Abstract
An effective assessment of energy-related policy instruments requires the use of models capable of simulating the technological change necessary to induce long-term, economical shifts towards a sustainable global energy system(s), while simultaneously representing in adequate detail key energy-economy-environment interactions.

This paper contains substantial components of Estonia’s Fourth National Communication project what prepare under the UN Framework Convention on Climate Change.

Keywords
CO₂ emissions, pollution reduction, energy resources, energy consumption forecast

Introduction
Estonia signed the Framework Convention on Climate Change at the United Nations Conference on Environment and Development held in Rio de Janeiro in June 1992. In 1994 Estonia ratified the UN FCCC and in 2002, the Kyoto Protocol. Under the Protocol Estonia is obliged to reduce during the period 2008-2012 the emissions of air polluting greenhouse gases from its territory by 8% as compared with the 1990 level.

In response to UNFCCC requirements Estonia has prepared since 1994 every year National Inventory Reports and three National Communications. The current Fourth National Communication covers the GHG inventories of the years 1990 to 2003 including also the years for which inventories have been reported earlier but have now been recalculated. The purpose of all recalculation was to improve the accuracy and completeness. Now, the inventory of all years is estimated using the same methodology, adjusted statistical data and emission factors.

The general trends in the emissions and sinks are obvious. In 2003 the net emission in GWP units was only 22% of that in 1990 and the decreasing trend is continuing. The sink comprises from total emissions in CO₂ equivalents about 30%. The favorable trends are mainly due to the restructuring of economy but also political measures. In 1994, when the first National Inventory Report was completed, Estonia belonged to the group of the world’s greatest emitters of GHG per inhabitant, but in 2003 we are already quite close to the average level. The reliability of our initial data has improved, legislation and surveillance have greatly developed and we can be sure that Estonia is capable of achieving the 8% reduction of GHG emissions as compared to the 1990 level by the year 2012 envisaged in the Kyoto Protocol.

1 Methodology and basic considerations
1.1 MARKAL model features
The analysis has been carried out using the Estonian MARKAL model.

MARKAL is an energy-system optimization model that represents current and potential future technology alternatives through the so-called Reference Energy System (RES). The MARKAL model is a generic technology-oriented model tailored by the input data to obtain the least-cost energy system configuration for a given time horizon under a set of assumptions about end-use demands, technologies and resource potentials. It represents the time evolution of a specific RES at the local, national, regional, or global level [1]. The MARKAL models allow a wide flexibility in representation of energy supply and demand technologies and are typically used to examine the role of energy technologies under specific policy constraints, e.g. CO₂ mitigation, local air pollution reduction, etc.

1.2 Forecast of main energy indicators
The development of the main energy indicators until 2010 as forecast in the Draft National Long-Term Development Plan for the Fuel and Energy Sector until 2015 (with a vision until 2030) can be found in the following Table. 1
Table 1. Estonian main energy indicators until 2010.

<table>
<thead>
<tr>
<th></th>
<th>2000</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary energy supply (PJ)</td>
<td>189</td>
<td>220–250</td>
</tr>
<tr>
<td>Consumption of oil shale (Mt)</td>
<td>13.2</td>
<td>11–13</td>
</tr>
<tr>
<td>Share of renewables in primary energy supply (%)</td>
<td>10.5</td>
<td>13–15</td>
</tr>
<tr>
<td>Share of renewables in electricity generation (%)</td>
<td>0.1</td>
<td>5.1</td>
</tr>
<tr>
<td>Final consumption of electricity (TWh)</td>
<td>5.4</td>
<td>6.5–8.0</td>
</tr>
<tr>
<td>Necessary net capacity of power plants (MW)</td>
<td>1980</td>
<td>2200–2500</td>
</tr>
<tr>
<td>Share of CHP in electricity generation (%)</td>
<td>12–14</td>
<td>15–20</td>
</tr>
<tr>
<td>Maximum net load of Estonian power system (MW)</td>
<td>1400</td>
<td>1600–1900</td>
</tr>
<tr>
<td>Openness of electricity market (%)</td>
<td>10</td>
<td>35–40</td>
</tr>
<tr>
<td>Heat consumption (TWh)</td>
<td>8.5</td>
<td>8–9</td>
</tr>
<tr>
<td>Share of CHP in heat production (%)</td>
<td>33</td>
<td>35–40</td>
</tr>
<tr>
<td>SO$_2$ emissions (% of limit in 2008)</td>
<td>181</td>
<td>90–100</td>
</tr>
<tr>
<td>CO$_2$ emissions (% of limit in 2008)</td>
<td>48</td>
<td>50–55</td>
</tr>
</tbody>
</table>

1.3 Basic modelling assumptions

The following basic assumptions were made in all scenarios:

1. Electricity and biomass imports and nuclear plants are restricted.
2. Electricity net export is allowed until 2015.
3. Price of natural gas will increase rapidly to the European level.
4. Gross Domestic Product (GDP) forecast is based on the actual value of 2000 GDP at market prices, actual growth in 2001 and 2002 [2], and the annual growth forecast from [3], that in turn bases on the forecast of the Ministry of Finance of Estonia until 2030 [4]. The base year GDP and energy data are taken from publications of the Statistical Office of Estonia [2, 5, 6, etc].
5. All scenarios use low energy consumption forecast. Introduction of large-scale energy intensive industry is not envisaged. A possible future new pulp & paper plant is modelled as a separate unit and it can be closed and easily excluded from the results, if this investment is not actually made. It is assumed that high energy prices will stimulate the implementation of conservation measures in all sectors of economy. Heat consumption is assumed to be stable over the planning period, but electricity consumption is forecast to increase.
6. The planning period is 2000-2030 and the discount factor is 0.05.
7. The number of population remains stable around 1.4 million over the planning period. The number population is presently actually decreasing [4], but this decrease is assumed to be compensated for by immigration here.

The value of Estonian GDP was 5.584 billion EUR (4076 EUR per capita) in 2000 [2]. The annual growth forecast for the current project was taken from [3] (average forecast) and the forecasts of population and GDP used in the modelling are presented in Table 2.

Table 2. Forecast of population and GDP.

<table>
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<tr>
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<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Population</td>
<td>1.37</td>
<td>1.35</td>
<td>1.35</td>
<td>1.4</td>
<td>1.4</td>
<td>1.4</td>
<td>1.4</td>
</tr>
<tr>
<td>GDP/capita</td>
<td>EUR/cap</td>
<td>4076</td>
<td>5533</td>
<td>7327</td>
<td>8847</td>
<td>10630</td>
<td>12407</td>
</tr>
</tbody>
</table>

The primary energy resources of Estonia are estimated as follows [3, 7]:

**Oil shale** – active resources of the deposit are ca 1.2 Gt and passive resources 4 Gt. Latest research results of the Mining Department of TUT estimate that the resources can last 60 years under current level of exploitation.

**Peat** – total deposits 775 Mt (annual limit for extraction is 2.78 Mt/a = 31 PJ/a, annual growth is 0.5 Mt/a = 5.6 PJ/a).

**Biomass and waste** – theoretical total annual resources are 102 PJ, economically feasible annual resources for CHPs are 21 PJ.

**Hydro** – potential is 30 MW (corresponds to the annual production of 0.5 PJ/a).

**Wind** – theoretically a very large resource, but its use is involves several restrictions [8, 9]. Considering the possibilities of the Estonian power system and its neighbours to integrate the windmills, the capacity limit is ca 400 MW, which corresponds to...
the annual production of 0.84 TWh/a = 3 PJ/a. Maximum long-term annual utilization of wind energy is estimated at 10 PJ/a (requires 1400 MW of installed capacity of windmills).

**Solar** – the estimates of annual utilization vary in a wide range: from 0.5 to 8 PJ/a.

**Geothermal** – in principle 0, only ground heat pumps can be used.

All other fuels have to be imported. The existing **natural gas** pipelines can supply up to 70 PJ/a.

Coal and oil products can be imported via rail and harbours.

Average consumer prices of fuels, electricity and heat in 2000 are presented in Table. 3 [1].

<table>
<thead>
<tr>
<th>Table 3. Average fuel and energy prices for consumers in 2000.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Coal</td>
</tr>
<tr>
<td>Oil shale</td>
</tr>
<tr>
<td>Sod peat</td>
</tr>
<tr>
<td>Peat briquette</td>
</tr>
<tr>
<td>Firewood</td>
</tr>
<tr>
<td>Wood chips and waste</td>
</tr>
<tr>
<td>Natural gas</td>
</tr>
<tr>
<td>LPG</td>
</tr>
<tr>
<td>Heavy fuel oil</td>
</tr>
<tr>
<td>Shale oil</td>
</tr>
<tr>
<td>Light fuel oil</td>
</tr>
<tr>
<td>Diesel oil</td>
</tr>
<tr>
<td>Gasoline</td>
</tr>
<tr>
<td>Electricity</td>
</tr>
<tr>
<td>Heat</td>
</tr>
</tbody>
</table>

The forecasts of tax-free production and import prices (without inflation) of the main fuels for MARKAL modelling were the following:

- The oil shale price 14.2 EEK/GJ=0.91 EUR/GJ will remain constant until 2020 and then it will rise to the level of 18 EEK/GJ. This forecast is based on the information from the oil shale mining company “Eesti Põlevkivi” [10].
- The import price of coal will be stable on the level of 25 EEK/GJ=1.6 EUR/GJ [7].
- It is assumed that stable prices of oil shale and coal will slow down the growth of the prices of wood and peat. The production price of peat is assumed to grow from 20 EEK/GJ to 30 EEK/GJ and the price of wood fuel from 13 EEK/GJ to 30 EEK/GJ during 2000-2030.
- It is assumed that Estonia’s joining the EU brings rapidly about the same price levels and its growth predictions for natural gas and oil products. It means the growth of the heavy fuel oil price from 50 EEK/GJ=3.2 EUR/GJ in 2000 to 170 EEK/GJ = 10.9 EUR/GJ in 2030 and the growth of the natural gas price from 35 EEK/GJ = 2.24 EUR/GJ to 125 EEK/GJ = 8 EUR/GJ during the same period.

Forecasts of final energy consumption of industry* (without a new large pulp and paper factory) and agriculture are presented in Figure 4. As it was mentioned before, the possible new pulp & paper factory was modelled separately.

The transport sector of Estonia as a transit country between East and West is assumed to grow rather fast. The main growth will come from the road transport (trucks, buses, trams, trolleys and company cars) and private cars. The corresponding forecasts are presented in Table 4.

The household sector was modelled as much as possible on the basis of useful energy consumption. The corresponding forecast is depicted in Figure 5. In addition to the specific electrical appliances, electricity is used also for lighting, cooking, space heating and water heating.

The energy consumption of commercial and public services was modelled via final demand of electricity and heat. The corresponding forecast figures are presented in Table 5.
Fig. 4. Final energy consumption forecasts of industry (without a new pulp & paper factory) and agriculture.

Table 4. Forecast of transport energy consumption, PJ/year.

<table>
<thead>
<tr>
<th></th>
<th>2000</th>
<th>2010</th>
<th>2020</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Railways</td>
<td>2.0</td>
<td>2.5</td>
<td>2.8</td>
<td>2.9</td>
</tr>
<tr>
<td>Road transport</td>
<td>11.0</td>
<td>18.9</td>
<td>22.6</td>
<td>26.6</td>
</tr>
<tr>
<td>Private cars</td>
<td>10.0</td>
<td>15.0</td>
<td>20.0</td>
<td>24.0</td>
</tr>
<tr>
<td>Inland waterway</td>
<td>0.3</td>
<td>0.4</td>
<td>0.5</td>
<td>0.6</td>
</tr>
<tr>
<td>Air transport</td>
<td>1.0</td>
<td>1.8</td>
<td>2.6</td>
<td>3.9</td>
</tr>
</tbody>
</table>

Fig. 5. Useful energy consumption projections of households.
Table 5. Forecast of final energy consumption in the service sector, PJ/year.

<table>
<thead>
<tr>
<th></th>
<th>2000</th>
<th>2010</th>
<th>2020</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity consumption</td>
<td>4.9</td>
<td>7.0</td>
<td>9.7</td>
<td>12.4</td>
</tr>
<tr>
<td>Heat consumption</td>
<td>4.6</td>
<td>5.0</td>
<td>5.5</td>
<td>6.0</td>
</tr>
</tbody>
</table>

The reference level of 1990 total CO$_2$ emissions from fossil fuel combustion is 37.5 Mt. Considering the Kyoto obligation to reduce the emissions by 8% by the years 2008-2012, the limit of emissions of Estonia for the year 2010 can be set at 34.5 Mt. Estonia’s net GHG emissions (including all gases, sources and sinks) in 1990 were 37.2 Mt [11]. The actual total CO$_2$ emissions were 16.43 Mt in the year 2000. It means 56% reduction compared with the reference year 1990.

2 Energy related CO$_2$ emission scenarios

2.1 With measures (WM) scenario

In this scenario approved or already decided policy measures are as described in “Policy and Measures”. The following basic assumptions were considered in the scenario:

- Starting from 2008 our power plants have to comply with the EU directive on the limitation of emissions into the air from large combustion plants. During the accession negotiations with the EU Estonia got some transition periods but the existing oil shale pulverized combustion units cannot work after 2015. So Estonia will close these power plants before the end of 2015 in accordance with the schedule agreed with the EU. As a result, only 6% of the capacity of power plants that existed in the 1990s (over 3000 MW) can continue operating after 2015.
- Estonia will fulfill requirements on emission reductions and introduction of renewables. The national target for the introduction of RES in electricity production is 5.1% of the total domestic electricity consumption in 2010. Estonian Environmental Strategy and agreements with Finland state that sulphur dioxide (SO$_2$) emissions in 2005 should not exceed 20% of the 1990 level, emission of solid particles must be reduced by 25% as compared to 1995 and NO$_X$ emissions should not exceed the 1987 level.
- Environmental taxes continue to increase 20% annually and they will reach the European forecast values at the end of the planning period.

According to the Estonian Pollution Charge Act the level of fees for emissions that do not exceed the volume limits are presented in Table 6. (1 EUR=15.64664 EEK).

Table 6. Forecast of final energy consumption in the service sector, PJ/year.

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>SO$_2$</th>
<th>CO</th>
<th>CO$_2$</th>
<th>Nontoxic dust</th>
<th>Oil shale ash, fly ash</th>
<th>Soot and coal dust</th>
<th>NO$_X$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Charge EEK/t</td>
<td>55.2</td>
<td>7.9</td>
<td>5.0</td>
<td>39.6</td>
<td>55.2</td>
<td>79.2</td>
<td>126.4</td>
</tr>
</tbody>
</table>

There are different multiplication coefficients of fees (from 1.2 to 2.5) depending on the location of the pollution source. The fees will rise 5–100 times if the permitted volumes are exceeded.

To fulfill the environmental requirements of the year 2005, reconstruction of two production units of the oil shale power plants with the total net capacity of 390 MW and renewal of ash filters of all units had to be completed in 2004. The new units use circulating fluidized bed combustion technology that raises conversion efficiency from 29% to 34% and minimizes sulphur emissions. Next steps in the new capacity building will be decided after gaining experience from the operation of the first units. Considerable options are also coal, peat and co-combustion of different fuels. It is important to continue research of pressurized fluidized bed combustion of oil shale. Only this technology could provide oil shale plants the necessary conversion efficiency (ca 44%) and emissions reduction in the longer perspective. Ash removal systems of oil shale power plants have to be renewed before July 2009.

WM scenario is conservative concerning technological development of oil shale combustion. It trusts only the circulating fluidized bed combustion (CFBC) technology and does not consider the more advanced and efficient but premature pressurized fluidized bed combustion (PFBC) option.

New power plant and electric grid investments of this scenario base mainly on [13]. This plan envisages partial reconstruction of oil shale power plants on the basis of CFBC technology, but also investments into gas turbines, biomass CHP and wind turbines.

The investment plan [10] states that the power production capacity of Eesti Energia Ltd will decrease from present 100% of peak load + reserve capacity down to 85% of peak load in 2010. As a result of this statement, new independent producers or imports (import is restricted under this modelling exercise) have to cover the rest of the necessary capacity.

There were no specific “forced solutions” in the heating sector.
Estonian CO₂ emissions will never climb up to the Kyoto limit under any scenario. Therefore the additional reduction targets were set in relation to the MARKAL model estimate for the year 2010 under WM scenario. This estimate was 16.52 Mt.

2.2 With additional measures (WAM) scenario

In this scenario approved or already decided policy measures are as described in “National Programme for the Reduction of GHG Emissions”. The following basic assumptions were made in scenario:

- The long-term objective of the National Programme is reduction of greenhouse gas emissions by 21% by 2010 as compared with the 1999 emission level. This includes reduction of carbon dioxide emissions by 20%, reduction of methane emissions by 28%, and increase of nitrogen dioxide emissions by 9%.

Development in accordance with the information given above yields an infeasible solution with assumptions described before.

Instead the following scenarios are used:

a. WAM-LEVEL1 – gradual reduction of CO₂ emissions by 1% during 2010-2030 compared to the 2010 level in WM scenario.

b. WAM-LEVEL2 – gradual reduction of CO₂ emissions by 15% during 2010-2030 compared to the 2010 level in WM scenario.

Also there where third scenario made - Without measures (WOM) scenario, where all measures described in chapter 2.1 (WM scenario) were excluded.

2.3 Comments on results

Estonia has mainly two renewable energy sources – biomass and wind. Hydro potential is only ca 30 MW. Wind power is limited by the balancing capability of the existing power system. The model uses these resources up to their limits.

Future solutions in the Estonian energy system are very sensitive to the price of natural gas. The security of the Russian gas supply is an extremely important factor as well. Here the high gas price scenario was used. The share of natural gas determines largely the CO₂ reduction. If the gas price forecast was lower, condensing power plants and CHP plants mainly on natural gas would be built instead of using oil shale. Considering the carbon emission factors (tonnes of carbon per 1 TJ of fuel) of oil shale (29.1 tC/TJ for pulverized or CFB combustion under atmospheric conditions and 22 tC/TJ for PFBC [7]) and natural gas (15.6 tC/TJ) and the efficiency coefficients of condensing oil shale power plants (29% for pulverized combustion, 34% for CFBC, 44% for PFBC) and combined cycle natural gas plants (56%) as well as the lower specific investments and O&M costs and other advantages of natural gas plants, the preference of natural gas is not surprising.

A nuclear plant was prohibited under the considered scenarios. The Baltic States are still discussing very seriously the construction of a new joint nuclear plant after Ignalina 3 GW plant is closed down. A nuclear plant appears in the optimal solution of energy modelling when it is allowed, emission taxes are high and CO₂ targets are strict. It appeared also in the scenario LEVEL1 in the model special test run. A nuclear plant changes the scenario results significantly.

Research on co-combustion of different fuels with oil shale in the fluidized bed boilers of large power plants is conducted in Estonia [7], but has not been not tested and implemented. The options are coal, peat and woodchips. It is evaluated that the co-combustion of wood in oil shale power plants would require wood import.

This study did not use the electricity and biomass import options as possible ways for reducing GHG emissions.

MARKAL model bases on the concept of Reference Energy System and therefore the representation of energy flows differs slightly from the official energy balance statistics.

Without measures scenario:

Power plants continue to use oil shale as the main fuel. The existing capacity of power plants will be utilized until the end of planned lifetime. During 2004–2010, 200 MW of new condensing and 190 MW of new CHP net capacity will be built using CFBC technology to replace the capacity of the old pulverized combustion plants. Coal will dominate after 2015

With measures scenario:

Power plants continue to use oil shale as the main fuel. During 2004-2015, 1230 MW of new condensing and 190 MW of new CHP net capacity will be built using CFBC technology. The new capacity will replace less than half of the initial installed capacity of the old pulverized combustion plants. This will raise the average conversion efficiency from 28% to 34%, eliminate sulphur emissions and solve fly ash problems.

The more advanced pressurized fluidized bed combustion (PFBC) technology will not be used for oil shale power plants under WM scenario. This technology could give conversion efficiency of 44% and lower the specific CO₂ emissions, but its large-scale implementation is technically questionable today.

At the end of the planning period, a coal power plant will be built.

The total capacity of the CHP plants will increase quite rapidly providing the main future solution for heat production as well. This tendency is common in all scenarios. The CHP potential will be used fully at the end of the planning period in all scenarios, only market shares of different fuels differ by scenarios.

Renewables will be used extensively under this scenario. Wood fuels will reach their resource limit quite fast and the capacity of windmills will reach
the limit at the end of the planning period. More extensive use of renewable energy would require import of cheap biomass (wood).

Condensing natural gas power plants will be built starting from 2010. Their capacity will be substantial, but their utilization factor will be very low. They will be used for covering sharp peak loads, balancing wind power and for reserve capacity. One reason for the low utilization factor is the limited possibility of MARKAL model to describe the load curve in detail.

The main driving factors for CO$_2$ reduction are the improvement of the conversion efficiency of fossil technologies, and increase in the share of CHP and renewables. In spite of decreasing specific emissions, the total CO$_2$ emissions will increase after 2005 due to growing energy consumption. The increase is not fast and the emissions will not reach 1995 level, not to speak about the 1990 level.

**Scenarios with additional measures.**

CO$_2$ emission limits will be met mainly by wider use of natural gas in high efficiency condensing power plants. Use of oil shale in electricity generation will decrease and PFBC technology will be a considerable option starting from 2015.

The higher the target for CO$_2$ reduction, the higher will be the share of imported energy carriers (mainly natural gas in addition to motor fuels, coal and fuel oils).

The main CO$_2$ emissions modelling results for all scenarios are presented in the following Figures 6.

![Fig.6. CO$_2$ emissions from the energy system.](image)

### 3 Conclusions

During 1990–1993, the energy demand fell due to the economic decline and a sharp rise in the fuel and energy prices as well as a decrease in electricity exports, this resulted in a 45% reduction of CO$_2$ emissions. The trend of CO$_2$ decrease continued until 2000 and now the emissions are stabilized on more than 50% lower level than in 1990. For the same reasons, Estonia has been able to meet the requirements set in the agreements on SO$_2$ and NO$_x$ emissions. To meet the more rigid SO$_2$ restrictions and growing energy consumption in the future, Estonia must invest in abatement and in new clean and efficient oil-shale combustion technology. Along with the closing of the old oil-shale plants and growing electricity consumption, other fuels will be used. The increase in energy demand then should not be fast due to constantly rising prices and efficient energy use. Measures to reduce SO$_2$ and NO$_x$ emissions will also reduce CO$_2$. In MARKAL runs the Kyoto Agreement level of CO$_2$ emissions will never be exceeded. Restricted availability of imported fuels, acceptability of nuclear power or enabling large-scale electricity import can change the results significantly. The results presented here can also change because the database is being improved.

Real actions will be also affected by their social costs and political considerations not taken into account in the modelling. Substitution of oil shale is not easy. It will bring about increasing imports. Being an indigenous fuel, oil shale creates a sophisticated complex of economic, political, national security, social and environmental problems.

The reference level of 1990 total CO$_2$ emissions from fossil fuel combustion is 37.5 Mt. Considering the Kyoto obligation to reduce the emissions by 8% by the years 2008–2012, the emissions limit of Estonia for the year 2010 can be set at 34.5 Mt. Estonia’s net GHG emissions (including all gases, sources and sinks) in 1990 were 37.2 Mt [11]. The actual total CO$_2$ emissions were 16.43 Mt in the year 2000. It means 56% reduction compared with the reference year 1990.

The main findings are as follows:

- Estonian CO$_2$ emissions will never climb up to the Kyoto limit under any scenario. There is no need to buy emission permits in the future.
Main driving factors for CO₂ reduction are the improvement of conversion efficiency of fossil technologies, and increase in the share of CHP and renewables, but also the reduction of grid losses of heat and electricity and energy conservation and efficiency measures.

This study did not use electricity and biomass import options as possible ways to reduce GHG emissions. Analysis of markets of neighbouring countries and the EU shows that the import possibilities of those commodities can be very limited after 2010.

Total capacity of CHP plants will increase quite rapidly giving the main future solution for heat production as well. This tendency is common in all scenarios. The CHP potential will be used fully at the end of the planning period in all scenarios, only market shares of different fuels will differ by scenarios.

Future solutions in the Estonian energy system are very sensitive to the price of natural gas. The security of Russian gas supply is an extremely important factor as well.

In the scenarios With Additional Measures (WAM), the more rigid CO₂ emission limits compared with the With Measures (WM) scenario will be met to a great extent by larger use of natural gas in high efficiency condensing power plants. Use of oil shale in electricity generation will decrease, but the PFBC technology is a considerable option starting from 2015. This shows that it is important to continue the research of pressurized fluidized bed combustion of oil shale. Only this technology could provide oil shale plants with the necessary conversion efficiency and emissions reduction in the longer perspective.

The higher the target for CO₂ reduction, the higher will be the share of imported energy carriers (mainly natural gas in addition to motor fuels, coal and fuel oils).

From the viewpoint of supply and also national security, high dependence of the power and heating sector on natural gas (economically optimal under strict environmental restrictions and taxes) is not desirable until Estonia has only one gas supplier – Russia. Increase of the share of imported energy carriers in the energy balance can probably be restricted by the national foreign trade balance.

GHG mitigation options for Estonia are:

Supply side:
- Change of fuels, especially reducing the share of oil shale in electricity production;
- New clean and efficient fossil conversion technologies;
- Wider use of CHP;
- Wider use of renewables (mainly wood and wind);
- Reduction of grid losses of heat and electricity;
- Possible introduction of nuclear power;

References