp declines in May 2006 and in 2007 were caused by the situation in the market where, after the first certified emissions had been publicized, it turned out that there were actually more units available in the market than there was demand for them. In other words, until May-April 2006 when real emissions into the air in the first so-called trading year were identified, the ratio of the emission allowances available on the market to actual emissions was not yet known to the public (e.g. for 2005 the European Commission allocated the emission limit of 16,747,053 t/CO_2 to Estonia but the real emissions were 12, 621,824 t/CO_2, or nearly 4 million tonnes of emission allowances were put on the market (Climate web 2010).

The so-called overabundance of vacant emission allowances on the market was indeed the cause which led to the decline that started in 2006 and lasted till the end of 2007 (when the so-called pre-Kyoto trading period in Europe came to an end).

The EU GHG emission allowance trading scheme 2008-2012

By the start of the new trading period, or the so-called Kyoto first trading period in Europe (2008-2012), the European Commission had made extremely radical cut-back decisions in total emission allowances allocated to Member States (the so-called National Allocation Plan − NAP) to stabilise and prevent the situation which had dominated in the pre-Kyoto trading period. The results are shown in Figure 1, where the EUA price level is perceived to be more or less stable (which is the objective of the carbon dioxide market – real demand in the market determines the actual value of 1 tonne of CO_2).

The CER (certified emission reduction) price development is affected by the fact that in the pre-Kyoto trading period operators had no right/opportunity to use emission units available in Kyoto flexibility mechanisms (flexible mechanisms are based on the following units: clean development mechanism – CDM: **CERs,** certified emission reductions; joint implementation mechanism – JI: **ERUs,** emission reduction units; emissions trading 2008-2012 – ET: **AAUs**, assigned amount units) for fulfilment of their obligations (the operator shall return to the State a number of allowances equal to the actual amount of emissions in the preceding year by 30 April of the year following the accounting year – the transaction takes place via a respective electronic register). In the Kyoto trading period, operators will have such a possibility within the limits allocated to each Member State (e.g. this percentage varies across European countries, but is on average between 10-20%). This means that when the EUAs allocated from NAP to an operator are not enough for the fulfilment of his obligations, he may buy from the market more Kyoto flexibility mechanism units within the nationally allocated limits.

For the 2008-2012 trading period, Estonia made a proposal to the European Commission (EC) for 24.4 million tonnes a year (122 million t/5 years). EC lowered the quotas to 12.7 million tonnes (63.5 million t/5y), i.e. by ca. 52%. 47 operators are involved in quota trading in Estonia, including 39 from energy production, 6 from mineral industry and 2 from paper and pulp industry. GHG emission allowance trading permits are issued by the Estonian Minister of the Environment pursuant to Regulation of the Government of Estonia No 257 of 20 December 2007, which establishes 1st January 2008 to 31st December 2012 as the period of GHG emission allowances from stationary sources of pollution. 11,678,257 tonnes are annually allocated to operators and 1,038,801 tonnes are annually kept in reserve for new operators entering the trading system.

Estonia filed an action with the European Court against the European Commission (Judgement of the Court 2009), claiming that the Commission made grave mistakes in taking the decision and exceeded its authority. The Court agreed with Estonia and stated that the Commission had no authority to substitute in the assessment of NAP Estonia's data with its own, which among other things did not sufficiently take into consideration the Estonian energy policies and was not based on the correct GDP growth prognosis. Additionally, the Court verified a violation of the principle of good administration.

This court judgement means that the European Commission has to take new decisions regarding Estonia's pollution quotas. Estonia may not issue pollution permits until the European Commission has made a new decision. Considering the favourable situation in the previous so-called practicing period 2005-2007, according to which the reference year for the quota trading was 1990 and the reduction percentages for Estonia are governed by the Kyoto Protocol (Ratification of the Kyoto Protocol 2002), Estonia is facing a situation where in 2008-2012 it has to reduce emissions 8% against the 1990 levels. But, considering the actual situation of Estonia in the reference year (we were a part of the USSR and with a different economic structure) and our economic restructuring later, we are in a situation where we have already achieved this target (National Inventory Report 2009). Several energy production enterprises used the favourable situation to improve their economic situation, for example, Eesti Energia AS (EE; 100% of shares owned by the Republic of Estonia), which in the 2006/07 financial year received approximately 95 M€ for selling emission quotas in the Nord Pool electricity exchange (EE's yearbook 2007/2008). In the financial year 2007/08, the impact of trading in emission quotas on economic performance reversed to -8.95 million EUR. Quotas were not sold in 2007 due to the lack of interest in the stock exchange, on the one hand; however, the significantly smaller than expected amount of quotas allocated to EE under the second NAP brought about a need to make additional expenditure for obtaining 2008 quotas. In the financial year 2007/08, EE was estimated to spend 8.95 million EUR (ca. 0.36 million tonnes CO_2/25€/t) on buying quotas.

Electricity production and CO_2 emission in Estonia in the reference year (2007)

According to the statistical overview Energy Balance 2007 prepared by Statistics Estonia (Energy balance 2007) (Figure 1, Table 2), Estonia produced **11402 GWh** of **oil shale**-based electricity, 350 GWh from natural gas, 235 GWh from oil shale gas, 22 GWh of hydro-energy, 91 GWh of wind energy, 36 GWh from other renewable energy sources and 22 GWh from peat.

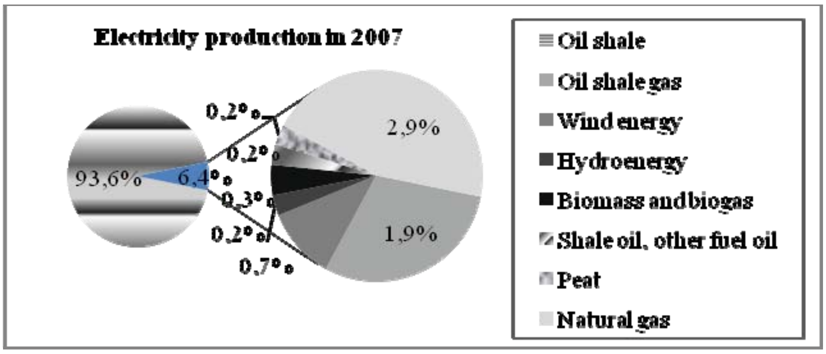

Figure 2. Electricity output of 12188 GWh in 2007. (Development Plan of the Estonian Electricity Sector until 2018)

The reference year for energy production and consumption calculations is 2007, which is also the reference year for Development Plan of the Estonian Electricity Sector until 2018.

Estonia has always managed to cover its electricity demand and also exported electricity. According to the 2007 statistics, electricity production amounted to 12188 GWh (Table 1. Of this quantity, oil shale-based electricity accounted for 93.6%), which implies the amount of electricity measured at the power plant's turbine terminals. If to deduct from this power plant's own use (889 GWh), then the amount transmitted via power networks to consumers is 11299 GWh. A part of it is consumed by local consumers and the other part is sold for exports (2765 GWh). After deducting network losses, domestic consumers consumed 7180 GWh in 2007.

Table 1. Electricity production and consumption in 2007 and CO_2 emission into the atmosphere

Consumer	Consumption (GWh)	CO_2 emissions from electricity production into the atmosphere (Mt)	Percentage of total consumption %
Consumption in Estonia	7180	**7.55**	**58.9**
Network losses	1354	**1.42**	**11.1**
Total consumption	8534	8.97	70.0
Export	2765	**2.91**	**22.7**
Network total	11299	11.87	92.7
Power plant's own use	889	**0.93**	**7.3**
Gross production	**12188**	12.81	100

Source: Statistics Estonia, author's calculations.

The quantity of CO_2 emissions into the ambient air from electricity generation and consumption in 2007 was found by calculating the physical indicators of various fuels used for electricity generation in Estonia and the specific CO_2 emissions from co-generation (1.05 $ktCO_2/GWh$, Table 2).

CO_2 emissions have been calculated by using the determination method of carbon dioxide emissions into the ambient air (Välisõhku eralduva 2004). The special emissions of carbon from combustion of oil shale in Estonian power plants and from depositing shale ash are calculated by using the following formula:

(1) $q_{c\ oil\ shale} = 10\left[C^r + k(CO2)^r_M 12/44\right]/Q^r$, tC/TJ

where
Q^r – calorific value of oil shale, MJ/kg;
C^r – carbon content of oil shale, %;
$(CO_2)^r{}_M$ – mineral carbon dioxide content of oil shale, %; (Ots 2004)
tC/TJ – tons of carbon to Tera Joule;
12/44 – C/CO_2 molecular mass ratio
k – product gained by multiplying the factors which take into account the extent of carbonate decomposition in oil shale combustion in boilers (k_{CO2}) and CO_2 binding in ash fields ($k_{unbound}$) (in pulverised combustion k = 0.64, in fluidised bed combustion k = 0.40).

For calculating the real carbon emissions and carbon dioxide emission values, the actual amount of carbon content in the combusted fuel is multiplied by the value characterising the oxidised part of carbon; the actual carbon emission value (*Mc*) is calculated in gigagrams (*GgC*) by using the following formula:

(2) $Mc = 10^{-3} \times B^{'} \times q_c \times Kc$

where
$B^{'}$ – fuel consumption (TJ);
q_c – specific carbon emission (tC/TJ);
Kc – share of oxidised carbon.

The CO_2 emission into the ambient air from combustion of a different kind of fuel (M_{co2}) in gigagrams ($GgCO_2$) is calculated by using the following formula:

(3) $M_{CO2} = Mc \times 44/12$

where
Mc – carbon emission value (*GgC*).

Total CO_2 emission into the ambient air is calculated by summing up the CO_2 emissions from combustion of all kinds of fuel.

CO_2 emission from combustion of oil shale in the co-generation regime (simultaneous production of electricity and heat) amounts to 12404 thousand tonnes (Table 2, second and fifth cells), while other fossil fuels emit into the atmosphere ca 3% compared to oil shale combustion. Wind energy, hydro-energy, nuclear energy, biomass and biogas as sources of energy are, according to the global agreement, regarded as sources not generating CO_2. Additional note: Estonia does not produce electricity on the basis of nuclear energy.

It is interesting that on the basis of data provided in Table 2, the lower scale of specific CO_2 emissions includes also natural gas (fossil fuel). Natural gas burns more cleanly than other fossil fuels, such as oil shale and peat, and produces less carbon dioxide per unit of energy released. Is this the reason why Russia and the European Union have agreed upon building the Nord Stream gas pipeline? The underwater part of the pipeline starts from the Portovaya Bay near Vyborg and runs approximately 1200 km by the bottom of the Baltic Sea as far as to Greifswald in Germany.

Table 2. Electricity production in Estonia in 2007 on the basis of different fuels

Fuel used for electricity generation (thous.tonnes, million-m^3)	Electricity production, (GWh (total))	Specific CO_2 emission for fuel (kg/MWh)	Electrical efficiency (total) η	Specific CO_2 emission per electricity production, kg/MWh
Oil shale	11402	359	0.33	1087.9
Peat	22	370	0.3	1233.3
Shale oil	30	276	0.3	920.0
Natural gas	350	201	0.35	574.3
Renewable sources	149			
Oil shale gas	235	201	0.32	628.1
	Σ12188			

Source: Statistics Estonia, author's calculations.

Oil shale-based electricity production efficiency has been calculated by taking into consideration that electricity is generated in fluidised bed combustion. We assume that the total efficiency of oil shale-based electricity is on average 33%. Shale gas as a product of *Eesti Energia Õlitööstus AS* is extracted in shale oil production and is burnt in pulverised combustion boilers at Narva Power Plants; thereby the efficiency is lower than in case of fluidised bed technology. *VKG Energia AS* is burning the gas generated in shale oil production in energetic boilers together with oil shale. The efficiencies of the co-generation regime of natural gas, peat, shale oil and fuel oil are, according to producers' information, between 0.3-0.35 or 30-35%.

Considering big reductions in the CO_2 quotas and the EU initiative for much more extensive use of renewable energy, the renewable energy generation is a rapidly growing sphere of activity. The main sources of renewable energy used in Estonia are wind and biomass and to a little extent also hydro and biogas.

The Electricity Sector Development Plan 2005-2015 established the objective to increase the share of renewable energy[1] (Renewable energy resources 2005) to 5.1% in total consumption by 2010 and to increase the share of electricity generated in combined plants of heat and electricity to 20% of total consumption by 2020 (European Renewable Energy Council 2009).

In 2007, renewable electricity accounted for 1.75% of total consumption. The potential output of new renewable electricity production projects that should be completed by 2010 will exceed the target (Kisel 2007).

[1] Renewable energy resource or renewable source of energy is the energy resource that can be sustained indefinitely, e.g. waves, tides, solar energy, wind, geothermal energy, or which can be regenerated in the course of biological processes in the ecosystem (biomass and biofuel − timber, reed, energy forest, sugar cane etc) without their quantities being essentially reduced in a time span of human significance; is not subject to CO_2 emission trading scheme, the quota is 0.

Support and subsidies for renewable energy

The cogeneration support schemes implemented in 2007 (Electricity Market Act 2003) to increase the share of electricity produced in combined heat and electricity plants to 20% of total consumption by the year 2020, have encouraged erecting of new cogeneration plants (in 2009 cogeneration plants were built in Tallinn and Tartu) and the share of cogeneration is increasing (a power plant is being erected at Pärnu and several small cogeneration plants are being planned in different regions of Estonia). The subsidisation[2] has sharply increased investors' and energy producers' interest in using biofuels.

With its resolution of 28th January 2010, the *Riigikogu* essentially amended the Electricity Market Act so that a producer has the right to receive support from the transmission network operator for the electricity supplied starting from 1st July 2010 if it is generated from biomass in efficient cogeneration regime, unless electricity from biomass is produced in the condensation regime.

The Republic of Estonia also promulgated (Decision No 621. 2010) the law amending the Electricity Market Act, which was passed by the *Riigikogu* on 28th January 2010. At the same time, the President sent the Chancellor of Justice a letter requesting that he should pay special attention to a provision of the aforementioned Act, which will abolish as of 1st May 2007 the support for operators who generate electricity from biomass in summer.

The President can only reject a law as a whole. This would mean that provisions which are in line with the Constitution and must be passed as soon as possible to open 35 per cent of the Estonian electricity market as of 1st April 2010 and to avoid threatening of the construction of an EU supported second submarine communications cable between Estonia and Finland, would also remain ineffective. The Chancellor of Justice has the right to contest single provisions of any law, if appropriate.

In 2009, the Minister of the Environment with his Regulation No.14 approved of the structural aid award measure for more extensive use of renewable energy sources for energy generation. The purpose of the aid was to increase the share of renewable energy sources in the energy balance and to reduce pollutant emissions from the energy generation system. This Regulation should increase producers' and investors' concern for the energy production development in different regions of Estonia and disperse energy concentration in the eastern region.

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[2] For example, peat fuel boiler houses operating in efficient co-production regime are paid for produced and net transmitted electricity according to the Estonian Electricity Market Act, which is 81 cents/kWh (Estonian currency, 1EUR=15.6466EEK), or receive subsidy 50 cents/kWh, correspondingly. For using wood fuel (as a renewable fuel), the subsidies are significantly higher: subsidy of 80 cents/kWh or electricity sold to the net for the price of 115 cents/kWh.

Main provisions and scenarios in the electricity sector development plan

The Development Plan of the Estonian Electricity Sector (Development Plan of Estonian Electricity Sector 2009) underlines that oil shale is a strategic mineral resource for Estonia and electricity generation from oil shale is a characteristic of the Estonian energy sector – nearly 94% of electricity is produced from oil shale.

Considering the best scenario set out in the electricity sector development plan (Table 3), the capacity of co-generation plants must be increased to 300 MW (net capacity during peak hours 260 MW) by 2014; 2x300 MW oil shale fluidised bed combustion units (net capacity 270 MW) should be erected by the end of 2015; by 2012, desulphurisation and denitrification systems (net capacity of 4x150 MW) must be installed in four of the existing old 200 MW oil shale units; by 2013, the capacity of on-shore wind turbines must be increased to 400 MW (Table 3). The decisions concerning the investments in all these capacities shall be made before the end of 2010. For that purpose, application programme of the electricity development plan for 2009-2010 and prognosis up to year 2018 were approved by the Government of the Republic of Estonia. Since then the following has been done: 13^{th} March, the Board of Eesti Energia AS (BEE) signed a contract with the company Alstom for the installation of desulphurisation system (4 units) for the Eesti Power Plant oil shale pulverized energy blocks; on 21^{st} May 2009, BBE took a decision to construct 2x300 MW oil shale fluidised bed combustion units (the procurement process in progress); on 16^{th} July 2009, the Baltic Republics' most powerful Wind Park (Aulepa) with the capacity of 39 MW was opened in Noarootsi Municipality; on 17^{th} December, BBE approved of the construction of Waste to Energy Block (50 MW_{th} and 17 MW_e) at Iru Power Plant (in March 2010, a contract was signed with the enterprise CNIM) (Eesti Energia 2009).

The subsequent increase in the capacity of wind parks (included in the list of renewable energy sources and has a positive effect on the CO_2 trade balance) is most expedient on the sea, but this matter requires further studies. Production capacities must be constructed in the range of the capacity of wind turbines to balance the instability of the production of wind turbines and also to cover the consumption peaks. Partial closure of the units supplied with purification equipment in Narva Power Plants may be considered after putting the shale oil fired gas turbines into service presumably in 2018.

A need to increase the capacity of emergency reserves in 2016 is conditioned by the erection of the submarine cable Estlink 2 (with the estimated capacity of 600 MW).

Such an increase in transmission capacity is also a precondition for future integration of the Baltic Republics' energy market into the Nordic power exchange Nord Pool Spot. Moreover, the new link will increase the reliability of the Baltic energy systems, at the same time reducing their dependence on Russia. Advantages of the second cable between Estonia and Finland were analysed in a cross-regional study with the participation of Nordel, BALTSO and Polish regions, which was completed in February 2009. The results show clearly that the cable will be socio-economically useful for the Baltic Sea region (Figure 3).

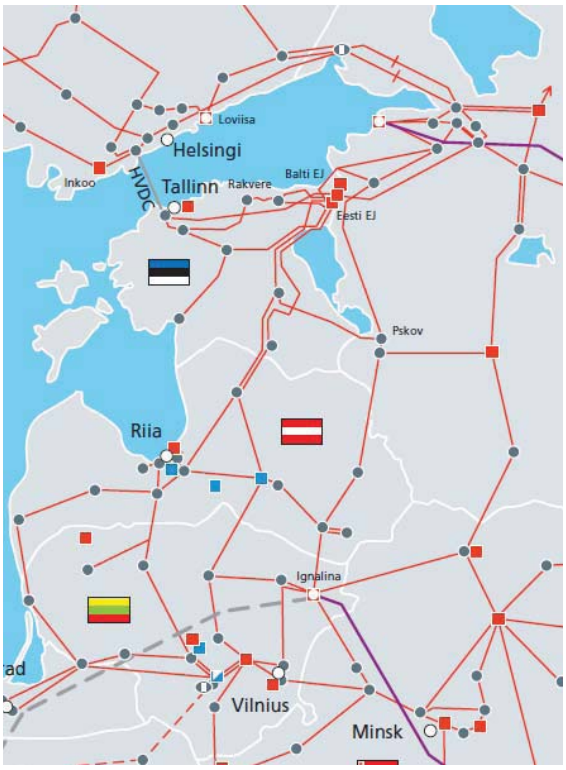

Figure 3. Integration of the Estonian electricity network into the neighbouring countries' network in 2010.

Capacities of the emergency power installations can be used also for ensuring the reserve capacity of nuclear power plants (in CO_2 trade nuclear installations are regarded as not emitting carbon dioxide). All gas turbine installations must be capable of using at least two types of fuel, preferably domestic resources and renewable sources of energy (author's remark).

The electricity production of every power plant depends on the market situation in a particular year and therefore it is nearly impossible to predict the volume of their electricity production. Electricity market regulation must guarantee that the structure of production capacities in Estonia is diverse and we have sufficient production capacities in case it is not possible to buy electricity cheaper elsewhere. However, a justified question arises in the case of importing cheaper electricity (for example, from Russia) about the true existence of the so-called clean electricity certificate. In a free market situation, electricity producers face an unequal competition situation in case of cheaper electricity inflow from third countries.

Electricity production under free market conditions

On the basis of 2020 prognoses, the situation should change fundamentally (Table 4, Figure 4), i.e. the share of oil shale-based electricity generation will decrease to ca. 40%, whereas the share of renewable energy will increase to the approximate level of 31%.

The results gained by using the CO_2 calculation methodology show that the CO_2 emission amount will be ca. 5.7 Mt (million tonnes) in 2020. In 2020 compared to 2007, the domestic consumption of electricity is estimated to increase: in 2007 the domestic consumption of electricity was ca. 8200 GWh (Table 1, export and transmission losses excluded) and in 2020 it is estimated to be 10480 GWh, i.e. the growth is ca. 22% (Table 4). Decrease in the emission amount of CO_2 will be gained due to the expected use of different energy sources, compared to those used in 2007 (Figure 2), in the designed power plants based on renewable energy sources or gas (Figure 4). The share of oil shale-based energy production will decrease from 83% to 44% resulting in a further reduction of CO_2 emissions from ca. 12 Mt to 4 Mt.

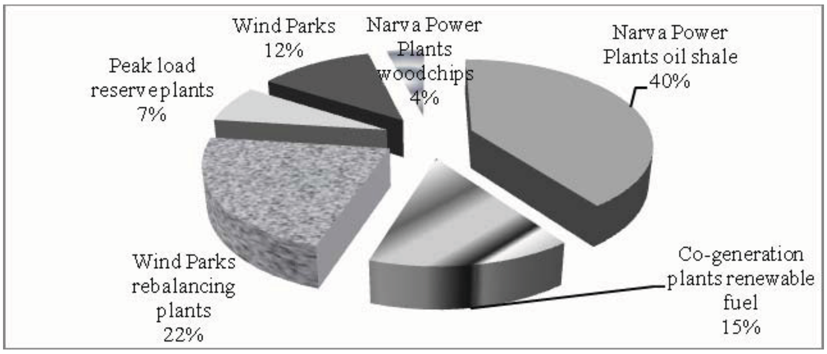

Figure 4. Electricity production in Estonia in 2020. (Author's calculations)

Table 3. Electricity production development trends until 2020

Type of power plant	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Co-generation plants	150	200	220	240	260	260	260	260	260	260	260
Oil shale-based plants	1660	1660	1630	1630	1630	2170	1520	1520	920	920	920
−not renovated	1280	1280	640	640	640	640					
−fluidised bed	380	380	380	380	380	920	920	920	920	920	920
−with purification equipment			600	600	600	600	600	600			
On-shore wind farms*	150	200	200	400	400	400	400	400	400	400	400
Balancing units for wind power							200	200	500	500	500
−including oil shale-based gas turbines							200	200	500	500	500
Peak reserves**	100	100	100	100	100	300	300	300	300	300	300
Emergency reserves**				100	200	300	300	300	600	600	600
Total guaranteed production capacity	**1810**	**1960**	**2150**	**2470**	**2590**	**3230**	**2980**	**2980**	**2980**	**2980**	**2980**

* The capacities are not taken into account in the total guaranteed production capacity
**Capacities under 100 MW

Source: Development Plan of the Estonian Electricity Sector until 2018.

Table 4. Projected electricity production and CO_2 emission values in 2020

Type of power plant	Capacity	2020	Output	Division	Specific CO_2 emission t/GWh	CO_2 emission from electricity generation (Mt)
	MW	Working hours*	GWh	%		
Co-generation plants	260	6000	1560	14.9	0	
Oil shale based power plants	920	5000	4600	43.6		
−including oil shale 90%			4140	39.5	997,2	
−wood chips 10%			460	4.4	0	
On-shore wind farms**	400	3000	1200	11.5		
Off-shore wind farms**	500					
Balancing units for wind power	900	2600	2340	22.3	502,5	
Peak reserves	300	2600	780	7.4	502,5	
Emergency reserves	600					
Total	**2980**	**3517**	**10480**	**100**	**0**	**5.7**
Total renewable electricity	1160		3220	30.7		
Total oil shale			4140			
Total natural gas			3120		0	

* Projected working hours of power plants.
** The capacities are not taken into account in the total guaranteed production capacity.

Source: Author's calculations.

Conclusions and discussion

In 2007 Estonia generated 12.2 thousand GWh or 12.2 TWh (terawatt-hours) of electricity, including 8.2 TWh for domestic consumption after deducting export losses. The domestic production projected for 2020 is ca. 10.5 TWh, which makes an annual growth of ca. 2.2%. The transmission network operator (now called Elering OÜ) has planned 1.8-3.5% for annual electricity production growth (Development Plan of the Estonian Electricity Sector 2009; Elering OÜ 2009), which is associated with the economic growth of 3-7%. Elering's plans coincide with the author's prognosis.

According to the National Allocation Plan 2008-2012, quotas are allocated to the energy enterprises participating in the CO_2 emission allowance trading scheme in the amount of 12.7 $MtCO_2$ annually. Hence, considering the 2.2% growth of electricity production, we are short of relevant quotas (12.8 $MtCO_2$/y2007) which we need to obtain from the trade sector. In case the European Commission respects the judgement of the European Court to re-negotiate the quotas allocated to Estonia in a positive direction for Estonia (in which the author doubts), then Estonia will have excess carbon dioxide quotas (ca 12 Mt/y) and energy producers will have an opportunity to avail them to make energy generation more effective and consumer friendly.

Considering the prognosis that electricity exports will remain on the level of 2007 (Table 1), i.e. ca 3 $MtCO_2$, the CO_2 emission values in 2020[1] would be ca 9 $MtCO_2$, i.e. ca 30% less than in 2007.

On the basis of calculation results presented in Table 1 we can see that energy can be saved and CO_2 emissions reduced not only by reduction of the fossil fuel usage (for example, implementation of a different economic structure from year 1990 in Estonia, usage of different renewable fuels, etc.), but the relevant spheres where energy can be saved and CO_2 emissions reduced are: energy consumption (the CO_2 emission level ca. 60% of total production), electricity export (correspondingly ca 23%), a smaller effect of network losses (11%) and plant's own electricity use (7%). These intermediate stages concerning the whole power system should constitute the main study targets either when choosing energy efficient products, auditing one's home energy use, implementing energy smart plans when building a new home or saving on transportation costs.

From 2013 the European Union Energy and Climate Package (European Parliament 2010) will take effect. In the framework of this Package, the EU Heads of State and Government set a series of demanding climate and energy targets to be met by 2020 – reduction in EU greenhouse gas emissions of at least 20% below 1990 levels; 20% of EU energy consumption to come from renewable resources; 20% reduction in primary energy use compared with projected levels, to be achieved by improving

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[3] As the quota trading rules for the period after 2012 are not clear yet, this topic will be developed further in the next market analyses and studies.

energy efficiency. This subject is not analyzed in this paper, but will be elaborated in future research.

In order to implement the best scenario described in the Development Plan of the Estonian Electricity Sector until 2018, so as to ensure the competitiveness of electricity producers in the free market conditions influenced by the CO_2 emission allowance trading, the erection of power plants (Development Plan of the Estonian Electricity Sector 2009) must be ensured under national regulations with the help of support schemes, state aid, tax policies and legislative measures. The CO_2 quota allocation policies after 2012 require further in-depth analysis and will be discussed in the next articles.

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CO_2 KAUBANDUSE MÕJU ELEKTRITOOTJATELE ERINEVATE ENERGIAALLIKATE KASUTAMISEL EESTI TINGIMUSTES

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Eesti on koos maailma teiste riikidega valinud säästva arengu tee, kus riikide heaolu kasvu aluseks on tasakaalu saavutamine loodusvarade ja keskkonna säästliku kasutamise vahel.

Euroopa Liidu (EL) direktiiviga 2003/87/EÜ, 13. oktoober 2003, on loodud kasvuhoonegaaside (KHG) saastekvootidega kauplemise süsteem, mille eesmärgiks on suunata ühiskonda tõhusamale ressursikasutusele ja innovatsioonidele, teadvustada fossiilsete kütuste põletamisel tekkiva CO_2 (süsinikdioksiidi) kahjustusi ja nende rahalist kulu ühiskonnale, tõhustada Kyoto protokolliga kehtestatud kohustuste täitmist kasvuhoonegaaside heitkoguste vähendamisel.

Käesoleva artikkel fikseerib olulisemad Eesti energeetikat ja majandust puutuvad asjaolud ja faktid, mis on tähtsad autori poolt koostamisel oleva uuringu „Kasvuhoonegaaside lubatud heitkoguste kauplemise mõju Eesti energeetika-majandusele“ arendamiseks ja põhiseisukohtade mõistetavaks tegemiseks.

Artiklis on toodud olulisemad faktid Eesti CO_2 kaubanduse esimese (2005-2007) ja teise (2008-2012) kauplemisperioodi kohta, on kirjeldatud Eesti elektritootmist baasaastal 2007 kehtiva elektrimajanduse arengukava alusel ning sellest tulenevalt CO_2 heitkoguste arvutust kasutatud kütuste järgi. Artikkel puudutab põhilisemaid taastuvenergeetika toetusega seotud seadusandlusest tulenevaid seisukohti, mis oluliselt mõjutavad taastuvenergeetika arendust ja kaudselt CO_2 kaubandust. Analoogselt baasaasta 2007 arvutusmetoodikale on arvutatud CO_2 heitkogused aastaks 2020. Elektritootmise prognoos aastaks 2020 baseerub autori elektri-majanduse arengukava interpretatsioonil.

CO_2 kvoodikaubandus on sümbioos energeetikast ja finantsmaailmast, mis on oluline kõigile energiatootjatele ning muudele kvoodikaubandusse haaratud tööstusharudele. Läbi energiahindade mõjutab CO_2 kaubandus aga ka kõiki ettevõtteid, kes energiat tarbivad. Käesolev artikkel on üks kavandatud artiklite seeriast, mis on koostatud uuringu „Kasvuhoonegaaside lubatud heitkoguste kauplemise mõju Eesti energeetikamajandusele“ raames.

Euroopa Liidu kliima- ja energiapaketiga (hakkab kehtima aastal 2013) kaasnevad mõjud energeetikasektorile vajavad täiendavat süvaanalüüsi ja selles artiklimaterjalis neid ei käsitleta.

KHG saastekvootide kauplemise süsteem 2005-2007 oli kui treeningetapp. Kasulikkus oli piiratud, kuna puudus pangandus 1. ja 2. etapi vahel ning ühikud olid ülehinnatud. Ühikute ülehindamise tulemusena nende hind perioodi lõpuks lähenes

0-le. Põhjuseks pakkumise ja nõudluse vahekorra muutus tööstussektori aktiivse turundustöö tulemusena.

2008. aastal alanud uueks kauplemisperioodiks, nn Kyoto esimeseks kauplemisperioodiks Euroopas (2008-2012), tegi Euroopa Komisjon väga radikaalseid kärpeotsuseid liikmesriikidele lubatavate heitkoguste üldsummas (nn Riiklik Jaotuskava RJK), et stabiliseerida ja ära hoida eel-Kyoto kauplemisperioodil valitsenud olukorda. 2008-2012 kauplemise perioodiks tegi Eesti ettepaneku Euroopa Komisjonile (EK) 24,4 mln tonni kohta aastas (122 mln t/5a). EK vähendas kvoote 12,7 mln tonnile (63,5 mln t/5a), so ca 52%.

Eesti on suutnud pidevalt katta oma elektrivajaduse ning ka eksportinud elektrienergiat. 2007. a statistikaandmete alusel toodeti elektrit 12 188 GWh, millest põlevkivienergia moodustab 93,6%. Välisõhku paisatav CO_2 kogus 2007. a elektrienergia tootmises ja tarbimises erinevate kütuste füüsikaliste näitajate ja koostootmisel tekkiva CO_2 eriheite (1,05 $ktCO_2$/GWh) arvutamise tulemusena on ca 12,8 Mt.

Arvestades CO_2 kvootide olulist vähendamist ning EL-i algatust taastuvenergia praegusest tunduvalt laiemaks kasutamiseks, on taastuvenergeetika näol tegemist kiiresti areneva valdkonnaga. Eestis leiab taastuvenergia allikatest kasutust peamiselt tuul ja biomass ning vähesemal määral ka vesi ja biogaas. Elektrimajanduse arengukavas 2005-2015 seati ülesandeks saavutada aastaks 2010 taastuvenergia osakaaluks 5,1% brutotarbimisest ning aastaks 2020 soojuse- ja elektri koostoomise jaamades toodetud elektri osakaaluks 20% brutotarbimisest. 2007. aastal moodustas taastuvelekter 1,75% brutotarbimisest. 2010. aastaks valmivate uute taastuvelektri tootmise projektide potentsiaalne toodang ületab seatud eesmärki.

2020. a elektri- ja soojuse koostootmisjaamades toodetud elektri osakaalu 20% brutotarbimisest saavutamiseks on 2007. aastal rakendunud koostootmise toetusskeemid (Elektrituruseadus 2003) soodustanud uute koostootmisjaamade rajamist (2009. a valmisid koostootmisjaamad Tallinna Elektrijaam ja Tartu Elektrijaam) ning koostootmise osakaal on suurenemas (ehitamisel Pärnu Elektrijaam ja planeerimisel veel mitmed väiksemad koostootmisjaamad Eesti erinevates piirkondades). Soodustus aktiveerib hüppeliselt investorite ja energiatootjate huvi bioenergia kasutamise vastu.

28. jaanuari otsusega muutis Riigikogu elektrituruseaduse taoliselt, et tootjal on õigus saada põhivõrguettevõtjalt toetust alates 2010. aasta 1. juulist elektrienergia eest, kui ta on selle tootnud biomassist tõhusa koostootmise režiimil, välja arvatud juhul, kui biomassist toodetakse elektrienergiat kondensatsioonirežiimil.

Eesti elektrimajanduse arengukavas on rõhutatud, et põlevkivi on Eesti strateegiline maavara ja põlevkivist elektri tootmine on Eesti energeetika eripära – ligi 94% elektrienergiast toodetakse põlevkivist.

Arvestades elektrimajanduse arengukava parimat tulevikustsenaariumi, tuleb 2014. aastaks suurendada koostootmisjaamade võimsust 300 MW-ni (netovõimsusega tipuajal 260 MW), 2015. aasta lõpuks rajada 2x300 MW (netovõimsus 270 MW) põlevkivi keevkihtplokid, aastaks 2012 aga paigaldada neljale olemasolevale 200 MW vanale põlevkiviplokile väävli- ja lämmastikuheitmete püüdmise seadmed (netovõimsus 4x150 MW), aastaks 2013 suurendada maismaatuulikute võimsust 400 MW-ni. Kõikide nende võimsuste investeeringuotsused tuleb teha enne 2010. aasta lõppu.

Järgnev tuuleparkide võimsuse suurendamine on otstarbekas merel, kuid vajab täiendavaid uuringuid. Tuulikute võimsuse ulatuses tuleb rajada ka tootmisvõimsused, mis tasakaalustaksid tuulikute toodangu ebastabiilsust ning kataksid ka tarbimise tippe. Pärast põlevkiviõlil töötavate gaasturbiinide kasutusse võtmist eeldatavalt aastast 2018 võib kaaluda Narva elektrijaamade puhastusseadmetega plokkide osalist sulgemist.

Avariireservjaamade võimsuse suurenemise vajadus 2016. aastal on tingitud Estlinki 2 merekaabli (eeldatava võimsusega 600 MW) valmimisest.

Sellise ülekandevõimsuse suurendamine on ka üheks eelduseks Balti riikide tulevase energiaturu integreerimiseks Põhjamaade energiabörsiga Nord Pool Spot. Lisaks sellele suurendab uus ühendus ka Balti energiasüsteemide töökindlust, vähendades samal ajal nende sõltuvust Venemaast. Eesti ja Soome vahelise teise ühenduse eeliseid analüüsiti regiooniüleses uuringus, milles osalesid Nordel, BALTSO ja Poola piirkonnad ning mis valmis 2009. aasta veebruaris. Tulemused näitavad selgelt, et plaanitav ühendus on Läänemere regioonile sotsiaal-majanduslikult kasulik.

2020. a prognooside tagajärjel võiks olukord kardinaalselt muutuda, st põlevkivienergeetika osatähtsus kahaneb ca. 40%-le, samas taastuvenergia osakaal suureneb ca. 31%-le.

CO_2 arvutusmetoodika kasutamise tulemusena saame aastaks 2020 CO_2 heitkoguseks ca 5.7 Mt (miljonit tonni). 2020. aastal võrreldes 2007. aastaga elektrienergia sisetarbimine suureneb, mis 2007. a oli ca 8 200 GWh ja 2020. a 10 480 GWh, st kasv on ca 22%. CO_2 emissiooni vähenemine on põhjustatud planeeritavate taastuvate ja gaasil töötavate elektrijaamade erinevate energiaallikate kasutuselevõtust võrreldes 2007. a kasutatavatega. Põlevkivienergeetika osatähtsus väheneb 83%-lt 44%-le, mis omakorda vähendab CO_2 heitmeid ca 12 Mt-lt 4 Mt-ni.

Vastavalt riiklikule jaotuskavale 2008-2012 eraldatakse CO_2 heitmekaubanduse skeemis osalevatele energiaettevõtetele EL kaubandusskeemis 12,7 $MtCO_2$ kvoote aastas, siis elektrienergia tootmise 2,2%-st kasvu arvestades jääb meil vajalikke kvoote puudu (12,8 $MtCO_2$/a2007), mis tuleb kaubandussektorist juurde muretseda. Juhul kui Euroopa Komisjon arvestab Euroopa Kohtu otsust Eestile eraldatud kvoodikogust positiivses suunas muuta (milles autor kahtleb), siis Eestil jääks süsinikdioksiidi kvoote üle (ca 12 Mt/a) ja energiatootjatel tekib võimalus neid kasutada energiatootmise tõhustamiseks ja tarbijasõbralikumaks muutmiseks.

Arvestades prognoosi, et elektrotoodangu eksport jääb 2007. a tasemele, st ca 3 $MtCO_2$, oleks CO_2 heitmekoguseks aastal 2020 ca 9 $MtCO_2$, st ca 30% vähenemist võrreldes aastaga 2007. Kuna pärast 2012. aastat kehtima hakkavad kvoodikaubanduse reeglid ei ole veel päris selged, siis arendatakse teemat edasi järgmistes artiklites.

Arvutustulemuste põhjal näeme, et peamised kohad, kus on võimalik energiat säästa ja CO_2 heitmeid vähendada, on energia tarbimine, võrgukaod, eksport ja omatarve.

Eesti elektrimajanduse arengukavas aastani 2018 toodud parima stsenaariumi elluviimiseks, et tagada elektritootjate konkurentsivõime vabaturumajanduse tingimustes mõjutatuna CO_2 heitmekaubanduse mõjudest, tuleb kindlustada nende jaamade teke siseriiklike regulatsioonidega toetusskeemide, riigiabi, maksupoliitika ja seadusandlike meetmete abil. CO_2 kvoodieraldamise poliitika pärast 2012. aastat vajab täiendavat analüüsi.