

# Energy for Sustainable Development III



Jaroslav Knápek, Wolfgang Streicher, Ondřej Vojáček et al.



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## **Energy Savings-Economics and Links to other Policies**

Jaroslav Knápek  
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## Preface

The life of modern society cannot be conceived without enough secure energy. The requirements on securing reliable supply of energy increase with the development of technologies, concentration of urban populations, and ever increasing requirement on transportation of raw materials, semi-finished products and goods. The several recent crises in importation of primary energy resources from areas outside the EU (such as the reduction and interruption of supplies of natural gas from Russia via Ukraine to Europe in the early 2009 and the turn of 2005) fully demonstrated the strong dependence of the EU on the importation of energy commodities. The EU's dependence on importation of primary energy resources was over 50% (approx. 54%) in 2006 and continues to grow. The issue of securing long-term and reliable supplies of primary energy resources to the EU is therefore ever more important, alongside with the need for reducing the dependence on imports from outside the EU by way of energy savings and increased use of renewable energy sources. The Czech Republic is slightly better off than the EU as a whole concerning its dependence on importation of primary energy resources: its dependence on importation of primary energy resources was between 40 and 45% in 2009. Nevertheless, the issue of securing long-term and reliable supplies of primary energy resources is increasingly important to the CR as well due to the rapid depletion of its currently available reserves of domestic coal.

The globalized world economy puts an ever increasing pressure on the competitiveness of national economies. The costs of energy inputs and the related costs (e.g., CO<sub>2</sub> emission permits, charges for pollutant emissions to the air, etc.) are an ever more substantial cost item especially in the energy-intensive industries (production of iron and steel, heavy machinery, production of some energy-intensive chemical products, cement, etc.) that affect the competitiveness on the global market. However, the growing prices of energy not only affect the competitiveness of companies active on the global market, but are reflected in the costs of households, either directly (e.g., costs of fuel) or indirectly in the form of growing prices of food, other products and services. Household energy expenditures are becoming an ever more important item and in many cases, one can speak about the socially worse-off households being threatened by energy poverty (i.e., a situation where households have difficulty paying their heating, electricity and fuel bills). The economic aspect of securing the supply of energy for the industry and services sectors as well as households is thus gaining significance.

Energy generation is an industry with substantial impacts on the environmental components, ecosystems and, directly and indirectly, on human health. The contribution of energy generation to the production of greenhouse gases and the

greenhouse gases as a result of human activity is of particular significance. The development of energy generation therefore cannot be separated from other development policies of developed countries as well as the global community as a whole. Such policies include, above all, the Earth's climate protection policy. In 2007, EU leaders defined an integrated approach to the climate protection energy and the energy development policy as the key to combating climate change and the need to secure supplies of primary energy resources for the EU as well as the need to make the EU competitive in global economy. After that, the 20-20-20 strategic objective was formulated for the EU as a whole. The objective means that the EU shall reduce its CO<sub>2</sub> emission by no less than 20% by 2020 (compared to 1990), while achieving a share of renewable energy sources in the (final) energy consumption of at least 20% and a 20% reduction in the primary energy resource consumption (based on the assumed development) by means of measures to increase energy efficiency.

Energy generation as a system is characterized by a great inertia of processes, high capital intensity of construction of new energy facilities, long construction periods and service life of these facilities, a complex permitting process, and last but not least, great demand for technologies and staff qualifications. In terms of energy generation development—electricity generation is a good example—there are a number of key factors which are often contradictory and even incompatible. From the point of view of the potential investor, building an energy facility is fraught with a number of risk factors, which often lead investors to prioritize activities with rates of return shorter than building one's own energy production facilities or infrastructures. The endeavour to reduce the environmental impacts of energy generation leads to ever stricter requirements on reduction in emission burden and waste production. The increasing prices of energy and stricter energy consumption standards result in an insecurity among investors concerning investment in energy facilities with respect to future energy supply. This in turn results in a risk of future deficit in some energy commodities (such as electricity), and the related increase in the prices of these products. That may have adverse impacts on the competitiveness of the economies of the EU member states as well as household energy expenditures. This further highlights the need to respect the economic dimension of the development of energy systems.

Individual countries, as well as the EU as a whole, try to support the achievement of their strategic objectives in the area of renewable energy sources and energy savings using various support systems. At present, one can say that each EU country essentially has its own unique system of promoting the development of RES and energy savings. In many cases, however, these support policies are not interlinked and do not lead towards an economically effective fulfilment of the system objectives (if at all defined consistently). Not only on the example of the CR and the unrestrained photovoltaic boom in 2009–2010 but also in other

EU countries can be point out a number of ill-conceived aspects of the support system, leading to money from public budgets and private pockets not being used in a way that is systemically effective.

Energy generation is a strategic industry without the development of which no development of any sector of a national economy or the EU economy as a whole is possible in the modern era. At the same time, however, energy generation is an industry where—perhaps like in none other—there are interconnected requirements on securing economic effectiveness (competitiveness in the global economy, social aspects of energy supply), energy efficiency (requirements on energy savings), minimization of environmental impacts, including reducing the impacts on the Earth's climate system, and last but not least, requirements the strategic security of supplies of primary energy resources. At the same time, we must keep in mind the enormous capital intensity of investment in energy facilities, high degree of system inertia and long time constants (long preparation and development of energy facilities and long service life). Roughly speaking, these aspects can be visualized as the vertexes of a quadrangle (economics, ecology and energy efficiency, energy security, high development inertia), with each vertex is interconnected with the others. These means that a single issue (one vertex) cannot be solved without a connection to the others.

The energy policy of the state and its constituent regions, cities, etc. plays an ever more important role in developed countries. The fact that making an energy policy (especially at the system–national–level) is a very complex task can be demonstrated on the Czech Republic. The current official national energy policy dates from 2004. According to the initial assumption, the policy should have been revised once or twice by now. Nevertheless, in spite of the great effort initiated by the Independent Expert Committee headed by Prof. Pačes (outcomes in 2008) and the development of several draft updates by the MoIT, the Czech Republic still does not have an updated energy policy reflecting all the changes that have occurred since 2004.

The present book contains a selection of papers by Czech and Austrian authors mostly active in the CZ-AT EEG (Czech-Austrian Energy Expert Group), who focus on various aspects of energy savings, utilization of renewable energy sources, connections between the air protection and energy policies, long-term aspects of energy development, and economic effectiveness of support to energy savings and utilization of renewable energy sources. The uniting link here is the effort to point out the interconnectedness of all the aspects of energy development. An example may be the relationship between energy savings and utilization of renewable energy sources. Both energy savings and utilization of renewable energy sources contribute to the fulfilment of the CR's and EU's strategic objectives such as reducing the impacts on the climate system and other environmental impacts of energy generation and consumption, and reducing the dependency on

imported primary energy sources from areas outside the EU. Both energy savings and utilization of RES play an important role in maintaining global economic competitiveness of the EU member states (including the CR). Economic aspects of achieving the defined objectives in energy savings and utilization of renewable energy sources therefore also play an important role here. The key issue is the question of system effectiveness of the different support schemes aimed at energy savings and utilization of renewable energy sources.

# **Energy Autarky for Austria in 2050**

## **Feasibility Study**

The following work was conducted 2011 for the Federal Austrian Ministry of Agriculture, Forestry, Environment and Water and was financed by the Austrian Kommunalcredit, Public Consulting (Streicher et al., 2011).

### **1.1 Introduction**

In order to limit climate-change induced global warming to 2°C, the Council of the European Union requested (2009) all negotiating parties of the Copenhagen climate change conference to work for the 2°C target. By the year 2050 the industrialised countries would have to reduce their greenhouse gas emissions by at least 80% to 95% compared to the level of 1990. A similar recommendation was presented by the top players of the G8 at their 2009 meeting in L'Aquila. This implies the opting out of fossil energy supply. The present study investigates if and under which framework conditions Austria could achieve complete energy autarky through its own renewable energy sources by 2050.

### **1.2 Boundary conditions for the study**

#### **1.2.1 General assumptions for the study**

- In 2050, Austria will be at 100% supplied from domestic sources of renewable energy.

- It is assumed that the present net energy import of gray energy in commodities will not further increase. At the moment Austria imports by far more energy in the form of gray energy in commodities than it exports in that same way. If this net balance with foreign countries via “energy in commodities” were taken into account, Austria’s consumption of fossil energy would presently be 44% higher than the figures in the energy statistics imply. This is of relevance also for the interpretation of the term “energy autarky” and for the scenario developed in this study.
- Only agricultural surplus land is used to cover the energy demand by means of renewable energy sources. Austria’s demand for agricultural land dedicated to the food and feedstock production remains the same.
- Energy exchange with the neighbouring EU countries is permitted in imports/exports on a daily/weekly basis—on annual average the import/export balance is zero.
- As regards electricity storage, it is assumed that all Austria has to do is to immediately store its electricity overproduction in summer in its own pumped storage power stations or chemical storage systems.

The role which smart grids may play in the future to interconnect (decentralised) producers, storage systems and consumers is taken into account in the study only in so far as this is a precondition required to maintain the presently high level of supply security and ensures the compensation of fluctuations in the demand and production of electrical energy over several hours up to few days.

### **1.2.2 Potentials of renewable energy sources**

The technical potentials inherent in renewable energy sources have been determined on the basis of existing studies and expert literature. The potentials have not been fully exhausted in the scenarios observed, as this was not necessary under the assumptions made.

#### **Renewable energy sources considered**

- Biomass (forestry, agriculture and green waste, sewage sludge and black liquor, residues from industry and trade, waste cooking oil and fats). Biomass can be converted into low- and high-temperature heat, electricity, biogas and synthetic gas and fuels. However, also in the future priority will be given to the recycling of biomass (as a building material and industrial raw material), a fact which is taken into account accordingly when determining the potential available for energy production.

- Hydropower and its conversion into electricity and as an electricity storage application to make up for daily and seasonal fluctuations by means of pumped storage power stations.
- Wind energy and its conversion into electricity as well as its need for storage to make up for daily and seasonal fluctuations.
- Photovoltaics and its conversion into electricity as well as its need for storage to make up for daily and seasonal fluctuations.
- Solar thermal energy and the possibility of using it for low-temperature heat in buildings and production.
- Near-surface geothermics and ambient heat and its potential use for low-temperature heat in buildings and production via heat pumps (with the corresponding demand for electricity).
- Deep geothermics and its potential use for heat and electricity generation.
- Non-biogenic waste is not taken into account, as we expect a significantly higher rate of recycling for 2050.

### **1.2.3**

#### **Technologies to convert primary into secondary energy sources considered in the study**

- Cogeneration
- Facilities to generate bio-ethanol from biomass
- Facilities for gasification and biogas (methane) from biomass
- Facilities for the production of 2<sup>nd</sup> generation fuels (FT diesel, bio-methane)
- Facilities for the production of fuels and methane from electricity and atmospheric CO<sub>2</sub> (renewable methane, long-chain hydrocarbons from electricity and CO<sub>2</sub>)

### **1.2.4**

#### **Structures of energy demand and efficiency**

The energy demand was defined in the sectors buildings and mobility via energy services (m<sup>2</sup> of floor space warmed up / cooled down, passenger kilometres and tonne kilometres). Based on a given level of comfort and mobility requirements of the population, this approach allows considering both the efficiency enhancement in buildings (reduction of the energy demand through high-quality renovation of old buildings and the construction of new passive houses) and mobility (reduction of fleet consumption) and the coverage through other technologies (public transport, non-motorised private transport) on an equal footing with the use of renewable energy sources via different technology paths. For lack of data,

a different approach was chosen in the field of production. As, due to the great variety of outputs, the concept of energy services cannot be applied to the production sector, the energy demand was in the course of the study assigned to individual energy demand categories as specified in ÖNACE, the Austrian classification of the economic activities of enterprises.

### **1.2.5**

#### **Scenarios of the energy demand and their basic assumptions**

The spectrum of the demand for energy services for the year 2050 has been outlined via three scenarios, of which only the constant scenario and the growth scenario were fully calculated.

- Constant scenario: In 2050, the level of the energy services of mobility and buildings and the gross value added of the industry will be the same as in 2008.
- Growth scenario: Until 2050 constant growth of the energy services of mobility and buildings and gross value added of the industry 0.8% p.a., i.e. increase by a little less than 40% compared to 2008.
- Efficiency improvement: Same as growth scenario, but with higher efficiency.

The end-use energy demand for the defined energy services for 2050 will thus be the result of improvements in the efficiency (= energy saving) of technologies on the one hand and of a move to less energy consuming technologies on the other hand.

## **1.3. Results**

### **1.3.1 Results per Sector**

In the field of private mobility the consumption of energy can be reduced for the long term by a shift in the modal split and a marked reduction in the consumption of fleets. A great part of the passenger car traffic could and would have to rely on electrical energy. The rather small quantities of fuels from renewable resources that are available in Austria can then be used for heavy commercial vehicles and machines in agriculture and the building industry, where it would be much harder to shift to electricity. In the case of passenger cars this will involve a high



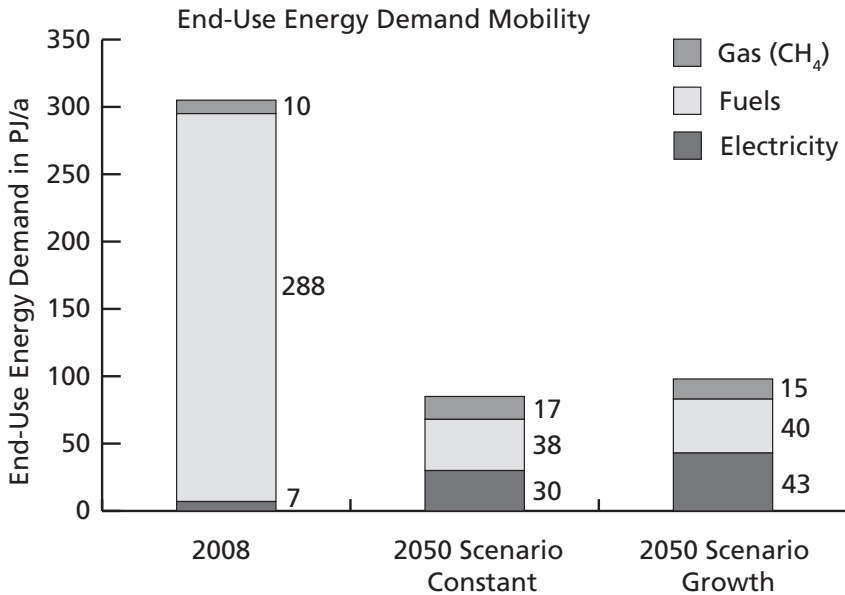
share of plug-in hybrid vehicles and pure electric cars. Distances driven with combustion engine vehicles would have to be covered with about 3ltr/100km on average, kilometres driven with electric vehicles with approximately 0.12kWh/km. Moreover, there will be a strong move towards public transport (PT) and non-motorised private traffic (NMPT) whose share will then amount to next to 50% in the constant scenario and over 60% in the growth scenario. Long-distance freight transport is almost completely transferred from road to rail or ship; the consumption of fleets is reduced. Also mobile machinery and equipment, air transport and pipelines are under discussion. Regional air transport is in both scenarios almost completely transferred to rail. Taking everything into account the above-described changes will lead to a reduction of the energy demand for mobility by over 70% in the constant scenario and by about two thirds in the growth scenario. Figure 1 illustrates the end-use energy demand in the field of mobility for 2008 and for the two scenarios calculated.

In the field of buildings thermal refurbishment will until 2050 lead to a reduction of the average demand for heating energy from presently approx. 144kWh/m<sup>2</sup>.a to 61kWh/m<sup>2</sup>.a in the constant scenario and 49kWh/m<sup>2</sup>.a in the growth scenario. It is assumed that, in spite of climate change, the energy demand for cooling will slightly decline due to improved building envelopes. The demand of electrical power for residential buildings and service buildings will until 2050 altogether decline by next to 20% in the constant scenario and by 7% in the growth scenario. As a consequence, the energy demand of buildings will decrease by 51% in the constant scenario and by 44% in the growth scenario. Indoor thermal comfort is in the growth scenario almost exclusively achieved by a combination of heat pumps and solar thermal energy—in this way the available biomass can be provided for mobility and the industry. Figure 2 shows the end-use energy demand of buildings for 2008 and for the two scenarios calculated.

In analogy to the requirements of the EU's Energy Efficiency Directive an efficiency improvement of 1% p.a. is assumed for the production sector; in the constant scenario this leads to a reduction of the energy demand by 35%. This is due to the continuous endeavor to reduce production costs and consequently to improve the energy efficiency of processes. In the growth scenario for the production sector the energy demand will until 2050 in spite of an assumed 0.8% annual increase in the gross value added see a decline of 2.3% compared to 2008. Figure 3 shows the end-use energy demand in the field of production for 2008 and for the two scenarios calculated.

Taking everything into account the end-use energy demand of 2050 will therefore see a 53% reduction from approx. 1,100PJ in 2008 to 497PJ in the constant scenario and a 38% reduction to 647PJ in the growth scenario. With additional, presently not foreseeable efficiency measures it might be reduced even more.

Only if, thanks to efficiency improvements and smart energy use, the energy demand is reduced as strongly as assumed in this study can energy autarky be achieved and will it be possible for Austria to satisfy its energy demand completely with domestic renewable energy.



*Figure 1: End-use energy demand of mobility in 2008 and for the two scenarios for 2050*

### 1.3.2 Energy system 2050 for the constant scenario and the growth scenario

Figure 4 shows the energy system for the constant scenario and Figure 5 for the growth scenario. Biomass and hydropower cover in both scenarios considerably more than half of the energy demand.

In the constant scenario the biomass utilisation of 216PJ in the year 2008 is extended by 13% to 244PJ and electricity generation from hydropower from presently 38TWh to almost 45TWh. Wind energy generation increases by more than five times to more than 13TWh. Photovoltaics contributes with 16TWh more than 500 times more to energy generation than in 2008. Also the utilisation of heat from solar energy (increase by the factor 10) and heat pumps (factor 8) increases decisively compared to the base year.

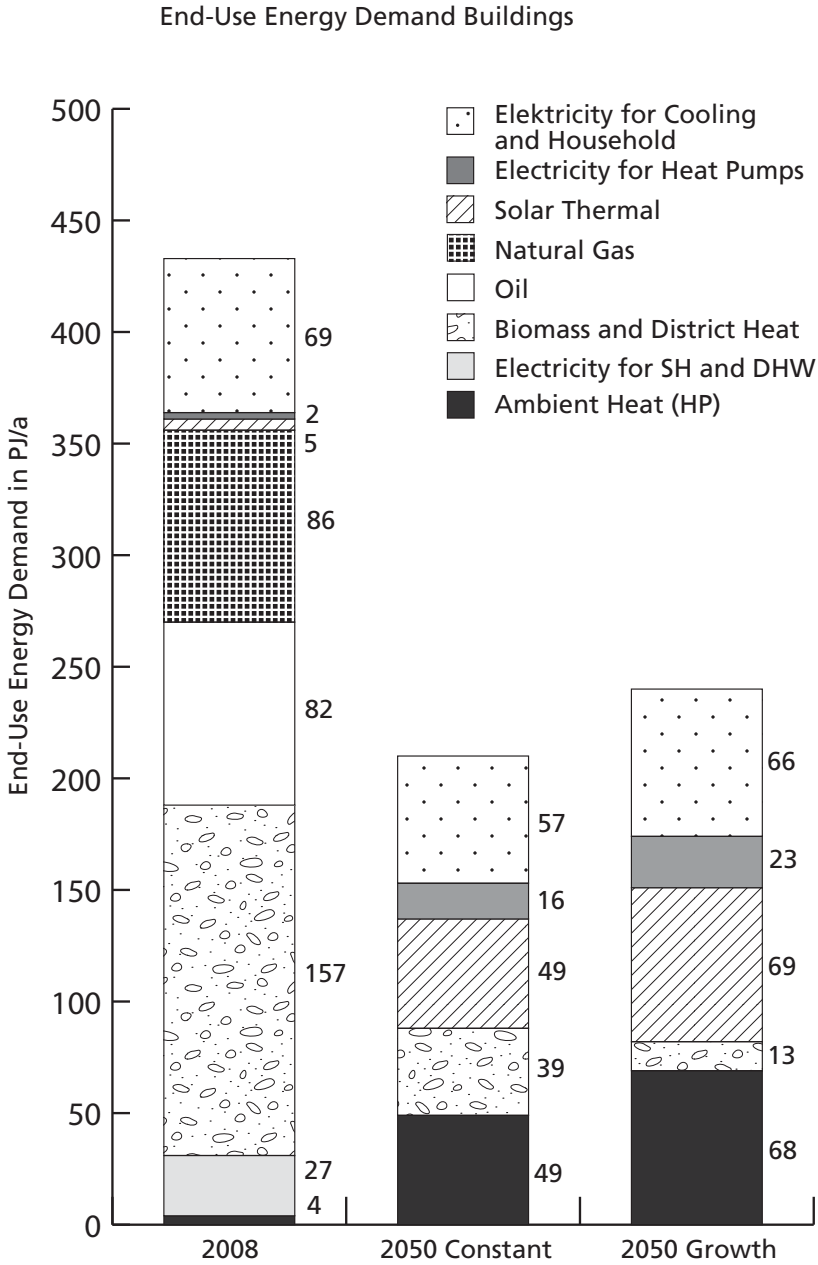


Figure 2: End-use energy demand of buildings in 2008 and for the two scenarios for 2050 (HW: hot water; HP: heat pump)

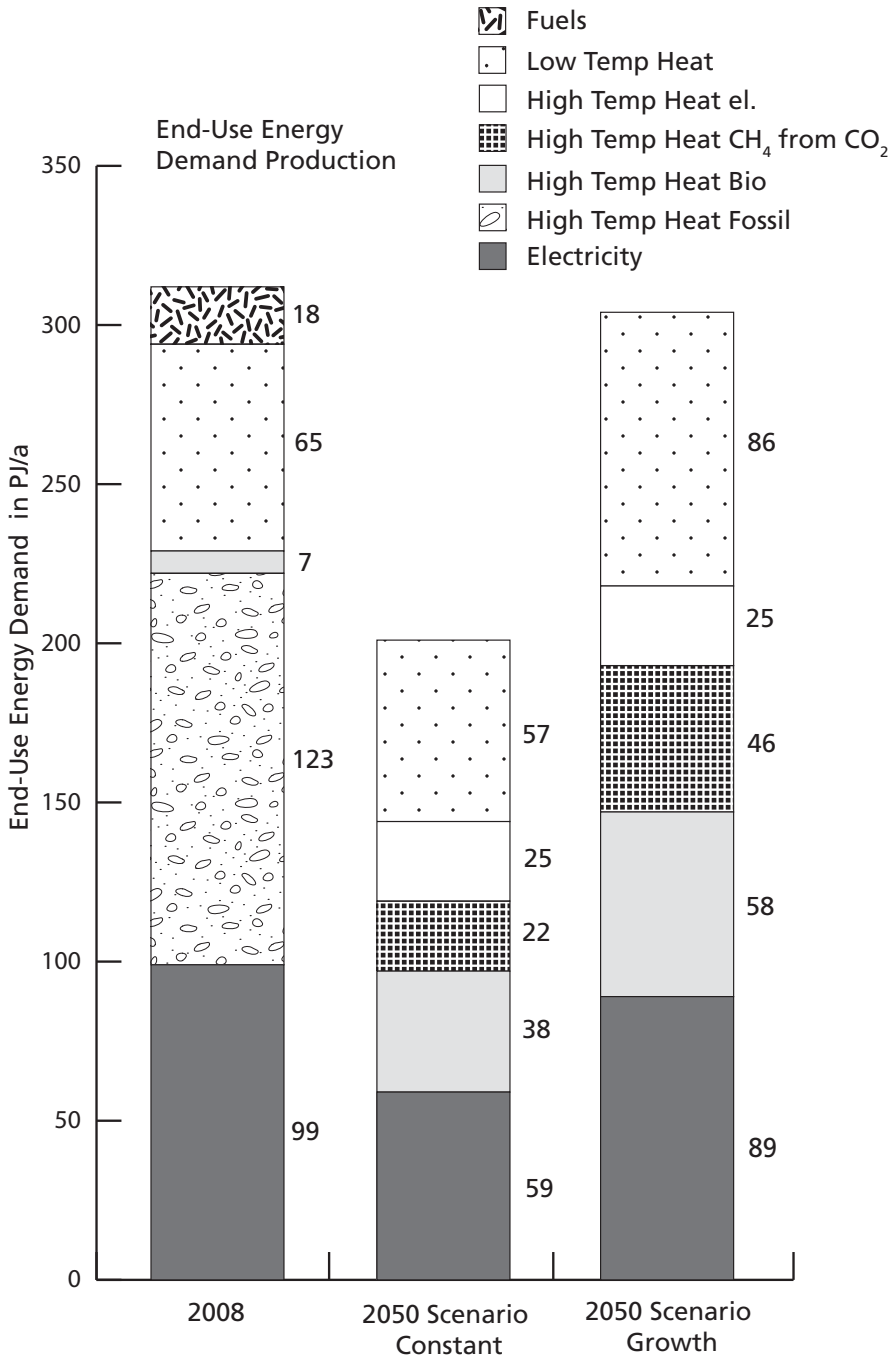


Figure 3: End-use energy demand of production in 2008 and for the two scenarios for 2050 (LT: low temperature; HT: high temperature)

In the growth scenario the renewable energy potentials are exploited even more strongly. Biomass production increases by 36% to 293PJ and exploits thus 95% of the available potential—in this context it is proceeded on the assumption that only agricultural surplus areas are used and that areas for food and feed production remain constant compared to 2008. Hydroelectric power is further developed to 177PJ (almost 50TWh) and uses thus almost 90% of the potential worth being developed which is said to amount to 56TW/h. The potentials of wind energy, with more than 14TWh, and of photovoltaics, with a little bit less than 20TW/h, are also exploited at 80 and 85% respectively. This applies in a similar way to the utilisation of solar energy (75PJ). Near-surface geothermics (68PJ) is limited in its utilisation due to the electricity demand. Moreover in this scenario electricity generation from deep geothermics constitutes another renewable source of energy—which is, from the present point of view, judged to be extremely expensive—that makes with 71PJ a considerable contribution to covering the energy demand.

Among the new transformation technologies the generation of CH<sub>4</sub> and longer-chain hydrocarbons and CO<sub>2</sub>, as well as the generation of 2<sup>nd</sup> generation fuels from biomass are applied.

The necessary economic and organisational framework conditions in order to reach the further development of these technologies should be examined in further studies.

What is not entered into the flowchart is the necessary further development of pumped storage power stations in order to balance the volatility of electricity generation from photovoltaics, hydropower, and wind energy. The present pumped storage performance of about 3.8GW would increase in the constant scenario to 7GW and in the growth scenario to 9GW.

## **1.4. Measures**

The necessary framework conditions required for energy autarky call for committed, clear unequivocal political decisions and course settings. This applies, among other things, to economic instruments (e.g. energy prices), rules and regulations, infrastructural investments (in particular in the fields of mobility, power grid infrastructure, energy storage) and increased energy research efforts. In order to increase the social acceptance for the measures to be taken target-group-specific harmonised information activities as well as awareness-raising measures are to be initiated. It is to be carefully weighed against, whether increased opening-up of potentials or far-reaching efforts in the field of efficiency meet with higher acceptance.

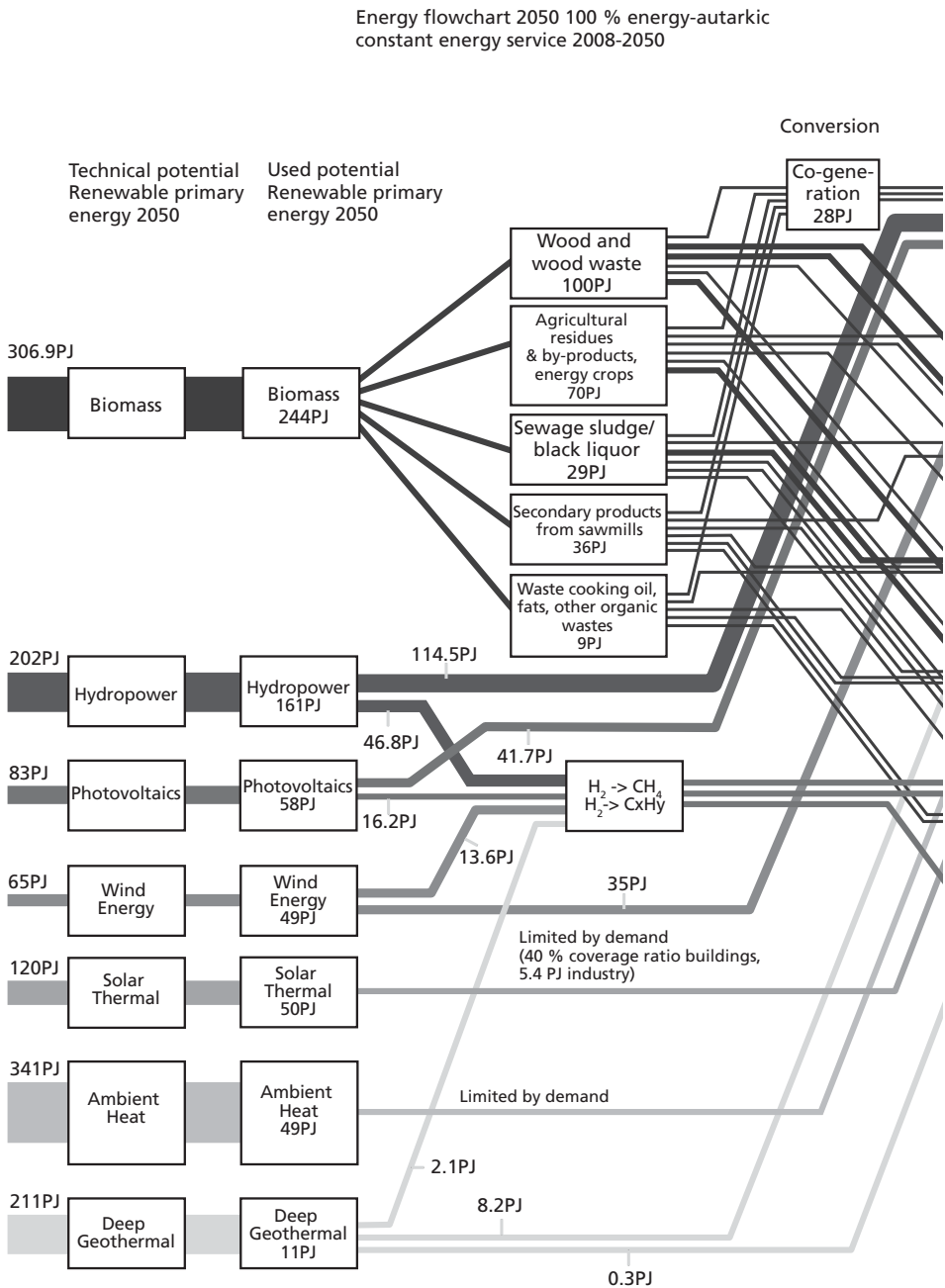
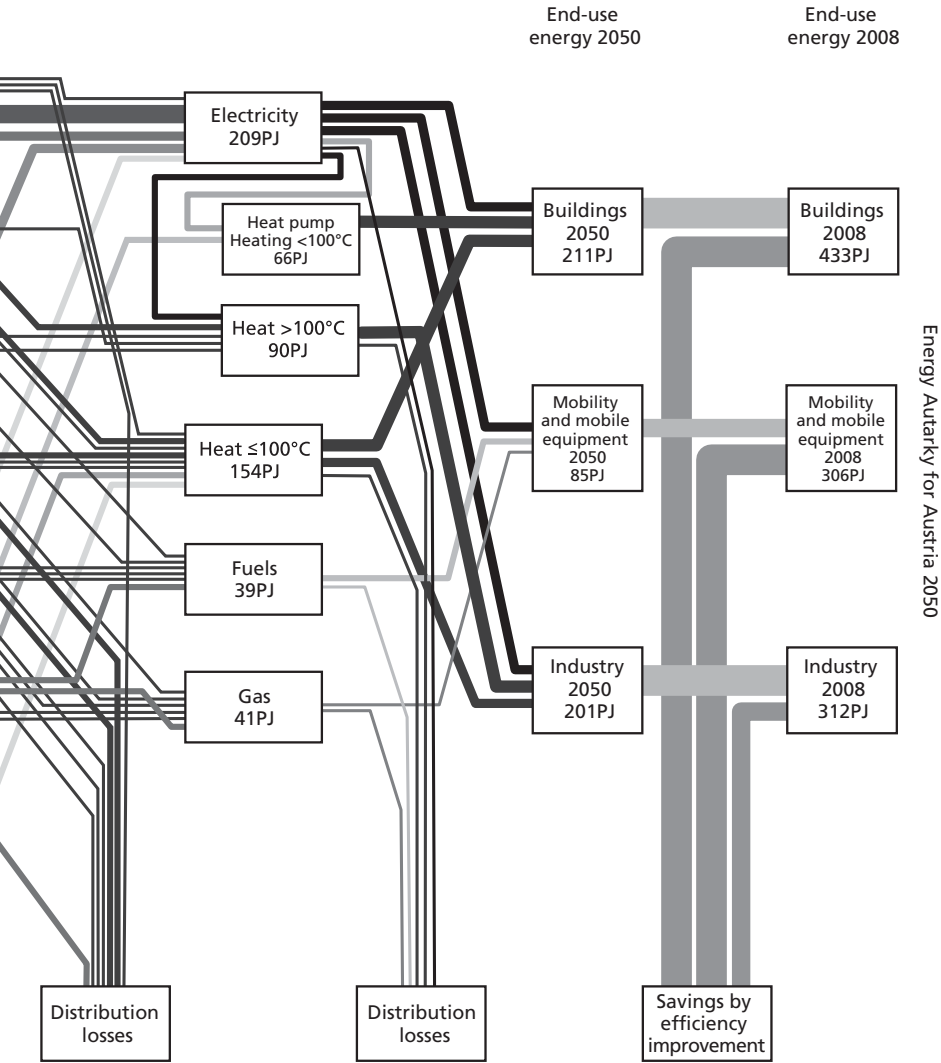


Figure 4: Energy flowchart Austria 2050 with energy autarky for constant energy service until 2050



Energy flowchart 2050 100 % energy-autarkic  
constant energy service 2008-2050

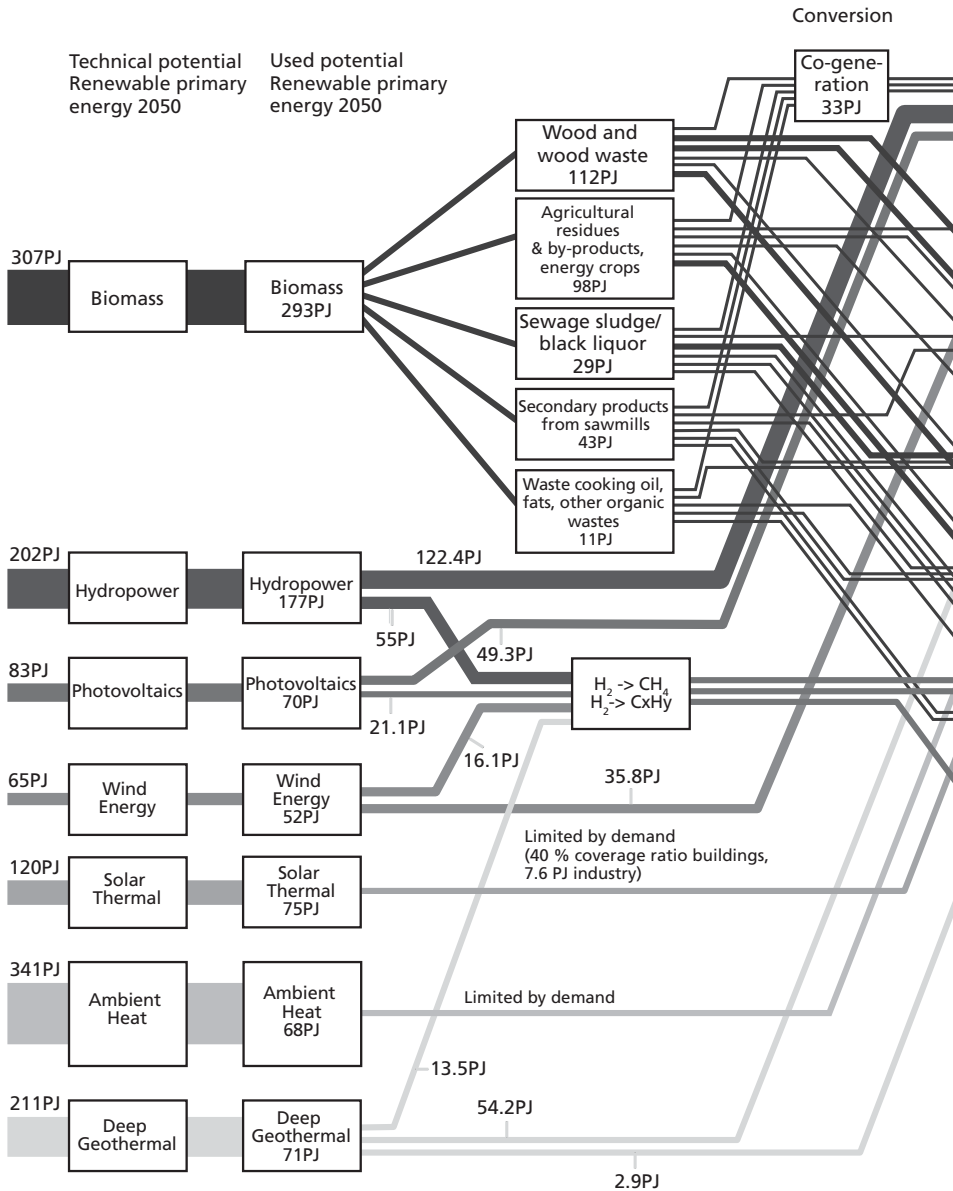
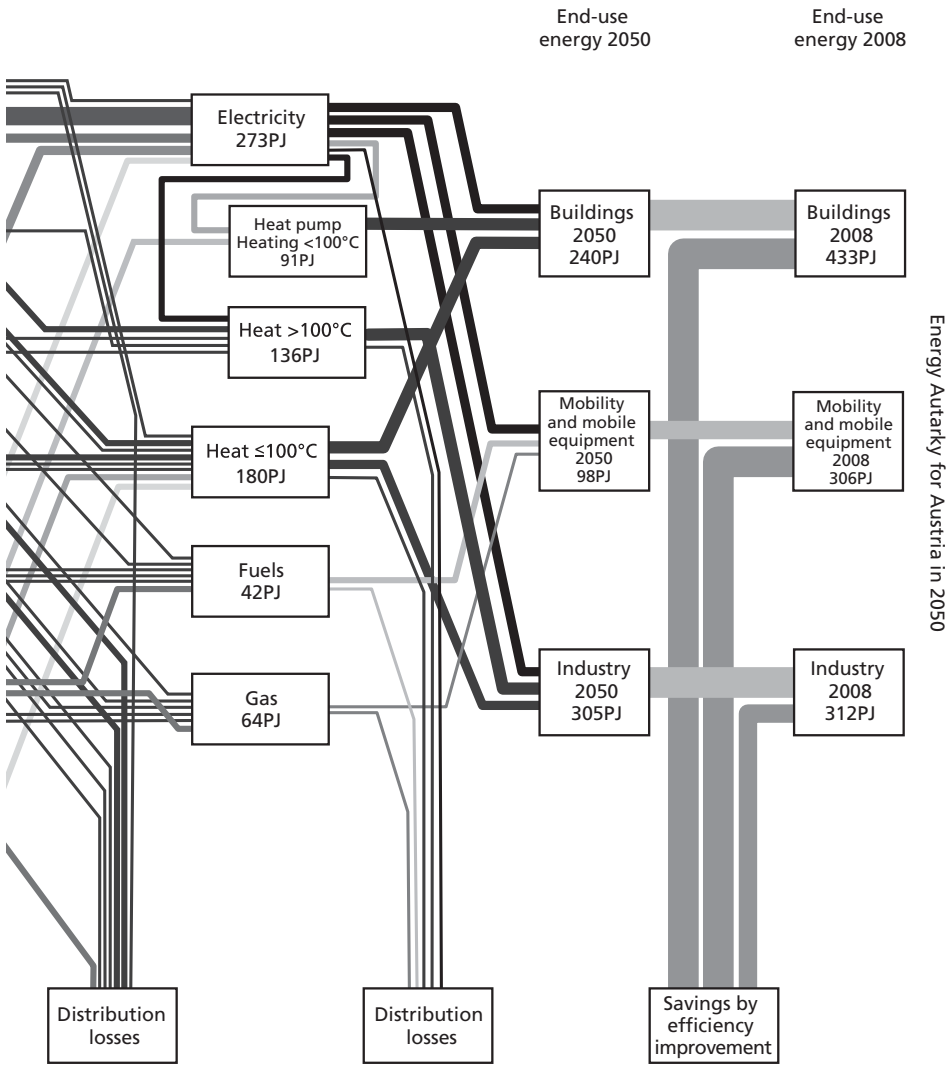


Figure 5: Energy flowchart Austria 2050 with energy autarky for a growth of the energy service by 0.8 %/a





The strong increase in efficiency due to the reduction of the fleet consumption of mobility (smaller and more efficient private cars so to speak) is a measure which results in saving costs for every private individual, but requires a change of values in the society. A shift of the long-distance goods transport from the road to the rail as well of passenger and freight transport from the aeroplane to the rail would require a strong further development of rail infrastructure.

It will be comparably easier to achieve savings in the fields of building and production. In any case the increase of the rate for high-level thermal sanitation in the building sector to the 3% per year, already outlined by the Federal Government in the energy strategy, will be necessary. In the production sector the reduction of the energy demand is due to the permanent improvement of production processes, the development and market penetration of efficiently conceived technological solutions makes a considerable contribution in this respect. With this efficiency increase in all sectors the remaining energy demand can be covered by renewable sources of energy.

The calculations have shown that energy autarky in Austria is feasible, but that the room for manoeuvre is relatively small. This is, among other things, due to the fact that Austria has—for example compared to other EU Member States—no possibilities to use offshore wind energy and cannot apply solar thermal energy generation due to the low share of direct radiation from the sun. In the case of a further increase of the energy service level or in the case of lower efficiency increases than assumed in this study we reach the limits of the available potentials of renewable sources of energy.

Statements with respect to costs and benefits at macro-economic level are presently still premature and require further analyses.

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## **Interlinkages and effective coordination of clean air, climate protection and energy efficiency policies using the abatement cost concept**

The debate of energy saving in connection with emission reduction is typically bound to reducing CO<sub>2</sub> emissions. A great deal of room is dedicated to the issue as it is tightly linked with climate change policy. However, less attention is given to the link between energy saving and emissions of pollutants with a direct effect on local and regional air quality, chiefly SO<sub>2</sub>, PM, NO<sub>x</sub>, VOC (Jílková et al., 2010a). Reducing the emissions to air with the objective to improve the pollution situation is a very urgent necessity in many areas of the Czech Republic and Europe. It also generates an energy saving potential.

In practice, there are both policies aimed at reducing the CO<sub>2</sub> emissions by conserving energy in households, industry and transport, and those motivated by improving air quality through reduction of emissions to air in the same sectors as with CO<sub>2</sub> emission reduction policies (e.g., MoE, 2007).

The lack of interlinkages between these policies then results in the policies sometimes sending contradictory signals to the economic agents and thus causing contradictory effects; in other cases, they “only” fail to make full use of potential synergisms that could be achieved if the policies were interlinked (Jílková et al., 2010b). In economic terms, therefore, they are not an optimal solution to the problems that they focus on, and from the macroeconomic point of view, inefficiencies and wastage of resources occur.

The present paper focuses on an economic analysis of the potential synergisms between climate protection policy (here represented by CO<sub>2</sub> emission reduction) and air quality improvement policy (here represented by particulate matter–PM–emissions). The measures in the household sector examined in this paper were chosen deliberately to represent energy saving measures. This analysis uses data on PM and CO<sub>2</sub> abatement costs in the household and transport sectors (ARR et IREAS, 2011, pp. 184–216). The analysis employs the marginal abatement cost

concept and the comparative analysis method. It also employs data for the Czech Republic acquired in projects or students' theses.

The household and transport sectors are the subject of the analysis because the unsatisfactory pollution situation in villages and smaller towns is largely due to household heating using fossil fuels in obsolete boilers, and that in larger settlements mostly due to transport. Particulate matter was selected for the analysis because it is the chief pollutant affecting human health (especially the very small fractions sized 2.5 and 1 $\mu$ m). The paper therefore examines the total emissions of particulate matter, which are quite a reliable proxy for very small pollutants.

## 2.1

### Households: existing climate protection instruments

The costs of reducing greenhouse gas emissions from households can be analyzed, for example, based on the completed projects of The Green Savings programme. Within this programme, the Ministry of the Environment utilizes funds raised by selling redundant emissions units (so-called assigned amount units, AAU) for investment to reduce greenhouse gas emissions.

The total allocation of funds in the programme is CZK 24.3 billion, and the average investment **místo poznámky 1) dát: (MŽP, 2011)** costs.<sup>1)</sup> The scheduled investment of all the funds within the programme can be expected to result in a total saving of 18.2 million tonnes of greenhouse gas emissions.<sup>2)</sup> Given the Czech Republic's total **místo poznámky 2) dát: (MŽP, 2009)** is in 2008, the amount of emissions conserved (during the useful life of the measures) translates to 12.9 per cent of the CR's annual emissions. As concerns the fulfilment of the climate protection goals, the amount can be compared with the current climate protection policy, in which the Czech Republic committed itself to reduce its greenhouse gas emissions by 30 million tonnes by 2020 (from 146 million tonnes in 2005 to 117 million tonnes in 2020).

From the point of view of CO<sub>2</sub> emission reduction in the household sector, investment in a new biomass source is the most effective measure; the most expensive way of cutting one tonne of CO<sub>2</sub> is to invest in solar-thermal collectors and new passive buildings. The programme design only assessed the CO<sub>2</sub> emission reduction over 15 years, using the so-called greening factor indicator.<sup>3)</sup>

However, the following analysis focuses **místo poznámky 3) dát: (SFŽP, 2009)** the entire useful life of the investment measure.

<sup>1)</sup> *MoE, Dotace z programu Zelená úsporám vyplatí MŽP do konce března (MoE to disburse subsidies under Green Savings by end of March), 2011.*

<sup>2)</sup> *MoE, Emise jednotlivých skleníkových plynů (Greenhouse gas emissions by type), 2009.*

<sup>3)</sup> *SEF, Program Zelená úsporám, Programový dokument (Green Savings Programme, Programming Document), p. 31.*

The amount of costs required to achieve a CO<sub>2</sub> emission cut of one tonne by type of measure is shown in Figure 6 below.

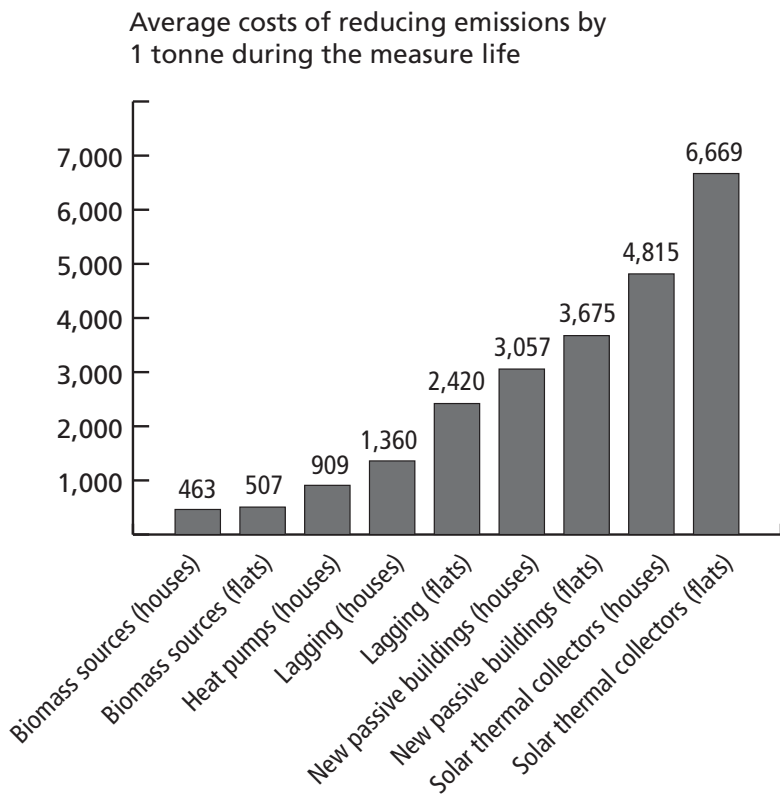


Figure 6: Average costs of reducing CO<sub>2</sub> emissions by 1 tonne during the measure life (CZK)

Source: Priesolová, 2011, p. 45

As is evident from the chart, investing in biomass boilers, purchasing of thermal pumps and investing in lagging are the most effective methods of reducing the emissions from households. A detailed method of calculating the average costs can be inferred from the Table 1.

Measure/project	Total average project investment costs (CZK)	Average CO <sub>2</sub> emission reduction during the measure life (tonnes)	Average costs of reducing emissions by 1 tonne during the measure life (CZK)
Biomass sources (houses)	73,313	158	463
Biomass sources (flats)	402,298	793	507
Heat pumps (houses)	108,695	120	909
Lagging (houses)	213,793	157	1,360
Lagging (flats)	996,732	412	2,420
New passive buildings (houses)	374,148	122	3,057
New passive buildings (flats)	229,885	63	3,675
Solar thermal collectors (houses)	105,692	22	4,815
Solar thermal collectors (flats)	512,820	77	6,669

*Table 1: Average costs of reducing emissions by 1 tonne during the measure life*  
*Source: Priesolová, 2011, p. 44*

For the sake of completeness, let us also consider an additional measure such as replacing a boiler with a low-emission type burning fossil fuels. Given the average consumption of 55GJ of heat in an average single-family house and 36GJ in a flat, and the standard efficiency increase by 20 percentage points when replacing a boiler, the expected greenhouse gas emission reduction will be 1.9 and 1.2 tonnes of CO<sub>2</sub> a year for a house and a flat, respectively. Given the assumed useful life of the investment of 30 years, the costs per tonne conserved are CZK 611 and CZK 1,140, respectively, making this investment one of the most efficient measures.

## 2.2

### Households: existing air protection instruments

The amounts of air pollutants in the Czech Republic are among the highest in Europe and have a significant adverse impact on health in the worst-affected

Moravian-Silesian Region in particular.

Legislation in force defines tolerable air quality as a situation where the 24-hour PM10 concentration exceeds the pollution limit of 50mg/m<sup>3</sup> no more than 35 times a year. For this reason, the 36th violation of the permitted pollution concentration is registered when monitoring air quality. However, as illustrated by the map in Figure 7, this concentration was exceeded in more than 21% of the geographical area of the CR in 2008 (CENIA, 2009).

Air quality is therefore probably the most serious environmental problem in the CR at present, and receives relatively great attention by both the professional public and the politicians. Given the intensity of the air quality problem in the Moravian-Silesian Region, the analysis of measures to improve air quality in this paper focuses on that region.

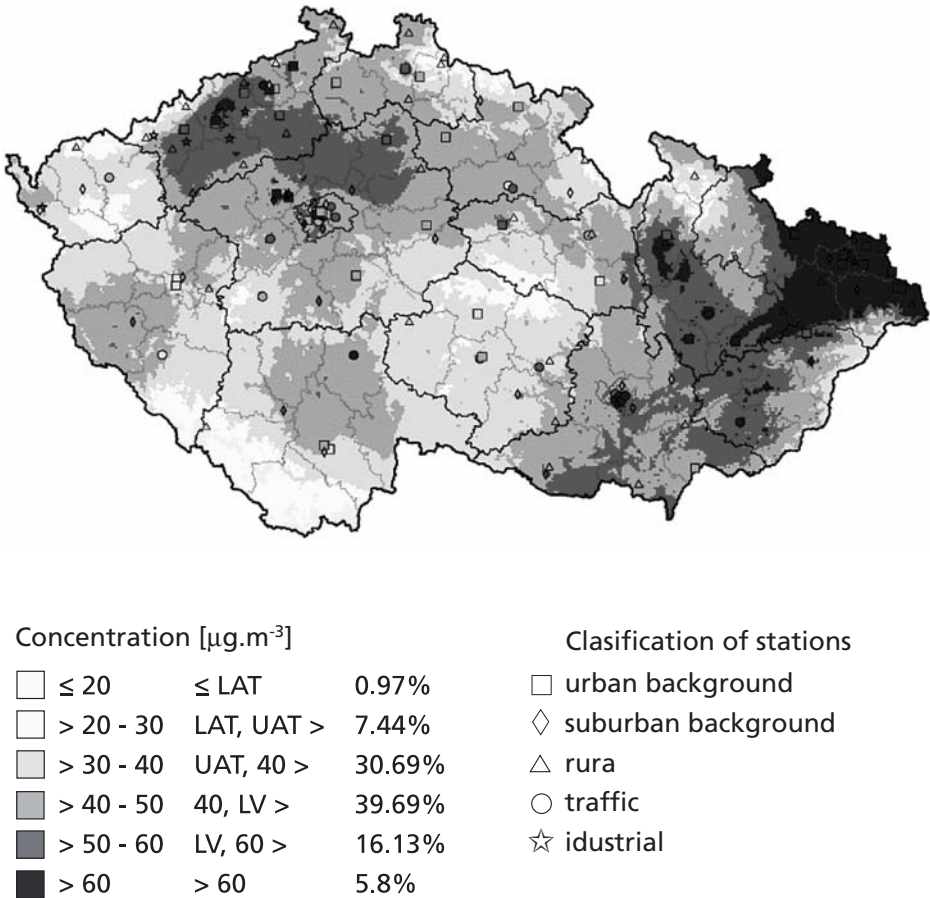


Figure 7: 36<sup>th</sup> highest 24-hour PM10 concentrations, CR, 2010  
Source: CHMI, 2008

The household sector is important in terms of air quality especially given the dynamics of the recent development. The emissions of PM from local heating sources have increased significantly in the worst-affected Moravian-Silesian Region in the recent years (see Figure 8). The share of emissions from these sources has gone up from about 15% to 34%. The trend is generally associated with the region's decreased economic performance and its population's purchase power; emissions from these sources can be expected to continue to grow in near future.

Ostrava-Karviná agglomeration and Třinec district:  
trend in  $PM_{10}$  emissions from REZZO 3 sources

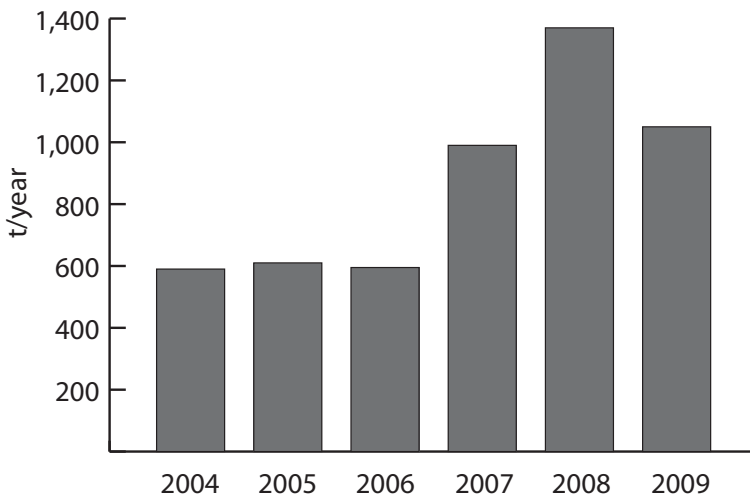


Figure 8: Trend in  $PM_{10}$  emissions from local heating sources

Source: Bilek, 2010

The contribution of local heating sources to the PM pollution concentrations in the study area may be between 2 and  $10\mu\text{g}/\text{m}^3$ . However, the local effect of a heating source may worsen the pollution situation by up to 50 per cent or more. Local heating sources can have a cardinal effect on the pollution situation especially in periods with no wind (up to 30% of the year).

Emissions of particulate matter produced by local heating sources are directly determined by the household heating method. The most common heating method in the Moravian-Silesian Region is central heat supply along with gas combustion (see Table 2). Given the increasing prices of these energies in the recent years, however, the households increasingly tend to burn solid fuels, chiefly coal, wood and waste in some cases.



Out of the 299 municipalities, 243 have gas infrastructure, meaning an easy potential transition to natural gas heating for over 98% of the population of the Moravian-Silesian Region.<sup>4)</sup> místo poznámky 4 dát: (Machálek, 2008) since there is a great discrepancy between registered heating sources and fuel types actually utilized.

	Ostrava		MSR	
	2001	2011 (estimate) <sup>5)</sup>	2001	2008
Coal	4	10	10,3	10,1
Electricity	2	9	4,3	3,3
Gas and Central	93	81	82,5	83,7
Wood	1	-	2,9	2,9

Table 2: Household heating structure in Ostrava and the Moravian-Silesian Region using selected fuel types (per cent)

Source: Own analysis, adapted from ARR et IREAS (2011)

The implementation of the studied measures can be expected to have the greatest effect especially in the locations with the highest pollution concentrations (ARR et IREAS, 2011). Some types of measures, such as mass connections to central heating supply, can also be implemented in a blanket manner, best in locations with a particularly serious contribution of local heating sources to bad pollution situation. Such areas can be identified based on the household heating structure of the location or the amount of PM emissions produced by local small pollution sources. The greatest PM emissions from small-scale sources in 2008 were in the following municipalities and municipal districts: Orlová, Slezská Ostrava, Karviná, Havířov, Vratimov, Šenov, and Radvanice a Bartovice.<sup>6)</sup> The municipal districts of Ostrava with the highest shares of solid fuel heating were the following: Nová Bělá (49%), Michálkovice (34%), Slezská Ostrava (24%), Vítkovice (23%), and Radvanice a Bartovice.

<sup>4)</sup> ~~Machálek P. 2008. Moravskoslezský kraj – problematika emisí. Ochrana ovzduší, 5–6 2008, p. 5.~~

<sup>5)</sup> **do této poznámky 5 dát: (MMO, 2010)** ~~opatření ke zlepšení kvality~~

<sup>6)</sup> Krajský program snižování emisí MSK, 2010.

The analysis focuses on three types of standardized households:

- households using brown coal for heating;
- households using black coal for heating;
- households using wood for heating.

The assumed average annual heat consumptions for heating a single-family house and a model flat are the figures quoted by the MoE, i.e., 55GJ/year and 36GJ/year, respectively.<sup>7)</sup>

A portion of the households using solid fuels for heating employs flow-through heaters or electric heaters for domestic hot water (DHW). The emissions generated by DHW production are disregarded due to the high uncertainty concerning the structure of DHW production methods.

As mentioned above, the policy synergism analysis in this paper employs the abatement cost concept. The method of calculating them is not firmly anchored in the literature; instead, they are used as a theoretical concept for explaining certain aspects of environmental regulation. In this paper, the calculation proceeds as follows: first we define the potential measures to improve air quality (i.e., the baseline scenario and the change that occurs, such as replacement of an old brown coal boiler with a biomass boiler); then we identify the costs of implementing such measures, the useful life of the measures, and the amounts of emissions that are not produced during the useful life as a result of the cost of implementing the measures. Based on this information, we can then calculate the average unit emission abatement costs for each measure.

### **Specification of scenarios and measures to reduce PM emissions from households**

First, we specify three reference scenarios:

- brown coal boiler;
- black coal boiler;
- wood boiler.

Emissions from heating sources using solid fuels are modelled using nominal PM emissions related to the heat produced; the actual figures are adopted from the literature. A brown coal boiler is assumed to produce a nominal emission of 601g per GJ of heat produced.<sup>8)</sup> Given the average final heat consumption for heating of 55GJ and 36GJ for a house and a flat, respectively, this yields an average emission of 32kg of PM from a single-family house and 2kg for an average flat.

<sup>7)</sup> *Programový dokument zelená úsporám, Příloha 4, 2009.*

<sup>8)</sup> *Krajský program snižování emisí MSK, 2010.*

Emissions from heating using black coal are modelled analogously, using an emission factor of 179g/GJ. The total annual PM emissions are thus 9.8kg and 6.4kg for a house and a flat, respectively.

The third reference scenario uses wood as the fuel, with an emission factor of 332g/GJ.<sup>9)</sup> The emissions under this scenario are 18.3kg and 12.0kg for a house and flat, respectively.

The first potential measure assumed is the replacement of an old coal boiler with a modern coal boiler. This category includes new coal hot-water boilers EKOFEKT, CARBOROBOT, VARIMATIC and BENEKOV, for instance, with outputs starting from 24kW. Controlled coal combustion and reduced heat loss from the waste gases result in an efficiency of 89%; the emission limit is 150mg/m<sup>3</sup> and the applicable emission factor is 210g/GJ. After implementing this investment, the annual PM emissions are 11.55kg from a house and 7.56kg from a flat; the emission reduction compared to previous brown coal heating is 21.5kg and 14.1kg respectively. The purchase price of a new coal hot-water boiler, including installation, is assumed to be CZK 65,000 for a single-family house and CZK 132,000 for an apartment building with six apartment units. The assumed useful life of the new boiler is 30 years. The annual abatement costs per tonne of PM is thus CZK 100,000 for a single-family house and CZK 52,000 for an apartment unit.

Another of the analyzed investments that reduce PM emissions is the installation of a low-emission biomass boiler. The model fuel is wood pellets, which have an emission factor of 0.11kg/GJ when combusted in a hot-water boiler and result in a total PM emission of 5.8kg from a house and 3.8kg from a typical flat. The investment in a low-emission biomass boiler is analyzed in all the three reference scenarios (i.e., replacement of a brown coal boiler, and black coal boiler, and a wood boiler). The resulting annual PM emission reduction in a house is 27.2kg, 4.0kg and 12.5kg compared to previous brown coal, black coal and wood heating, respectively. In an apartment building, the annual emission reductions are 17.8kg, 2.6kg and 8.2kg respectively. The assumed useful life is 30 years; the assumed average investment in a low-emission boiler is CZK 71,000 for a single-family house<sup>10)</sup> and CZK 37,500 for an apartment building.<sup>11)</sup> These investments, spread over 30 years of operation, result in an annual depreciation of CZK 2,567 and 1,250 (house and apartment building). Dividing the figure by the total PM emission reduction as a result of the measure yields the abatement cost per tonne of PM (see table below).

The third analyzed measure is the replacement of a brown coal boiler, a black coal boiler or a wood boiler with central heat supply. The assumed source of heat

<sup>9)</sup> *Programový dokument zelená úsporám, Příloha 4, 2009.*

<sup>10)</sup> *e.g., Bionk 16 wood pellet boiler with an output of up to 16kW*

<sup>11)</sup> *model examples from Green Savings programme*

is a power plant brown coal boiler with a fluid bed and “dry” desulphurization, which produces a nominal PM emission of about 20g/GJ (given a unit output over 100MW).<sup>12)</sup> **Místo poznámky 12) dát (Skácel et Tekáč, 2007)**

length of the heat line between the source and the end users, for instance, we construct the abatement costs from a specific investment that could reduce the pollution burden in Karviná district. This example of investment in central heat supply is the construction of a heat line network in Český Těšín and its connection to a source in Třinec. The implementation of the project would make it possible to supply heat from Třinec heating plant to Svibice housing estate, single-family houses in the vicinity and part of an adjacent industrial estate. The rough estimate of the investment in the heat lines and exchanger stations, including construction work, is CZK 550 million. Given the estimated 3,000 equivalent households connected, the cost per connected household is CZK 183,000. Central heat supply projects are very diverse and modelling the costs depending on the residential unit type is complex disproportionately to the result. It is therefore well in order to assess the project as a whole and settle for dividing the costs equally among houses and flats. The annual PM emissions are calculated with the applicable emission factor as a weighted average of the emissions from apartment units and single-family houses with an estimated ratio of 6:1, resulting in an annual PM emission of 0.92kg per household. The assumed useful life of 30 years makes it possible to determine the abatement costs per tonne of PM as CZK 295,000 when shifting from brown coal heating; CZK 1,107,000 when shifting from black coal; and CZK 352,000 when replacing a wood boiler.

With public fund support, thus reduced investment costs paid by the investor, the broad connection of nearby end users and use of central heat as the main heat source can be assumed, because the assumed delivery price of heat around CZK 300/GJ means the costs of central heating become equal to the annual costs of coal heating.

The price per GJ of heat supplied is the pivotal variable, especially in a region with a lower purchase power, where the price largely decides on the success of the project. For the sake of overview, the Table 3 shows the current prices of heat in different regions.

The last assumed measure consists in a complete lagging of the envelope of a model house, resulting in the achievement of the low-energy standard. Specifically, it involves lagging the perimeter walls with a thermal insulation system, lagging the upper floor ceiling, replacement of all windows with plastic frame windows with thermal triple glazing, and replacement of the front door. Given the standard floor area of 136m<sup>2</sup> per house, the final heat consumption for

<sup>12)</sup> F. Skácel, V. Tekáč: *Přehled poznatků o emisích znečišťujících látek vznikajících při spalování tuhých paliv ve spotřebičích malých výkonů*, VŠCHT, 2007.

heating yields the nominal heat demand for heating of 112.3kWh/m<sup>2</sup>/year. The implementation of complete lagging reduces the nominal heat demand for heating to 61.1 kWh/m<sup>2</sup>/year<sup>13)</sup>, místo poznámky 13) dát (Preislová, 2013)

PM for a shift from brown coal heating, 4.5kg of PM for a shift from black coal, and 8.3kg of PM for a shift from wood burning. Given the assumed investment of CZK 284,000 and a useful life of 30 years, the abatement costs per tonne of PM are CZK 628,000 (brown coal previously), CZK 2,109,000 (black coal previously), and CZK 1,137,000 (wood previously). It must be noted, too, that all the measures presented result in an energy saving in the households.

The above information, including the calculation of the abatement cost per tonne of PM, are shown in the Table 4.

Heating plant	Price of heat, CZK/GJ incl. VAT	Annual payment in CZK given an average consumption of 40GJ
Plzeňská teplárenská	392	15,688
Teplárna České Budějovice	490	19,620
Dalkia, Ostrava	482	19,280
Pražská teplárenská	469	18,788
Teplárny Brno	605	24,222
Teplárny Liberec	637	25,500

Table 3: Prices of heat in 2011, selected heating plants

Source: cenyenergie.cz, 2011

<sup>13)</sup> Preislová M. 2011. *Analýza nákladů na zamezení emisí CO<sub>2</sub> v rámci dotačního programu Zelená úsporám. Praha, VŠE v Praze; and own calculations.*

Measure		Previous heating boiler	Emission factor kg/GJ	Emission reduction kg/year*	Purchase price	Abatement cost per tonne of PM
New coal boiler	flat	brown coal	0.210	14.1	22,000	52,098
Biomass boiler	flat	brown coal	0.106	17.8	37,500	70,083
Biomass boiler	house	brown coal	0.106	27.2	77,000	94,192
New coal boiler	house	brown coal	0.210	21.5	65,000	100,752
Biomass boiler	flat	wood	0.106	8.2	37,500	153,337
Biomass boiler	house	wood	0.106	12.5	77,000	206,084
Central heat supply	avg.	brown coal	0.024	20.7	215,686	347,082
Central heat supply	avg.	wood	0.024	17.3	215,686	414,664
Biomass boiler	flat	black coal	0.106	2.6	37,500	472,769
Complete lagging	house	brown coal	0.601	15.1	284,170	628,169
Biomass boiler	house	black coal	0.106	4.0	77,000	635,401
Complete lagging	house	wood	0.332	8.3	284,170	1,137,138
Central heat supply	avg.	black coal	0.024	5.5	215,686	1,301,927
Complete lagging	house	black coal	0.179	4.5	284,170	2,109,105

\* compared to reference scenario

*Table 4: Local heating measures, ranked by abatement cost amount*

The abatement costs per tonne of PM calculated are illustrated and ranked in the Figure 9. The measure descriptions include the initial situation (brown coal (Br), black coal (Bl) and wood heating) and the investment measure.

### **Households: interlinkages between air and climate protection policies**

This paper examines the effectiveness of the expenditure programmes on climate and air protection using the average abatement costs, expressing the costs of reducing the pollutant, or greenhouse gas, emission by 1 tonne. A cost-effective policy is defined as one that primarily aims at measures that have the least emission reduction (abatement) costs.

It should be pointed out again that the below analysis is principally a demonstration of the potential utilization of the abatement cost concept to optimize the design of policies on the example of air and climate protection policies (the examples here being CO<sub>2</sub> and PM).

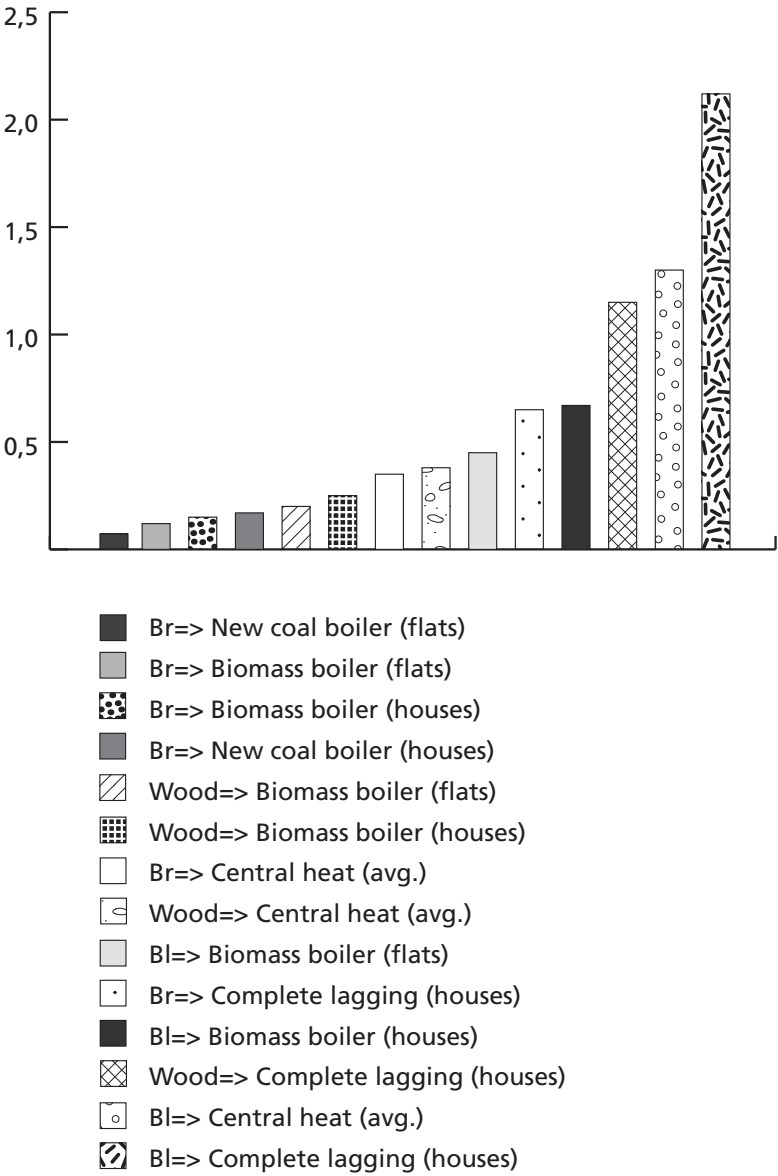


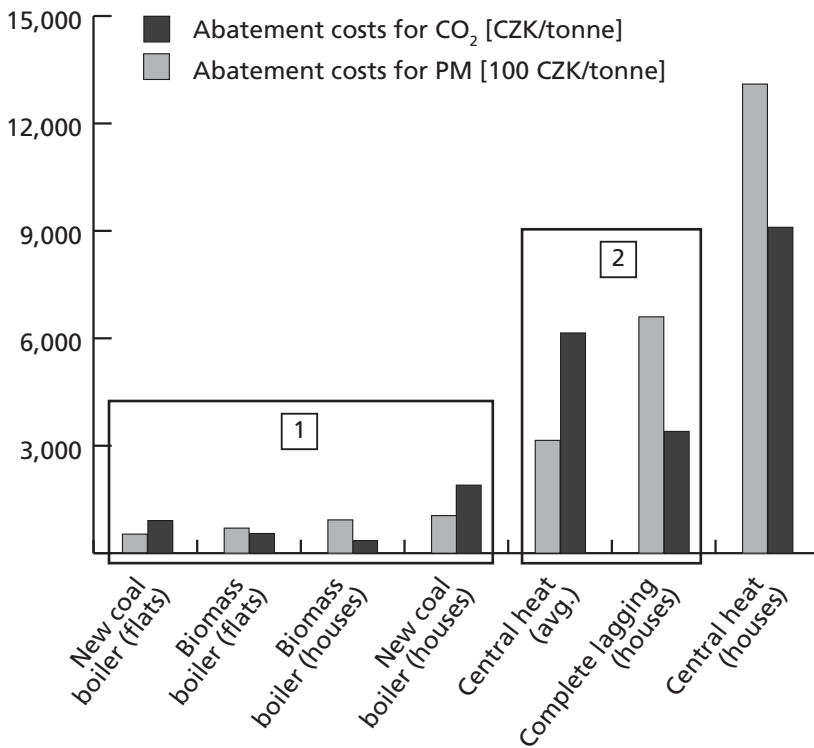
Figure 9: Unit abatement costs of PM emission in households by the measure  
Source: own analysis

The Table 5 and Figure 10 make a summary comparison of the CO<sub>2</sub> and PM emission abatement costs of the above measures in the household sector.

Measure	Abatement costs for CO <sub>2</sub> [CZK/tonne]	Abatement costs for PM [CZK/tonne]
Biomass source (house)	356	94,192
Biomass source (flat)	535	70,083
Complete lagging (house)	3,289	628,169
Central heat supply (avg. house)	6,566	347,082
Central heat supply (avg. flat)	8,942	1,301,927
New coal boiler (house)	1,913	100,752
New coal boiler (flat)	971	52,098

Table 5: Comparison of abatement costs for households

Source: own analysis, adapted from ARR et IREAS, 2011





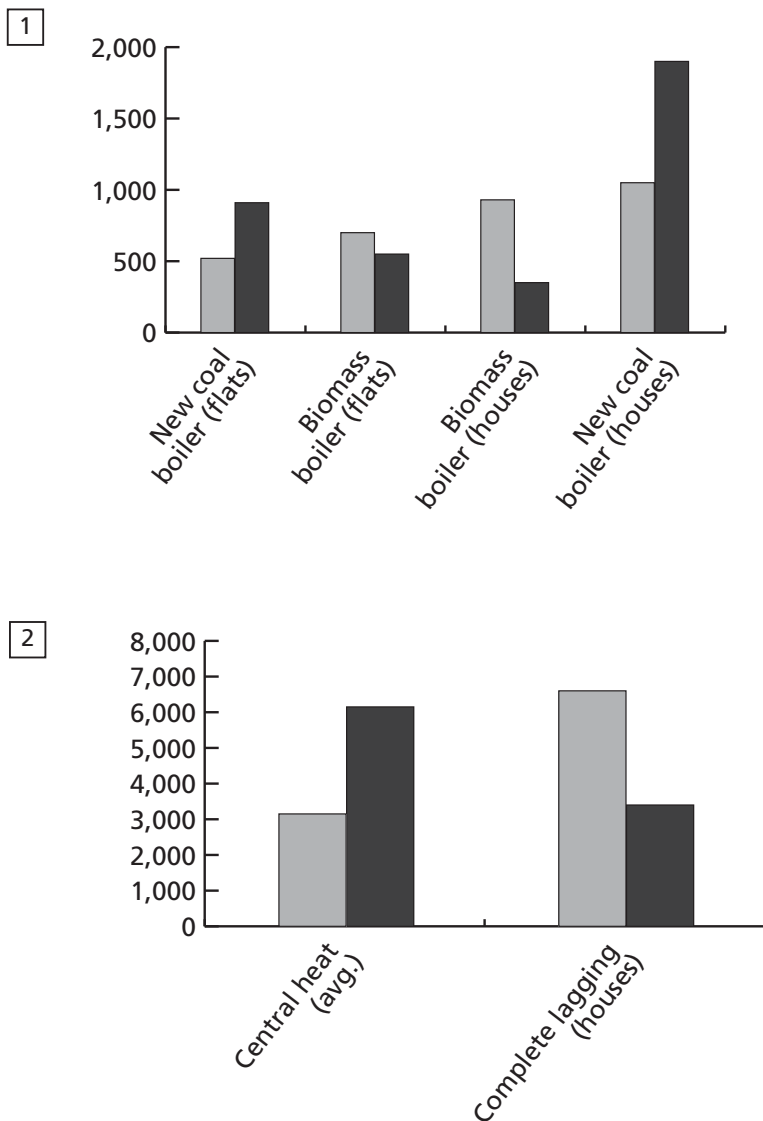


Figure 10: Comparison of CO<sub>2</sub> and PM emission abatement costs for households

Source: own analysis, adapted from ARR et IREAS, 2011

It follows from the chart that mutual synergisms can be sought for in policies supporting measures to reduce CO<sub>2</sub> and PM emissions, while conserving energy as well. Since handling dust particle pollution is considered a priority in the Czech Republic, the measures are ranked in the chart by their PM abatement

costs, in an ascending order from the left. The CO<sub>2</sub> abatement costs are included for each measure.

The ellipses in the chart define two areas in which the abatement costs for the two types of pollutants differ more significantly. The chart also indicates that low PM abatement costs tend to be associated with relatively low CO<sub>2</sub> emission reduction costs; conversely, higher PM abatement costs tend to be associated with relatively higher CO<sub>2</sub> emission reduction costs.

Taking a closer look at area 1, we can see that the CO<sub>2</sub> abatement costs differ in this group. For example, the measures “Biomass source (house)” and “New coal boiler (house)” (see above for their descriptions), which show nearly identical PM abatement costs (CZK 94,192 and CZK 100,752 respectively), have very different CO<sub>2</sub> abatement costs (CZK 356 and CZK 1,913 respectively). Having to choose one of the two measures with the objective to reduce PM emissions, support to the measure “Biomass source (house)” would receive clear priority, *ceteris paribus*. The implementation of one such measure will achieve a CO<sub>2</sub> emission reduction at less than 1/5 of the costs with the same effect and PM emission abatement cost. The other measures should be regarded in the same way from the point of view of both the PM emissions and the CO<sub>2</sub> emissions. However, if the policy makes an absolute priority of reducing PM emissions, then support should be given to measures such as “New coal boiler (house)”, where the same total costs achieve a much greater effect of reducing the PM emissions compared to the other measures (by CZK 6,560 to CZK 24,109 per tonne of PM); CO<sub>2</sub> emissions are also reduced but at a higher cost than in two other potential measures analyzed. A different situation occurs if both the emission types are assigned the same importance and both are to be reduced simultaneously: then support should primarily be given to measures such as “Biomass source (flat)”, where the abatement costs for both the pollutants are relatively low.

Area 2 in the chart demonstrates two different measures which differ substantially in their unit costs of PM and CO<sub>2</sub> abatement. Whereas the measure “Central heat supply (avg. house)” has relatively lower PM emission abatement costs, the measure “Complete lagging (house)” has relatively lower CO<sub>2</sub> emission abatement costs. When choosing whether to support the former or the latter measure, the objective of the policy plays a major role. If the policy focuses on PM emissions, then the former should be supported; if it aims at reducing CO<sub>2</sub> emissions, then prioritize the latter. In spite of the relatively greater difference in the unit costs of abatement of both the studied pollutants in the two policies, both the pollutants are still reduced synergically. The situation would be different if we studied CO<sub>2</sub> and NO<sub>x</sub> emissions, for example (where a reduction in one often tends to increase the other).

The analysis shows that a particular policy design (supporting certain types of measures) has the potential to significantly affect the resulting environmental

effect while expending identical costs, while still stimulating energy savings. Different prioritization of measures may achieve very different results in the form of reduced emissions of different pollutants and energy consumption. The analysis also shows that if policies are well coordinated (here, PM and CO<sub>2</sub> emission reduction), abatement costs for both the emission types can be reduced thanks to the potential synergisms between the PM and CO<sub>2</sub> policies. In some cases, support to a specific measure is more a question of policy priority (whether to aim more at reducing PM or CO<sub>2</sub> emissions).

### 2.3 Transport: climate protection policy

At present, the Czech Republic's transport sector is responsible for almost one tenth of all the greenhouse gas emissions, and the share is growing dynamically. The Figure 11 shows the trend since 1990 and a prediction for the coming decade.

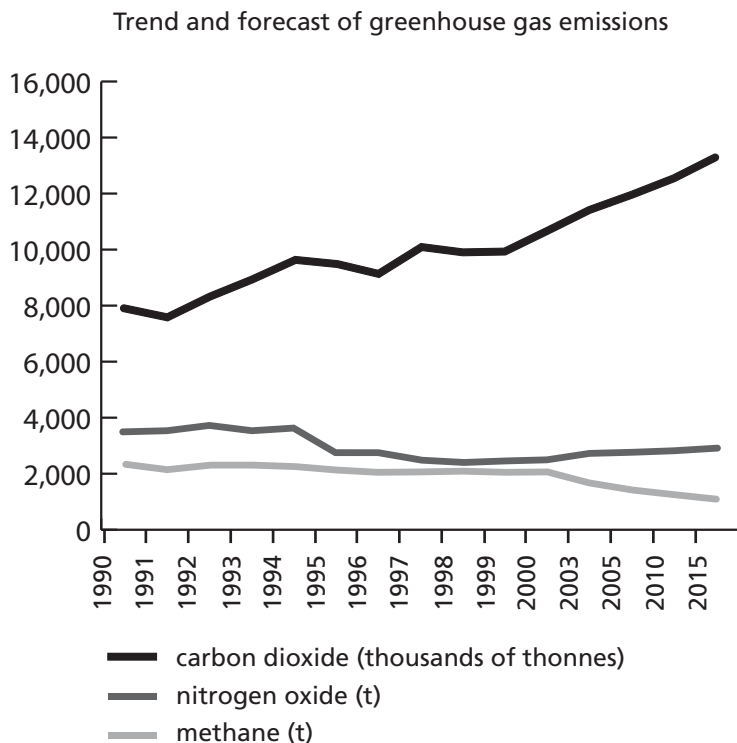


Figure 11: Trend and forecast of greenhouse gas emissions from transport  
Source: Adamec, CDV

Expenditure programmes to reduce greenhouse gas emissions from the transport sector are not in use at present, but the climate protection policy utilizes other instruments. They include the involvement of air transport in the emission trading system and the defined minimum proportion of biofuels in transportation fuels. Expenditure programmes only play a minor role, e.g., as support to alternative fuel systems in the form of subsidies for building CNG stations.

The Table 6 shows the choice of measures to reduce greenhouse gas emissions that are subject of the analysis in this chapter.

Measure	Annual mileage (km) (g/km)	Engine emission factor (t)	Annual CO <sub>2</sub> eq. emission eq./year)	Emission reduction (t CO <sub>2</sub> )	Investment cost	Useful life	Annual depreciation	Costs of abatement per t CO <sub>2</sub>
Reference scenario Old bus (EURO II)	60,000	1,300	78					
CNG bus	60,000	1,150	69	9	5,100,000	15	340,000	37,778
Diesel bus (EURO V)	60,000	1,100	66	12	4,300,000	15	286,667	23,889
Trolley bus	60,000	1,100	66	12	11,000,000	20	550,000	45,833
Ecodriving				1	2,500	2		896

*Table 6: Choice of measures to reduce greenhouse gas emissions from transport*  
Source: own analysis

The reference scenario involves an elderly bus in the EURO II emission class; the measures are its different low-emission substitutes. The last measure is a course of eco-friendly driving for drivers; taking it results in a fuel saving (thus emission reduction) of 2 per cent on average.<sup>14)</sup>

## 2.4 Transport: air protection policy

Mobile sources are a major source of solid pollutant emissions; the contribution of transport to the total PM<sub>10</sub> pollution concentration in the critical Moravian-Silesian Region is between 0.5 and 5mg/m<sup>3</sup>. The solid pollutant emissions show poor dynamics and no clear trend, as illustrated by the Figure 12.

<sup>14)</sup> SUMMA: Marginal abatement costs of environmental problems caused by transport.

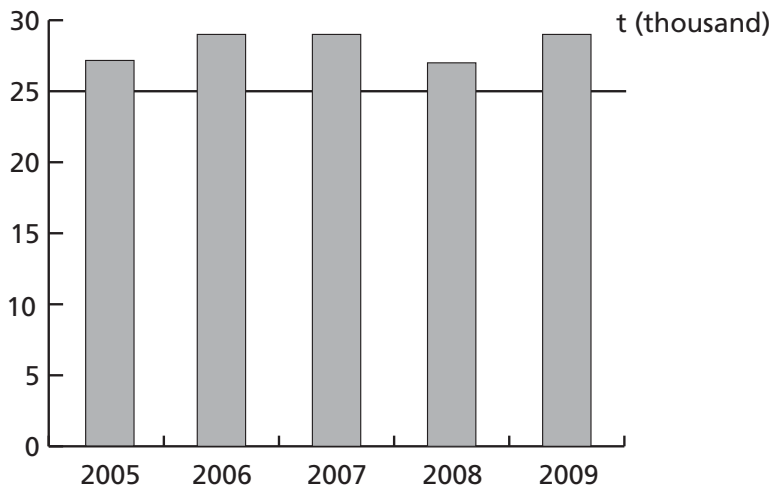


Figure 12: Trend in PM emissions from transport (REZZO 4-mobile sources)

Source: ~~J. Bílek, 2011~~ **Bílek, 2011**

Within public transport modernization and eco-upgrade, the analyzed measures included purchasing buses running on compressed natural gas (CNG), diesel buses compliant with EURO V standard, investing in electric buses and trolley buses.

The reference scenario involves an elderly bus compliant with EURO II emission standard and having an emission factor of 486g/km, which produces 29.2kg of PM on average during its annual operation. Measures suitable for implementation in the Moravian-Silesian Region are examined with respect to the serious pollution in the region. A total of 160 buses operated by Ostrava Public Transport Company failed to conform to EURO III in 2010.

The first of the measures to be examined is purchasing new buses running on compressed natural gas (CNG) for public transport. The average purchase price of a CNG bus is CZK 5,100,000, about CZK 800,000 higher than a similar bus with a diesel engine (CZK 4,300,000).<sup>15)</sup> The measure is examined in two alternatives: one with the full price of a new bus (in case the vehicle is not needed and is only purchased to reduce the emissions), and the other with only the difference between the bus prices as the invested amount. This calculation is correct in case a public transport operation is forced to renew some of its fleet regardless of public fund support.<sup>16)</sup> Calculating the variable costs of investment

<sup>15)</sup> Public transport in Prostějov, operational data, 16 March 2011.

<sup>16)</sup> Ostrava Public Transport Co. has declared the need to replace at least 160 vehicles over the coming 4 years.

in a CNG bus means a return on the extra costs of the CNG within 6 years thanks to the price being CZK 3.8 lower per kilometre on average.

The process is analogous for the diesel engine compliant with EURO V emission standard (annual costs of CZK 4,300,000), the trolley bus (CZK 11,000,000) and the electric bus (CZK 10,000,000). Given the applicable emission factors and the invested amounts, the abatement costs per tonne of PM are displayed in Table 7.

Measure	Annual mileage (km)	Engine emission factor (g/km)	Annual CO <sub>2</sub> eq. emission (t)	Emission reduction (t CO <sub>2</sub> eq./year)	Price increase	Abatement costs for CO <sub>2</sub> (in tonnes)
Reference scenario:						
Old bus (EURO II)	60,000	0.486	29.2			
CNG bus	60,000	0.066	4.0	27.2	4,300,000	12,508,743
Diesel bus (EURO V)	60,000	0.033	2.0	25.2	5,100,000	11,375,661
Electric bus	60,000	0.039	2.7	27.2	11,000,000	30,658,682
Trolley bus	60,000	0.045	2.3	25.2	10,000,000	21,825,396

*Table 7: Abatement costs per tonne of PM from transport*

*Source: own analysis*

However, the abatement costs of CZK 1,962,000 are only applicable to a situation where an entity is already going to purchase a diesel bus (the diesel engine being the reference scenario here) and a CNG drive is one of the alternatives. This calculation is not performed for other types of drives, since the reduction by several kilograms is offset by the extra cost of several million crowns, making the abatement costs per tonne of PM extremely high.

A comment must be made as to the fact that when analyzing the trolley bus investment, we did not consider the construction of new lines. Such investment would naturally further increase the already above-average abatement costs. The emission factors of the two electric motors assumed are obtained from the vehicle consumption (1.05g/km for the electric bus; 0.9g/km for the trolley bus) and the emission factor of electricity generation by ČEZ Group (0.043g/kWh in 2007). Theoretically, we might assume zero emissions and factually shift them to, say, the northern parts of the CR, but the emissions are considered as local given the existence of coal power plants in the MSR.

The calculation of the costs of the electric bus uses data from a pilot electric bus project in Ostrava. Given a daily route of 170km, the electric bus runs more than 60,000km a year, but the need to recharge it results in its operation being limited to peak hours; alternatively, multiple vehicles would have to be purchased for the same line, which would further dramatically increase the abatement costs.

The analysis shows affirmative results for investing in CNG buses and diesel buses; the results for trolley and electric buses are not favourable. The analysis makes a detailed description of the emissions due to combustion, but it should be noted that some of the PM emissions are generated by the wear of tyres and brake pads; secondary dustiness due to dust stirring also plays a great role. However, these emissions are not going to be reduced substantially whichever of the low-emission transport modes is chosen, meaning the analysis disregards them.

Another possible investment measure is the purchase of road sweepers and sprayers. The investment in a new automatic vehicle capable of intercepting PM<sub>10</sub> dust particles is approx. CZK 6,500,000 (Mercedes Benz Actros 1832). Its annual operation costs are CZK 3.3 million<sup>17)</sup>; but the additional road cleaning benefit is extremely difficult to quantify **místo poznámky 17 napsat (MMO, 2010)** the literature.<sup>18)</sup>

### **Transport: interlinkages between air and climate protection policies**

Within investment measures for the transport sector, we analyzed several methods of greening transport, namely purchasing new diesel (EURO 5) buses, CNG buses, electric buses, and trolley buses. These measures were compared to a reference situation, involving an elderly EURO II emission class bus. The results obtained clearly indicate that the most effective measure is to invest in CNG buses, followed by new EURO V diesel buses. Investing in electric and trolley buses is identified as less efficient; however, it is always necessary to interpret the analysis results in the context of the assumptions and comments made in the relevant chapters.

The Table 8 and Figure 13 make a summary comparison of the CO<sub>2</sub> and PM abatement costs of the above measures in the transport sector.

The trends in the PM and CO<sub>2</sub> emission abatement costs indicates that cost-effective CO<sub>2</sub> emission reduction measures are also cost-effective PM emission reduction measures. Both the policies are therefore synergetic, and unlike in the policies supporting measures in the household sector, there is no trade-off between the cost-effectiveness of the PM emission reduction policy and the CO<sub>2</sub> one. If the regulator had a free choice of any of the studied measures, they should go for those on the left in the order shown in the chart above. In practice, however, several circumstances significantly affect the preference for supporting certain measures. Examples may include restrictions on possible support of certain measures from public funds (public subsidies), targeting of current expenditure (subsidy) schemes, and regional dimensions of the environmental issues on which the policies focus.

<sup>17)</sup> ~~MMO, 2010: Konkrétní opatření k zlepšení kvality ovzduší na území statutárního města Ostravy.~~

<sup>18)</sup> ~~VŠCHT, 2005: Souhrnná metodika pro hodnocení emisí znečišťujících látek ze silniční dopravy.~~

Measure	Abatement costs per tonne	
	CO <sub>2</sub> [CZK]	PM [CZK thousand]
CNG bus	37,778	12,509
Diesel bus (EURO V)	23,889	11,376
Trolley bus	45,833	21,825
Ecodriving	896	8

Table 8: Comparison of abatement costs in transport  
Source: own analysis

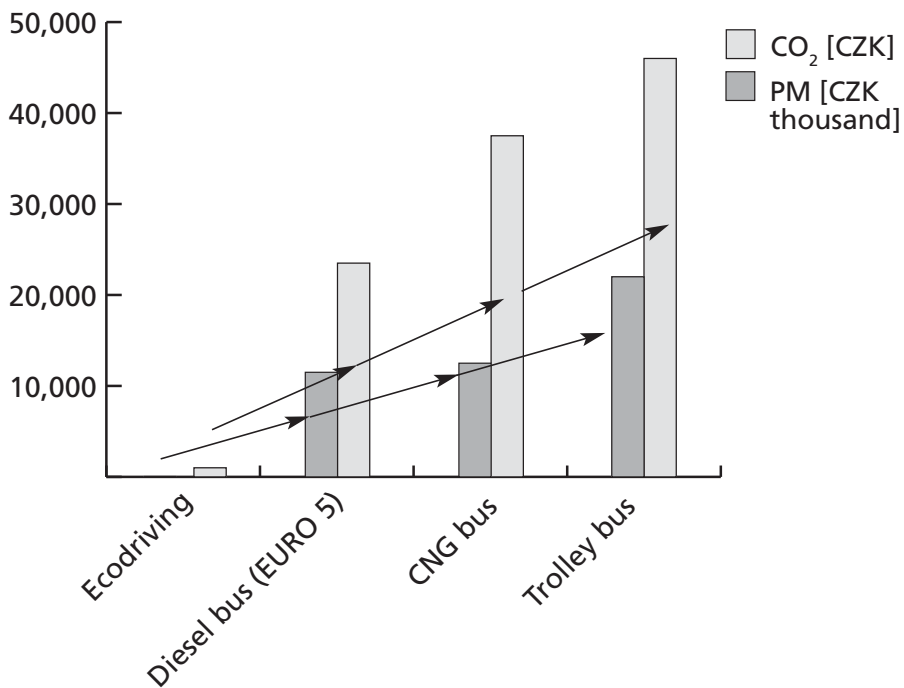


Figure 13: Comparison of CO<sub>2</sub> and PM abatement costs in transport  
Source: own analysis



## Conclusions

The present analysis uncovers some possible synergisms in climate and air protection policies with an energy saving potential. For the purposes of this paper, the analysis is restricted to greenhouse gases and particulate matter (PM); a comprehensive treatment should also include abatement costs for SO<sub>x</sub>, NO<sub>x</sub> and VOC emissions.

The selected measures within both the policies in the household and transport sectors are examined using the concept of so-called abatement costs, corresponding to the costs of reducing the emission of a given substance by 1 unit (here, a tonne).

Some of the current policies (such as The Green Savings for climate protection and the OPENV for air quality) indicate efforts to design them effectively in order to maximize their effect. Measures are then assigned priorities based on certain criteria, but they mostly fail to lead to the intended end. This chapter has attempted to demonstrate an approach which, if applied consistently, might lead to more effective policy design, thus considerable savings of funds in achieving the set goals.

The analysis has also pointed out that an isolated treatment of a single policy (e.g., air protection) does not allow exploitation of synergisms (air and climate protection policies, energy efficiency policy), where marginally higher abatement costs for one substance (such as CO<sub>2</sub>) are offset by a great difference in the abatement costs for another (e.g., PM). This fact was demonstrated in the paper on a sample of 7 measures in the household sector, where such synergisms were identified. An example of a specific recommendation resulting from the analysis is to prioritize measures subsidizing biomass boilers over the other measures examined, since the costs of reducing the PM emissions are comparable to those under the other measures, but the CO<sub>2</sub> emissions are reduced at less than 1/5 the cost.

An analogous analysis of a selected sample of measures in the transport sector showed that the abatement costs of the measures focusing on CO<sub>2</sub> emissions or PM emissions are proportionately either increasing or decreasing for all the measures. These two policies are therefore synergic by nature, and the regulator does not have to choose between cheaper PM emission reduction and more expensive CO<sub>2</sub> emission reduction or vice versa.

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## **Increasing the energy efficiency in the Czech Republic: subsidy schemes and their evaluation**

### **3.1**

#### **The importance of increasing energy efficiency**

Increasing energy efficiency is one of the main pillars of the European Union's energy policy and is referred to as one of the pillars of the Czech Republic's (CR) energy policy too. Energy efficiency is one of the principal building blocks and an indispensable component in ensuring the energy security of a country or territory.

The benefits of increasing energy efficiency are generally known. Besides lower nominal energy consumption and lower per-unit (and absolute) costs of energy, they frequently include better working environments, improved state of the environment (both locally and globally), and from the macroeconomic perspective, job creation, reduced dependence on imports, and more (see, e.g., IPCC 2007 for more details). (see, e.g., IPCC, 2007 for more details)

Goals related directly to energy efficiency are set at both the European and international levels. At the international level, these are mostly goals resulting from the Kyoto Protocol; the most notable package at the European level is the Climate-Energy Package, including the so-called 20-20-20 target until 2020, specifying, among other things, a goal to increase the energy efficiency by 20% by 2020<sup>19</sup>). The Energy Services Directive (2006/32/EC) also includes an indicative target of 9% energy savings by 2016, and the CR has committed itself to achieving a 13% share of renewable energy sources (RES) in its gross final energy consumption by 2020.

These goals are based on the generally accepted assumption that there is an economically effective and currently unexploited potential for savings (e.g., IPCC 2001, Sorrell et al. 2004, Schleich and Gruber 2008). The estimated size of

(IPCC, 2001, Sorrell et al., 2004, Schleich et Gruber, 2008)

<sup>19</sup> For more on the climate-energy package, see the European Commission website [http://ec.europa.eu/clima/policies/package/index\\_en.htm](http://ec.europa.eu/clima/policies/package/index_en.htm).

the potential is 20–30%. However, its exploitation is precluded by the existence of barriers to energy efficiency, including especially the price of energy (too low) and the price of technologies (too high), lack of information and the related insufficient ability to evaluate it correctly, wrong risk appraisal, thus discounting, and impaired access to capital.

Above all, various subsidy schemes, currently an important incentive for increasing energy efficiency in both public and private organizations and households in the Czech Republic, are an attempt at dealing with the latter barrier.

This paper therefore describes the two principal operational programmes (their components in fact) focusing on support to energy efficiency, their benefits so far and an evaluation of their effectiveness.

## 3.2

### The importance of increasing energy efficiency

The Czech Republic has EUR 26.69 billion (approx. CZK 654 billion) available from the Structural Funds and the Cohesion Fund in the current programming period (2007–2013)<sup>20)</sup>. To help you make a picture, it is about half the expenditures of the CR's national budget in 2011.

The Table 9 presents an overview of operational programmes focusing on supporting energy efficiency.

As one can see in the table, the Operational Programme Enterprise and Innovations (OPEI), Priority axis 3 (ECO ENERGY programme) and the Operational Programme Environment (OPE), Priority axis 3 (Sustainable energy uses) are the most important in respect of supporting energy savings. The following section will therefore deal with these two programmes.

### 3.2.1

#### OPE, Priority axis 3: Sustainable energy uses

The primary objective of the OPE is to “improve the environmental quality as the fundamental principle of sustainable development” (MoE 2008). (MoE, 2008) cific goals relating to energy efficiency is the utilization of renewable energy sources and energy savings.

Within the total OPE allocation, less than 14% is allocated to Priority axis 3. The total amount of resources for this Priority axis is therefore EUR 792 million for the entire programming period 2007–2013. Within that, EUR 673 million is a contribution by the European Union and EUR 119 million comes from

<sup>20)</sup> See, e.g., [www.strukturalni-fondy.cz](http://www.strukturalni-fondy.cz) for more about the Structural Fund system in the Czech Republic.

national sources. The national sources for Priority axis 3 are the State Environmental Fund (SEF; one third) and public sources (two thirds). Public sources refer to the public budgets of the support beneficiaries (public service entities as eligible applicants).

The supported activities and measures include principally:

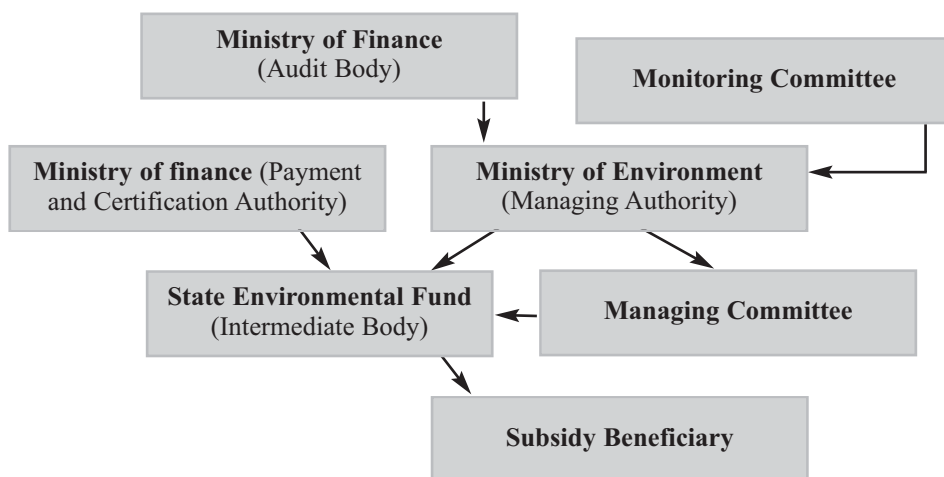
- use of renewable energy sources in power and heat generation;
- development of combined heat and power production;
- reducing energy consumption by improving the thermal and technical properties of building envelopes; and
- reuse of waste heat.

Programme	Measures supported	Applicants	Total allocation (CZK million/year)	Notes
<b>OPEI, Priority axis 3</b>	Savings RES	Private businesses	1,493	EUR 418,000,000 for 2007–2013
<b>OPE, Priority axis 3</b>	Savings RES	Public entities	2,828	EUR 792,000,000 for 2007–2013
<b>IOP, 5.2b</b>	Revitalization	Owners of residential and non-residential spaces	225	EUR 63,000,000 for 2007–2013
<b>Rural development programme, Axis III.1.1.</b>	RES	Agricultural businesses	1,057	EUR 296,000,000 for 2007–2013

Table 9: Overview of programmes supporting energy efficiency in the CR (2011)

Source: Implementation documents of the programmes, available e.g. at [www.strukturalni-fondy.cz](http://www.strukturalni-fondy.cz)

A simplified structure of the OPE procedure is shown below:



As obvious from the list of subsidy beneficiaries, updated as of 18 July 2011, most of the subsidy beneficiaries under OPE Priority axis 3 are municipalities of towns and villages, regional governments and their allowance organizations. These four types of organizations combined make up 92% of all the beneficiaries under this axis so far (Figure 14).

### 3.2.2 OPEI-ECO ENERGY Programme

The global objective of the OPEI is to increase “the competitiveness of the Czech Republic’s economy and bring the innovative performance of the industry and service sectors closer to that of leading European industrialized countries” (MoIT 2010). (MoIT, 2010) relating to energy use efficiency is to “increase the efficiency of energy uses in industry and utilization of renewable and secondary energy sources (except support to incinerators)” (MoIT 2010). (MoIT, 2010)

Within the total OPEI allocation, less than 12% is allocated for Priority axis 3. The total amount of resources for this axis is thus EUR 418 million for the period 2007–2013. Within that, EUR 355 million is a contribution by the European Union (85%) and 63 million comes from national sources<sup>21)</sup>. The assumption is that about one half of these resources should be divided among projects to increase energy efficiency and energy savings, and the other half among renewable energy projects.

<sup>21)</sup> The initially planned allocation for this Priority axis was EUR 143 million, but the massive demand of applicants under calls I and II resulted in increasing the allocation to EUR 418 million at present (SEVEN 2010).



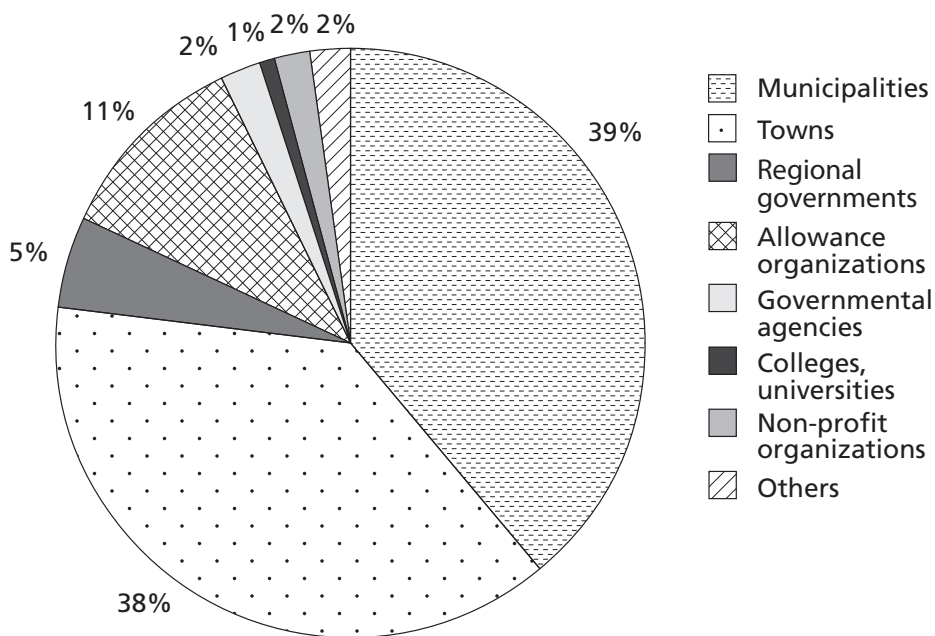


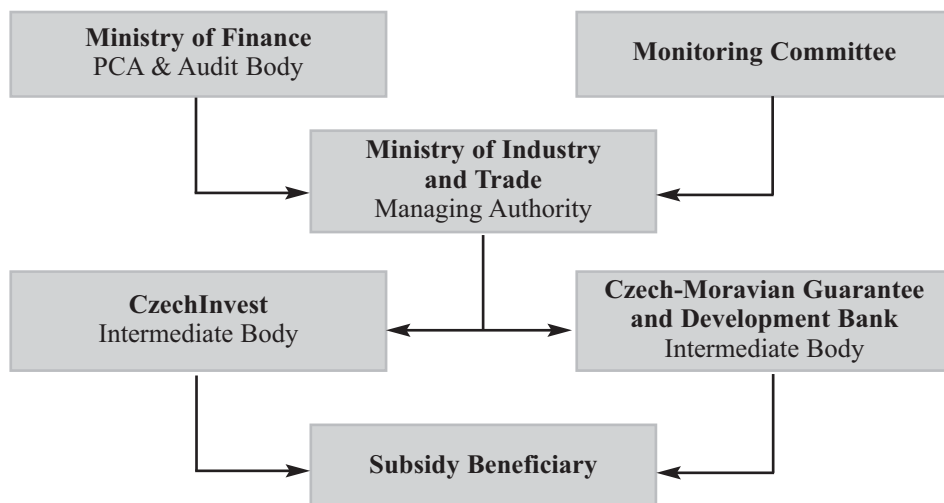
Figure 14: Structure of support beneficiaries under OPE Priority axis 3

Source: Based on data from [www.opzp.cz](http://www.opzp.cz), adapted by the authors

Priority axis 3 “Efficient energy” is implemented by means of the ECO ENERGY programme. Especially measures related to the following are supported under this programme:

- utilization of renewable and secondary energy sources except photovoltaic, geothermal and wind power plants; and
- increasing efficiency of energy production and consumption, and reuse of secondary sources of energy.

A simplified structure of the OPEI procedure is shown below:



The eligible applicant in the ECO ENERGY programme are, above all, small and medium-sized businesses except those in excluded domains such as fishery, agriculture, coal and steel industry. Most often the applicants are limited companies (52% of the applicants) and joint-stock companies (37%). The remaining 11% is mostly made of natural persons doing trades. The average size of approved subsidy is CZK 10 million to limited companies, CZK 15 million to joint-stock companies, and under CZK 3 million to the others. Overall, about three-quarters of the projects are in the energy savings category and one-quarter is in the renewable energy sources category.

Three calls have been made under the ECO ENERGY programme so far; a fourth call is in the pipeline.

### 3.3

#### The importance of increasing energy efficiency<sup>22)</sup>

In the operational programmes, just as in general public expenditure schemes, not only is their setting and administration crucial but also their correct evaluation and monitoring, that is, assessment of the programme benefits.

This section summarizes an ex-ante assessment of the benefits of the subsidy programmes described above, based on the expected benefits of the projects already implemented or very likely to be implemented.

<sup>22)</sup> Calculations in this chapter were published in Valentová, Honzík 2011.

(It turns out there is a great difference between the number of projects approved and the number of projects actually implemented. To give a picture, 508 full applications were admitted under the second call of the ECO ENERGY programme, support to 408 projects was approved, and only 352 projects have been or are going to be implemented.)

### 3.3.1

#### Ex-ante evaluation of OPE, Priority axis 3

According to the SEF, subsidy agreements had been signed 1,130 projects by October 2011. Within those, 63 projects were in subsidy chapter 3.1 “RES”, 87 were in subsidy chapters 3.1 and 3.2 “combined thermal insulation and RES”, and by far the most, 980 projects, were in chapter 3.2 “thermal insulation”.

The Table 10 shows the expected benefits in the most prevalent area of support, being thermal insulation of buildings.

No. of projects	Energy saving [GJ/year]	Costs [CZK thousand]	Subsidy from SF [CZK thousand]	SEF cofinancing [CZK thousand]	Subsidy share in INV [%]	CO <sub>2</sub> emission reduction [t/year]	Total insulated area [m <sup>2</sup> ]
980	827,869	11,372,828	6,174,193	349,888	57.37%	65,853	3,640,717

*Table 10: Priority axis 3.2–Energy saving implementations in the non-business sphere (subsidy agreements signed)*

The implementation of all the above projects should result in a total annual final energy consumption reduction of about 915TJ. This corresponds to about 1.2% of the indicative savings target based on the CR’s first National Energy Efficiency Action Plan (NEEAP) pursuant to Directive 2006/32/EC.

The implementation of the projects of heat production from RES should result in an annual increase in gross heat production from RES by about 85,257GJ.

### 3.3.2

#### Ex-ante evaluation of the ECO ENERGY programme

This section recapitulates the expected benefits of the ECO ENERGY programme with respect to the ex-ante evaluation of benefits of calls I and II.

The national indicative target in energy savings for 2016, based on the CR's first NEEAP, is approx. 71,431TJ/year off the total final energy consumption (FEC)<sup>23)</sup>.

In total, we evaluated 352 projects under call II, which were supported with total investment subsidies of approx. CZK 4.1 billion, and 96 projects under Call I, supported with total investment subsidies of approx. CZK 1.2 billion.

The implementation of the above projects should result in an annual FEC reduction of approx. 3472TJ. Within that, an annual reduction of at least approx. 2,385TJ comply with the FEC reduction pursuant to Directive 2006/32/EC based on our expert estimate. The reduction corresponds to approx. 3.3% of the indicative savings target based on the CR's first NEEAP.

The implementation of the projects of electricity production from RES should result in an increase in the installed RES power capacity by about 107MW, and a related increase in the annual gross electricity production from RES by about 674GWh. According to MoIT statistics, the annual gross electricity production from RES was 3897 GWh in 2009. This production made up 6.79% of the gross electricity consumption in the CR in 2009. This means that the implementation of these projects might result increase in the gross electricity production from RES by about 17.3%.

The implementation of the CHP and biomass heating plant projects should result in an increase in the annual gross heat production from RES by approx. 924TJ.

This ex-ante evaluation does not take into account changes in the binding indicators for projects subjected to change procedures. The ex-ante evaluation of these projects is made based on the binding indicators of energy savings and energy production from RES using which the projects were evaluated under the respective calls.

The Table 11 shows a comparison of the overall results of the ex-ante evaluation for calls I and II with the indicator targets under ECO ENERGY according to the OPEI implementation document.

It follows from the table above that the implementation of the ECO ENERGY programme should essentially satisfy the targets set by the OPEI implementation document, 2010 version.

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<sup>23)</sup> Based on the said Directive, defined excluding consumption in facilities falling under the EU ETS and energy consumption by armed forces.

Indicator	Based on ex-ante evaluation for calls I and II	Targets (2015)*
Installed capacity–RES (MW)	107	180
Energy saving (TJ)	3,472	8,000
Electricity production from RES (GWh)	674	1,100
Heat production from RES (TJ)	924	1,200

\* Source: Ptáček 2011

*Table 11: Comparison of the overall results of the ex-ante evaluation for calls I and II with the indicator targets under ECO ENERGY*

### 3.3.3

#### Ex-ante evaluation of OPE, Priority axis 3<sup>24)</sup>

Nevertheless, it is not enough in order to evaluate the effectiveness of the programmes to compare the expected benefits with the expended subsidy. To compare the overall effectiveness, one also has to watch the so-called transaction costs of these programmes. In other words, these are the costs of their managing bodies administering the subsidy programmes and the induced costs to the subsidy applicants and beneficiaries.

As indicated in studies dealing with these issues abroad, the transaction costs of (subsidy) programmes supporting energy efficiency are of a non-negligible scale: between 10% and 40% of the total project or subsidy amount depending on the programme type (Valentová, Knápek 2010). (Valentová et Knápek, 2010) directly comparable as they differ in both the purpose of the programmes and their measurement methods.

Induced costs to the subsidy beneficiaries are chiefly associated with searching for and evaluating the programme information, developing the applications, agreement negotiations, implementation of measures (and the related organization of tenders), payment applications, monitoring and evaluation.

Based on a survey among subsidy beneficiaries under the above programmes (OPEI ECO ENERGY programme and OPENV Priority axis 3), Valentová and Honzík (2011) conclude that the average induced costs to the applicants are between 8% and 12%, the minimum being around 1% and the maximum being 52%. The Table 12 shows more detailed results.

<sup>24)</sup> See Valentová and Honzík (2011). See Valentová et Honzík (2011) of selected programmes supporting energy efficiency.

Programme	Average	Median	Minimum	Maximum
OPEI, ECO ENERGY	12 %	10 %	1 %	52 %
OPE, PA 3	8 %	6 %	0.2 %	30 %

*Table 12: Induced costs of OPEI and OPE*

To interpret the above figures, CZK 100 of subsidy granted under OPE Priority axis 3, and the OPEI ECO ENERGY programme, respectively, entails CZK 8 and CZK 12 of induced costs respectively on average. Developing the application and organizing the tender are the most demanding parts of the administration of a supported project from the subsidy beneficiary's point of view.

It is important to note that the above data only include information from successful subsidy beneficiaries. Additional induced costs are associated with applications by failed applicants. For example, up to 50% of the applicants to OPE Priority axis 3 fail (SEF 2010).

(SEF, 2010)

The administrative costs are identical, to some extent, to the costs of technical assistance under the programmes. Each of the operating programmes has a priority axis called Technical assistance, reserved for costs associated with the management and administration of the programme. The technical assistance is therefore mostly intended to ensure effective programme administration from development to implementation, monitoring and evaluation of the programme activities, as well as to pay for any studies, promote information dissemination and publicity for the programme.

The Table 13 shows the proportions of technical assistance in the OPEI and OPE. It follows that the technical assistance is about 3% of the programme allocation or allocation to support specific projects.

The expenditures on this Priority axis therefore match (albeit not exactly) the administrative costs of the operational programme. The costs do not include the expenditures of the entire administrative system: they exclude, e.g., the expenditures by the Ministry of Finance, being the disbursement and certification body, and the costs of developing the programme at both the national and European levels.

Programme	Technical assistance (% of total allocation)	Technical assistance (% of allocation to support the projects)*
OPEI	2.93 %	3.02 %
OPE	2.91 %	2.99 %

\* For the OPE, this is the share in the allocation for Priority axes 1–7; for the OPEI, this is the share in the allocation for Priority axes 1–6.

\* For the OPE, this is the share in the allocation for Priority axes 1–7; for the OPEI, this is the share in the allocation for Priority axes 1–6.

Table 13: Technical assistance in the OPEI and OPE

Source: Valentová, Honzík 2011

Valentová et Honzík, 2011

### 3.4 Other energy saving options

The above programmes make it possible to implement relatively investment-intensive measures such as thermal insulation of buildings. There are, however, also other ways of achieving energy savings.

Energy Performance Contracting (EPC) can be a suitable supplement to the above thermal insulation of building envelopes in selected cases. The basic principle of EPC is that the efficiency measures are paid for with the money saved.<sup>25)</sup>

The most common type of measures for which EPC is used is refurbishment of the building's energy system (metering and control, refurbishment of the heating system, air-conditioning and ventilation units, etc.). Savings achieved by optimizing the energy system can then be combined with savings achieved by giving the building thermal insulation, funded from subsidy programmes.

Not all energy efficiency measures are associated with (high) initial investment, though. Significant savings without (noticeable) reduction in the energy service comfort can be achieved using numerous cost-free measures, such as optimization and correct setting of the energy system, metering and control. A simple example may include setting the right temperature for water heating, reducing the temperature in unused rooms and reducing lighting where not necessary. As for electrical appliances, it is often sufficient to follow the manufacturers' instructions concerning their proper placement and operation.

<sup>25)</sup> See, e.g., [www.epc-ec.cz](http://www.epc-ec.cz) and [www.european-energy-service-initiative.net/cs](http://www.european-energy-service-initiative.net/cs) for more information about EPC.

Simple, low-cost measures with a very fast return on investment include investing in energy-efficient lighting in both the business sector and households. Replacing a conventional light bulb with a quality compact fluorescent lamp (commonly known as an “energy-saving bulb”) yields a rate of return of under six months with an average of three hours of lighting a day; the useful life of this lamp (with that amount of lighting) is six to ten years (or even more).

Another way to conserve energy, especially in the household, is to replace old electrical appliances with new, energy-efficient one. The energy demand of some appliances has gone down to one half to one third over the last ten or fifteen years (Valentová, Krivošík 2011). **Valentová et Krivošík, 2011**

Standby power consumption: 10–15% of a household’s electricity consumption (Valentová 2009). **Valentová, 2009** Electronics (televisions and accessories, such as DVD recorders, amplifiers, gaming consoles and hi-fi sets) and office equipment (computers and accessories, such as printers, speakers, monitors, routers and modems) are the appliance categories with the greatest power demand in the standby mode. One way to reduce the standby consumption is to use extension cords (power socket bars) with a switch. This one switch can turn off all the appliances connected, thus bringing the standby consumption to zero.

Master-slave cables are a more sophisticated solution: they look like normal extension cords but any connecting appliances (e.g., a printer, monitor, or DVD player) are turned off and on automatically with the main appliance (PC, TV).

## Conclusion

The cheapest energy is the one that is not consumed. Increasing energy efficiency is a significant component of national, European and international energy policies.

The economic potential of savings is up to 20–30% of total energy consumption. Continuing barriers such as lack of information, poor access to capital, etc., cause this potential to remain largely unexploited.

Subsidy programmes, funded mostly through European funds, are an important tool for supporting energy efficiency in the CR. However, for these programmes to function well, it is extremely important to monitor and evaluate their benefits and costs continuously.

The evaluation should encompass the expected benefits of the programmes (e.g., converted to CO<sub>2</sub> emission reduction) and allocated subsidy as well as the so-called transaction costs of these programmes, i.e., the administrative costs and the induced costs to the beneficiaries and applicants.

A survey among beneficiaries of subsidies from the OPE and OPEI showed that their average induced costs are an additional 8–12% of the subsidy granted; the administrative costs are more than 3% of the support granted. These figures ought to be made complete by adding the costs incurred by failed applicants.



Last but not least, considerable energy savings can be achieved cost-free, such as by slightly altering the system settings or one's behaviour, in addition to investment-intensive measures.

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## **Comprehensive economic evaluation of support to energy savings projects**

The objective of this chapter is to formulate requirements on correct economic evaluation of support to energy savings projects from public funds. The evaluation as practised at present shows certain inconsistencies; it is by far not comprehensive evaluation. The paper is based on the author's research and points out problematic aspects of the economic evaluation, and presents suggestions to include additional indicators in the evaluation in order to improve its comprehensiveness.

### **4.1 Energy savings and energy policy**

The proportion of energy savings in energy policy has been increasing radically in the world and in the Czech Republic in the recent years. Specific types of energy savings (apartment buildings, single-family houses, public institution buildings, other entities) have led to various requirements on the amount of support. It must also be kept in mind that the primary purpose of investment in energy savings is to achieve socially and politically desired effects rather than actual electricity or heat savings. In order to achieve systemic goals (e.g., reduced CO<sub>2</sub> emissions), multiple strategies at the system decision-making level can be employed. Starting from the premise that we do not assume a radical change in the Czech Republic's economic structure (and GDP generation structure), the following competitions arise in these potential strategies:

- among savings types and focuses;
- among the entities that implement the savings;
- among the savings implementation techniques; and
- between energy savings and renewable energy sources (RES).

The different types of savings, different techniques for their implementation, and different entities implementing them—as well as the different possible investment in renewable energy sources—generally result in differing requirements on

support. The different projects have different lifetimes, different investment and operating costs, as well as different outcomes in the form of savings and different induced costs to different categories of entities.

Finding an optimum strategy for developing and supporting savings at a system level must respect all the systemic consequences of supporting a specific type of savings project (technique, application) and, above all, the economic cost effectiveness of the support.

## 4.2 Ex-ante evaluation of investments into energy savings projects

Research work and our own analysis of the current situation in supporting energy savings from public budgets conclude rather unambiguously that the current system of support to savings projects is too complicated and problematic and has clearly not resulted in an economically rational and consistent meeting of the target, set in all the current international and strategic documents among other places. The public image of support to energy savings has suffered serious damage in the recent months due to the reports on the combined impacts of support to RES amounting to billions of CZK over a period of 15 years and the reports on the MoE and SEF “Green Savings” scheme. The situation obviously has to be changed, which is only feasible—realistically speaking—by means of making all the forms of support to savings projects in the CR more effective and simpler.

Starting from the basic economic assumption of limited or precious economic resources, then formulating the methodology may start with an analogy with optimization of choice among investment alternatives (by a business entity), respecting the limited nature of investment resources. The analogy of the limited nature of investment resources of a private entity is the limited nature or set limit on the total direct and indirect expenditures on support to savings from public budgets.

The exercise is then defined as:

$$\begin{aligned} \sum_{i=1}^n NPV_i &= MAX \\ \sum_{i=1}^n C_i &\leq C_{lim} \end{aligned} \tag{1}$$

Where:

i            i-th project within possible project portfolio among which the investor chooses

$NPV_i$     net present value of the i-th project

n	total number of projects in the project portfolio
$C_i$	investment costs of the i-th project
$C_{lim}$	investment cost limit

The exercise can be formulated as an analogy to maximizing the effect of application of limited investment resources, i.e., modification to the basic formula (1).

However, not only do private entities (investors) strive for effective capital allocation. An identical attitude should be assumed by entities that grant subsidies for achievement of specified goals or effects. In this case, the desired effect is not maximization of the NPV of the investment implemented, but maximization of the effect(s) for which savings projects (and, analogously, renewable energy source utilization projects) are implemented. The effects of these projects exist throughout the lifetime of the projects just as the cash flows (CF) exist in the basic exercise of maximizing the NPV. Redefinition of basic task (see formula 1) results in substitution of NPVi (present value of i project) with the new component  $E\_PV_i$  which is a sum of the effect of the i-th project implemented throughout its lifetime.

The limiting factor used in the basic exercise according to formula (1) was the investment cost limit as of the period in question in which the decisions on implementing investment projects within a project portfolio offered are made. The decision-making period in standard investment decision-making of business entities is one year as a rule. Nevertheless, the decision-making period can be generalized and defined as a period to which the limit condition applies, allowing us to work with time frames longer than one year. We only have to consistently discount all the model components (effects, support expenditures) to the same moment in time.

An optimum strategy (i.e., maximization of desired effect while considering the limited nature of the support funds) is then achieved by choosing projects (i.e., inclusion of projects in the preferred project portfolio when formulating the national-level system strategy) based on their nominal effectiveness, ranking them from the highest nominal effectiveness to the lowest.

The total sum of support,  $CP\_PV_i$ , can be expressed in present value using the following formula:

$$\begin{aligned}
 CP\_PV_i = & IP_i + \sum_{t=1}^{T_p} PP_{t,id} \cdot (1+r_d) + \sum_{t=1}^{T_p} PP_{t,ip} \cdot (1+r_p) + \sum_{t=1}^{T_p} PP_{t,ivs} \cdot (1+r_{vs}) + \\
 & + \sum_{t=1}^{T_p} PCF_{t,i} \cdot (1+r_{vs}) + \sum_{t=1}^{T_p} NP_{t,i} \cdot (1+r_p)
 \end{aligned} \quad (2)$$

Where:

$r_d$	discount-price of money for households
$r_p$	discount-price of money for business entities
$r_{vs}$	discount-price of money for the public sector

- $IP_i$  investment support provided to the  $i$ -th project type [CZK]  
 $PP_{t,id}$  operating support to the  $i$ -th project type in the  $t$ -th year of the comparison period to the debit of households  
 $PP_{t,ivs}$  operating support to the  $i$ -th project type in the  $t$ -th year of the comparison period to the debit of the public sector  
 $PP_{t,ip}$  operating support to the  $i$ -th project type in the  $t$ -th year of the comparison period to the debit of business entities  
 $PCF_{t,i}$  support to the cash flow of the  $i$ -th project type in the  $t$ -th year of the comparison period (e.g., support by means of tax reliefs and exemptions)  
 $NP_{t,i}$  indirect support to the  $i$ -th project type in the  $t$ -th year of the comparison period (e.g., support to science, research and development)

The fundamental methodological starting points are as follows:

- choice of one effect as the primary effect;
- respecting the complementarity principle;
- respecting all the project requirements;
- respecting the transaction costs to involved entities;
- respecting all the funding sources;
- inclusion of the time factor.

I will now deal with the so-called transaction costs of support to energy savings projects from public funds.

### 4.3 Transaction costs of energy savings projects

Transaction costs are a category associated with institutional economics; some authors define these costs as the “costs of running (functioning) of the economic system”. Another way to define transaction costs is to associate them with the implementation of a transaction (project) besides the actual operating (production) costs. All the authors dealing with transaction costs agree on the conclusion that “a transaction (project) would not be executed without transaction costs and, conversely, no transaction costs should be incurred without a transaction (project)”.

The literature indicates rather clearly that transaction costs have a more substantial proportion in smaller projects (compared to the total project costs) and in institutions whose mission is to support a greater quantity of heterogeneous projects (such as governmental extra-budgetary funds).

Relatively significant costs have had to be expended by both the support applicant (e.g., energy audit, choice of contractors, time consumption, etc.) and the

support provider—the State Environmental Fund—in projects supported by the SEF under the “Green Savings” scheme, for instance. The increase in the costs of the Fund Office (numbers of employees in the unit specialized on Green Savings) is evident.<sup>26)</sup>

- Transaction costs can be further divided into implicit (project preparation, time spent by involved persons, etc.), and explicit (concrete costs of, e.g., the energy audit or technical assistance).
- Explicit transaction costs include, among others, costs of energy audits and expert position papers; typical implicit costs include capacities (expressed both financially and in kind) expended to prepare the programme or complete the forms.

Time is another aspect for dividing transaction costs: speaking of transaction costs in relation to support programmes, we distinguish between transaction costs in the support programme preparatory stage, implementation stage, and subsequent review of fund utilization (review of adherence to project conditions).

Ex-ante costs are transaction costs expended during the project preparation and implementation; ex-post costs are costs after the termination of the investment programme associated with subsequent inspection (support provider) and costs of ensuring so-called sustainability of the outcomes of the supported project (support beneficiary).

Considerable transaction costs are also incurred by changing external conditions for the support provision, and costs of any arbitration proceedings; arbitration is typically sought by applicants who have not been able to utilize the support in its initially expected amount and form; the state, being the guarantor of the support schemes announced, is typically the accused.

Moreover, transaction costs have to be expended by both the support provider and its beneficiary. Existing methodologies and expert papers only include transaction costs partially or only on one side (support beneficiary as a rule), yet it is clear that a truly systemic approach (a comprehensive perspective of support effectiveness) requires the inclusion of all the costs (requirements) of the support, with the complete costs to the support beneficiary and provider.

It is therefore obvious that transaction costs are objectively incurred by both the support provider and the support beneficiary, while their distribution (i.e., proportion of transaction costs to the provider to their proportion to the beneficiary) is and will be different in place and time, from programme to programme, from project to project. In any case, a systemic approach to formulating a methodology for evaluating the effectiveness of projects should include transaction costs, or an estimate of them in extreme cases, in the evaluation methodology (especially when comparing the effectiveness of different support schemes).

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<sup>26)</sup> According to official (press) information from the SEF Office, the Office employed about 60 employees to administrate the Green Savings programme on average in 2010.

Specific aspects of transaction costs seen comprehensively and included in the methodology are arbitration costs as mentioned above and transaction costs of multi-source support (e.g., concurrent support with subsidies under different operational programmes (EU SF), where the adherence to all the requirements, which may often be inconsistent across the programmes, has to be checked both during and after implementation). If multi-source funding is not excluded under the support scheme in question, then it should be reasonable to set the total support amount in a way that public funds are not expended ineffectively. This concept of support and the related inspection work then incur more transaction costs.

#### 4.4 Support to savings in the form of subsidies

Subsidy schemes are announced by a public service authority (state, region, municipality, state fund) and subsidies are funded under public expenditures. As a rule, subsidies are executed as part of subsidy schemes (such as the State Energy Savings and Renewable Energy Sources Programme). A *subsidy provider* has to notably/at least ensure the correct announcement of the scheme tender, appoint a committee for opening the envelopes, exclude applications that do not conform to the prerequisites, appoint the Scheme Council, which is responsible for the choice (evaluation) of projects to receive subsidies under the scheme. In addition, it has to develop legally correct contracts on the provision of a subsidy for a project, perform due financial and factual inspection, and organize interim and final review procedures. It also has to organize the proper disbursement of the subsidy advances, review the final accounts, and pay the costs of the selected project up to the contractual subsidy amount. First and foremost, a *subsidy beneficiary* has to monitor public tenders announced in which it can participate, prepare a tender bid (to make sure its project receives a subsidy), and furnish it with all the prerequisites for the tender. If it is awarded the subsidy, it has to negotiate the legal conditions for the provision of the subsidy, keep accounts of the subsidy funds, typically separately from the other funds in its accounts. It has to write interim project implementation reports, participate in discussing them, and write a final project report and final accounts and quantify the project outcomes upon its conclusion. Outcomes of a projects for which a subsidy was granted often have to be treated in a specific way (again generating extra costs).

The activities described above are a mere enumeration, but they indicate the fact that they generate costs which fit the definition of transaction costs.

A mere simple estimate after allocating minimum hourly rates for the activities described above shows that these costs are by no means negligible or marginal.

It is clear that transaction costs are generated in all forms of support to energy savings project regardless of the actual source or method of the support.



Specifically, we need to point out that:

- The requirements of evaluated projects on both the provider and the beneficiary are increased by the transaction costs, which differ across types of support mechanisms.
- Transaction costs may represent a very significant portion of the total costs, yet they are not included in the evaluation according to existing methodologies, or they are not included correctly.
- Different mechanisms of support to energy savings projects clearly entail very different transaction costs, which should be reflected particularly when selecting and optimizing the support system at the national level.
- As concerns the correct inclusion of transaction costs in the effectiveness criteria, a distinction has to be made among the types of transaction costs: transaction costs in the public sector have to consider a different discount level (public sector discount) from that for the private sector.
- Quantification of transaction costs is a specific issue; often they are not expressed in monetary terms, which tends to result in their factual absence from correct economic evaluation.
- A number of compact expert studies deal with transaction costs and their quantification; I see the estimate of the average share of transaction costs in the total project costs as important: according to Valentová and Knápek (2011), in different countries, programmes and projects, the average transaction costs in energy savings projects are 8–40% of the total project costs.

Based on a survey among beneficiaries of subsidies under the OPEI ECO-ENERGY programme and OPENV Priority axis 3, Valentová and Honzík (2011) state that the average induced costs to applicants are 8–12%, with the minimum being about 1% and the maximum at 52%.

## Conclusion

The objective of the paper was to point out deficiencies in the current economic evaluation of energy savings projects, and suggest procedures and indicators to improve the comprehensiveness of this economic evaluation. The paper is based on the author's own research (Geuss, 2011) and discusses recommended measures focusing on the overall consistence of the economic evaluation methodology. Special attention is paid to so-called transaction costs and the importance and purpose of their inclusion in comprehensive economic evaluation.

We can summarize that such a consistent methodology for economic evaluation of energy savings products should be implemented in all of the following steps:

- Investment support
- Operating support

- Cash flow support
- Indirect support
- Expenditures on system administration
- Expenditures of third parties

The concrete outcomes of the outlined methodological module could then be practical applied as follows, for example:

- evaluation of effectiveness of support to different project types;
- evaluation of effectiveness of support to different savings types (electricity, heat, etc.);
- evaluation of effectiveness of support to energy savings in relation to support to RES.

In general, we must highlight the crucial need to employ consistent economic evaluation of all types of projects supported from public budgets, including all types of energy savings projects.

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## Effective policies to reach the 20-20-20 target: biomass use for energy purposes in the Czech Republic

### 5.1 Introduction

The Climate-Energy Package, adopted in 2009, sets out the so-called 20-20-20 targets to be reached by the European Union until 2020. Taking a closer look at the targets, 20% of the green house gas (GHG) emissions should be saved by 2020, the share of renewable energy sources (RES) in final energy consumption is to increase to 20% and energy efficiency should increase by 20% by the same year.

Binding targets at the member state level have been set for RES<sup>27)</sup>; the Czech Republic is bound to have a 13% share of RES in final energy consumption by 2020. Indicative targets for energy efficiency have been set as well: 9% savings of final energy consumption by 2016, and a new energy efficiency directive is in the final stage of preparation.

However, such ambitious targets require a significant pool of financial resources, which mostly come from public sources (either national or European, such as Structural and Cohesion Funds).

Large-scale support schemes have been developed in the Czech Republic to achieve the above targets. Yet, the support is often not systemic and therefore ineffective, in the sense that the distribution of the (limited) financial resources may not lead to maximized effects and vice versa, it is likely, that the targets (RES development, energy savings, GHG emissions) might be reached at lower system costs.

The paper therefore outlines an approach to setting effective support schemes that will reach the targets effectively. The systemic approach is presented on a case study of the main renewable energy source in the Czech Republic: the biomass; however, it can be easily applied to either of the other policies, i.e., energy savings and GHG emissions.

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<sup>27)</sup> Through Directive 2009/28/EC on the promotion of the use of energy from renewable sources.

The structure of the paper is as follows: First, the paper analyses how the goals set for development of renewable energy sources (and specifically biomass) are reflected in the strategic documents of the Czech Republic. Next, we analyse the current status of energy production of RES, with a focus on biomass, and provide an overview of the current status of support schemes for biomass. Finally, we outline the general approach to developing an optimized and coherent support system for RES that ensures that the above goals are achieved effectively. Conclusions also pertaining to energy savings and GHG emission policies are drawn.

## 5.2

### **Current status of biomass use for energy purposes in the Czech Republic**

Looking at the structure of primary energy from RES in the Czech Republic (CR), it is evident that biomass is the key source with a total share of 87% (Figure 15). The main contributors within the biomass category are households (chiefly consumption of firewood); the second largest is biomass production excluding households, which covers mainly heat production in district heating and industrial facilities, but also electricity generation.

Figure 16 presents the detailed structure of electricity generation in the Czech Republic. It clearly shows that despite the rapid development of biomass use, currently only 2.5% of electricity in the CR is generated from biomass. Most of this electricity is generated from solid biomass (mainly dendromass and waste); biogas stations only contribute 0.6% to the total gross electricity generation.

Biomass utilization (both burning of solid biomass and biomass processing in biogas stations) for power generation has played an increasingly important role in recent years (Figure 17).

Intentionally planted biomass currently plays a less important role in power generation compared to other kinds of biomass (Figure 18). Agricultural land is preferably used (speaking about energy utilization) to produce inputs into biogas stations (chiefly fresh maize) and not to produce solid biomass for direct burning or for solid biofuel production.

The last category of biomass use for energy purposes is biofuel production. A total of 184,188 tonnes of FAME (fatty acid methyl ester) and 69,038 tonnes of bioethanol were consumed in the Czech Republic in 2010. The consumption stems from the minimum required share of biofuels in motor fuels.

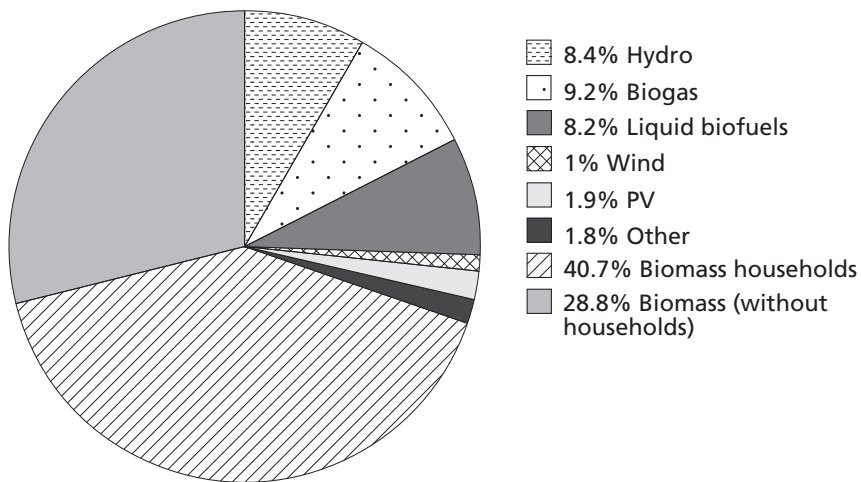


Figure 15: Total energy from RES in the CR in 2010

Source: MPO, 2011

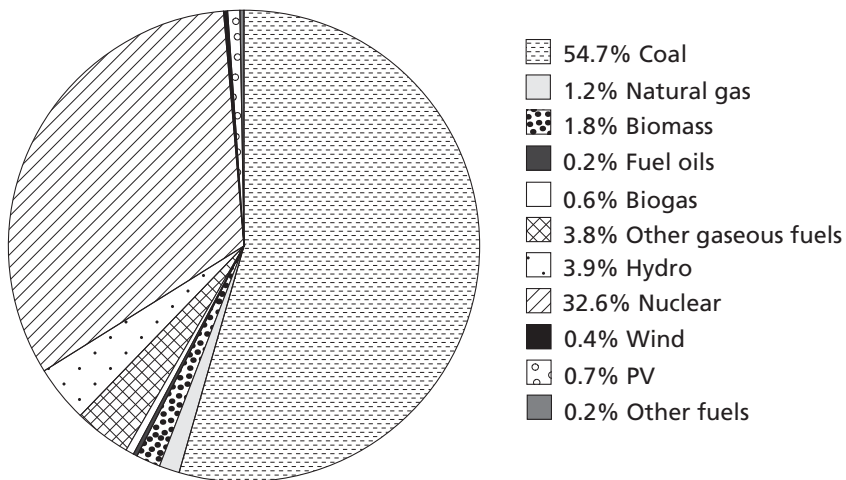


Figure 16: Structure of electricity generation in the CR (gross).

Source: ERÚ, 2011

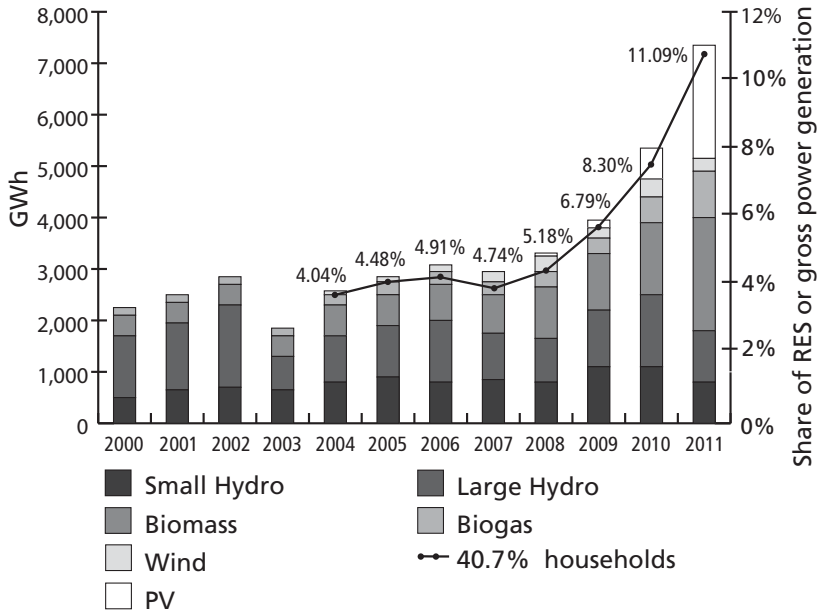


Figure 17: Structure of electricity generation in the CR (gross).  
Source: MPO, 2011

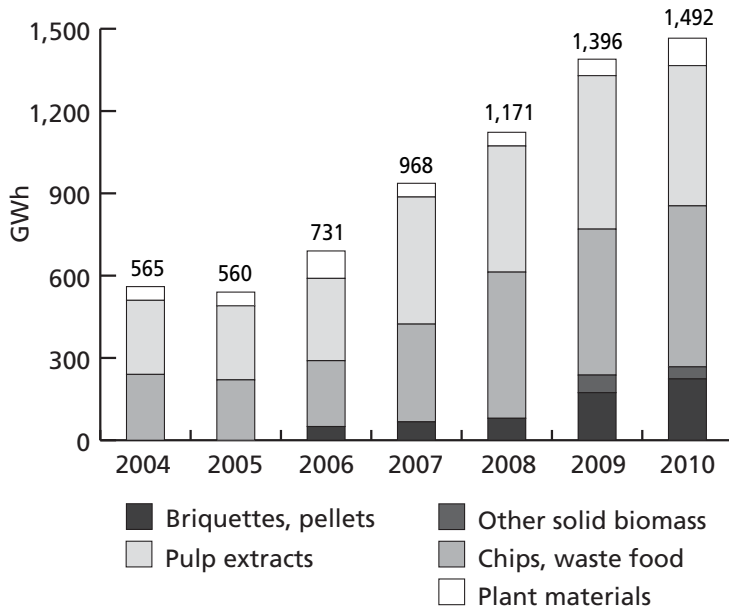


Figure 18: Structure of biomass utilization for power generation in the CR (gross), 2010  
Source: MPO, 2011

### 5.3

## **Strategic goals for renewable energy sources in the Czech Republic, focusing on biomass**

Several strategic documents on energy, and specifically on RES, have been prepared and adopted in the Czech Republic in the last decade. They have focused on the current status, potential and future development of renewable energy sources (RES) and, more specifically, on biomass. The most notable documents are the State Energy Policy from 2003 and its update from 2010<sup>28)</sup> (MPO, 2003, MPO, 2010a) the so-called Paces Report from 2008 (Úřad vlády ČR, 2008), the National Renewable Energy Action Plan of the Czech Republic from 2010 (MPO, 2010b), and a specific Action Plan for Biomass in the Czech Republic for 2009–2011 (MZE, 2009) and the successive Action Plan for Biomass for 2012–2020 (MZE, 2011), which is currently (spring 2012) under preparation. The documents differ significantly both in their level of detail on RES and biomass, and in the categorization used.

The State Energy Policy (SEP, 2003) mentions RES as one aggregated group without further breakdown into specific categories (e.g., wind, hydropower, PV, biomass, etc.). The reason seems to be that at the time of writing the SEP, policy makers did not accentuate the RES as much as nowadays. Figure 19 shows the estimated consumption of RES as defined in various scenarios in the SEP. The Figure shows that the total consumption does not differ much among the scenarios and the total expected consumption in 2030 is approx. 225PJ.

Based on Government Resolution no. 77 of 24 January 2007, a strategic document “Report of the Independent Commission for Assessing the Energy Needs of the Czech Republic in the Long Term” (known as the Paces Report, (Úřad vlády ČR, 2008)) was elaborated. The report is based on a number of partial studies and evaluates the energy policy in the Czech Republic from various angles: economic, environmental, security and social.

Figure 20 shows that in comparison with the SEP (MPO, 2003), the total RES consumption in 2030 increases by about 90 PJ. Moreover, the RES are further stratified by type and it is clear that biomass is to play the key role in RES development.

Furthermore, the Paces Report provides another important piece of information, not mentioned in any other previous strategic energy document, which is an estimate of total energy potentials for specific biomass categories, as shown in Table 14. It is evident from the table that intentionally planted biomass on agricultural land plays the key role.

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<sup>28)</sup> A brand new State Energy Policy is currently under preparation.

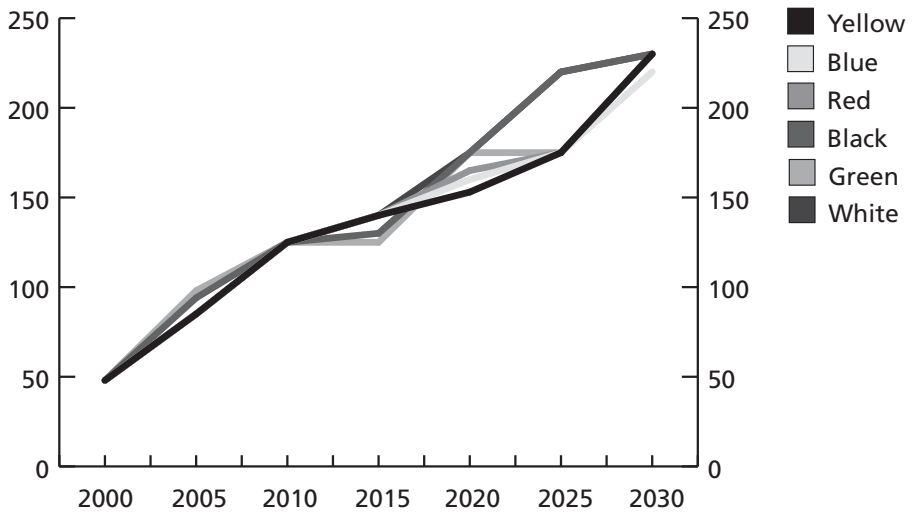


Figure 19: Consumption of RES as per different scenarios (PJ)  
Source: MPO, 2003

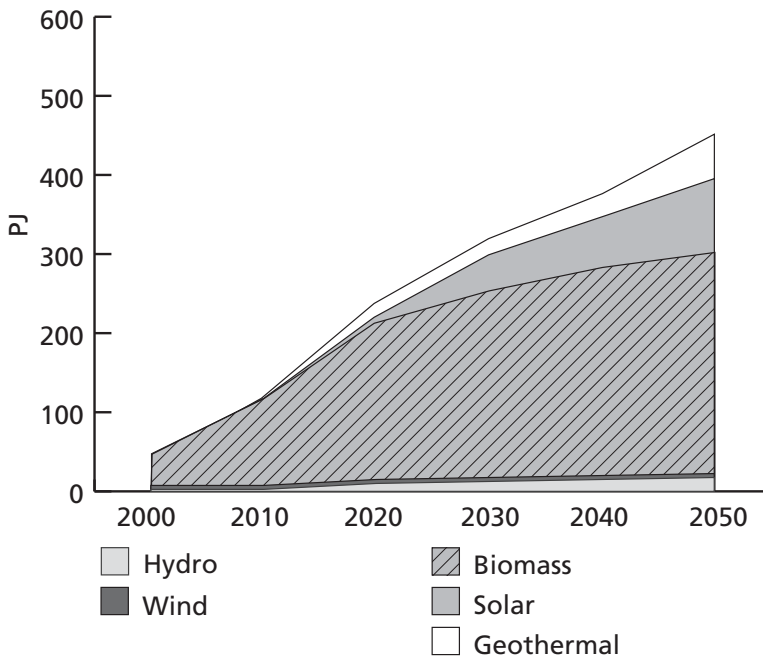


Figure 20: RES scenario in Paces Report  
Source: Úřad vlády ČR, 2008



<b>Biomass</b>	<b>PJ</b>
Agricultural	194
Forest	50
Residual	32
Total	276

*Table 14: Estimate of total biomass potential in the CR*

*Source: Úřad vlády ČR, 2008*

Last but not least, the Paces Report has opened a debate on the fuel basis for the Czech Republic's district heating. It refers to the potential lack of coal, which in turn may provide room for wider biomass use.

In 2010, the Ministry of Industry and Trade submitted a draft of the State Energy Policy update. The document respects the widely used RES categories; however, biomass is aggregated into one category only. The estimate of the structure and consumption of renewable and secondary energy sources is presented in Figure 21. Conversely to Paces Report, the estimate of total RES consumption returns to the values of the 2003 SEP in the reference year 2030.

As said above, the data on specific biomass types are missing and all the recommendations pertaining to biomass are of a general nature.

In 2010, the Czech Government adopted yet another strategic document, the National Renewable Energy Action Plan of the Czech Republic (NREAP). The document has been developed on the basis of requirements of Directive 2009/28/EC on the promotion of the use of energy from renewable sources<sup>29)</sup> (MPO, 2010b). For biomass, the NREAP mainly focuses on biomass use in electricity generation and district heating. The domestic biomass supply in the Czech Republic is estimated at 123PJ in 2015 and 136PJ in 2020. The NREAP expects that in 2020, the biomass share will be more than 50% of the total RES electricity generation (11.7TWh); see Figure 20. The main problem with this document is its inconsistency. There are several places in the document where contradiction between different data sets occurs.

<sup>29)</sup> The Directive requires that the CR reach a 13% share of RES in final energy consumption in 2020 and also requires the states to develop NREAPs, which define how to attain this goal.

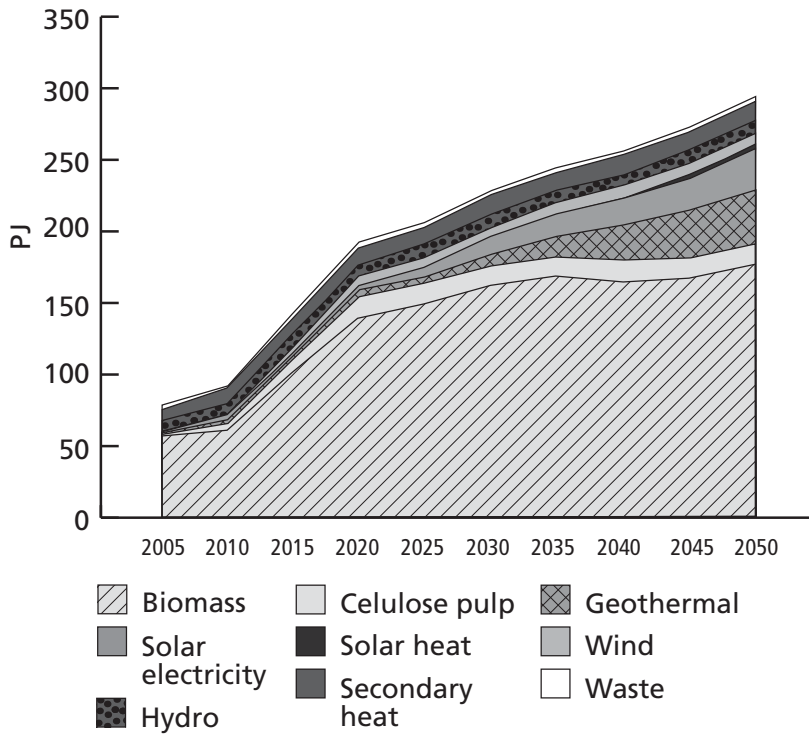


Figure 21: Structure and consumption of RES and secondary sources (PJ)  
Source: MPO, 2010a

The Action Plan for Biomass (APB) for 2009–2011 was developed practically in parallel to the NREAP. The overall target is the same as in the NREAP, i.e., fulfilling the targets set by the RES Directive (MZE, 2009). The estimate of the biomass potential in the Czech Republic as provided by the APB is shown in the table below (Table 15).

Biomass type	Potential (PJ)
Agricultural biomass	159.4 (108.8)
Forest dendromass total	42.5
Total–range	201.9 (151.3)

Table 15: Total energy biomass potential in CR as per APB  
Source: MZE, 2009

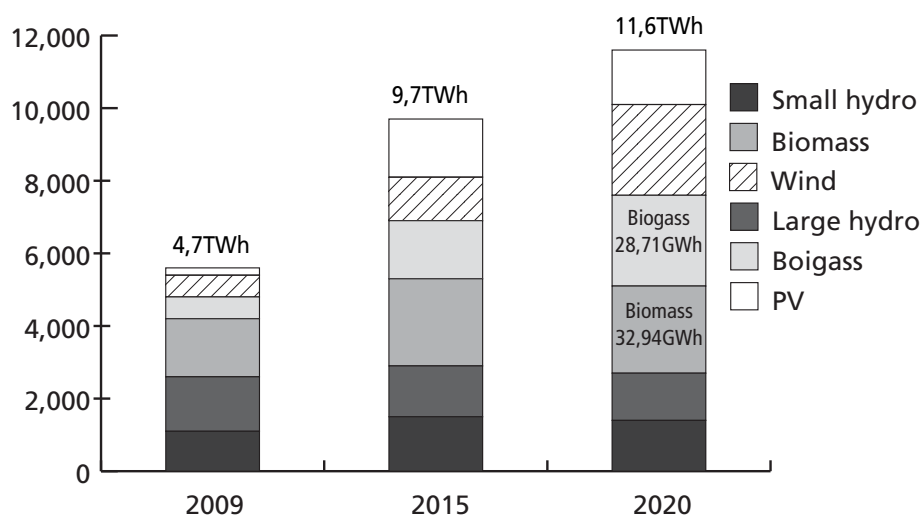


Figure 22: Structure and consumption of RES and secondary sources (PJ)  
Source: MPO, 2010b

The APB further provides a brief discussion on selected economic aspects of biomass use for energy purposes, including a notion of calculating cost curves. However, any further outputs or results are missing in the APB, as well as a comprehensive method for the cost curve calculations for different biomass types.

As a follow-up on the APB 2009–2011, the Ministry of Agriculture presented a new Action Plan for Biomass in the Czech Republic for 2012–2020 in January 2012; more specifically, its first part concerning the potential of energy biomass. The aim of the document is to update and provide ample information and inputs on the potential contribution of biomass to the CR's energy balance, mainly in respect of the preparation of the new State Energy Policy and the NREAP update.

The updated total potential of energy biomass in the Czech Republic, which now respects food security, is provided in Table 16.

Biomass type	Potential (PJ)
Agricultural biomass	133.9–186.8
Forest dendromass total	35–40
Total–range	168.9–226.8

Table 16: Total energy biomass potential<sup>1</sup> in CR as per APB 2012–2020  
Source: MZE, 2011

To provide an overview, the figure below (Figure 23) compares the potentials of biomass for energy purposes mentioned above, as they are mentioned in the analysed strategic documents. The data are related to the year 2020.

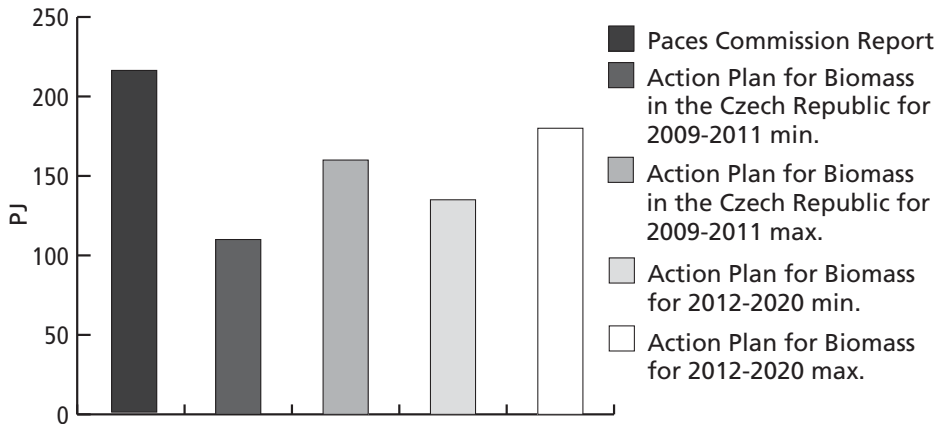


Figure 23: Comparison of exploitable potentials for energy biomass

It is important to keep in mind that the total potential is not constant in time and is limited by several factors. The most important one is the presumption that the “farmers are ready to take in the agrotechnical operations of by-product harvesting and/or are ready to learn new silvicultural techniques” (MZE, 2011). The total biomass potential and its change in time are shown in Figure 24.

Food security is another important factor that may significantly influence the total biomass potential. The potential changes in a non-linear fashion with different levels of food security (Figure 25). The non-linearity is caused by two factors with opposite impacts: 1) higher food security decreases the available area for energy biomass; and 2) a large biomass potential comes from agricultural by-products. Higher food security (and higher food production) then causes higher production of biomass by-products that can be used for energy purposes (MZE, 2011).

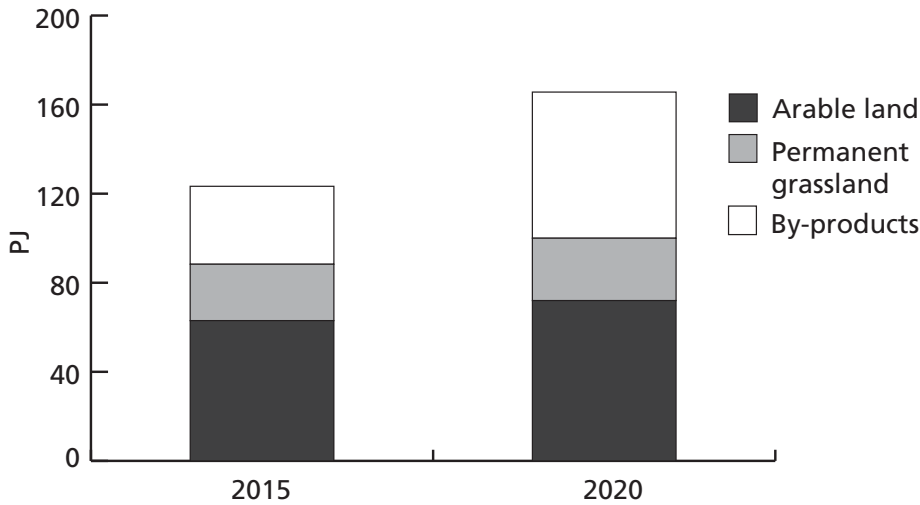


Figure 24: Biomass potential in time  
Source: MZE, 2011

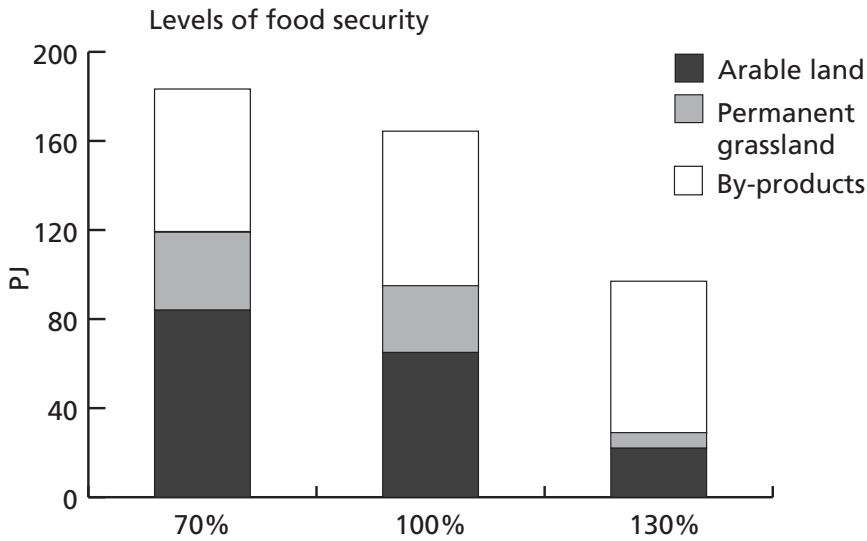


Figure 25: Biomass potential for different levels of food security  
Source: MZE, 2011

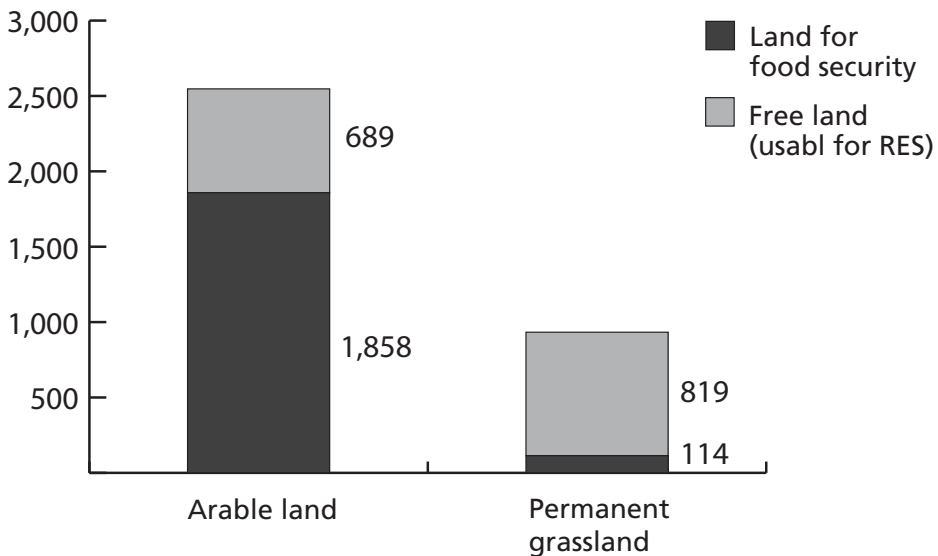
## 5.4

### Use of agricultural land for energy purposes

Clearly, realising the aforementioned potential requires use of significant areas of agricultural land. Currently, biomass for energy purposes is grown on about 30,000 ha of agricultural land (Knápek et al., 2011). However, as shown in the strategic documents discussed above, biomass (chiefly intentionally planted biomass) will play a key role in the RES development in the Czech Republic.

The figure below (Figure 24) therefore shows the available land which could be used for biomass purposes while maintaining 100% food security.

The figure above shows that the land available for energy biomass (or RES in general), including 100% food security, represents more than 43% of the total agricultural land in the Czech Republic. More specifically, it is about 689,000ha of arable land (27% of the total arable land) and 819,000ha of permanent grasslands (about 88% of their total area). Roughly, 15PJ can be obtained from 100,000 ha, which makes about 226PJ of energy potentially available, if all available land was exploited for energy biomass. That coincides with the numbers given above.



*Figure 26: Agricultural land potentially available for energy purposes, keeping 100% food security*

*Source: MZE, 2011, edited by authors*

## 5.5

### Support scheme for development of energy biomass use

The main characteristic of the current support to increasing biomass use for energy purposes is its high diversity and low coherence. The support mechanisms enter into different phases of the biomass cycle, from support of biomass production to its processing and transformation to its use. Most of the support aims at the last phase: the use. In this sense, the support system is therefore unbalanced.

Three main departments shield the support of use of biomass for energy purposes, i.e., the Ministry of the Environment (MoE) through the Operational Programme Environment (OPE), the Ministry of Industry and Trade (MoIT) with the Eco-Energy Programme within the Operational Programme Enterprise and Innovation (OPEI), and the Ministry of Agriculture (MoA), which apart from the Rural Development Programme (RDP) also administers the direct subsidy payments to farmers under the Common Agricultural Policy.

A summary of selected main support and subsidy schemes currently in place in the Czech Republic is provided below<sup>30)</sup>. The summary does not include the support schemes for liquid biofuels (for transport)<sup>31)</sup>.

- Biomass production
  - SAPS, total of approx. CZK 140–150 million, from EU's Common Agriculture Policy
- Biomass transformation (except biogas)
  - RDP, support to biofuel production and indirectly through construction and technology investment, total of approx. CZK 325 million until 2011
- Construction of electricity generation facilities (biogas stations, BS)
  - OPE, subsidy for BS construction, approx. CZK 584 million until 2011
  - OPEI–Eco-Energy, subsidy for BS construction, total of approx. CZK 742 million
  - RDP, subsidy for BS construction, total of approx. CZK 2,763 million until 2011
- Construction of heat generation facilities using biomass, and cogeneration
  - OPE, subsidy for construction of biomass boiler rooms, total of approx. CZK 74 million
  - OPEI–Eco-Energy, subsidy for construction of biomass boiler rooms and heating plants, total of approx. CZK 928 million
  - RDP, subsidy for construction of biomass boiler rooms, total of approx. CZK 118 million until 2011
- Use of biomass for electricity generation
  - Support under Act no. 180/2005 Coll., estimate for 2012
  - Biogas electricity generation, approx. CZK 3.6 billion (within which about 2.8 billion in AF1 category)

- Electricity generation through burning of solid biomass, approx. CZK 3 billion

The level of additional costs will remain even after the adoption of the new Renewable Energy Sources Act, which should enter into force in January 2013. The energy sources before this date should remain under original Act no. 185/2005 Coll.

Even though the support schemes cannot be compared directly, the analysis shows that currently the use of biomass for electricity generation is supported significantly more than the other phases and activities within the biomass fuel cycle.

Importantly, the total support to construction of biogas stations under all the subsidy programmes is very high: in total, it exceeds CZK 4 billion.

Conversely, biomass production is almost without subsidy (apart from the SAPS), even though there exists a close relationship between the operators of biogas stations supported from the RDP and biomass producers (Knápek et al., 2011).

It is estimated that the total heat and electricity generation from the biomass use projects implemented so far and supported under the OPE and OPEI amounts to about 1,608 TJ/year of heat and 400,000 MWh/year (net) of electricity (Valentová et Honzík, 2011).

## 5.6

### Use of agricultural land for energy purposes

Given the current economic conditions, the use of RES is uncompetitive in most cases compared to conventional primary energy sources. Therefore, without a certain level of subsidy, the goals mentioned above are hardly to be attained.

Furthermore, the issue is not only to attain the target level of RES use, but also to exploit the co-benefits, which are connected with the replacement of fossil fuels with RES. These are mainly reduction of CO<sub>2</sub> and other emissions, lower production of solid waste, diversification of energy sources, and reducing the dependence on importing energy from potentially unstable areas. RES, chiefly

<sup>30)</sup> One should be aware that most of the subsidy schemes are financed from Structural and Cohesion Funds of the EU and from the Common Agricultural Policy, which are both tied with the budgetary period 2007–2013. New programmes for the period 2014–2020 are currently (spring 2012) under preparation.

<sup>31)</sup> Neither does the overview include other subsidy programmes, such as the Green Light to Savings for use of biomass in heating, and indirect support to clean technologies, such as emission allowances.



biomass, also promote diversification of rural (agricultural) activities, supporting competitiveness of the agricultural sector.

Growing biomass for energy purposes on agricultural land (and its subsequent use for production of solid or liquid biofuels or for electricity and heat generation) provides farmers with additional business activities and makes it possible to decrease the dependence on the frequently volatile agricultural commodity market. RES, mainly biomass as the main RES in the CR, conserve domestic primary energy sources, which can be used as a strategic source for future generations.

The majority of the effects mentioned above are correlated to a large extent and can be represented by a single effect of green house gas (GHG), specifically CO<sub>2</sub>, emission reduction. If the total consumption remains the same, wider use of RES replaces conventional energy fuels and therefore saves CO<sub>2</sub> emissions.

RES are a very diverse category that encompasses different technologies and different uses. Similarly, biomass is a heterogeneous category itself and covers various energy crops and plants with different requirements for location, agro-technologies used and costs of biomass establishment and harvest. The projects further differ by their length: 20–25 years for short-rotation coppices, compared to approx. 10 years for energy grasses (reed canary grass). Some energy crops have only a one-year cycle (such as triticale or corn). The variability of agro-technologies, use of biomass and other factors then lead to large differences in the cash flow of such projects.

One of the main tasks, with respect to the above, is to find an optimum (effective) support scheme for growing biomass on agricultural land. The key aspect is to make growing energy biomass on agricultural land competitive. Effective or optimal then means finding a system of support that will make biomass intentionally planted on agricultural land competitive (compared with fossil fuels, coal, and other uses of the agricultural land) while at the same time minimizing the additional costs of the support scheme.

### **5.6.1 Specific effect method**

An optimum strategy for RES (and biomass) development at a system level has to respect all the system impacts of the given RES type (i.e., on technology, RES use, etc.) and above all the economic effectiveness of the support scheme.

The formulation of the optimum strategy is similar to decision making of private economic entities and their decisions on optimum investment alternatives respecting the scarcity of investment sources. The analogy to scarcity of investment sources to a private entity is the limited amount of direct and indirect expenditures related to the selected RES subsidy scheme.

The given targets for RES (and biomass) are achieved by means of projects implemented by private entities. For each of these projects, the Net Present Value (NPV) can be calculated. The task is then formulated as follows:

$$\begin{aligned} \sum_{i=1}^n NPV_i &= MAX \\ \sum_{i=1}^n N_i &\leq N_{lim} \end{aligned} \quad (1)$$

Where:

- i            a project in the portfolio of possible projects from which the investor selects
- NPV<sub>i</sub>    Net Present Value of project i
- N          total number of projects in the portfolio
- N<sub>i</sub>        investment costs of project i [CZK]
- N<sub>lim</sub>      limit of investment costs [CZK]

One of the possible ways to approach the task is to maximise the sum of NPV of the possible projects, while using the penalty function for solving the optimization task with a set of restrictive conditions. The Lagrange multiplier method is the most widely known.

A Lagrange function is constructed from the criteria function including the annulled restrictive condition:

$$\max [f(x) - \lambda \cdot g(x)] \quad (2)$$

Where:

- $\lambda$         is the Lagrange multiplier
- f(x)    criterion function
- g(x)    annulled restrictive condition

The task can be solved using a system of equations, which we get through partial derivation of the Lagrange function by individual variables.

Another option for solving the problem is using a so-called coefficient of profitability. The value of the Lagrange multiplier for the optimal solution has to ensure that the sum of finance for making selected investments does not exceed the given limit. For the last investment that will still be made, the following relation has to be valid:

$$(DCF_j - \lambda \cdot N_{ij}) = 0 \quad (3)$$

From this we derive the coefficient of profitability. To reach the optimum of the function, the projects are selected according to their coefficient of profitability up to the limit of the financial (investment) resources:

$$r_i = \frac{NPV_i}{N_i} \quad (4)$$

Where:

$r_i$  coefficient of profitability of investment  $i$   
[CZK/CTK]

When finding the optimal way to support RES (and biomass for energy purposes), the aim is not to maximize the NPV of the investment projects implemented, but to maximize the effect(s) of the RES projects. The effects last for the whole period of the lifetime of the projects, which is similar to cash flow in the original task of maximizing the NPV.  $ED_i$  in the next equation (5) therefore represents the sum of effects of project  $i$  over its lifetime.

In the original task (Equation 1), the restrictive factor was the limit of investment resources in the given period in which the decision on the portfolio of projects took place. In a standard investment decision-making process, the decision stage is one year. Nevertheless, the decision stage can be generalized as a stage to which the restrictive condition applies, and therefore it is possible to work with time periods longer than a year. One simply has to discount consistently all the items of the model (effects, subsidy expenditures) to a single moment in time.

We can then modify the original equation (1) to an equation based on maximization of attained effects of the supported projects:

$$\begin{aligned} \sum_{i=1}^n ED_i &= \text{Max} \\ \sum_{i=1}^n PD_i &\leq PD_{\text{lim}} \end{aligned} \quad (5)$$

Where:

$ED_i$  sum of discounted effects of project  $i$  for its lifetime

$PD_i$  sum of discounted support (of all kinds) attributed to project  $i$  on RES  
(or energy savings) throughout its lifetime

In line with Equation 4, the strategy (state or system) to select projects is based on the preference of projects according to their specific effect (which is an analogy to the coefficient of profitability).

$$e_i = \frac{ED_i}{PD_i} \quad (6)$$

The optimum strategy (to maximize the required effect with limited resources in the support scheme) leads us to select projects (i.e., to include projects in the portfolio of preferred projects within the state system strategy) according to the level of their specific effect—from the highest specific effect to the lowest.

The item  $PD_i$  in Equation 6 can be further described as:

$$PD = PPD_i + SSD_i + TSD_i \quad (7)$$

Where:

- $PPD_i$  present value of the sum of all (direct) subsidies of project  $i$  throughout the project duration
- $SSD_i$  present value of the administration of the system for project  $i$  throughout the project duration
- $TSD_i$  present value of the sum of expenditures of third parties (usually consumers, who have to invest into change of technology; e.g., they have to buy a new biomass boiler) relative to project  $i$

The total sum of subsidies ( $PPD_i$ ) in the present value includes mainly the following:

- investment subsidy for project  $i$ ;
- operational support to project  $i$ , which is paid by residential and commercial sector (e.g., transfer of additional costs stemming from support to biomass use for electricity generation, which is transferred to consumers in electricity prices as a fee per kWh consumed);
- operational support to project  $i$  paid by the public sector (e.g., state subsidy in the system of feed-in tariffs);
- support to cash flow of project  $i$  (e.g., with soft loans); and
- indirect support to project  $i$  in year  $t$  of the time compared (e.g., through tax relief).

Support to a given type of RES (or given type of biomass and its use) should motivate private entities economically to implement such projects. As mentioned above, RES (and biomass) projects are very diverse not only in terms of technology, but also in terms of requirements (costs, subsidy levels) and effects (e.g., GHG saved).

Thanks to the specific effect method, one can rank all the RES (and biomass) projects according to their economic effectiveness. This in turn makes it possible to select and support, from the wide spectrum of technologies and processes, the ones that will ensure that the given targets (share of RES, GHG savings) will be achieved effectively. This applies fully in case of energy biomass on agricultural land, but more broadly for any public programme.

## 5.7

### Conclusions and further researchs

Biomass will play a key role in the renewable energy source development in the Czech Republic in the coming years. At the same time, it is clear that the massive development (also anticipated in the CR's strategic documents) will require wide-scale (financial) support.

The additional costs of the current system, which arise from the development of biomass and biogas for electricity, may amount up to about CZK 14 billion in 2020.

It is clear that a systemic approach to developing a coherent support scheme is highly needed and the same applies in general to the GHG emission reduction system.

It has been shown that in an effective support scheme, all impacts of a given subsidy are assessed and the system effectiveness is evaluated based on cost-benefit analysis. This way, the most effective projects are selected and the targets are reached effectively (at lowest costs).

However, such a coherent approach (both in RES support schemes and more generally in GHG emission schemes) is currently lacking in the Czech Republic. This paper provides an insight into how the system should be set.

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# **Energy for Sustainable Development III**

Energy Savings-Economics  
and Links to other Policies

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