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ENERGY AND ENVIRONMENTAL INDICATORS FOR ESTONIAN ENERGY SECTOR

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Oil shale has a major role in Estonia's energy supply. This paper gives a brief analysis of indicators on efficiency and on environmental impact of the energy sector in Estonia. A more detailed overview is given on emission of greenhouse gases and on relevant possibilities of their reduction. Increase in energy efficiency is an important factor for the energy usage but also for the economic development of society. Therefore an overall assessment of trends on the national level is given, and a brief comparison with relevant indicators in other EU member states is presented.

Introduction

During recent years, an increasing emphasis has been put on improving energy efficiency in order to tackle environmental concerns, especially global climate change. Nevertheless, improving energy efficiency is also important for increasing energy security, industrial competitiveness, job creation and for several other economic and social areas. In Estonia the combining of fast economic growth with environmental targets is a great challenge.

In Estonia the transition from planned economy to market one started after regaining the independence in 1991. Major reforms were launched after the monetary reform in 1992. Estonian economy passed radical restructuring, which in the initial phase resulted in a sharp decline. Nevertheless, the reforms have been successful and resulted in achieving early macroeconomic stabilization and the creation of a favorable environment for economic development. Estonia has achieved a relatively high level of commercial and financial integration with the European and global economies. By today Estonia, being a member of the European Union (EU) since May 2004, has completed the transition period, and the pace of economic growth has been high, e.g. 5.8% per year between 1995 and 2003.

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Methods

The approach used in the current study is based on combining indicators from the fields of environment, energy and economic activities. This type of indicator-based analysis is quite widely used in the EU since the second half of the 1990's [1]. Nevertheless, the approach is new in Estonia, up to now only some studies by Laur and Tenno can be referred to [4, 13].

Indicators relating to greenhouse gas (GHG) emissions, energy consumption and economic activity data can be used to describe and analyze conditions and trends, but can be also used as a basis for deeper research of these fields. Comparison of these indicators can also help to evaluate improvements caused by implemented policies and enable forecasting (e.g. likelihood of reaching targets or early warning of undesirable changes) and make it possible to measure the progress in implementing policy.

Results and Discussions

The dynamics of some key indicator developments in Estonia since 1993 is presented in Fig. 1 [2, 3]. The population in Estonia has been decreasing every year since 1990 at an average annual rate of –0.98%. Partially, this is due to net emigration, but mainly due to a dramatic fall in the birth rate.

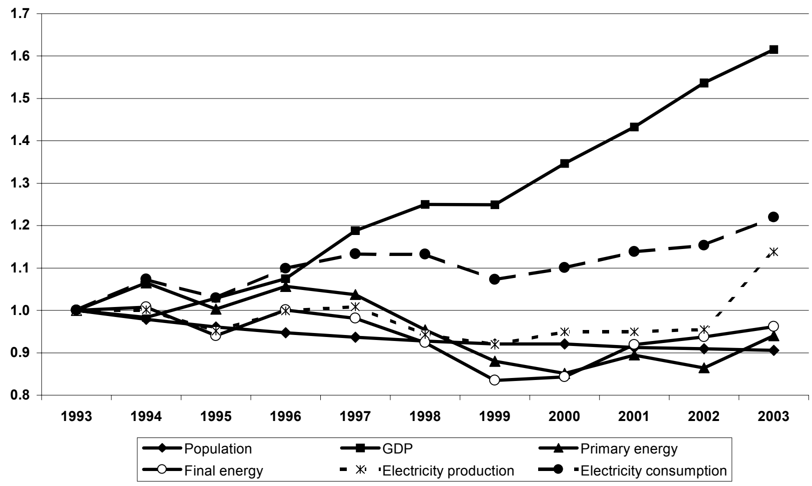

Fig. 1. Dynamics of key economic and energy indicators (1993–2003)

During last ten years the gross domestic product (GDP) (measured at constant prices) has grown by 61.6%, at the same time the amount of total primary energy supply (TPES) utilized for this growth has declined by 6% as average, indicating a certain increase in efficiency. The decrease has not been stable and has been affected by several factors.

Electricity production volume has been a key driver among these factors. So, the increase in electricity production in 2003 by 19.1% has been one factor causing the growth of primary energy use by 8.8% in the same year. A similar but less pronounced trend can be observed in the case of final energy consumption (FEC), which has reduced as well, but with more fluctuations resulting in slower average pace – 0.4% per year. Since 2001 the final energy consumption has turned towards increase. The values of electricity production have fluctuated between increase and decrease, depending heavily on export conditions, mainly on the need of electricity in Latvia. At the same time the electricity production depends on final electricity consumption in Estonia, which has had a steady tendency towards growing since 1996.

For comparing energy efficiency levels, both within a country during a time period and between countries, several indicators can be calculated. Three most general macrolevel indicators are commonly used for characterizing overall energy efficiency in a country. The first one is the primary energy intensity of the GDP, which relates the total amount of primary energy used in a country to the GDP at constant prices. This indicator represents both efficiency in the energy transformation sector and efficiency at the level of final consumers. The second indicator – the final energy intensity – concentrates on final consumers only. This is the ratio of final energy consumption to the value of GDP, being therefore suitable for monitoring the overall development of end-use energy efficiency (FEC/TPES). The third indicator is the ratio of final energy consumption to that of primary energy one. The progress of these and some other intensity indicators related to economy and energy use in Estonia are presented in Fig. 2.

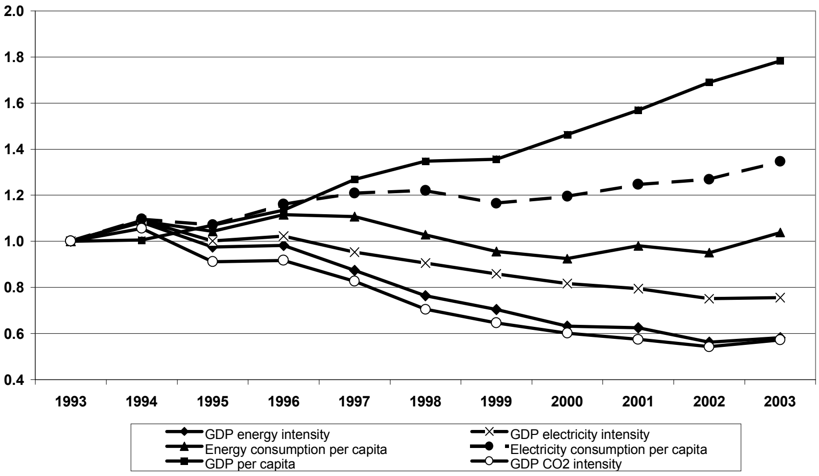

Fig. 2. Dynamics of energy-related intensity indicators (1993–2003)

To enable the proper analysis of annual changes, the intensity should be cleaned from the influence of climatic variations. During the period covered here, in particular since 1997, the climatic variations have played a relatively important role in dynamics of energy consumption. Since 1997, heating seasons have been warmer than the normal long-term average: in 2000 even by 13%. To remove the impact of climatic variations on energy efficiency indicators, the calculations have been made with climatic corrections. As the result, the energy intensity with climatic corrections represents the theoretical value of the intensity corresponding to a "normal" (i.e. long-term average) winter. In the period 1995–2003, the final and primary energy intensities have decreased – by 6.3 and 5.4% per year, respectively. The ratio of final to primary energy consumption has been slightly improving since 1995 – being in range from 48 to 54%.

In calculation of these indicators it has to be considered that the denominator, the GDP, represents many diverse activities. Since the energy intensities of these activities differ widely, changes in the mix of activities can cause significant variations in the ratio of energy to GDP over time, regardless of changes in specific intensities. Therefore, the GDP-related energy-intensity indicators are too general to enable finding out the real drivers of changes in the energy use. To gain a better understanding of the factors that affect energy use, it is important to analyze energy demand by sector, using more detailed end-use energy indicators.

An in-depth analysis of energy intensity and efficiency of Estonia's economy has been a complicated task. In Estonia the system of official statistics on economic development and energy use is not yet fully compatible for this task. The main difficulties in calculating the efficiency indicators have been related to the availability, coverage, relevance, compatibility as well as transparency of data. Also, there is no national body (e.g. energy agency), which would conduct relevant analyses regularly. Nevertheless, some analyses have been conducted at Tallinn University of Technology. In the beginning of this decade the first studies were published on sustainable development and energy intensity in relation to economic convergence of Estonia in the EU [4, 5].

The latest comprehensive and detailed analysis of the energy consumption trends and the progress achieved in energy efficiency in Estonia at the level of the whole economy as well as by sector was carried out in frames of the EU SAVE programme two-year project "Energy Efficiency Indicators for the Central and Eastern European Countries", which was completed in March 2004 [6]. The general objective of the project was to monitor the energy efficiency progress achieved in each country and to compare their performance in the field of energy efficiency with the EU countries.

The compatible time series for the study were available only for the period from 1996 to 2001. The time span was too short to make thorough conclusions on structural changes in economy, but nevertheless, the analysis indicated that the final energy intensity in most sectors had a trend towards decrease: it is the case not only for actual intensity, but also for intensity corrected for climate. On this general improving background, changes in the structure of GDP have only slightly contributed to the lower decrease of intensity – by 0.3%/year, or about 5% of the overall intensity decrease during the period from 1996 to 2001. It means that in Estonia, the major energy related changes in the GDP structure took place already earlier – in the first half of the 1990's.

To compare the energy intensity of Estonian economy with the situation in other EU member states the latest statistics from Eurostat were used [7, 8]. The primary energy intensity of GDP in 2002 was calculated using GDP values at constant prices (EUR 2000). The calculations of energy intensity using the market exchange rates of national currencies indicated that Estonia has the second highest primary intensity of GDP in the EU – 669 toe[1]/MEUR 2000, the highest intensity being in Slovakia – 723 toe/MEUR 2000 (Fig. 3).

As the market exchange rates quite often reflect other elements than price level differences alone, the method of purchasing power parities (PPP) is often used. The PPP based calculation makes it possible to eliminate the combined impact of price level differences and other elements from the comparison of national GDP values. In the EU for this type of comparisons the purchasing power standard (PPS)[2] is commonly used.

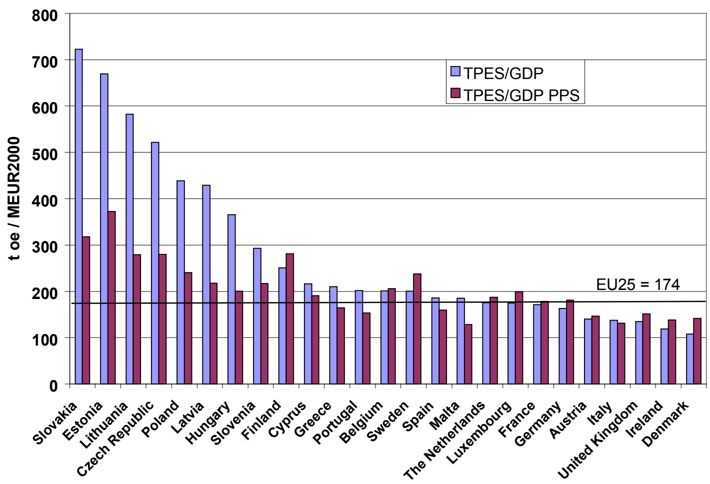

Fig. 3. Primary energy intensity of the GDP in EU countries (2002)

[1] toe – tonne of oil equivalent. 1 toe = 41.868 GJ = 11.63 MWh.
[2] The PPS is an artificial common currency that eliminates the differences in price levels between countries allowing meaningful volume comparisons of GDP between countries. Aggregates expressed in PPS are derived by dividing aggregates in national currency at current prices with the respective PPP [7].

The data on GDP intensity in EU member states are presented in Fig. 3. The calculations of GDP energy intensity using PPP method show that in 2002 Estonia had the highest value – 372 toe/EUR PPS, which is more than double of the average intensity in EU countries and exceeds 1.5 times the average intensity (248 toe/EUR PPS) in new member states.

The ratio of FEC to TPES demonstrates the low efficiency of energy use in Estonia – with the value of 0.52 Estonia is at the 23rd position among EU countries. There are several reasons for loosing 48% of energy before final consumption. In Estonia the efficiency of electricity generation is low (in old oil-shale-firing power plants even below 30%) and the share of co-generation of heat and power (CHP) in electricity production is small (approximately 13-14%). Also, the total share of electricity and district heat in final consumption is relatively high, if compared to other EU countries, causing additional transmission losses at the supply side. It has to be noted that the referred statistics [7, 8] does not take into account climatic conditions, which in Estonia, as well as in Finland and Sweden, are significantly more severe than in other EU countries.

Improving the environment with reduction of greenhouse gas emissions addressed to climate change is closely related to energy efficiency. Estonia has ratified the United Nations Framework Convention on Climate Change in 1994 by which the countries took the voluntary obligation to stabilize their greenhouse gases emissions to the level of 1990 by the year 2000. Estonia joined in the frame of the Convention concluded Kyoto Protocol in 1998 (and ratified the protocol in 2002), by which the emission amounts of greenhouse gases should be reduced equally with the member states of the European Union in 2008–2012, i.e. by 8% relative to the year 1990. By this goal the total emission of CO_2 for years 2008–2012 should be reduced to the level of 40.01 million tonnes of CO_2 per year (in 1990, 43.49 million tonnes, respectively). Mainly due to the reduction of electricity export, industrial production and restructuring, Estonia has reduced its greenhouse gas emission in 2003 by 51% compared to 1990 [9].

In 2003 the total anthropogenic greenhouse gas emissions without removals from land-use change and forestry (LUCF) in Estonia were 21.5 million tonnes of CO_2 equivalent ($CO_{2\,eq}$). The largest source, CO_2 accounted for 89% (19.1 Mt), CH_4 for 8.9% (1.9 Mt in $CO_{2\,eq}$) and N_2O for 2.1% (0.5 Mt in $CO_{2\,eq}$) of the total national greenhouse gas emissions (Fig. 4) [9].

Energy industries are causing most of the greenhouse gas emissions in the energy sector[3] in Estonia[4]. In 2003 the share of the energy industries sub-

[3] According to the methodology of Intergovernmental Panel of Climate Charge (IPCC) energy sector includes all sub-sectors (i.e. energy industries, manufacturing industries and construction, agriculture, transport, residential, commercial and other sectors) were fuel combustion is used.

[4] Hereafter, when referring to total greenhouse gas emissions in Estonia the removals and emissions from the land-use change and forestry sector are excluded.

sector (including power and heat generation and production of converted fuels) was 84% of the greenhouse gas emissions in the energy sector. Transport sector, including also GHG emissions from motor fuels combustion by private cars, contributed 11% and the other sectors (residential, agriculture and commercial) the rest of 3%.

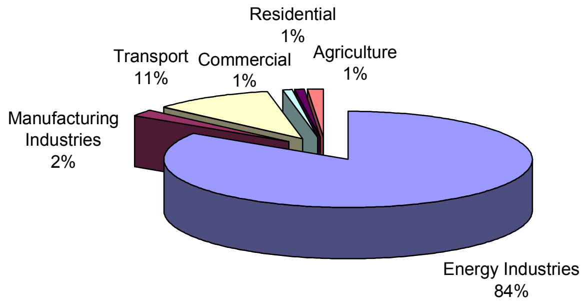

Fig. 4. Main source categories of the greenhouse gas emissions in the energy sector in Estonia (2003)

In Figure 5 the share of different fuels in the total CO_2 emission is presented. As one can see, the biggest contributor of carbon dioxide emissions is oil shale contributing 72% of carbon dioxide emissions, combustion of fuel oils gives 12%, natural gas 8%, motor fuels 5% and other fuels (coal, coke and peat) the remaining 3% of the total CO_2 emissions from fuel combustion.

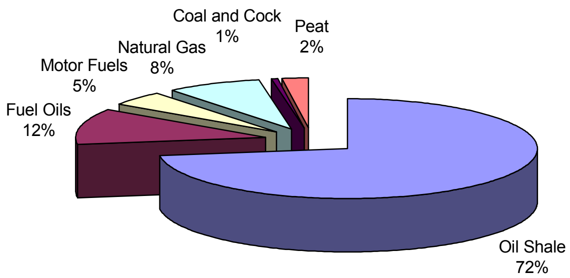

Fig. 5. Carbon dioxide emissions from fuel combustion (2003)

The main GHG emission indicators are: CO_2/TPES, CO_2/GDP, CO_2/capita and CO_2 emission per kWh.

In Figure 6 the emissions of carbon dioxide per capita in EU25 countries are presented. Estonia is among eight biggest emitters of carbon dioxide per capita in Europe. In 2002 Luxembourg emitted 20.0, Czech Republic 12.5, and Estonia 10.4 tonnes of carbon dioxide per capita (without LUCF). EU25 average was about 9 t per capita and in Lithuania and Latvia this indicator was only 4 and 3 tonnes per capita, respectively. It is important to point out that while in EU15 CO_2 emission per capita has been almost stable, then in Estonia it started to decrease since 1990. The CO_2 emission per capita was in 1990 about 25 t and in 2002 – 12.2 tonnes per capita in Estonia, it means, that the reduction has been almost 51% [10].

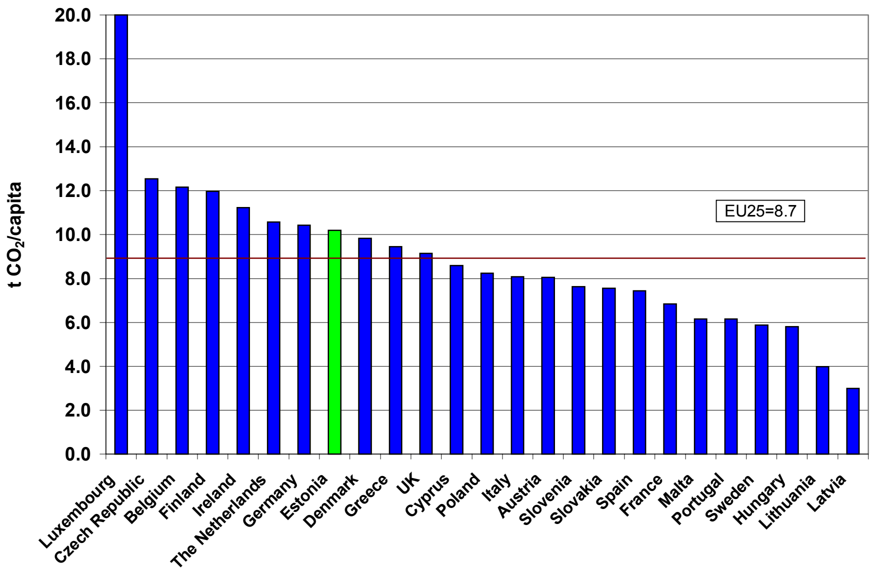

Fig. 6. Emission of carbon dioxide per capita in EU25 countries (2002)

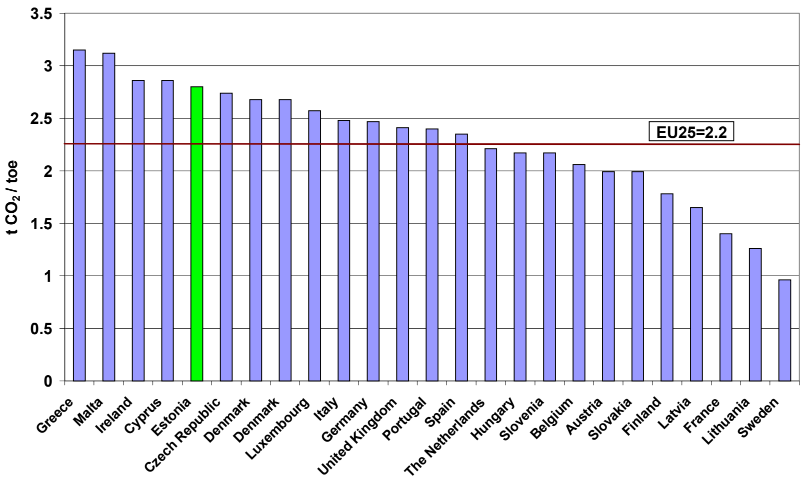

Fig. 7. Carbon intensity of primary energy supply in EU25 (2002)

In Figure 7 the data on the carbon intensity of EU25 are presented. Carbon intensity is one of the most important greenhouse gas indicators.

CO_2/TPES ratio is expressed in tonnes of CO_2 per tonne of oil equivalent (toe) and indicates carbon intensity of primary energy supply in the country. When in EU countries the average intensity in 2002 was 2.24 tonnes of carbon dioxide per toe, then Estonia exceeds this value for 1.25 times. Such a high carbon intensity of TPES in Estonia is related with the dominating share of oil shale in the primary energy supply (about 60% in 2002) [3].

Carbon intensity of TPES has a significant impact on country's GHG emissions and carbon intensity of economy. CO_2/TPES and TPES/GDP can be used for decomposition of carbon intensity of economy – CO_2/GDP.

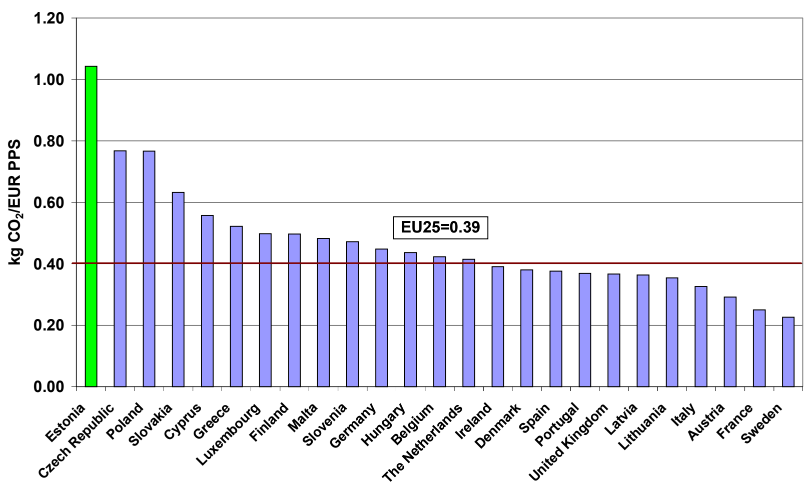

Fig. 8. Carbon dioxide intensity per GDP (PPS) in EU countries (2002)

The amount of GHG emissions follows the development trend of primary energy supply in Estonia. Intensity of CO_2 emission reflects the contribution of the economy and whole society to the global warming. The CO_2/GDP (PPS) intensity indicator is defined as the amount of CO_2 emitted in the country to generate a unit of GDP. The intensity of CO_2 emissions decreased during 1990 to 2002 almost by 50% in Estonia. Nevertheless, as one can see from Fig. 8, Estonia's carbon intensity indicator per GDP (PPS) distinguishes from that for other countries exceeding the average EU25 value of this indicator about 3.5 times. It means, that despite of the perceivable GDP growth (about 62%) during the last ten years mentioned before is the amount of TPES (and accompanied emission of CO_2) used for generation of a unit of GDP still to high. This is mainly related to the high energy intensity of economy in general and carbon intensive structure of total primary energy supply.

The analysis of the development tendencies using the most up-to-date data series ensure that there is a clearly pronounced trend towards improving of efficiency: the energy intensity of GDP has been falling and the GDP per capita has been increasing with only minor fluctuations during last ten years (see Fig. 9).

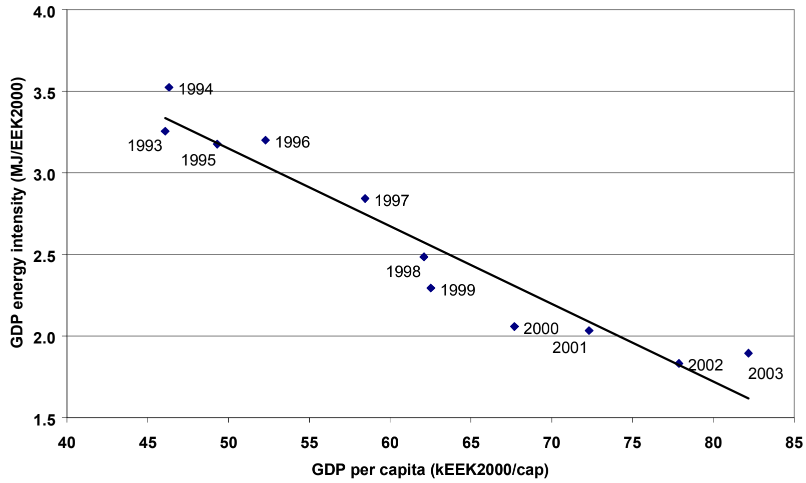

Fig. 9. Dynamics of efficiency and energy use in economy of Estonia (1993–2003)

The increase of efficiency and principles of sustainable development are major drivers in the latest strategy document for Estonian energy sector approved by the Estonian Parliament in December 2004 [10]. The most ambitious general goal is to maintain until 2010 the volume of primary energy consumption at the level of the year 2003. Several other environment and efficiency related strategic objectives set in the document include:

- to ensure that by 2010 renewable electricity forms 5.1% of the gross consumption;
- to ensure that by 2020 electricity produced in combined heat and power production stations forms 20% of the gross consumption;
- to ensure that, in the open market conditions, the competitiveness of the domestic market of oil shale production is preserved and its efficiency is increased;
- to ensure that modern technologies which reduce harmful environmental impact will be introduced in oil shale sector;
- to ensure compliance with the environmental requirements established by the state;
- to increase the efficiency of the energy consumption in the heat, energy and fuel sector.

Most long-term projections for Estonian energy sector have envisaged reduction of the share of oil shale in the energy balance as a result of the increasing share of renewable resources and more extensive use of combined production of heat and electricity, the latter mainly on the basis of plants firing natural gas. Nevertheless, the oil shale combustion technology is reaching the new level. Using the circulating fluidized-bed combustion (CFBC) technology, two 215 MW_{el} energy blocks started to operate in 2004. The introduction of CFBC technology means not only more efficient utilization of oil shale and higher thermal efficiencies but also much less atmospheric emissions [14]. Compared to the old power units utilizing the pulverized firing of oil shale, the fluidized-bed units have 35 MW higher maximum capacities and generate the same amount of electricity with 20% less fuel [11].

Conclusions

Combining supply and demand side of energy efficiency measures with the economic growth should decrease the energy intensity of Estonian economy quite significantly. Nevertheless, the convergence with the EU in this field would be an extremely long process. The latest projections on convergence to the EU level of energy efficiency in Estonia were made in the Estonian Institute of Economics at Tallinn University of Technology in 2001. Attempts were made to evaluate the continuation of this process by calculating the GDP energy intensity in Estonia on the basis of different development scenarios of GDP and TPES [4]. The result indicated that according to the most optimistic prognosis, the Estonian GDP energy intensity might reach the EU 1998 level in 2025.

As to the future of oil-shale-based electricity production, the internalizing of external costs in electricity production is presently an extremely important issue in Estonia, particularly in relation to planning of the future development of oil shale-based energy production. The current elements of the external costs – resource tax and pollution charges – have only minor impact on the price of oil shale-based electricity production. There have been made some studies on methodology for internalizing external costs of oil-shale-based electricity production [12, 13].

The results of the latest study show that only the abolishment of the present discount on the water consumption charge for oil-shale mining and electricity production would increase the environmental costs in the oil-shale-based electricity production price by 1.5 times and electricity production price by 2 sents per kWh, if compared with the base scenario.

According to the scenario with a significant increase of air pollution charge rates the oil-shale-based electricity production price may rise 4-5 times. Therefore, the principles of internalizing of external costs should be more consistently taken into account in the process of projecting the future of oil shale based energy production.

Energy consumption is the main contributor to GHG emissions in Europe and Estonia as well. Combining supply and demand side energy efficiency measures with the economic growth should decrease the energy intensity of Estonian economy quite significantly. At the same time, the reduction of the impact on environment should be a key driver for planning of the future of the oil shale sector in Estonia.

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