DEVELOPMENT OF LONG-TERM ENERGY SCENARIOS FOR THE CZECH REPUBLIC

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1 Introduction

The Czech Government faces important decisions that will have a large impact on future energy supply and demand. These decisions need to be taken in the preparation of the Energy Policy Document of the Czech Republic, which is on-going at the moment (July 1999). This paper contains an executive summary of the results of the study "Development of integrated energy-environment scenarios for the Czech Republic", which was carried out in the scope of the EU Synergy Programme. The study aimed at providing policy makers insight in the impacts of key policy decisions in Czech energy policy in the next 35 years. The results were used for the preparation of the new Energy Policy.

In addition to financing of the Synergy programme of the European Commission, the Dutch Ministry of Economic Affairs, the Czech Ministry of Industry and Trade, the Czech Ministry of Environment, the Czech union of employers in the power and heat sector, the Czech union of employers in the coal and oil sector and the Czech gas union kindly co-financed this project.

2 Methodology

To deal with the many uncertainties within a transition economy, a scenario approach was chosen as the basis of the analysis. The time horizon of these scenarios is the year 2030. Because the integration into the EU is a key political objective in the Czech Republic, three EU scenarios were used as the starting point to develop scenarios for the Czech Republic. These EU scenarios, which were developed by the European Commission, are called Battlefield (BF), Forum (FO) and Hypermarket (HM) [2]. The BF scenario assumes protectionism, fragmentation and low economic growth, combined with strong government intervention and an active social policy. In the FO scenario, global political consensus will pull economic growth. The European integration will stimulate technological innovation and harmonisation of taxes. The prospering economy and high environmental awareness result in a largely ecologically influenced energy policy. Finally, the HM scenario describes a well-developed market economy driven world, with little market imperfections such as trade barriers and ineffective government interventions. Short-term economic growth will be very high, but market tensions will slow down this growth in the longer run.

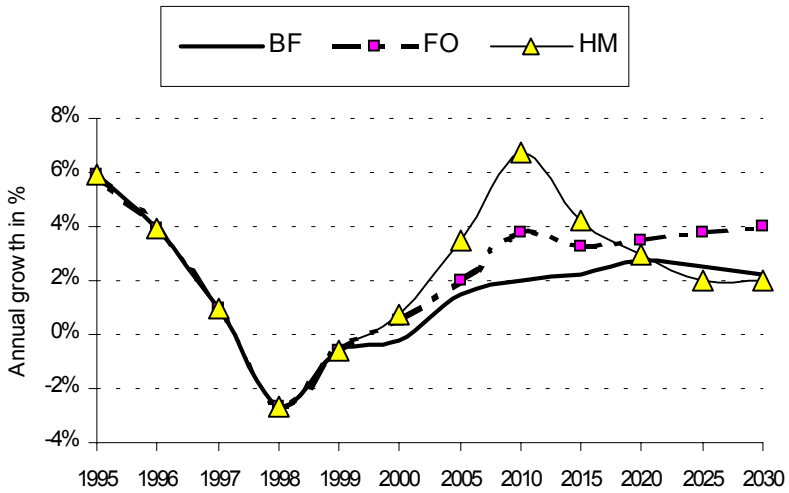
The EU scenarios provide quantitative time-series on a wide range of macro-economic indicators for the EU as a whole, like the price of oil and gas on the world market, the economic growth within Europe, general technological innovation, and labour and capital productivity. On the basis of the EU-scenarios, a further translation of quantitative and qualitative macro-economic scenario indicators to the Czech Republic was made. Assumptions were made on national economic growth, the integration of the Czech Republic into the EU, environmental restrictions and the development of VAT and excise taxes.

The modelling system that was used for the analysis has two components. The macro-economic analysis and the calculation of the future energy demand were carried out with a Computable General Equilibrium (CGE) model of the Czech Republic. The CGE model takes account of all the interactions between markets, as well as the functioning of individual markets. In other words, all transactions within the economy are covered. The Energy Flow Optimisation Model (EFOM-ENV) was used to analyse the optimal energy supply and demand system. The EFOM-ENV model is a linear programming energy model, which describes the energy system by specifying energy conversion, transport, distribution technologies and energy saving options. The calculations are based on minimisation of the total discounted costs of the energy system.

3 Economic growth

The results show that the average economic growth in the Czech Republic will range between 1.9 and 3.3% annually (see Figure 1). Somewhat higher economic growth can either be achieved on the basis of European political consensus (Forum), or within the market-driven economic world as is assumed in the Hypermarket scenario. The realisation of an average macro-economic growth of 3% over a period of 35 year would bring the Czech Republic in an economically stable situation that significantly decreases the gap with EU economies.

Figure 1 Development of annual GDP growth for the three scenarios Battlefield, Forum and Hypermarket. The historical time series 1995-1998 is also presented.



4 Energy efficiency

Five factors influence the energy efficiency of the Czech economy: changes in economic structure, energy efficiency in end-use (energy conservation), technological innovation in energy supply and appliances, energy pricing and fuel switching.

The relative low increases in final and primary energy demand result from the modelling assumption of maximal increase in energy efficiency in energy supply and demand, i.e. all cost-effective measures are implemented. In reality, there are different kinds of market barriers that hamper the increase in energy efficiency, resulting in higher growth rates for energy demand. Therefore, strong and effective policy measures are required to reach the relatively low growth rates mentioned. Large efficiency increases can especially be obtained in heat supply.

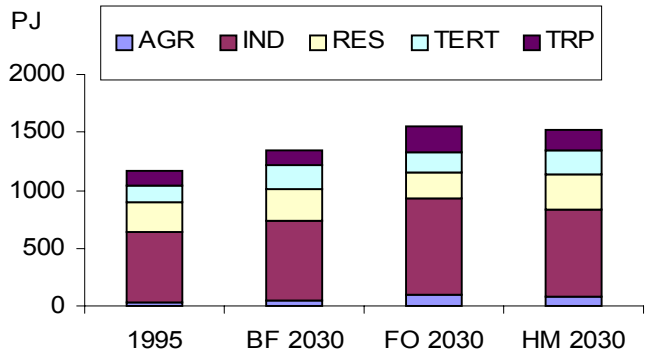
The technical energy saving potential till the year 2010 is estimated at 48%. The economic potential (potential which is repaid during the lifetime of measures) is about 20%. For further details on the potentials of end-use energy efficiency, barriers and energy efficiency policy, see [3].

5 Final energy demand

Final energy demand (FED) is expected to increase over the time period considered, mainly as a result of economic growth. The yearly increase in total FED ranges between 0.4% (BF) and 0.8% (FO). FED growth rates are lower than economic growth rates since high increases in energy efficiency are assumed (see section 4). Higher GDP growth rates in FO and HM induce relatively higher growth in FED than in BF. The relative share of industry will decrease, especially of energy-intensive industries in the FO and HM scenarios. The share of commercial services in the tertiary sector, and transport will increase.

In all scenarios the share of electricity increases: from 14% in 1995 to 18% in 2030. This matches the increasing electrification that has taken place in other European countries in the past years. Demand for heat also increases. The share of heat in FED goes from 17% in 1995 to 23-24% in 2030. This results in a growth of the district-heating sector.

Figure 2 Final energy demand for the three scenarios in the year 2030 compared to 1995



6 Primary energy requirement

Figure 3 presents the expected developments in total primary energy requirement (TPER). The average yearly increase is moderate in both the FO and HM scenario (about 0.5%/year) and small in the BF scenario (+0.1%/year). In all scenarios, the growth in the demand of energy services is for a part compensated by the implementation of cost-effective energy efficiency improvement in supply and demand (see section 4).

Figure 3 TPER development in the base cases [PJ]

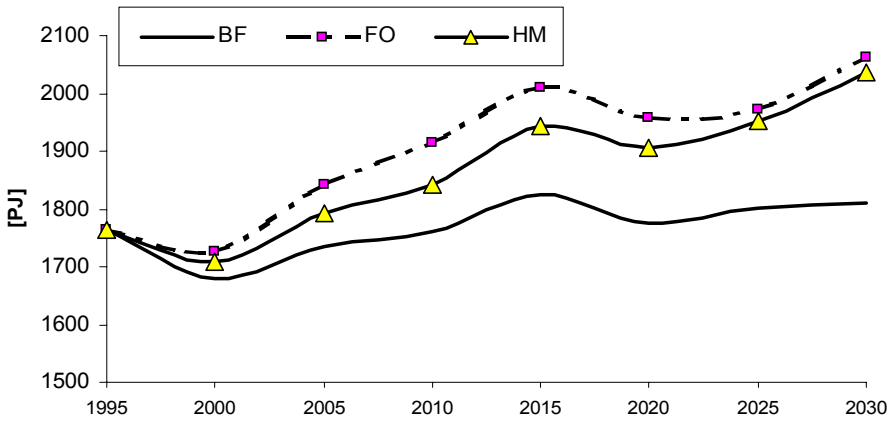
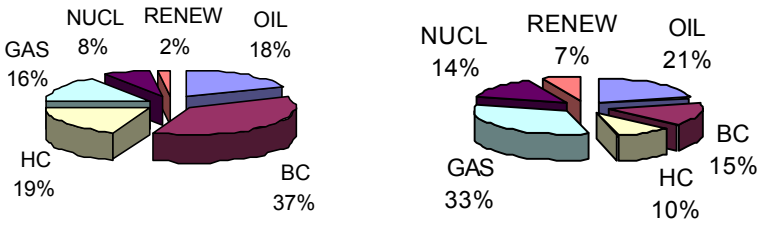


Figure 4 shows the fuel mix of TPER in the base year 1995 and in the year 2030. Clearly the large share of brown coal significantly reduces. As a result of the commissioning of the Temelin NPP, the share of nuclear significantly increases. When appropriate policy measures

are taken, the share of renewables could be increased to around 7% of TPER, but a strong promotion policy is required for this.

Figure 4 Structure of TPER, 1995 and 2030 (FO). BC: brown coal; HC: hard coal



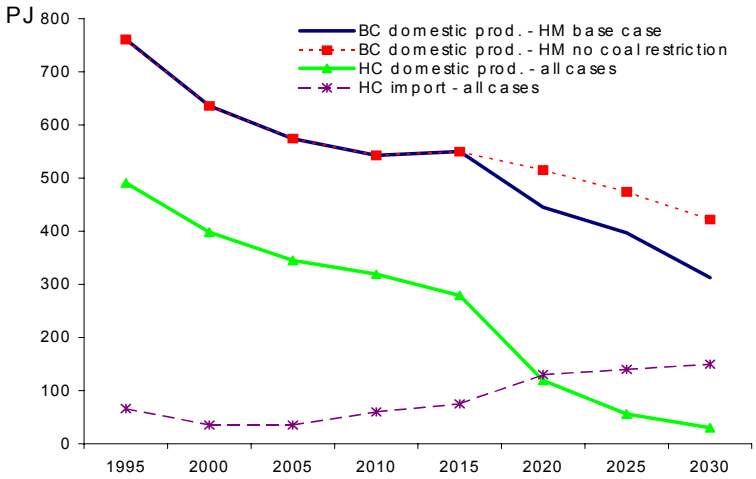
The share of coal in the Czech Republic remains relatively high compared to the EU. Whereas the EU highly depends on imported oil products, the share of oil in the Czech Republic could remain almost stable, if sufficient measures are taken.

7 Prolonging domestic coal production

Although in recent years its share has decreased significantly, domestic coal is still the dominant energy carrier. In the current Czech energy policy, geographical restrictions to coal mining have been introduced for environmental reasons, which would lead to a further decrease of production capacity in the future. In the period 1995-2030 brown and hard coal production capacity will decrease by more than 50% and more than 90% respectively (see Figure 5).

Since coal prices are expected to remain lower than natural gas prices (environmental externalities are not taken into account), the switch to natural gas in the power and heat production is limited. In central electricity production, the share of coal diminishes and is replaced by nuclear power. Commissioning the Temelin nuclear power plant and retrofitting the Dukovany nuclear power plant increases the share of nuclear power in public electricity production, leaving fewer opportunities for maintaining coal-fired public power production. New coal-fired technologies, in particular fluidised bed combustion, will replace conventional thermal coal-fired technologies, of which a large part will have to be decommissioned around the year 2015. The share of combined heat and power production increases strongly in industrial heat and power production as well as in district heating.

Figure 5. Development domestic brown coal (BC) and hard coal production (HC), and hard coal imports, with and without coal-mining restrictions (HM scenario)



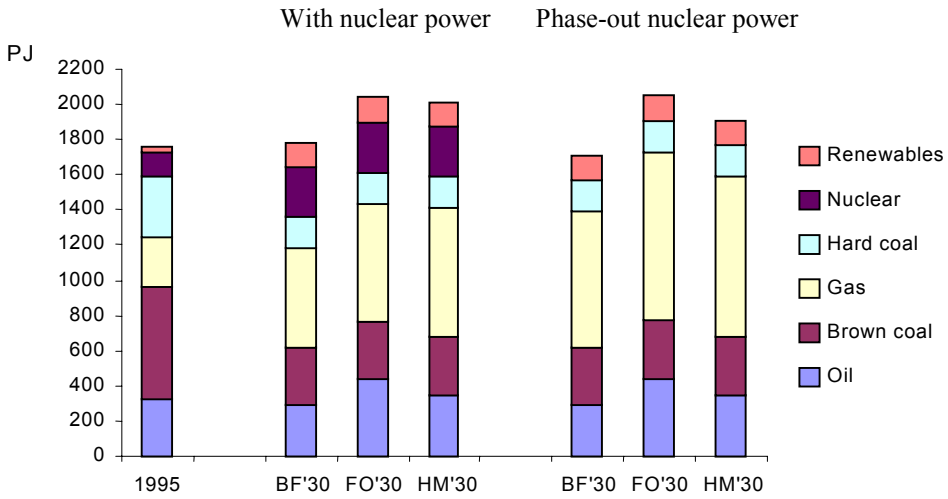
If the current coal-mining restrictions are abolished, relatively more brown coal is used in electricity and heat production. In central electricity production, condensing hard and brown coal power plants maintain a higher share than in the base cases (see Figure 5). Existing coal-fired plants are used at full capacity throughout the whole planning period and conventional plants are retrofitted, partly to fluidised bed combustion plants.

8 The role of nuclear power

If both the lifetime of the Dukovany NPP are extended till the year 2030 and the Temelin NPP is commissioned as planned, the share of nuclear power in public electricity production increases from 25% in 1995 to about 50% in 2030. The Temelin nuclear power plant will partly replace the production of existing coal fired plants. If nuclear power is phased out, the amount of gas-fired power production (combined-cycle technology) increases, which results in a further increase of gas imports. Figure 6 presents the fuel mix of total supplies in both cases. If, in addition, the coal-mining restrictions are abolished, part of nuclear power production is taken over by domestic coal-fired power production (not included in figure 6).

As a part of the strategy focused on the reduction of natural gas import dependency and self-sufficiency in power production, a further increase of nuclear power has been analysed. In this case, due to the lack of domestic coal resources and restrictions on net power import, the most cost efficient option is commissioning an additional nuclear unit of 600 MW around the year 2030 (not included in figure 6). Nevertheless, additional investigations are needed as this can seriously diminish the necessary load flexibility of power supplies and should be politically acceptable.

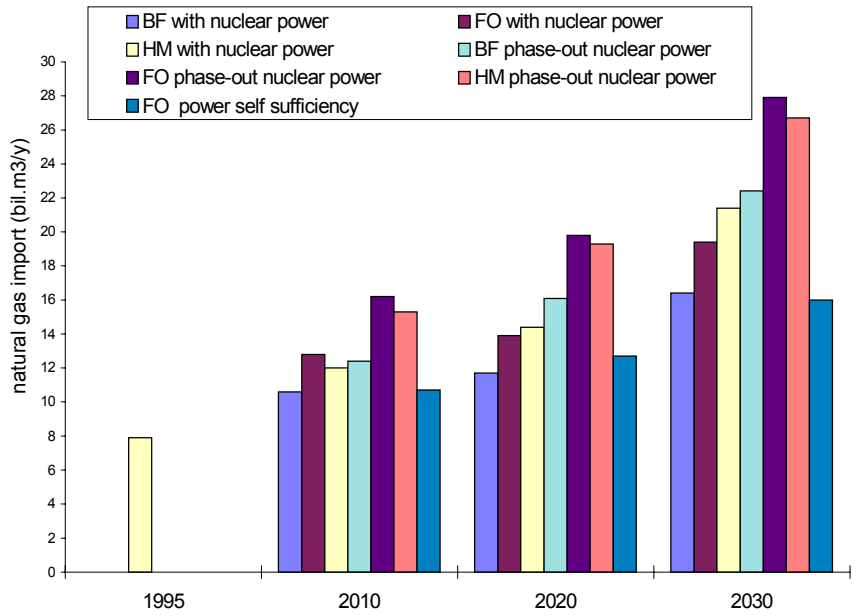
Figure 6 *TPER 2030 with nuclear power and with phase-out of nuclear power*



9 The role of natural gas

The share of imported natural gas in the TPER has constantly increased in the Czech Republic over the last years, from 16% in 1995 to 18% in 1997. It is assumed that the contracts for Russian and Norwegian gas are assumed to last until 2030. In addition, new contracts become available on the mid-term. As a result, the share of natural gas will continue to increase strongly. The largest increase occurs after the year 2015, when many coal-fired power plants will be decommissioned. The increase in imports are the highest in the HM and FO scenarios as result of the higher economic growth and the relatively low gas prices (see Figure 7). Although the average rate of increase of gas imports in the period up to 2015 (3%/year) seems incredibly high, it is good to realise that this is still much lower than the rate of increase in recent years, and therefore not unfeasible.

Figure 7 *Development of gas imports, base cases and with phase-out of nuclear power*



The results illustrate that nuclear power phase-out would substantially increase the import of natural gas. The relatively high share of gas in total energy supply in the year 2030 (up to 50%) could be a threat to diversity of energy supply. Maintaining the role of nuclear power would keep the share of gas on a much lower level (around 35%).

10 Import dependency

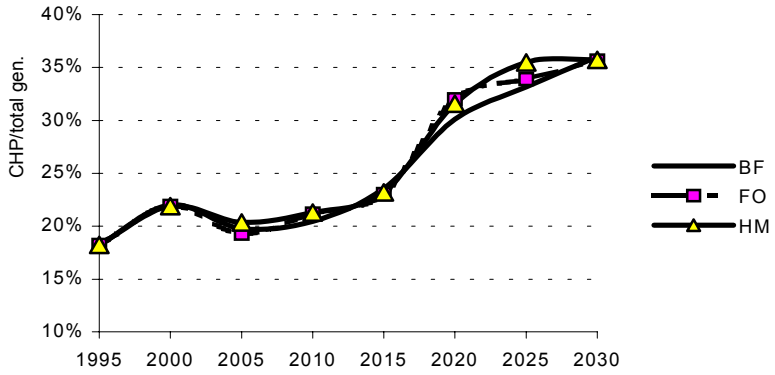
One of the main reasons to build new nuclear power is to reduce the future import dependency of the Czech Republic. Whereas currently the import dependency is very low (17%), it is expected that this will increase significantly in the next decades, even to over 50% when nuclear power capacity is not expended and domestic coal-mining restrictions are not abolished. The largest contribution to increased imports are the large increases in gas imports, supported by continuing oil imports and even small increases in coal imports. The costs of energy imports increase in absolute terms, but in relative terms – as a share of GDP - will remain at the current level of around 5%.

Large gas imports will lower the security of supply where import dependency is concerned. On the other hand, the resulting larger fuel diversification positively supports the security of supply. With large gas imports diversification of supplier is important. The increase in gas imports would require significant investments in the transport infrastructure. These costs have been considered in the analysis.

11 Combined heat and power production

Large-scale combined heat and power (CHP) district heating and industrial applications, as well as small-scale applications have a large potential, which can be exploited in the long-term. CHP can contribute significantly to the reduction of environmental emissions, and increase of energy efficiency. The total potential in terms of share of electricity production is estimated at about 35% (see Figure 8), comparable to current levels in the Netherlands and Denmark. Especially in the period 2015-2020, when many existing coal-fired power plants will have to be replaced, the share of CHP could increase swiftly. However, in the short-term, CHP faces several market barriers that must be overcome by targeted promotion policy. Furthermore, when the share of CHP in electricity production increases, the issue of load management needs to be addressed, especially when large nuclear power capacity is operated.

Figure 8 *Share of combined heat and power production in total electricity production*

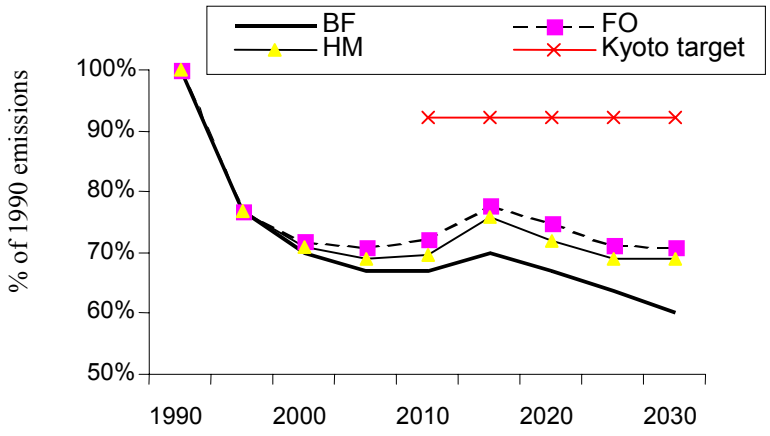


12 The development of CO_2 emissions

Several strategies are possible to reduce CO_2-emissions: promotion of energy efficiency in end-use ('energy conservation'), promotion of renewable energy, increased efficiency in energy supply, and fuel switching. All four options are considered in the analysis. Apart from reducing CO_2 emissions, these options have other important benefits, in particular the reduction of SO_2 and NO_X emissions.

Energy-related CO_2-emissions in 1995 have decreased by 24% compared to 1990. Therefore, the Kyoto Protocol (8% reduction of greenhouse gas emissions in 2008-2012, compared to the 1990 level) seems relatively easy to achieve. However, further reduction of emissions may be necessary. Figure 9 shows the development of total energy-related CO_2-emissions in the period 1995-2030 for the three scenarios with nuclear power and with current coal-mining restrictions. The results indicate that CO_2-emissions could largely decrease if all cost-effective measures are implemented. The growth in TPER will cause a growth of CO_2 emissions. However, the use of nuclear power in both the Dukovany and Temelin plant significantly reduces CO_2 emissions. On the longer term, the decrease in coal consumption and increase in gas consumption will further reduce the emissions.

Figure 9 *Total CO_2-emissions 1995-2030 in percentage of 1990. The historical time series 1990-1995 has been added.*

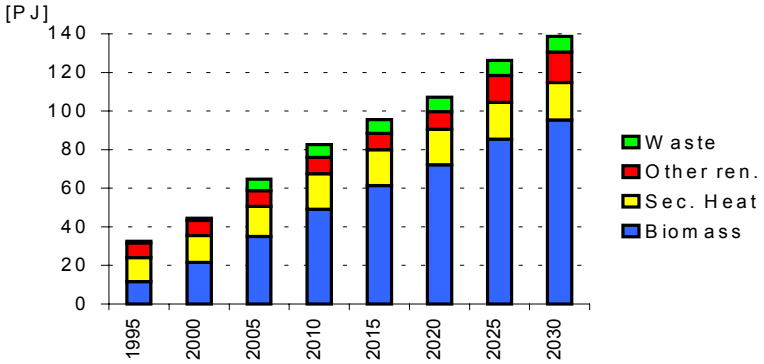


Abolishing the restricting on coal mining will lead to moderately higher CO_2 emissions beyond the year 2010 (+4% in the year 2030). A nuclear phase-out will increase CO_2 emissions with 7% in the year 2030. This is the result of the limited share of nuclear in the primary energy balance as well as the fact that nuclear in the policy case is mainly replaced by the low carbon energy carrier natural gas.

13 Renewable energy

The currently low share of renewables in TPER (1.5%) could increase to around 4% in 2010 and 7% in 2030 if large additional policy efforts are taken. Biomass and waste have the largest potential, up to 100 PJ in the year 2030. The potential of wind power is small, only a small market share is gained. Extension of hydropower and installation of solar thermal systems and solar photovoltaic capacity is not cost-effective without additional promotion measures. Figure 10 shows the potential development of renewables, with other renewables comprising wind power and hydropower. For further information on the potential of renewable energy in the Czech Republic, the market barriers and promotion policy see [3].

Figure 10 *Development of renewables, 1995-2030*

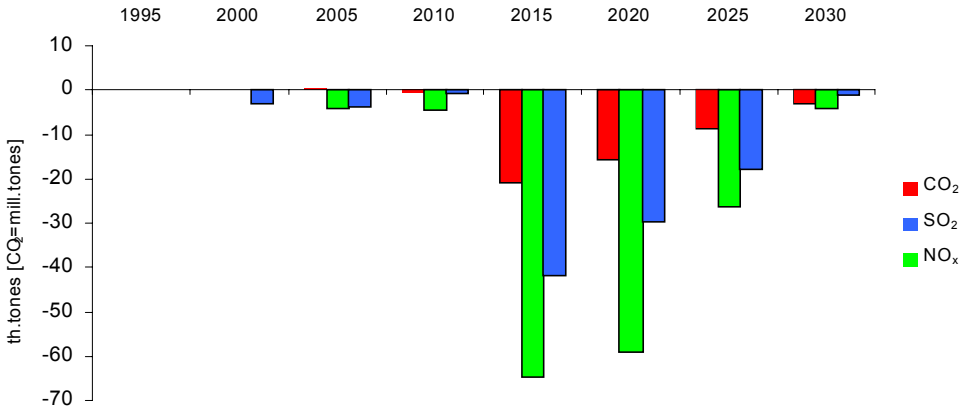


14 Energy taxation

Introduction of an environmental tax in the form of a carbon tax could significantly support the increase of energy efficiency in both energy supply and end-use, thereby significantly reducing emissions, particularly CO_2 emissions. The latest tax scheme as proposed by the Ministry of Environment starts from the year 2010 and gradually increases tax levels till the year 2025. These taxes, that will effectively double energy prices on the long term, could result in additional decreases in emissions as is shown in Figure 11. TPER in the period 2015-2020 will decrease by 200 PJ as a result of the increase in energy efficiency, induced by higher end-use prices.

The direct impact on renewable energy production, however, is limited in the short-term, because of the limited technical potential and the limited cost-effectiveness. The tax will increase end-use consumer prices, since the production and distribution companies will pass on the increased fuel costs to their customers. Furthermore, if the government decides to compensate these consumers by partly subsidising the price rises, the governmental expenditures will rise accordingly.

Figure 11 *Reduction of emissions after introduction of a carbon tax*



15 Conclusions

The results of analysis for the period 1995-2030 of energy supply and demand in the Czech Republic lead to the following conclusions:

- Average annual economic growth ranges between 1.9 and 3.3%.
- Total primary energy requirements increase from 1750 PJ in 1995 to around 2000 PJ if all cost-effective energy measures are implemented. If not, total requirements are significantly higher.
- The economic potential of end-use energy savings is around 20% of total primary energy demand in the period 2000-2030.
- The structure of energy requirements will change significantly. Coal will largely be replaced by natural gas and partly by nuclear power (except in case of a phase-out of nuclear power).
- The share of imported gas increases largely up to 3% per year (in the non-nuclear case). Diversification of supplier should have high priority.
- If coal-mining restrictions are not abolished, the available domestic hard coal and brown coal production capacities reduce to 30 million tons in 2030. Otherwise, the domestic coal production capacity will be 43.5 million tons in 2030.
- Prolonging the lifetime of the Dukovany nuclear power plant and commissioning the Temelin nuclear power plant as planned will increase the share of nuclear power in public power production to around 50%.
- Import dependency will increase to over 50% if coal-mining restrictions are kept in place and nuclear power capacity is not expanded.
- The long-term cost-effective potential of combined heat and power generation is around 35% of total electricity production.
- The Kyoto target on reduction of greenhouse gases could be met without large difficulties. Beyond 2010, CO_2 emissions could remain constant or even decrease if all cost-effective measures are implemented.
- Renewable energy could gain a market share of 4% in 2010 and 7% in 2010 if appropriate policy measures are taken to tackle market barriers.
- Energy taxation would in the long-run double end-use prices and largely increase energy efficiency. The impact on promotion of renewable energy is only small, because of limited potentials and limited cost-effectiveness.

References

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