Energy for Sustainable Development II

Jaroslav Knápek, Reinhard Haas, Jiřina Jílková et al.

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Research Papers of the Czech-Austrian Energy Expert Group

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Preface

Since the end of 2002, the joint Czech-Austrian Energy Expert Group (CZ-AT EEG), has been operating, having been established by an initiative of the "Protocol on the Negotiations between the Czech and the Austrian Governments, led by Prime minister Zeman and Federal Chancellor Schüssel with the participation of Commissioner Verheugen from the EU" generally known as Melk Protocol. The admission of this document was led by a good-will of both sides for the further development of neighborhood relations. With respect to the basic differences between the national policies on energy in both countries, it is evident that the activities of such a working expert's group is exceedingly important from the point of view for the development of new energy technologies, but useful from the view of open debate about the energy policies of both countries as well.

Within the activity of the CZ-AT EEG group, there has been a permanent timing of two standard meetings managed each year (one in each country). The main agenda of those meetings consisted of an assessment of previous activities and the preparation and adjustment of the action plan for the future. The scientific seminars and conferences were arranged by the group every year. The main interest of discussion was concentrated predominantly on the questions of renewable sources of energy, possibilities of the energy spending reduction and upon other connected topics.

Another important point is the fact that there are more than 100 students of Czech and Austrian universities up-till-now, being introduced into the expert's group activities the last few years. Such success is further conditioned by organizing winter and summer schools for the students of the economy or energy study programs.

The first publication of the group expert's reports was edited in 2005. Now we are presenting the 2nd issue of publications presenting the results of joint research. A significant part of these contributions creates the joint reports of both countries' experts. A reader can find here not only some non-traditional views on the new technologies of energy resources, but an open discussion about the approaches of the utilization of them in the frame of national policies as well.

In conclusion of the short foreword to the publication it should be emphasized that all activities of the CZ-AT EEG were supported by financing of the Ministry of Foreign Affairs of the Czech Republic and the Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management. Certain student's activities were supported by the program AKTION and by the personal resources of participating universities. The members of the CZ-AT EEG hope that the promising activities opened during the past few years will continue to be maintained and to be developed in the future.

PART

A

ENERGY AND ENVIRONMENTAL POLICY

1

A sustainable economy beyond GDP and beyond energy consumption

Is the economic crisis that has started in 2009 over? Companies, policy makers and those who are concerned about their jobs—and these are in most countries more than half of the work force—anxiously look at the latest figures for Gross Domestic Product, since a rising GDP is considered as good news.

The economic crisis which started out essentially as a banking crisis taught us some valuable lessons: our accounting systems may just not be adequate, they may even conceal essential warning signals of an immediate disaster.

This, therefore, is the proposition we might want to consider: economic welfare is not necessarily well indicated by measuring just the volume and the value of economic activities. But this is essentially done by the GDP measure. The same may hold for our perception of energy: the volume of energy consumption, now still seen as being closely tied to GDP, may be even irrelevant for the wellbeing of our society.

What seems to be emerging is a fundamental shift of our understanding about measuring the success of economic activities. In a nutshell: we observe a shift from measuring just the volume of economic activities to the welfare they are expected to provide, as access to housing, persons and cultural services. Or in other words: we observe a shift from just measuring the volume of goods to the functionalities they are expected to provide.

1.1 Looking beyond GDP

Realizing that we may be trapped in an accounting system that is not only getting increasingly irrelevant for evaluating economic welfare but even in danger of disguising critical warning signals may turn out as the next big challenge in our shared vision about a good economic system.

The conventional products based paradigm

Mainstream economics is still focused on what we could coin the products paradigm since the focus of economic analysis is on the flow of products. A very limited list of resources, mainly human capital and reproducible capital, as machinery and buildings, are considered for providing products.

The deficiencies of this paradigm are obvious. An increasing volume of economic activities, such as health services, is needed just to repair the damage done by other economic actions. Many products, such as fossil fuels, deplete valuable exhaustible stocks.

Building blocks for an emerging functionalities based paradigm

Realizing these fundamental flaws of the mainstream products oriented paradigm, we identify the emergence of a paradigm which is focused on functionalities and the factors that are supporting them. Three propositions seem to be the essential building blocks of this paradigm.

Functionalities are a better proxy for welfare than products

A fundamental progress in the discussion about the deficiencies of GDP related measures was the insight, that it is not the volume of products but their functionalities that are relevant for our welfare experience.

These functionalities may be categorized as

- thermal functionalities, e. g. of buildings,
- mechanical functionalities, e. g. of the different modes of mobility,
- communicative, e. g. of the channels of culture and knowledge, and
- emotional, e. g. of the pleasure of wearing a nice piece of clothing.

Functionalities are provided by a wide range of resources

In our attempt to obtain an understanding how these functionalities are provided we need first to consider a wide range of resources and second the use of these resources by their flows and the impact on their stocks.

A minimal categorization of this extended range of resources would comprise:

- reproducible resources, as machinery and buildings,
- human resources of various skills,
- natural resources as water, soil and air,
- social resources, visible by qualities as trust,
- energetic and non-energetic resources, as fossils, renewables and minerals

The interaction between functionalities, products and resources needs to be explored

After having agreed upon the role of functionalities as a better suited proxy for economic welfare than just products, we need to investigate the interactions between the building blocks of the functionalities based paradigm

These are some insights we may obtain:

- A specific functionality, e. g. thermal services of a building, may be provided with a wide range of flows of energetic resources and reproducible capital that determines the thermal quality of a building. This explains the challenge to switch to low-energy or even plus-energy standards for buildings.
- Similarly we can analyze the mechanical functionalities in our mobility system by evaluating their needs (e. g. caused by bad zoning regulations) and the impact of various choices of transport modes (e. g. public transport or private cars).

1.2 Looking beyond energy consumption

Switching from products to their functionalities has a similar strong bearing for obtaining a better understanding of our energy system. The analogous fundamental shift of attention is from the flows of energy consumption to the energy services that are provided.

These energy services may be categorized as

- thermal services, e. g. for buildings or industrial processes,
- mechanical services, e. g. for mobile or stationary applications,
- specific electric services, e. g. for lighting and electronics.

Building a shared vision for the future energy system

Based on this paradigm shift from products to their functionalities and the analogous paradigm shift from energy flows to their related services, we encourage a comprehensive policy debate for building a shared vision for our future energy system.

It is never too early to develop perspectives about the long-run perspectives of our energy structures since energy systems are heavily dependent on investments decided upon in the past decades. This is the reason why we need insights already now about the potential and desirable structures in decades ahead for shaping the next investment decisions.

There are basically two fundamentally different approaches for developing perspectives about our energy systems: the supply focused approach and the demand focused approach. We want to put forward the proposition that only an integrated approach that takes into account the intimate link between supply and demand is capable of providing constructive insights into the potential futures of our energy systems.

The limits of the conventional approach: Extrapolating current supply structures

Most conventional analyses, above all many of the International Energy Agency (IEA), are based von extrapolating current supply structures. The limits of this approach are obvious if we look at some key components of energy supply.

If we would imagine people living in China and India using the same amount of crude oil per capita as people living in Europe, world production of crude oil would need to be doubled. There is simply no evidence that this can be done in view of the ongoing peak-oil discussion. Similar arguments limit a multiple expansion of natural gas from current volumes not only because of limits in reserves but the much more difficult distribution logistics needed either via pipelines or via an energy-intensive liquidification process and transport by tankers.

The top energy consumers as China and United States are heavily dependent on coal in particular for electricity generation. Since coal is compared to other fossils still available in abundance, major efforts are going on to improve coal-based transformation processes by more efficient combustion technologies, by adding an additional conversion process via synthetic fuels based, and by limiting the particularly heavy greenhouse gas impact of coal by developing carbon capture and storage (CCS) technologies. The common characteristic of all these technology options for coal is a considerable increase of generation costs. The currently estimated costs for CCS start beyond € 70 per ton of CO_2. If limiting global GHG emissions remains on the policy agenda, this requires a radical cap for the use of coal.

Nuclear energy currently contributes less than 4% to global final energy consumption in about 370 installations. Doubling their number would under past trends not compensate more than the additional energy requirements of two years. Looking at construction times of more than ten years for nuclear installations currently built there is no perspective for a significant contribution of nuclear energy to the global energy supply problem under past trends that are undisturbed by an economic crisis.

With these obvious limits for all kinds of fossils and nuclear energy attention turns to renewables. A first look, however, reveals similar limits also for almost any kind of renewable energy. Energy from all sorts of biomass faces the competition with food and fibers and turns out to be very land-intensive compared to other renewables. Biofuels are confronted with the low efficiency rates in mobile combustion engines. There are limits to big hydro installations because of many negative environmental impacts. Even wind turbines are confronted with these allegations. Thermal solar is available on various scales but turns out to be very cost-efficient in small scales for supplying heating and cooling for buildings. Although the direct conversion from sunlight to electricity via photovoltaic is currently the most expensive renewable energy there is reason to expect major technological breakthroughs for this supply technology both by improving the current technologies and switching to technologies based on abundantly available organic substances.

Summing up we realize that extrapolating the current supply structures of energy on a global scale turns out to be a dead end road.

1.3 A radical innovative approach: Matching the energy demand of a high-efficiency energy system by an adequate supply structure

The main lesson learned from an attempt to extrapolate past energy supply trends is the insight that looking into the future via the rear mirror of past trends is just not viable. We therefore switch from the conventional methodology of forecasting the future from the past to the innovative methodology of backcasting from potential viable futures to the present. We demonstrate this for the energy system of Austria.

Starting point is the current demand for energy split up into various categories of use. Current energy flows to 100 in 2010 thus providing the percentage shares of categories for this year.

Energy losses

We realize that about 15% of energy that enters as an input into the energy system is lost in transformation and distribution activities. Although this is a relatively low share compared to many other industrialized countries there is still a substantial potential for switching to co- and polygeneration technologies in thermal transformations and lowering distribution losses by more decentralized structures. We could imagine that by 2050 losses are reduced by a factor of three.

Low-temperature heating

21% of energy is currently needed for low-temperature heating. Given our ample evidence that there is a high potential for improving the thermal structure of these buildings and by switching to passive-house and even plus-energy standards in new buildings it seems obvious that even substantially higher energy services, i. e. a much larger volume of buildings for housing and production could be maintained by a forth of the current flows of energy for low temperature heat in 2050.

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Mobility

28% of the current energy flows is used for mobility, almost only in combustion engines technologies. Given the high potential for getting rid of redundant energy services by redesigning the use of space and time and by a technological quantum leap that redesigns the current generation of cars both by using fully electric powered cars in light-weight designs based on polymers we can imagine to cut energy flows for mobility by a factor of three by 2050.

Remaining uses

Losses, low temperature heat and mobility account in almost all industrialized countries as in Austria for about two thirds of energy consumption. We put forward arguments that given our current knowledge of existing and emerging technologies the energy volumes for these three energy categories could be cut by factors ranging between three and four by 2050.

But even the remaining categories for using energy have potentials for stepping up energy productivity. Outstanding are the prospects for switching to light emitting diodes (LED) for lighting which provide the same services of lighting with less than five percent of energy needed for a candelescant lamp.

1.4
A new perspective for renewables

It seems thus to be highly credible that by 2050 countries like Austria could meet all desired energy services by at most half of the current energy flows. These radical improvements in energy efficiency open surprising new perspectives for the role of renewables in energy supply. If we follow suggestions discussed within the EU that Europe should aim for a share of renewables of 90% by 2050, this would mean for Austria an increase of the current volume of renewables of about 30 units of 2010 to 45 units, that is an expansion of about 50%. Given our current knowledge of the potential and the dynamics of costs and technologies this is a very reasonable perspective.

1.5
Some guidelines for restructuring the current energy systems from the perspective of 2050

The perspectives developed for the structures of the energy systems to be expected in about four decades from now have a substantial bearing for decisions about the next steps needed to put the current energy system on a viable transformation path. The following guidelines for policy makers, companies and consumers are emerging:

Viable energy systems will require a multiplication of current energy productivities

In mobility, buildings and production many technologies are either already available or visible for providing the currently required energy services with one forth or even less energy flows.

Higher energy productivity is coupled with higher energy quality

If we measure the quality of energy by exergy, that is the ability of a certain type of energy to provide work, the transformation processes are characterized by lower energy volumes but with a higher exergy quality. This means, for example, there will be a lower demand for low temperature heat but a higher demand for electricity for electronics and motors.

The energy supply mix needs to adjust to these shifts in demand

The expected demand shifts in the quality of energy need to be reflected by a matching supply mix with a higher share of high exergy energy as electricity and a lower share of low exergy energy as low temperature heat.

The energy supply structure will become more decentralized

This is caused both by the inherent decentralized availability of renewables as thermal and electrical solar, wind, hydro and biomass and the need to locate installations closer to the applications in order to reduce distribution and transformation losses. In addition all thermal transformations should be done as close as possible to the locations where heat is needed.

Primary energy is to be used and reused in a cascadic structure

Some feed stocks as crude oil but also biomass can be transformed both into materials (e. g. for producing polymers and other structures) and energy (e. g. heat and electricity). These feed stocks need to be used in the full cascade of their potential use, that is priority is given to the use as materials which should be recycled and only afterwards used as input for the energy system.

1.6
Key energy supply technologies expected to emerge by 2020

These are some key technologies for redesigning the supply structures:

Thermal transformation technologies for heat and electricity

According to the guidelines developed above, the scale and location for technologies that supply heat and electricity should match demand, i. e. they should be as close as possible to demand for heating and cooling. The adequate transformation technology will be a co- or poly-generation unit based either on a combustion engine or a (micro) gas turbine using for the time being natural gas but expected to switch to gas from biogenic waste. Stand-alone technologies either for heat and electricity thus should be phased out.

Energy from buildings

Buildings may play a substantial role not as a consumer but as a supplier of energy. Thermal und electric solar technologies will be integrated into roofs and walls and may provide surplus energy to the grids for heat and electricity. Additional components in the energy system of a building will be heat pumps and—in a reverse cycle—cooling units.

In a transition phase service buildings as hospitals, hotels with swimming pools and office buildings with poly-generation facilities could be developed as focal points for the distributed generation technologies for heat and electricity to come.

Smart grids for heat and electricity

Because of relocating thermal transformations to the demand for heat this means keeping the distances for heat transport shorter. Together with the sharp decline of demand for heat by buildings because of their stepped up thermal efficiency this questions any major investments in grids for heat with a big central transformation unit.

Even more pronounced is this shift to decentralized structures for electricity because of the inherently decentralized availability of renewable energy and the perspectives of electric cars whose batteries serve as a storage device for the electricity grid.

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2

Climate change and air quality policy: synergies and trade-offs

2.1 Scope of the problem

Both climate change and air quality belong to the major current environmental problems. It can be seen that there are many interactions between these two areas and that it is useful to examine the background to these interactions and to identify synergies, where measures to improve air quality can help to mitigate climate change and vice versa. On the other hand, certain policy measures in these two areas may act in opposition and trade-offs should be considered, e. g. the use of end-off-pipe installations due to stringent emission limit values leads to increased CO_2 emissions.

Both of these areas are covered by international legally binding instruments—the Kyoto Protocol to the United Nations Framework Convention on Climate Change (UN FCCC) in the case of climate change (reduction of greenhouse gases emissions) and the Gothenburg Protocol to the Convention on Long-Range Transboundary Air Pollution (UN ECE CLRTAP) in the case of certain air pollutants like sulphur dioxide, nitrogen oxides, VOCs and ammonia. All EU and EEA (European Economic Area) countries are parties to these protocols and have accepted the quantitative targets in emission reduction. Comparing the targets laid down by these protocols with the actual values of national emissions of greenhouse gases (GHGs) and air pollutants, it can be seen that certain countries might have compliance problems in both areas. In addition, there can be observed compliance problems with air quality standards, especially as for ground level ozone and suspended particular matter (at present PM_{10}, in the near future also $PM_{2.5}$).

Countries which have indicated potential compliance problems both with the Kyoto target and with the Gothenburg target(s) are listed in the following table 2.1.

It is evident that certain countries may face compliance problems with both protocols. In addition, it is well known that the “new generation” of more

Kyoto Target	Gothenburg Targets			
	SO_2	NO_X	VOC	NH_3
Spain	Spain	Spain	Spain	Spain
Denmark	Denmark	Denmark	Denmark	Denmark
Austria		Austria		
Italy		Italy		
Slovenia		Slovenia	Slovenia	
Finland				Finland
Greece			Greece	
Luxembourg		Luxembourg		

Source: AEA, 2008.

Tab. 2.1: Countries they have indicated compliance problems with Kyoto and Gothenburg Targets

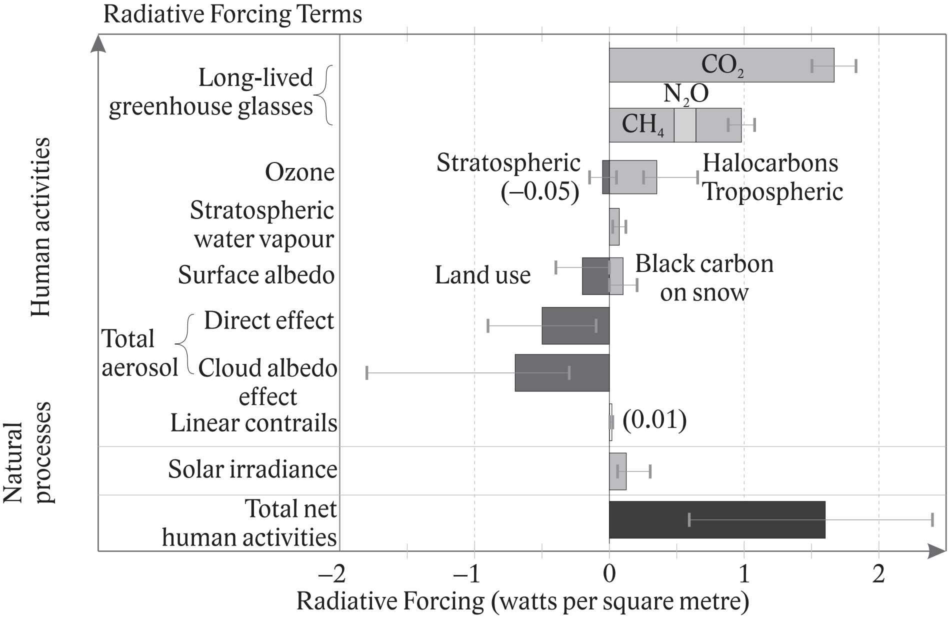
stringent quantitative targets is being negotiated both in the case of GHGs and in the case of "classic" air pollutants. This is the reason why emission reduction measures related to both GHGs and air pollutants should be implemented in coordination to utilize synergies. On the other hand, measures leading to the improvement in one area "paid" through worsening the situation in the second area should be avoided.

The Czech Republic does not seem to have a compliance problem with the Kyoto Target, nevertheless its per capita emissions of carbon dioxide are significantly higher than the EU-15 average (14.25 t $CO_{2eq.}$ for the CR versus 12.95 t $CO_{2eq.}$ for EU-15). As for the Gothenburg Targets, the Czech Republic could meet problems in the case of nitrogen oxides (2006 national emissions of nitrogen oxides were at the target level). In addition, the Czech Republic has serious problems in the field of air pollution by suspended particulate matter PM_{10}, polycyclic aromatic hydrocarbons (PAHs) and ground level ozone.

2.2
Interactions between air quality and climate change

Interactions between air quality and climate change are extremely complex. Predictions of future temperatures using global models are subject to substantial uncertainties related to aerosols (suspended particulates) and ground level ozone.

Effects of air pollutants and greenhouse gases are indicated in graph and in table 2.2.



Source: IPCC, 2007

Fig. 2.1: Radiative Forcing

In general, air pollution has an opposite effect compared to GHGs. Aerosols (suspended particulates) scatter solar radiation back to space and have a negative (cooling) radiative effect on climate. In addition, aerosols also act indirectly by modifying the radiative effect of clouds (towards cooling). Nitrogen oxides, sulphur dioxide, VOCs and ammonia are precursors of secondary aerosols. Tropospheric ozone is, after GHGs, one of the largest single components of the current radiative forcing of climate. Nitrogen oxides, VOCs and carbon monoxide are precursors of ozone and have thus an indirect effect on climate. Air pollutants may also have a significant effect on concentration of

	PM	SO_2	NO_X	VOC	NH_3	CO_2	CH_4	N_2O	Fgases
Health effects	×	×	×	×					
Ozone (O_3)			×	×			×		
Impact on vegetation									
Ozone (O_3)			×	×			×		
Acidification		×	×		×				
Eutrofication			×		×				
Radiative forcing									
Direct						×	×	×	×
Indirects via aerosols	×	×	×	×	×				

Tab. 2.2: Effects of air pollutants and greenhouse gases

carbon dioxide and methane through their impacts on ecosystem sources and sinks. On the other hand, an increase in temperature caused by the climate changes may lead to changes in the chemistry associated with the ozone formation.

2.3 Policy instruments and measures

There is not any integrated policy on climate change and air quality at the EU level. Each of these issues is covered by particular strategy (the European Climate Change Program, the Thematic Strategy on Air Pollution). Recently, integrated approach to climate change mitigation measures and air quality management is being assessed in certain OECD countries (e. g. Japan, USA), the EU Member States (e. g. United Kingdom) as well as in some international organizations or institutions (e. g. The European Environment Agency, the World Bank, International Institute for Applied System Analysis, Global Atmospheric Pollution Forum).

The United Kingdom seems to be the EU leader in this field (DEFRA, 2007), followed by Sweden. The examples of broad categories of measures for climate change and air quality mitigation with their effects, as shown in the above mentioned document, are presented in the following table 2.3.

Measure	Effect
Mitigation measures that could reduce emissions of air quality and climate-active pollutants	
Power generation	
Fuel switching to lower carbon or renewables (e. g. coal to natural gas)	Reduction in CO_2, SO_2, NO_X (especially if used with abatement)
Combined heat and power (CHP)	Reduction in air quality and climate-active pollutants if used to replace conventional electricity generation.
Transport	
Use of certain new technologies and fuels (e. g. hybrid vehicles)	Reduces point of use and fuel chain emissions of CO_2 and air quality pollutants; H_2 from renewable sources or derived from natural gas and used in a fuel-cell vehicle; lean-burn petrol vehicles with lean NO_X traps.
Low emission zones	Only if newer (more efficient) vehicles replace older (less efficient) vehicles.
Efficiency improvements	
More efficient domestic appliances/industrial processes; improvements in technology	Often a proportionate reduction in climate-active and AQ pollutants; benefits of improved efficiencies can be reduced through encouraging increased demand in same (or other) products.
Demand management	
Road-user charging	
Conservation	
Home insulation	

Measure	Effect
Climate mitigation measures that could increase emissions of air quality pollutants	
Increased aircraft fuel efficiency	Trade-off: reduction in CO_2 but increase in NO_X.
Fuel-switching (transport)	Increased use of diesel in place of petrol (increased NO_X, PM)
Biofuels—general	Use of nitrogen-based fertilisers could increase NH_3 emissions; emissions of N_2O potentially important for some fuels.
Biofuels—transport	Potentially increased emissions at point of use if used neat or if mixed with petrol/diesel fuels in high proportions. Increased fuel production emissions of air quality pollutants.
Biofuels—domestic use	Could result in increased air quality pollutants (PM) e. g. if used in place of electricity or natural gas.
Waste management	Incineration (including CHP) instead of landfill. Reduced methane (CH_4) but increases in AQ pollutants.
Forests as a sink for carbon	Potential to increase emissions of biogenic hydrocarbons; other air quality emissions if used for fuels.

Measure	Effect
Air quality mitigation measures that could increase emissions of climate-active pollutants	
Power generation: Flue gas desulphurisation (FGD)	Reduced generation efficiency hence increased CO_2 per unit electricity generated. Formation of CO_2 through use of limestone in wet scrubbing.
Transport: Abatement of air quality emissions	For diesel vehicles: use of particle filters; four-way catalysts; lean-NO_X traps; potential to increase N_2O (e. g. selective catalytic reduction).
Reduced sulphur in fuel	Increased refinery CO_2 emissions. However, could reduce point of use emissions of CO_2 (e. g. lean NO_X trap fitted to a petrol vehicle).
Measures that could result in increased air quality and climate-active pollutant emissions	
Increased demand for products/services	Aircraft—increased fuel efficiency has been exceeded by increased demand.
Transport modal shifts	Increased use of short-haul flights at the expense of rail.
Increased use of coal for electricity generation	If used in place of renewables, nuclear or natural gas.
Use of biofuels under certain circumstances?	Significant increase in N_2O if nitrogen-based fertilisers used; transportation emissions over long distances (if imported); increased air quality emissions if used in high proportions at point of use; fuel-chain emissions increase particularly if significant use of fossil fuels.

It can be seen that there is a couple of measures available whose application leads to the reduction of emissions of both GHGs and air pollutants. These measures could be divided into two basic groups:

- ↗ Energy efficiency and savings at the side of both energy generation and energy consumption (decreasing demand)
- ↗ New energy generation technologies (covering existing demand by low-emission or even "zero-emission" technologies).

The conclusion is that the optimum mix of measures lies in the combination of both of these two basic groups.

2.4
Macroeconomic models

Examples of macroeconomic models applied in the field of climate change and air quality sectors are presented in the following table.

Combined model GAINS, developed and operated by the International Institute for Applied System Analysis (IIASA), seems to be the most advanced modeling tool to explore synergies and trade-offs between the control of local and regional air pollution and the mitigation of global greenhouse gas emissions.

Over the last years IIASA has extended its RAINS (Regional Air Pollution Information and Simulation) model to explore synergies and trade-offs between the control of local and regional air pollution and the mitigation of global greenhouse gas emissions. This new GAINS (Greenhouse Gas and Air Pollution Interactions and Synergies) model assists in the search for pollution control strategies that maximize benefits across all scales. The European implementation of the GAINS model has been released in December 2006. It covers 43 countries in Europe (including the European part of Russia). The new GAINS model incorporates the latest version of the RAINS-Europe model as it has been prepared for the 2007 revision of the NEC directive. GAINS combines it with estimates of emissions, mitigation potentials and costs for the six greenhouse gases included in the Kyoto protocol, fully compatible with the methodology applied for the conventional air pollutants.

Model GAINS offers 40 different emission scenarios based on assumptions of future policy developments. Particular scenarios are derived on National Emission Ceilings scenarios in combination with either national projections or the results of other models: PRIMES for energy (at different costs of carbon dioxide) and CAPRI for agriculture and with the assumptions on implementation rates of EURO standards for vehicles.

Model	Application
Air Quality	
RAINS	European Environmental Outlook
Climate Change	
FAIR	OECD Environmental Outlook to 2030; European Environmental Outlook
MAGICC	OECD Environmental Outlook to 2030
Combined Models: Air Quality and Climate Change	
IMAGE Framework model applied in combination with FAIR (policy options) and TIMER (energy system).	OECD Environmental Outlook to 2030, European Environmental Outlook
GAINS	Revision of Directive 2001/81/EC on national emission ceilings.

Tab. 2.3: Macroeconomic model implemented in the field of climate and air policy

As an example, the 2020 detailed emission projections and cost estimates for the Czech Republic for 2 scenarios (the first is close to the "business-as-usual" approach while the second is the most ambitious one) are presented in table 2.4.

Scenario NEC_NAT_CLEV3 is based on national projections and NEC Scenario No 3 under the assumption that the existing legislation will remain in place. Scenario NEC_PRIMESCOH_MRRV4 is based on projections from international models PRIMES and CAPRI and NEC Scenario No 5.

The more ambitious scenario requires annual costs higher by 18% than the "business-as-usual" one but could lead to substantial reductions of both carbon dioxide emissions (by 38%) and emissions of air pollutants (e. g. by 60% in the case of PM_{10} or 52% in the case of NO_X).

EUR 2 billion represents less than 2% of the national GDP of the Czech Republic.

	Real emissions 2006	NEC_NAT_ CLE_OPIV3	NEC_ PRIMESCOH_ MRRV4
CO_2 (kt/year)	129.0	124.51	77.82
NH_3 (kt/year)	63.44	76.53	57.94
NO_X (kt/year)	280.12	187.69	90.01
SO_2 (kt/year)	210.83	178.34	32.45
VOC (kt/year)	178.81	148.00	62.56
TSP (kt/year)	63.44	96.25	46.39
PM_{10} (kt/year)	36.0	51.39	20.69
$PM_{2.5}$ (kt/year)	25.0	32.41	11.32
Annual costs (EUR mio/year)	—	1726.4	2043.2

Source: GAINS online (for Europe)

Note: Results of RAINS/GAINS models may differ from the results of national emission inventories which are caused by the differences in both activity data and emission factors applied. These differences are being mitigated through co-operation between IIASA and the Czech Hydro-meteorological Institute..

Tab. 2.4: Emission scenarios and cost estimates

2.5 Potential for cost reduction

Several studies, which are dealing with the possible cost reduction of implementing climate change policy and/or air protection policy, were published last years. According to these studies, cost savings could be achieved by co-operation or integration of air protection and climate protection policies. Barker et Rosendahl use the E3ME model to calculate the benefits of the combination of these policies. According to their estimates, cost savings could be about 9 bn euro per year (Barker et Rosendahl, 2009). Vuuren et al. (2006) estimate that the decrease of air pollution expenditures by 6.6 bn euro per year could be achieved. According to the European Environment Agency (2006), the costs of controlling air pollution could be lowered by 10 bn euro per year.

Conclusions

Coordination or integration of air protection and climate change policies is a new research topic. Both policies have similar goals—reduce the emissions caused mainly by combusting fossil fuels. Other policies are related to the field—energy policy and transport policy. The idea of policy integration is aimed to achieve synergies and cost reduction and avoid antagonistic effects. The estimates based on macroeconomic models indicate significant potential for cost reduction and ancillary benefits resulting from the coordination of policies.

The need and potential benefits of policy integration are widely recognized.

However, in the EU and at national level a multiplicity of strategic documents and multiplicity of agenda can be observed.

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3

Development of residential energy consumption—a comparison of "East" and "West" applied to Czech Republic and Austria

3.1 Introduction

3.1.1 Motivation

A large share of every country's total final energy consumption stems from the residential sector even thoughstraightforward, energy conservation possibilities exist in this sector. But structure as well as growth rates are different in various countries. Hence it is of interest what are the differences in drivers (like income, price...) and slowers like efficiency (of heating systems, buildings, appliances etc.) between different countries.

3.1.2 Objective of this project

This project aims to identify the drivers for residential energy demand in typically (former) Eastern and Western countries by analyzing the differences in development in the Czech Republic (CZ) and Austria (AT).

The following analyses are conducted in detail:

- Documentation of the shares of residential energy consumption in total energy demand;
- Documentation of the historical development and the current state of residential energy consumption and CO_2 emissions in CZ and AT categorized by energy carrier (Coal, biomass, district heating, electricity...) and application (Space heating, water heating, private transport, cooking, electric-specific uses...);

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- Documentation and analysis of structural parameters (m per dwellings, persons per dwellings, number of dwellings categorized by building size (single and multi-family dwellings, number of cars per household ...);
- Documentation, comparison and analysis of some intensity/efficency parameters (e.g., thermal quality of buildings, electricity consumption per appliance, gasoline consumption per car ...);
- Discussion of the impact of energy carrier prices and household incomes;
- Discussion of future trends with special focus on the use of renewable energy.

3.1.3 Background

Residential energy demand in AT as well as in the CZ contribute about 30% (excl. private transport) to total energy demand. As Fig. 3.1 depicts this share in CZ is slightly increasing and in AT slightly decreasing.

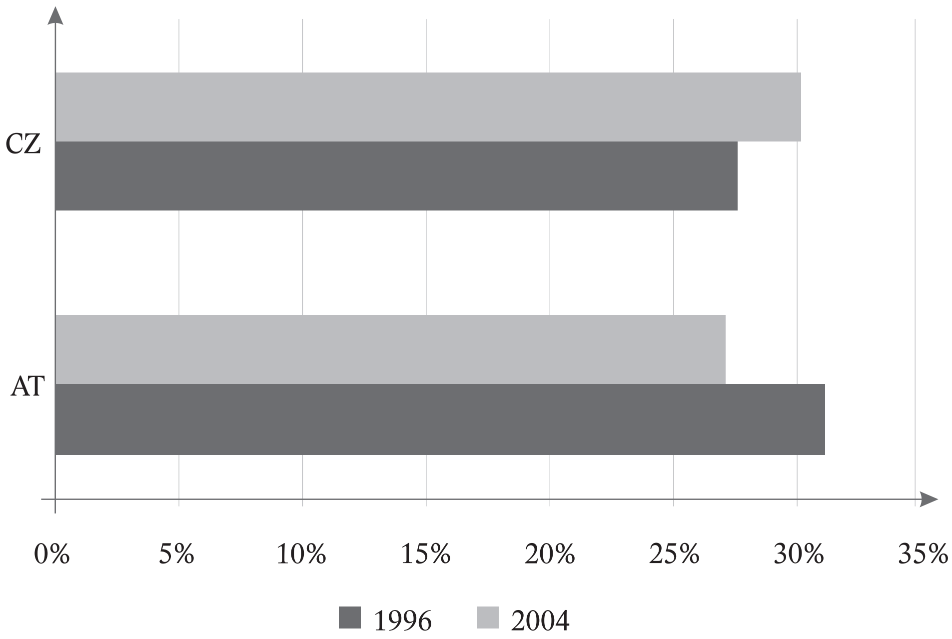


Fig. 3.1: Shares of sectors in final energy consumption in AT and CZ in 1996 and 2004

Table 3.1 documents a comparison of some fundamental structural data. Population grew by 4% in AT from 1991 to 2001, it remained constant in the CZ.

	Austria			Czech Republic		
	1991	**2001**	**Change**	**1991**	**2001**	**Change**
Population (in millions)	7.71	8.02	4%	10.3	10.27	0%
GDP (in billion EUR)		246.0 (in 2005)			100.2 (in 2005)	
Nr. of buildings total (Mio)	1.809	2.046	13.1%	1.8599	1.9696	6.0%
With dwellings (Mio)	1.641	1.830	11.5%	1.597	1.6307	2.1%
Nr. of dwellings total (Mio)	3.393	3.863	13.9%	4.0772	4.369	7.2%
Occupied dwellings (Mio)	2.967	3.315	11.7%	3.706	3.8277	3.3%

Tab. 3.1: Comparison of some fundamental structural data

Fig. 3.2 depicts a comparison of the development of the number of buildings in AT as well as in the CZ, Fig. 3.3 the comparison of the Development of the number of dwellings is described.

3.1.4 Organisation of this chapter

In the next section a comparison of (historical development of) residential energy consumption and CO_2 emissions by fuel and end use (heating, electric-specific, transport) is conducted. In Section 3.3 the major heating-related features of the building stock in CZ and AT are compared.

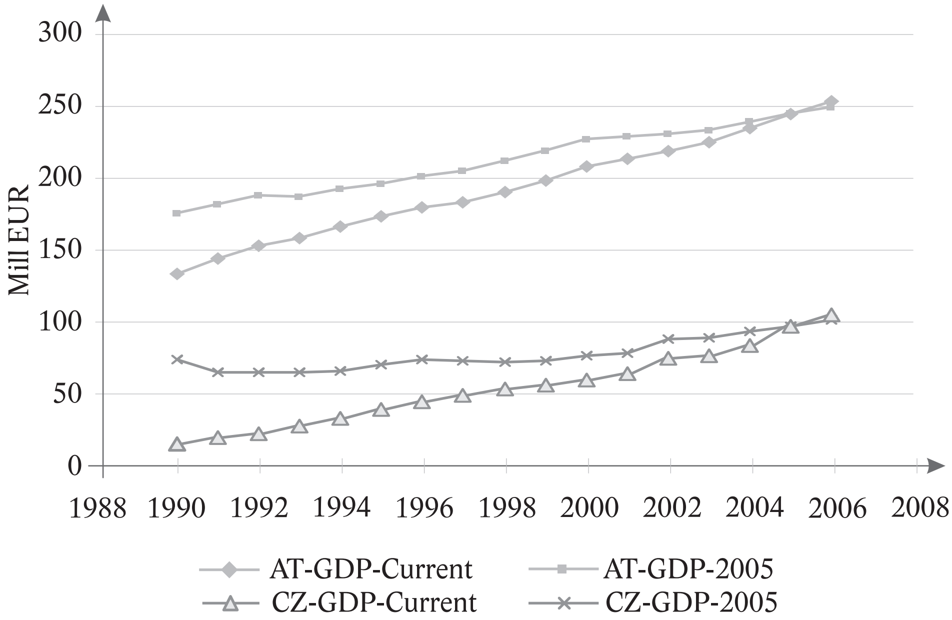


Fig. 3.1a: Comparison of the development of the GDPs (current and 2005 values) in AT and the CZ

3.2 Comparison of (historical development of) energy consumption and CO_2 emissions by fuel and end use 1996–2004

In this section the differences in the absolute magnitude of energy consumption and CO_2 emissions by fuel and by end use, structure (shares) and the dynamic development of end use shares (heating, electricity, and transport) are compared and analyzed. Special focus is put on specific values per capita and on recent trends.

3.2.1 Structure of final consumption of energy—the Czech Republic

Fig. 3.3 depicts the development of the structure of final energy consumption in CZ.

Despite some fluctuation final energy consumption has remained fairly stable after a decrease at the beginning of the 1990s.

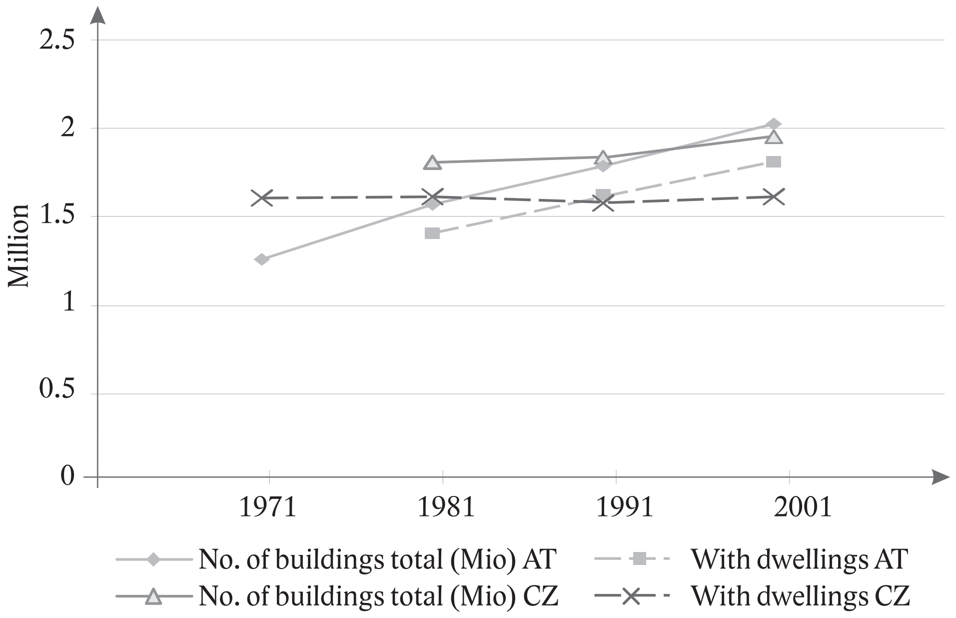


Fig. 3.2: Comparison of the development of the number of buildings

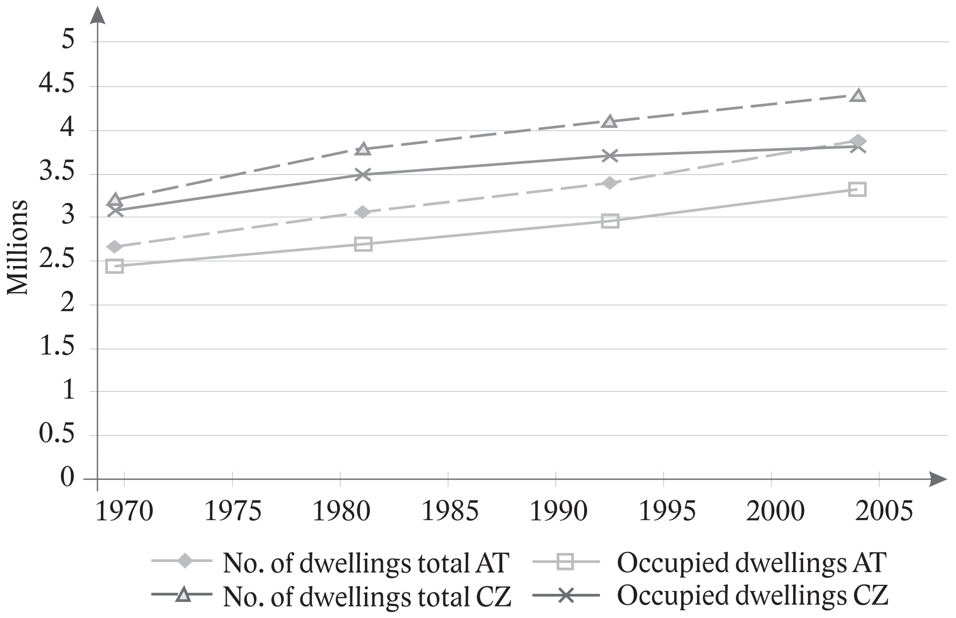
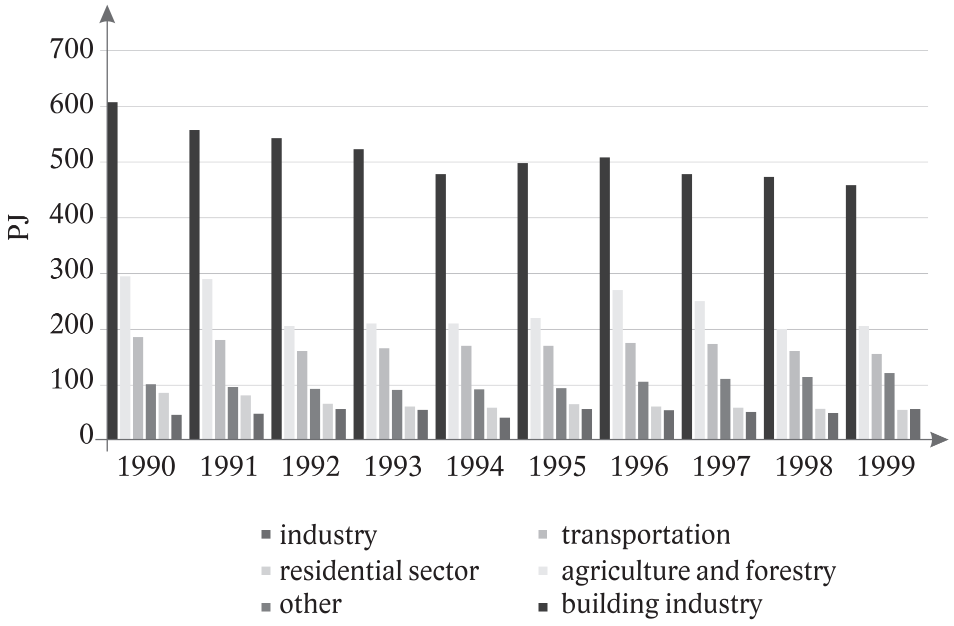


Fig. 3.3: Comparison of the development of the number of dwellings



Source: http://www.czso.cz/csu/2001edicniplan.nsf/t/1300329E0C/ $File/graf5.gif

Fig. 3.4: Development of total final residential energy consumption in CZ from 1990 to 2004

The residential sector consumed about 330 PJ (i.e., 25.4% of total final consumption) in 1990. This decreased to 251 PJ in 1995 (22.9% of total final consumption) and remained practically stable with consumption in 2001 reaching 262 PJ (24.8% of total final consumption)

The changes in the structure of the final consumption in the residential sphere are, however, more important. The following table demonstratesthe especially fast decrease in solid fuel utilization and the rapid increase in natural gas use.

3.2.2 Structure of final energy consumption in Austria

The development of total final residential energy consumption in AT from 1970 to 2004 is depicted in Fig. 3.4. Interestingly, final residential energy consumption has increased continuously since 1986 when oil prices dropped.

	1990	1995	1998	2001
Solid Fuels	47.1	33.0	21.5	18.6
Liquid Fuels	12.8	0.0	0.2	0.1
Gaseous Fuels	15.0	28.9	37.5	40.2
Heat	15.8	16.8	19.2	21.5
Electricity	9.3	21.3	21.6	19.6
Total	100.0	100.0	100.0	100.0

Source: http://www.czso.cz/csu/2003edicniplan.nsf/o/8106-03-1999_2001-vyvoj_palivo_energetickeho_hospodarstvi_ceske_republiky_od_roku_1990

Tab. 3.2: Share of individual fuels and energy on residential final consumption

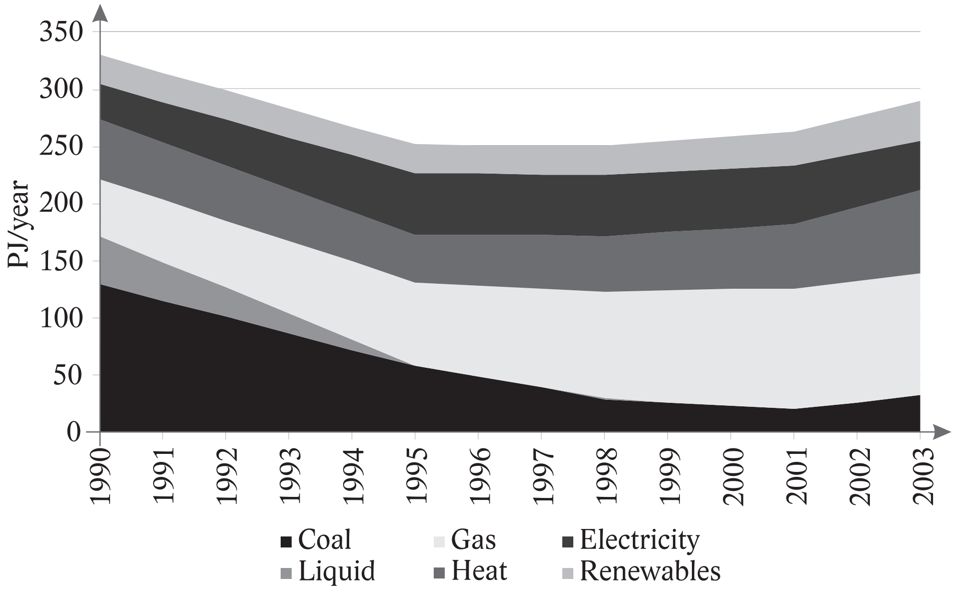


Fig. 3.5: Development of total final residential energy consumption in CZ from 1990 to 2004

3.2.3
Comparison of structure of final energy consumption in Austria and the Czech Republic

The development of total and per capita residential energy consumption in AT and CZ from 1996 to 2004 is depicted in Fig. 3.7. While in AT demand slightly increased in CZ it slightly decreased or at least stagnated.

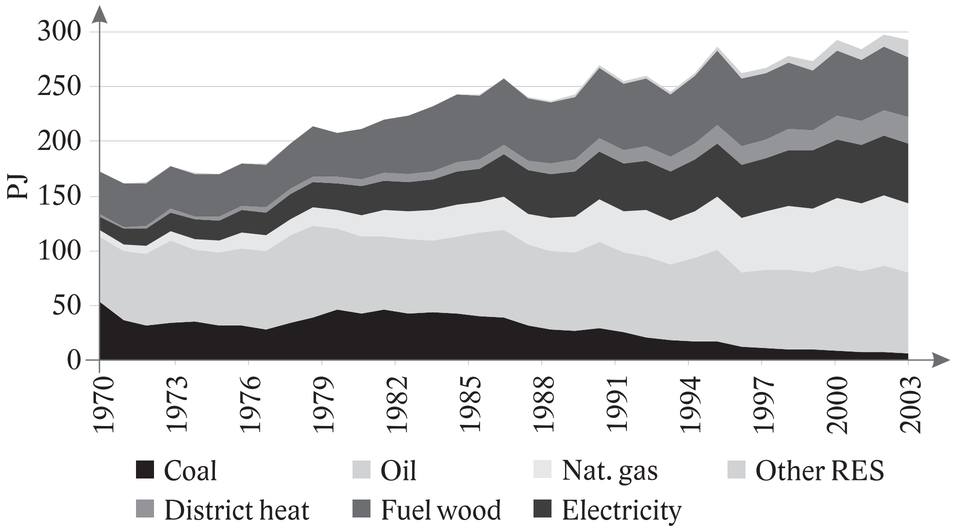


Fig. 3.6: Development of total final residential energy consumption in AT from 1970 to 2004

Specific energy consumption per capita slightly increased in CZ while it remained constant in AT, see Fig. 3.8. Per dwelling energy consumption in CZ slightly increased and in AT it slightly decreased.

The development of residential energy consumption broken down by energy carrier in AT and CZ from 1990 to 2004 is depicted in Fig. 2.6. The high and still increasing share of grid-connected fuels in the CZ is very interesting. In Austria there is a high share of oil products (virtually negligible in the CZ).

In Fig. 3.10a and 3.10b the shares of end uses on total residential energy consumption in CZ and in AT are compared. Surprisingly the shares fit almost perfectly except the split-up between water heating and space heating.

The specific residential energy consumption per household area in AT and the CZ from 1996 to 2004 is depicted in Fig. 3.11. It decreased—in CZ even more—to virtually the same level in 2004 in both countries.

The specific residential energy consumption per capita in AT increased for the total energy as well as for electricity, see Fig. 3.12. In the CZ it markedly decreased.

The development of residential CO_2 emissions in total and per capita from 1997 to 2004 is shown in Fig. 3.13. In 1999 the level of total CO_2 emissions was the same in AT and CZ. Total CO_2-emissions in AT were stagnating while in the CZ CO_2 emissions in 2004 were about 20% lower than in 1999. Residential CO_2 emissions per capita were significantly lower in the CZ than in Austria.

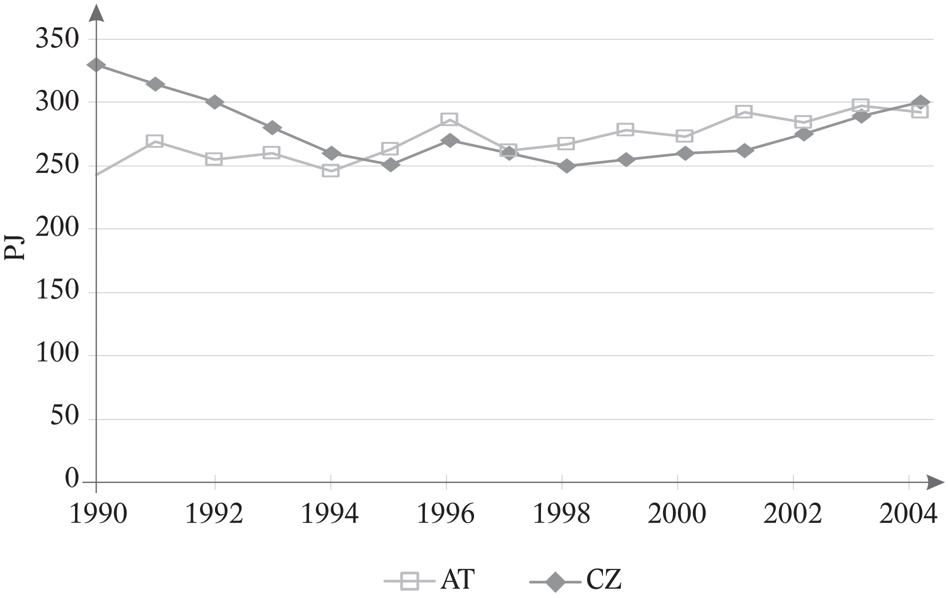


Fig. 3.7: Development of total and per capita residential energy consumption in AT and CZ from 1996 to 2004

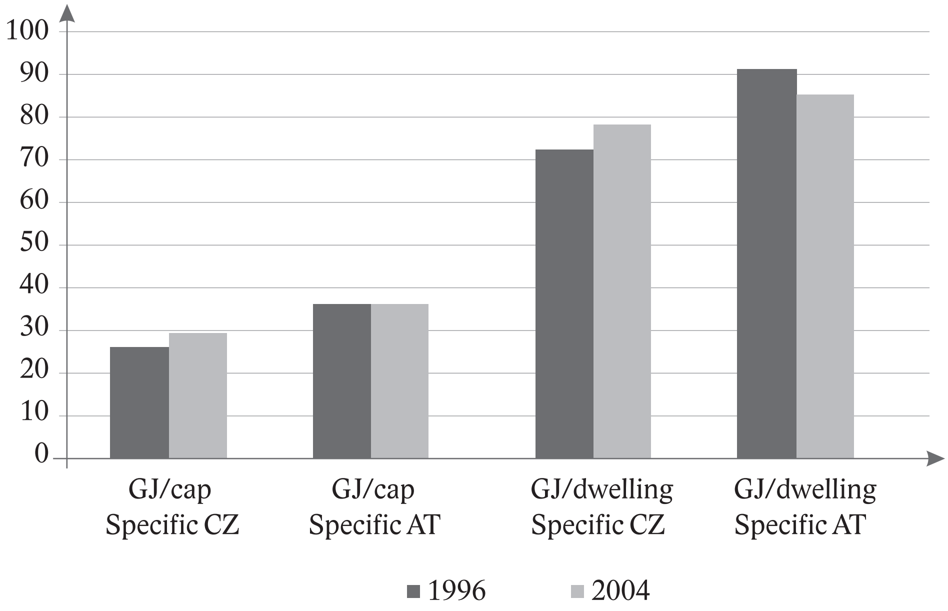
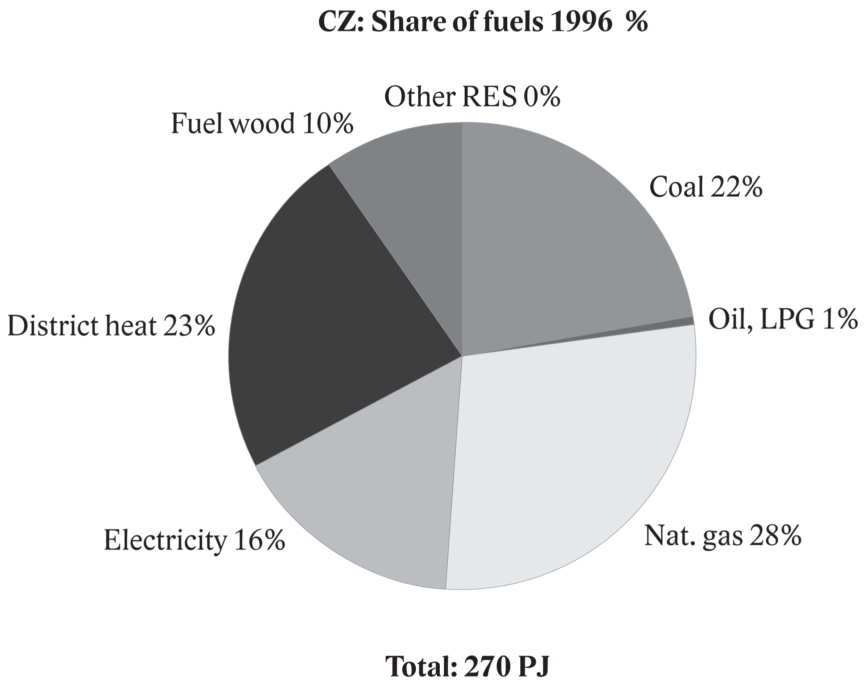


Fig. 3.8: Development of specific residential energy consumption per capita and per dwelling in AT and CZ in 1996 and 2004



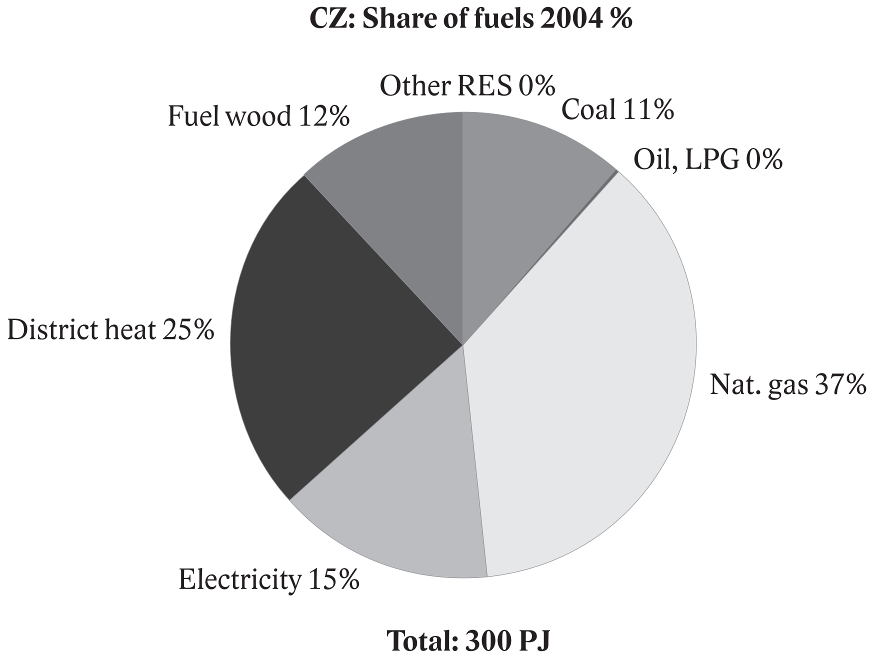
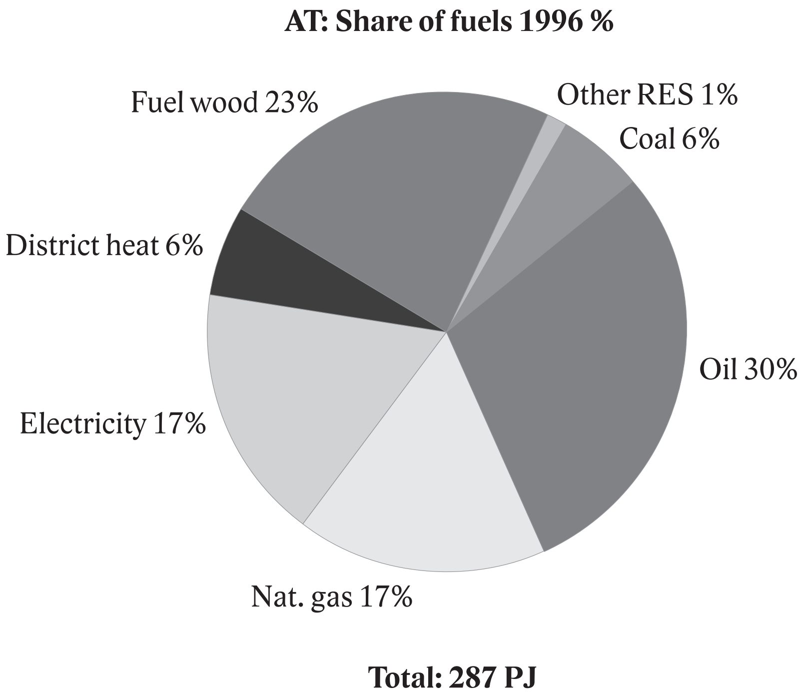


Fig. 3.9: Development of residential energy consumption by energy carrier in AT and CZ from 1990 to 2004 (part 1)



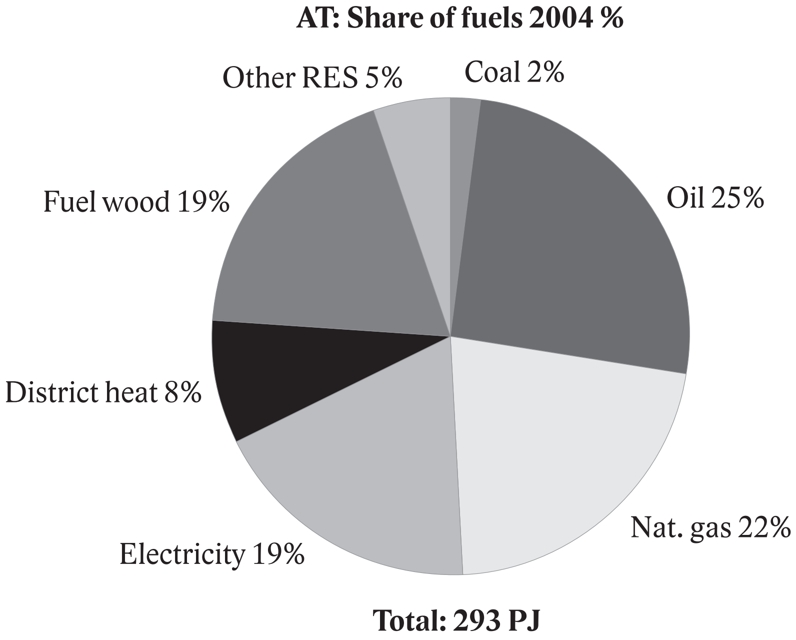


Fig. 3.9: Development of residential energy consumption by energy carrier in AT and CZ from 1990 to 2004 (part 2)

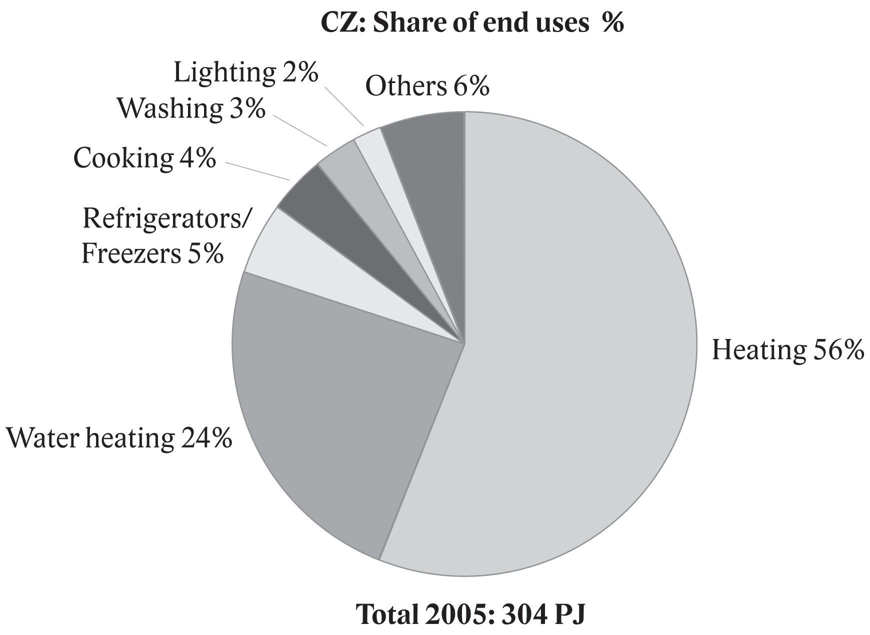


Fig. 3.10a: Shares of end uses on total residential energy consumption in CZ in 2005

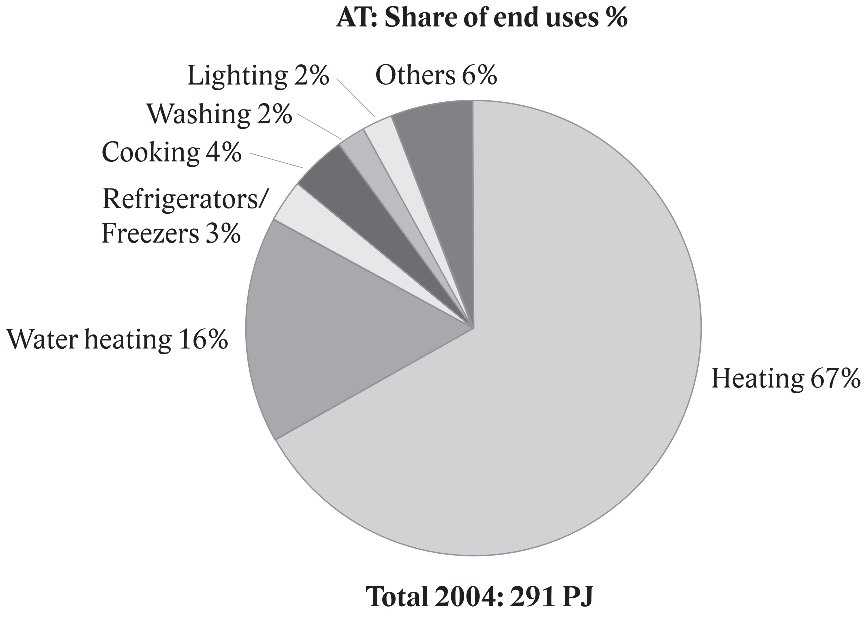


Fig. 3.10b: Shares of end uses on total residential energy consumption in AT in 2004

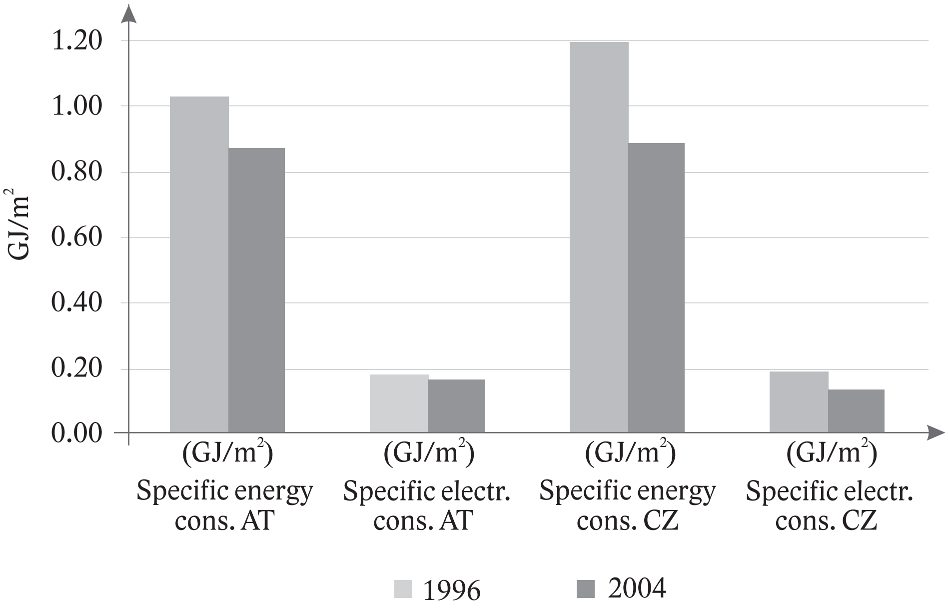


Fig. 3.11: Development of specific residential energy consumption per m in AT and CZ from 1996 to 2004

3.3 Comparison of the building stock in Austria and the Czech Republic and its energy demand due to heating

In this section we discuss the differences and similarities in the building stock between AT and CZ. The major focus is put on structural differences and on thermal performance features.

3.3.1 The Austrian Building stock

3.3.1.1 Data bases for the building sector

"Statistik Austria", the official Austrian statistics institute, is the main data source for the building sector. Since 1951 there is an inquiry in all Austrian households comprising type of building, m of the dwelling(d), number of persons per dwelling, type of fuel used for space heating etc. Additional

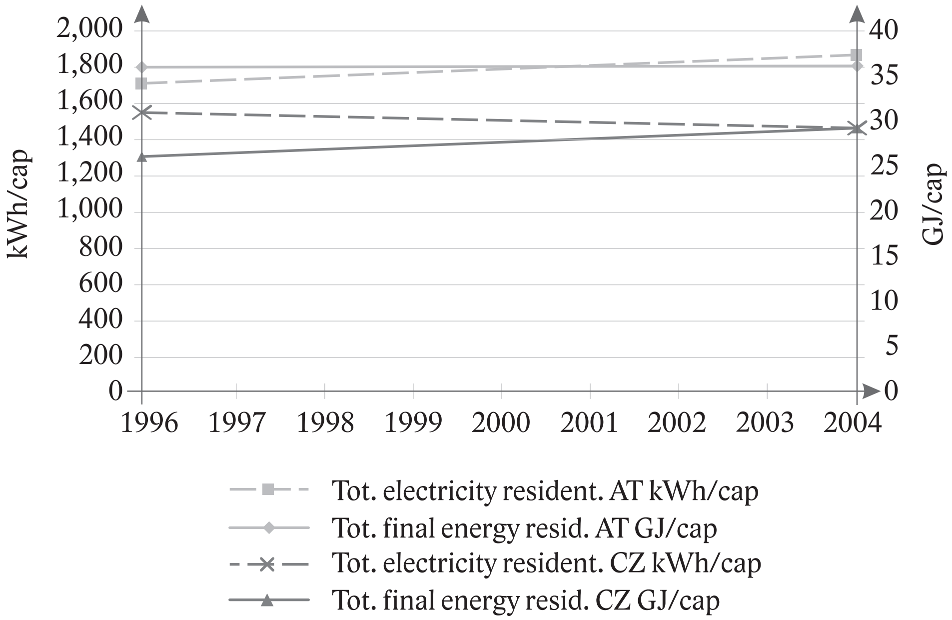


Fig. 3.12: Development of per capita residential energy and electricity consumption in AT and CZ from 1996 to 2004

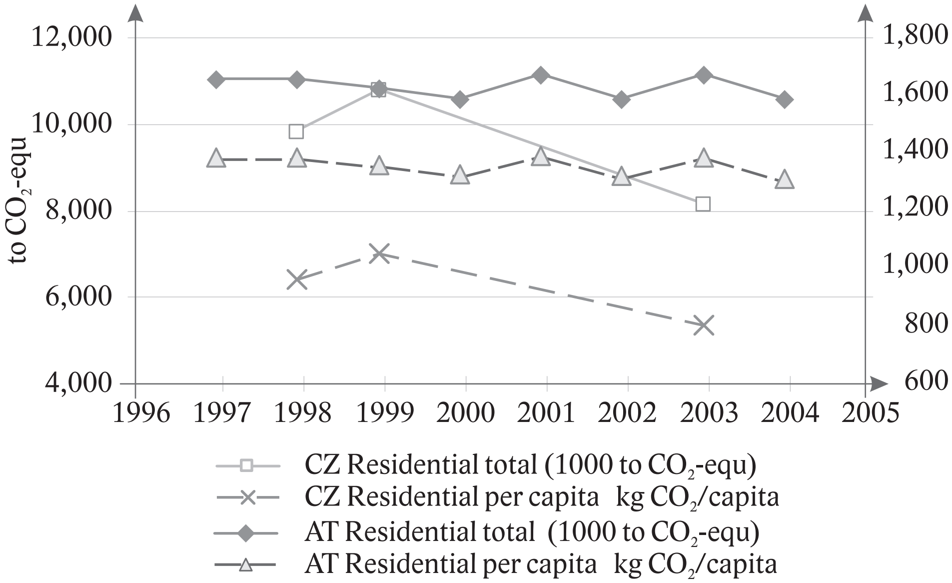


Fig. 3.13: Development of residential CO_2 emissions (total and per capita) in AT and CZ from 1997 to 2004

information can be gained from the statistics of newly built buildings and the so-called “Mikrozensus”, a quarterly sample census. Unfortunately all statistics are related to dwellings. Therefore only limited data is available for non-residential buildings. In general “Statistik Austria” differs between the following building types:

Residential buildings

- 1 or 2 dwellings
- 3 to 10 dwellings
- 11 or more dwellings

Non-residential buildings

- Hotel or similar
- Office building
- Market and trade
- Buildings for transportation or information
- Work shops, industrial building, warehouse
- Cultural, sports or educational building
- Other buildings

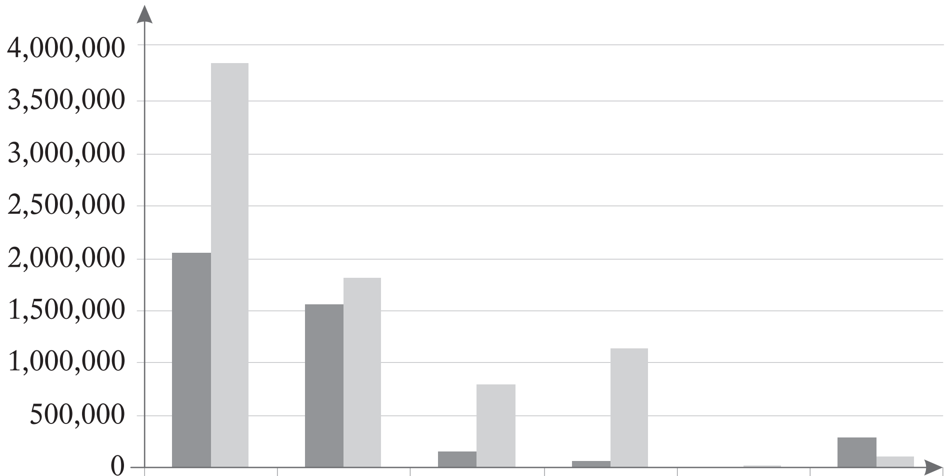
The main data used in this study comes from the following sources:

- Gebäude- und Wohnungszählung 2001 (Statistik Austria (2004))
  The survey of all buildings and dwellings 2001 was conducted for May 15th 2001. Evaluated data include the main use of the building, the structure of ownership, the technical equipment in the dwellings, the size of the dwellings, a block of questions concerning the space heating system and questions about the renting of dwellings.
- Mikrozensus-Sonderprogramm Juni 2000 “Energieeinsatz der Haushalte” (Statistik Austria (2000))
  In this special inquiry the energy carrier, amount of energy used and the costs for energy consumption were evaluated,
- Statistisches Jahrbuch 2005 (Statistik Austria (2005))
  The statistical almanac of Austria comprises demographic, social and economic data of Austria. Additionally special analysis for the building sector is given.

3.3.1.2
The Austrian building stock

The Austrian building stock with about 2 Mio Buildings (3.9 Mio dwellings) is dominated by buildings with one or two dwellings (about 76% of all buildings but only 47% of all dwellings belong to this category). About 50%

of the dwellings are in buildings with three and more dwellings. The rest are dwellings in non-residential buildings (see Figure 3.14).



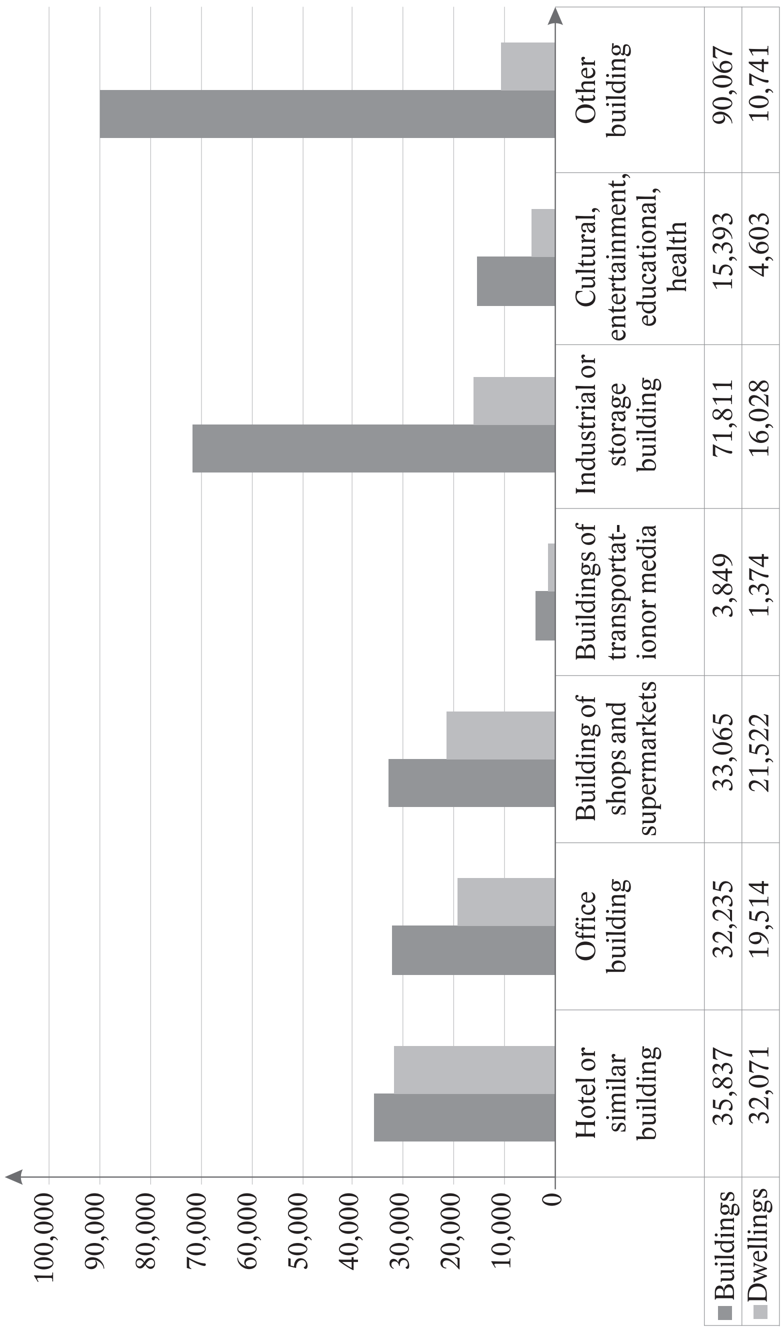
	Total	1 or 2 dwellings	3 to 10 dwellings	11 or more dwellings	For associat-ions	Non-residential buildings
Buildings	2,046,712	1,557,420	142,351	61,196	3,488	282,257
Dwellings	3,863,262	1,809,380	791,584	1,134,782	21,663	105,853

Source: Statistik Austria (2004)

Fig. 3.14: Buildings and dwellings per building type 2001

The number of non residential buildings shown in Figure 3.15 is one order of magnitude smaller than the residential buildings. Mostly the function is not known. The second largest number belongs to the group of industrial buildings. Hotels, office buildings and shops/supermarkets have the same number of buildings with in total about 1.5 times the ones of industrial buildings. Nevertheless, for non residential buildings the main building categories with dwellings are hotels, office buildings and buildings with shops and supermarkets.

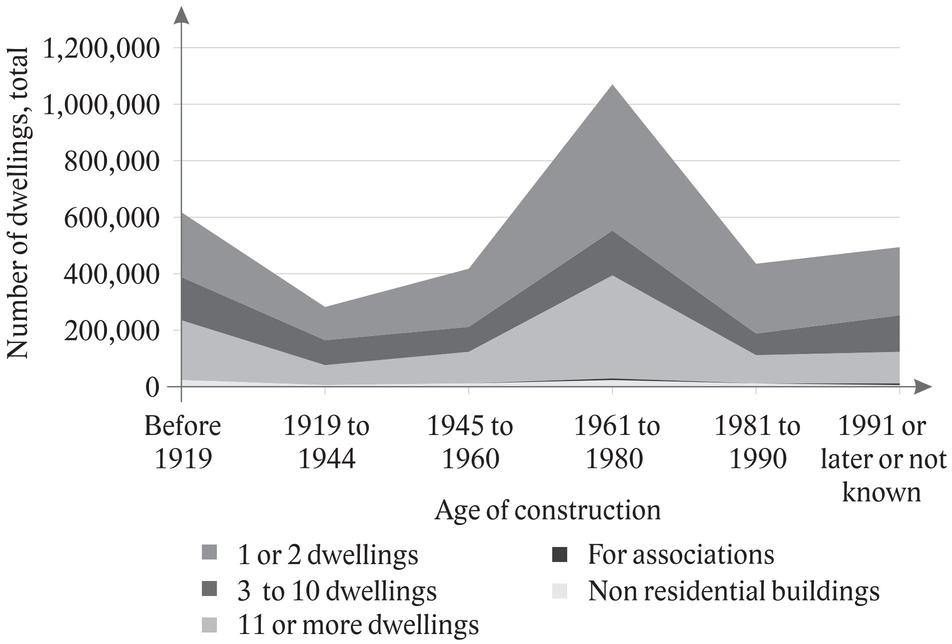
The largest building activity was in the years 1961–1980 and lays since then on high rate. Most of the buildings are houses with one to two dwellings. For multi family houses from houses with more than 10 dwellings dominate until 1980. After 1991 there was a trend to smaller houses with 3–10 dwellings (Figure 3.16).



	Hotel or similar building	Office building	Building of shops and supermarkets	Buildings of transportat-ionor media	Industrial or storage building	Cultural, entertainment, educational, health	Other building
Buildings	35,837	32,235	33,065	3,849	71,811	15,393	90,067
Dwellings	32,071	19,514	21,522	1,374	16,028	4,603	10,741

Source: Statistik Austria (2004)

Fig. 3.15: Non residential buildings



Source: Statistik Austria (2004)

Fig. 3.16: Number of Austrian dwellings per building type and age

3.3.2
Existing housing and dwelling stock size in the Czech Republic

3.3.2.1
Total number of buildings

The Czech Republic (CZ) today has about 2 million houses[1] in total. A decisive part of which (more than 1.6 million) is used for permanent residence[2]. Over 86% of these houses are family houses[3] (1.4 million), 12% (195 thousand)

[1] *A house is here and throughout the whole text understood to mean a construction or part of a construction, which has an independent entrance and own number.*

[2] *This is understood to mean that at east one person is registered as having their permanent residence here.*

[3] *A family house is here and throughout the text meant a residential building which has at maximum three independent flats and two over ground and one underground floors; this category includes family houses, which are detached, terraced, semi-detached and also those houses, which are used for recreation purposes.*

then multi-family or apartment houses[4]. The remainder (29 thousand) are other types of houses[5].

As for the dwelling stock it now includes almost 4.4 million flats[6]. From this figure, about 88% of flats, or more than 3.8 million, are used for permanent residence, only about an eighth (539 thousand) is at the moment classed as uninhabited. 2,160 thousand permanently inhabited dwellings are situated in apartment houses, of which nearly 1.2 million being in HRRBs (i.e., prefab buildings), and 1.635 thousand then in family houses, the rest (35 thousand) being in the houses used for other than entirely residential purposes.

Whereas during 1960–1990 the increase in the housing and dwelling stock was predominantly realized through the collective housing construction using largely prefabricated panel technology, after 1990 the situation fully changed and new housing construction was mainly done by individuals.

3.3.2.2 Share of multi-family houses

A significant share of the Czech housing and dwelling stock has been built in the form of multi-storey residential buildings. According to the Public Census in 2001, nearly 150 thousand residential houses in the CZ have been built with 3 or 4 floors (including ground floor) and over 80 thousand with 5 or more stories.

It is these houses, with five or more floors, that are called here and throughout the whole text as **high-rise residential buildings** or **"HRRBs"**. And to a large extent they have been constructed using prefabricated (panel) technology.

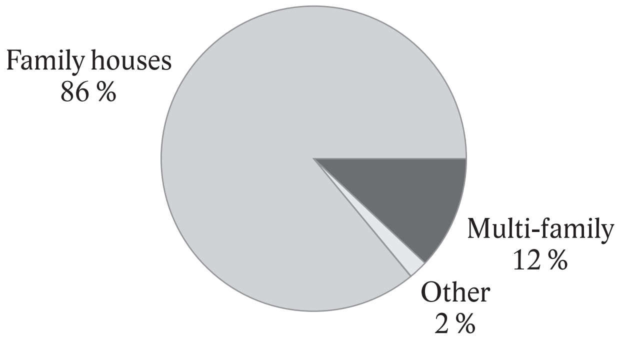
The first prefab houses in the CZ were built at the end of the 1950s and their construction was undertaken until 1990/91, when the last buildings were completed. The highest prefab housing construction was recorded between 1966 and 1975.

[4] *An apartment house is here and throughout the text meant a residential building, which has several flats accessible from a common entrance or stairway that is not a family house.*

[5] *Others include all other properties, which serve various purposes, meaning administrative buildings, health and social care institutions, accommodation and recreation facilities etc.*

[6] *A flat is understood to mean a collection of rooms (or as the case may be one room for habitation), which fulfils the technical construction layout of which and fittings fulfil the requirements for permanent residence and are intended for this purpose (§ 3 letter l) decree of the MMR No. 137/1998 Col., concerning general technical requirements for construction).*

Total number of houses	1,969,018	
Of which permanently occupied:	1,630,705	
Divided according type of housing:		
– Family houses	1,407,248	(see fig.)
– Multi-family (apartment) houses	194,826	
– Other	28,631	
Divided according material of walls:		(of which family/ apartment houses)
– Profiled bricks	991,080	(875,362/102,551)
– Stone and kiln bricks	432,181	(400,149/22,257)
– Panel, reinforced	79,867	(12,695/65,457)
– Other	113,088	(107,745/3,677)
Divided according time of construction:		(of which family/ apartment houses)
– Before 1900	135,218	(118,141/12,161)
– 1900–1945	446,041	(398,460/40,226)
– 1946–1990	855,024	(717,452/128,692)
– 1991–2001	171,092	(154,936/11,448)



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Tab. 3.3: Basic figures on extent and structure of present housing in the CZ as of 1.3. 2001 (Source: Czech Statistical Office—CSU, Public Census, 2001)

In total, more than 62 thousand panel buildings have been constructed in the CZ during this period, and almost 1.2 million households live in them nowadays.[7]

Panel buildings were usually built with 5 to 8 floors (the highest have 13 stories).[8]

Throughout the time 14 basic (nation-wide) types of prefabricated construction technologies were gradually developed and used for prefab housing construction, which were on a regional level further modified according to local conditions (esp. as far as building materials used are concerned) creating approximately 70 different types of panel-built houses.

Prefab houses have been more or less equally built by the government (51.8%) and housing cooperatives (48.2%). However, in their case it was rather based on the "assignment" (and with subsidies) of the State administration which, for the achievement of the state housing development plan, renewed the cooperative concept in order to meet demand for new housing construction steeply rising esp. in the late 1960s and early 1970s.

Year of construction	Number of flats [thous.]
1959–1960	58.7
1961–1970	344.8
1971–1980	467.1
1981–1990	294.4
Total	1,165

Source: Ministry for Regional Development (MMR)

Tab. 3.4: Number of flats in HRRBs built in the CZ during 1959–1990

7 In terms of the Public Census in 1991 a total of 62,456 houses built in prefabricated technology were registered in the Czech Republic with 1,165 thousand permanently inhabited flats (Source: MMR bulletin no. 1, 2000)

8 Further in the text any residential house with at least 5 stories incl. ground floor is called as the high-rise residential building or just "HRRB". According to estimates over 80 thousand residential buildings with 5 or more stories have been built in the CZ so far, of which about 75% (more than 60,000) being houses built in prefabricated technology as mentioned above.

3.3.3
Comparison of the Czech and Austrian building stock

Housing and dwelling stock is about the same size in Austria and the Czech Republic (4.3 Million dwellings in the Czech Republic and 3.8 million dwellings in Austria). In both countries there is a steady increase in the number of buildings as well as in the number of dwellings (see Figure 3.17).

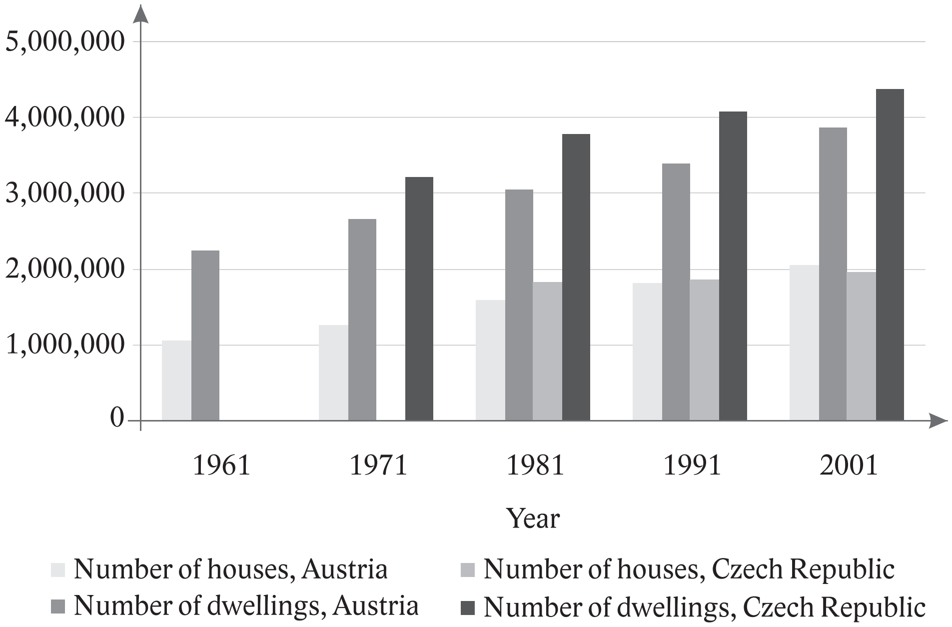

Fig. 3.17: Number of houses and dwellings in Austria and the Czech Republic

If we look in more detail, however, significant differences exist. Whereas in Austria there was nearly the same number of single and multifamily houses with both steady increasing from 1970 to 1990, the share of multifamily buildings have increased since then. In the Czech Republic there seems to be a slightly different situation. Single-family houses dominated until 1970 but their number slowly decreased from 1960 to 1990. Afterwards a slow increase occurred. The number of dwellings in multi-family homes on the other hand had a steep increase and have become the dominating dwelling type since 1980. The increase stopped in 1990 (Figure 3.18).

As the increase of the number of dwellings is higher than the population growth rate, the number of persons per dwelling decreases steadily in both countries. Additionally dwelling size increases in both countries (Figure 3.19).

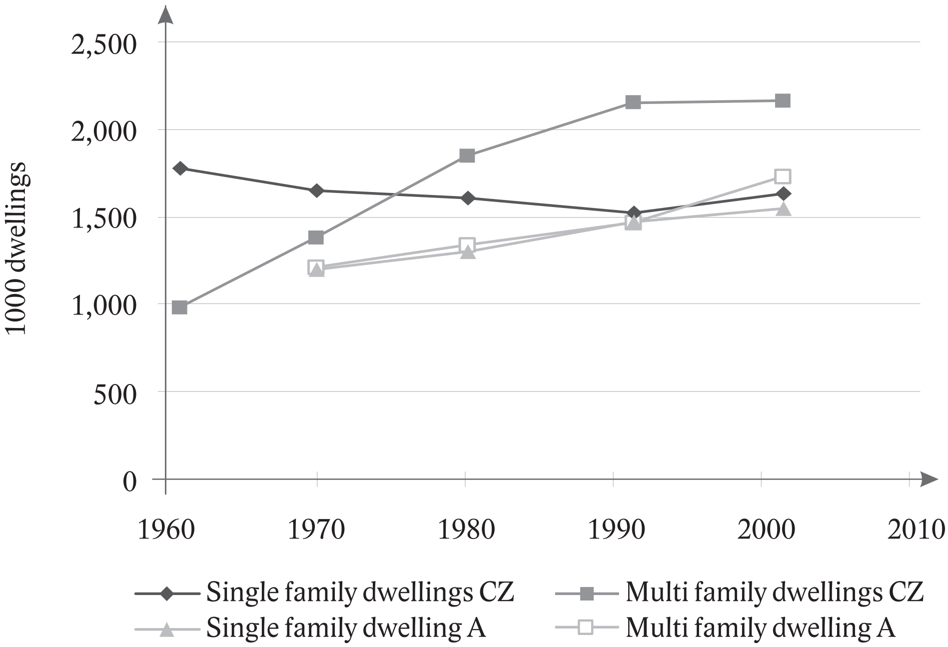

Fig. 3.18: Development of single- and multi-family dwellings in Austria and the Czech Republic

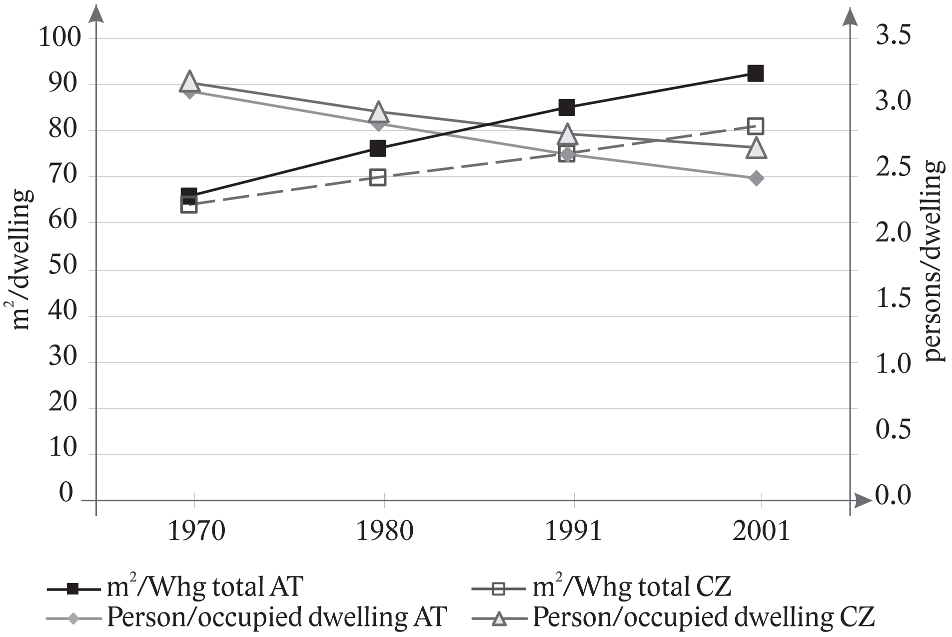

Fig. 3.19: Number of houses and dwellings in Austria and the Czech Republic

3.4
Electricity consumption by end use 1990–2004

In this section the historical development of electricity consumption by end use and appliance (1970(1990?)–2004) (saturation of appliances, specific demand by appliance...) differences in the absolute magnitude of electricity consumption by end use, structure (shares) and the dynamic development are analyzed. Special focus is put on specific values per capita and on recent trends.

The development of Residential electricity consumption is depicted in Fig. 3.20. There is is a significant decrease from 1996 to 2003 in the CZ while in Austria electricity consumption continuously increased.

Specific residential electricity consumption per capita and dwelling is depicted in Fig. 3.21. Per capita consumption grew in AT and slightly decreased in CZ and the same effect can be observed for Per dwelling consumption

Fig. 3.22 depicts the development of the saturation of major appliances in AT and CZ from 1995 to 2003.

Conclusions

In principle total energy consumption patterns in the residential sector in the CZ and AT are rather similar. Yet the underlying drivers and their dynamic development are quite different. While in Austria energy prices are still significantly higher than in the CZ the available income is also higher and so compensates—to a large extent—for the higher prices. In the CZ income as well as prices are rapidly catching up. It seems that the steep increases in prices in the CZ in the last years led to a reduction in Residential energy as well as electricity consumption. (Further conclusions to be derived after the verification of the Czech data).

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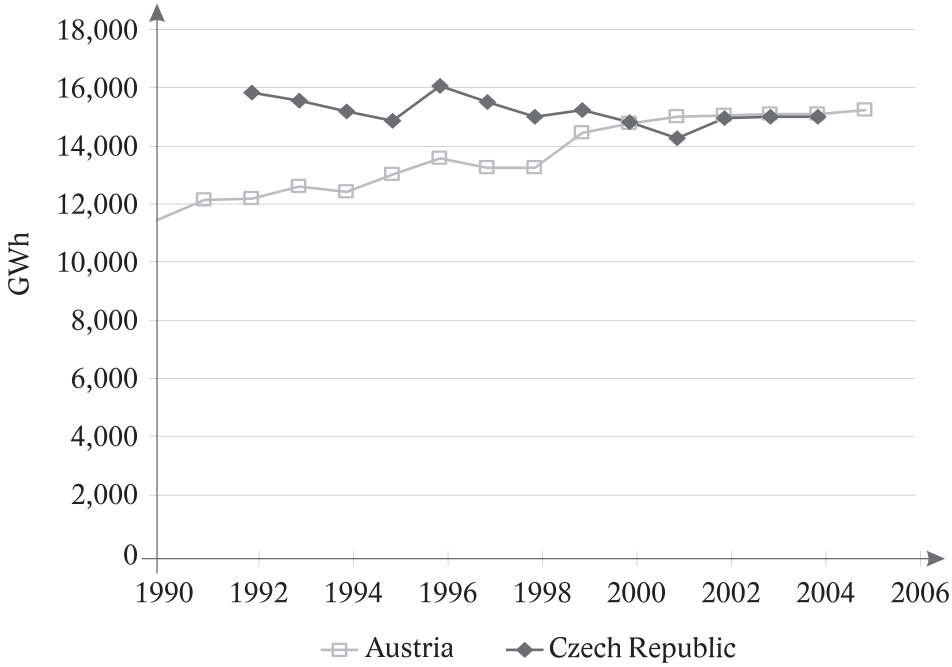

Fig. 3.20: Development of total residential electricity consumption in AT and CZ from 1990 to 2004

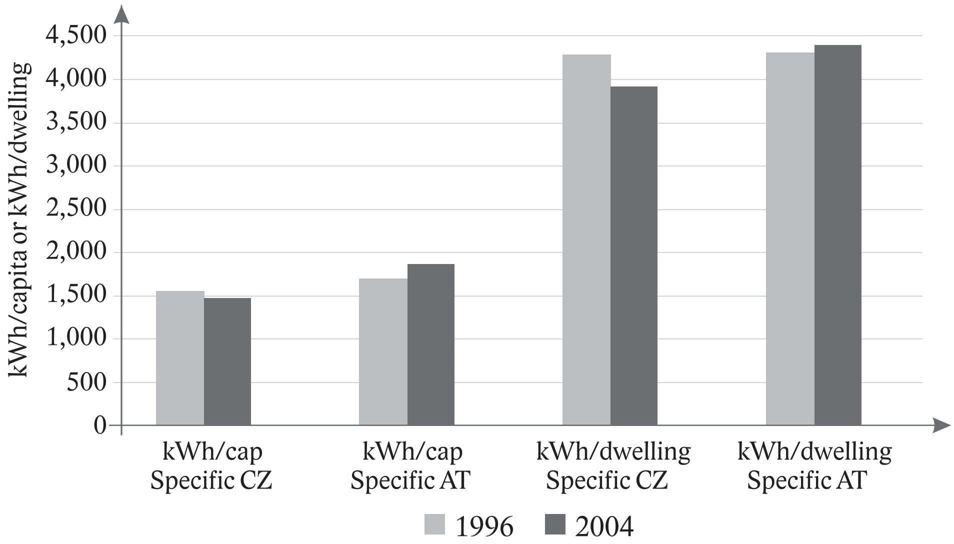

Fig. 3.21: Development of specific residential electricity consumption (per dwelling and per capita) in AT and CZ from 1990 to 2004

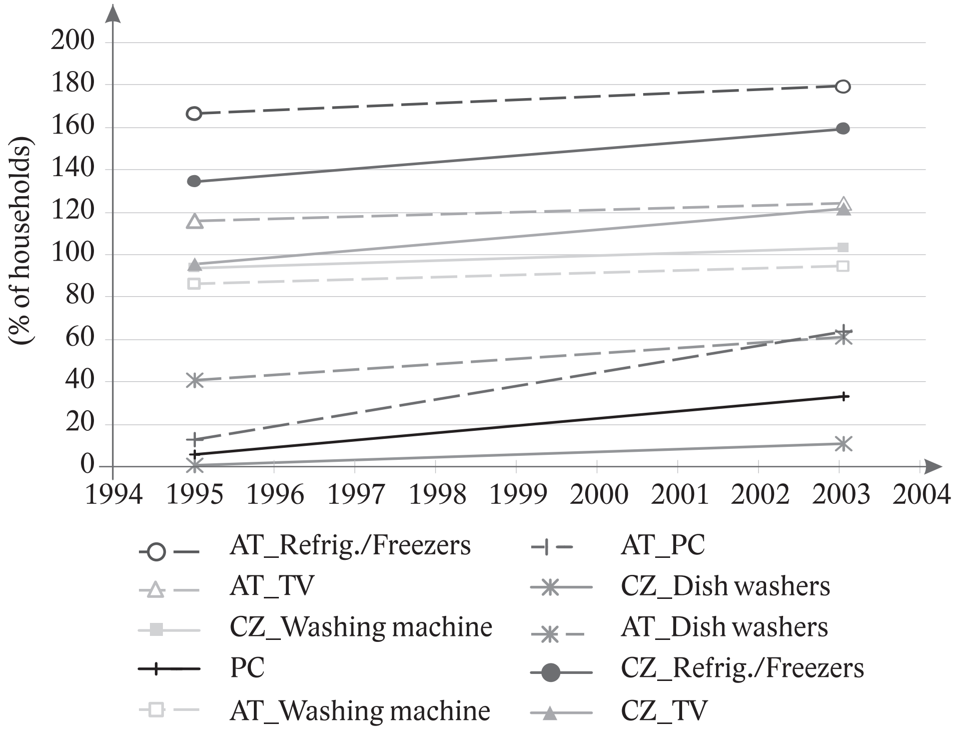

Fig. 3.22: Development of the saturation of major appliances in AT and CZ from 1995 to 2003

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4

Concept of "energy poverty" and multi-dimensional perspectives of social inequalities and their impacts: Case of the Czech and Slovak republics

4.1 Introduction

Social inequalities have been steadily increasing all over the world (OECD 2008). Steep rises in global energy demand and costs, and the acceleration of income inequalities at an international scale are among the key contributing factors in this trend. In this chapter we deal with social inequalities as reflected in access to energy—to the basic resource important for life and participation in the society. To study the affordability and access to energy based on social characteristics of households, concepts of energy or fuel poverty were introduced in literature and policy practice.

Fuel poverty research as originally started in the UK in the beginning focused on fuel for heating. In the last years, however, it also has included spending on energy for water heating, lights and appliances and cooking. In the chapter we operate with the term energy poverty, while we refer to the term fuel when it is used in other reports or publications. In this case we also refer to what is the coverage of data analyzed. Even if the research specifically focuses on fuel and does not include electricity it provides valuable information (bearing in mind that around 80% of energy in Central European households is usually used for heating purposes).

Poverty is a complex issue, requiring for its analyses and understanding a very broad range of approaches, data collection and research methodologies. Besides research on more "traditional" forms of social inequalities (e.g., access to education, or labor market) we may find additional perspectives when looking closely at the people in risk-of-poverty. These may require research of other poverty dimensions. One of them is access to energy as a basic resource for life and participation in modern societies in developed countries. This is of special importance for the countries of Central and Eastern Europe (CEE) where the economic transformation has radically changed not only the energy sector, but also welfare systems and where we see rather rapid growth of social inequalities.

Yet energy poverty is not limited to the CEE, but is pan-European problem. An estimated 50 to 125 million people in Europe are affected by fuel poverty. This number may increase due to the high pressure that is exerted on conventional energy as their prices will continue to grow and the number of households that can no longer cope with their energy bills will rise (EPEE 2008). Energy poverty, a painful symptom of social inequality, is linked to social exclusion and serious health impacts—including excess winter mortality rates (Clinch/Healy 2000, Healy 2003). It is problem of social impacts on the affected households, or environmental consequences of some of the coping strategies of the energy poor.

The key problem is the percent of expenditures from the total household budget spent on energy consumption and the ability/inability to pay for this consumption. As we will argue, energy prices have been steadily growing over the years (although there are signs that the global economic crisis has been slowing this trend). These energy prices are (or are gradually becoming) a burden, especially for low-income households and people in the risk-of-poverty.

Yet, the problem arises with how to set up thresholds for households that are in energy poverty and how to define it (the threshold or energy poverty? or both?). When can we say that a household is in energy poverty? How much expenditure on energy from the total household budget should be considered as imposing problematic burden on the consumers? To assess the scope, forms and impacts of the problem, different concepts and definitions of energy (or fuel) poverty have been developed in different countries and by different scholars and/or governments.

"Fuel poverty" is the term used predominantly in the UK, while other scholars doing research in Europe have adopted the term "energy poverty". One of the first European countries that started with the systematic research of the problem is the UK. The Fuel Poverty Index (FPI), developed in the UK, is when the ratio of required fuel cost to disposable household income exceeds 10%. The term "energy burden" is used largely in the US, where the focus of policy action is on households faced with the threats of disconnection and those in poverty. To emphasize more the solution instead of the problem, the problem has also been referred to as, "affordable warmth." We will analyze these different concepts later in the chapter. Here we will be using the term energy poverty defined as the inability to heat households to an adequate temperature (safe and allowing normal activities of people in the household), and/or inability to bear expenditures for electric energy needed for basic operation of the household.

As pointed out by Barnes/Toma (2006), reducing barriers in access to energy is an important condition in addressing poverty. Energy poverty is not only a problem of the total number of people living in poverty, but it is especially a problem of poverty affiliated with certain life stages. Retired people, single parents, unemployed, or families with children are among the most vulnerable. Any energy policy analysis, as well as policy action must therefore take into consideration these aspects.

The chapter opens with a description of research and data on energy poverty in Europe. Methodological aspects in energy-poverty research are discussed and available definitions analyzed. We discuss possible approaches and data sources for research and analyses. Based on the discussed theoretical framework, the chapter explores the situation in the Czech and Slovak republics. Given the absence of comprehensive studies of this phenomenon in both countries, the case studies build on specific proxy data available for each. Case studies provide estimation of the potential scope and impacts of fuel poverty and outline possible paths of further research.

An important factor in energy poverty is energy consumption—i.e., energy efficiency of households. We will discuss four main categories of households from the perspective of income/energy efficiency factors. Then we argue that access to energy is also an important aspect of environmental protection reflected in the problem of illegal logging and timber trade, or indoor/outdoor air quality caused by burning low-quality fuel. There are many ways of addressing energy poverty. In the last part of the chapter we discuss schools of thoughts upon which we may build structural policy responses to the phenomenon. Several examples from different countries (and involving different stakeholders) are discussed.

4.1.1
Energy poverty in the European context

The risk of energy poverty in Europe is increasing. Commission President Jose Manuel Barroso asserted that, “Rising fuel prices are squeezing the purchasing power of all EU citizens, with the strongest impact on the lowest-income families in Europe.” (Reuters 2008). Twenty percent of households in North Rhine-Westphalia (the most populous German Bundesland state) currently have difficulty paying their heating and electricity bills. In Germany, 840,000 power cuts are imposed in the space of one year (Schlüns 2008). Government-sponsored studies in the UK indicate that as many as 3.5 million households are fuel poor. These numbers indicate that the problem is rather deep and affecting a significant number of households.

Access to energy has been studied in detail especially in the UK and Ireland. Extensive literature on fuel poverty has been written (Boardman 1991, Green et al. 2000, Healy 2001, Healy 2002, Boardman et al. 2005). In the UK fuel poverty research is based on very extensive and regular surveys of households *(The English House Conditions Survey)*. Data indicate a rather dynamic development of fuel poverty. While fuel poverty decreased in the UK between 1996 and 2006 by around 2.25 million vulnerable households (approximately 11.5% of households), rising energy prices and other factors contribute to its increase. Not surprisingly, the most affected are families with children, the elderly, and unemployed. The 6th Annual Progress Report (DEFRA 2008) shows that 2006 was the second consecutive year in which the number of fuel-poor households in the UK rose. In 2006, there were approximately 3.5 million households in fuel poverty, an increase of around 1 million households since 2005 (DEFRA 2008). These trends are illustrated in Table 4.1.

	2002	**2003**	**2004**	**2005**	**2006**
Total Fuel Poor	1.4	1.2	1.2	1.5	2.4
Vulnerable	1.2	1.0	1.0	1.2	1.9
Non-Vulnerable	0.2	0.2	0.3	0.3	0.5
Social Housing	0.3 (0.7)	0.2	0.2	0.2	0.4
Private Housing	1.1 (1.3)	1.0	1.0	1.3	2.0

** All values in millions.*

Source: Adopted from DEFRA 2008.

*Tab. 4.1: Numbers of Households in Fuel Poverty in England 1996–2006**

Interesting data and analyses can be found in the 2008 European *Fuel Poverty and Energy Efficiency Poverty Project* (EPEE 2008). The project aimed to increase knowledge and understanding of fuel poverty causes and effects and to devise some effective operational mechanisms to tackle them. The survey of fuel poverty involved France, Belgium, Spain, UK and Italy. The project evaluated the scope of fuel poverty in each country by analyzing 3 variables from the EU-SILC surveys (an annual, EU-wide, survey conducted in countries as part of an EU-wide program to obtain information on the income and living conditions of different types of households):

- HH050: Ability to pay to keep one's home adequately warm;
- HH040: Leaking roofs, damp walls/floors/foundation, or rot on window frames/floors;
- HS020: Arrears on utility bills (electricity, water, gas).

Based on modeling outcomes of the three variables they concluded that the number of households living in fuel poverty in the UK was 1.2 million households (i.e., 5.9%) in 2003. This figure reached 2.47 million (i.e., 11.8%) in 2007. In Italy, the number of households in fuel poverty more than doubled (from 2.1 to 5.3 million), because the highest percentage (23%) is linked to the state of the accommodation (dampness, leaks, mould). In France the number of these households doubled (from 1.59 to 3.13 million), and the highest percentage (12%) was linked to the state of the accommodation (dampness, leaks, mould). In Spain the number of households quintupled (from 0.5 to 2.6 million), and again, the highest percentage (17%) relates to the state of the accommodation (dampness, leaks, mould).

It is very interesting to compare the ability to pay to keep one's home adequately warm. The percentage with problems to reach an adequate temperature was smallest in the UK (5.79%), followed by France (6.29%), Spain (9.09%), Italy (10.9%) and Belgium with 14.6%. In each of these countries the survey found strong correlation between life cycle and fuel poverty. Unemployed, single-parent families, and the retired are among the most vulnerable groups in these societies. The survey concluded that the three main causes of fuel poverty in the countries involved are low income, dwelling characteristics and the energy price. Dwelling characteristics are in direct relation to the energy efficiency and (as we will explore later in the chapter) strongly influence energy poverty of households.

Only indirect data on Central and Eastern Europe are available, but they indicate that the scope of the problem is significant and increasing (e.g., EU-SILC household surveys). For example, comparative UNDP research of human development in Hungary and Slovakia, conducted in 2004, indicates that many households vulnerable to poverty face great difficulties in covering their utility bills, such as water, electricity, and gas; and they accumulate unpaid bills for several months. The average outstanding utility bill sometimes amounts to more than 175% of their total monthly expenditures (UNDP 2005). Buzar (2007) undertook comparative analyses of Macedonia and the Czech Republic concluding that energy poverty is a present and serious problem for lower income households in both countries. A field survey of randomly sampled rural shantytowns in Eastern Slovakia conducted between 2004–2006 indicates that access to energy is a problem especially for marginalized communities and has strong social and environmental impacts (Filcak 2007). These energy poverty aspects are further explored in the subsequent sections and discussed using the case studies of the Czech and Slovak republics. Yet, the very fundamental question remains as how to meaningfully and practically define energy poverty.

4.1.2 Defining energy poverty

Individual countries of the European Union approach the problem in different ways and using different approaches (Dubois 2007, Schlüns 2008, EPEE 2008a). There is no single European methodology that would complexly evaluate the scope and impacts of this problem, while paying special attention to the most vulnerable households such as unemployed, marginalized ethnic minority, or single parents. These people are most likely to live in low standard houses and be affected in their access to energy. In most of the European countries (and particularly in the new member states) recognition of this phenomenon as a complex issue is lacking despite that access to energy or problem with payment for services is present in many qualitative and quantitative household surveys (UNDP 2002, GAC 2006, Steger et al., 2007, Filadelfiova et al. 2007a).

The systematic survey of households in the UK builds on the definition that a household is said to be in fuel poverty if it needs to spend more than 10% of its income on fuel to maintain a satisfactory heating regime (usually 21 degrees for the main living area, and 18 degrees for other occupied rooms). The "Fuel poverty ratio" is therefore defined as: Fuel poverty ratio = fuel costs (usage x price) $\div$ income (DECC 2009).

According to DECC (2009), in the calculation of this ratio, the fuel usage is modeled to ensure the household achieves the satisfactory heating regime. Therefore, if the dwelling is actually heated to a temperature below the level defined as being satisfactory, the estimated bill for that household will be higher than the actual bill and vice versa. In addition to space heating, the methodology includes also the fuel costs component through modeled spending on energy for water heating, lights and appliances and cooking.

Empirical analyses in France, Spain and other European countries point to the problem of defining fuel or energy poverty too narrowly. It may comprise more dimensions and its scope evaluation should not limit itself into the area of income defining versus calculating percentage spent on energy. A high share of household income spent on energy does not necessarily mean problems with bills, and vice versa. Paying less for energy does not automatically mean that the household is free from payment problems.

The European Fuel Poverty and Energy Efficiency study (EPEE 2008a) suggests using a simplified definition that fuel poverty is the inability to keep the home adequately warm at an affordable cost. It seems to be easier to agree on what is adequate warmth. Boardman (1991), Healy (2002, 2003), Alyin et al. (2001) and other authors claim that we may set temperature at 20° C as the biological limit for health and comfort. Living in houses for a longer period below this temperature endangers people's health and social functions. It is more difficult to define what is an affordable cost.

In the UK 10% of household income has been given as the defining limit. Yet there are some problems with setting such a threshold. The percentage shows a ratio between income and fuel expenditures, but it does not necessarily indicate the impact of this amount on the households. For instance, some households may pay more than 10% on energy, but it is not significantly affecting their budget. In other cases, families may pay less than the percentage because they live in an overcrowded space, depend partly or fully on illegal fuel sources, or simply do not adequately heat the space. Energy expenditures differ also because of settlement type and access to alternative fuels (i.e., urban or rural) and geographic location (e.g., south or north). It means that applying a standardized percentage may be problematic not only among countries, but also within different regions of the same country. The purchasing power of households is another specific problem that would require country specific assessment of how 10% of spending influences overall ability of households to pay for other goods and services (based on local prices).

The key challenge for further research appears to be how to define households in energy poverty, given the different economic, social, but also geographic contexts. Besides share of expenditures on energy from the total household bills, alternative indicators such as numbers of households disconnected by an energy supplier can be used. Number and dynamics in the increase (or decrease) of disconnected households indicates how many of them have real problems with paying bills. Households disconnected, however, may represent only the tip of the iceberg. Buzar (2007) suggests that people in Central and Eastern Europe put great emphasis on paying energy bills on time and that energy debts in the region are associated with a negative social stigma. This means that people would pay their household bills instead of other important expenditures.

Providers in some countries have introduced technical devices built on the principle of pre-paying for energy consumption. The number of these devices installed could indicate how many households the utility providers have selected as being unreliable in payment. Data collection, however, presents a problem. Most countries do not centrally collect data on the number of people who do not pay their energy bills. These data are available from the individual companies. Yet private or semi-private companies are not obliged to publish them. Measuring thermal comfort in low-income households could provide very important data, but it is costly and very rarely done.

Given the circumstances and data available, we must rely mostly on indirect data from research of energy poverty in CEE. These are from statistical offices and EU-SILC surveys, and from other surveys that monitor the dynamics of energy prices vis-à-vis income and other indicators. For the purpose of the chapter we define energy poverty as the inability to warm a household to an adequate temperature (allowing safe and normal activities of its members) and/or inability to pay for the energy and use it for basic household operations.

4.2 Case studies: Indicators of energy poverty

In this chapter we look more specifically at the indicators of energy poverty in two Central European countries: the Czech and Slovak republics. Figure 4.1 illustrates that both republics have one of the highest shares of expenditures for natural gas from the total expenditures of households. In the same sample of countries both are among the countries with the highest shares of expenditures for electricity from the total expenditures of households (ORNI 2008).

The Czech and Slovak republics went through radical changes during the economic transformation of the past 20 years. These changes have also affected their energy markets and cost of energy. They also impacted social cohesion and were reflected in growing social inequalities. How are these growing energy prices and social inequalities reflected in access to energy and what are the scopes and impacts of the problem?

Data and information on energy prices and risk-of-poverty (especially in life cycle) indicate that energy expenditures represent a substantial burden especially for low-income families. There are differences in patterns and scope of the energy poverty between the two countries, based on the different social indicators (e.g., risk of poverty, social transfers), or economic performance (e.g., energy prices versus income). There are also some other differences within each country based especially on regional disparities and urban/rural characteristics.

In this section, we focus on the following aspects of the energy poverty problem: (i) identifying the main trends in the energy prices vis-à-vis income dynamics; (ii) identifying the most vulnerable groups in the population and spatial/geographic aspects of the problem; and (iii) outlining the main impacts associated with energy poverty. Based on these aspects we conclude with a comparative evaluation of the two countries.

In comparison to the UK or Ireland, in the Czech and Slovak republics there is no specialized and periodical research branch focused on fuel (or

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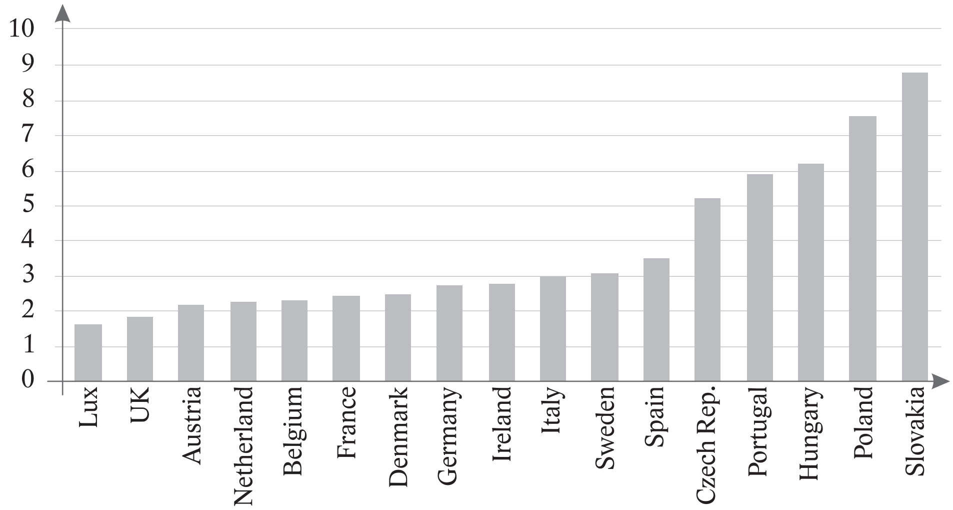


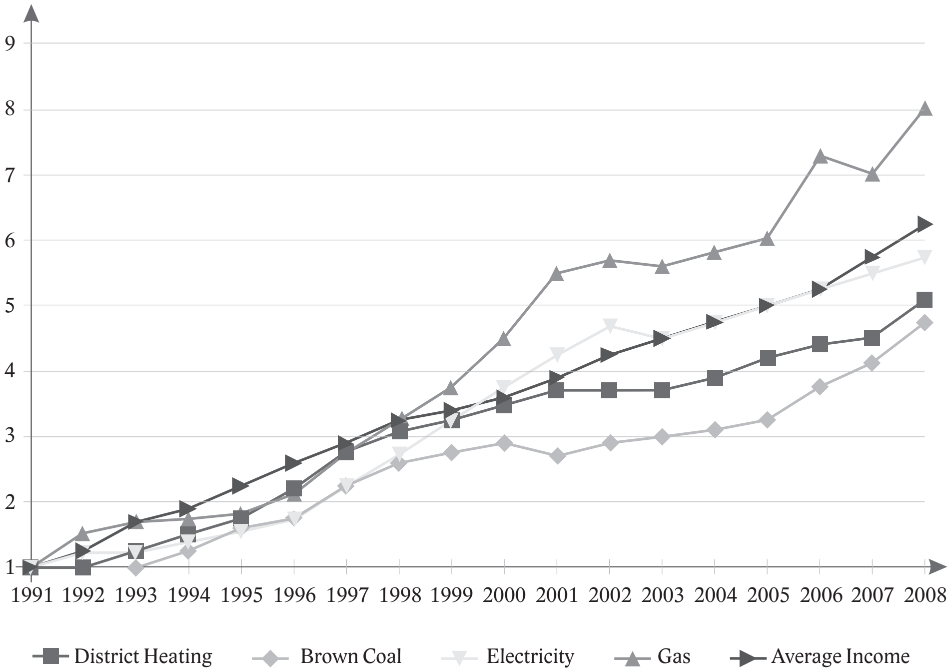
Source: Office for the Regulation of the Network Industries in the Slovak Republic—ORNI, 2008.

Fig. 4.1: Percentage of expenditures for natural gas from total household expenditures in selected European countries (2007).

energy) poverty. There are, however, several surveys that tackle the questions of energy and energy prices. We therefore have to operate with available data and information, combined with qualitative data. The main source of data for structural evaluation of energy poverty would be those from the statistical offices (i.e., household budget surveys), Eurostat EU-Statistics on Income and Living Conditions Survey (EU-SILC), specialized surveys conducted, and data from energy producers and distributors.

4.2.1 Case study: The Czech Republic

The Czech Republic has long been labeled one of the most developed countries among the new EU member states, reporting one of the lowest risk of poverty rates in Europe. The share of the population at risk of poverty was 10% in 2007 for the general population in the Czech Republic. For children aged 0–17 it was 16%, for people aged 18–64 it was 8%. For people aged 65+ it reached 5% (Wolff 2009). For instance in Lithuania or in the UK the percent for 65 and above was as much as 30%. In the same time Czech Republic has experienced a regular increase in real wages, but the social inequalities in the income distribution are growing too (CSO 2009). The GINI coefficient (measure of inequality of income or wealth distribution) went up from 19.49 in the 1992 to 25.5 in 2007. Prices of all energies for households were also increasing (Figure 4.2). The sharper increase in price was reported for natural gas, followed by electricity, district heating and coal.

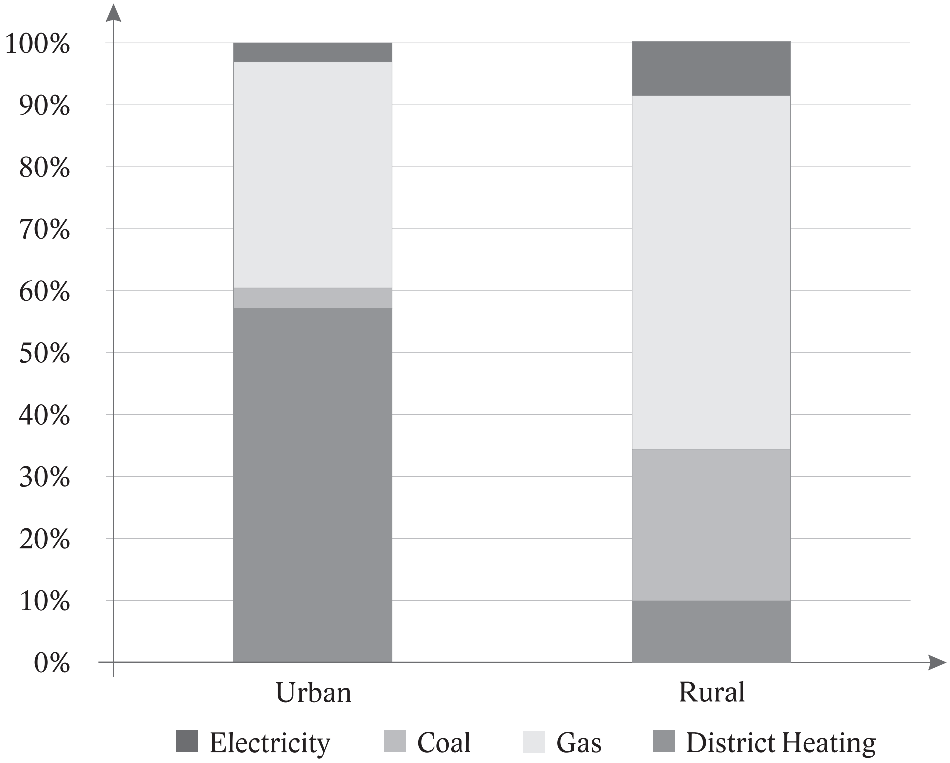


Source: Association for the District Heating of the Czech Republic 2009.

Fig. 4.2: Average wage and fuel prices for households in the Czech Republic from 1991 to 2008 (1991 = 1).

Approximately 80% of energy consumed in the country goes for heating purposes (CSO 2004). Energy sources for urban and rural households in the Czech Republic are illustrated in Figure 4.3. When we compare data from Figures 4.2 and 4.3, it is visible that there are substantial differences between urban and rural areas. Figure 4.3 illustrates the fuel mix for both types of dwellings. Comparing to urban areas, rural households are more dependent on natural gas. At the same time, natural gas prices have increased sharply over the past 17 years (see Figure 4.2 for comparison).

CSO (2004) survey also indicates that there are differences in energy consumption depending on altitude. In the measured sample of dwellings (at an altitude from 200 to 500 meters above sea level) there was a difference of up to 200 MJ/m^2 of energy used between rural dwellings in the lower and higher parts of the country. There were no differences recorded in the case of urban dwellings. This would indicate that the most expensive heating is for rural dwellings at higher altitudes.



Source: Czech Statistical Office Energo Survey 2004.

Fig. 4.3: Energy sources for urban and rural households in the Czech Republic.

The 2006 data from the Household income and living Conditions in the Czech Republic Survey (conducted by the Czech Statistical Office/EU—SILC) found relatively few people who subjectively feel they have problems paying for heating, electricity, gas, and water. The average total for all households is 5%. This number is below the official risk-of-poverty rate in the country (Table 4.2). However, this percent is based on a rather small sample in comparison to the family budget survey. As many as 38% of households interviewed stated that housing costs represent a "significant financial burden" on their family budget, while 11.7% thought that they could not afford an "adequate" amount of heating in the home (Buzar 2007).

	Households Total	Employees Total	Employees Lower	Employees Higher	Self--employed
Yes	5.0	4.1	6.2	1.9	6.1
No	93.8	94.6	92.5	96.8	92.4
NA	1.2	1.3	1.3	1.3	1.5

	Pensioner total	With working person	Without working person	Unem-ployed	Other households
Yes	2.7	4.0	2.6	25.1	11.7
No	96.4	95.5	96.5	73.4	84.7
NA	0.8	0.5	0.9	1.6	3.6

Source: Household income and living Conditions in the CZ 2006, Czech Statistical Office/EU—SILC Survey

Tab. 4.2: Percentage of people having problems with paying for heating, electricity, gas, and water in the Czech Republic (opinion)

There are regional disparities in the number of positive answers when we go to the level of *kraj* (county). While in both Bohemia and Moravia the average percentage of positive answer is 5.0%, the regional disparities range from 2.3% and 2.4% (Jihočeský and Plzeňský kraj) to 8.5% for Olomoucky kraj or even 9.1% for Královéhradecký kraj. These disparities point to the factor of regional differences in energy poverty. The counties differ in unemployment level, percentage of pensioners and GDP per capita. The CSO (2004) survey estimated that for instance energy expenditures are about 20% higher in Prague than in the Pardubicky kraj.

In 2003 the Czech Statistical Office conducted an extensive survey of the energy consumption in households in the Czech Republic. When we compare data for energy payments against average income for the same year, we may calculate that on average, energy expenses comprised as much as 15% of expenditures of the households in the third and fourth income deciles. For pensioners the number reaches 19% in the first income quintile and was above 10% in all the other quintiles. For the 10th deciles of the households with the highest income it was less than 5%. We may assume, that given the types of dwellings and average space differences between the households of those who are better off and those who are in the bottom deciles of income, total energy consumption of the latter is significantly smaller and they are more prone (or forced) to saving energy. According to Buzar (2007), the households in the bottom deciles decreased their energy consumption between 1995–2004 by more than 5% in relative terms. This may indicate increased awareness, but also a growing problem with payment for energy consumption.

Based on the data available, we may conclude that risk of energy poverty in the Czech Republic relates to geographic location and is affiliated with life cycle. The most vulnerable group would be households of pensioners living in rural areas. Pensioners are usually vulnerable not only because of income and location, but also because they usually spend more time at home than others. Nevertheless, the data indicate that share of energy expenditures is rather high also for households with employed adults—those normally better off than the rest of the population. This reflects the rather high energy prices in the Czech Republic comparing to the average incomes.

Last but not least, there is specific problem of people in extreme poverty, where the risk-of-energy poverty is significantly higher. This is for instance, a specific problem of the Roma communities in the Czech Republic, where the problem with access to energy is reported. Because of problems with paying for services, there are households and even whole localities disconnected from electricity and where energy is not connected for long periods (GAC 2006). Based on structural indicators (e.g., high rate of unemployment, discrimination on the labor market, families with more children and life in rural areas) we may assume that the social and ethnic group will have the highest risk-of-energy.

4.2.2
Case study: The Slovak Republic

Repeated surveys of the EU-SILC in the Slovak Republic estimated the risk-of poverty-in the general population to be 13.3% in 2004, or 11.6% in 2005. From the social groups analyzed, the risk has increased for people above 65 years (by 1.4%). Although, only 7.1% of the elderly were identified as living in poverty in 2005, in 2007 it was already 8%, one of the highest percents of materially deprived elderly population in the EU. With a rate of 19% in EU-27, children are at greater risk-of-poverty than the rest of the population in most countries. Child poverty rates are higher than rates for the total population in 21 of the 29 countries covered by the EU-SILC survey, and are higher by 50% or more in the Czech Republic, Hungary and Slovakia.

The survey reveals that risk-of-poverty is closely affiliated with different stages of life and social condition. Filadelfiová (2007) points out that in

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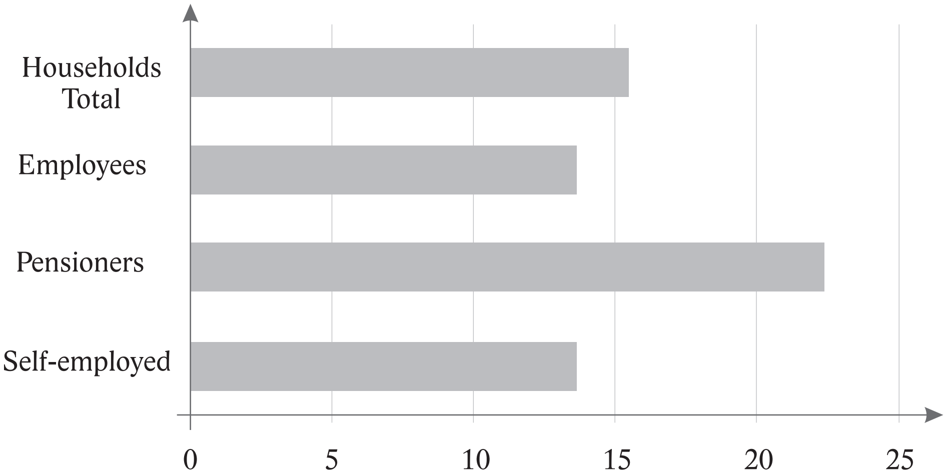
2004, households with children had double the rate of poverty, comparing to households without children. 18.4% of children live in poverty. The most vulnerable group is households with children. In families with children and single-parent families the risk of poverty is 31.7%, while in families with both parents and 3 or more children it reached almost 25%.

Similarly to the Czech Republic, geography is an important factor in energy poverty. There is significant difference in the heating season between the south and north parts of the country. Lower average incomes, and higher unemployment (especially North and East of the country) contribute to the situation. The risk of poverty is higher for people living in marginalized regions, especially in combination with single parenting, higher number of children, lower education or unemployment.

The Statistical Office of the Slovak Republic published that in 2006 the average share of energy expenditures of private households was 15.5% (family bills). Comparing to the specific data collection in the UK, Slovakia collects only aggregated data for all energies (i.e., natural gas, other fuels and electricity).

Figure 4.4 illustrates what is the share of energy expenditures in the total household expenditures for 2006. The share is above 10% for all main types of households. The most vulnerable groups in this context are pensioners, where energy represents almost a quarter of their expenditures.



Source: Adapted from the Statistical Yearbook of the Slovak Republic, 2007.

Fig. 4.4: Share of energy expenditures in the total household expenditures in 2006 (in percentage).

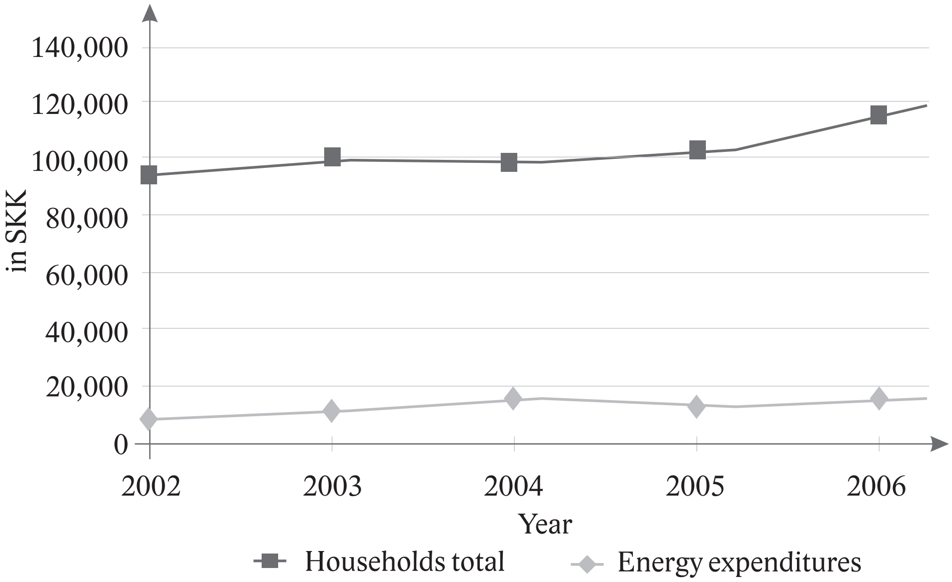
According to the EU-SILC, the share of households with debts for energy expenditures decreased from 9% to 5.9% between 2005 and 2006. During this time energy prices were growing, yet there was also an increase in disposable income. This trend is illustrated in Figures 4.5 a) and b). From this perspective it may be interpreted that the share of energy in household expenditures is decreasing, and so is the number of people who face problems paying for energy services. The data above provide a snapshot of the situation in times of economic growth and increasing average income. This consequently also decreases the percentage of expenditures for energy vis-à-vis income.

Yet, at the same time the index of consumer prices for natural gas and other fuels went up from 115.7 in 2002 to 185 in 2006. Index of prices of industrial producers (according to statistical classification production—total) in the same period increased from 120.1 to 181.3 (SOSR 2007). The GINI coefficient for the Slovak Republic has been steadily growing, increasing from 26.2 to 28.1 between 2005 and 2006 (comparing to 19.49 in the 1992). There was also an increase in the ratio S80/S20 of the income of the highest and lowest quintile from 3.9 to 4.1 (EU SILC 2005 and 2006). These data indicate that besides income growth there are also growing disparities in its distribution.

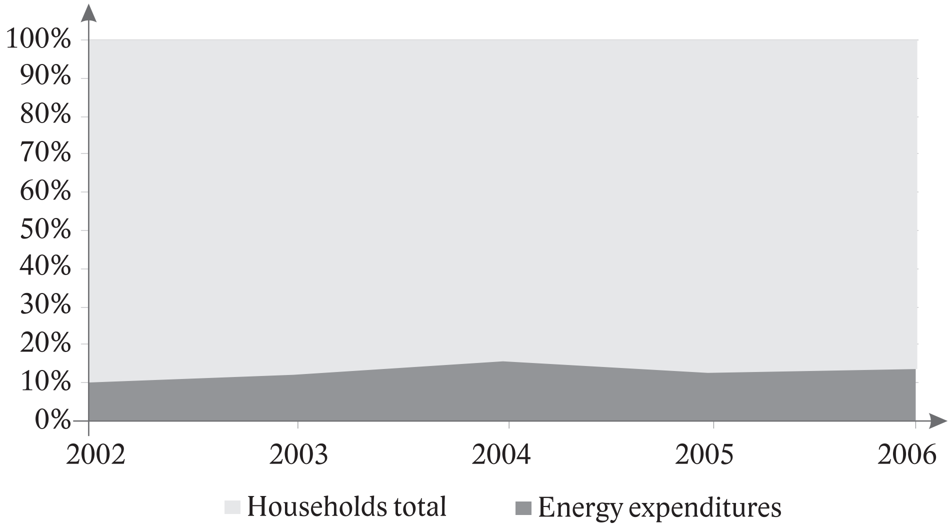
Another indicator of the above-mentioned trend is the perception of ability/inability to pay cost of housing. As many as 36.2% of Slovak households mentioned that the payments are a problem for them, while 55.6% has a minor problem and only 8.2% do not perceive any burden (EU SILC 2007). These figures are rather high when we compare them with the Czech Republic. Similarly to the Czech Republic, poverty and access to resources a specific problem in marginalized communities of the Roma ethnic minority (WB 2002, Filadelfiová et al. 2007a). This is evident especially in the eastern part of the country where the communities are concentrated. The Eastern part is also the most deprived region of the country. Illegal logging and conflicts with authorities over fuel criminality is present in most of the 40 randomly sampled Roma shantytowns where I conducted field research in 2004–2006 (Filcak 2007).

Generally we may conclude that the ratio of expenditures for energy is growing for low-income households, while for the high-income end it is relatively decreasing. This is because prices of energy are similar for all households, while income is gradually diversifying. Deflation, slow down of the industrial production (accompanied by decreased energy demand) influences energy prices. Energy prices will most probably not grow in the short run, and we may even see their decrease (resulting from the global economic crisis). Yet, we may witness a decrease of real wages, an increase of unemployment and thus the proliferation of energy poverty.

a)



b)



Source: Adapted from the Statistical Yearbook of the Slovak Republic, 2007.

Fig. 4.5: a) Gross household income and expenditures; and b) share of energy in total household expenditures (2002–2006).

4.2.3
Comparative study of the two cases

The study of the Czech and Slovak republics leads to several challenges. The first is the problem of data on the scope and distribution of risk-of-energy poverty. Using EU-SILC and household surveys of the statistical offices we can estimate the problem, but more precise data are needed. Another problem arises with the definition of energy poverty in CEE conditions. There are households that can warm their dwelling to an adequate temperature and do not fall in debts with utilities providers, but cost of energy is a relatively high share of their expenditures. There are people who cannot afford to pay for energy at all and face threat of disconnection from the network.

Energy poverty seems to be closely related to life cycle and some social groups are more exposed to the problem than others. These include single-parent families, unemployed or pensioners. A question for further study is then how are the social welfare policies helping in addressing energy poverty and how to combine them with other specific policies and projects focused on energy poverty.

All energy prices have been steadily growing in both republics. Although, the average income has been growing as well, there are gradually growing inequalities in its distribution. Cost of energy has become a problem for part of the population. Examples from other countries point to the need of properly designed programs and projects helping people who are facing energy poverty. These programs may have different design, implementing agencies and ways to target the population. They should nevertheless be tailored to a country's specific situation and needs.

Energy poverty has strong correlation with geography and regional disparities matter. In the case of the Czech Republic we see differences between rural urban areas. Energy costs represent a higher burden for people in the rural areas. There are also differences between different parts of the country depending on the climate, but also regional economic factors (e.g., differences between income level within the country). A similar pattern is also visible in the Slovak Republic, amplified because regional difference are stronger in Slovakia than in the Czech Republic. The regions of Prešov and Košice are among the poorest in the European Union (Nomenclature des Unites Territoriales Statistiques—NUTS II category according to the EU classification).

Not surprisingly, energy poverty is higher for people living in poverty. Besides risk of poverty affiliated with life cycle (described above), there is also a problem of people living in absolute poverty. Both countries face specific problems of marginalized communities of ethnic Roma, where we find specific settlements in rural shantytowns or urban ghettoes. Access to energy among their inhabitants would require further surveys. The focus could be on energy as the factor in development, but also on social and environmental impacts of energy poverty.

The paradox of energy poverty is that the poor sometimes have to pay for energy more than other better-off inhabitants. In the subsequent section we focus on energy efficiency as an important factor in forming energy poverty. Energy efficiency is also an important aspect for addressing the development of general policies and projects tackling energy poverty.

4.3 Energy efficiency and poverty

The price of energy and household income are the key factors that determine access to energy. The price is predominantly influenced by world and local prices of fossil fuels, alternative renewable energy sources, cost of production and delivery. Regulation or deregulation of the market matters, as well as different subsidy policies, and taxes or internalization of external costs of energy production. Disposable income of households vis-à-vis end user energy price is an important indicator of energy affordability.

Energy efficiency is a factor that influences energy consumption of households and. plays a very important role in energy poverty (Boardman 1998, Green et al. 2000). By efficiency we mean using less energy to lower costs and reduce emissions, while accomplishing the same task, such as heating or lighting a building of certain size. Energy efficiency of a household is determined by design and quality of the dwelling, efficiency of the heating and lighting systems, and last but not least individual behavior of the dwellers.

For simplified classification of households (using energy efficiency as the energy poverty factor) we use a 4-category scale described in Figure 4.6. In the proposed scale we divide households based on their income and energy expenditures. It is based on an assumption that there is a link between household income, energy efficiency and type of energy. The four categories represent types of behavior and investment, while in reality the picture is much more complicated and households do not strictly follow most optimal energy efficiency strategies even if they can afford it. This is a complex problem of motivation, prioritization and consumers behavior that goes beyond the scope of this chapter.

Category 1 in Figure 4.6 represents low-income households with low energy-efficient dwellings. These could be older houses and flats, sometimes built from lower quality materials. Most of them have low energy efficiency due to the materials used, old windows or thin walls. Efficiency of heating systems is problematic and losses high. Energy consumption per heated unit is high

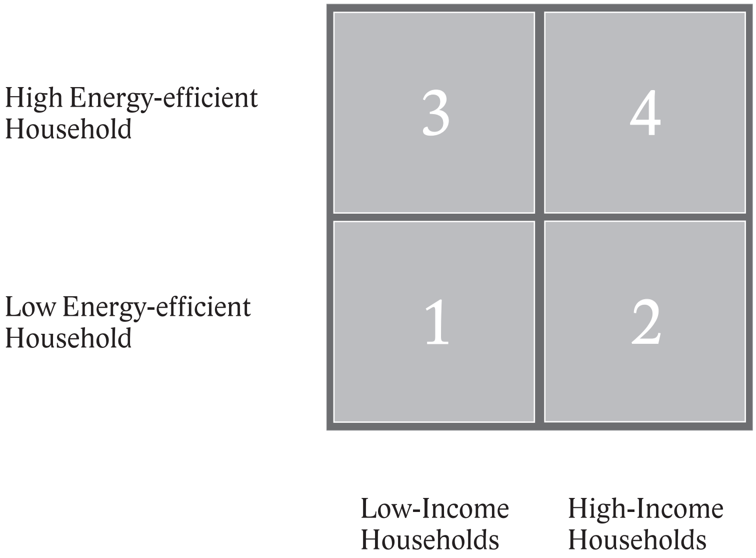


Fig. 4.6: Household Income and energy efficiency as the factors in fuel poverty.

and its payment represents a burden for the households (in the context of total income). It may be difficult to document sources of fuel (i.e., in rural areas).

Lower income or risk of poverty may also be reflected in a lower level of social capital, or in the access to information and decision making on different supporting schemes that may exist, e.g, grants or low-interest loans for energy insulation and renewable energy sources, or various social support for low income households. These households often do not possess enough resources for investment into energy efficiency measures, do not have access to bank loans or guarantees and do not have social skills for accessing supporting schemes.

Price elasticity of demand for these households is low, because they cannot consume much less or adequate substitutes are hard to find. In the short run, households may switch to cheaper fuel (low quality coal, burning waste), or to illegal logging for fuel wood (rural areas). In the longer run, initial investment for energy efficiency represents an uncrossable threshold for these households. The main possibility of coping with increasing energy prices is decreasing energy consumption. This may lead to regular or ad hoc problems to maintain adequate indoor temperature.

In the second category we find households with higher income, but still low energy efficiency. Energy expenditures are relatively high, but do not represent a significant burden on the household budget. Price elasticity for energy is higher than in the first category. The investment into energy efficiency may be influenced by access to stimulating governmental or utility schemes. This category could be the primary target of energy efficiency campaigns and programs.

In the third category we find households with lower income but rather high energy efficiency. These could be for instance households in a block of flats that were insulated under supporting schemes, or households with alternative lifestyle in rural areas. These households crossed the threshold of initial investments into energy efficiency that have helped them to avoid the potential threat of energy poverty.

The fourth category is households with higher income and high energy-efficiency. Usually new or reconstructed houses with state-of-the-art materials and technologies and very good to extremely energy efficient performance. This category includes households with the highest incomes, or people who purposely invest in high tech solutionssuch as high energy-efficient technologies (e.g., passive houses) and use of alternative energy sources (e.g., heat pumps, solar collectors). Yet, overall consumption of these households if often rather high anyway, given the occupied space (i.e., number of square meters per person), technical devices (e.g., number of electric appliances), or leisure activities (e.g., heated swimming pools).

Dividing households in this way is for illustration. Many households do not really fit into one of the categories. Moreover, it is difficult to draw a line as to what is a higher income level and how it is reflected in willingness to invest in energy efficiency. Investing in energy efficiency is a much more complicated decision than the question of money, or available supporting schemes.

Nevertheless, this general division into categories serves for practical discussion of whom to support in energy efficiency policies and programs. Transition from category 1 and 2 to category 3 or 4 means higher investment, but lower operating cost. The outcome is the first paradox of energy poverty: namely, that in the long run low-income households with poor energy efficiency pay more for energy than the higher income ones (whose initial investment pays back after some period of time). The second paradox is that those households that have a very high potential for energy savings are not able to overcome the threshold of initial investments.

The problem of public policies and supporting schemes is that they often facilitate transition from category 2 to category 4. At the same time, households in category 1 do not possess the required social skills, social capital and know-how needed for access to grants and loans for transition to category 3. In this way, many households may find themselves exposed to the risk-of-energy poverty. Households that could afford to invest in energy efficiency are unnecessarily supported. Energy efficiency program are good for addressing energy poverty, but they require targeted approaches that take into consideration social aspects of the households' inhabitants.

4.4
Environmental aspects of the problem

Nature and the environment are important dimensions of energy poverty. The environment may both contribute to its increase, as well as provide some coping strategies. Last but not least, social pressures that stem from energy poverty may impact nature. Availability of affordable energy (e.g., solar or biomass) decreases pressure on households, but there are a multitude of environmental impacts caused by poverty. Two examples include: (i) Indoor and outdoor air quality; and (ii) illegal logging and timber trade.

Lack of financial sources leads to a situation, when low—income households seek alternative sources of energy. This could be low quality coal, or in extreme cases various types of waste. Indoor air quality was identified as one of the main causes of mortality in developing countries (Barnes and Toman 2006). Smoke from ovens and heaters may contain different particles and carcinogens. In the CEE context, this happens in marginalized households and extreme poverty (e.g., Roma rural shantytowns, urban ghettoes). Burning of low quality fuels seriously impacts outdoor quality and is a problematic non-point source of emissions.

Fuel prices are in causal relationship with illegal logging and timber trade, a specific problem of rural areas with high poverty concentration. Forests are becoming an important source of fuel for low-income households, helping overcome problems with affordability of energy. This may even sometimes mean danger of repression from the side of forests owners and managers. An example is the Spiš region in eastern Slovakia, where there is a latent problem of illegal logging in the buffering and core zones of the national park Slovak Paradise (Slovenský Ráj). Originally this illegal logging was limited to the park's northern part, where there is a high concentration of rural poverty and marginalized Roma settlements. Recently, however, the southern part where no such marginalized settlements exist has also been affected. The higher the risk of poverty is, then the higher the pressure on forests as an energy source and lower the preventing danger of repressions from the side of authorities.

The environment and natural resources provide a last resort alternative for people in energy poverty. We can find a similar correlation between fuel quality and household income. Addressing environmental impacts of energy poverty requires targeted programs and approaches to the people in risk-of-poverty. Another alternative is repression, which does not address the causes of the problem and may prove to be counterproductive in the longer run.

As described in the previous section of the chapter, energy efficiency is a key approach to addressing energy poverty. It is also a key approach to minimize environmental impacts that accompany energy production and consumption.

4.5 Policy options

In the early stages of industrial society the economy produced far too little energy to give every member of society a decent standard of living. The industrial revolution raised energy production significantly for the first time in history (due to access to energy) we have witnessed enormous growth in production, but also human development. The energy poverty challenge in modern developed societies is how to reach universal access to affordable energy in a way defined by Vilfredo Pareto in his Pareto improvement: A change that can make at least one individual better off, without making any other individual worse off (Pareto 1976, Powers 1987). The answer on how to attain this varies.

We may look at the problem of energy poverty (similarly as at the problem of poverty as such) from two different perspectives that would subsequently define (but also limit) suggested solutions. If we build on the traditional approach based on *laissez-faire* individualism and economic liberalism, poverty is the failure of individual men. This approach may gradually lead to a downgrading spiral to a deepening social pathology that can replicate itself in the so-called "culture of poverty" (Lewis 1975, Zurcher 1973).

An alternative approach is based on principles of basic needs and development theories (developmentarism) that interprets poverty as an inevitable outcome of structural conditions rooted in the very core of the system that disadvantage certain groups and individuals. This approach leads to the development of modern welfare states, a concept that arose especially after the World War II in developed countries.

The first approach prefers market-based solutions based on economic policies connected to what is remaining from social policies focused on psychological rehabilitation of the poor (Hardiman and Midgley 1989). Understanding poverty as a structural problem supports solutions based on state interventions, a promotion of affirmative actions focused on changing starting conditions for people. This is done through redistribution of incomes within society. In our case it is through the mechanisms of the welfare state that have proven themselves highly effective in reducing relative as well as absolute poverty in all analyzed high-income OECD countries (Kenworthy 1999, Bradley et al. 2003). Connecting households to electricity was in most developed countries a government project (e.g., electrification of the US South as a part of the New Deal, broad electrification program in European countries after World War II).

We may look at the problem of energy-poor households as a problem of individual people who are unable (unwilling?) to allocate enough resources to energy, or we may look at the problem as the structural problem of growing inequalities and its impacts. Some of the policy options explored and being used by countries can be summarized as follows:

- *Special (social) tariffs for energy:* Low-income households may ask for discounted energy price (e.g., in Belgium, a special tariff that focuses on low-income households has been in place since 2005 in France.);
- *State-supported social program for energy efficiency:* These programs are helping to overcome the problem of initial investment into energy efficiency and are specifically designed for low-income households (e.g., Warm Front in the UK);
- *Solidarity Funds:* In France, these special funds are in each department. The funds aim to provide support to people who are in debt to their energy suppliers. In 2004 some 45 million EUR were earmarked for payment of fuel debts. The Energy Fund in Walloon Region/Belgium has a similar goal;
- *Advisory services:* Advice and assistance to people in need (e.g., Walloon Union of Municipalities in Belgium have coordinated centers advising people on how to reduce their energy bills);
- *Supporting non-state actors:* Support to non-governmental organizations assisting people with a high energy burden (e.g., *Low-Income Home Energy Assistance Program* in the USA). Private charity and social organizations (in countries where there is limited state support or program) directly support the poor.

Different assistance program may have their pros and cons. They reflect the problem's history in a given country and the "philosophy" of governments in addressing the poverty problem. The elementary questions arising from the different approaches to energy poverty policies can be discussed from at least three perspectives. Firstly, how should a state address the problem of poverty as such? According to Wolff (2009) social transfers are most effective in the Nordic countries, Hungary, the Netherlands, Austria, France, the Czech Republic and Slovenia where they reduce poverty by 50% or more. These are the countries with the lowest risk-of-poverty rates. The USA and the UK have comparatively lower amounts of the social transfers and traditionally focus more on a community type of assistance.

Secondly, what are the concrete approaches to helping people in energy poverty? Is it better to subsidize energy directly through social tariffs, or rather provide assistance directly to households? Subsidized energy may have a short-term effect on households, but does not solve the question of energy consumption. It may be better to assist households in energy efficiency (e.g., insulation). Thirdly, how should assistance be provided? Is it better to set up a system of governmental or municipal agencies, or rely on non-governmental organizations, or even charities?

Different policy options may lead to different results. The problem is how to evaluate effectiveness and outcomes of policies and program addressing energy poverty. In spite of systematic monitoring of the problem and broad supporting program the number of households in fuel poverty is increasing in the UK. Although 11.5% less households were documented as being in fuel poverty in 2006 in comparison to 1996, it seems that energy prices, economic development and social situation are key factors. In the fluctuating economic cycles (exacerbated recently by the global economic crisis) it is difficult to estimate what are the benefits of the energy poverty policies. We may, however, demonstrably argue that without these policies the trend may be much more adverse.

Energy poverty is only a fraction of the overall problems poor people have to face. It cannot be therefore addressed as a separate and limited problem, but should be part of a complex approach to poverty. Meaningful and effective solutions of social exclusion and marginalization are needed to decrease energy poverty.

In addition to looking at approaches to energy poverty as a part of overall strategies and policies addressing poverty, concentrated effort on energy efficiency is needed. Solutions to energy poverty involving energy efficiency improvements do not mean just expenditures, but also benefits. By benefits we do not mean only immediate access to energy, but also social impacts like employment (e.g., employment opportunities in technologies and construction), decreased dependence on energy import, or positive impacts on the environment).

Conclusions

Access to energy is a basic requirement for life and participation in a modern society, involvement in the employment market, and is a health and environmental issue. In the past, energy policies were predominantly focused on energy production, and not much attention was paid to demand and access to it. Various studies and data indicate that vulnerable households and people are especially hit by the growing energy prices. The definition of poverty as a complex phenomenon must be broadened to encompass these and other forms of social inequalities. The present approaches and analytical methods need to be deepened and broadened to include elaborated, complex and effective solutions to the exclusion in energy services.

With the exception of very few European Countries (e.g., UK, Ireland), for example, energy or fuel poverty is not systematically measured and information is not consistently available. The magnitude of the issue is then visible only from secondary data (e.g., trends in welfare subsidies for heat and electricity bills). While efforts are being made both at the country level and the EU level (e.g., EPEE), the complexity of energy poverty in the context of global and international trends is not widely understood by stakeholders in a way that would allow meaningful and effective action at the EU level.

The present understanding of energy poverty is to a great extent influenced by missing complex data and analyses of the problem. Nevertheless, indirect data from different household surveys (described also in this chapter) indicate that energy poverty is also present in CEE countries (i.e., Czech and Slovak republics). Its scope and impacts differ based on the overall social situation in a given country, infrastructure and energy markets.

European countries have become a world leader in policies that nurture social equality in a diverse society and strengthen access to basic living necessities. Social inequality manifested as disparities in access to important resources for daily living, however, is a growing challenge as a higher proportion of Europeans' incomes is spent on gas and electricity bills (simultaneously decreasing the marginal utility of their income), and at the same time, the low-income strata are increasing.

With the process of liberalization and privatization of energy markets, and rises in global energy demand and costs, there have been dramatic changes in tariffs. Hence, energy poverty like other forms of poverty and social exclusion arises out of a combination of complex, interwoven institutional and structural challenges. At the same time, there is space for decreasing energy consumption in the developed countries without negatively affecting quality of life.

Research and multi-stakeholder engagement on energy poverty on the country and the EU level is needed.

More projects need to be designed to meet this need by establishing a more in-depth and shared understanding of energy poverty—what it is, how to measure it, and ultimately how to address it—across Europe involving some of the more vulnerable or challenged regions.

In the context of the European and national policies it is apparent that the solutions to the problem must be part of the overall discussion of how to address problems of social inequalities, especially within the context of the global economic crisis, the latent climate change challenge and its impacts. The European Union, declaring economic and social cohesion (together with sustainable development) as its goals, is in a strong position to spearhead safety mechanisms to protect vulnerable households from energy poverty with the provision of a sound knowledge base and a policy framework.

To meet this challenge, there needs to be a clearer, cross-cutting understanding of energy poverty (including how to measure and address it in the most effective way) to determine a sound policy framework for preventing and alleviating energy poverty in Europe. Further research of energy poverty should be practically oriented and supply relevant information and analyses to the decision-making process. It should provide multi-sectoral access to addressing the problem, based on solid and relevant data, knowledge and know-how.

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5

Impact of the EU emission trading system on microeconomic level

On June 5th a new directive 2009/29/EC that amended Directive 2003/87/EC was published in the EU official journal. This new directive aims to improve and extend the greenhouse gas emission allowance trading scheme of the Community, which fundamentally changes the European system of emission trading (EU ETS) after 2012.

The principal basics of the new directive include the following:

1. significant reduction of greenhouse gas emissions in the EU (reduction by 21% until 2020 against the base year 2005 for economic branches included in the EU ETS);
2. effort to shift from the current system of free allocation based on historical emissions (so called grandfathering) to the system based on purchasing of allowances by individual enterprises in auctions.

The first point will not be addressed in this article. Attention is rather paid to the second point.

The amended directive is formulated in such a way to enable member states to take advantage of a wide range of exemptions from an otherwise rather severe start of auctions in 2013. It is in full competence of member states whether they decide to apply for exemptions formally and vindicate their validity before the European Commission. Work has currently begun, for example, on identifying jeopardized branches of industry that should obtain free allowances based on branch specific benchmarks. The Czech Ministry of Environment is striving for inclusion of heating plants among these exempted branches.

5.1 Producers of electricity

If a member state does not take advantage of possible exemptions, then from 2013 companies generating electricity will be forced to buy 100% of allowances at auctions (Article 20a, paragraph 3). The directive enables the temporary allocation of free allowances in connection with streamlining of technology to electricity generation. The directive contains a provision that

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producers may obtain 70% of allowances calculated from verified average emissions in the years 2005–2007 free of charge and this allocated amount will decrease to 0% in 2020. In the Czech Republic, an ad hoc amendment of the Act on excise duties (note: it is a local oddity in the Czech Republic to use various legal Acts that are on the agenda in the Czech Parliament at that moment to amend somewhat unrelated topics) brought this possibility to those producers investing in more efficient technologies and therefore in the following simulations we respected this amendment when calculating allocation for the heat plant in Strakonice.

5.2 Producers of heat (or heat and electricity in a combined regime)

1. Article 10, paragraph 4 of the Directive states that free allowances will be given to producers from 2013, according to Article 9 the total amount of allowances will decrease annually by 1.74%, of which 80% will be allocated free of charge and the remaining 20% will be available at auction. In 2020, only 30% will be given free of charge, with the target being full auction in 2027.
2. According to statements of representatives of the Ministry of Environment of the Czech Republic (MoE), MoE strives for inclusion of the heat sector among endangered economic branches (alongside others like cement or lime production) and for implementation of commonly accepted fuel-specific benchmarks. Benchmarks for different fuels would be set on the basis of BATs (best available techniques). Unfortunately, there are no unified benchmarks for the heat sector defined in BATs and this problem with benchmarks is still on the agenda with a decision expected to be made no sooner than in 2010. At this moment, there are two most likely variants:
   a) Benchmark will be set on the basis of most efficient heat production from natural gas. This could cause problems for the Czech heat sector, because it depends substantially on coal-based fuels with nearly double the emission factor than for natural gas—it means that Czech heat plants would receive only 50% of free allowances with such a benchmark.
   b) Or benchmarks may be fuel specific so that higher specific emissions of CO_2 for heat produced from coal would be taken into account. The Czech Republic makes an effort to make use of fuel specific benchmarks at least for the heat sector. In any case, from 2027

onwards we can expect full auctioning for all branches (with the only exception being endangered branches of industry, but they have not been specified yet).

With respect to the above-mentioned uncertainties, an analysis of impact on the heat plant Strakonice was carried out in variants (differing in the method of allocation of free allowances)—see specification of scenarios in section 5.3.3.

5.3
Risk analysis resulting from auctioning of allowances: Case study of the heat plant in Strakonice

5.3.1
Methodology used for simulation of impact

A tool used to model uncertainty is the Monte Carlo simulation. When this method is applied, some model inputs are no longer considered as deterministic but as stochastic values (i.e., random values) with defined random distribution. All simulations were done with the aid of Visual Basic add-in for MS Excel. Simulations consisted of repetitive calculation with some inputs generated from random distributions as defined below in this text. Results were primarily directed at impact on earnings before income tax ("gross profit"). For presentation of results two limits of estimated (lower and upper limit) delimiting area in which should modelled variable occur with 80% probability. A probability of 20% that gross profit will be outside this interval defined by lower and upper limits still exists. Projection is carried out for years 2008–2020, and years 2002–2007 are actual economic results from annual reports of the company used also for setting the input parameters for simulations.

5.3.2
Model assumptions

Projection of the Strakonice heat plant's economic activity is based on joint assumptions as shown in the following tables.

Parameters of random distribution functions were inferred from the past development and only partially corrected in the view of the current economic situation. The background scenario does not take into consideration the significant influence of economic recession, because projection is not aimed at assessment of the impact of the current economic crisis, but assessment of the impact of the EU ETS on gross profit of the company.

The following tables (5.1–5.4) show expected development of stochastic values used in the economic model.

Other additional assumptions used in the economic model:

- Heat generated from boilers is used in the same proportion for electricity and heat production 50% : 50% (though currently this ratio is 42% : 58% for heat : electricity production);
- Aggregated cost items differ in the share of fixed and variable component, the economic model presupposes that at least a part of cost is correlated with total revenues, which means that the increase in revenues causes an increase in variable costs as well
- Additional cost from purchases of allowances are passed on equally between sold electricity and heat (ratio 50 : 50);
- In all scenarios allowances needed for covering emissions of carbon dioxide resulting from electricity production are calculated in this way: in 2013 the company should receive 70% of allowances free of charge and the rest should be purchased on the market at market price. Allocation of allowances free of charge declines linearly by 10% a year until 2020, when all allowances should be bought on the market;
- Allowances needed for covering emissions of carbon dioxide from heat production are solved in variants (see below description of alternate scenarios). There are several variants showing how different ways of allocation would influence economic activity of the company and prices of sold energies.

5.3.3 Description of scenarios

All scenarios for simulations introduced below and their results aim at modelling future earnings (gross profit). Scenarios calculating with passing on of additional cost to the prices of energy commodities are also extended by demonstration of effects of this cost on prices of energy commodities. Expected impact on energy prices focuses only on additional cost resulting from emission trading, it does not include cost of increased depreciation (from proposed reconstruction of boilers) and increase in variable costs caused by increase in total revenues.

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Selling price of electricity (CZK/MWh)*	1,384	1,411	1,439	1,468	1,498	1,528	1,558	1,589	1,621	1,653	1,687	1,720	1,755
Standard deviation of the price of electricity (CZK/MWh)*	107	110	112	114	116	119	121	123	126	128	131	134	136
Selling price of heat (CZK/GJ)**	323	333	343	352	363	372	359	369	379	391	403	415	427
Standard deviation of the price of heat (CZK/GJ)**	16	17	17	18	18	19	19	20	20	21	22	22	23

** 2% annual increase from 2007.*

*** 3% annual increase from 2007.*

Note: We used normal distribution, which defines the prices of electricity and heat according to the normal distribution function (defined using mean and standard deviation).

Tab. 5.1: Expected development of prices of sold energy commodities in 2008–2020

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Sold quantity of electricity (MWh)*	116,523	117,688	118,865	120,054	121,254	122,467	123,692	124,928	126,178	127,439	128,714	130,001	131,301
Standard deviation of the sold quantity of electricity (MWh)*	5,061	5,111	5,162	5,214	5,266	5,319	5,372	5,426	5,480	5,535	5,590	5,646	5,703
Sold quantity of heat (TJ)**	777	761	746	731	717	702	688	675	661	648	635	622	610
Standard deviation of the sold quantity of heat (TJ)**	57	56	55	54	53	52	51	50	49	48	47	46	45

** 1% annual increase from 2007.*

*** 2% annual decrease from 2007.*

Note: Used normal distribution—quantities used for simulation are defined using normal distribution function with mean and standard deviation as stated in Table 5.2.

Tab. 5.2: Expected development of sold quantities of energy commodities in 2008–2020

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Lower limit of the expected price of allowance (€)*	5.0	5.2	5.3	5.5	5.6	5.8	6.0	6.1	6.3	6.5	6.7	6.9	7.1
Upper limit of the expected price of allowance (€)*	50	52	53	55	56	58	60	61	63	65	67	69	71

** 3% annual increase from 2007.*

Note: For simulation, a uniform distribution function was used meaning that the input price generated in the model may be any value from the defined interval with the same probability. For conversion from EUR to CZK the same exchange rate of 27 CZK/EUR was used for the whole period.

Tab. 5.3: Expected development of the price of allowance in 2008–2020

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
The price of purchased fuels (CZK/GJ) (4% annual increase from 2007)	55	57	59	62	64	67	70	72	75	78	81	85	88
Standard deviation of the price of fuels (CZK/GJ) (4% annual increase from 2007)	5	6	6	6	6	7	7	7	7	8	8	8	9

Note: In the projection, when 30% share of biomass in fuel mix was calculated, the same price of coal and biomass is assumed, though in practice we may rather expect a higher price of biomass (including higher transportation and storage costs).

Tab. 5.4: Expected price of utilized solid fuels

Scenario 1: Fictive scenario

- This scenario does not take into account the existence of the EU ETS from 2008;
- It does not include reconstruction of boilers;
- No biomass is used in the fuel mix.

Scenario 2: with the EU ETS; Fictive scenario

- Reckons with existence of the EU ETS in the period 2008–2020;
- No reconstruction of boilers;
- No biomass in fuel mix;
- Additional cost from emission trading is not passed on to prices of energies;
- Allocation used in simulation for needed allowances for covering released emissions from electricity generation is the following: negotiated exemption (see joint assumption in section 3.2);
- Allocation used in the model for covering emissions released from heat production: amount of allowances free of charge diminishes by 1.74% each year from 2013 to 2020;

Resulting allocation of allowances as input into the model is the following (see Table 5.6):

Scenario 3: with the EU ETS

- Reckons with existence of the EU ETS in the period 2008–2020;
- Reconstruction of boilers (initial investment CZK 500 million, annual depreciation of 25 million CZK is however not calculated as additional cost of the EU ETS)
- Biomass is used in fuel mix from 2013 (30% share in fuel mix, bought at the same price as coal);
- Improvement in efficiency of boilers contributes to saving of fuel
- This scenario does not count with passing on of additional cost to prices of sold energies;
- The same allocation of allowances as in Scenario 2;

Resulting allocation of allowances as input into the model is the following (see Table 5.7):

Scenario 4: with the EU ETS; with additional cost

- The same assumptions as in Scenario 3

	2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
Calculated emissions of CO_2	241,997	239,840	237,752	235,731	233,777	231,889	230,066

	2015	**2016**	**2017**	**2018**	**2019**	**2020**	
Calculated emissions of CO_2	228,306	226,609	224,974	223,399	221,885	220,429	

Tab. 5.5: Expected emissions of CO_2 for Scenario 1

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Calculated emissions of CO_2	241,997	239,840	237,752	235,731	233,777	231,889	230,066	228,306	226,609	224,974	223,399	221,885	220,429
Allocation free of charge	242,629	242,629	242,629	242,629	242,629	192,271	177,812	163,798	150,218	137,061	124,316	111,974	100,024
Balance (+/−)	632	2,789	4,877	6,898	8,852	−39,619	−52,254	−64,509	−76,392	−87,913	−99,083	−109,911	−120,405

Tab. 5.6: Expected allocation of allowances for Scenario 2

	2008	2009	2010	2011	2012	2013	2014
Calculated emissions of CO_2	241,997	239,840	237,752	235,731	233,777	169,052	167,733
Allocation free of charge	242,629	242,629	242,629	242,629	242,629	192,271	177,812
Balance (+/−)	632	2,789	4,877	6,898	8,852	23,219	10,079

	2015	2016	2017	2018	2019	2020	
Calculated emissions of CO_2	166,461	165,233	164,051	162,912	161,816	160,763	
Allocation free of charge	163,798	150,218	137,061	124,316	111,974	100,024	
Balance (+/−)	−2,663	−15,016	−26,990	−38,595	−49,842	−60,740	

Tab. 5.7: Expected allocation of allowances for Scenario 3

- Passing on of additional cost of the EU ETS into the prices of electricity and heat (approximately, the additional cost is assigned equally to electricity and heat production—by a 50 : 50 ratio between sold electricity and heat).

Resulting allocation of allowances as input into the model is the following (see Table 5.8):

Scenario 5: with the EU ETS; with additional cost; the most realistic scenario

- The same assumptions as in Scenario 4
- Different method of allocation of allowances is applied—i.e., paragraph 11 of the Article 10a of the Directive is included, which means that 80% of allowances is allocated free of charge for heat production in 2013 and this amount decreases by an equal amount each year so that only 30% of free allowances is allocated in 2020 aiming at full auctioning in 2027.

Resulting allocation of allowances as input into the model is the following (see Table 5.9):

Scenario 6: with the EU ETS; with additional cost; with fuel nonspecific benchmark

- Same as the Scenario 4;
- Different method of allocation of allowances is applied—allocation of allowances will decrease in the same way as in the case of Scenario 2, in addition, a benchmark based on heating plants combusting natural gas is applied so that only 50% of allowances is allocated free of charge.

Resulting allocation of allowances as input into the model is the following (see Table 5.10):

	2008	2009	2010	2011	2012	2013	2014
Calculated emissions of CO_2	241,997	239,840	237,752	235,731	233,777	169,052	167,733
Allocation free of charge	242,629	242,629	242,629	242,629	242,629	192,271	177,812
Balance (+/−)	632	2,789	4,877	6,898	8,852	23,219	10,079

	2015	2016	2017	2018	2019	2020	
Calculated emissions of CO_2	166,461	165,233	164,051	162,912	161,816	160,763	
Allocation free of charge	163,798	150,218	137,061	124,316	111,974	100,024	
Balance (+/−)	−2,663	−15,016	−26,990	−38,595	−49,842	−60,740	

Tab. 5.8: Expected allocation of allowances for Scenario 4

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Calculated emissions of CO_2	241,997	239,840	237,752	235,731	233,777	169,052	167,733	166,461	165,233	164,051	162,912	161,816	160,763
Allocation free of charge	242,629	242,629	242,629	242,629	242,629	180,961	157,301	136,735	118,857	103,317	89,809	78,067	67,860
Balance (+/−)	632	2,789	4,877	6,898	8,852	11,909	−10,432	−29,726	−46,376	−60,734	−73,103	−83,749	−92,903

Tab. 5.9: Expected allocation of allowances for Scenario 5

	2008	2009	2010	2011	2012	2013	2014
Calculated emissions CO_2	241,997	239,840	237,752	235,731	233,777	169,052	167,733
Allocation free of charge	242,629	242,629	242,629	242,629	242,629	113,100	111,132
Balance (+/–)	632	2,789	4,877	6,898	8,852	–55,952	–56,601

	2015	2016	2017	2018	2019	2020	
Calculated emissions CO_2	166,461	165,233	164,051	162,912	161,816	160,763	
Allocation free of charge	109,199	107,299	105,432	103,597	101,795	100,023	
Balance (+/–)	–57,262	–57,934	–58,619	–59,315	–60,021	–60,740	

Tab. 5.10: Expected allocation of allowances for Scenario 6

5.3.4
Results of simulations for the Strakonice heat plant

The results of simulations carried out for the Strakonice heat plant are below briefly summarized with comments given.

Scenario 1: Fictive scenario

It is obvious from the results of simulation that in Scenario 1 the expected mean value of gross profit fluctuates between 20 and 30 million CZK. We may expect with 80% probability a gross profit between 0 to 60 million CZK.

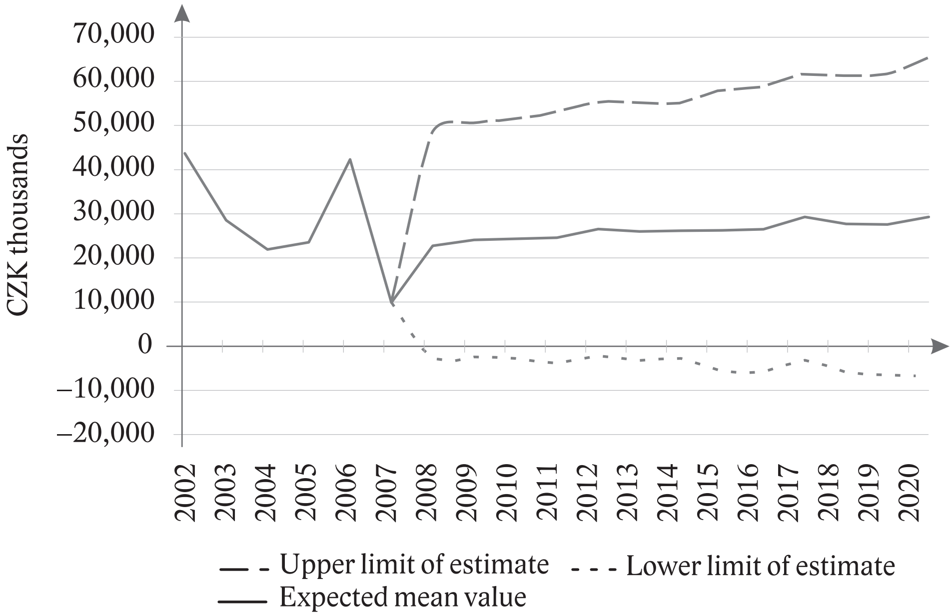

Fig. 5.1: Projection of gross profit in the years 2008–2020

Scenario 2: with the EU ETS; Fictive scenario

The results of simulation in Scenario 2 are characterized by a sharp decline in earnings into loss caused by preservation of relatively high emissions (no reconstruction of boilers and no utilization of zero-emission biomass in fuel mix) and also by a rather higher expected price of allowance (uniform distribution within interval 5–71€). The reader must be reminded here that additional cost of emission trading is not passed on to prices of produced energies in this scenario (the prices of produced energies remain the same as in Scenario 1).

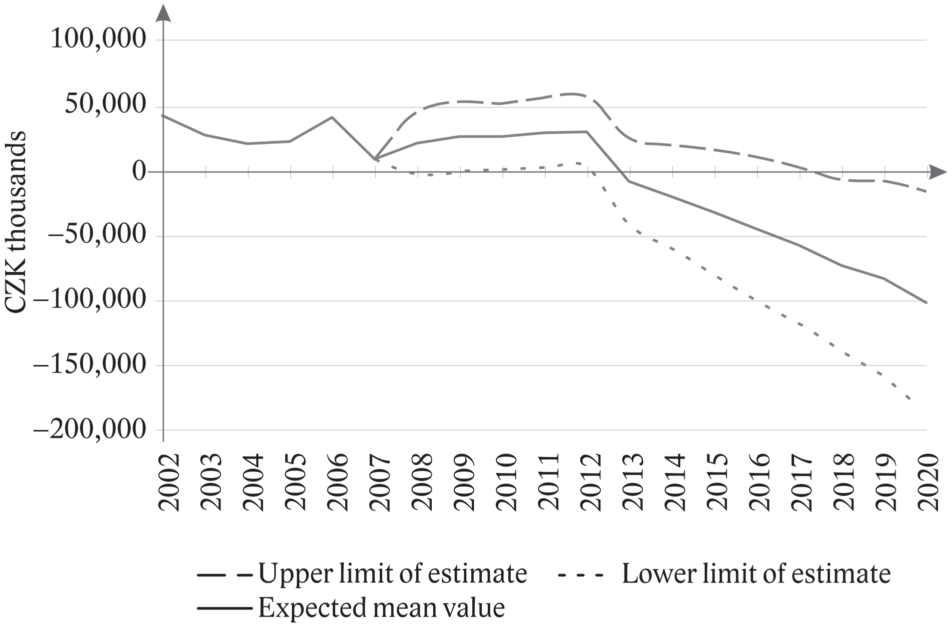

Fig. 5.2: Projection of gross profit in the years 2008–2020

It is also appropriate to point out that allocation of emission allowances needed for covering emissions released from heat production is the most moderate of all simulated scenarios, giving weight to this scenario. Even in this case the company's gross profit quickly goes in the red.

Scenario 3: with the EU ETS

This scenario, if compared to Scenario 2, demonstrates the isolated impact of reconstructing boilers and co-firing of biomass in the Strakonice heat plant. Allocation of allowances and other assumptions remain the same as in the previous scenario.

The results of this simulation show that the company is able to keep gross profit in positive territory until 2016. After this year the company begins to create losses up to 60 million CZK in 2020. At the same time, it is also appropriate to notice the range depicting 80% confidentiality interval, which can be read as follows: in the worse case, the company may be in the red already from 2013 (in the picture shown by the lowest dotted curve), in the

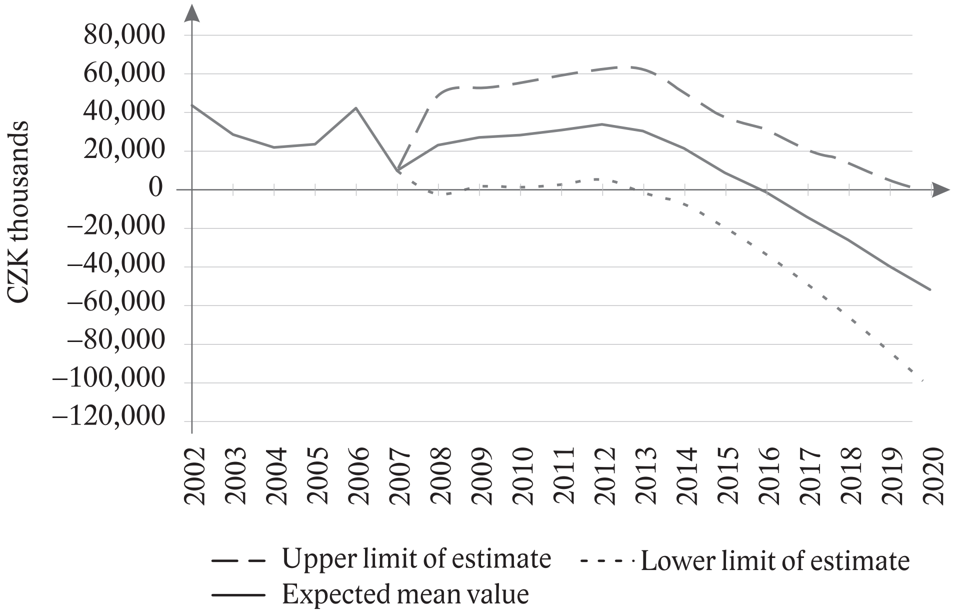

Fig. 5.3: Projection of gross profit in the years 2008–2020

better development of events, it can remain at zero profit even in the year 2020 (in the picture shown by the highest dashed curve)

Scenario 4: with the EU ETS; additional cost passed on to prices

The results of this scenario are substantially more favourable than in the previous case because additional costs of allowance purchases are fully passed on to consumers of energies through increased prices. Allocation and other assumptions are the same as in the previous one, i.e., the company will undertake reconstruction of boilers in 2013 and will co-fire biomass at a 30% share from the same year. Gross profit is in comparison to Scenario 1 lower, which can be explained by the two factors:

- Increased depreciation of invested tangible assets (25 million CZK) is not passed on to process energies
- Revenues from sales boosted by increase in prices (caused by passing on the additional cost of the EU ETS) influence variable component of some cost items in the income statement. This presupposes that some cost items will move upwards as the amount of revenues increase in time, though this may not be true in the specific case outlined by this scenario. This part of the model is not methodologically too strong and in later

versions will be improved to eliminate this rather unrealistic reaction of cost items.

To fully compensate the decrease in gross profit, a bigger increase in prices of sold energies would be necessary. This problem was not solved in this study, because this study was interested principally in the isolated impact of the EU ETS.

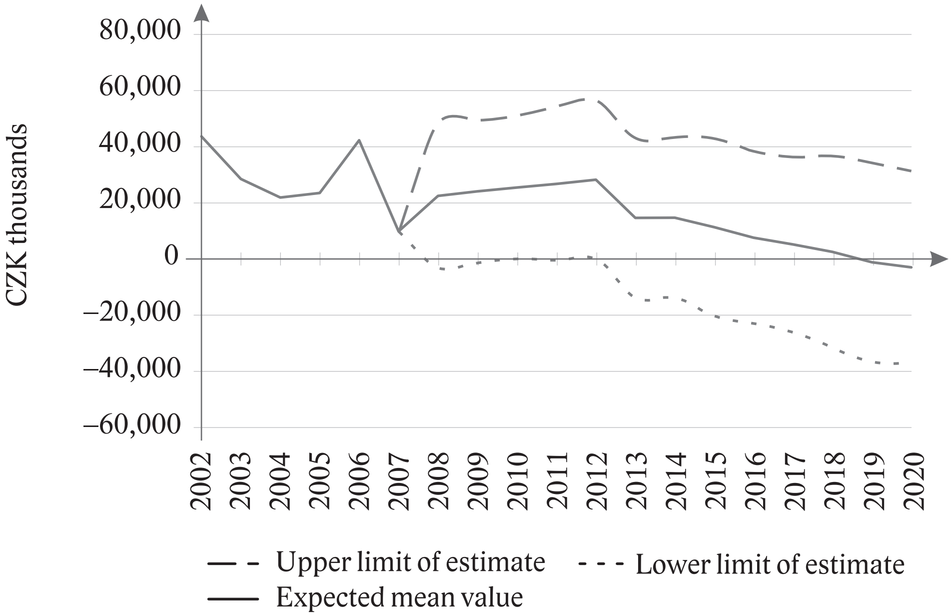

Fig. 5.4: Projection of gross profit in the years 2008–2020

As can be seen in the chart above, the company maintains a positive gross profit until 2018. After this year it begins to create modest losses annually, but overall impact is significantly compensated by an increase in prices of sold energies.

Impact on the prices of sold electricity and heat is depicted in the following two charts.

The previous charts show that the increase in the prices of heat and electricity is gradual and in time gets more intensive as the share of allowances purchased at auctions will increase. The difference in the price of electricity in 2020 is nearly 300 CZK compared to the situation without the EU ETS (Scenario 1). In the case of the price of heat the difference adds up to 50 CZK compared to the price of heat in Scenario 1. If the increase in the prices

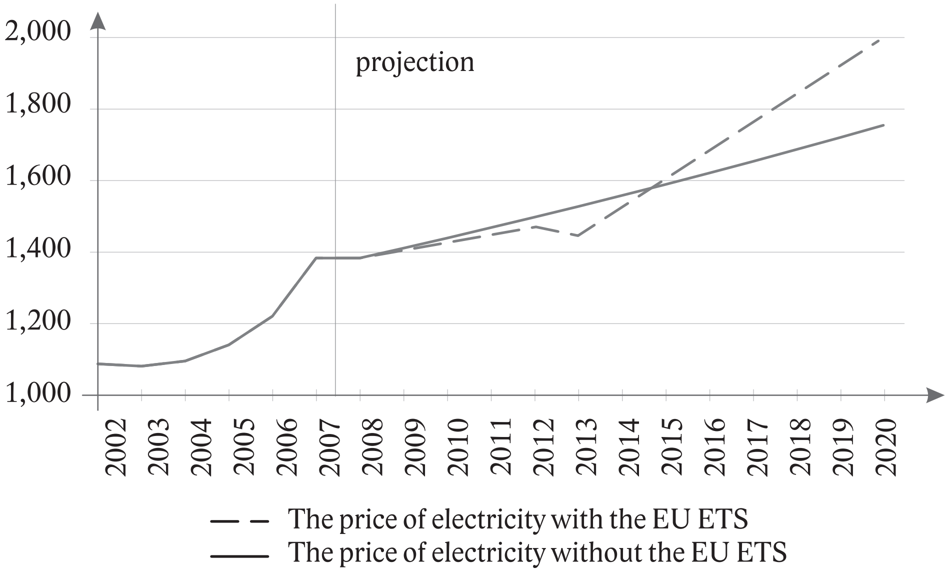

Fig. 5.5: Comparison of the prices of electricity without and with existence of the EU ETS (50% of additional cost is passed on to the price of electricity) in CZK/MWh

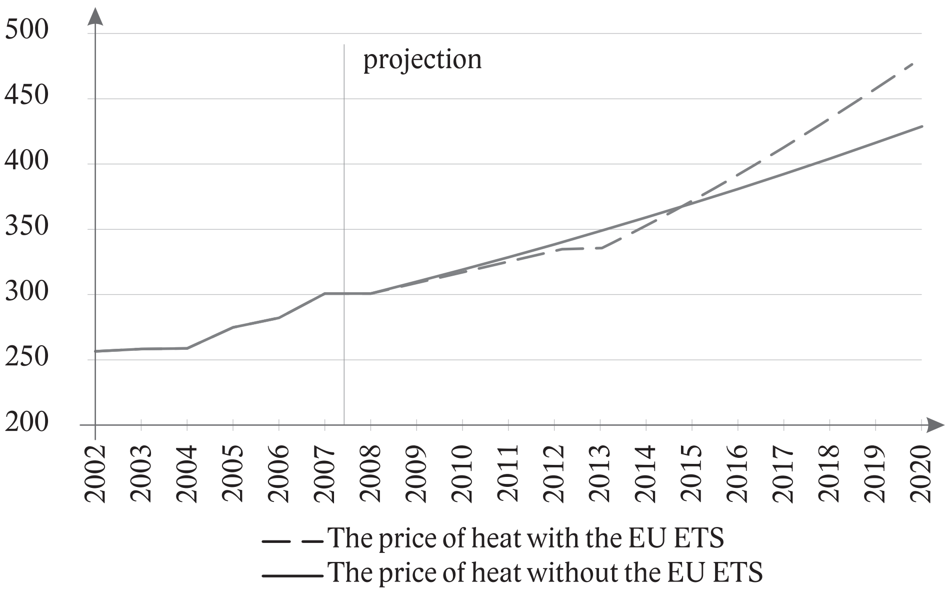

Fig. 5.6: Comparison of the prices of heat without and with existence of the EU ETS (50% of additional cost is passed on to the price of electricity) in CZK/GJ

of energies should compensate full cost incurred by the EU ETS and related reconstruction of boilers, impact on prices would be more substantial.

Scenario 5: with the EU ETS; additional cost passed on to prices; the most realistic scenario

This scenario contains probably the most realistic allocation of allowances for the Strakonice heat plant. Simulation results show that this method of allocation brings loss to the company already in 2016. Remember that in this scenario we deal with impact on a modernized heat plant using 30% of biomass in its fuel mix and prices of sold energies include additional cost of purchases of deficient allowances.

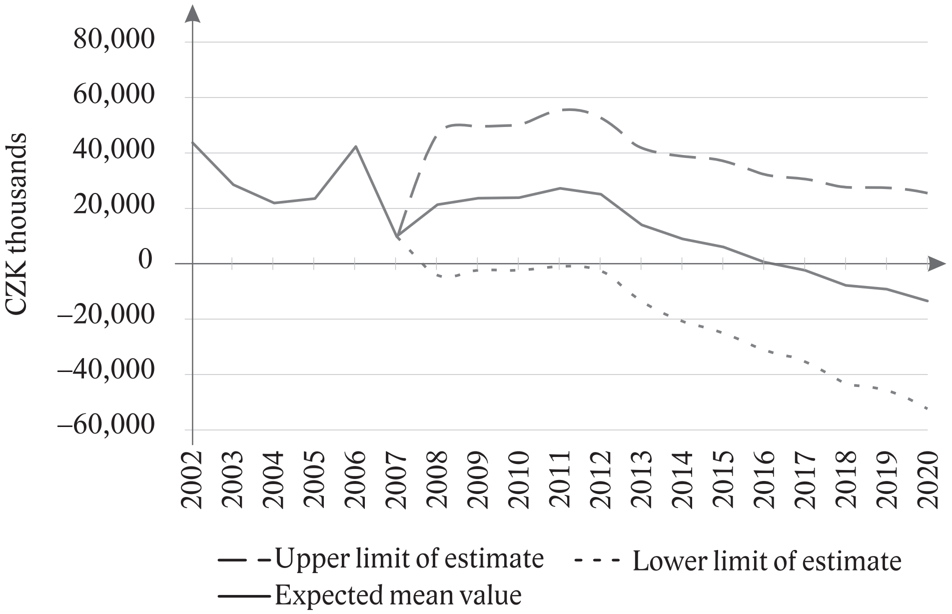

Fig. 5.7: Projection of gross profit in the years 2008–2020

An increase in the prices of electricity and heat is depicted on the following two charts. In the charts we can see that increase in price of sold energies is continual and steady with an increase in the share of allowances that have to be bought on the open market or at auction at actual market price. The difference in the price of electricity in 2020 is around 400 CZK per megawatthour in comparison to the background scenario (Scenario 1 without emission trading). Impact on the price of heat in the last year of simulation (2020) is nearly 100 CZK per GJ.

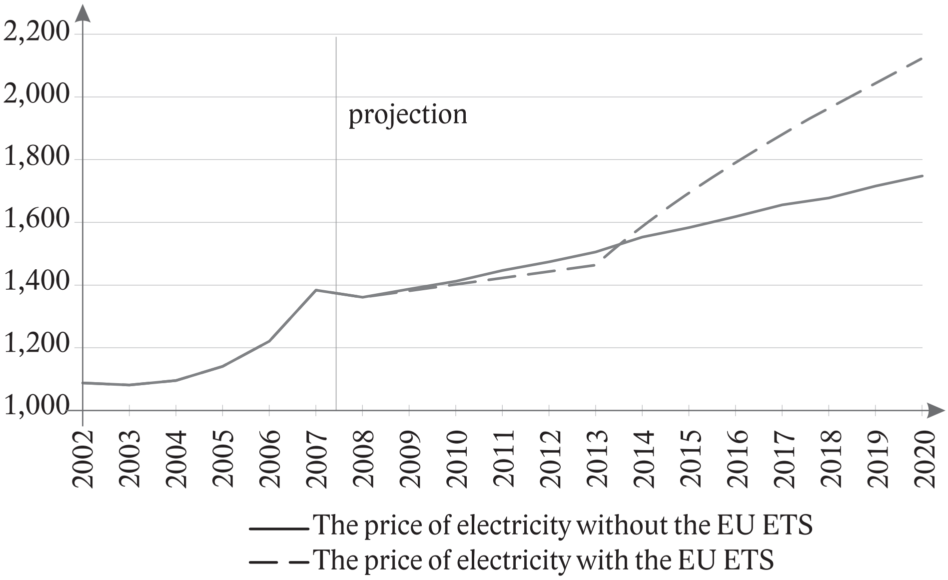

Fig. 5.8: Comparison of the prices of electricity without and with existence of the EU ETS (50% of additional cost is passed on to the price of electricity) in CZK/MWh

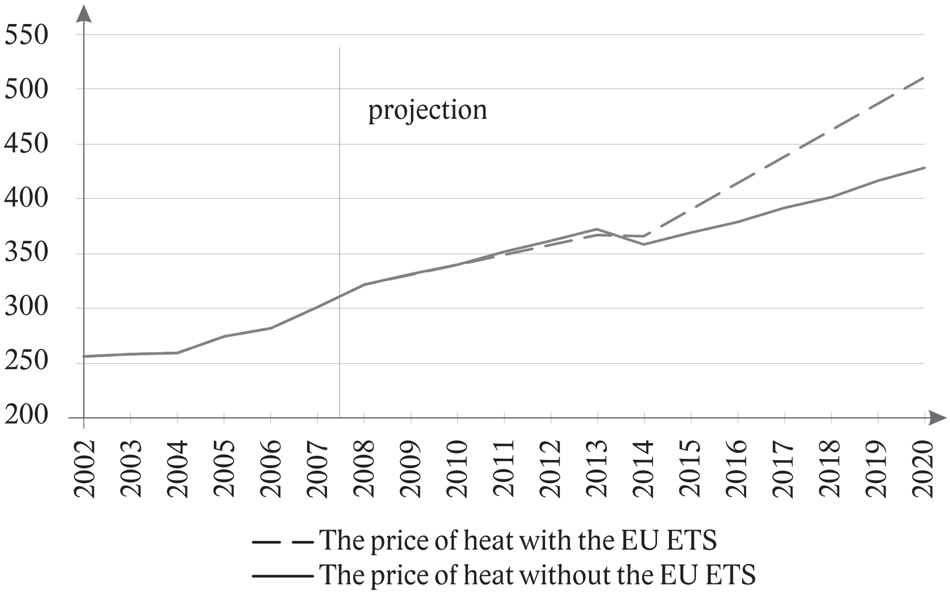

Fig. 5.9: Comparison of the prices of heat without and with existence of the EU ETS (50% of additional cost is passed on to the price of electricity) in CZK/GJ

Scenario 6: with the EU ETS; additional cost passed on to prices; with fuel nonspecific benchmark

In the last scenario the simulated situation was when allocation of allowances was solved with the aid of a fuel non-specific benchmark (for explanation see section 3.3.6). This scenario may be realistic if the Czech Republic will not succeed in procuring its interests in the EU and will not manage to enforce fuel-specific benchmarks varying for different fuels with respect to the high share of coal-based fuels in the domestic heating sector (the emission factor of brown coal mostly used in the CZ is nearly double compared to the emission factor of natural gas). With respect to the last information obtained when preparing this scenario it seems that allocation applied in the economic model for this scenario is still too favourable for the model company than it would be in practice, because in real allocation it would be necessary to diminish allocation by an additional 20% in 2013 with continual decrease up to 70%; in the model we calculated only with a linear decrease of the allocated amount of allowances by 1.74% each year from 2013 to 2020.

Results show that the company's gross profit would drop to slightly negative territory from the first year of auctions (2013).

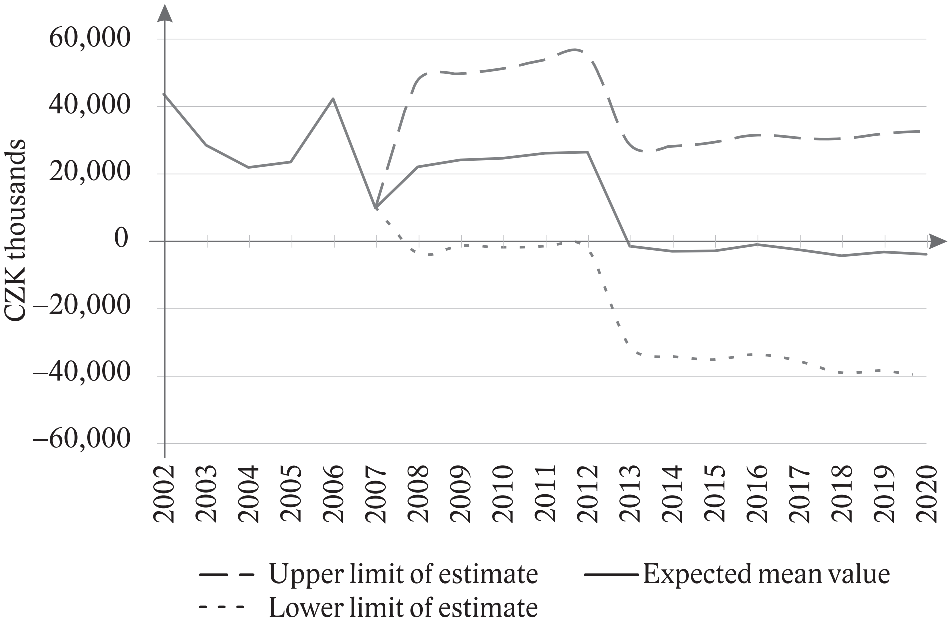

Fig. 5.10: Projection of gross profit in the years 2008–2020

The same approach was adopted for modelling the impact on prices of sold electricity and heat as in the previous scenarios. As can be seen in the two following charts, the increase in the prices of energies remains stable over the third trading period; the price of electricity would increase by 200 CZK per MWh and the price of heat by 40 CZK per GJ.

Conclusion and discussion

Results of the conducted simulations indicate that the third emission trading period under the European emission trading scheme (EU ETS), i.e., from 2013 to 2020, will influence the economic activity of the analyzed company significantly. Results of alternative scenarios indicate that the company's earnings depend substantially on the method of allocation of allowances. This allocation is then dependent on the negotiated terms for the Czech Republic (particularly represented by the Ministry of Environment) for the heating sector in the CZ. The higher the price of allowance is, the more significant is the expected impact on earnings or price of produced electricity and heat because additional cost is directly proportional to the price of allowances.

Results of alternative scenarios show that to maintain sufficient earnings in the new EU ETS conditions it will be necessary to significantly increase prices of produced electricity and heat (this is also valid for the scenario with boiler reconstruction and biomass coburning). Simulated increases in prices of electricity and heat however do not cover the price increase due to increased investment cost (annual depreciation) and also increase in variable costs induced by revenues increase.

The simulation results indicates that there is still a surplus of received free allowances until 2013 and selling of exceeding allowances at market price still enables decreasing prices of produced energies compared to Scenario 1 (which can be considered as Business-As-Usual scenario). From 2014 on, however, as a result of sharp decline in quantity of allowances allocated free of charge, there is a need to purchase additional allowances to cover all released emissions. The result may also be interpreted as follows: for the company, purchasing allowances is a steady outflow of financial resources and this payment cannot be avoided without significant costs, because we cannot expect that it would be possible to substitute biomass for all coal for many reasons.

In this case study the most dramatic scenarios are not included. These include when the company has to buy all allowances at auctions at market prices for emissions from both electricity and heat production. At the same time, there is no scenario assuming that allowances would be allocated according to a specific benchmark for coal.

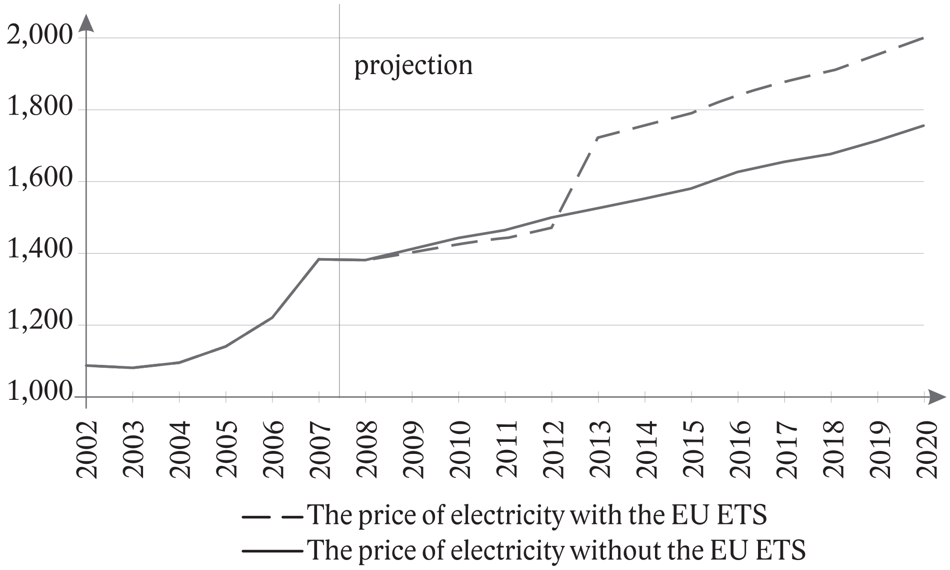

Fig. 5.11: Comparison of the prices of electricity without and with existence of the EU ETS (50% of additional cost is passed on to the price of electricity) in CZK/MWh

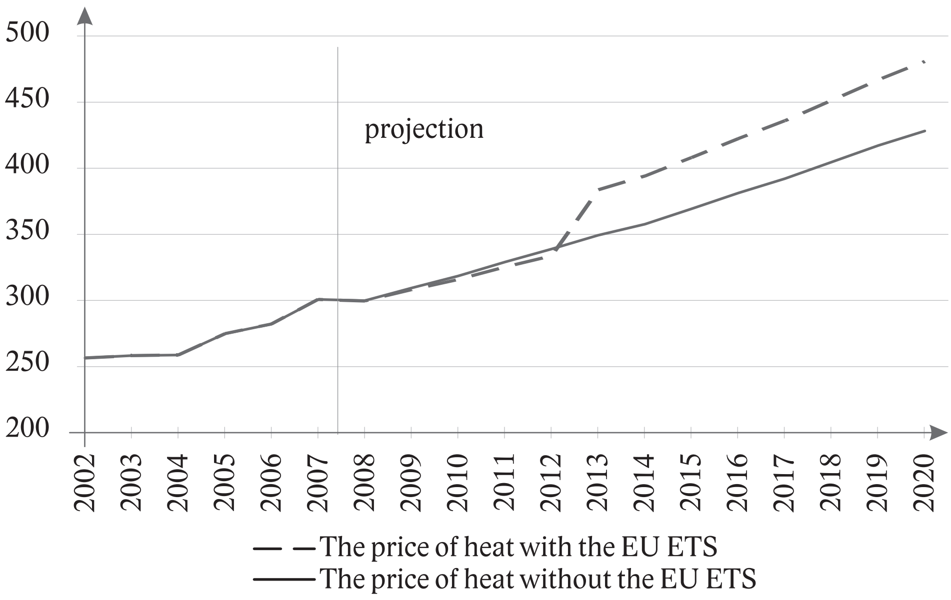

Fig. 5.12: Comparison of the prices of heat without and with existence of the EU ETS (50% of additional cost is passed on to the price of electricity) in CZK/GJ

Despite that this case study is only a demonstration of impact of the EU ETS after 2013 on only one company, there is no reason to presume that simulation results would be significantly different for other similar companies. The authors of this study believe that such material (impact of different methods of allocation on a sample of similar subjects—companies producing combined heat and electricity) could be a proper argument for vindication of the CZ official position before the European Commission in negotiation process about the extent of exemptions enabled by the Directive. At the same time, the authors are continuing work on the modelling tool to improve reliability of results by eliminating some simplifications still contained in the model presumptions and enabling better handling of input and output data using advanced modelling languages instead of an MS Excel spreadsheet. In the future MS Excel will be used only as an interface for data handling and interpretation of results.

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6

Nuclear power plant of Temelín (social dimension)

6.1 Introduction

Large-scale projects, such as nuclear power plants, as a rule have significant impacts on the natural and social environments in which they are located. Assessment of their social impact is obviously related to the concept of risk, more precisely to the way a local community is able to cope with it. Metaphors such as "landscape of risk" or "risk perception shadow" can be used to delineate the scope of the view, each highlighting a particular aspect of risk assessment—objective and subjective. The former is used to denote areas potentially exposed to radioactive contamination, as defined by science (Blowers, 1999), whereas the latter isdefined as a human collectivity that considers itself to be at risk from a proposed or operating project. It is thereby open to measurable social impacts regardless of whether or not adverse human or environmental risks have been scientifically established (Stoffle et al., 1993).

The Temelín nuclear power plant is the biggest industrial construction ever built in South Bohemia (Fig. 6.1 and 6.2). Originally, the area where the construction took place was a traditional rural landscape, attributed with all the features of marginal areas, including the character of the local population—rural and conservative. Due to the size of the plant and also because both its construction and operation were based on "know-how", which was not available in the locality before, the power plant was largely perceived as an alien phenomenon by local people (Těšitel et al., 2005). As such, it was assumed to become a factor affecting local social dynamics, at least in two aspects: 1) it forced the local population to cope with the consciousness of the permanent risk of the hazard to life, while 2) it was said to stimulate, directly or indirectly, socio-economic development of the area (Vaishar, 1999).

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Fig. 6.1: South Bohemia landscape without the Temelín nuclear power plant (photomontage Daniel Bartoš)

Fig. 6.2: South Bohemia landscape with the Temelín nuclear power plant (photo Michael Bartoš)

Looking at the Temelín nuclear power plant from a risk perspective, it can be considered a "manufactured risk" in the sense of Giddens (2000)[1]. The risk ascribed to the plant, aside from the addressed environmental aspects of its operation, also concerns the impacts of the plant's operation on the everyday life of people within its reach. Hence, it turned into a "political dilemma" used in both national and international arenas. Internationally, it has been a subject of hot political debate between Austria and the Czech Republic since the early 1990s.

The Temelín nuclear power plant is a multifaceted phenomenon. The debate on the power plant, however, did not address the social science aspects for a long time. This changed partly in 2000 when the Melk Protocol between the Czech and Austrian governments was signed. This protocol set a base for long-term research to address the power plant's social dimensions. This paper, building on data gained in the framework of this research, aims at supporting a social debate about the power plant, hence, trying to fill some of the still present information gaps.

6.2 Methods used

The concept of quality of life (Massam, 2002) was applied as the main interpretation framework for the research, building on the idea of manufactured risk with its attention being paid to social life, and considering the "developmental aspect" attributed to the power plant. The aim of the research was to identify how the building process and, later, the operation of the plant influenced particular aspects of the quality of life for the population living in South Bohemia. For the sake of the research, the concept was slightly modified—extended by the indicators of the quality of work, housing and

[1] *According to this concept, there are two types of risk—external and manufactured. While external risks originate in nature and can be seen as an innate part of life, manufactured risks are assumed to emerge, as induced by the human effort to manipulate the world. Manufactured risks are not limited exclusively to environmental problems, they are tightly interwoven with all day-to-day human activities. As they have little historical reference, they are largely unpredictable. Politicians are supposed to play an important role in the process of coping with these risks, however they could be blamed anyway. If they underestimate the risks—they obscure reality; if they overestimate these risks—they spread panic. Giddens does not assume the contemporary world to be more risky, compared to the historical world. Only the proportion of both risk types has been changing, in favor of the manufactured one. As risks obviously cross state boundaries, there is an urgent need for cooperation among particular states as well as for establishement of new institutions to monitor and assess technological changes. Giddens, ultimately, attributes the manufactured risk with some dynamizing effects, and hence, with optimism of some kind: When thinking about a support to science-based innovations and changes in general, we probably will have to adopt more courage, rather than conservative behaviour in the future.*

recreation, human relations, free time activities, participation in community life, feeling of personal and social safety, civil liberty and chance for personal career.

Another key component of the research was the definition of local population presumably affected by the nuclear power plant, a collectivity commonly referred to as the "locally affected population" (Stone, 2001), assumed to provide geographic and sociocultural framework for the analysis. Much evidence can be found in pertinent literature about locally affected populations being defined with a variety of measures, such as pre-existing political jurisdictions (USNRC, 1983); pre-determined distance-from-site criteria (USNRC), 1983); various ecosystem approaches at levels ranging from macro-systems (Puntenney, 1995), to regional (SAB, 1991), and local (Moran, 1990; Cortese et al., 1997); and the extent of known contamination (Edelstein, 1988). When delineating the model area/population, we combined the first two criteria mentioned above. The administrative perspective was preferred and the whole South Bohemian region/population was taken as the locally affected population for the analysis (Fig. 6.3), divided however into ten-km-wide concentric zones, with the nuclear power plant in the center.

Within the framework briefly outlined above, comparative analysis was conducted having a form of longitudinal questionnaire-based quantitative research addressing two time horizons—November and December 2004 and December 2008[2]. A modified questionnaire Quality of Life Profile (Adult Version), standardized by the Centre for Health Promotion, University of Toronto (Massam, 2002) was used for the purpose. Respondents were asked to assess the extent to which particular aspects of their quality of life were influenced by the building, and later on by the operation of the Temelín nuclear power plant. Questionnaires of 2004 and 2008 were structured the same way. However, the version of 2008 was extended by two questions—aimed at getting to know the opinion of the local population on the proposed extension of the nuclear power plant, and about the possible locating of a nuclear waste repository in South Bohemia, more specifically in the area of the Temelín power plant.

The adult population of South Bohemia i. e. people older than 15 years, permanently living there, was defined as the basic set. The sample was derived from this set by combining quota and random sampling, with quotas being the size of the municipality (in terms of number of permanently living

[2] *In particular cases, we as well compared our results with those obtained in 1993 within the the project titled "Changes in South Bohemia 1992–1993". The project was aimed at mapping changes in the quality of life of the South Bohemian population during the beginning of socio-economic transformation (tax reform, separating Czech and Slovak states, etc.). Attitudes of local people to the Temelín nuclear power plant was, at that time, only one of the issues researched. The empirical survey was done using questionnaires; 500 respondents were addressed, readers of the Jihočeské listy newspaper; 406 completed questionnaires returned (Kopáček et al., 1993).*

Fig. 6.3: Schematic map of South Bohemia. The circle represents the zone of emergency management reaching up to 13 km from the Temelin nuclear power plant

inhabitants) and its distance from the nuclear power plant (in terms of presence of the municipality in a particular 10-km-wide concentric zone). Field surveys were conducted using pollsters, students of high schools located in the model area—in Český Krumlov, Vimperk, České Budějovice, Jindřichův Hradec, Dačice, Třeboň, Písek, Tábor, Strakonice and Veselí nad Lužnicí. Empirical data was obtained from 1 043 respondents in 2004, and from 937 in 2008. The basic set was composed of 560,284 and 544,967 inhabitants respectively in 2004 and in 2008[3]. The samples amounted to about 0.2% share on the basic sets in both surveys, which set a good base of their representativeness. Obtained data was statistically analyzed, primarily by use of the first, second and, in some cases, third level classifications. For higher order classifications, goodness-of-fit and contingency tables methods were used (SPSS for Windows, ver. 12.0. respective 15.0.). Graphical outputs were produced using Excel 2000 for Windows.

[3] *http://www.czso.cz/x/krajedata.nsf/oblast2/obyvatelstvo-xc, [cited November 8, 2010].*

6.3
Results and discussion

6.3.1
Adaptation

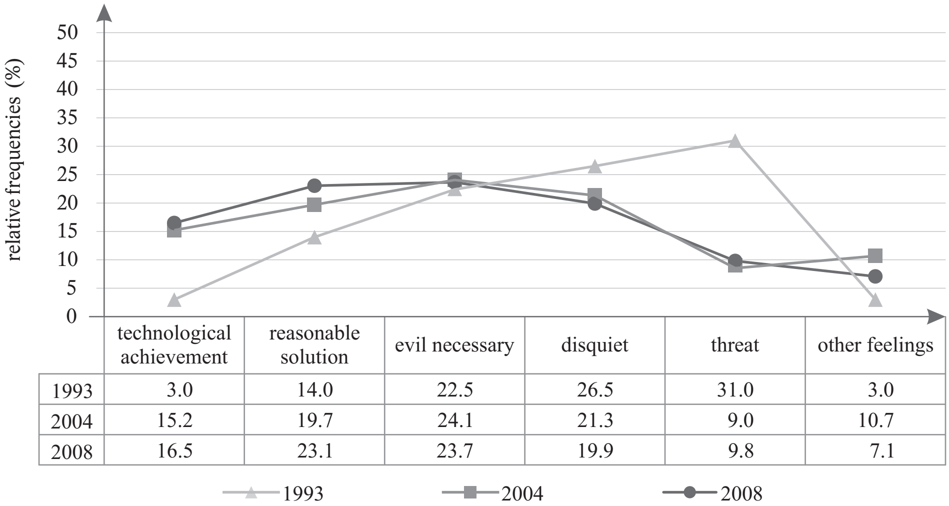
The emergence of the Temelin nuclear power plant in the picturesque landscape of South Bohemia can be considered an "abrupt change" in local and regional social systems. Temelín induced stress for the population as with any other sudden change (e. g. Adger, 2000), and consequently, adaptive processes occurred as a response to it.

The process of **gradual adaptation to the perceived risk** can be documented by comparing emotional attitudes of respondents to the cooling towers of the nuclear power plant in three time horizons (Graph 6.1). The differences in distributions of frequencies proved to be statistically highly significant (Tab. 6.1). In 1993, the cooling towers only started to modify the skyline, and the previously only abstractly perceived problem started to take the shape of its more concrete manifestation. The distrust in nuclear power plant technology in general, emphasized by the Chernobyl accident in particular, most likely caused the majority of respondents to perceive the power plant primarily as a threat or disquieting. Viewing the plant as a reasonable solution was a rather marginal standpoint at that time. The survey in 2004 brought results distributing frequencies in a more balanced way. The data obtained in 2008 even slightly pronounced the tendency of the distribution to be shaped in a "normal-like" way, as the rating of reasonable solution was slightly emphasized. The reason behind the "reshaping" may be that in 2004, people were already confronted with the reality of the nuclear power plant being operated accident-free, whereas ten years earlier, they had to cope with the prognostic vision only or, in other words, with a so far nameless risk.

distribution of frequencies	χ^2	D. F.	asymp. sig.*
1993/2004	825.544	5	0.000
2004/2008	19.980	5	0.001

** As usual, statistical significance results are indicated by the asymp. sig. values below 0.05.*

Tab. 6.1: Comparison of distribution of attitudes (Goodness-of-fit test)



	technological achievement	reasonable solution	evil necessary	disquiet	threat	other feelings
1993	3.0	14.0	22.5	26.5	31.0	3.0
2004	15.2	19.7	24.1	21.3	9.0	10.7
2008	16.5	23.1	23.7	19.9	9.8	7.1

Graph 6.1: The cooling towers of the Temelín nuclear power plant evoloke feelings

The social milieu has changed profoundly during the last fifteen years—people have become so accustomed to the nuclear power plant to the extent that they frequently see it as an innate part of the "normal South Bohemia scenery" (Fig. 6.4). In parallel, there is an ongoing worldwide renaissance of nuclear energy, documented by recent professional literature (e. g., Whitfield et al., 2009; Colvin, 2005; Moore, 2000), and reflected as well by the South Bohemian population (Graph 6.2; Tab. 6.2). All that, together with the desire to achieve national self-sufficiency in energy, triggered by the recent energy policy measures applied by the Russian Federation towards Europe, apparently eased South Bohemians to rationalize their emotions regarding their reconciliation with the nuclear power plant located in the region, and hence, its factual acceptance.

distribution of frequencies	χ^2	**D. F.**	**asymp. sig.**
2004/2008	24.624	3	0.000

Tab. 6.2: Comparison of distributions (Goodness-of-fit test)

It can be generally stated that the role of the Temelín nuclear power plant, as a **generator of regional social dynamics,** has changed recently, viewed from individual, municipal or regional levels.

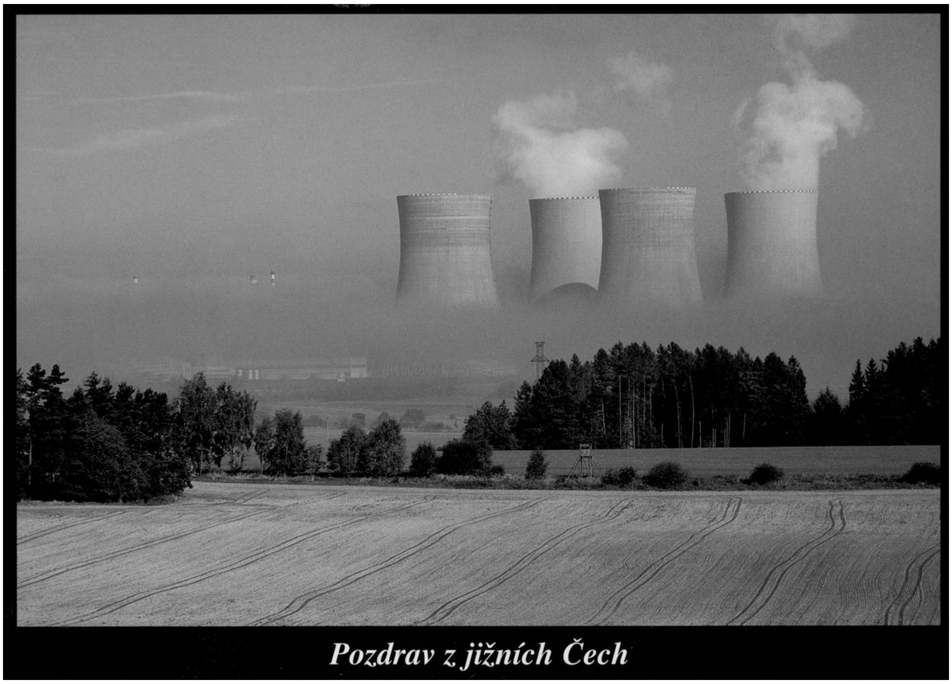
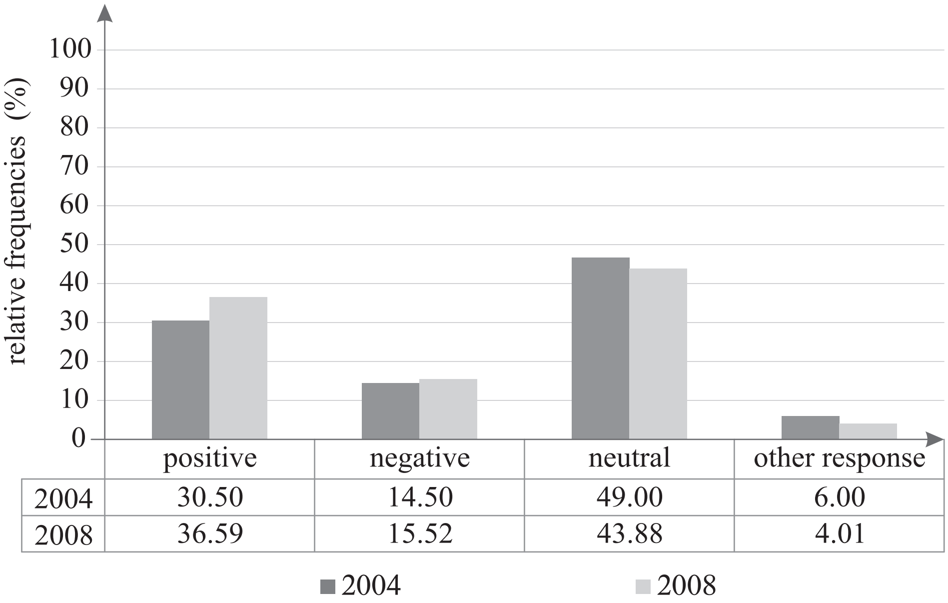


Fig. 6.4: Postcard "Greetings from South Bohemia" (photo Libor Sváček, archive MCU Publishing)

Individual people in South Bohemia obviously do not consider the nuclear power plant as something that can markedly influence the place in which they live (Graph 6.3.), nor do they see it as having an effect on their day-to-day free-time activities. Viewing the power plant from this perspective, only people living in its close vicinity can be considered the affected population. When assessing the role of the power plant, these people do it rather positively. Most people living in South Bohemia absolutely refused the idea of moving out of the region just because of the presence of the nuclear plant there (Graph 6.4). Building on figures obtained both in 2004 and in 2008, it is apparent, that this attitude has remained unchanged when we compare the two time horizons. The general stability of a conservative South Bohemian population could be used to account for this, as well as that the population has already come to terms with the nuclear power plant.

TV, press, wireless, friends and acquaintances appeared to be the most frequently used sources of information for South Bohemians to get informed about what was happening with the Temelín nuclear power plant; recently, the role of the Internet has been slightly pronounced (Graph 6.5). As this structure matches a more general pattern, reflecting in fact the popularity of information



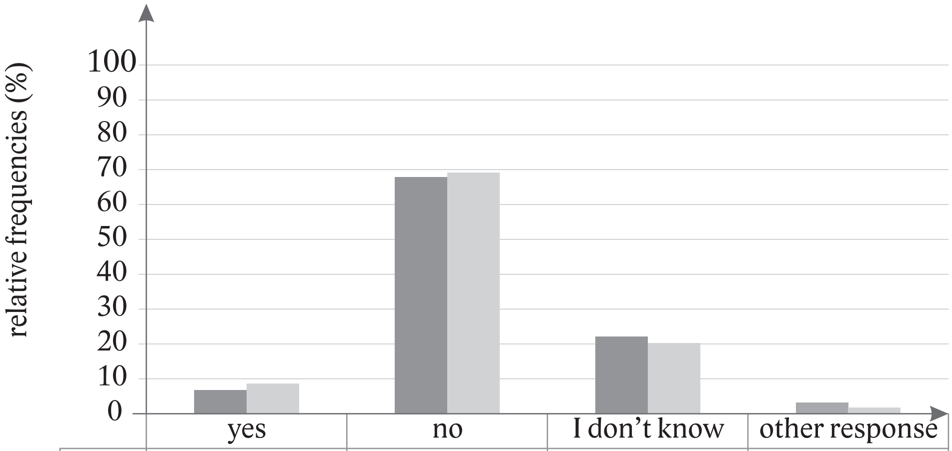
	positive	negative	neutral	other response
2004	30.50	14.50	49.00	6.00
2008	36.59	15.52	43.88	4.01

Graph 6.2: What is your attitude to the nuclear energy?

sources themselves, rather than its relation to a particular subject reported about, the fact that there is a group of people, amounting to about 16% of the sample in both surveys, who explicitly stated that they did not care about the Temelin nuclear power plant at all in principle, could be considered the only interesting finding.

The general level of awareness as far as the Temelín nuclear power plant is concerned seemed to be relatively high within the region (Graph 6.6). Those living in the zone of emergency management were undoubtedly well informed. Nevertheless, both figures indicate what can be termed "apathy of rating" shown by the sixteen per cent of "those who do not care" in Graph 6.5, as well as the apparent changes in the distribution of responses in Graph 6.6. The statistically significant "rescaling" (Tab. 6.3), characterized by the accumulation of scores in the middle of the scale, can be interpreted as "the situation getting normal". The same tendency could be found when we applied qualitative analysis, as it is evident from the authentic respondents' statements, such as "I am indifferent to Temelín", "I do not search for information about it at all"; "I do not need information about it at all"; "the issue of Temelín has been out of my interest", "I do not need information about it".

The Temelín nuclear power plant is proving to be neutral as to its **affect on municipalities'** concerns as well. The table below can be seen as evidence to support the statement. There are only 2% and 3% of people respectively



	yes	no	I don’t know	other response
2004	6.80	67.90	22.10	3.20
2008	8.68	69.21	20.35	1.76

■ 2004 ■ 2008

Graph 6.3: Do you think that your neighbourhood is somehow affected by the Temelín nuclear power plant?

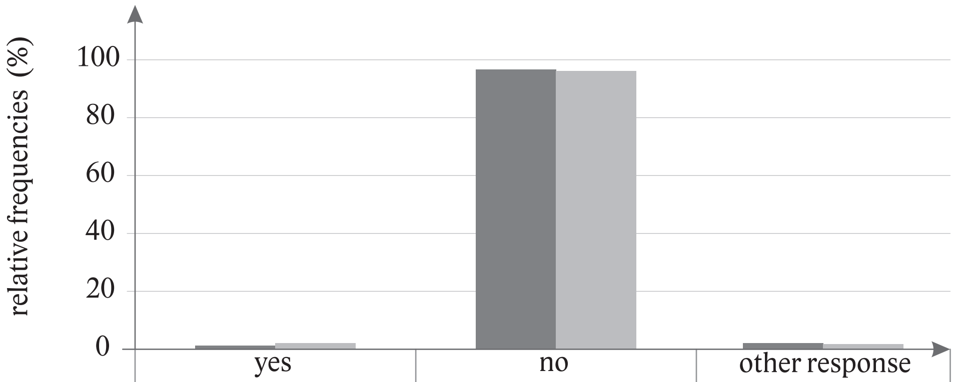
distribution of frequencies	χ^2	D. F.	asymp. sig.
2004/2008	11.381	5	0.044

Tab. 6.3: Comparison of distributions (Goodness-of-fit test)

who see the nuclear power plant as affecting positively *(direct sponsoring of municipalities, improvement of infrastructure)* or negatively *(the most expensive electricity in the Czech Republic)* the places in which they live (Tab 6.4).

It appears that “Temelín” has ceased to be a “hot topic” of debate in South Bohemia, a factor influencing local and regional social networks. For more than 85% of South Bohemians, the nuclear power plant was never a subject of dispute with friends or within the family. Nor has it led to the breaking up or establishment of personal, social or other relations in their neighborhood (Tab. 6.5).

Nevertheless, the South Bohemian population still perceives the Temelín nuclear power in terms of risk. These people have solidarity with those who are expected to be exposed to the higher risk, namely with those who are settled in the 13-km zone of emergency management (Graph 6.7). Almost half of the population would explicitly support the idea. As stated above,



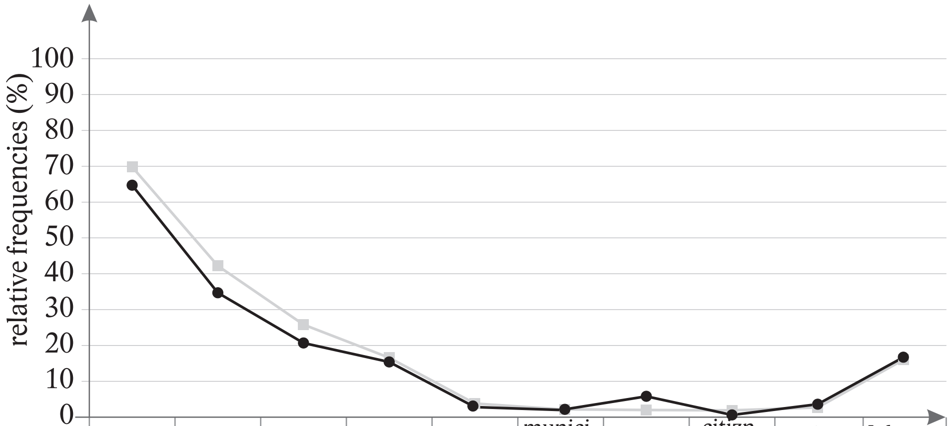
	yes	no	other response
2004	1.20	96.70	2.10
2008	2.16	96.08	1.75

Graph 6.4: Do you think about to move out of the region because of the Temelín nuclear power plant?

Do you know concrete cases when the Temelín nuclear power plant affected everyday life in your municipality? (%)				
	positively		**negatively**	
	2004	**2008**	**2004**	**2008**
Yes	2.1	3.6	1.7	3.8
No	**82.2**	**79.2**	**83.1**	**79.3**
I do not know	15.1	17.0	14.4	16.7
Other response	0.6	0.2	0.8	0.2

Tab. 6.4: Affect of the Temelín nuclear power plant on everyday life in municipalities, as perceived by their inhabitants

the population accepted de facto the nuclear power plant (they ultimately could not do anything else). The solidarity in this context, rather than being a common revolt against the power plant, has been focusing on compensations of the risk, realized either by direct payments or indirectly, in the form of particular advantages. The prevailing opinion says that low prices of electricity



	TV	press	wire-less	friends	info-centre	munici-pal re-present.	Internet	citizn-action publics	other response	I do not care
2004	69.8	42.2	25.8	16.6	3.8	2.2	2.0	1.9	2.7	16.0
2008	64.7	34.7	20.7	15.4	2.8	2.0	5.8	0.6	3.6	16.7

2004 2008

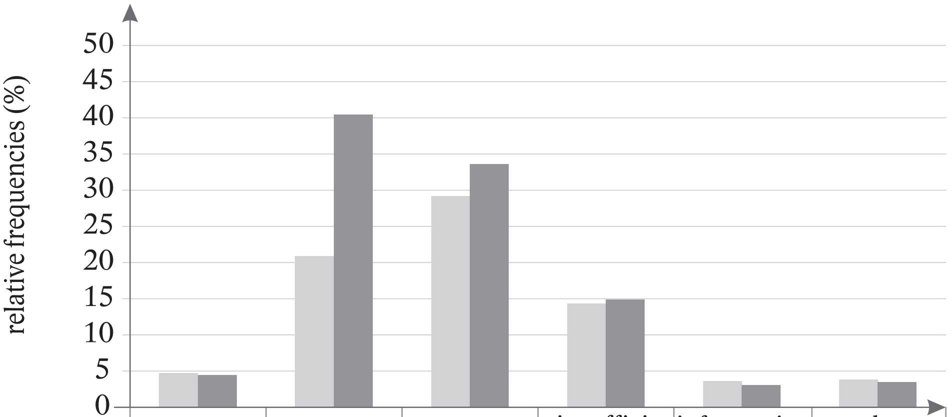
Graph 6.5: Sources of information about the Temelín nuclear power plant

Do you know concrete cases in your neighborhood when the Temelín nuclear power plant caused? (%)				
	breaking up of personal, social or other relations		**establishing of** personal, social or other relations	
	2004	**2008**	**2004**	**2008**
Yes	1.7	3.0	3.3	4.5
No	**89.9**	**86.6**	**86.4**	**82.4**
I do not know	8.3	10.4	9.9	12.7

Tab. 6.5: Affect of the Temelín nuclear power plant on personal, social and other relations, as perceived by South Bohemia population

would be the most appropriate compensation in this respect.[4] Lower taxes

[4] *Providing a low price of electricity for people living in the vicinity of the Temelín nuclear power plant was an argument frequently used since the very beginning by advocates of having Temelin in the region. The aim was to support their standpoint of economic efficiency of the presence of the power plant there. However, the promise was never kept.*



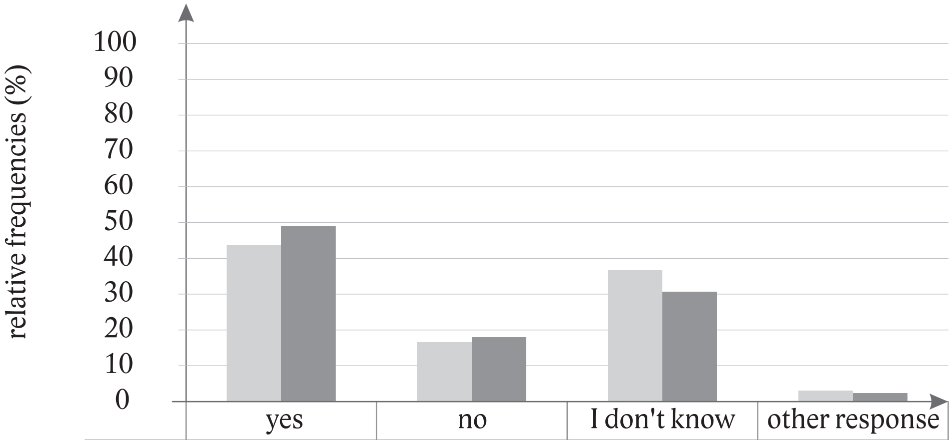
	very well	sufficiently	not particularly	insufficiently	information is lacking	other response
2004	4.70	44.50	29.20	14.30	3.60	3.80
2008	4.44	40.45	33.64	14.86	3.10	3.51

■ 2004 ■ 2008

Graph 6.6: I feel to be informed about the Temelín nuclear power plant . . .

or, on the other hand, increased subsidies to the nearby lying municipalities follow. Another idea was to compensate the price of real estate or land, when they are sold, or to invest into infrastructure and services in the affected municipalities. The idea of compensating "life under risk" in the zone of emergency management by improving medical care for their inhabitants occurred frequently as well *(e. g,. regular medical monitoring, psychological service free of charge, or contribution of the state to medical insurance, etc.)*

Only about 20% of South Bohemian inhabitants consider the nuclear power plant to be an impetus for **regional development** that contributed to the increase of the living standard in South Bohemia. Most people, however, consider the nuclear power plant and increased standard of living as two independent phenomena. The current role of the plant as a job provider could not be overrated as well (Graph 6.8) with only 3% of respondents persuaded that their jobs are, directly or indirectly, somewhat related to or affected by the Temelín nuclear power plant. According to the official statistical data, the share of people directly employed by the Temelín nuclear power plant is approximately 0,6% of the total South Bohemian working power, and approximately 0,4% of the total adult population. The number of people indirectly engaged with the operation of the nuclear power plant can be, according to the same information source, estimated to amount to 0,7% of the working



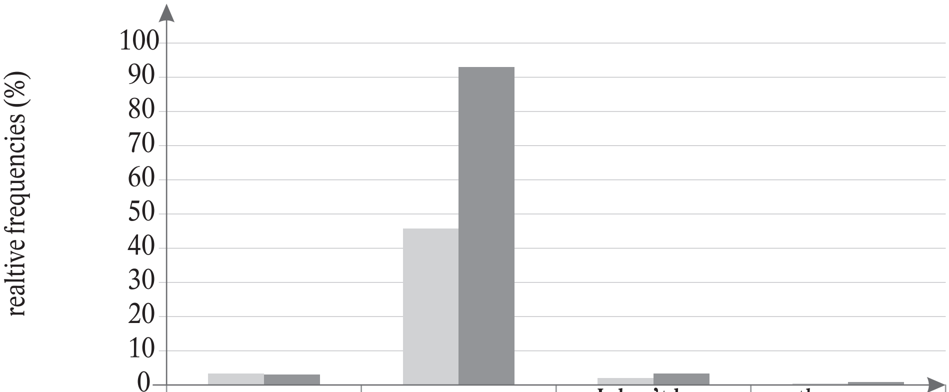
	yes	no	I don't know	other response
2004	43.70	16.60	36.70	3.00
2008	48.91	17.99	30.71	2.38

Graph 6.7: Do you think that "living with risk" should be compesated to the people who are settled in the zone of emergency management?

power and 0,5% of the total population[5]. Currently, the power plant cannot be expected to produce any new job opportunities. The potential change on the job market induced by the plant could then be expected only in relation with its potential expansion of two additional units.

Tourism has recently developed into a crucial segment of regional economics in South Bohemia. Long-term regional development strategy is then inevitably interwoven with image building of South Bohemia as a tourist destination, the main characteristics of which are the scenic countryside, sound environment and nature of high quality. It is not easy to fit the nuclear power plant into such an idyll. Nevertheless, about one-half of the population does not see the plant as a barrier to tourism (Graph 6.9). Some of them even consider the plant to be a tourist attraction of some kind as is evidently documented by the following authentic statements *("technical landmark", "well equipped and functioning information center")*. On the other hand, about 10% of respondents expressed their worry that South Bohemia was about to lose its tourist attractiveness due to the presence of the power plant there, because *"as a nasty dominant it would attract only curious people, whereas wise people would be discouraged to come"*.

[5] *http://www.czso.cz/x/krajedata.nsf/oblast2/obyvatelstvo-xc, [cited November 8, 2010].*



	yes	no	I don’t know	other response
2004	3.30	94.30	2.00	0.40
2008	2.98	93.01	3.29	0.72

■ 2004 ■ 2008

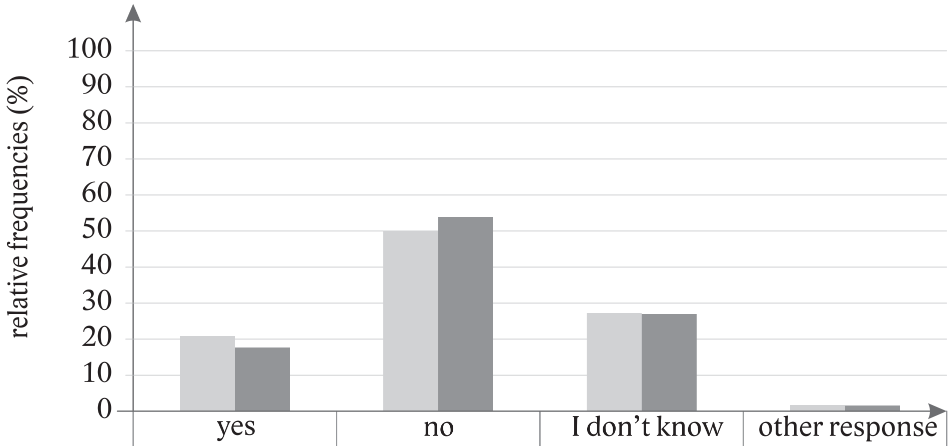
Graph 6.8: Do you think that your present job is somehow affected by or related to the Temelín nuclear power plant?

6.3.2
Fragility of the adaptation

It can be stated that the Temelín nuclear power plant has not yet ceased to be an emotion-laden phenomenon in the South Bohemian region. Approximately two-thirds of the population view the nuclear power plant as something that splits the regional society, forming groups of its advocates and its opponents (Graph 6.10). The ambivalence of the plant, as perceived by the population, is apparent from the responses to the two antithetic questions, which brought almost the same distribution of frequencies (Tab. 6.6). The “social schism” is omnipresent, and the South Bohemian population as a whole evidently has not adopted a consistent position on the nuclear power plant.

Let us come back to the emotional attitudes toward the power plant, as they have changed over the course of the last fifteen years. As already said above, the South Bohemian population has currently been able to cope with the stress induced by the nuclear power plant. The diminished feeling of threat, apparent in Graph 6.1 are also documented in the figures below (Graph 6.11) showing, that only about 10% of the South Bohemian population relate the nuclear power plant to concerns about their health.

Nevertheless, at the same time, more than one-third of the same population was concerned about their safety, related to the nuclear power plant operation (Graph 6.12). Opponents are most concerned about *“nuclear accident”,*



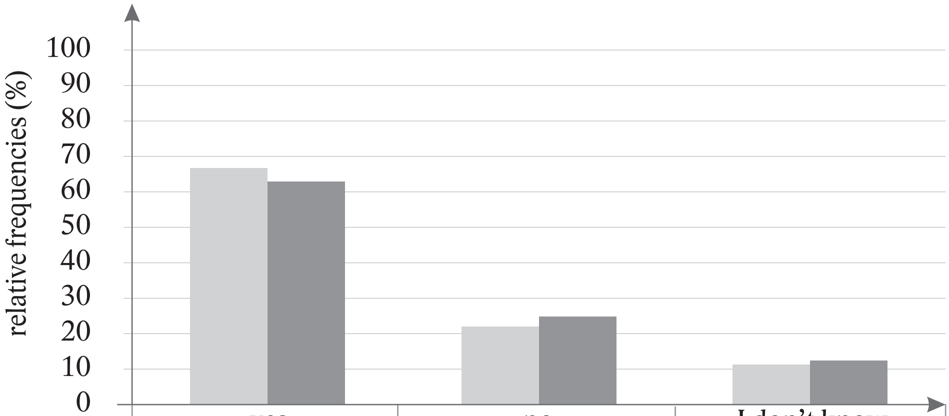
	yes	no	I don't know	other response
2004	20.90	50.10	27.20	1.70
2008	17.70	53.81	26.95	1.54

Graph 6.9: Do you think that the Temelín nuclear power plant has affected attractiveness of the region for tourists?

According to your opinion, the Temelín nuclear power plant rather . . . ? (%)				
	brings benefit to the region		**harms the region**	
	2004	**2008**	**2004**	**2008**
Yes	19.7	18.7	15.6	15.8
No	32.0	38.0	41.0	44.3
I do not know	44.5	39.8	40.6	37.9
Other response	3.9	3.5	2.8	2.0

Tab. 6.6: Role played by the Temelín nuclear power plant in regional development, as perceived by South Bohemian population

"release of radioactivity", "human error", and "failure of control mechanisms", "problems of nuclear wastes disposal", "cancer" and "climate change". It is evident that the nuclear power plant has still kept its image of being a "potential jeopardy". In this respect, the South Bohemian population seems to have applied a scheme that is used more generally when evaluating nuclear power



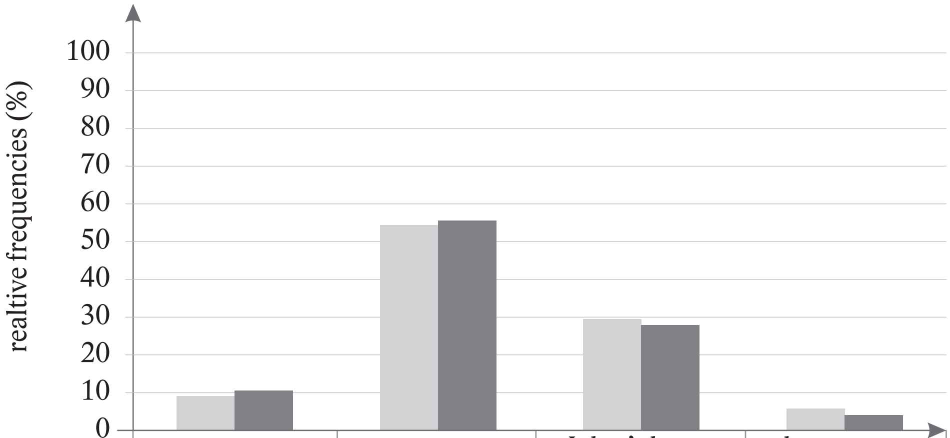
	yes	no	I don't know
2004	66.70	22.00	11.30
2008	62.82	24.82	12.36

Graph 6.10: Do you think that, in some way, the Temelín nuclear power plant divides South Bohemians?

facilities. According to the scheme, public opposition is obviously tied to perceptions of reactor safety, concerns about the disposal of nuclear wastes, and low levels of trust of the nuclear establishment-concerns that persist in the most recent public opinion polls (Rosa, 2004; 2007)[6].

The feeling of threat that was dominating the locals' emotional attitude to the plant in 1993 has gradually disappeared. It is still persistent, however, in a latent form, having been transformed into the feeling of subconscious disquiet. As such, it is assumed to be permanently triggered due to the "visual aggressiveness" of the plant—almost 60% of the South Bohemian population can see the nuclear power plant everyday, or at least its cooling towers or steam rising into the sky. The power plant changed the character of the South Bohemian landscape profoundly, as it is very visible. Its visibility evokes a specific "hello effect", or in other words, "Temelín accounts for everything" effect, that can be illustrated by the following authentic statements: *"People cannot escape, it is visible from everywhere; when people see it, they realize that the plant is here"*. As soon as the towers were constructed, a problem emerged. It is the steam. Clouds are beautiful when in the sky; when they ascend from the

[6] The opposition is thus tight to what is termed "epistemic distrust", the concept that was established and used as important for risk perception and related attitudes by (Sjöberg, 2001; Sjöberg and Wester-Herber, 2008). Epistemic distrust is expressed by someone who says: "Yes, I do trust these people and their organizations, but I still believe that the science backing up their risk assessment is not final and that there may unknown factors at play, risks that science does not know about today" (Sjöberg, 2009).



	yes	no	I don't know	other response
2004	9.40	54.70	29.80	6.10
2008	10.29	56.38	28.30	4.63

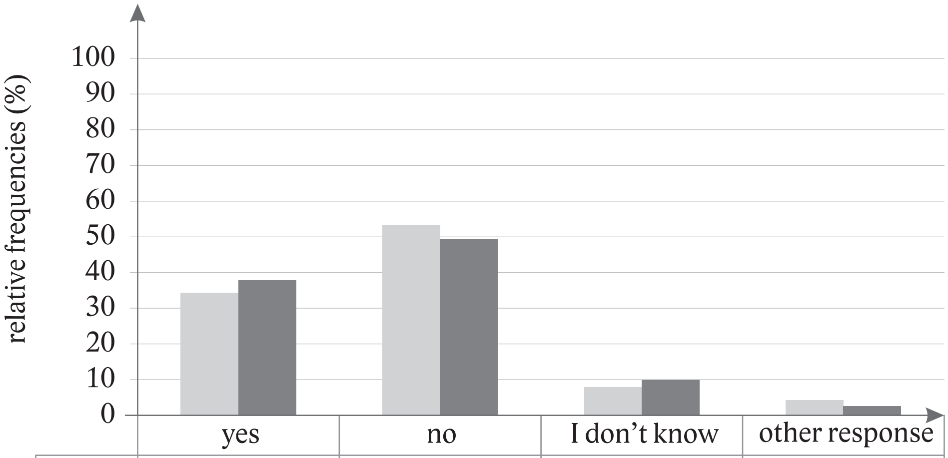
■ 2004 ■ 2008

Graph 6.11: Do you think that the Temelín nuclear power plant is affecting your health?

ground, it is strange. Sometimes it even looked like a mushroom-like cloud of a nuclear explosion.

As stated above in the text, the quality of life was used as the main explanatory framework in our research. Respondents were, inter alia, asked to evaluate the extent to which the quality of their lives was affected by the existence and operation of the nuclear power plant, if at all. A three-point scale was used for this evaluation (−1 = negative affect; 0 = zero affect; 1 = positive affect). The results are summarized in Graph 6.13. It is apparent that scores of particular aspects of the quality of life oscillated around the zero value, more or less. The only more prominent minus value concerned the dimension of mental well being (*"I have a fear from something that could not be remedied"),* which seems to conform with the existence of a subconscious disquiet as formulated above in the text.

We can sum up then with the saying that our results are similar to those obtained by Kebza et al., (2004), who studied the psychological characteristics of adult population in the surroundings of the Temelín nuclear power plant. According to them, "during the period of building and of the step-by-step setting of the plant into operation, the public has gradually ceased to be afraid of this phenomenon, and has acceded to the principle of well calculated risk, the level of which is perceived as acceptable in comparison with reality of life". It has to be emphasized however, that stability like this is a very fragile one,



	yes	no	I don't know	other response
2004	34.40	53.40	7.90	4.30
2008	37.84	49.48	10.08	2.60

Graph 6.12: Are you concerned about your safety considering operation of the Temelín nuclear power plant?

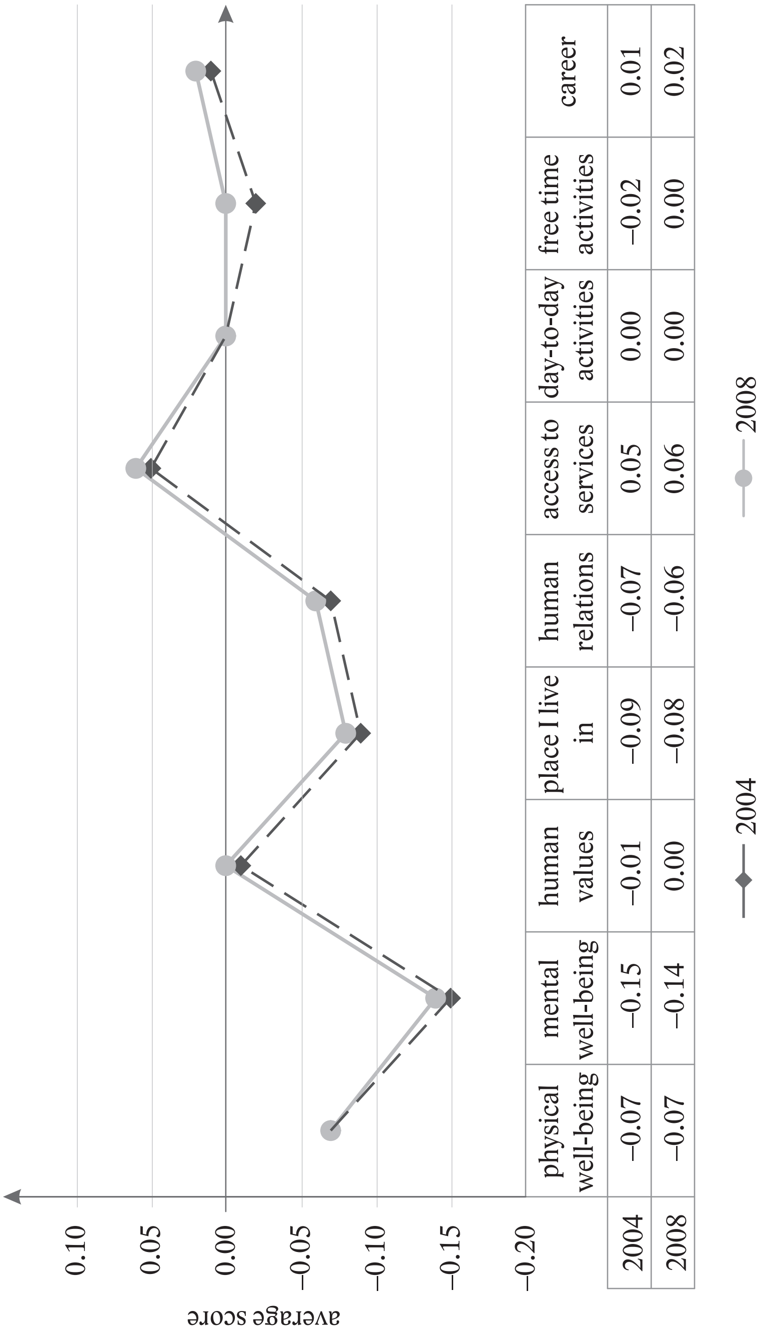
and any extraordinary situation related either to the operation of the Temelín nuclear power plant itself, or to nuclear energy in general, which would be accompanied with a negative publicity, may change the situation rapidly.

6.3.3 Extension of the power plant

The ability to perceive the Temelín nuclear power plant in terms of a risk that can be calculated, and then used for economic development of the region as a whole[7] as well as for the development of particular municipalities[8] has evidently become a part of the adaptation process applied by the South Bohemian population, at least its political representatives. In April 2009, the representatives of the South Bohemian regional government canceled the part of the resolution accepted in 2004, by which their predecessors refused extension of the Temelin nuclear power plant. Based on the newly signed general

[7] *http://byznys.lidovky.cz/statni-pokladna.asp?r=statni-pokladna\&c=A090407_133836_ln_ekonomika_nev, [cited November 8, 2010].*

[8] *http://byznys.lidovky.cz/temelin-bude-ceskym-kuvajtem-di6-/firmy-trhy.asp?c=A090527_100743_firmy-trhy_bat, [cited November 8, 2010].*

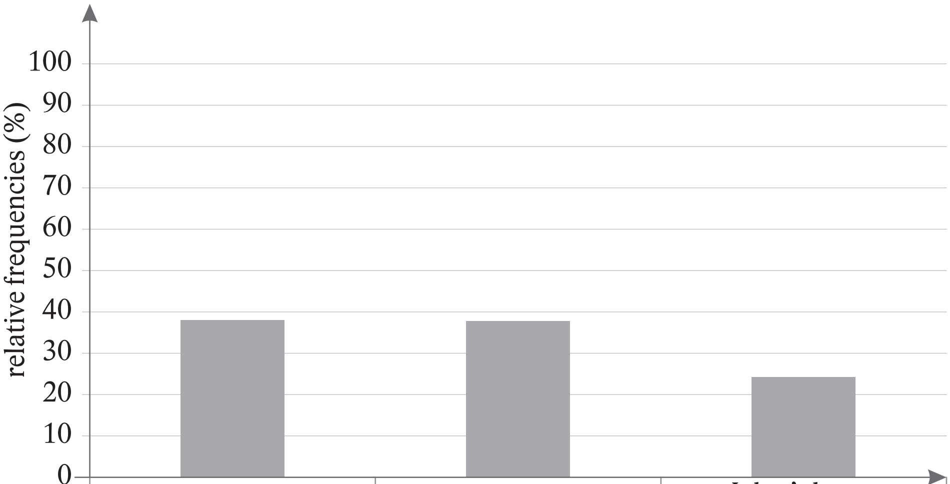


	physical well-being	mental well-being	human values	place I live in	human relations	access to services	day-to-day activities	free time activities	career
2004	–0.07	–0.15	–0.01	–0.09	–0.07	0.05	0.00	–0.02	0.01
2008	–0.07	–0.14	0.00	–0.08	–0.06	0.06	0.00	0.00	0.02

Graph 6.13: How do you think the Temelín nuclear power plant affects particular aspects of your quality of life?

agreement between CEZ Group, the owner of the nuclear power plant, and the South Bohemian government, four billion Czech Crowns (CZK) are expected to be invested in the region to compensate the simple fact that "Temelín is located there". Compared to the pragmatically unambiguous attitude manifested by the regional political elite, the attitude of the general public to the extension of the nuclear power plant by two additional units (which means in fact doubling the already existing one) is more ambivalent (Graph 6.14). The share of advocates and opponents is pretty balanced, about 40% each, and roughly one-quarter of the population were not able to take an unambiguous stand.

The attitude to the extension appeared to be driven by gender and by the emotional attitude to the already existing nuclear power plant, as documented in Tab. 6.7 and 6.8. Primarily, men perceived the nuclear power plant as a "reasonable solution" or "technological achievement", and they have displayed a supportive attitude to the idea of expanding the plant. Women, on the other hand, who relate the power plant to feelings such as "disquiet" or "threat", opposed the idea of its extension.



yes	no	I don't know
38.00	37.80	24.20

Graph 6.14: Do you support the idea of extension of the Temelín nuclear power plant by additional two units?

Advocates of the extension justify their attitude by arguing that *"there is still growing consumption of electricity, and nuclear power is the only way to satisfy it, once considering economic and ecological aspects". "Readiness of the building site"*

	Extension of the nuclear power plant by two additional units		
Gender	**yes**	**no**	**I do not know**
men	**8.6**	**−4.9**	**−4.1**
women	**−8.6**	**4.9**	**4.1**

** Obviously, values of this statistics greater than 3 indicate statistical dependancy between the row and column variables.*

Asymp. sig. (2-sided) =0.000.

Tab. 6.7: Relation between attitude to the extension of the Temelin nuclear power plant and gender (adjusted standardized residuals)*

	Feelings perceived when seeing the cooling towers of the plant					
Extension of the plant	**tech. achieve-ment**	**reasonable solution**	**evil necessary**	**disquiet**	**threat**	**other feelings**
yes	**8.3**	**7.7**	−2.8	**−8.7**	**−7.3**	2.0
no	**−6.7**	**−9.1**	1.4	**9.6**	**8.7**	−2.8
don't know	−1.9	1.6	1.6	−1.0	−1.6	0.8

Asymp. sig. (2-sided) =0.000.

Tab. 6.8: Relation between attitude to the extension of the Temelin nuclear power plant and feelings perceived when seeing the cooling towers of the plant (adjusted standardized residuals)

is another supporting argument, as well as the optimistic one supposing that *"electricity will finally be cheaper for South Bohemians"*. The opponents argue that *"electricity will not be cheaper after all; and the extension could not bring any benefit to South Bohemia. Furthermore it may cause an ecological burden for the whole region"*.

Nuclear power seems to have become a popular source of energy when evaluated on the national level. A nation-wide survey conducted by STEM in March 2009 revealed that 70% of the total Czech population support further expansion of nuclear energy (in 2004, the share of people supporting nuclear power was 52%)[9]. According to the same information source, almost 70% of respondents supported the idea of extension of the Temelin nuclear power plant. This figure differs profoundly from that obtained within the South Bohemian region itself. The difference could be explained by evidence that suggests that support for nuclear energy is sensitive to siting issues (e. g. Macintosh, 2007). That nuclear energy attracts support at a general level but an opposition or ambivalent standpoints from local communities when concrete proposals are put forward suggests the presence of the "Not in my back yard" (NIMBY) phenomenon. That is, even if people support nuclear power plants at a general level, they often object to proposals to construct them in their local areas. Part of this phenomenon is probably due to the way people evaluate risks. Research from Japan, for example, found that when people assess the value of nuclear power at a general level, they weigh both the perceived risks and potential benefits. Yet when it comes to a siting situation, perceived risks become the overriding factor and the weight given to potential benefits is greatly diminished (Tanaka 2004). Such a rationale could be used to explain the difference between the rather straightforward support to the plant extension manifested by the elite ambivalence to the same issue articulated by the local public.

6.3.4
Locating of a nuclear waste repository in South Bohemia

Unlike the extension of the power plant, the locating of the nuclear wastes repository evidently represents a much more unambiguous case. It is opposed by 60% of the South Bohemian general public (Graph 6.15), sometimes as well by use of happening-type activities (fig. 6.5). Gender and emotional attitude to the already operating plant appeared to be related to the preferences about it (Tab. 6.9 and 6.10).

Concerns about environment and health assumed to be affected by the repository are the main arguments used by opponents. They are women relating nuclear power with feelings of disquiet and threat. Advocates of the repository make about 17% of the South Bohemia population. Among them men dominate. They obviously consider the already operating nuclear power plant as a reasonable solution, and when asked for their rationale, they mostly use "technological-economic" arguments that, however, have some ecological grounds—spent uranium must be stored somewhere after all, and having it here means minimizing risk of transport to another place.

[9] *http://byznys.lidovky.cz/tiskni.asp?r=firmy-trhy\&c=A090402_152023_ln_ekonomika_nev, [cited November 8, 2010].*

Obec Chanovice pořádá
v sobotu 3. ledna 2009

PĚŠÍ POCHOD

Chanovice – Dobrotice – Holkovice – Plácek
Újezd u Chanovic (Šumava jako na dlani) – Chanovice

Novoroční procházka krásným územím,
které je mezi vytipovanými lokalitami
ke stavbě
úložiště radioaktivního odpadu!!!

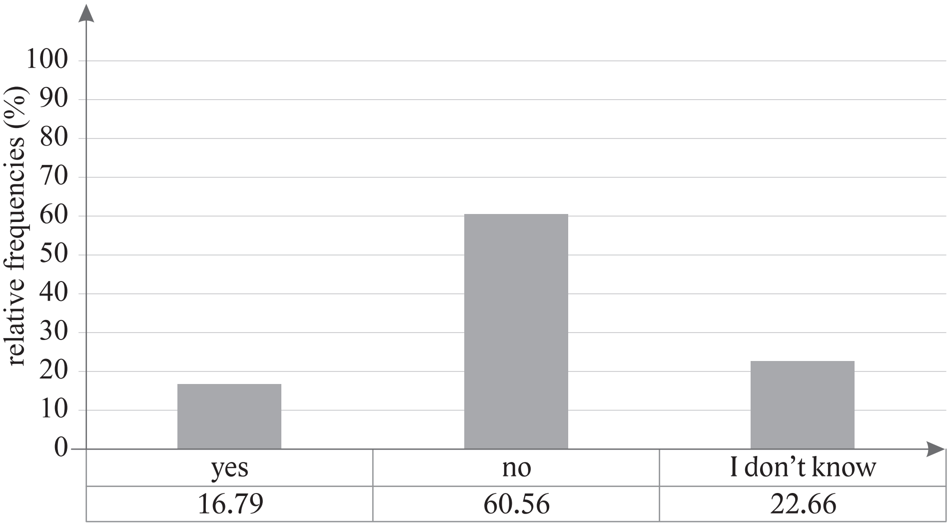
Start: **8.3o - 9.3o hodin od zámku Chanovice**
Ukončení: **ve 13.oo hodin s hudbou a se zpěvem v Kulturním domě v Chanovicích**
Startovné: **60,- Kč bude použito na úhradu občerstvení účastníků a na tiskoviny**

- Podpořte svojí účastí snažení naší obce o veřejné, reálné, odborné, odpovědné a ohleduplné hledání řešení velkého celorepublikového problému: „Kam s ním“???
- Zamysleme se při procházce v Pošumaví nad činy, které mají mít důsledky deseti tisíců roků!!!

Chraňme naši obec a naši republiku pro zdravý a plnohodnotný život našich dětí!

Fig. 6.5: Poster, inviting people to participate in a march against the repository, issued by the mayor of the Chánovice village, one of localities proposed for repository locating

The opinion held by the regional political elite seems to resonate with "vox populi" in this case—the part of the above-mentioned resolution from the year of 2004, that disagreed with repository locating in South Bohemia, was left unchanged.



Graph 6.15: Do you support the idea of locating the nuclear wastes repository in the area of the Temelín nuclear power plant?

	Locating of the nuclear wastes repository		
Gender	**yes**	**no**	**I do not know**
men	**6.0**	−**4.4**	−0.3
women	−**6.0**	**4.4**	0.3

Asymp. sig. (2-sided) =0.000.

Tab. 6.9: Relation between attitudes to the locating of the nuclear wastes repository and gender (adjusted standardized residuals)

	Feelings perceived when seeing the plant's cooling towers					
Repository locating	**tech. achieve-ment**	**reasonable solution**	**evil necessary**	**disquiet**	**threat**	**other feelings**
yes	1.5	**4.7**	−0.8	−2.4	−**4.0**	−0.2
no	−2.2	−**5.5**	0.4	**5.2**	**4.4**	−1.6
don't know	1.2	2.3	0.3	−**3.9**	−1.6	2.0

Asymp. Sig. (2-sided) =0.000.

Tab. 6.10: Relation between attitudes to the locating of the nuclear wastes repository and feelings perceived when seeing the plant's cooling towers (adjusted standardized residuals)

Conclusions

Based on the research results, we can state that as far as the quality of life concerns, the local population has successfully adapted itself to the risk induced by the Temelín nuclear power plant. There is ambiguity among the population towards the idea of expanding the power plant. At the same time however, most of the South Bohemia population oppose locating of the nuclear waste repository there. When we apply the concept of manufactured risk, we can interpret this attitude as a reaction of the people to an emerging "so far nameless risk".

The "adaptation to Temelín" can be found as well on an international level, as can be documented by the recent decision of the Regional Control Office of Upper Austria to inspect the financial administration of fifteen Czech and Austrian ecological organizations, sponsored by the Upper Austrian government, which organized "anti-Temelín" campaigns. The aim of the inspection is to assess the "purposefulness of the financial support to these campaigns nowadays when Temelín has been in operation for quite some time"[10].

When we set the findings into a more general context, we can state that they are consistent with a long series of public opinion polls showing public ambivalence toward nuclear power that persists even in the face of renewed interest for nuclear power in policy circles (e. g., Kasperson et al., 2001; Gallup, 2007; Rosa, 2004; Whitfield et al., 2009).

[10] *http://www.lidovky.cz/ln_noviny.asp?r=ln_noviny\&c=A090702_000006_ln_noviny_sko, [cited November 8, 2010].*

Acknowledgements

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PART

B

ELECTRICITY MARKET

7

Rising energy prices and their impact on household income and energy consumption from the Czech and Austrian perspective

7.1 Introduction

Currently, steeply increasing energy prices (natural gas, gasoline, electricity) pose a serious burden for households in Central and Eastern Europe. The restructuring of energy markets in these countries—which are heavily dependent on Russia—started already in the 1990s but the final transformation to "western" market prices has not yet been completed. However, these steep price increases have major impacts on available household income and also on the dynamics of the fuel and the emissions mix. For example, in the Czech Republic more households are currently switching back to coal.

7.2 Objective of this project

The core objective of this project is to analyze the impacts of recent energy price increases on available household income in the Czech Republic (and some other selected Central and Eastern European countries) in comparison to Austria.

In detail the following analysis will be conducted:

- Documentation of the major basic facts and figures on historical development and the current state of household energy prices and expenses in CZ and AT divided by energy carriers (e.g., natural gas, gasoline, diesel, electricity);
- Discussion of the impact of energy prices on available household income;
- Discussion: What are the future perspectives for energy price developments for residential customers?

7.3
Historical development of prices and income for final household energy consumption

In this chapter the historical development of electricity and natural gas prices in the residential sector is described. Note that for the other energy carriers no comparable time series are available. The current prices in the Czech Republic almost doubled (!) between 2000 and 2007. While average wages had increased quite constantly between 2001 and 2007, energy prices in the CZ varied in different ways. The largest price increase was noticed between 1997 and 2001 when natural gas prices more than doubled. Between 2002 and the middle of 2004 energy prices were almost stagnant. In Austria prices stagnated at a rather high level until 2003 and started to increase slightly afterwards.

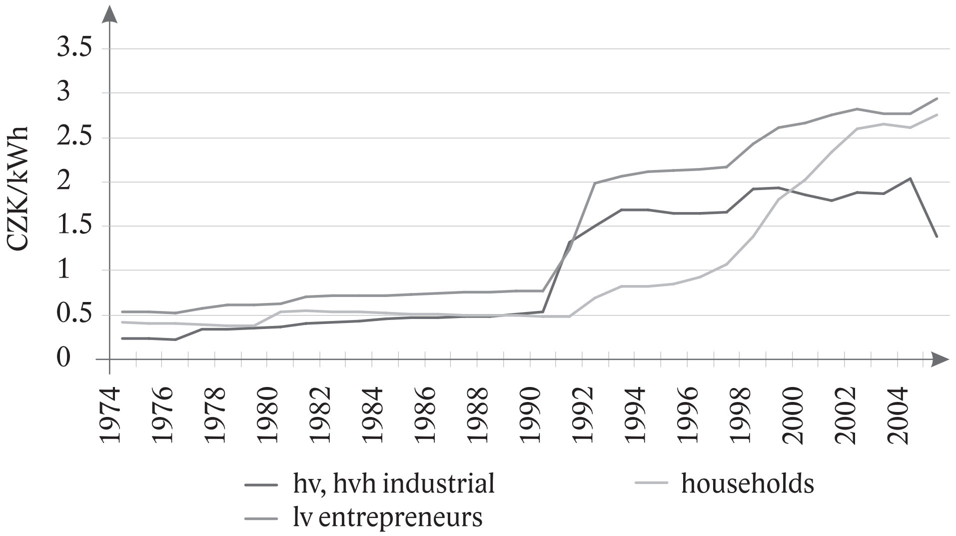
Several reasons can be found for the fast increase of energy prices in the CZ for the residential sector at the end of the 1990s. The most important of these is that initial growth of energy prices for the residential sector was lower than general inflation and fully incomparable with the development of prices paid by industrial and commercial consumers. The situation at the end of the 1990's was characterized by significant cross subsidizing between industrial consumers and the residential sector. According to Czech government decision Nr. 1250/99 the goal to cut off cross subsidies up to the end of the year 2002 the fastest price growth occurred in the period 1999–2002. A typical family's expenses for electricity and heat, gas and other fuels were about 11% of total expenses in 2002, which was significantly higher (up to 3 times) than in EU member states (e.g., Germany, France) at the time.

7.3.1
Electricity prices

The development of CZ electricity prices for different types of consumers is documented in Figure 7.1. Continuous cutting of cross subsidies is visible from 1999–2002 (light grey curve for households).

Prices of energy carriers, especially those of electricity and natural gas continued to go up significantly after 2002. The following are the main reasons for the increase in electricity prices:

- ↗ demand for electricity in the Czech Republic went up thanks to the relatively fast development of the whole economy (5%–6% in the last two years),



Source: ERO, Annual electricity report, 2006

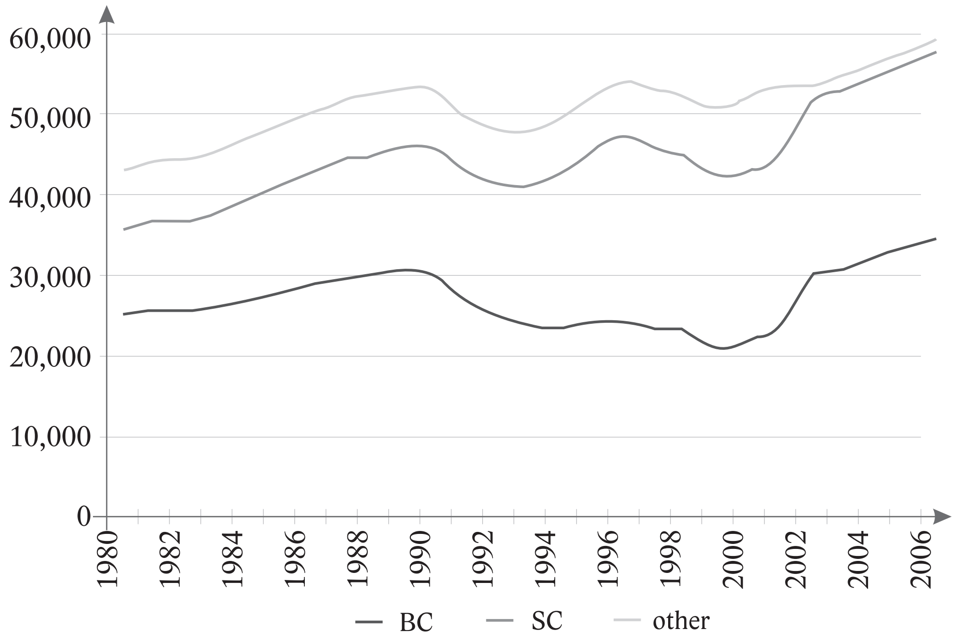
Note: from 1993 including VAT, from 1. 1. 1998 VAT increased from 5% to 22%. From 1. 5. 2004 VAT is 19%. Price for industrial consumers for high voltage and very high voltage doesn't include the system services fee

Fig. 7.1: Development of CZ electricity prices in nominal values (current prices)

- prices of electricity in surrounding countries are higher (incl. Slovakia, Hungary, etc.), but the situation on the German market is key,
- reduced competition on electricity market—actually, electricity wholesalers cannot offer cheaper electricity from abroad or from independent Czech electricity producers. These producers practically follow the price policy of the dominant producer CEZ.

The development of electricity consumption of big and small consumers is documented in Figure 7.2.

In the long-term perspective, there are other factors that effect electricity prices, e.g., necessity to completely reconstruct almost all or to build new coal-fired power stations between 2012–2015. Due to the very high investment costs these new plants will increase the cost of electricity generation significantly. According to currently known investment plans, no 100% coal-fired plants will be renewed because of the so-called regional limits for coal that have blocked utilization of some coal reserves. Not enough coal is available to meet 100% coal-fired generation capacity for the perspective 40 years. It is even expected that the Czech Republic can become an electricity importer



Source: ERU, Annual electricity report 2006

Fig. 7.2: Development of CZ electricity consumption; BC—big consumers, SC—small consumers

(app. after 2012–2015) and not be an exporting country as it is today, which would create another pressure to increase electricity prices.

A similar situation has occurred with natural gas prices. argument about ineffective market is even more valid. During privatization of the company Transgas (owner of transit lines and underground reservoirs) and regional gas distributors this entire infrastructure has been sold to RWE. In a fact the residential sector, and to a significant extent even industrial companies have no other way for gas delivery than from RWE[1]. Trade with natural gas is still regulated by the Energy Regulatory Office, regulation ended from beg. of April 2007 (for all types of consumers)[2].

[1] In 2007 new wholesalers started to operate in CZ. These wholesalers are not connected to RWE, but to Gazprom and other companies. They focus esp. on delivery to the largest industrial consumers, but their total share is just a few percent at the moment.

[2] Opening of the gas market resulted in an immediate price increase for eligible customers. The Energy Regulatory Office decided to start to regulate final gas prices again from 1. 1. 2006 to 31. 3. 2007 arguing that the market did not effectively function. Since 1. 4. 2007 fees for gas transmission and distribution have been regulated. The price of imported gas is app. 80% of the total gas price.

Fig. 7.3 compares the development of current electricity prices in the CZ and AT. The current prices in the Czech Republic almost doubled (!) between 2000 and 2006. In Austria prices were stagnating until 2003 at a rather high level and started to increase slightly afterwards.

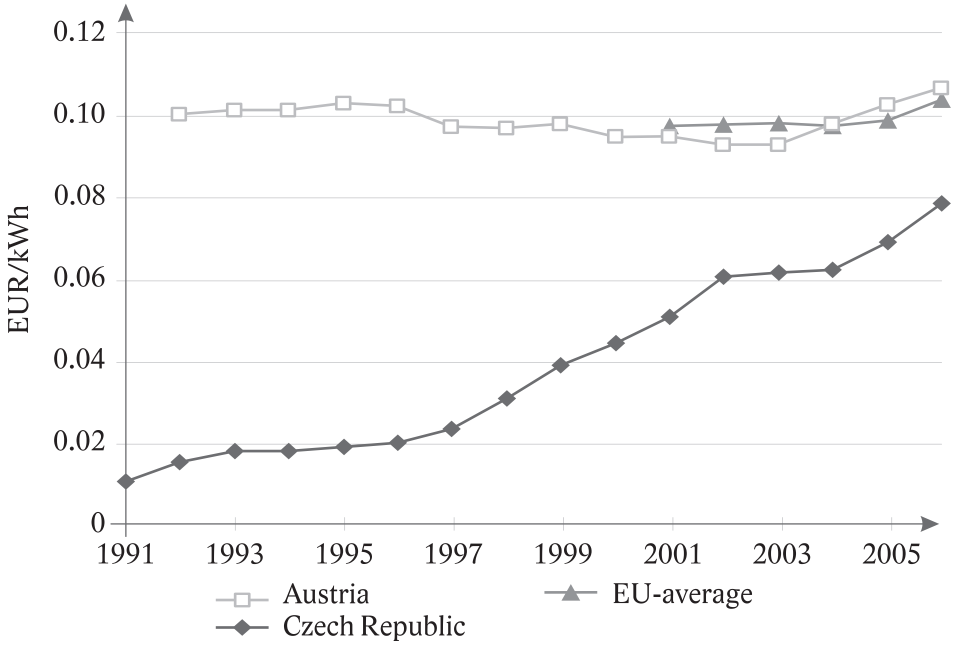


Fig. 7.3: Development of current electricity prices in AT and CZ from 1991 to 2006

Fig. 7.4 compares the composition of electricity prices. The share of taxes and other fees is significantly higher in Austria.

7.3.2 Natural gas prices

The development of current natural gas prices is depicted in Figure 7.5. The current prices in the Czech Republic more than doubled (!) between 1999 and 2008. In Austria, prices almost continuously increased.

A more detailed look at the development of natural gas prices in the Czech Republic is presented in Figure 7.6.

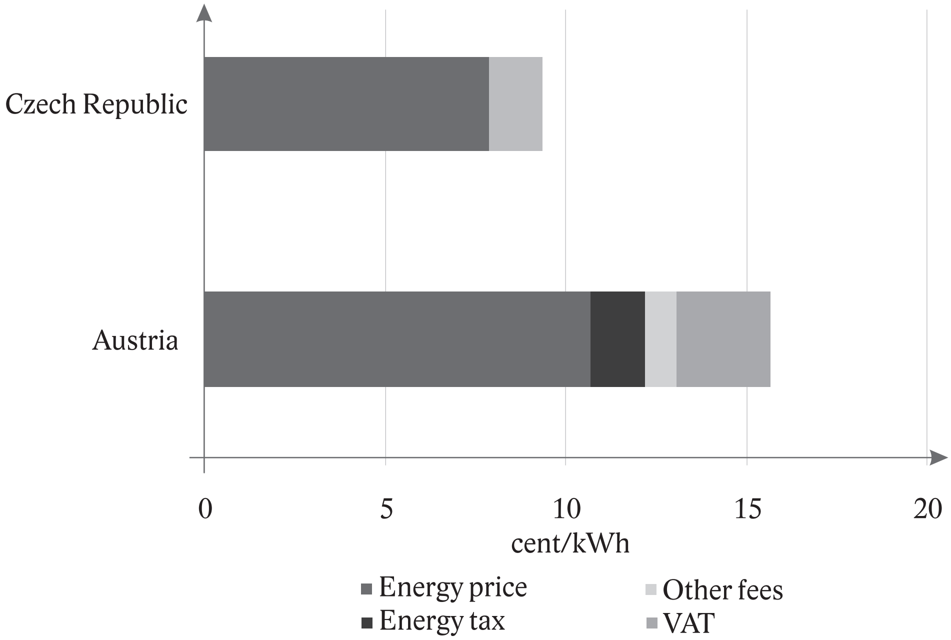


Fig. 7.4: Comparison of the composition of residential electricity prices in AT and the CZ 2008

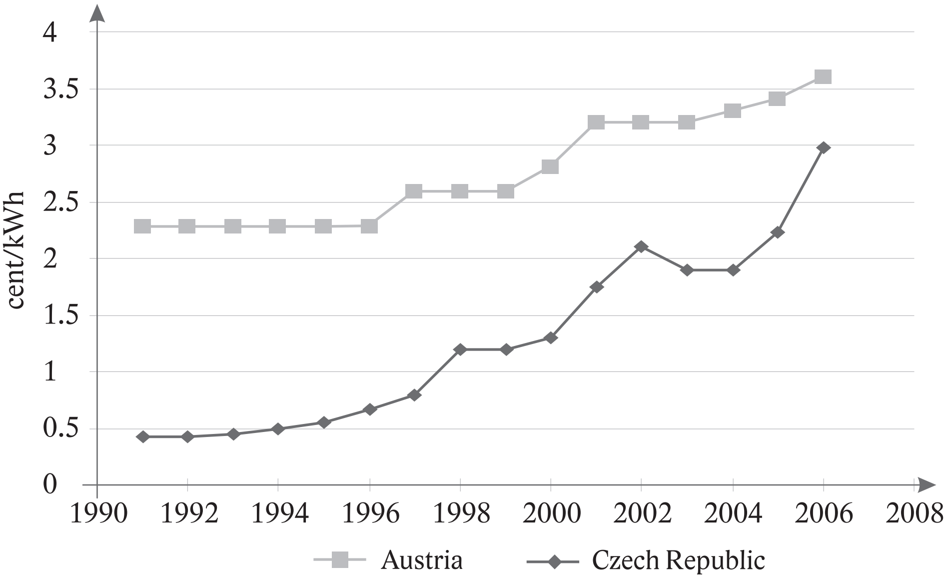
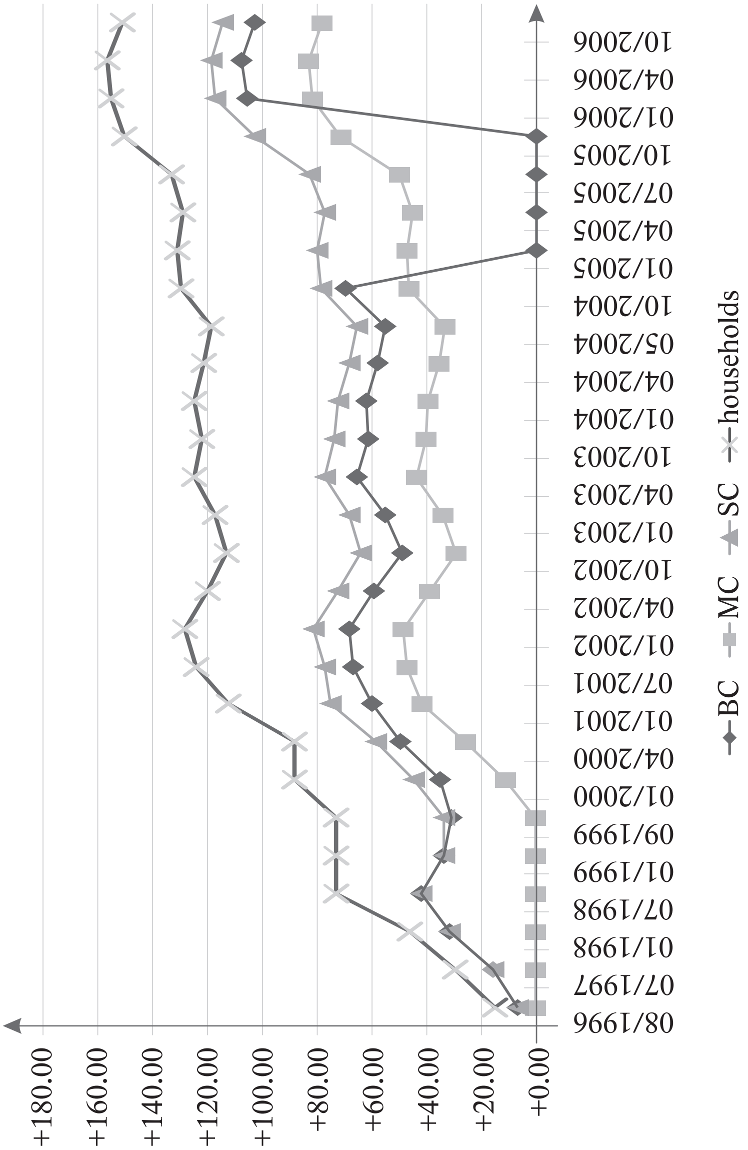


Fig. 7.5: Development of current natural gas prices in AT and CZ from 1999 to 2006



Source: ERU, Gas statistics, 2006

Note: From 1. 1. 1998 VAT increased from 5% to 22%, from 1. 5. 2004 VAT was reduced from 22% to 19%, from 1. 1. 2005 price was regulated only for non-eligible customers, from 1. 1. 2006 regulation was reinstalled and maximum prices for eligible customers were set up (reason for missing data in 2005 for BC), from 1. 1. 2007 all customers are eligible, BC—big consumers, MC—medium consumers, SC—small consumers

Fig. 7.6: Development of CZ price index for natural gas from 1996 for different categories of consumers.

7.3.3 Diesel and gasoline prices

Fig. 7.7 depicts the development of current diesel and gasoline prices. The most remarkable feature in this figure is that the current prices of diesel and gasoline in the Czech Republic *decreased* after the year 2000. *Why* did this decrease occur? The major reason is described in Figures 7.9, 7.10, 7.11. It is mainly due to the development of exchange rates and because of changes in tax structures (à tax decreases).

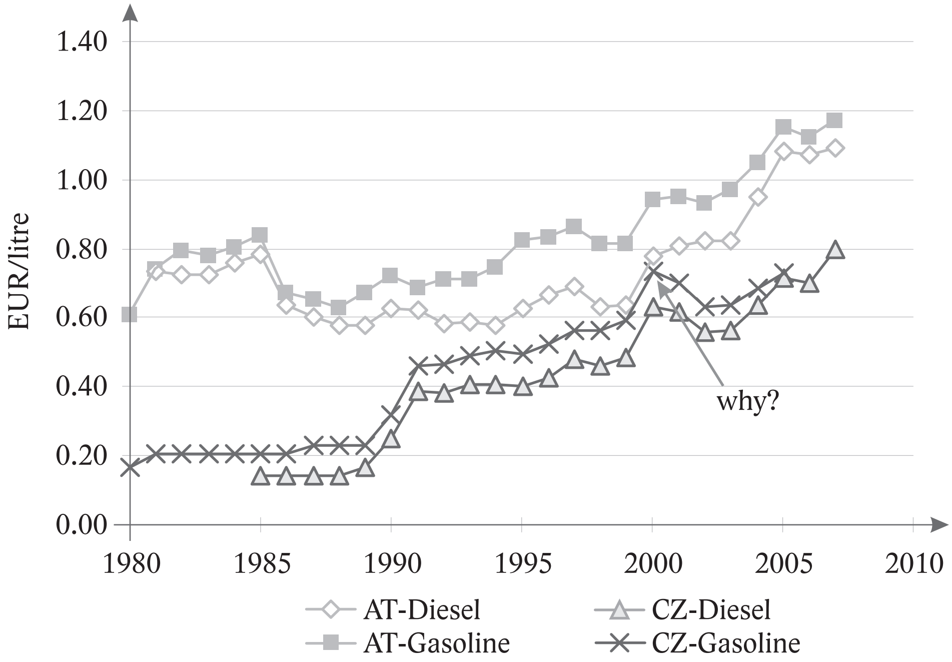


Fig. 7.7: Development of current diesel and gasoline prices in AT and CZ from 1980 to 2006

A more detailed look at the development of diesel and gasoline prices for households are presented in the Figures 7.9, 7.10, 7.11. In the CZ case, figures for gasoline and diesel prices presented in EUR or USD are significantly affected by changes in exchange rates (CZ-USD and CZ-EUR). The impact of exchange rate changes and fluctuation in years close to the year 2000 cause a different behaviour in the curves that use CZK and USD or EUR.

The different behaviour of the curves given in CZK compared those given in USD can be explained by the way in which gasoline and diesel market prices are created. The CZ prices basically follow the prices on the Rotterdam

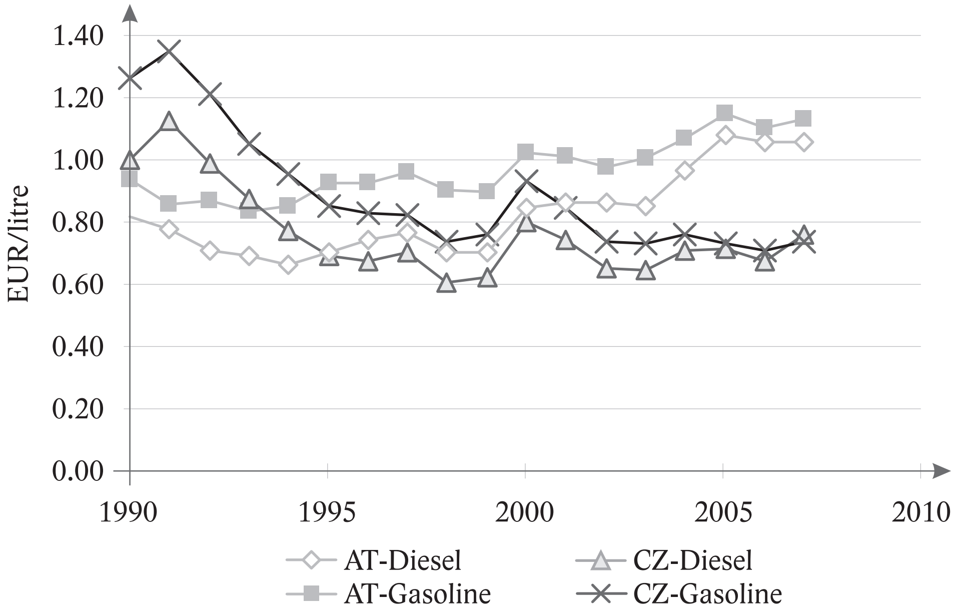
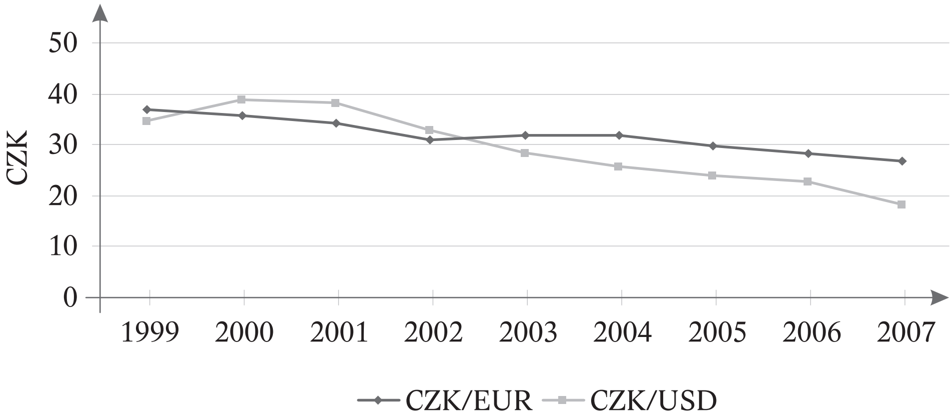
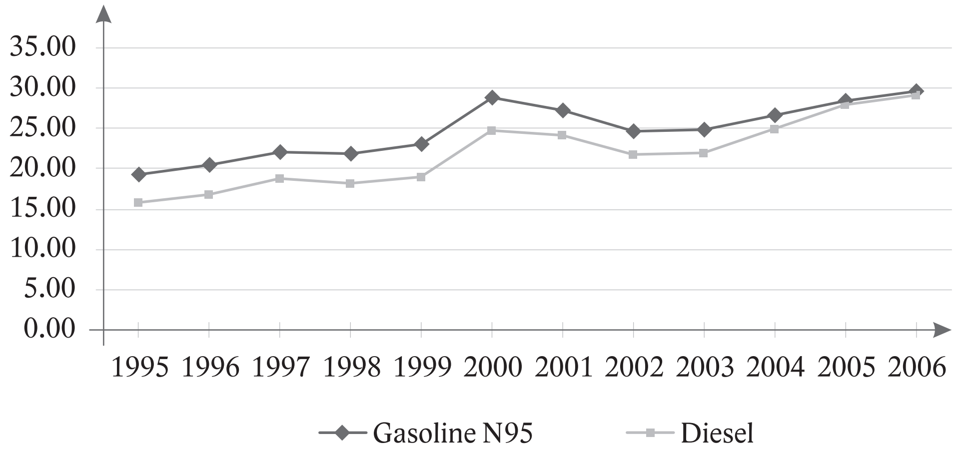


Fig. 7.8: Development of (real) diesel and gasoline prices of 2005 in AT and CZ from 1980 to 2006



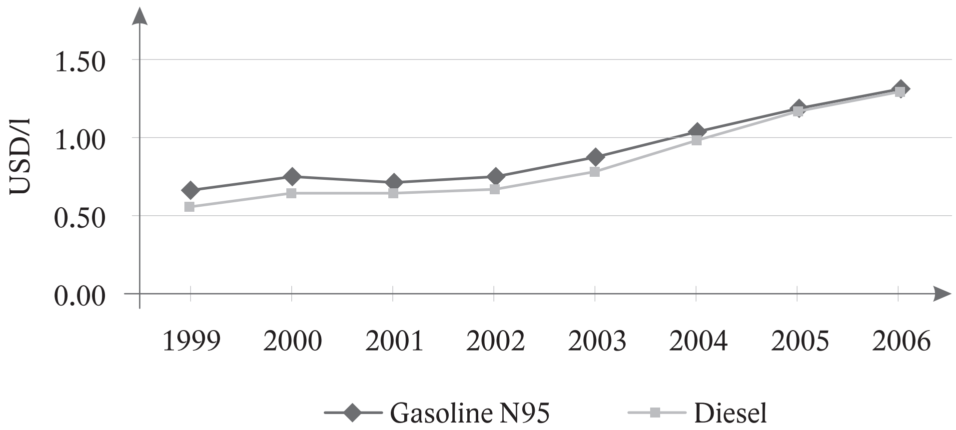
Source: Czech National Bank

Fig. 7.9: Development of CZK/USD exchange rates



Source: CZ transportation yearbook 2006, 2001

Fig. 7.10: Development of gasoline and diesel prices in the Czech Republic in CZK/l, nominal values, VAT included



Source: CZ transportation yearbook 2006, 2001

Fig. 7.11: Development of gasoline and diesel prices in the Czech Republic in USD/l

commodity exchange given in USD. If the CZK gets stronger than a significant break in the price increase occurs.

Fig. 7.12 provides a comparison of the levels of GDP and the actual development of GDP in the Czech Republic and Austria. Overall GDP in AT is more than twice that in the CZ. However the growth rates are higher in the CZ while the slope of the increase is very similar.

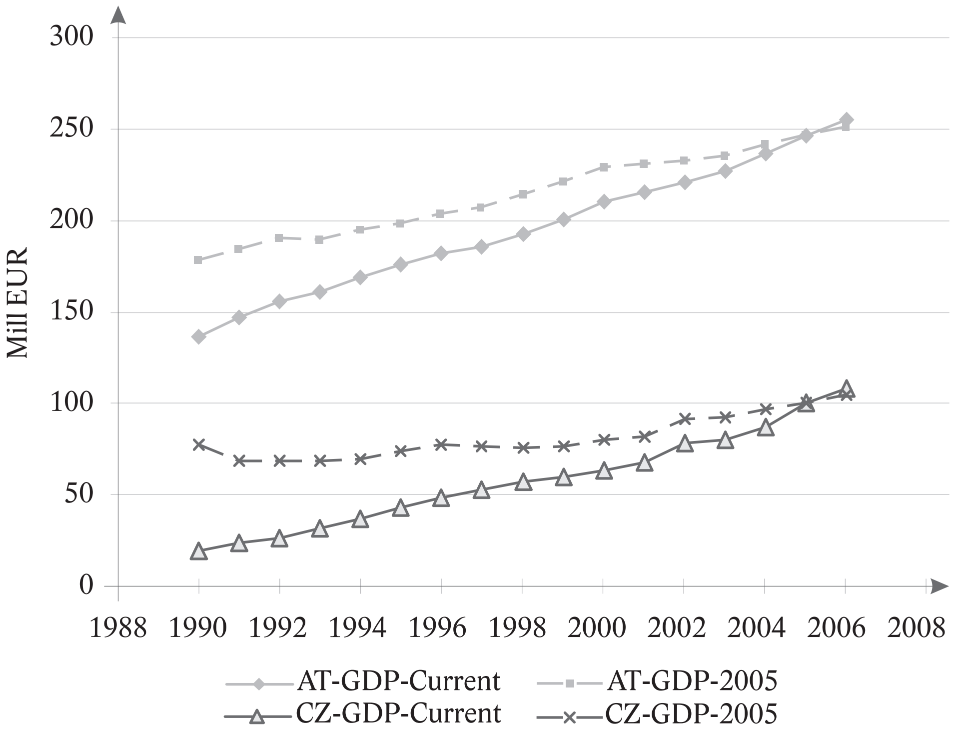


Fig. 7.12: Development of GDP in the Czech Republic and Austria

7.3.4
Household expenditures and prices for energy

Fig. 7.13 provides a comparison of the total household expenditures in the CZ in 2005 prices and the natural gas and electricity prices from 1990 to 2006 setting all figures equal to 1 in 1990.

The corresponding figures for Austria are depicted in Fig. 7.14.

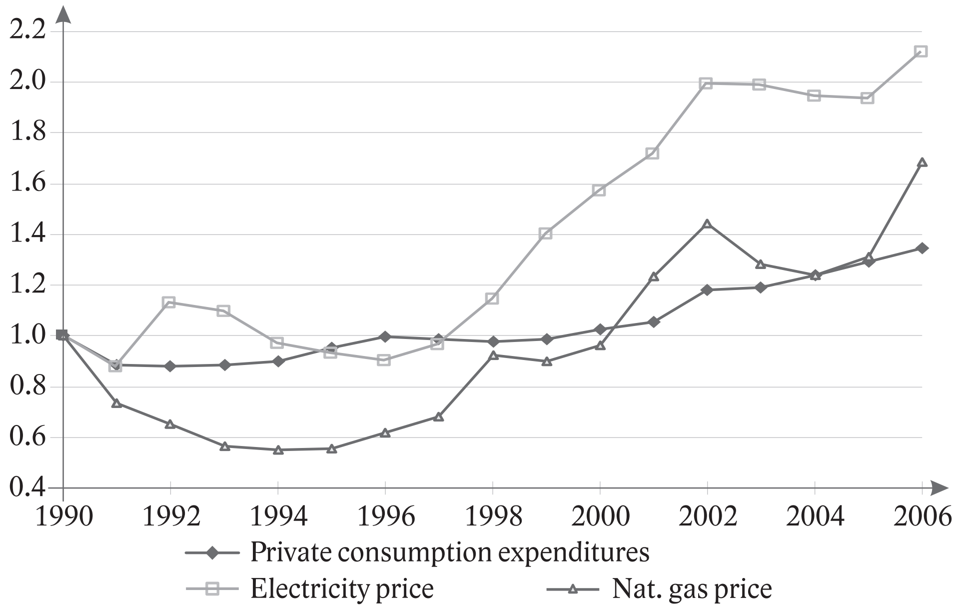


Fig. 7.13: Comparison of the total household expenditures in the CZ in 2005 prices and the natural gas and electricity prices from 1990 to 2006

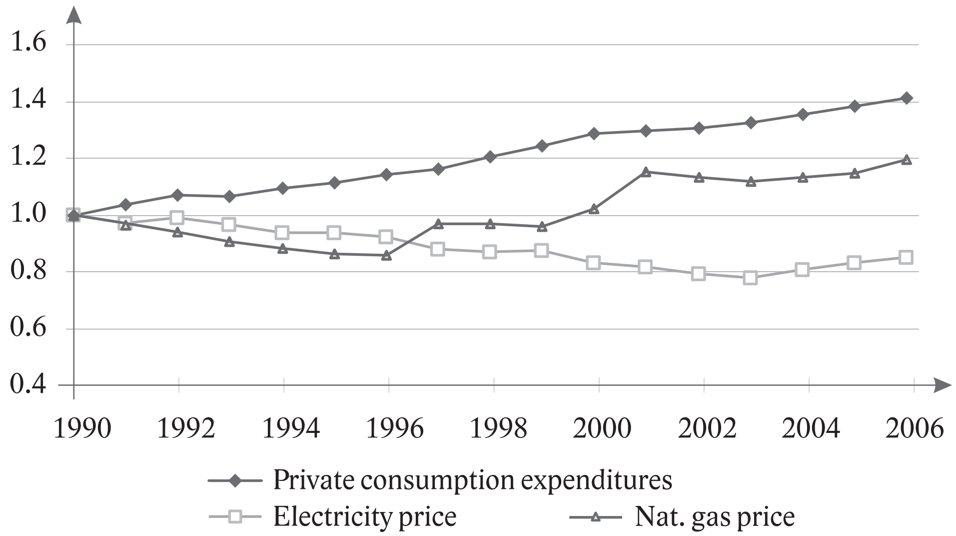


Fig. 7.14: Comparison of the total household expenditures in AT in 2005 prices and the natural gas and electricity prices from 1990 to 2006

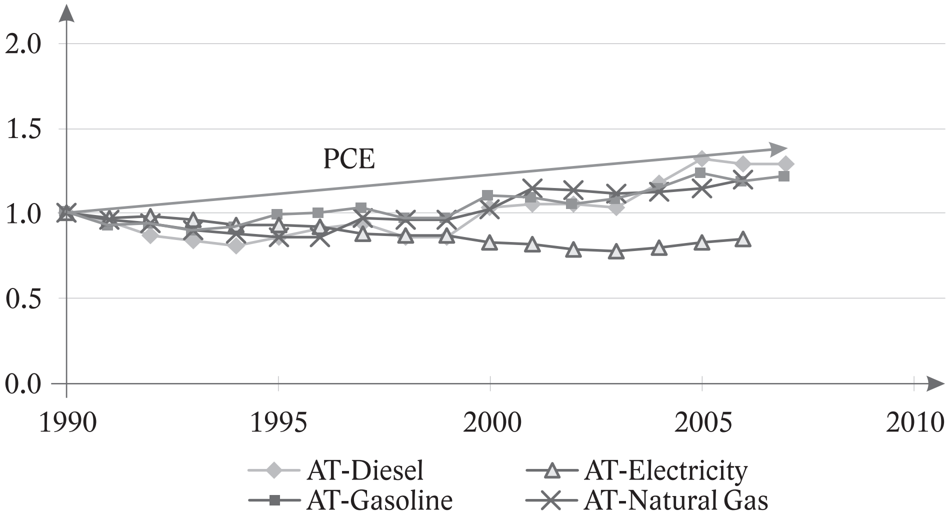


Fig. 7.15: Comparison of total household expenditures in Austria in 2005 prices and the natural gas, Diesel and gasoline and electricity prices from 1990 to 2006

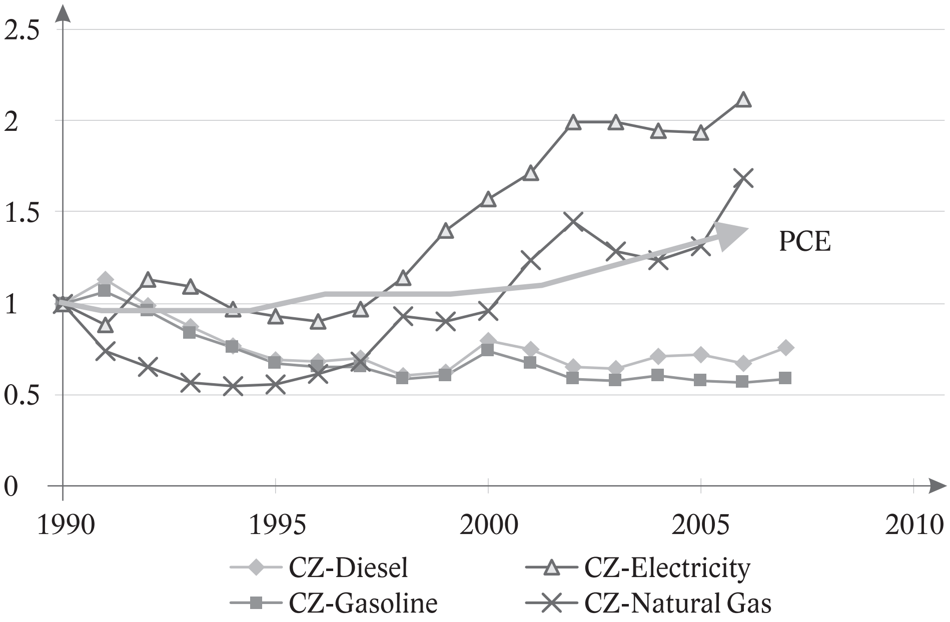


Fig. 7.16: Comparison of the total household expenditures in the CZ in 2005 prices and the natural gas, Diesel and gasoline and electricity prices from 1990 to 2006

7.4
Households expenditures for energy

Figs. 7.17 and 7.18 provide a comparison of the total average household expenditure in the CZ and AT and the corresponding shares for energy, electricity and driving fuels in the years 1995 and 2007. The major perception is that in Austria this share remained virtually constant—about 8% in both years—while in the CZ it increased considerably from 9% to 13%. Aside from that the total households expenditures also increased remarkably in both countries: in Austria from 20380 to 31500 EUR/household and year in nominal terms (+50%) and from 3348 to 10500 EUR/household and year in the CZ, an increase of almost 200%!!!

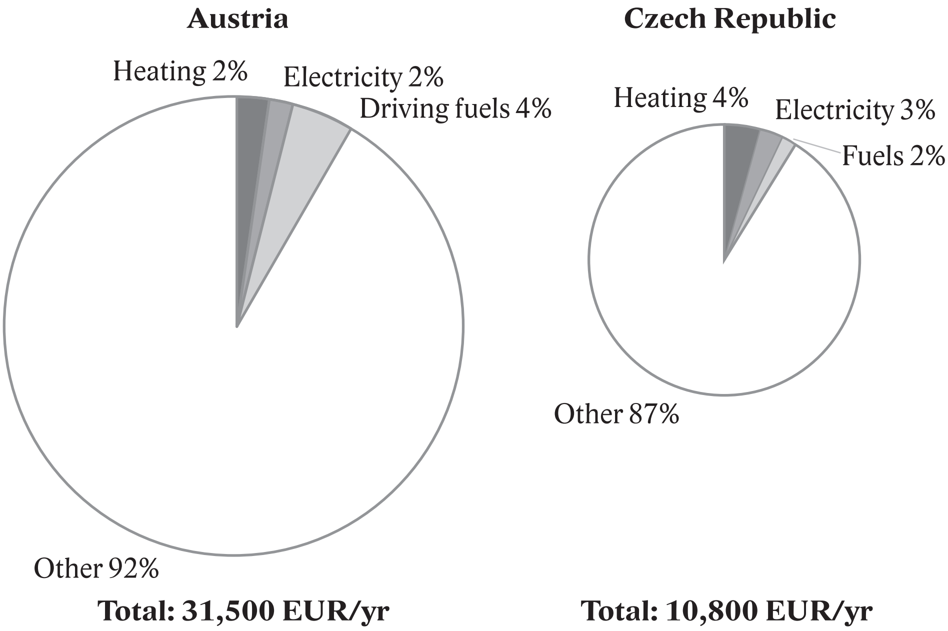


Fig. 7.17: Comparison of the total average households' expenditures in the CZ and AT and the corresponding shares for energy, electricity and driving fuels in the year 1995

Total household expenditures (est. based on 1–6/2007) in 2007 are about 10,800 EUR per household and year (4,695 EUR per capita and year). The exchange rate used is 26.7 CZK/EUR. The structure of household expenditures in 2007 is shown in Figure 7.18.

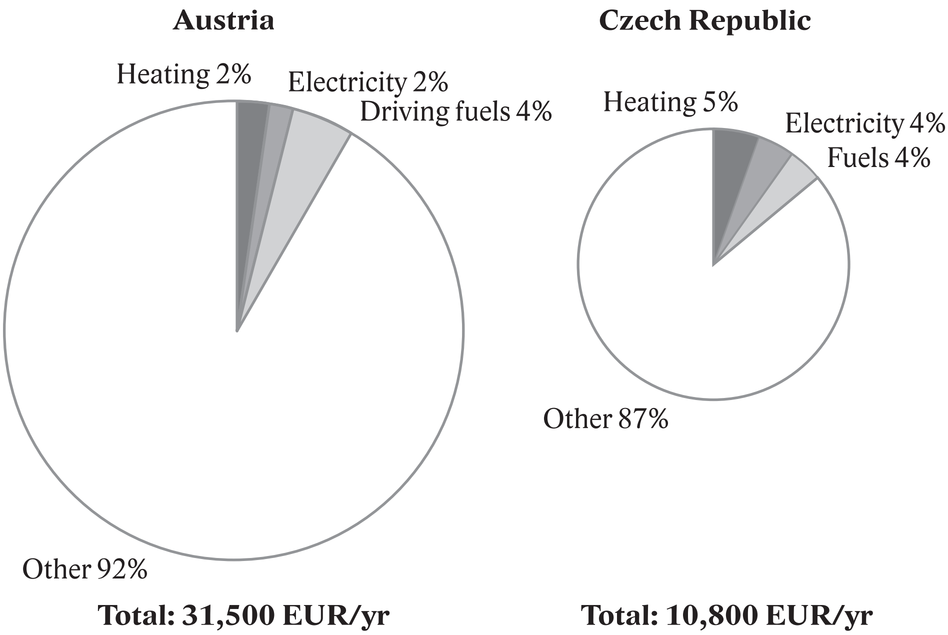


Fig. 7.18: Comparison of the total average household expenditure in the CZ and AT and the corresponding shares for energy, electricity and driving fuels in the year 2007

Figure 7.18 depicts that the total share of energy expenses in the CZ in 2007 is approximately 13% of total net household expenditures, increasing by about 45% since 1995! (from 9% to 13% in relative terms!). Due to the increase in VAT from 5% to 9% and also to the expected growth of electricity prices (app. 10% for households) and prices of centralized heat (impact of VAT and introduction of ecological tax on coal) the share of energy in the total balance can be expected to increase further.

Conclusions

The current shares of energy consumption in the Czech Republic and Austria range from 8% to 13%. However, the current trends in prices are different. While in Austria the real natural gas and electricity prices have been stagnating for about ten years, in the CZ prices for electricity and natural gas are steeply increasing. With respect to fuel prices in transport the situation is vice versa. Here in recent years the prices in the CZ have been stagnating while they increased in Austria. All in all, in Austria energy prices are still significantly higher than in the CR. In Austria the share of energy expenses will remain by and large the same. Yet, the available income is also higher and so compensates for the higher prices. In the CZ income as well as prices are rapidly catching up. Finally, the expectations are that prices in the CZ will grow faster than income and so the share of household expenditure for energy will increase.

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8

The central European electricity market: Signs of full integration?

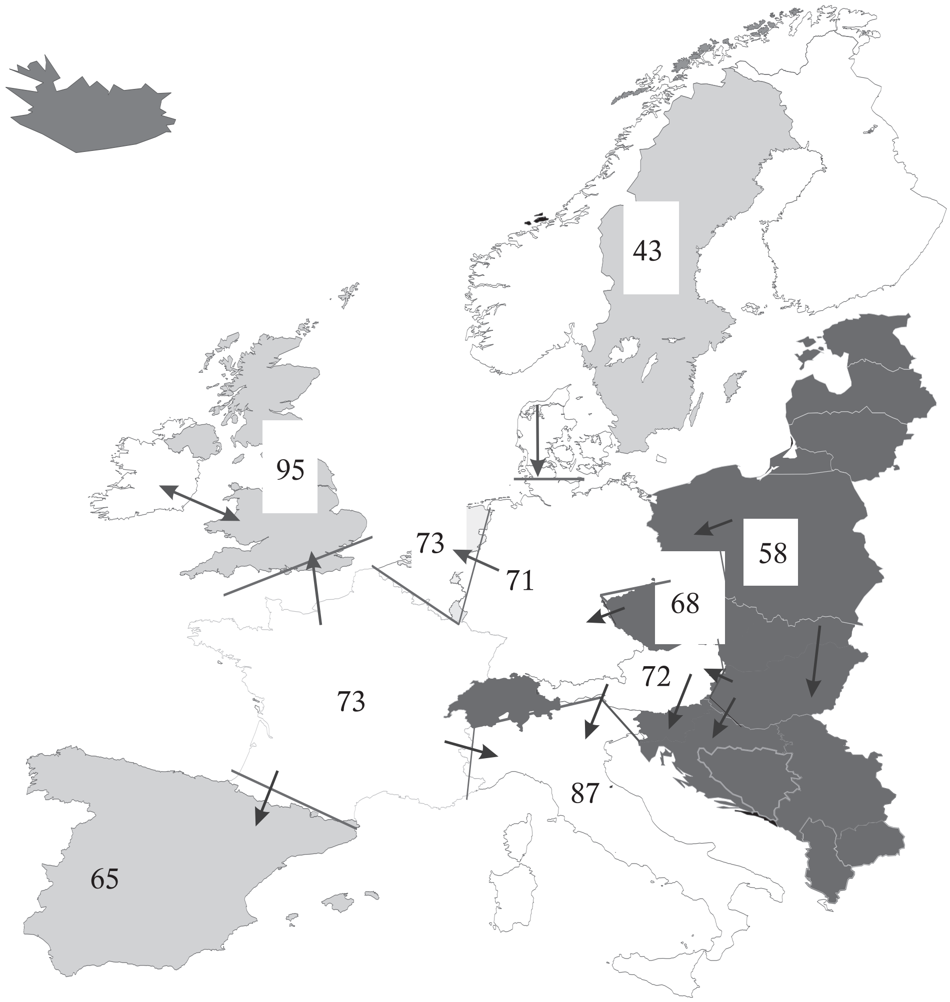
8.1 Introduction

The restructuring process of electricity markets in the European Union started in the late 1990s and continues today. This process was triggered by Directive 96/92/EC of the European Parliament and of the Council concerning common rules for the internal market in electricity (EC, 1997).

A major objective of liberalizing the European electricity supply industry has been the creation of ONE common competitive market. Currently, Europe still consists of several sub-markets separated partly by insufficient transmission capacity and differences in access conditions to the grid. Another major obstacle for a joint competitive European market is too few competitors resulting in a general lack of competition in virtually all local and national wholesale and retail electricity markets also because barriers to entry and incentives to collude remain too high. Figure 8.1 depicts the average wholesale prices in these different sub-markets in 2008. The range is broad, starting with 43 EUR/MWh in the Nordic market and ending at 95 EUR/MWh in UK. These differences result from cross-border transmission bottlenecks or other exchange barriers (e. g., long-term contracts).

The most important sub-market is the market comprising France (FR), Germany (DE), Austria (AT), and Switzerland (CH).[1] Because no cross-border transmission capacity bottlenecks exist for these countries, electricity can be traded virtually without limitations between these countries and prices have converged (see Figure 8.2). The European Energy Exchange (EEX), located in Leipzig, is the leading exchange in this sub-market. Hence, when modelling EEX prices the whole EU-4 electricity sub-market consisting of the mentioned countries has to be considered. Prices in eastern Europe (especially

[1] *In the following, this market will be referred to as "EU-4".*

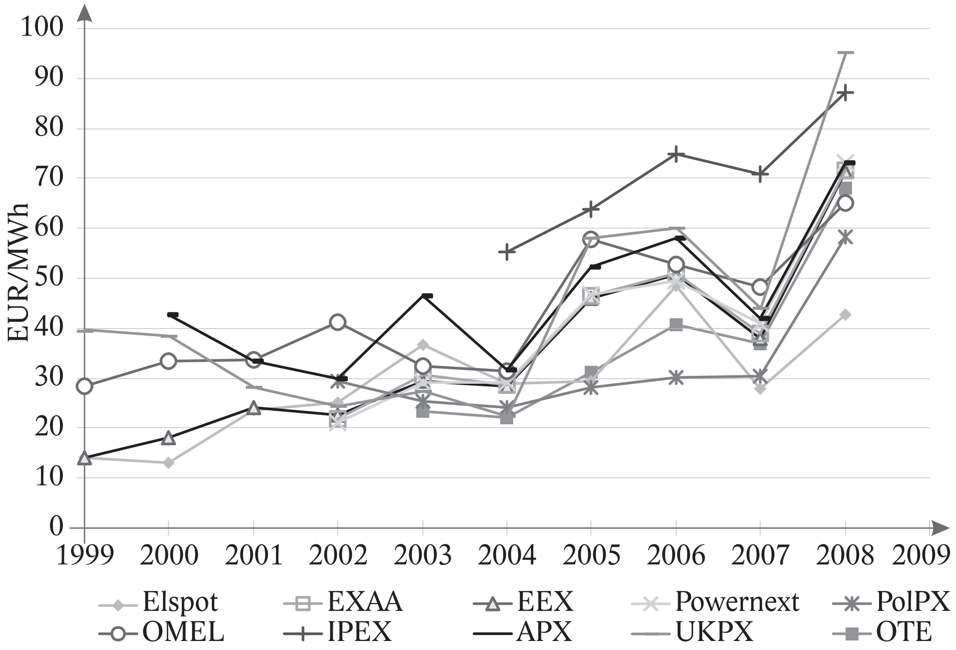


Source: Power exchanges

Fig. 8.1: Average wholesale electricity prices in [EUR/MWh] and transmission grid bottlenecks in Europe in 2008.

Poland—PL), however are at the lower end.[2] Nord Pool prices follow generally a low price pattern because the Scandinavian power market is dominated by hydro and nuclear generation. Still, low hydro availability as, e. g., in

[2] In 2007, Czech power prices (CZ) almost reached western European levels for a number of reasons. CO_2 certificate prices fell dramatically during 2007, and more cross-border capacities became available due to a reduction in long-term contracts between Germany and the Czech Republic.



Source: Power exchanges

Fig. 8.2: Development of wholesale spot market prices in Western and Central Europe

early 2003, implying congested transmission grids and increased generation in inefficient thermal power plants, causes prices to soar above EEX levels.

The most important perception from Fig. 8.2 is that while in 2007 prices converged (except Italy) and a declining trend was observed in 2008 the opposite situation emerged: a broad spreading price range and a strongly increasing trend.

8.2 The "old" Western European EU-4 power market

To assess the performance of a liberalized electricity market it is of superior interest how electricity prices have developed after restructuring. Therefore, a major question for further investigations is whether these prices are a competitive outcome. In competitive markets—at least in theory—marginal generation costs are relevant for price formation. Due to the dominance of fossil-fuelled power plants in the EU-4 power market, primary energy prices and CO_2 emission allowance prices crucially determine the development of power prices.

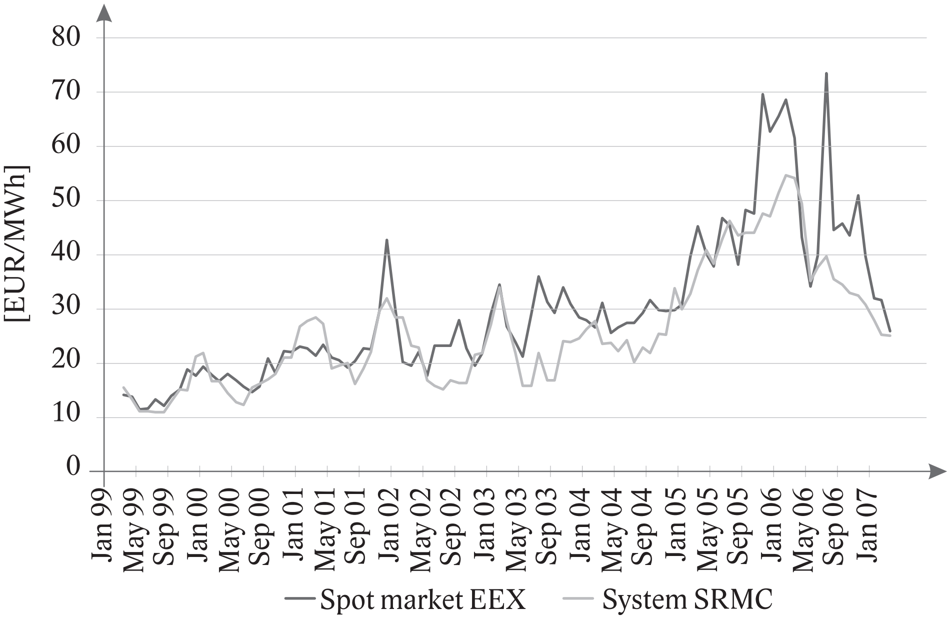
Figure 8.3 shows the comparison of realized EEX spot market prices and modeled system marginal costs. The model shows a close correlation of prices and costs from 1999 to 2001 with a structural break in December 2001. Prices and costs diverge between June and October 2002 and between June 2003 and November 2004. This mark-up induced the following interpretation. Müsgens (2004) argues in an analysis of the German wholesale market: "The difference between marginal costs and prices is attributed to market power. … there is strong evidence of market power in the second period from September 2001 to June 2003". In late 2006 and early 2007 prices again significantly diverge from the competitive benchmark model.

For effective competition to take place many companies are required. No other model has so far been successful. This is, e. g., proven clearly by the example of England and Wales where the number of generators has been increased several times by the regulatory authority (as well as by investors, notably the regional distribution & supply companies, the RECs). The "merger-mania" on continental Europe after the start of liberalization indicates that the major strategy of the bigger incumbent utilities is to compete by merging to purchase market shares. In many eastern European countries, national companies have been sold to strategic investors from abroad, with EdF, E.On, RWE, Electrabel and Vattenfall being particularly active. In reaction, some countries like the Czech Republic, Slovakia & Slovenia have been concerned to retain national champions.

Of course, an easy solution with respect to the number of generators in each relevant market would be to have more generators and some divestment. Yet, with some minor exceptions (Spain, Italy) currently no signs in any country are pointing in this direction. In this context privatization is often considered to be more important than carefully designing the competition mechanisms. However, as Newbery (1998) asserted for England "competition rather than privatization is the source of the benefits". Similarly, under competitive pressure public utilities performed reasonably in the Nordic countries.

Taking a closer look at electricity supply, one can identify a strong convexity of the merit order curve with a high slope of the supply curve when approaching system capacity limit. Figure 8.4 exemplarily depicts the merit order curve of the EU-4 power market for May 2006. About 50% of total generation stems from power plants with low short run marginal costs. These comprise run-of river hydro power plants, "new" renewable plants that are subject to national support schemes and, finally, nuclear power plants.[3] Generation costs of fossil

[3] *Clearly, some "new" renewable energy sources are associated with high variable costs (e. g., biomass). Nevertheless, from a wholesale market point of view, these technologies—in the short*



Source: EEX, BAFA, UCTE, own calculations

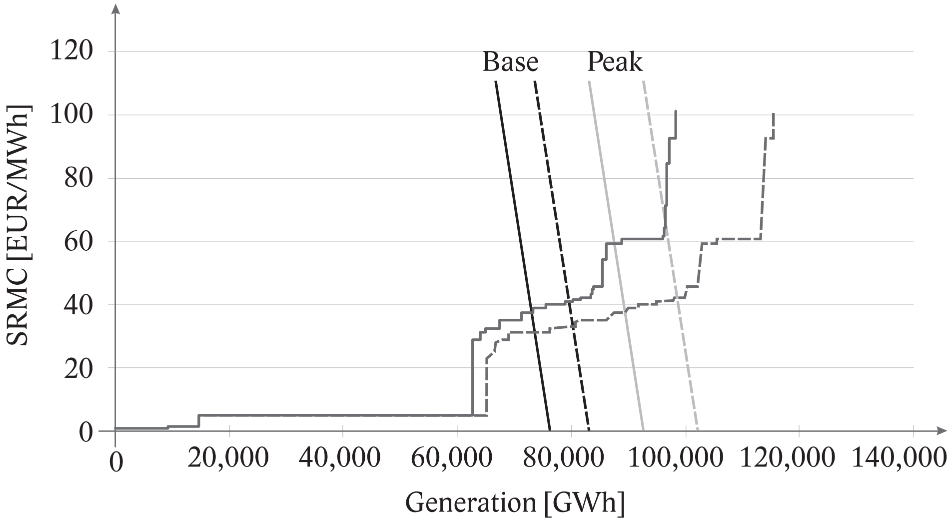
Fig. 8.3: Evolution of electricity prices and system marginal costs in the regional EU-4-market from 1999–2007

fuelled power plants are much larger resulting in a huge jump in the merit order curve whereas the ranking of conventional thermal power plants changes depending on the prevailing fuel and CO_2 price level.

As in most electricity markets that have been liberalized, European countries also started with significant excess capacities in generation built up in the time of regulated area monopolies. Indeed, it was a common motivation and driver for introducing competition.

Yet, excess generation capacity plays a core role in the restructuring process of an electricity supply industry. If utilities compete with excess capacity in generation—which also depends on transmission capacity—the price they receive for electricity will be equal to their short-term marginal cost. Under perfect competition without remarkable excess capacities the price will not rise above the long-run marginal costs of new technologies. But if there is no competition or a too tight capacity the price can be substantially higher than both marginal costs especially when demand is inelastic to price.

run—decrease residual load that has to be met on the conventional markets (see also Sensfuss et al. (2007)).



Source: UCTE, BAFA, EEX, own calculations

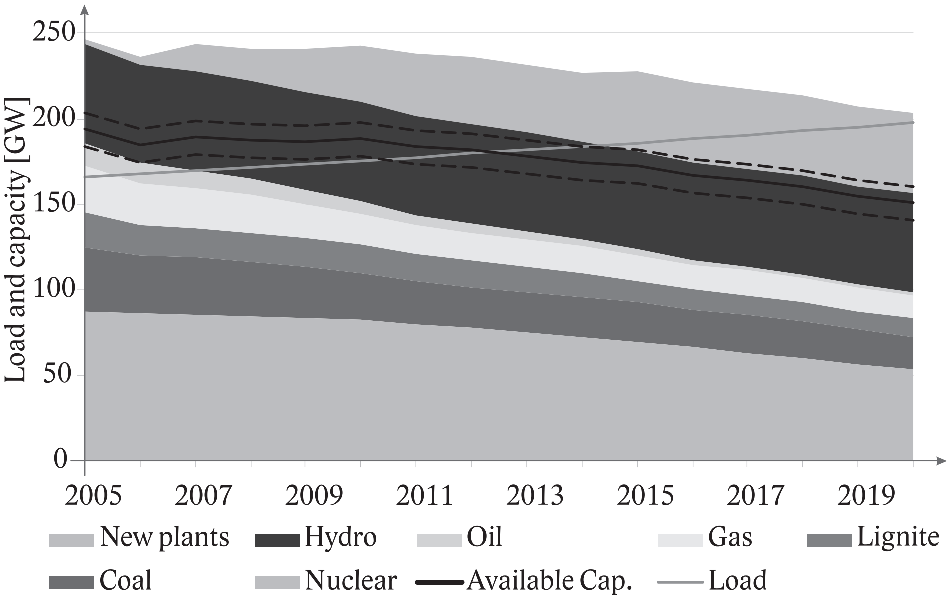
Fig. 8.4: Merit order curve for the EU-4 electricity market (AT+CH+DE+FR, solid lines) and for the EU-4+2 market (AT+CH+DE+FR+CZ+PL, dashed lines) for May 2006 and corresponding electricity demand

Fig. 8.5 depicts the currently looming developments of load and generation capacity.[4] In recent years spare capacity decreased continuously in the EU-4 sub-market (spare capacity = net capacity minus maximum load). In this context, variations and uncertainties in available capacities play a crucial role as indicated by the dashed black lines in Fig. 8.5.

Currently, transmission constraints have a substantial impact on the separation of sub- markets on continental Europe. Hence, another important prerequisite for a sufficiently wide market would be that there is sufficient transmission capacity to neighboring regions, increasing the number of potentially competing generators. Figure 8.6 depicts the situation at cross-border transmission lines in 2006.

In the following the effects of extending the EU-4 market by integrating the Czech Republic (CZ) and Poland (PL), both electricity-exporting countries, will be analyzed. A precondition for this market extension in the short run is making more cross-border transmission lines available due to a reduction of long-term contracts.

[4] *The figures for the trend in generation capacities are based on existing capacities, approved new capacities, decommissioning of nuclear according to IAEA, and a limited lifetime of fossil plants of 40 years. Load forecast is based on an earlier study of the authors.*



Source: Plants, national statistics, own calculations

Fig. 8.5: Trends of generation capacity and load in the EU-4 market

However, apart from lacking incentives for TSOs to invest in new interconnector capacities, the sector inquiry by the European Commission notes that a significant proportion of existing cross-border lines is still allocated on the basis of long-term contracts (EC, 2007).[5]

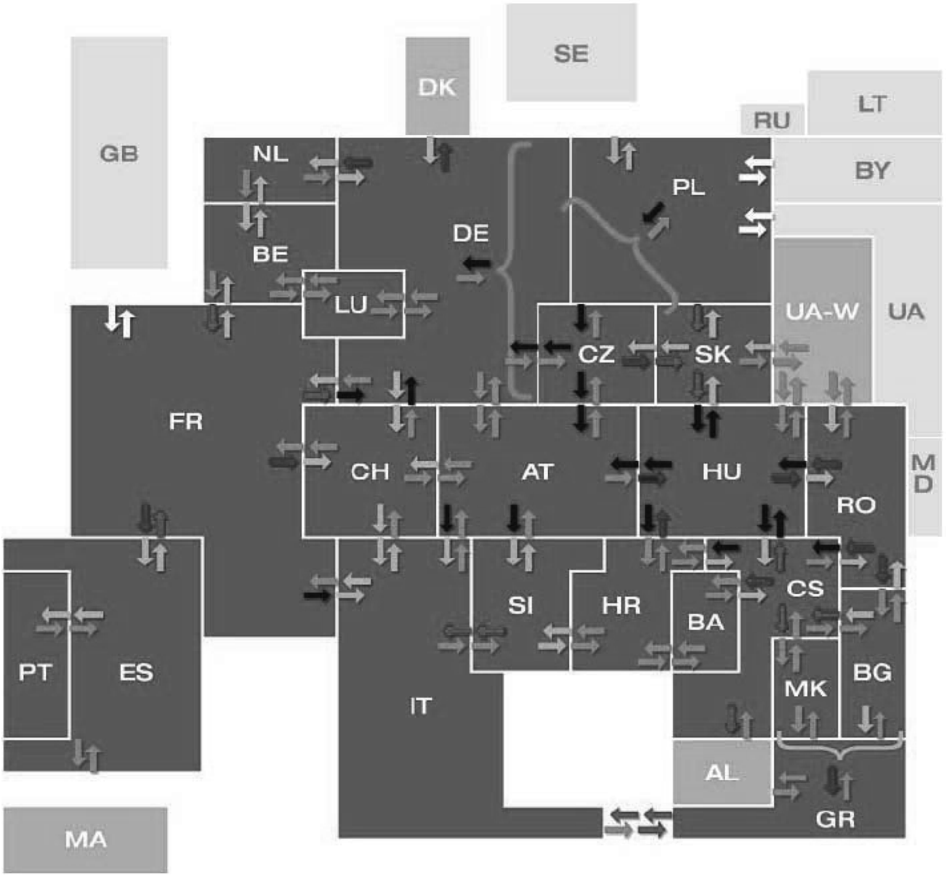
For example, at the Austrian-Czech border 150 MW of interconnector capacity for 2007 were auctioned in winter 2006.[6] This relates to 40% to 60% (with respect to summer and winter values) of Net Transfer Capacities (NTC) for 2007 published by the European Transmission System Operators (ETSO). Results of this auction yielded a capacity price of 4 EUR/MWh reflecting market participants' expectations on wholesale price differences.

Market integration of the Czech Republic and Poland into the EU-4 electricity markets

Figure 8.7 shows the theoretical result of market coupling of a low price market A (with "cheap" excess capacity, e. g., from the Czech Republic) and a high price market B (with no "cheap" excess capacity, e. g., the EU-4 market). As a result prices in market A increase, which goes along with an

5 In 2005, on the Czech-Austrian border 60%–70% of interconnector capacity was reserved for long-term contracts (EC, 2007).

6 See www.auction-office.at for results of cross-border auctions at the Austrian borders.



Occurence of congestion:

⇒ n. a. → 51–75%
→ 0% → 76–99%
→ 1–25% → 100%
→ 26–50%

UCTE region
Associate member
Synchronous Operation with UCTE region

Source: UCTE (2007a)

Fig. 8.6: Cross-border congestion on continental Europe in 2006

increase in producer surplus in market A, whereas prices decrease in market B increasing consumer surplus in B. Of course, sufficient cross-border capacities must be made available at low costs.

Figure 8.8 depicts the effect of full market integration for two different cases. In the first case, adding a "short" country B—a typical import country with demand exceeding capacities—results in price increases for the extended

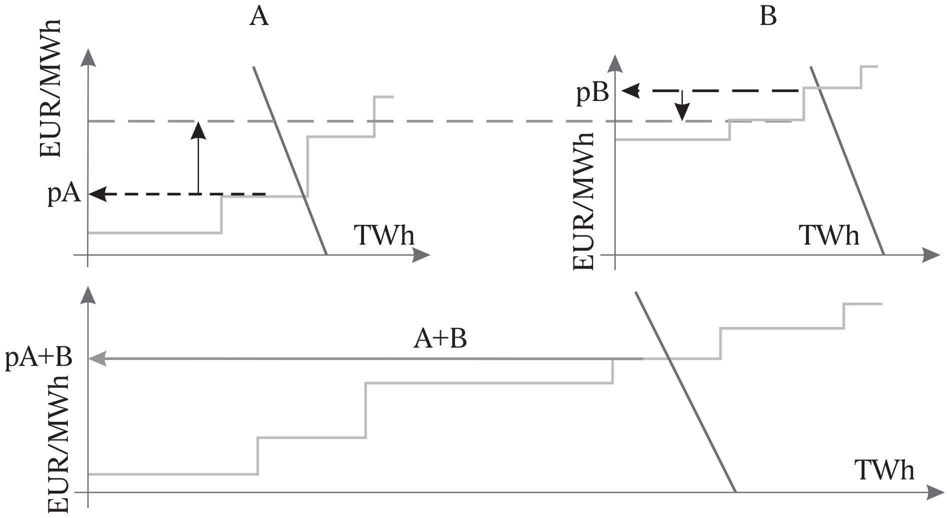


Fig. 8.7: Effects of market extension in an electricity market

market compared to the former single market A. On the other hand, when a "long" country B—where demand is less than the installed capacities—is added, prices decrease for the extended market compared to the single market A.

Finally, Figure 8.4 also shows the effects on supply when the Czech Republic and Poland become part of the Western European market. Hence, the dashed curve shows the hypothetic merit order for AT, CH, FR, DE, CZ and PL for May 2006. As can be seen, especially in the medium load segment of the supply curve a flattening is the result of the market extension that, in theory, could have the potential of reducing prices in the "old" EU-4 market.

The effects of market extension in the EU-4 countries from including the Czech Republic and Poland are shown in Figure 8.9. Due to the mentioned flattening of the supply curve, prices decrease slightly compared to the situation where only AT, CH, FR and DE form the market. Clearly, price increases result from this market extension in PL and CZ.

Clearly, "positive" price effects for the "old" EU-4 countries due to market coupling with the Czech Republic and Poland only occur as long as these two countries have enough access capacity. Figure 8.10 depicts the effects of extending the market to the Czech Republic and Poland. Compared to Figure 8.5 no improvements concerning security of supply can be expected from this market coupling.

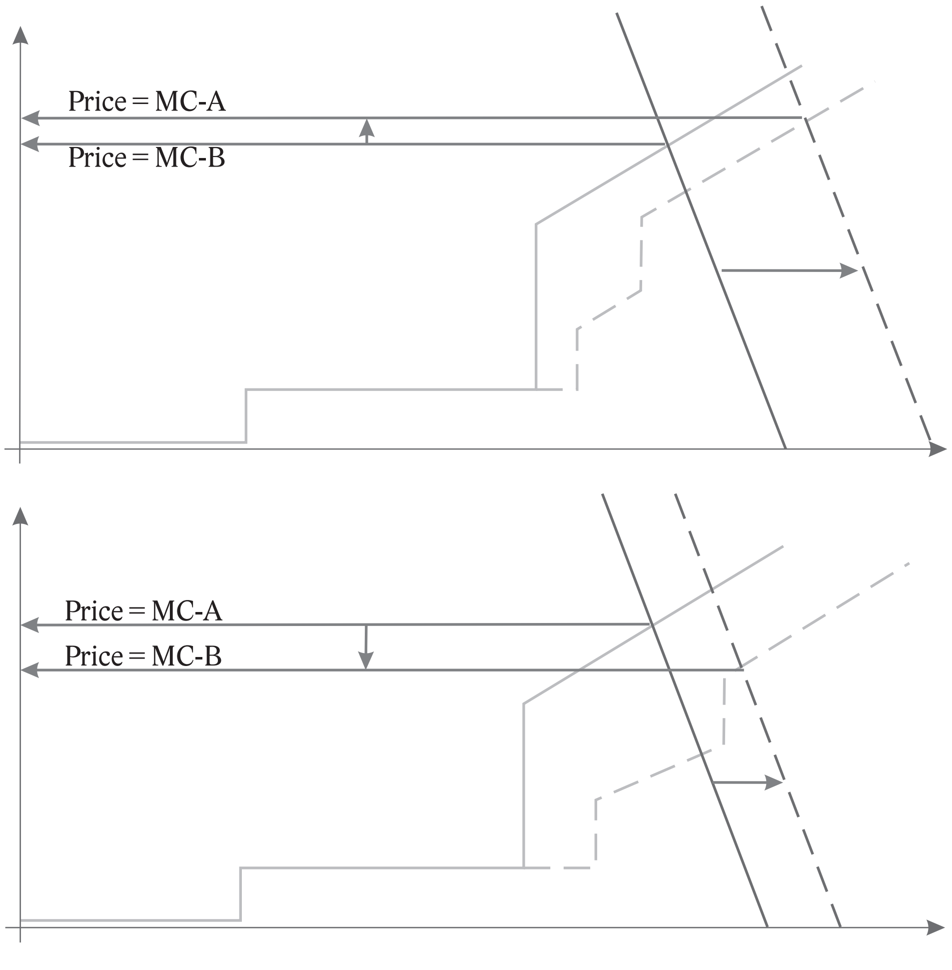
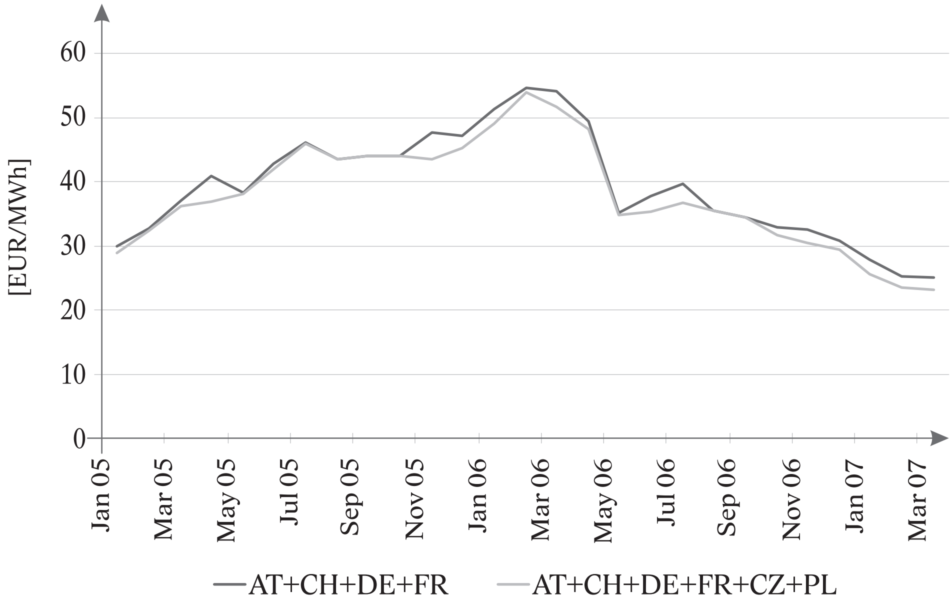


Fig. 8.8: Effects of integrating a "short" country (left) and a "long" country (right) in an existing market

Central Europe (i. e., the Czech Republic and Poland in the context of this paper) has adequate generation capacity for the foreseeable future. Nevertheless, after 2010 supply security will also become negatively affected due to lack of power plants being built and pronounced decommissioning of existing power plants (both nuclear and fossil-fuelled plants). One remaining major uncertainty in these countries is the magnitude of demand growth.



Source: EEX, BAFA, UCTE, national reports, own calculations

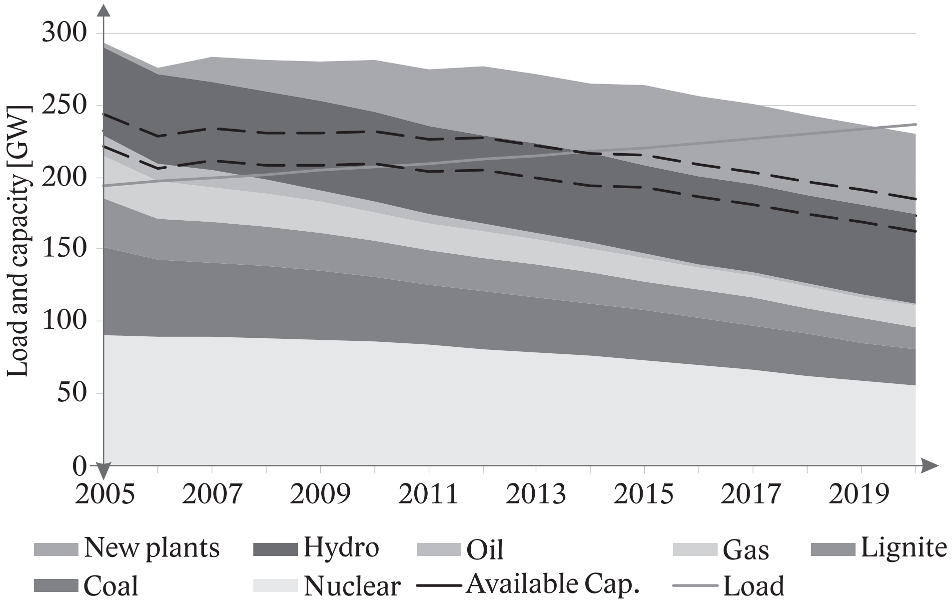
Fig. 8.9: Price effect of a hypothetical market coupling of the EU-4 and the Czech Republic and Poland.

8.3 Cross-border transmission capacities

In this section the issue of availability of cross-border transmission capacities in Central Europe (i. e., the area including the Czech Republic, Austria, Germany, Poland, Slovakia) is analyzed.

A coordinated solution in operation has been established in the CEE region since 2005 among Czech Republic, Poland, Germany and Slovak Republic. This solution of congestion management represented explicit NTC (net transfer capacity)—based capacity allocation under common Auction Rules with one Auction Office operated by ČEPS (the Czech Transmission Grid Operator).

The regional initiative, which was based on the request of the CEE regulators, has initiated the new status of cooperation since 2006. This new initiative has been targeted to develop coordinated capacity allocation for the whole CEE region facilitated by a common Auction Office, which is operating as a separate and independent company. The Central Allocation Office GmbH (CAO) was officially set up in July 2008 and is settled in Freising in Germany. The main target of this allocation office operation is to support coordination of the accurate capacity determination and allocation using a method that fully



Source: UCTE, Platts, national statistics, own calculations

Fig. 8.10: Trends of generation capacity and load in an integrated market consisting of AT, CH, DE, FR, CZ and PL

respects power physical flows. The so-called flow-based method (FBM) has been developed for this purpose. FBM is now being tested. The full application of FBM was originally expected in mid-2009, but probably will be delayed.

In May 2008, Czech and Slovak responsible ministers initiated a market-coupling project between the Czech and Slovak republics. The day-ahead Czech and Slovak electricity markets coupling is expected July 2009 and the transmission capacity will be allocated implicitly.

The algorithm for transmission capacity allocation works here based on the definition of net transfer capacity—NTC. NTC is the maximum exchange program between two areas with security standards applicable in both (compatible) areas and taking into account all the technical uncertainties on future network conditions. These uncertainties are defined as transmission reliability margin (TRM), which is a security margin that copes with uncertainties. NTC is therefore derived from the maximum exchange program between two areas compatible with operational security standards applicable at each system and the reliability margin. Indicative values for Net Transfer Capacities (NTC) in Central Europe are shown in the next figure. All values are in MW and agreed by both countries.

TO\FROM	DE	AT	PL	CZ	SK
DE		1400	1200	2250	–
AT	1500		–	250	–
PL	800	–		800	500
CZ	800	400	1600		1100
SK	–	–	–	1000	

Fig. 8.11: Indicative values of NTC in Central Europe

These indicative values in MW have been computed by extrapolation from standard situations, to evaluate the transfer capacity for a typical exchange situation. The previous table gives a basic overview of the relatively high capacity of interconnectors among the Czech Republic, Germany and Austria with impact against support of electricity trading.

The following graph shows the allocation in the long-term timeframe using the congestion management method implemented in Europe. This approach of allocating capacities means hedging by-products for a month, quarter of year and year.

In the Central Eastern Europe (CEE) Region, five TSOs from Germany (Vattenfall Europe Transmission and E.ON Netz), Poland (PSE-Operater), Czech Republic (CEPS) and Slovakia (SEPS) have been running joint auctions since 2006. In the central European region mainly explicit auctions (ATC based), which are non-discriminatory, transparent tools that enable allocation of different products and frequencies (Y, M, D) are used. In an explicit auction, the seller (TSO) determines the available transmission capacity, considering security of transmission and accepting bids from potential buyers. The TSO allocates capacity to the participant with the highest offer. The final price reflects the cost of using capacities and offers efficient signals to market players for the operation and the value of the network. Since no congestion problems between Austria and Germany have been experienced, there are no limitations between both control blocks, therefore there is no allocation method for using scarce capacity.

The auction office is managing joining allocation capacities and co-coordinating capacity calculation. Capacity is offered at yearly and monthly auctions, most-often used for capacity allocation. This capacity allocated at the yearly and monthly auctions can then be resold. Mainly allocated, non-utilized, long-term capacities and capacities released at short notice are available at day-ahead auctions. It is obvious that there is still a huge place for developing congestion management and for support of investing in new interconnectors.

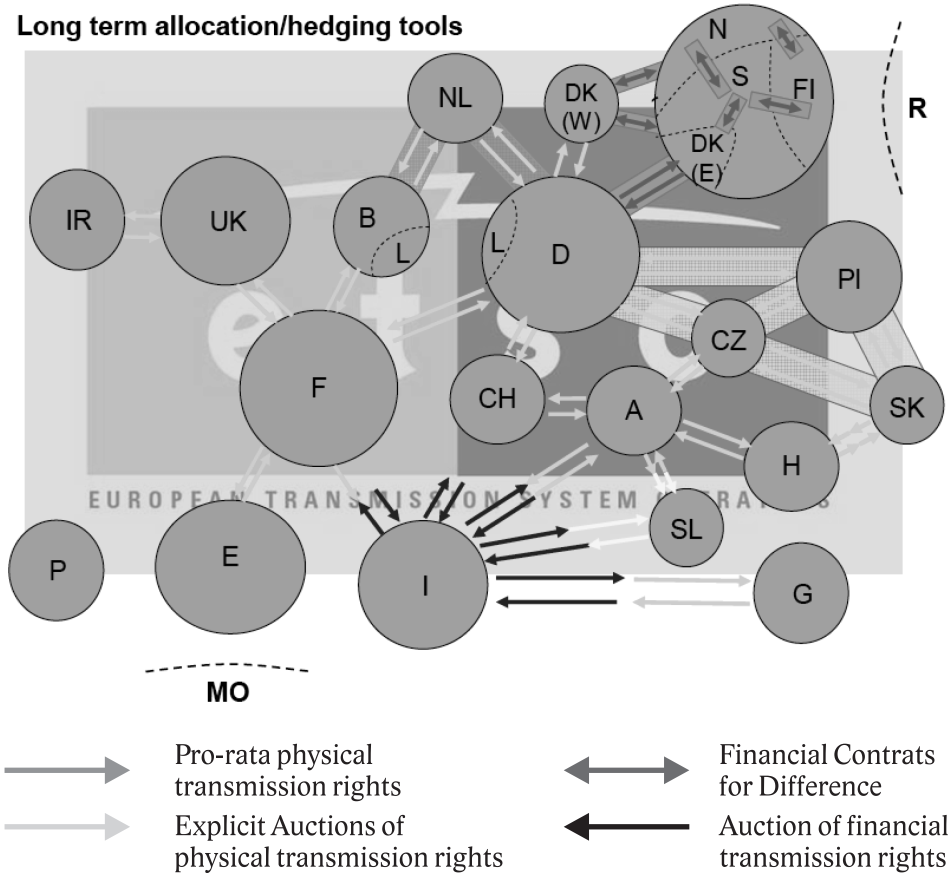


Fig. 8.12: Allocation of cross-border transmission capacities in the long-term timeframe using the congestion management method

These factors will then enable higher liquidity in the power market and higher capacity of a transmission network.

8.4 Towards a single European electricity market?

Recent developments in forming an integrated European market in electricity comprise a reduction in long-term contracts at Czech cross-border transmission lines which, among other important factors mentioned in section 8.1, has led to an increased convergence at the wholesale level. Moreover, implicit auctions at the French-Belgian and Belgian-Dutch borders have caused wholesale prices to converge for most of the time in these countries.

Hence, the continental European electricity market, originally consisting of Austria, Germany, France and Switzerland, is about to undergo a pronounced increase in size and complexity. Partly, this extension has already started in 2007. According to the analyses presented in the previous chapters wholesale prices will continue to be heavily influenced by German generation cost patterns.

In the medium term, a coupling of the continental and the Nordic market will constitute a major step towards further integration of European regional markets. Moreover, this coupling will have significant effects on price levels, patterns and volatilities since a thermal and a hydroelectric system will be merged. Among others, Newbery (2004) and Bjørndalen and Bugten (2008) have theoretically analyzed implications of coupling a hydro and a thermal system that potentially increases economic welfare. Market coupling between Germany and Denmark, scheduled to start in June 2008, as well proposed transmission lines between the Netherlands and Norway and Denmark and Germany will contribute to this integration.

Conclusions

Currently, in (Western) Europe a joint electricity market exists in Austria, Germany, France and Switzerland with a virtually uniform market price. France and Germany play a key role within this market because of their size and geographically central positions. Moreover, this market is characterized by a few dominating players. This low number is being reinforced by two others aspects: insufficient transmission capacity is available between adjacent submarkets; and there is increasing horizontal integration with natural gas supply.

An extension of this market to Eastern European countries like the Czech Republic and Poland by means of making more cross-border transmission lines available due to a reduction of long-term contracts would lead to a slight decrease in western European wholesale prices but increase electricity prices in the Czech Republic and Poland. In the medium term a further integration with the Nordic market can be expected that will bring together a thermal and a hydro-dominated system.

Finally, sufficient spare capacities in generation and transmission are still available in the region. However, current developments imply an upcoming security of supply problem by 2012 in the investigated markets even if the market is extended.

The definitive litmus test for liberalization will come in every sub-market on continental Europe at the point-of-time when the bulk of excess capacities has disappeared and demand has come close to available capacities. That is to say, the most important problem is to provide long-term incentives for investments in upgrading and in new generation and transmission capacities, as well as in demand-side efficiency and demand responsive measures. This issue is especially relevant in the context of decentralized vs. further centralized development of the electricity supply system.

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9

Methodology of analysis of biomass potential using GIS

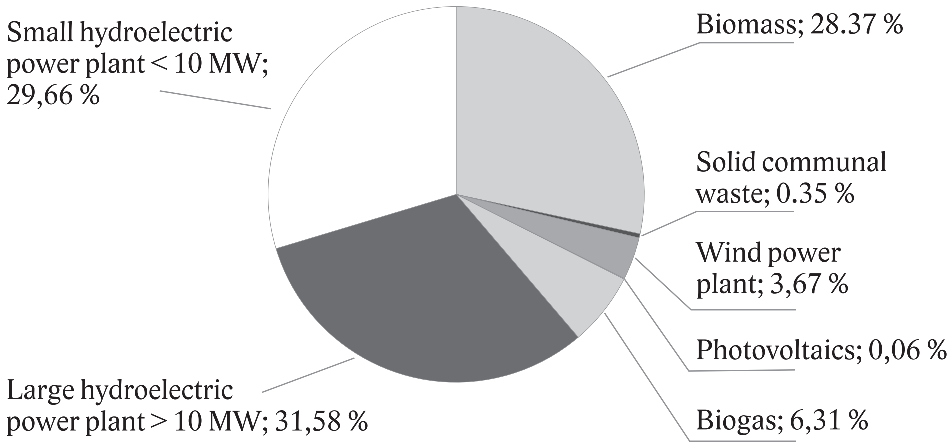
9.1 Introduction

Today, biomass energy continues to be the main source of energy in many developing nations, particularly in its traditional forms, providing on average 35% of the energy needs of three-quarters of the worlds' population. Biomass covers between 60% and 90% of energy demand in the poorest developing countries. However, modern biomass energy applications are increasing rapidly both in the industrial and developing countries, so that they now account for 20%–25% of total biomass energy use. For example, the United States obtains about 4% and Finland and Sweden 20% of their primary energy from biomass (Calle et al., 2007).

Biomass features strongly in virtually all the major global energy supply scenarios, as biomass resources are potentially the world's largest and most sustainable energy source. Biomass is potentially an infinitely renewable resource comprising 220 oven dry tonnes (odt), or about 4500 exajoules (EJ), of annual primary production; the annual bioenergy potential is about 2900 EJ (approximately 1700 EJ from forests, 850 EJ from grasslands and 350 EJ from agricultural areas) (Hall and Rao, 1999). In theory, at least, energy fading in current agricultural land alone could contribute over 800 EJ without affecting the world's food supply (Faaij et al., 2002).

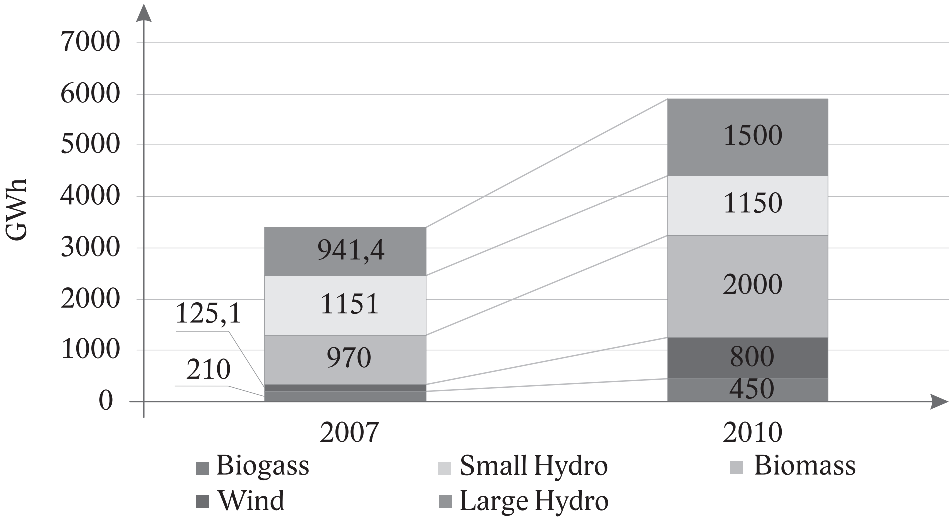
The national indicative goal for the Czech Republic is 8% by 2010. Brutto production of electricity from renewables was 4.7% of the gross electricity consumption in 2007. In the same year, renewables covered 3.9% of primary energy sources. The assessment relates to the energy content of used fuel and does not take into account technology efficiency.

The current share of power generation based on biomass utilization is app. 28%. This, however, is expected (scenario of Ministry of Industry and Trade—MPO) to increase to app. 34% in the year 2010—see Figure 9.2.



Source: MPO, Report on progress on National indicative goal fulfilment of electricity production from renewables for year 2007

Fig. 9.1: Production of electricity from RES in CZ in 2007



Source: MPO

Fig. 9.2: Current and expected structure of RES power generation

In the longer perspective, biomass is expected to have a far higher share in RES power generation—see scenario of State Energy Policy from the year 2004 in Figure 9.3.

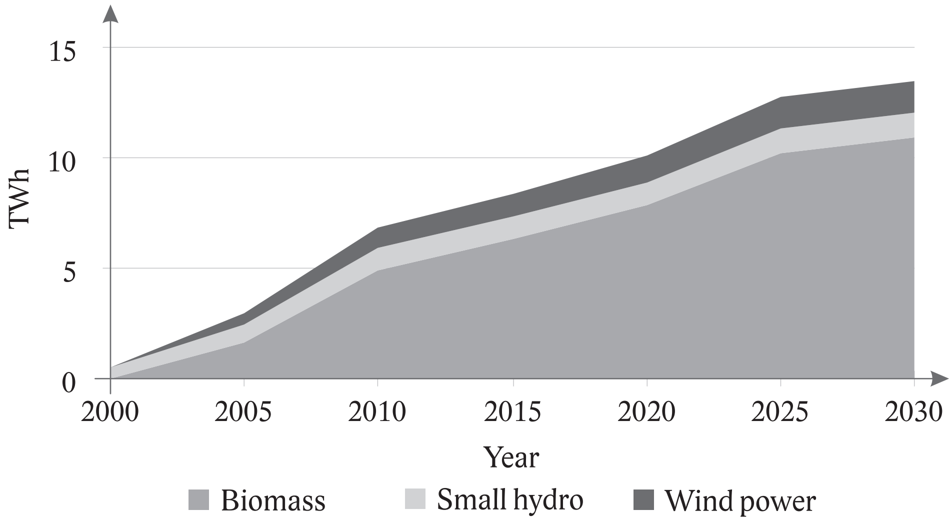


Fig. 9.3: Czech Energy policy—biomass utilization for power generation

The target share of biomass utilization for RES power generation in the year 2030 is 80%, and the share of biomass in total RES as primary energy sources is similar—85%.

Utilization of biomass for energy purposes is limited at the moment and is lower than originally expected (State Energy Policy 2004).

Biomass has the most promising technical potential of all renewable energy sources for production of electricity and heat in the Czech Republic. Its utilization is technically well managed and there are not problems with stability of fuel delivery as is with wind, solar or hydro sources. The stability of delivery can even be increased by combining biomass with non-renewable fuels. The main and difficult to overcome limit of biomass utilization is its total amount on the market and transportation accessibility.

9.1.1 Sources of biomass

As mentioned above, sources of relatively cheap biomass, namely wood residuals from wood and paper industry are already utilized to a significant extent. Sources of additional biomass are especially:

- Higher utilization of residual biomass from agriculture—esp. straw and grass from permanent grasslands.
- Utilization of small wood—residuals from timber felling.
- Intentionally planted biomass on agriculture land (energy crops).

Fuel	Consumed (t)
Wood chips, waste	402,987
Fire wood	0
Cellulose extracts	221,563
Plant materials	16,220
Briquettes, pellets	24,321
Other biomass	286
Total	**665,377**

Tab. 9.1: Electricity produced in 2007 from biomass according to biomass type

Fuel	Consumed (t)
Wood chips, waste	934,669
Cellulose extracts	888,915
Plant materials	22,260
Briquettes, pellets	15,529
Firewood	54,635
Other biomass	192
Total	**1,916,200**

Tab. 9.2: Amount of biomass used for heat production in 2007 according to biomass type

The first two sources are limited and their contribution to the future biomass delivery is less significant (see also Fig. 9.4). The decisive role will be played by energy crops, intentionally planted biomass from agriculture land for several different purposes.

Up to 1 million hectares of agricultural land (of total 3.6 mil. hectares of agriculture land) is assumed to be used for energy purposes in the long-run. Fast-growing trees (poplar and willow), reed canary grass, miscanthus, rescue grass, tall oat-grass, sorrel hybrid, and cocksfoot are among the most promising energy crops to be grown on these lands.

Fuel	Consumed (t)
Wood chips, waste	1,337,656
Cellulose extracts	913,236
Plant materials	243,823
Briquettes, pellets	31,749
Firewood	54,635
Other biomass	478
Total	**2,581,577**
Estimated household consumption of wood	3,585,103
Exported biomass for energy purposes	591,740
Overall biomass used, including export	**6,711,037**

Tab. 9.3: Biomass used for energy purposes in 2007

Poplar and willow (short rotation coppice)

A short rotation coppice (SRC) with fast-growing trees—poplar and willow—is a promising biomass producing agriculture crop system in the Czech Republic. The total planting area of poplar and willow short rotation coppices (SRC) on agricultural land is about 225 ha. About 25 ha of stool beds exists for production of planting material (cuttings). Length of rotation in a Czech SRC ranges between 3–6 years, which can be repeated 4–7 times. Planting density and schemes vary according to local conditions, but a one-row planting scheme with 10,000 cuttings per hectare are mostly used. Most plantings of SRC were done by small communities and land owners in the 1990s and early 2000s. In recent years private forestry enterprises and state forests planted the largest areas. The actual acreage of SRC, however, is small, only about 250 ha. This slow growth is caused by different reasons including an inconsistent subsidy system (not available now), low awareness of farmers and some legal and administrative barriers.

Sorrel Hybrid schavnat (*Rumex patientia L.* × *Rumex tianshanicus* A. Los.)

Sorrel is a perennial crop, which can be partially or fully used for biomass production (direct burning, biogas production). Moreover it is a very perspective crop for producing high quality forage, specialized food products and biologically active food and feed additives. Dry stalks can be harvested for

Fig. 9.4: Harvest of 15-year-old poplar short rotation coppice in Peklov (rotation 6-years, yield 11.7 tDM/ha/yr)

energy in the summer continuously for more than 10 years according to Usťak & Usťakova (2004). It has very few requirements for soil, fertilization and climate. It is registered as an agricultural crop under the commercial name 'Rumex OK-2' in the Czech Republic. The actual acreage of schavnat is about 1200 ha, which is relatively small, but it is the largest out of all lignocelluloses energy crops. Yields of dry stalks vary between 5–9 tDM/ha/year depending on site conditions and the quality of the agrotechnolgy.

Miscanthus (*Miscanthus* × *giganteus*)

Another promising biomass producing crop is *Miscanthus* × *giganteus*. It is a large perennial grass with high water efficiency usage (C4 type of photosynthesis), which can be used for energy production and to balance different cropping systems (food, forage, material, energy) to prevent some of the environmental risks of modern large-scale agriculture. Currently it is grown only on very small area in the Czech Republic. The main reason is the high cost of

Fig. 9.5: Sorrel Hybrid—dry stalks (15–17%) before harvest in Krnov

the planting material and the little knowledge about methods of growing and utilisation among farmers.

9.1.2 Zoning of agricultural land for energy crops

Despite the Czech Republic's relatively small size, it has a wide range of climatic and soil conditions. The diversity of conditions here stems mainly from the quite mountainous surfaces (altitudes 180–1600 m) and the republic's position in the transitional zone between the oceanic and continental types of climate. The average yearly temperature ranges between 5–10°C and annual precipitation between 400–900 (1500) mm.

Therefore a new agricultural land valuation was created for better agricultural planning in the Czech and Slovak Republics during 1980s and 1990s, based on an extensive land and climatic overview. The base units of the system are the production soil-ecological units (BPEJ) from which the main

Fig. 9.6: Field of Miscanthus × giganteus in third growing season (July 2009) in Lukavec

soil climate units (HPKJ) can be derived. There are 10 agro-climatic regions and also 10 main soil types that are further divided into 73 sub-types.

Results of willow and poplar and other new energy crops field testing showed that the factor of locality—its climatic and soil conditions—had the most statistically conclusive influence on yields and also other growth parameters. Therefore zoning of agriculture land was created to identify areas suitable, unsuitable or environmentally risky for biomass production using willow and poplar SRC (Weger et al., 2007). Zoning of agriculture land for other crops has been created in the last year (e.g., for canary grass, miscanthus, rescue grass, tall oat-grass, sorrel hybrid, and cocksfoot) to assess biomass potential in the Czech Republic.

9.1.3
Biomass utilization barriers

According to the last analyses, different lignocelluloses energy crops including SRC of fast-growing trees, sorrel hybrid, Miscanthus and others, are promising for agriculture crop systems in the Czech Republic. The actual acreage of these crops however, is small, being only about 2000 ha. This slow growth is caused by different reasons, including an inconsistent subsidy system (not available now), low awareness of farmers and some legal and administrative barriers. For instance only autochthonous species can be planted in the Nature Protected Areas (190 000 ha) and their buffer zones in the Czech Republic, meaning only black poplar, native willows and some native grasses.

There are not only different types of biomass competing against each other, but also different biomass users competing for biomass. But the primary limiting factor here is the agriculture land utilization. The area of agriculture land is limited and one should respect that for environmental reasons the requirements to reduce intensity of land utilization will be of higher importance. This can be seen at present in the case of forest residuals. Environmental protection calls for smaller areas of forest to be harvested, but in contrary it limits the (economic) effectiveness of residuals collection and processing into wood chips.

9.1.4
Biomass utilization effectiveness

What is the primary goal of biomass utilization? RES utilization, biomass included, has many positive effects—e.g., reduction of CO_2 and other pollutants emissions, reduction of dependency on the importing of primary energy sources, diversification of activities in the agriculture branch, creation of new job possibilities in rural areas, substitution of coal utilization (in places with connection to the natural gas grid), etc. Intentionally planted biomass for energy purposes is not typically directly competitive with classical fuels and needs some kind of financial support.

As mentioned above several different ways to produce intentional biomass on agriculture land and also different ways of its utilization exist. A consistent state strategy of support of biomass utilization for energy purposes should take into account the effectiveness of this support. The primary goal of biomass utilization cannot be volume of power (or heat) generated from individual RES plants using biomass as an input or number of litres of liquid biofuels produced. Theprimary goal of RES utilization, and biomass is not the exception, is to attain the above-mentioned system effects. These effects are to a significant extent mutually correlated and can be approximated by the saved emissions of CO_2.

Intentionally planted biomass uses two limited sources—money (through some support scheme) and agriculture land.

9.2 Materials/Methods

For the analysis to fulfill its goals, it must go through a certain process that can basically be characterized on an axis: defining the task—selection of a methodology, processing instruments and data sources—data processing—interpretation of the results. Following the given approach and principles allows for the attainment of reliable results that enable rational strategic decision-making about the utilization of biomass in the area considered. The methodology can contribute to the economically efficient and environmentally acceptable development of bioenergy in regions of the Czech Republic.

9.2.1 Defining the task

Defining the task is an important step in the process because it enables the selection of a methodology, the completion of concrete analysis and obtainment of suitable accuracy in the resulting data. The task is specified by the applicant and must obtain the following basic parameters:

- Quantification of the scope of the analysis or from which interested area is biomass to be utilized or how much energy potential from biomass is needed for the considered source.
- Determination of the required biomass sources or which form of biomass is to be used and under which parameters and eventually which technology is to be used.
- Definition of the type of biomass potential or what potential do we want to know—e.g., technical, exploitable, usable, available or economic.
- Determination of the time horizon or when, eventually in which period do we want to start using the potential.

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9.2.2
Methodological approach using GIS

The biomass sources considered include cereal straw, permanent grasslands, forest residuals and fast-growing trees. The process of assessing biomass potential from agricultural soils is based on assigning yields of individual biomass sources according to the production soil-ecological units (BPEJ) or the main soil climate units (HPKJ—a part of the BPEJ), which were created for better agricultural planning in the Czech and Slovak Republics during 1980s and 1990s.

The methodology for the analysis of biomass potential for forest land is based on a different principle than the assignment of yields according to the BPEJ. Forest management plans that describe the composition of all forest stands have been completed and are regularly updated. Data from these forest management plans can be used to determine in detail the potential of the forest in individual periods according to the plan for silvacultural treatment and major harvest of the wood. This detailed analysis is suitable only on the municipality level.

9.2.3
Main data sources

- maps (SMO 5 in Czech) on a scale of 1 : 5000.
- Another map base is the LPIS that also includes actual grown crops.
- Maps and databases of BPEJ, LHP.
- Site specification and the yield curves of energy crops in the BPEJ system from the results of field testing and research projects.

The main instruments for processing these data include the following:

- SW ArcGIS Desktop version 9.2,
- Microsoft Excel.

9.3 Results

9.3.1 Potential of individual biomass resources

Residual straw

To geographically analyze the potential of grain straw from conventional agriculture, yield tables are used for grain for individual production and ecological soil units (BPEJ). To ensure that straw yields are calculated only for arable lands it is necessary to check overlapping of grain yield maps and the map of actually grown crops (LPIS in Czech). In the next step straw yields are calculated from grain yields using the coefficient of the straw share (Ks) that according to experts, e.g., for wheat ranges between 0.8–1.0, barley 0.7, rape 0.8. Figure 9.7 demonstrates yields of straw in NUTS3—Central Bohemia region.

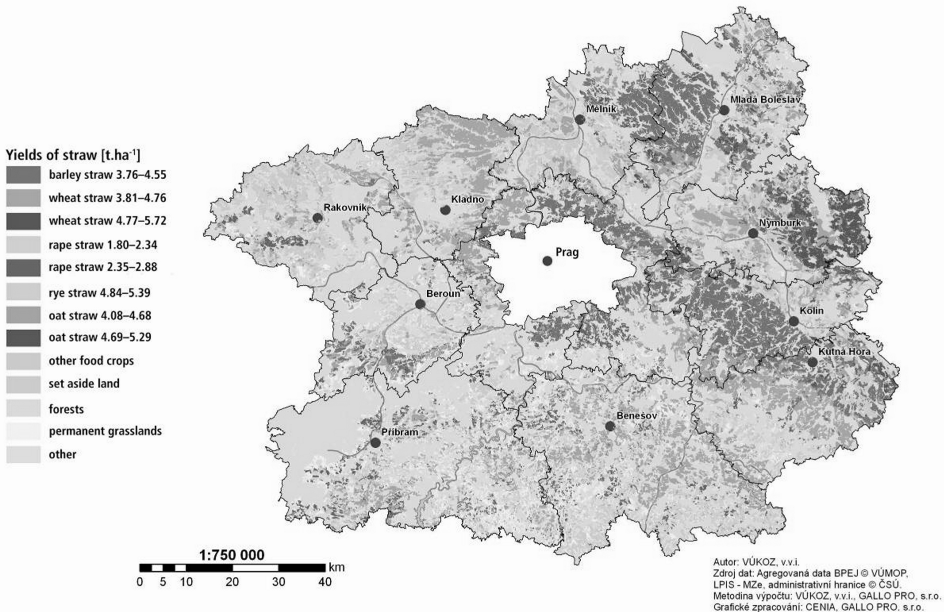

Fig. 9.7: Yield map of straw on arable land—NUTS3, Central Bohemian region

Finally, it is necessary to deduct the amount of straw needed for farm animals (cattle, sheep, rams, horses). In the final year, straw residuals that have the required amount for animal production deducted should be multiplied by the heating value. The energy potential for burning from conventional agriculture is the sum of the residual grain straw and rapeseed.

	in t	in GJ
Residual grain straw	5,057,443.75	79,401,866.86
Rape	620,249.12	10,854,359.6
Total	5,677,692.87	90,256,226.46

Tab. 9.4: Energy potential in the Czech Republic for burning from conventional agriculture

Permanent grasslands (TTP in Czech)

To determine the biomass potential of grassland areas, grass yields from tables are used similarly as with the grain straw. In the first step, grassland yields are assigned to each BPEJ unit and then entered into a GIS database. These tabular yields include "raw" grass yields, therefore they must be corrected to dry mass using a coefficient of 0.20 (20% dry mass). In the second step, the overlapping of the yield layer and the map of actually grown crops (LPIS) ensures that the grass yields are determined only on grasslands.

Energy potential from biogas stations takes into consideration the following sources: silage corn and permanent grasslands. The calculation of energy potential for silage corn is counted with 60% harvest humidity One ton of 35% dry corn silage can produce about 240 m^3 bioethanol, i.e., it has an energy potential of 4.5 GJ.

To calculate the energy potential of permanent grasslands, a coefficient is needed to correct the yields in tons/hectare because yields include "raw" yields per hectare (20% dry matter). One ton of 35% dry material from these grasslands can produce 175 m^3 biogas, i.e., it has an energy potential of 3.3 GJ.

Forest residuals

Analysis of biomass potential of forest stands is based on a similar principle as the agro systems—thus on the site values, but not using the BPEJ and LPIS. In the Czech Republic, forest management plants based on forest types (SLT in Czech) provide expected yields (reserves) of wood biomass. From

	in t	in GJ
Corn for silage	7,628,178.68	34,326,804.06
Permanent grasslands	14,502,192.97	47,857,236.8
Total	22,130,371.65	82,184,040.86

Tab. 9.5: Energy potential from conventional agriculture bioethanol production in the Czech Republic

these data, forest biomass potential can be determined in detail for individual periods according to the planned forest management (silviculture—thinning and felling) and to harvest, not only to the actual date, but also on a 10-year or longer horizon. This detailed determination of forest potential is appropriate for analyzing at the municipality level.

For higher administrative levels, the calculation of potential is very difficult to process, therefore in the project LHP analysis of selected areas was completed and a coefficient for forest logging residuals (KLZ) was calculated to quantify total amount and distribution of potential at the regional and district levels. The coefficient value is 0.63 t/ha at 60% water content and gives the average biomass yield for forest exploitation residuals related to forest area.

When completing an economic assessment of the utilizable potential to determine the cost of 1 GJ of heat in fuel, the above-mentioned layer is integrated with another layer that includes the results of the economic calculation aimed at determining an estimate price of the corresponding biomass forms. The estimate of biomass prices was created on the basis of an economic model that represents all steps needed for processing forest harvest residuals after logging. The resulting price of wood chips ranges from 90–105 CZK/GJ of heat in fuel and depends on the salaries of the workers participating in the processing.

Energy crops

To determine the potential of selected energy crops, the yield potential of these crops related to the site value, preferably to the BPEJ or HPKJ, must be known.

Energy crops used in the model include fast-growing trees, reed canary grass, miscanthus, rescue grass, tall oat-grass, sorrel hybrid, and cocksfoot. Basic site specification that gives expected yields in the HPKJ system was created for these energy crops. For computer analysis, these expected energy crop yields were entered into a database and assigned to each BPEJ unit, therefore creating the field layer for the GIS model, i.e., energy crop yields. In the next step energy crop potential can then be done by filtering through the yield layers with the suitable soil types. Figure 9.6 demonstrates yields of hybrid sorel in NUTS3—Central Bohemian region.

In the model, the variant using 10% of Czech agriculture lands that included mainly soils with the lowest production potential for cereal grains and other conventional agricultural crops, was selected. Here, the tabular yields are the lowest because we are dealing with permanent grassland areas.

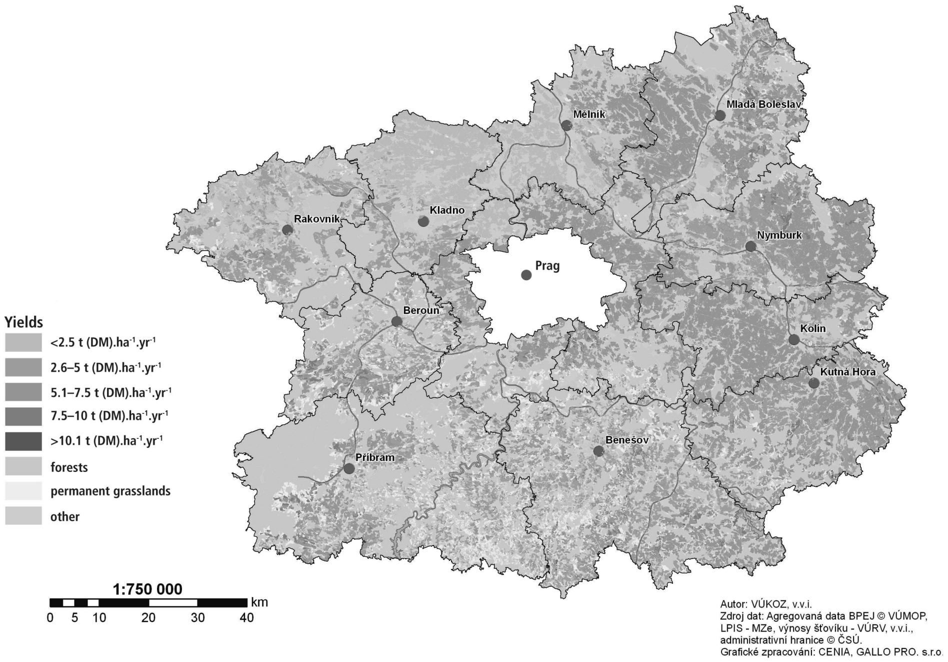

Fig. 9.8: Yield map of hybrid sorel—NUTS3, Central Bohemian region

Discussion and conclusions

Global use of modern biomass energy is in its infancy, especially in the transportation sector. Recently, various aspects of the production and use of bioenergy, especially so-called first-generation biofuels, have been criticized and debated in the scientific and non-scientific literature (Henke et al., 2005; Patzek et al., 2005; Moore, 2008; Rabbinge, 2008a). Food commodity prices increased sharply between 2004 and the summer of 2008, and many analysts and commentators pinpoint the market development of biofuels as one of the main causes (BBC, 2007; Wroughton, 2008), a key factor allegedly being the subsidized production of biofuels in the European Union and the United States (Monbiot, 2005).

Of the currently available options, many consider bioenergy to be important, because of its substantial growth potential (OECD/IEA, 2008a; OECD/IEA 2008b). In contrast with fossil fuels, use of biomass for energy (i.e., bioenergy) has the potential to reduce GHG emissions, but only if the biomass is sustainably produced (Dornburg et al., 2008b). It is a versatile energy source, it can be used to produce heat and power as well as solid, liquid and gaseous fuels. Due to rising prices of fossil fuels and decreasing production costs of modern bioenergy carriers, the competitiveness of bioenergy has improved considerably over the past ten years.

A positive factor for future biomass production in the Czech Republic is that many of the agricultural lands are marginal, i.e., usually in less-fortunate areas (LFAs) and having a lower production potential for conventional agriculture. About 45% of agricultural lands are located in mountainous and submontainous areas with rugged, hilly terrain and harsh climate conditions where intensive agricultural production is not economically efficient. Other soils that are considered "problematic" and are unsuitable for food production because of destructive anthropogenic activities can also be used for biomass production. These have an estimated area of 54 000 ha. Water-logged floodplains not suitable for classic agriculture are another possibility for SRC biomass production.

The initial results of our work show that the proposed methodology for analysis of biomass potential can produce very detailed geographical data about the distribution and amount of different biomass sources in landscape. It can be also concluded that biomass sources can be mobilized to fulfill national goals in consumption of biofuels and to be the dominant renewable source in the Czech Republic. The decision to use biomass for energy purposes should always be preceded by an analysis of the biomass potential for the area being considered.

Thorough mapping of biomass potential can help to create a state strategy for the utilization of biomass, which the Czech Republic, in comparison to other EU countries currently lacks. This thorough mapping would enable efficient decision-making not only for the investor but also for the state and regional governments when realizing projects on biomass utilization and when setting up an efficient support system. In the currently valid Czech Energy Policy, biomass is considered a decisive, dominant renewable energy source. Various barriers hinder the current development of biomass, especially the absence of a reliable databases and maps of biomass potential of individual biomass forms. Solving these issues would enable the formulation of a strategy for the utilization of biomass and serve as a basis for the revision of the Czech Energy Policy and to update the subsidy system.

Acknowledgements

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PART

C

RENEWABLE ENERGY

10

Biomass use and cross-border trade in Central Europe—Recent developments and future prospects

10.1 Introduction

Among the different renewable energy sources (RES) biomass is of crucial importance for the future energy supply in Central Europe (CE), not only because it already has the highest share of all RES, but also due to its vast potentials and its possible use in all energy sectors: for sole heat and electricity or combined heat and power generation as well as for the production of transport fuels.

With regard to the 2020 RES targets (as defined in the 2009 EU Directive on the promotion of the use of energy from renewable sources (European Commission 2009a) the current structure of bioenergy use, recent developments and the availability of environmentally compatible resource potentials are of high interest. The purpose of this work is to provide insight into these aspects as well as the importance of cross-border biomass trade. The considered countries include Austria, the Czech Republic, Germany, Hungary, Poland, Slovenia and Slovakia as well as Italy and Denmark[1].

The paper is organized as follows: Section 10.2 gives insight into the current contribution of biomass to the energy supply in CE. In section 10.3 the structure of biomass use and recent developments are analyzed. The topic of section 10.4 is cross-border trade of biomass resources and section 10.5 deals with resource potentials and prospects for a further increase of bioenergy use. The last section provides a summary and conclusions.

[1] These countries are referred to as "CE countries" in this work, even though Italy and Denmark are usually not considered to be part of Central Europe.

10.2
The contribution of biomass to the energy supply in central Europe

Despite that the considered countries are geographically close, the structures of their gross inland energy consumption (GIC) are quite inhomogeneous (Fig. 10.1). On average fossil fuels (petroleum (gasoline and diesel), natural gas, lignite and hard coal) account for 85% of total energy sources used, with Slovenia being least dependent on fossil fuels (70%). The share of hard coal and lignite ranges from less than 10% (Italy) to more than 50% (Poland) and the contribution of petroleum from 21% (Slovakia) to 44% (Italy). The share of natural gas is especially high in Hungary's gross inland consumption (40%) and relatively low in Poland and Slovenia (about 12.5%). In the Slovak Republic nuclear energy accounts for as much as 25%; in Austria, Denmark, Italy and Poland there are no nuclear power plants in operation.

Fig. 10.1 also shows that there are significant differences between the countries with regard to energy consumption per capita. In Hungary and Poland it is about 110 GJ/a, whereas in the Czech Republic it is more than 185 GJ/a and in Austria and Germany about 170 GJ/a.

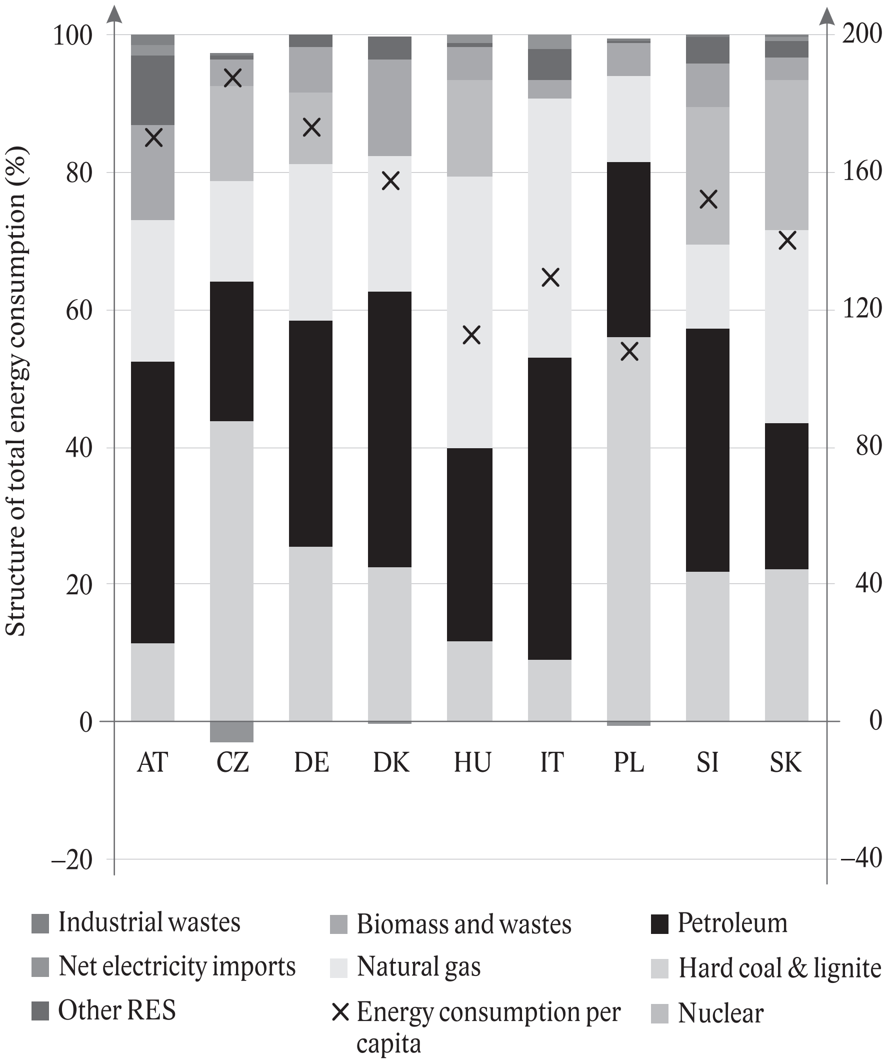
The shares of renewable energies in the total GIC of the considered countries range from 4.7% in the Czech Republic to 23.8% in Austria (2007), with biomass and wastes accounting for an average of about 70% of all renewables[2]. In the Czech Republic, Poland and Hungary biomass and wastes even account for more than 90% of the total renewable energy supply.

The share of biomass and wastes in the total gross inland consumption is illustrated on the map in Fig. 10.2. It is highest in Denmark (14.2%) and Austria (13.7%). The high contribution in Denmark is a result of ambitious energy policy measures that have led to a significant increase of biomass use in combined heat and power (CHP) and district heating plants, especially since the early 1990s.

Austria's high emphasis on biomass use is attributed to the following: First, Austria is a heavily wooded country. Almost 50% of the total Austrian area is forests, which is clearly more than in most other CE countries[3]. Second, the use of biomass for residential heating is traditionally high in Austria. Especially in the 1980s log wood boilers gained in importance due to the oil price shock and in recent years pellet boilers and other modern

[2] *The fact that non-renewable wastes are also included in "biomass and wastes" is neglected here. Especially in the field of electricity generation where the share of wastes is relatively high in most countries, it has to be noted that the fraction "biomass and wastes" is not entirely considered a renewable source of energy.*

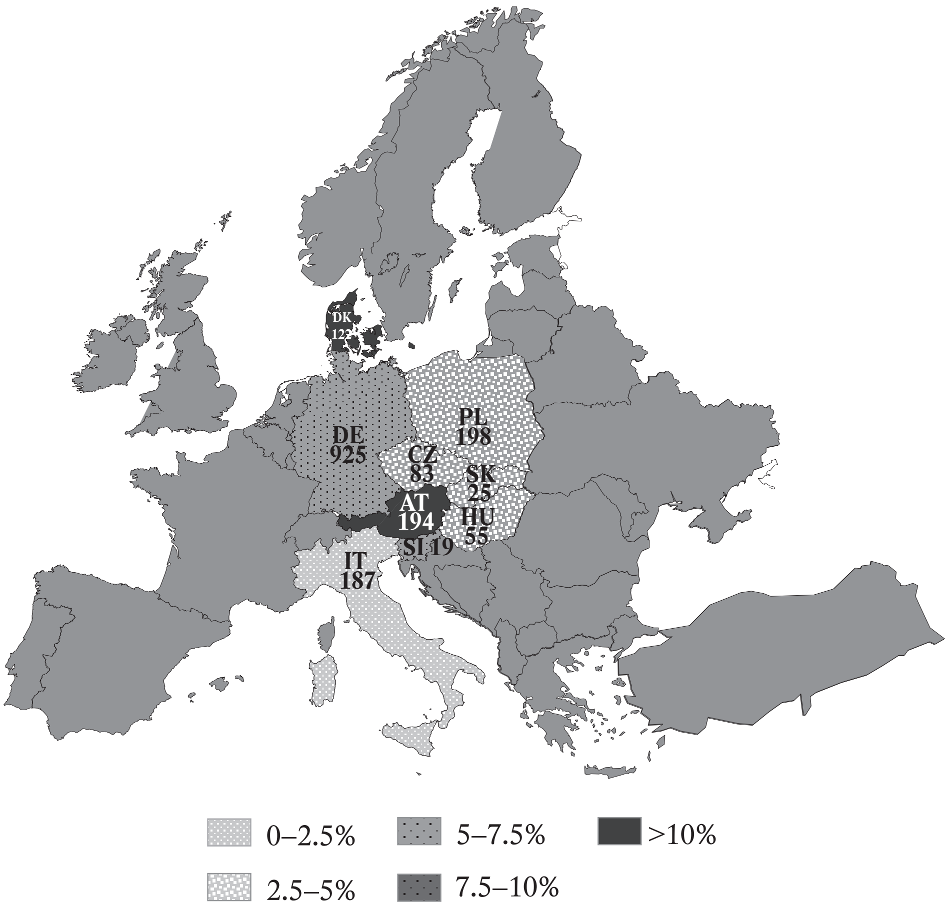
[3] *Slovenia has an even higher share of approximately 60%.*



Sources: DG TREN (2008), Eurostat (2009), own calculations

Fig. 10.1: Structure of the GIC in CE countries in 2007

biomass heating systems have become increasingly popular (partly due to attractive investment subsidies). Today more than 20% of the total residential heat demand is satisfied with biomass (Statistik Austria 2008). And third, the prominent role of the wood processing industry in Austria was crucial for the development of the Austrian bioenergy sector. The wood processing industry provides substantial amounts of wood residues for energy use, but



Source: Eurostat (2009)

Fig. 10.2: Bioenergy as share of gross inland energy consumption in 2007 (values in PJ/a)

a high proportion of their energy demand is covered with biomass. Therefore, the bioenergy share in the Austrian industry's energy consumption is also exceptionally high.

10.3
Structure of biomass use and recent developments

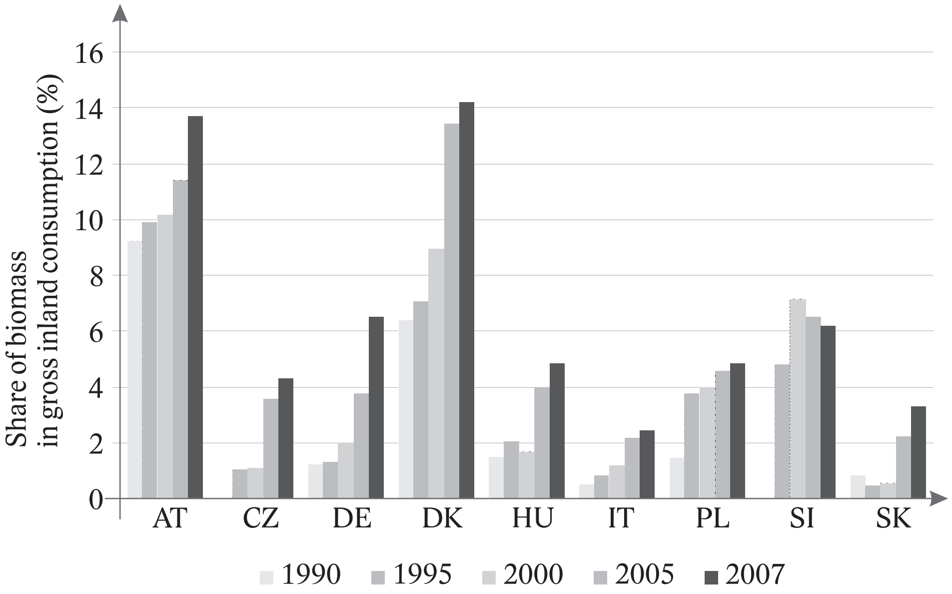
In Fig. 10.3 the historic development of the share of biomass and wastes (including renewable and non-renewable waste) in the total gross inland consumption (GIC) of CE countries is illustrated. The figure shows that in most CE countries the contribution of biomass increased significantly in recent years. The most notable developments were achieved in Germany and Denmark, but also in the Czech Republic, Hungary and Slovakia the importance of biomass for energy production has been increasing steadily, especially since the year 2000 or so. In Austria, the biomass consumption doubled from 1990 to 2007 but due to the rising total energy consumption (about 34% from 1990 to 2007), the biomass share in the GIC only showed an increase of about 50%. Apart from Denmark, Italy and Slovenia, the total energy consumption in the other CE countries declined from 1990 to 2007. In absolute numbers the biomass consumption in CE increased from about 450 PJ/a in 1990 to about 1800 PJ/a in 2007. Remarkably, the progress in Germany accounted for 55% of this increase. In 2007 about 50% of the total amount of biomass used for energy recovery in CE was consumed in Germany (see Fig. 10.4). Biomass consumption per capita is highest in Austria (about 23.3 GJ per capita and year in 2007), followed by Denmark (22.3 GJ), Germany (11.2 GJ) Slovenia (9.4 GJ).

Fig. 10.4 illustrates that the main increase of biomass use was achieved in the field of electricity and CHP generation. The share of biomass for sole heat generation, which was as high as about 80% in the 1990s has gone down to less than 50% since 2000. The main reason for the increase in electricity and CHP generation was the implementation of the EU Directive on electricity production from renewable energy sources (European Commission 2001) and the introduction of according support schemes (e. g., the German Renewable Energy Sources Act).

Among the considered countries the ratio of electricity generation from biomass and wastes to the total electricity consumption ranges from less than 1% in Slovenia to more than 10% in Denmark (2007). In Austria (6.4%), Germany (5.3%) and Hungary (4.7%) the ratio is also relatively high, whereas in the Czech Republic, Italy, Poland and Slovakia it is only about 2%. In the early 1990s only in Austria did electricity from biomass and wastes account for more than 2% of the total electricity consumption.

According to the Eurostat definition of “biomass consumption”, biofuels for transport are represented with the calorific value of the fuel (and not with the amount of biomass used to produce the fuel). Due to the relatively low conversion efficiencies (e. g., typically 55% for ethanol and 57% for biodiesel[4]; cp. AEBIOM 2007) the “actual” amount of biomass used for the production of transport fuels is clearly higher than the consumption of biofuels shown in

[4] The conversion efficiencies stated here are defined as the ratio of the energy content of the biofuel to the primary energy content of the energy crop used; by-products that can be utilized for energy recovery or material uses have not been taken into account in the calculation.



Source: Eurostat (2009)

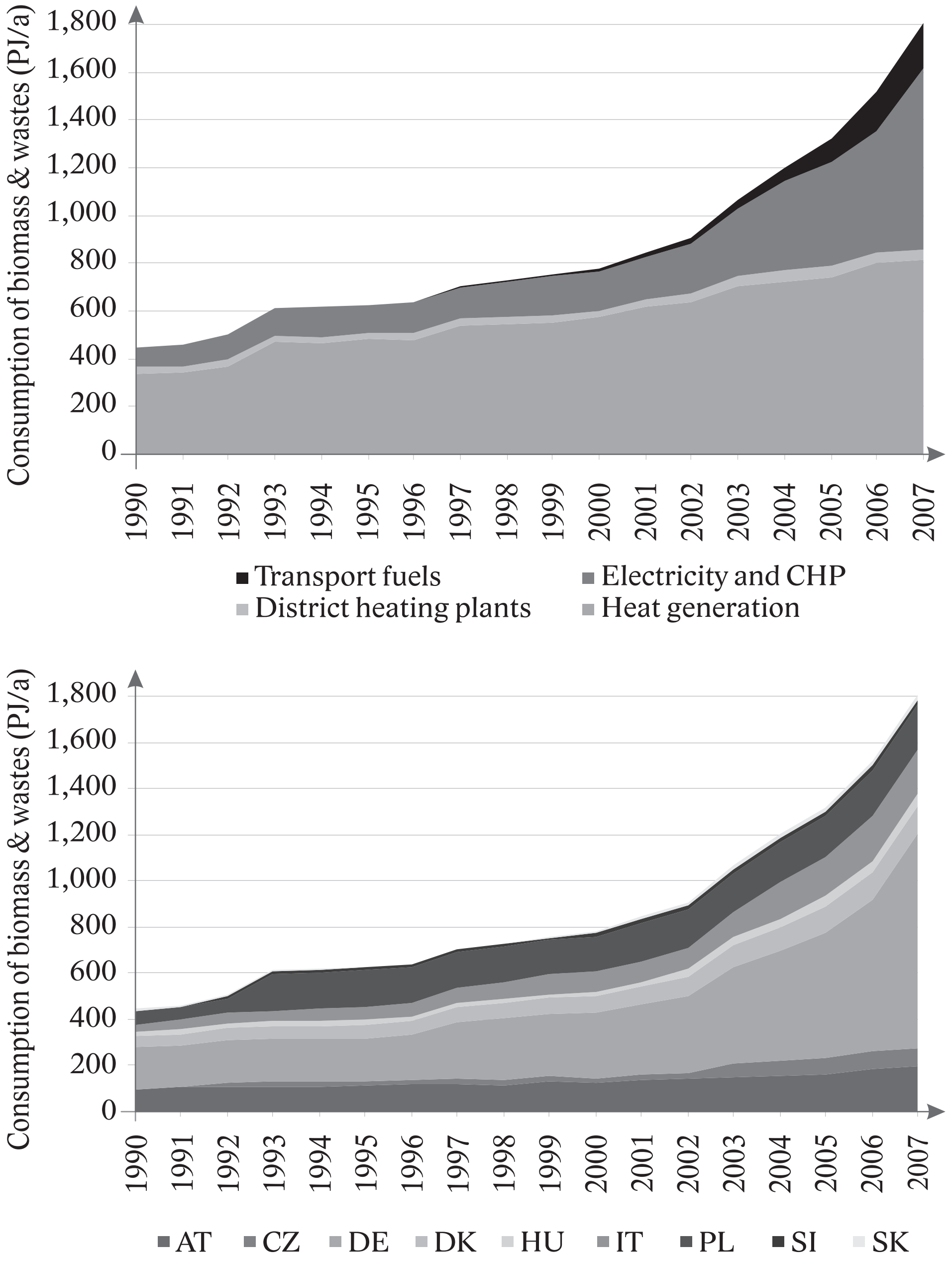
Fig. 10.3: Development of bioenergy as share of GIC from 1990 to 2007

Fig. 10.4. This needs to be taken into account when comparing statistical data from Eurostat with data on biomass resource potentials (see section 10.5).

The main progress in the use of biomass for transport started in 2003, primarily as a consequence of the "Biofuel Directive" (European Commission 2003). According to the directive, EU Member States are required to establish national targets on the proportion of liquid biofuels for transport. The following reference values for national targets are stated in this directive: 2% by the end of 2005 and 5.75% by the end of 2010, calculated on the basis of energy values.

Progress in the considered countries as well as the national target values are illustrated in Fig. 10.5. It should be noted that especially for Austria and Slovakia, data according to Eurostat (2009) are highly inconsistent with data reported in the national progress reports (European Commission 2008 and 2009b), represented by error bars in Fig. 10.5.[5] However, progress was very uneven among CE countries. Germany is the European leader in the field of biofuels. It had already surpassed its 2010 target of 6.25% in 2006. Based on the national progress reports, Austria had the second highest share of biofuels for transport in 2007 (about 4.23%), followed by Slovakia (2.53%). In the

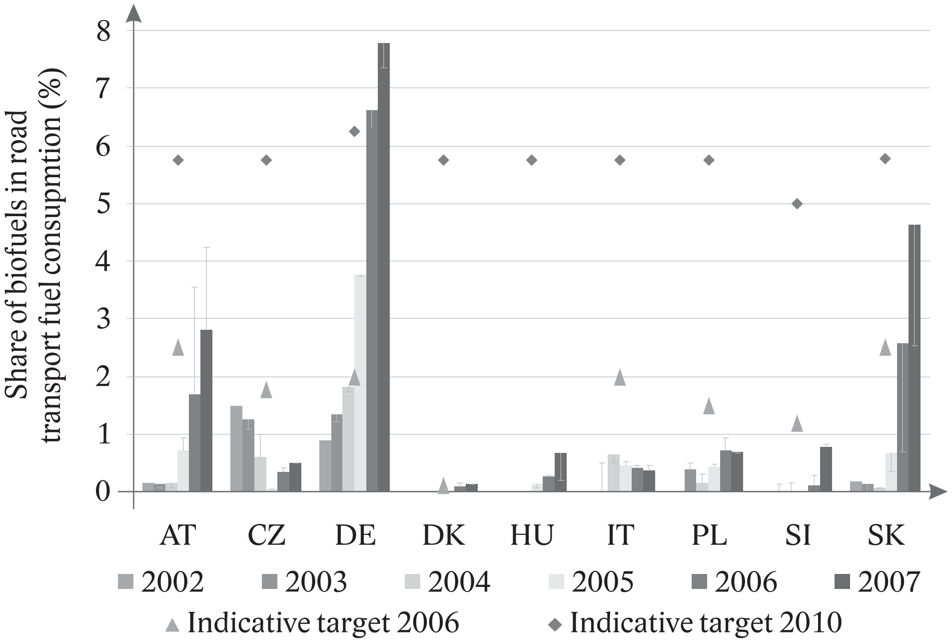
[5] *It is assumed that the consumption of liquid biofuels for transport is not sufficiently captured in Eurostat statistics in some countries.*



Source: Eurostat (2009)

Fig. 10.4: Biomass consumption in CE countries from 1990 to 2007 broken down by application and country

other CE countries progress was clearly slower. The following proportions of biofuels were achieved in 2007: approximately 0.5% in the Czech Republic, 0.46% in Italy, 0.68% in Poland, 0.83% in Slovenia and less than 0.2% in Hungary.



Sources: Eurostat 2009 (shares in 2002 to 2007), European Commission 2008 and 2009b (national indicative targets and error bars representing biofuel shares according to national progress reports), own calculations

Fig. 10.5: The share of biofuels for transport in CE countries in recent years and national indicative target values in the context of Directive COM 2003/30/EC

Fig. 10.6 shows the historic development of biodiesel and bioethanol production in CE countries. Germany is the major producer of both biodiesel and bioethanol among the considered countries. The German biodiesel production accounted for about 50% of the total production in the EU from 2002 to 2007. From 2007 to 2008 the production in Germany remained almost constant and its share in the total production in the EU declined to about 35%.

The capacity of biofuel production plants that have been installed since 2007 is substantial: From 2007 to mid-2009, the growth of biodiesel production capacities accounted for about 150% in the countries considered here (3.8

Million tons (Mt) in 2007 and 9.4 Mt in the second half of 2008 according to EBB 2009). The capacity of bioethanol plants installed in CE also increased significantly: in mid-2009 capacity was 2.39 Million tons, compared to 1.54 Mt in mid-2008 and a production of 570,000 tons in 2007 (EBIO 2009). More than 50% of the bioethanol capacities installed during 2008 and the first half of 2009 were constructed in Poland (440 Mt).

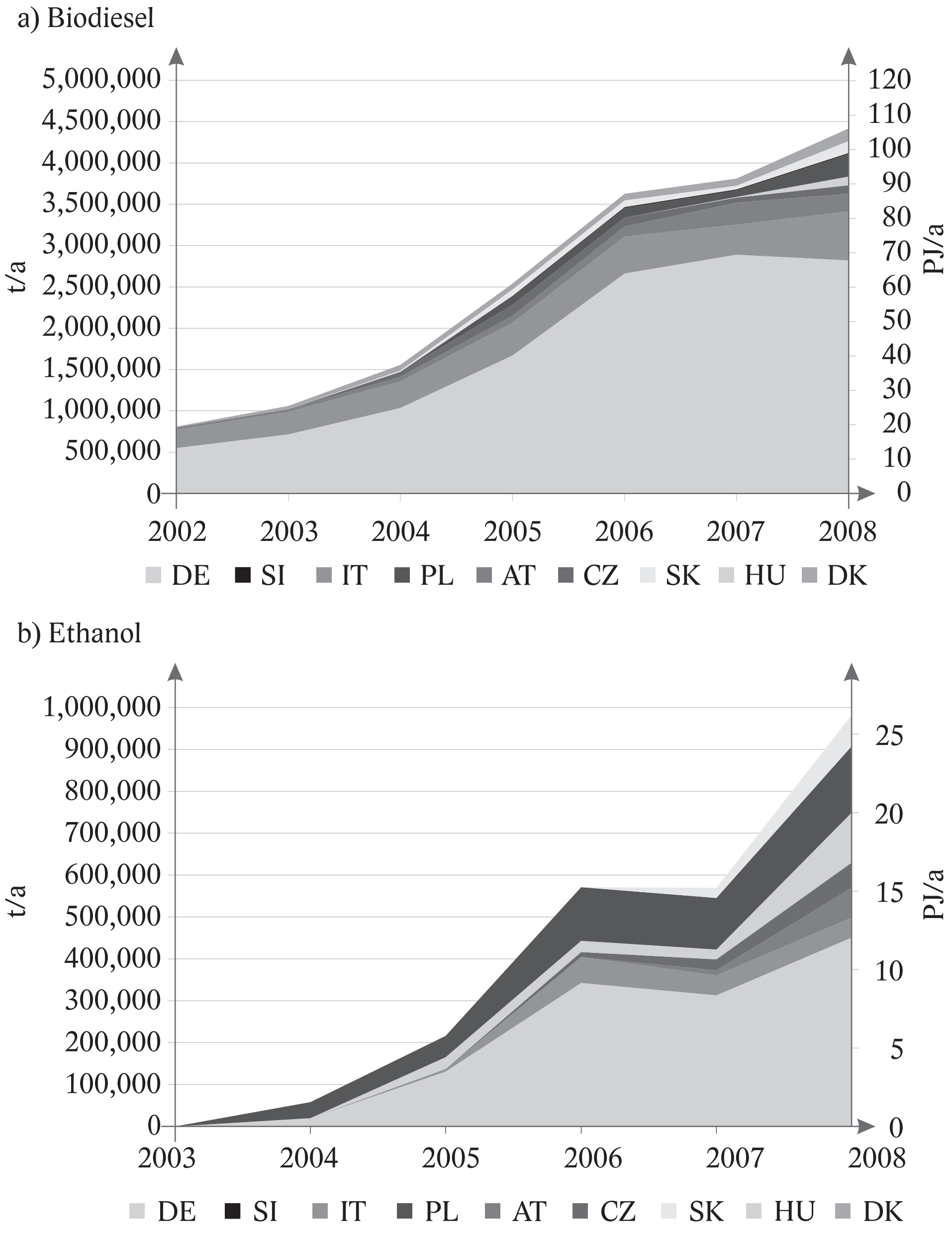
At full capacity, biodiesel and bioethanol plants installed in CE in mid-2009 could produce as much as 7.53% of the total fuel consumption in road transport in 2007. Therefore the 5.75% target for 2010 could theoretically be easily achieved in CE. However, actual production figures can be expected clearly lower, primarily because the German biodiesel industry is facing severe problems and numerous production plants are out of operation (partly due to the suspension of tax exemption for biodiesel). According to Resch et al. (2008), throughout the EU-27 the indicative target is very unlikely to be achieved.

Biodiesel self-sufficiency, however, decreased from 108% in 2005 to 79% in 2007. Bioethanol self-sufficiency increased from 67% to 84% during the same period[6]. Hence, the consumption in the EU-27 as well as in CE clearly exceeded the production in 2007. Furthermore, the increasing production of liquid biofuels had a significant impact on cross-border trade, especially with regard to oilseeds and plant oil (see section 10.5). According to the European Commission (2009b) the "biofuel self-sufficiency" (ratio of production to consumption of biofuels for transportation) of the EU-27 decreased from 109% in 2005 to 73% in 2007.

The most common instruments to promote biofuels in the transport sector are tax relief measures and obligations to blend. According to the European Commission (2009b) in 2005 and 2006 all CE countries used tax exemptions as the main support measure. In Austria and Slovakia there were also obligations to blend. Since 2007 obligations to blend have also been adopted in Germany, the Czech Republic, Italy and Slovenia, mostly in combination with increasing levels of taxation. For example in Germany the law on biofuels ("Biokraftstoffquotengesetz"), which came into force in January 2007 put an end to total tax exemption and established an obligation to blend (4.4% for biodiesel in diesel fuel and 1.2% for bioethanol in petrol).

As already indicated in the previous sections, in the field of transport and electricity generation EU directives resulted in notable increases in the use of bioenergy, at least in some CE countries. In the field of heat generation, no such directive was issued, and policy support was limited to diverse national or regional support schemes. These include investment subsidies (e. g., Austria,

[6] *Calculation based on production data according to EBB (2009) and EBIO (2009) and consumption data according to Eurostat (2009).*



Sources: EBB 2008; EBIO, 2008; EurObserv'ER 2008; own calculations

Fig. 10.6: Production of biodiesel (a) and bioethanol (b) in CE countries (amount in tons and net calorific value of the fuels produced)

Germany, Slovenia), tax incentives (e. g., Austria, Germany), bonuses to electricity feed-in tariffs for the utilization of waste heat from combined heat and power plants (e. g., Czech Republic, Germany), certificate systems (e. g., Italy) and soft loans (e. g., Poland, Slovenia)18. However, subsidies for biomass heat are often limited to certain conditions or applications and in general there are no systematic support schemes.

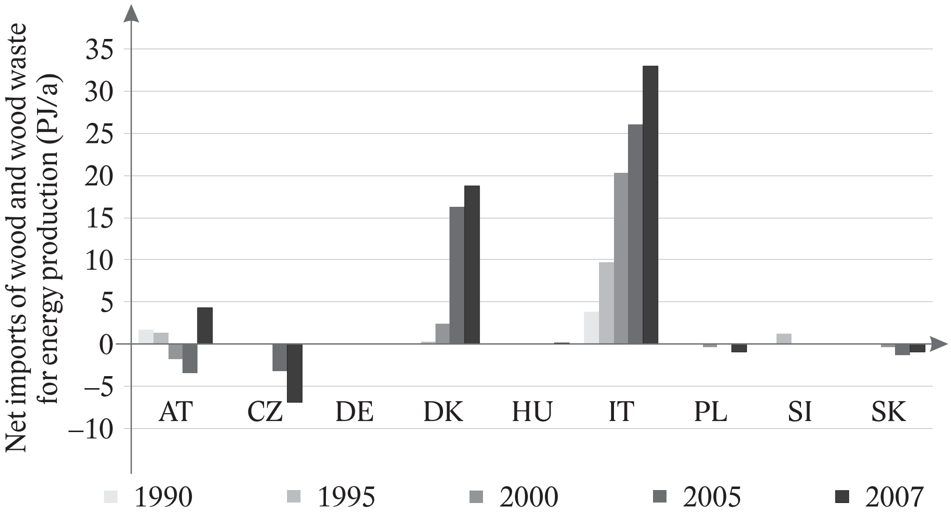
10.4 Cross-border trade of biomass

As Heinimö et al. (2009) emphasize, no comprehensive statistics and summaries aggregating separate biomass trade flows are available and there are several challenges related to measuring internationally traded volumes of biomass for energy generation. Many biomass flows are traded for several applications (both material and energy purposes) or are traded for material uses and ultimately end up in energy production. Investigations of the current state of biomass trade for energy purposes are therefore not straightforward.

In this work the following approaches have been used to illustrate the current state of biomass cross-border trade in CE: First, the amount of net imports and exports of wood biomass for energy production is analyzed on the basis of production and consumption statistics. Second, cross-border trade flows of fuelwood and other wood fractions in the Central European region are illustrated. And third, the impact of increasing resource demand for biodiesel production on trade statistics of oilseeds and plant oil is exemplarily analyzed for the cases of Germany and Austria.

The difference between wood biomass[7] production and consumption (i. e., the net imports/exports) in CE countries is shown in Fig. 10.7 in absolute numbers and in Fig. 10.8 related to the consumption of the respective country. The data indicate that the net imports of Italy and Denmark have increased significantly in recent years. More than 30% of the wood biomass consumption in Italy and about 24% of the consumption in Denmark is based on imports. From 2005 to 2007 Austria has turned from net exporter to net importer, primarily as a consequence of the increasing wood demand for CHP. The Czech Republic, however, has been exporting increasing amounts of wood biomass.

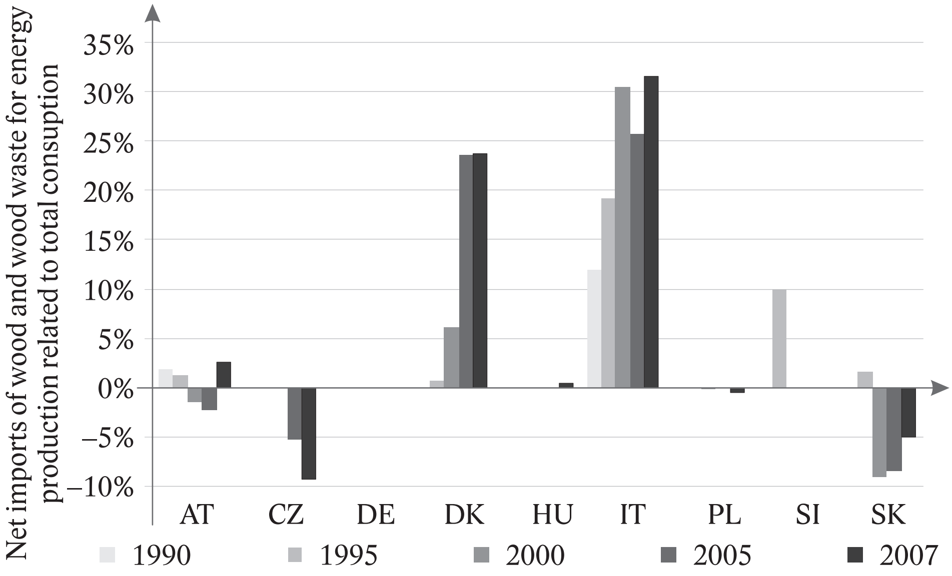
[7] *According to the Eurostat definition the fraction "wood and wood wastes" covers "a multitude of woody materials generated by industrial processes or provided directly by forestry and agriculture (firewood, wood chips, bark, sawdust, shavings, chips, black liquor, etc.) as well as wastes such as straw, rice husks, [...] and purpose-grown energy crops (poplar, willow, etc.)".*



Source: Eurostat 2009, own calculations

Note: The data for Germany indicate that there is no differentiation between production and consumption of this fraction in the German statistics

Fig. 10.7: Historic development of net imports of wood biomass for energy generation in PJ/a (based on production and consumption statistics) in CE



Source: Eurostat 2009, own calculations

Fig. 10.8: Historic development of net imports of wood biomass for energy generation as share of total wood biomass consumption in CE

In the following figures the wood biomass streams in the Central European region and neighbouring countries are analyzed in more detail and the main flows are identified. The figures are based on UN Comtrade (2009).[8] Fig. 10.9 gives an overview of all significant trade flows of fuelwood in CE in 2007.[9] Trade flows smaller than 50 TJ/a are not depicted in the figure. Unlabelled neighbouring countries do not have any relevant trade flows.

With total net imports amounting to 7.4 PJ in 2007 Italy is the main importer of fuelwood among the considered countries. However, the share of fuelwood in the total wood biomass net imports to Italy (shown in Fig. 10.7) is only slightly more than 20%. About 65% of the fuelwood imports come from CE countries. The rest is primarily imported from Croatia and Bosnia-Herzegovina. The major fuelwood streams are from the Netherlands (i. e., from overseas) to Germany and from Ukraine to Hungary. Other noteworthy fuelwood streams include Austria's imports from the Czech Republic, Slovakia and Hungary. However, the net imports to Austria accounted for less than 5% of its total fuelwood consumption in 2007.

Even though fuelwood cross-border trade among some CE countries has been increasing substantially in recent years (especially imports to Italy, increasing by close to 400% in the last ten years or so), it can be concluded that the trade volumes of fuelwood are rather moderate in relation to its utilization.

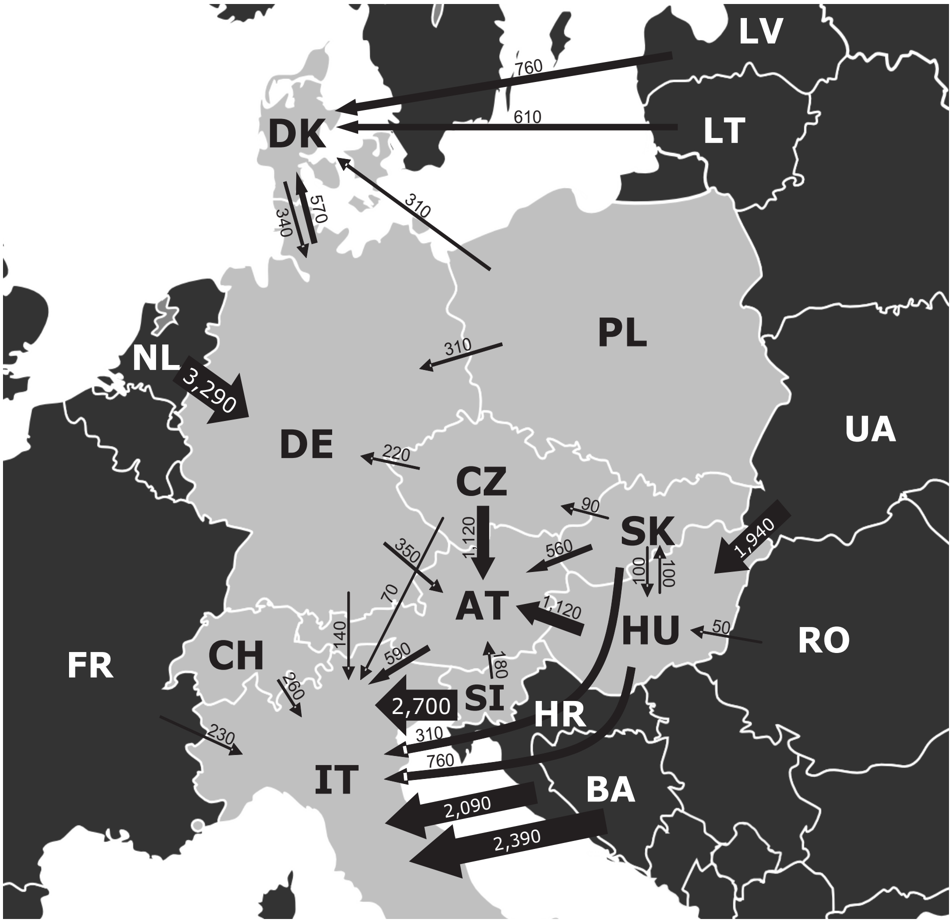
Fig. 10.10 illustrates the total cross-border trade of wood chips, sawdust, pellets etc.[11] (in the following the term "wood residues" is used for these fractions). Compared to the cross-border trade of fuelwood shown above the amounts are clearly higher. However, this category also includes wood that is used for material purposes, such as paper and pulp production.

The figure provides insight into the main wood streams in the Central European region: It is clear to see that apart from German overseas imports via the Netherlands, the main streams are Austria's imports from Germany and Austria's exports to Italy. In total Austria is the main importer of wood residues among the countries considered. This is primarily due to the high demand of the Austrian paper and pulp industry and the chip and particle board industry (which is related to substantial export volumes of wood products). Because of the highly increasing demand for low-quality wood fractions

[8] Note that there are notable uncertainties in connection with these statistics. E. g., data reported by the importing and the exporting country often differ significantly, which is partly due to different regulations concerning the notification of imports and exports and partly due to the methodology of data collection.

[9] "Fuelwood" in this context is a subgroup of wood biomass and includes "wood in logs, in billets, in twigs, in faggots or in similar forms" (CN Code 44 01 10 according to the European Commission Regulation (EC) No 1214/2007 19) exclusively used for energy purposes.

[11] Wood in chips or particles; sawdust and wood waste and scrap, whether or not agglomerated in logs, briquettes, pellets or similar forms (CN Codes 4401 10 00, 4401 21 00, 4401 22 00 and 4401 30).



Source: UN Comtrade, 2009, own calculations and illustration

Fig. 10.9: Cross-border trade of fuelwood in Central Europe in 2007 (in TJ/a; flows smaller than 50 TJ/a are not depicted)[10]

for both energy production and material uses in recent years, these industries have been importing increasing amounts of wood residues. From 1996 to 2007 the total cross-border trade of wood residues to Austria increased from about 850,000 tons to 1.9 Mt.

Austria's net imports in 2007 accounted for about 5% of the total consumption of wood residues for both energy and material uses. However, clearly larger volumes are imported indirectly as residue of industrial roundwood. If the amount of industrial residues originating from the processing of imported roundwood is taken into account, the share of imports in the total consumption of wood residues amounts to about 20%. Of the total consumption of wood residues (including forest wood chips, sawdust and other industrial residues) more than 50% were used for energy recovery in Austria in 2006.

A general increase in cross-border trade volumes of oilseeds could also be observed in Central Europe in recent years. In 1996, the net exporting countries for rapeseed[12] (including for non-energetic use) were the Czech Republic (140,000 tons), Hungary (118,000 t), Slovakia (50,000 t), Austria (30,000 t) and Italy (1,000 t). With net imports of 700,000 tons, Germany was the main importing country (the main trade partner was France) and Poland also had substantial net imports (285,000 tons, primarily coming from Germany and France). In total, the net imports of CE countries accounted for 600,000 tons (UN Comtrade, 20083).

In 2006, the total net imports to Central Europe were almost twice as high (1.14 Mio tons which equals about 30 PJ). Austria, the Czech Republic and Italy became net importers (190,000, 62,000 and 18,000 tons, respectively), whereas Poland became a net exporter (145,000 t). Germany's imports more than doubled (to 1.47 Mio t) and Hungary's and Slovakia's net exports increased by more than 100% (to 350,000 t and 110,000 t, respectively) from 1996 to 2006.

Increase of palm oil imports (from Indonesia, Malaysia, Colombia)

Estimate on import-based biofuels (Austria, Germany)

Imports of palm oil increased significantly (esp. Germany; imports/exports Netherlands—Rotterdam)

Rape seeds primarily from France, other CE and EE countries (like CZ, Hungary, Ukraine) (to Austria & Germany)

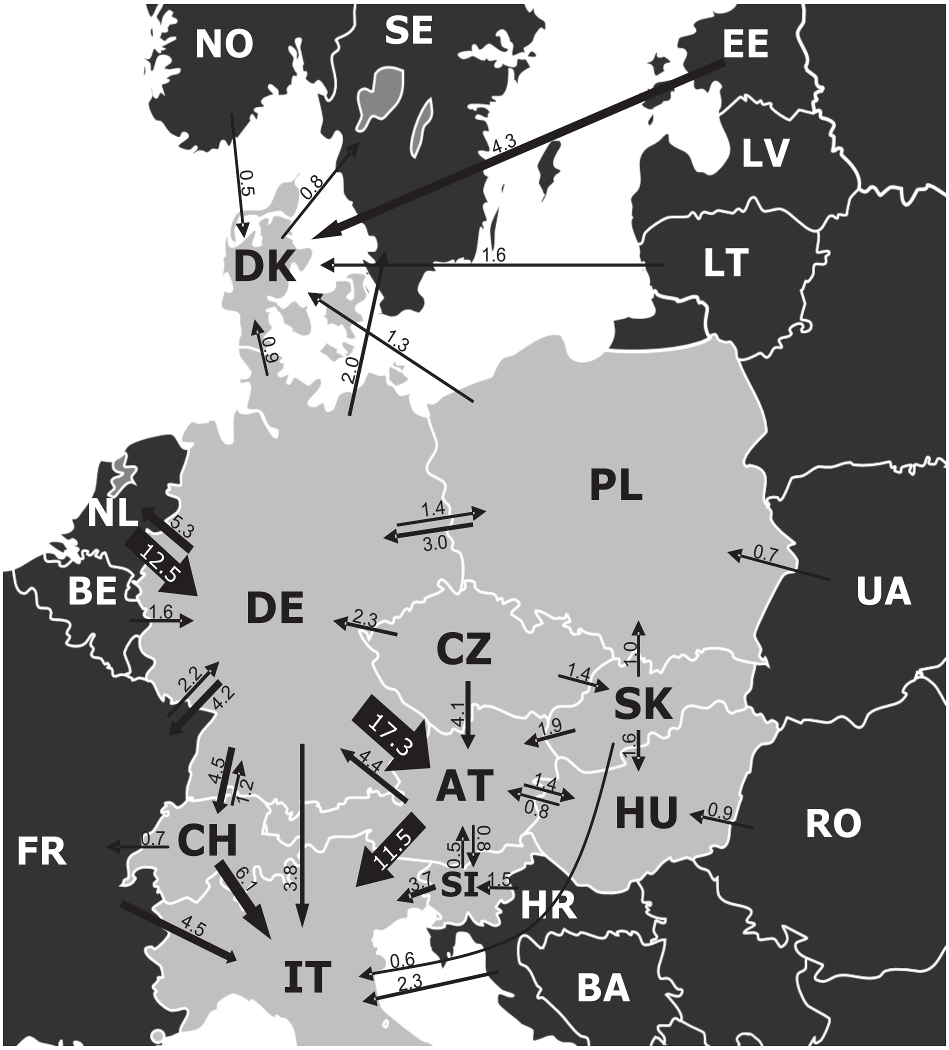
Significant increase in rapeseed production in some CE countries: PL increase from about 1 Mt in 2000 to more than 2 Mt in 2008; HU from less than 200,000 t in 2000 to about 650,000 t in 2008, also SK, DK;

Total increase of rapeseed production in considered countries about 4 Mt (in PJ, 43% of biodiesel production in CE countries in 2007 (EBB) could be produced with this amount)

Other oilseeds (sunflower, soja bean oil) neglected here/negligible—rapeseed accounts for approximately 80% of total oilseed production in CE.

Austria is also a main importer of biofuels. Biodiesel net imports accounted for 1.17 PJ in 2005 and 2.6 PJ in 2006 (Eurostat, 20092). This was more than 70% of the total biofuel consumption in Austria in these years. The main exporter of biodiesel is the Czech Republic. In 2006 the net exports accounted for approximately 3.3 PJ. Since April 2008, there is an obligatory

[12] *"Rape or colza seeds" (CN Code 1205) according to European Commission, 200718*



Source: UN Comtrade 2009, own calculations and illustration

Fig. 10.10: Cross-border trade of wood residues (including wood chips, sawdust, briquettes, pellets etc. for energy and material purposes) in Central Europe in 2007 (in PJ/a; flows smaller than 0.5 PJ/a are not depicted)

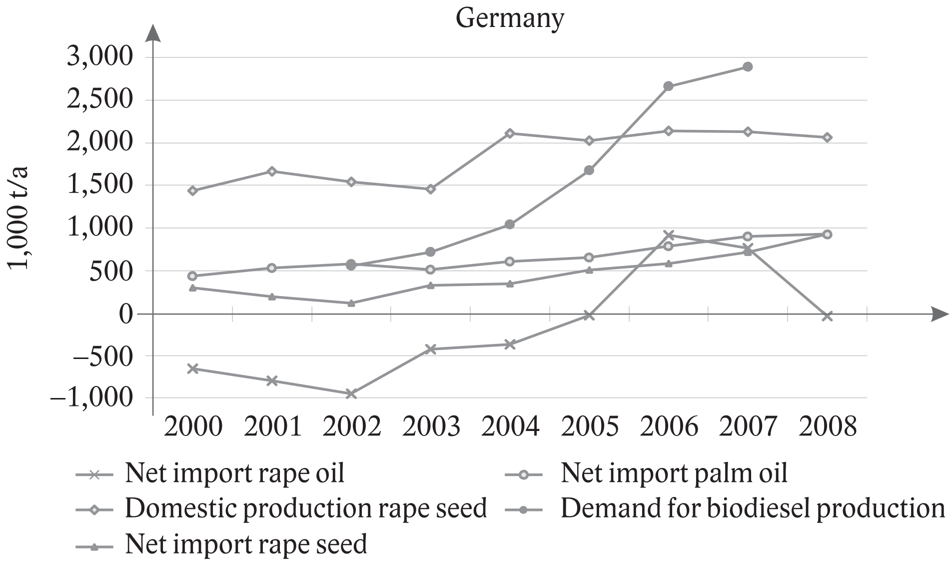


Fig. 10.11: Development of plant oil demand for biodiesel production and provision of plant oil in Germany (rape seed production and import converted to equivalent amount of plant oil)

quota for biofuels in the Czech Republic, so exports can be expected to decline significantly. For Germany no data on biofuel imports are available.

Concerning bioethanol, the available data indicate that only minor amounts were traded in Central Europe up to 2006. Cross-border trade of crops for bioethanol production have not been considered due to the minor amounts and the fact that there is no differentiation between energy and food or feed crops in statistics.

An increasingly important reason for uncertainty regarding biofuel trade is the growing amount of biofuels traded as blended fuels. These amounts are not yet properly covered by official statistics although their share strongly increased in the years after 2006.

10.5 Potentials and prospects

Assessments of biomass potentials are numerous and the results vary widely (see Rettenmaier et al., 2008, for example). Basically, there are different concepts of potentials (like theoretical, technical or environmentally compatible potentials). Usually potentials in literature are qualified according to these

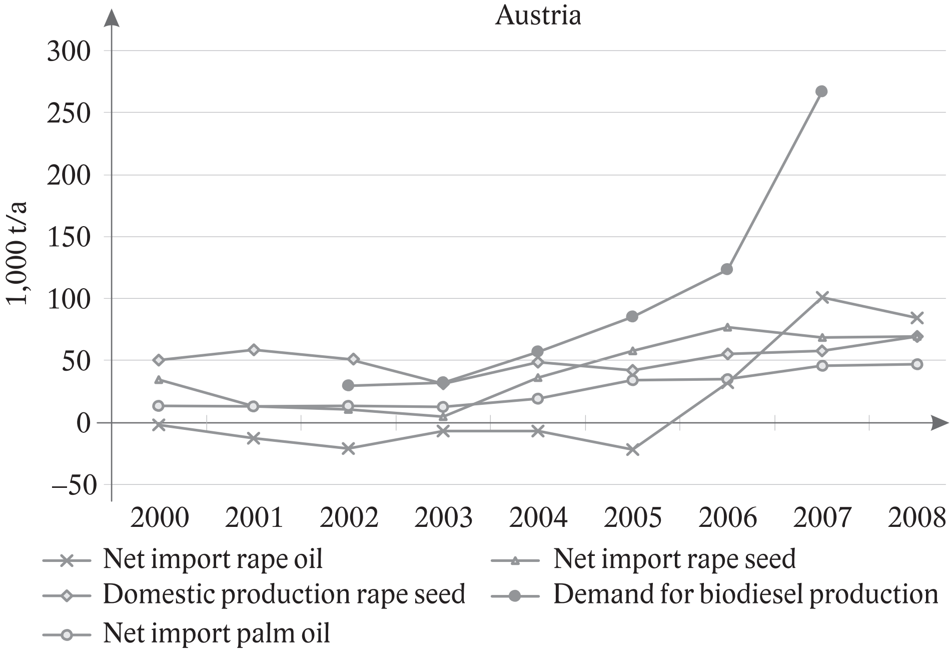


Fig. 10.12: Development of plant oil demand for biodiesel production and provision of plant oil in Austria (rape seed production and import converted to equivalent amount of plant oil)

definitions. Yet methodological approaches, assumptions and constraints of potential assessments differ from study to study, and therefore results are often not directly comparable.

In EEA (2006) a uniform methodology is applied for all EU countries, and all biomass fractions are considered. In the following figures the results of this study, which are defined as environmentally compatible biomass potentials, are compared with the current utilization in CE countries. The current biomass use (the reference year is 2007) shown in these figures do not exactly comply with the consumption according to the Eurostat definition for the following reasons: First, non-renewable municipal solid wastes are not included. And second, transport fuels and biogas are not represented with the calorific value of the fuel but with the calorific value of the biomass required to produce the fuel, to allow for a direct comparison with potentials. The following average conversion efficiencies were assumed: 55% for ethanol, 57% for biodiesel and 70% for biogas production (cp. [13]). In the following, the resulting biomass use is referred to as “actual primary biomass consumption”.

Fig. 10.13 shows the comparison of the actual primary biomass consumption in CE countries in 2007 with the resource potentials according to EEA (2006). Apparently, the current use in Austria and Germany is already quite close to the environmentally compatible potential for 2010, whereas there are vast unused resource potentials in Italy and especially Poland. It is generally assumed that the potential of energy crops increases significantly from 2010 to 2030 (which is basically a result of the underlying model for the agricultural sector and assumptions concerning the development of yields). This is especially relevant for Germany, Poland and Hungary.

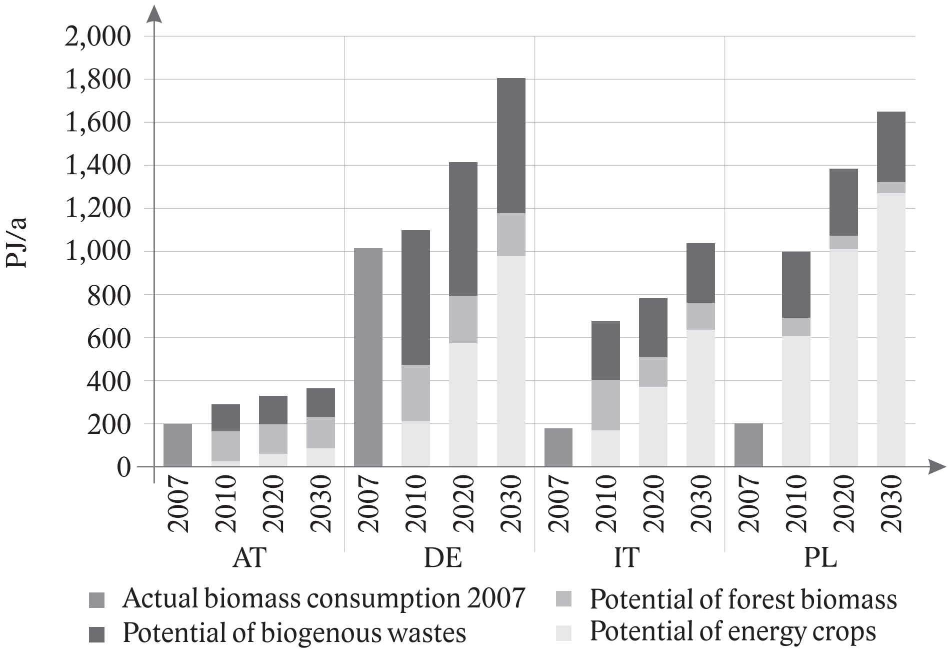
Regarding the other CE countries it is concluded that apart from Denmark, all countries shown in this figure have considerable unused potentials available. The current use in Denmark accounts for virtually 100% of the domestic potential. In fact a large proportion of this is based on imported fuels (as discussed in section 10.4). Thus, based on these data it is assumed that about 20 PJ of Denmark's environmentally compatible biomass potential remained unused in 2007.

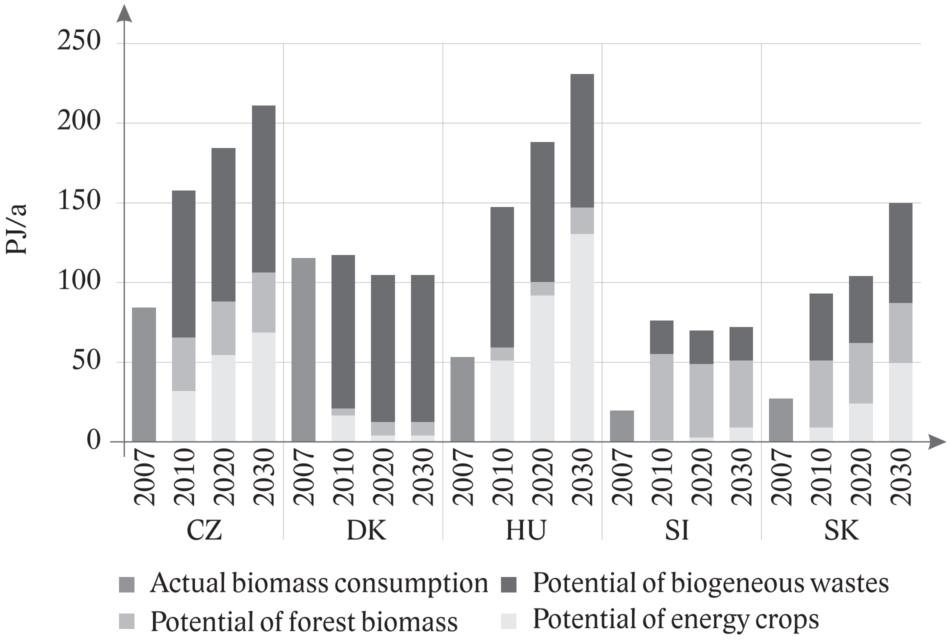
Conclusions

Bioenergy is currently the most important source of renewable energy in CE. Its contribution to the energy supply (gross inland energy consumption) in CE countries ranges from 2.4% in Italy to 14.2% in Denmark (2007).

European directives and corresponding national support schemes have already led to significant progress in recent years. However, progress was very uneven in the considered countries. The CE countries with the highest increase of biomass as a share of the total energy consumption from 2000 to 2007 were Denmark (+5.3%), Germany (+4.5%), Austria (+3.5%) and the Czech Republic (+3.2%). In absolute numbers, Germany showed by far the highest increase in biomass production and consumption. Currently, Germany is accountable for slightly more than 50% of the total biomass consumption/production in the considered countries and therefore dominates the structure of the energetic biomass use in CE.

Even though heat generation from biomass is the oldest (and often most competitive) utilization path, EU directives as well as national support schemes have focused on the electricity and transport sector in recent years. As a result, the annual increments in the biomass use for heat generation have been relatively stable since 1990, whereas in the field of power (and combined heat and power) generation and the production of transport fuels, growth rates increased considerably after 2000. It can be assumed that as a consequence of the 2009 EU Directive on the promotion of the use of energy from renewable sources (in which national targets for the share of RES in the final energy





Sources: Eurostat (2009), EEA (2006), own calculations

Fig. 10.13: Comparison of actual primary biomass consumption in 2007 and biomass resource potentials in CE countries

consumption are defined), more attention will be paid to biomass use in the heat sector in the years to come.

The rapidly increasing demand for energy crops for transport fuel production has already led to considerable shifts in international trade flows (e. g., increasing imports of palm oil to Germany). As a consequence, to avoid adverse (global) effects of the enhanced use of biomass (e. g., deforestation of tropical rainforests for palm oil production), certification of sustainably produced biomass is becoming even more urgent.

A high priority should be given to the mobilization and use of domestic biomass resources (especially residues and wastes). Increasing biomass imports to countries with rapid bioenergy sector growth, and evidence of unused domestic resource potentials on the other indicate that the supply with regional biomass has not been given enough attention within energy policy strategies, according support schemes and incentives.

Results of studies on biomass resource potentials indicate that there are vast unused potentials in most CE countries. According to EEA (2006) the environmentally compatible potential in the year 2010 in the considered countries is two times higher than the current utilization (2007) and the potential in 2030 even three times higher. On a national level the situation is highly diverse: In Denmark, Germany and Austria the unused resource potential is relatively small, whereas countries like Poland, Italy and Slovakia currently only use a small proportion of their environmentally compatible biomass potential.

It is assumed that to some extent the very uneven progress in biomass use (primarily resulting from diverging energy policies, support schemes and—as a consequence—diverging biomass price developments) encouraged cross-border trade between European countries. Increasing efforts in the field of bioenergy throughout all EU countries are likely to result in a further shift of trade flows towards international (long-distance) biomass trade (cp. Heinimö et al., 2009). For example, Austria is currently importing large amounts of plant oil and oilseeds (about 7.5 PJ/a in 2007) from its northern and eastern neighbouring countries. With an increasing domestic demand for energy crops in these countries, average transport distances—and costs—can be expected to increase.

The importance of bioenergy for reaching the 2020 targets (according to Directive 2009/28/EC) is stressed in simulations by Resch et al. (2009). These simulations indicate that among all RES, biomass can be expected to bring the biggest contribution to the achievement of the targets. Therefore, special attention should be given to the design of bioenergy policies. The following aspects should be considered within national biomass action plans:

Biomass can be used in all energy sectors (heat, electricity and transport) and the economic and environmental properties of the different bioenergy technologies often vary widely. Instead of promoting all utilization paths, support schemes should focus on the most efficient uses, to maximize the benefits of the bioenergy sector. For the case of Austria, a focus on heat generation and—provided that a high overall efficiency can be achieved—combined heat and power is recommended.

The structure of the available biomass potentials is quite diverse in CE countries. Especially the potential of agricultural resources (including energy crops as well as residues and wastes) is hardly tapped in some countries (especially Poland and Hungary). Specific measures for the mobilization and efficient use of locally available biomass resources should be developed and included in national biomass action plans.

Finally, it should be considered that increasing competition for biomass resources between the different types of biomass use (both for energy and material uses) can be expected with the progressing exploitation of biomass potentials. To facilitate the diffusion of the most efficient utilization paths, bioenergy policies should be designed to counteract resource competition as much as possible; both with supply-side measures and clear priorities for the most beneficial technologies and utilization paths.

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11

Prospects for renewables in the Czech Republic and Austria with special focus on biomass

11.1 Introduction

Biomass is the most important renewable energy source in mid- and longer term in the CR. The development of biomass markets is a crucial factor for future development of RES utilization. Several different barriers, however, decelerate higher utilization of RES; one of the most important is ineffectiveness in support schemes. Barriers need to be identifiedand their impacts reduced so that targets of State energy policies can be met. Identification of these barriers is an input for designing effective promotion schemes (based on analysis of current schemes) or improvement of currently existing schemes.

11.1.1 Objective of this project

The core objective of this project is to analyze the current opportunities and promotion schemes for further deployment of renewables in the Czech Republic and Austria. These countries' currently existing RES utilization promotion schemes with emphasis on electricity and biomass utilization will be reviewed. Another core objective is to identify the main barriers for biomass market development in the Czech Republic and Austria and to propose measures to eliminate them.

11.2
Development of renewable energy sources and corresponding policies in Austria

11.2.1
Background

The structure of the final energy consumption broken down by energy source and sectors is shown in Figure 11.3. “Space heating, cooling and water heating” comprises low-temperature heat generation and air conditioning in buildings, “Steam production” comprises industrial and commercial heat generation and industrial ovens industrial and commercial facilities, ranging from small bakery ovens to large blast furnaces. The fraction “stationary engines” includes the final energy consumption of all kinds of engines that are not used for mobility, ranging from small motors in household appliances to large engines in industrial production processes. Transport comprises road transport as well as rail, air and marine traffic. Further categories are “lighting and computing” and “electrochemical purposes”.

In November 2007 the parliament published a new draft amendment of the existing RES policy (“ kostromnovelle 2008”) that includes an increased annual allocated budget for RES-E support compared to the former law. The responsible authority, the “ kostromabwicklungsstelle” is obliged to purchase the electricity and pay the corresponding feed-in tariff. The level of the feed-in tariffs (FIT) will be adjusted annually by law. Because former FIT-systems stimulated significant growth especially for wind, biomass electricity and small hydro power, the new amendment is expected to further decrease the investment risk in renewable energy sources.

11.2.2
RES targets

The RES-E target to be achieved by Austria in 2010 is 78.1% of gross electricity consumption. Biofuels: National indicative targets for biofuels are: 2.5% in 2005; 4.3% in 2007 and 5.75% in 2008. With respect to 20% RES by 2020 EU target, Austria has to generate 34% of its final energy demand in 2020 using renewable energy sources.

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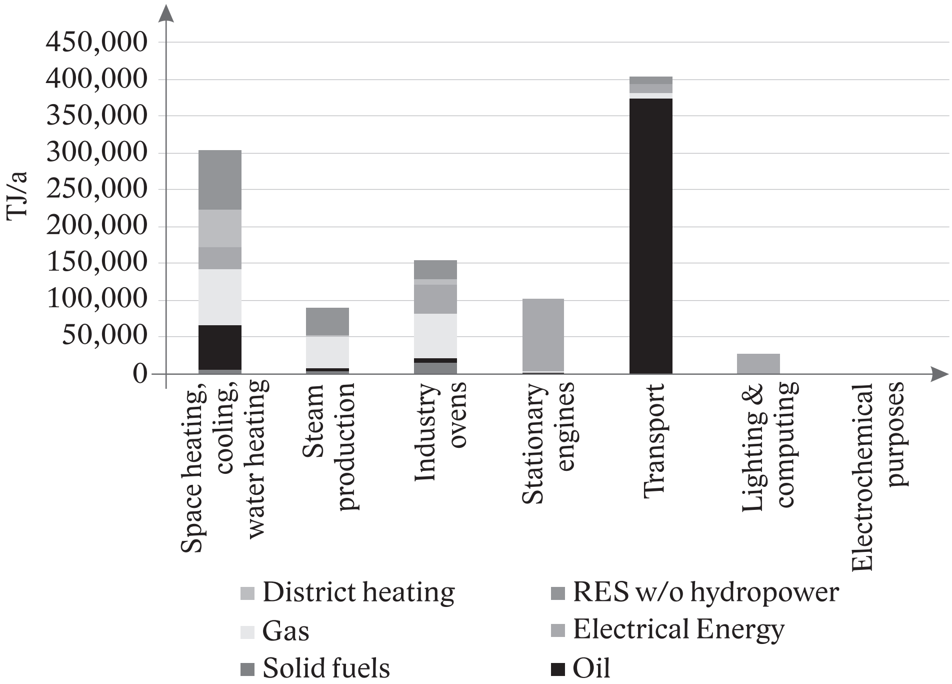


Source: Statistik Austria 2008

Fig. 11.1: Final energy consumption in Austria in the year 2006 broken down by energy sources and applications

11.2.3 Status of the renewable energy market

In general, the production of renewable energy in Austria is dominated above all by large hydropower and biomass heat production. Since favourable FIT were introduced in 2003, installed capacities of wind, biomass and biogas increased significantly, but after the new legislation passed through parliament, less favourable and partly insecure investment conditions implicated a stagnation of the RES-E development. However, a target of the new RES-E supporting scheme is to extend the capacity of hydropower and wind power each by 700 MW until 2015.

11.2.4
Current penetration of RES

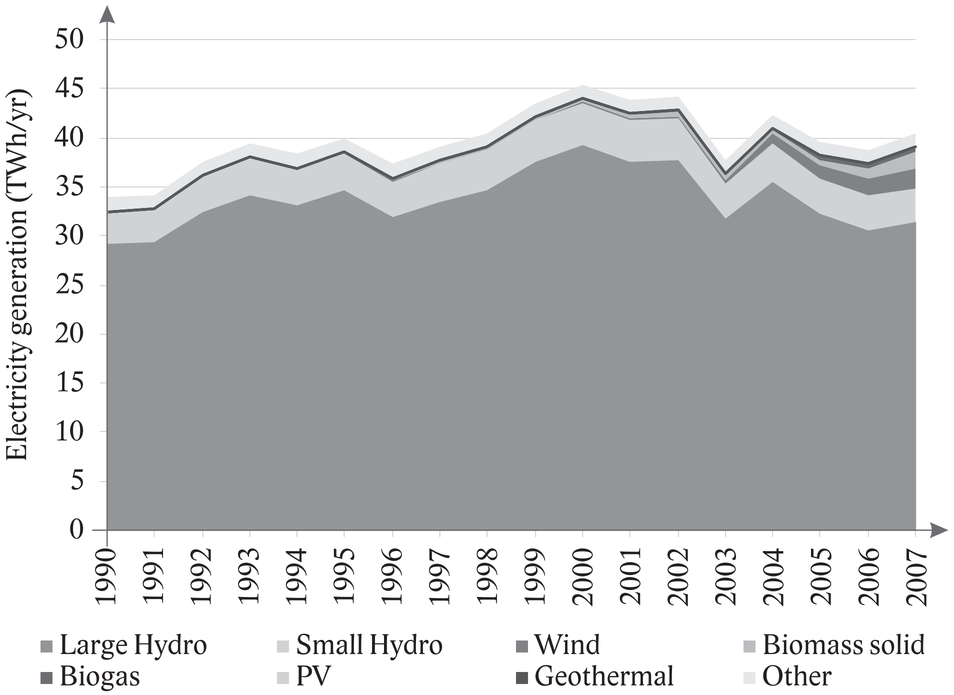
11.2.4.1
Current penetration of RES-E

Electricity production from RES grew moderately during the second half of the 1990s followed by a slight decline starting in 2001. The limited growth in relative figures has to be seen in correlation with the high overall production and share of RES-E dominated by large hydropower. Total RES-E production (compare Figure 11.2 and Figure 11.3) grew from about 34 TWh in 1990 to about 40 TWh in 2002, whereas the RES-E output in 2005 only amounted to 32 TWh. The installed **large hydro** capacity grew by only 0.6 GW during this period. The year 2005 was a very bad hydraulic year leading to a hydroelectricity production below the average, which should be considered when analyzing the 2005 figures. Similarly, in spite of an increasing **small hydro** capacity (816 MW in 1990 to 960 MW in 2003) the electricity generated from small hydro (4.0 TWh in 1990 to 3.6 TWh in 2005) diminished. In fact, the development of small hydro lagged far behind the potentials that are seen for this source in Austria—due to less financial support but also societal constraints at a regional level.

Electricity generation from **solid biomass** and **biowaste** almost doubled from 1993 to 2004 (from 984 GWh to 1,886 GWh). Most of the biomass electricity is attributed to industrial wastes especially from the paper industry. The remaining new biomass plants produced only a minor share in 2003. In this context, a broad set of new biomass installations will follow in the near future stimulated by the former favourable feed-in tariffs (which have received permission in 2004 but are not yet in operation)., Biomass plants based on industrial waste are not considered with regard to the quota in the Austrian Renewable Energy Act because they do not fall within the European definition.

Only those RES-E technologies, such as PV and wind energy where the use started basically from scratch, reached significantly higher growth rates. In the case of **wind energy** a very strong growth could be observed in the last two years as an effect of the established feed-in tariffs. The installed wind power capacity in Austria grew by 46% in 2004 and 35% in 2005, respectively. However, at the beginning of 2004 high uncertainty was caused, because temporarily no new feed-in contracts were awarded by the Austrian TSO “Verbund APG AG” for new renewable plants.

Fig. 11.4 depicts the developement of electricity consumption, electricity generation from renewables and the percentage of RES-E in total electricity consumption.



Note: Based on EUROSTAT data, national statistics, data from sector organizations and IEA data

Fig. 11.2: RES-electricity production in Austria 1990 to 2007

11.2.4.2
Current penetration of RES-Heat

The use of **biomass** is by far the most important source for RES-heat with a contribution of 2.9 Mtoe in 2005. The strong position is related to the continued and widespread use of traditional biomass-based heating. While the growth rate for biomass is low, the heat production from solar thermal heat and from geothermal heat including heat pumps increased (compare Table 11.1). The installed collector area for **solar thermal** heat generation in Austria grew from 433 thousand m^2 in 1990 to 2.66 million m^2 in 2002. Even higher growth rates were reached for **geothermal** heat.

With regard to the architecture of the energy sources, in both low- and high-temperature heat applications, a wider variety of energy sources are used more than in the other categories, where electrical energy and oil, respectively account for almost 100%. Furthermore, the share of renewable energy sources

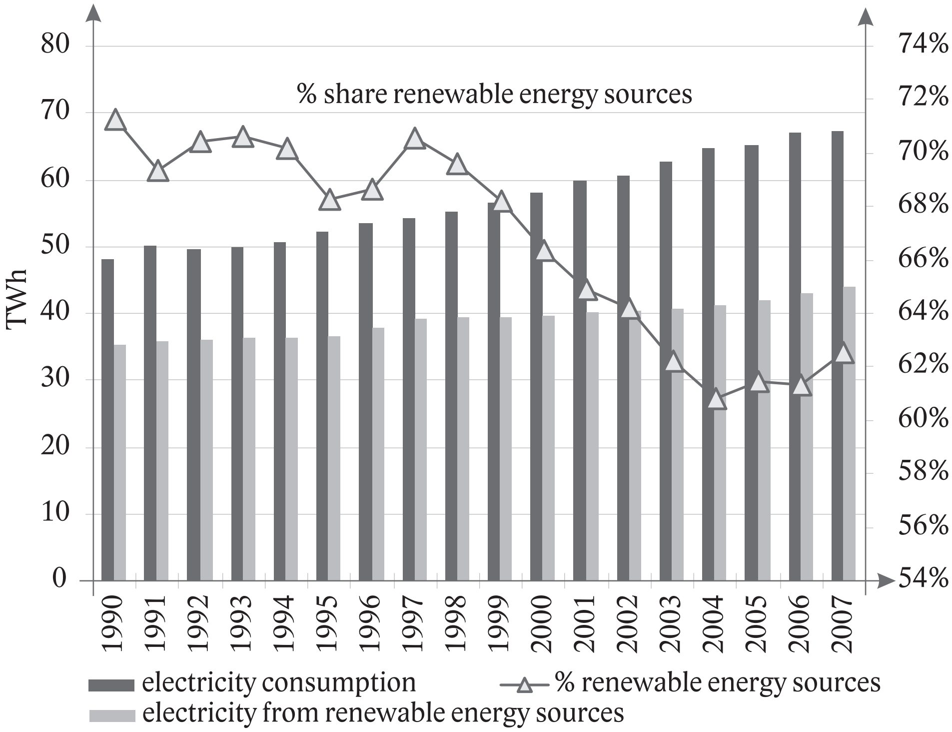


Fig. 11.3: Electricity generation from RES and total electricity consumption in Austria 1990 to 2007

RES Technology	1997 [ktoe]	2005 [ktoe]	Av. annual growth [%]
Biomass heat	2,319	2,896	3%
Solar thermal heat	48	91	10%
Geothermal heat incl. heat pumps	5	118	56%
Total	**2,372**	**3,106**	**4%**

Tab. 11.1: Production of RES-H in Austria in 1997 and 2005 in ktoe

in heat generation is already relatively high, accounting for more than one-fourth of the total energy consumption for low- and high-temperature heat generation, as Figure 11.4 illustrates. (The share of district heating and electrical energy from renewable sources—especially hydropower—is not considered here)[1]. The main contribution comes from solid biomass in its different forms (fuelwood, wood chips, pellets, wood residues etc.).

11.2.4.3
Current penetration of biofuels

Liquid biofuel use increased by an average of 24% from 1997 to 2005, reaching 76 ktoe. In light of this very moderate absolute contribution to fuel use, the growth rates could be judged as not very high.

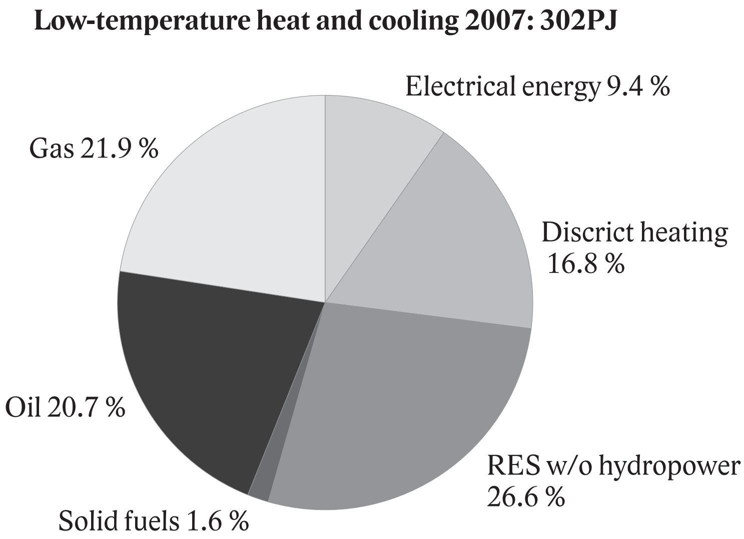
RES Technology	1997 [ktoe]	2006 [ktoe]	Av. annual growth [%]
Biodiesel	13	275	—
Bioethanol	0	0	—
Other biofuels	0	0	—
Liquid biofuels	**13**	**275**	55%

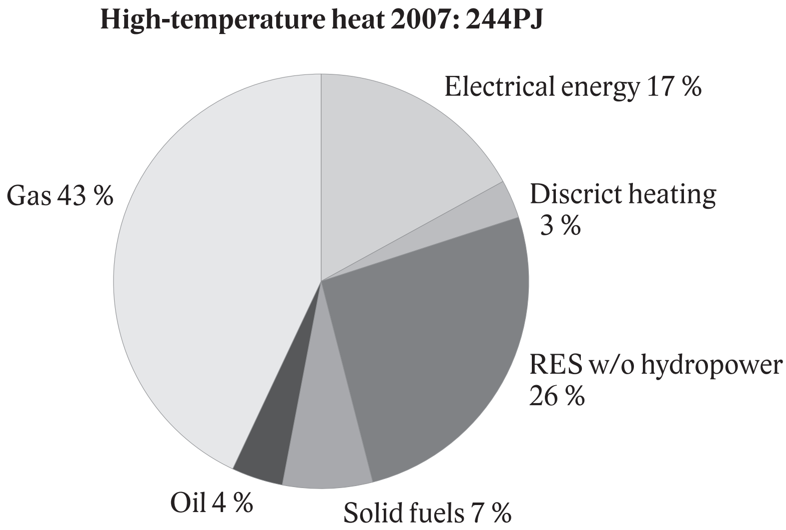
Tab. 11.2: Consumption of Biofuels in Austria in 1997 and 2006 in ktoe

11.2.5
Support schemes for RES-Electricity

Within the newly proposed legislation the total allocated budget of RES-E is restricted to 21 million Euros per year for "new RES-E" up to 2011. This yearly budget is pre-allocated in equal terms of 30% to biomass, biogas and wind, whilst for PV and other RES the remaining 10% are assigned. This yearly budget limitation was increased by 4 million Euros but still an uncertainty for RES-E producers is given. Furthermore new RES-E producers have to ask for permission, which will be given according to a "first come—first serve" principle—i.e., as long as enough budget is available in the certain year, if not the project has to be handed inagain the following year without a continuous verification of the projects. The level of FITs for all

[1] *Power generation in Austria in 2007: hydropower: 38.196 GWh (59.4%), thermal power: 23.353 GWh (36.3%), "new" renewables: 2.059 GWh (3.2%), others: 675 GWh (1.05%), Total: 64.283 GWh (100%); Share of hydropower and "new" renewables: 40.255 GWh (62.6%); Source: E-Control (2008);*





Source: Statistik Austria 2008

Fig. 11.4: Final energy consumption for low- and high-temperature heat (steam production and industry ovens) broken down by energy sources for 2007

technologies will be continued from 2006, except for wind power. The FIT for small hydro power will be continued from 2002. Entire FITs are guaranteed for only 10 years, but in individual cases the Minister of Economics might extend them to 13 years for fuel-independent technologies and 15 years for fuel-dependent technologies. For the period thereafter (until 24-year lifetime is reached) a purchase obligation to the market price (minus the costs for balancing power) is implemented.

	Duration	**2007**	**2008***
Technology	years	€/MWh	€/MWh
Small hydro	10 years, Individual cases to 13 resp. 15 years.	31.5–62.5	31.5–56.8
PV systems		300–460	299.9–459.9
Wind systems		75.5	75.4
Geothermal energy		73.0	72.9
Solid biomass and waste with large biogenic fraction**		111–156.5 63—max 50% for hybrid plants	110.9–156.4 62.9—max 50% for hybrid plants
Biogas		113–169.5	112.9–169.4
Sewage and landfill gas		40.5–59.5	40.4–59.4

** FIT calculation according to proposal of the new amendment (kostromnovelle 2008).*

*** Expressed values refer to "green" solid biomass (such as wood chips or straw). Lower tariffs in case of sawmill, bark (–25% of default) or other biogenic waste streams (–40 to –50%).*

Tab. 11.3: Feed-in tariffs in Austria 2008 (valid for new RES-E plants)

Mid-scale hydro power plants (10–20 MW) and CHP-plants receive investment support of up to 10% of the direct investment costs, maximally 400 EUR/kW. For the support of hydropower plants a total of 50 million € is available from 2006 to 2012.

11.2.6
Support schemes for RES-Heat

Promotion of solar thermal, heat pumps and biomass heating systems for residential appliances is strongly based on investment subsidies in Austria. Because these subsidies fall within the authority of the provincial governments, the support schemes vary from province to province. National policies only exist for large-scale plants (e.g., biomass district heating, commercial plants).

Within all provinces, traditionally quite substantial support schemes for residential building construction (and more recently also for renovation) exist. Since the 1950s, these schemes have represented the main promotion system for supporting the construction of new residential dwellings. Originally, no energy specific standards were required for receiving these subsidies. However, within the last years these support schemes have been adapted in several provinces, insofar as projects are now eligible only if thermal quality standards for the buildings are considered or renewable energy sources are used for heating (e.g., support is only granted in dwellings with solar thermal or biomass heating systems).

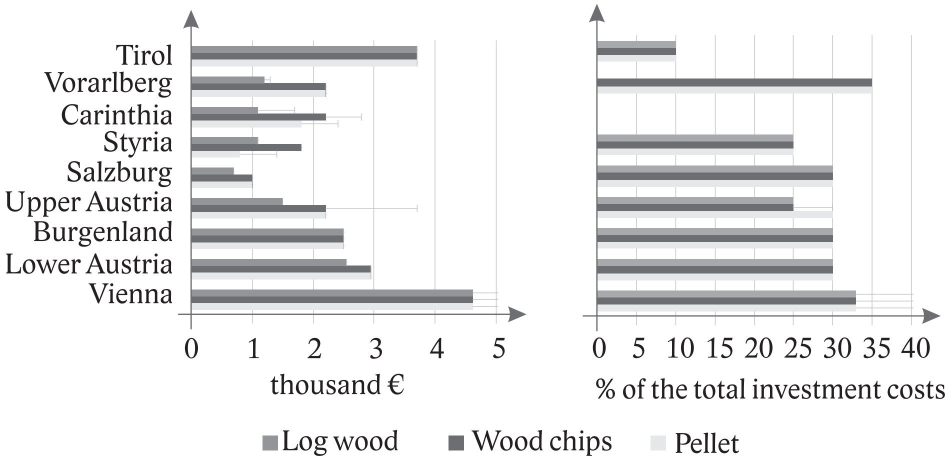
Investment subsidies for heating systems based on renewable energy sources and subsidies for residential building construction clearly represent the main support schemes for RES-H in Austria. Apart from these financial incentives, a number of awareness campaigns and training programmes have been carried out by regional energy agencies as well as the federal government (e.g., the “holz:w rme” for biomass and “solar:w rme” for solar heat within the programme “klima:aktiv”).

11.2.6.1
Subsidies for solar thermal systems

In general, the provincial subsidies started during the 1980s and developed strongly during the 1990s. Roughly speaking, the level of investment subsidies for solar thermal systems vary from 20% to 40% of investment costs (depending on the size of the installation, the type of collector and type of system, e.g., between 600€ to 1.700€ for water heaters, 1.100€ to 3.500€ for combined solar systems).

11.2.6.2
Subsidies for biomass systems

Investment subsidies for biomass heating systems are granted in every province but their amounts and conditions are diverse. In Carinthia and Vorarlberg, fixed amounts are paid out, whereas in other provinces, such as Burgenland or Styria, the subsidies account for certain proportions of the total investment costs. In some provinces there are also additional requirements and restrictions and thus, a comparison between the different support schemes is not straightforward.



Note: The investment subsidy in Vienna is between 33% and 51% of the total investment costs, depending on the emissions of the heating system. The maximum amount is 7,250 €.

Source: Haas, Havlickova, Kalt, Knapek, Kranzl, Weger 2005

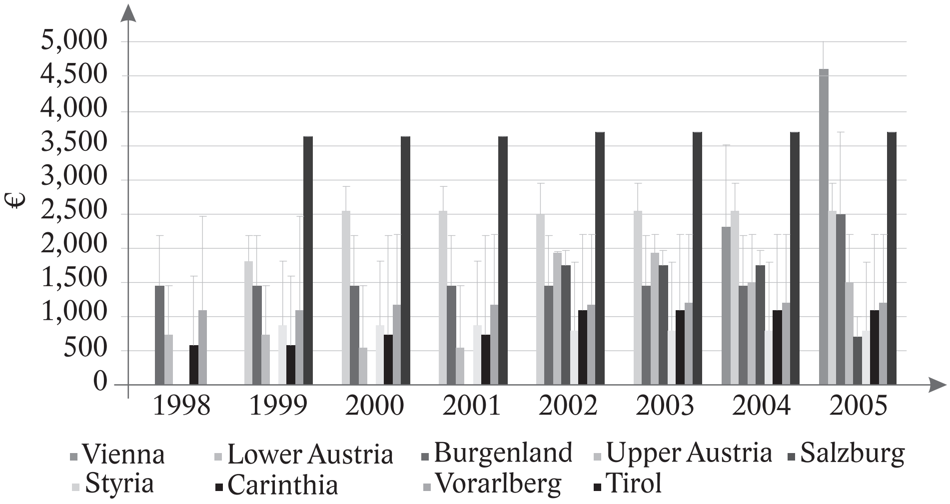
Fig. 11.5: Investment subsidies for domestic biomass heating systems in Austrian provinces in € (left) and % of the total investment costs (right).

In some regions, municipalities also grant subsidies for domestic biomass-fired heating systems and there are also support schemes for the installation of small-scale district and local heating systems in some provinces (e.g., Styria, Upper Austria, Carinthia). Biomass-fired combined heat and power systems and heating systems for agricultural purposes are subsidized both at federal and provincial level.

The following figure illustrates the dynamic development of investment subsidies for domestic biomass heating systems in Austrian provinces in recent years. In 1998, investment subsidies were granted only in Burgenland, Upper

Austria, Carinthia and Vorarlberg. There were no direct subsidies in the other provinces but the installation of new heating systems was supported by the granting of soft loans. In the following years, direct investment subsidies were introduced in all provinces and in most of them the amounts were raised significantly.

The effects of the subsidies were remarkable in the considered period. In 1998, about 1,900 wood chip and 1,300 pellet heating systems had been installed in Austria, in 2005 the number had risen to 3,900 and 8,900, respectively.



Note: The data in this illustration are representative values for investment subsidies. Due to the diversity of support schemes, the actual amounts can vary widely.

Source: Haas, Havlickova, Kalt, Knapek, Kranzl, Weger 2005

Fig. 11.6: Development of investment subsidies for domestic biomass heating systems

11.2.6.3 Subsidies for heat pumps

Investment subsidies for heat pumps range between 10%–30% of investment costs (depending on the type heat source, coefficient of performance etc). Moreover, for heat pumps several electricity utilities provide additional incentives like investment subsidies or/and reduced electricity tariffs.

11.2.6.4
Income tax allowance

Since 1979 the Austrian Income Tax Act defines energy savings measures as special expenses for which tax allowances may be reclaimed. These measures include among other things expenses for heat pumps, solar thermal systems and bioenergy systems.

Special expenses can be deducted from the net taxable income (tax base). Examples for such special expenses are expenses for voluntary insurance, convertible bonds, donations and also for building construction and renovation. This last section also includes renewable heating and DHW systems and energy efficiency measures (listed above).

There is no restriction regarding the combination of tax allowance schemes and investment subsidies. Thus, an accumulation of these schemes is possible. The tax allowance concerns the whole investment costs (i.e., material cost and installation cost of the appliance). All types of residences are eligible to the scheme.

Several parameters (e.g., taxable annual income, number of children) have an impact on the level of actual financial incentives that the tax allowance scheme induces for different types of tax-payers under various conditions. Depending on these parameters, typical tax reductions due to RES-H investment vary widely. Considering investment costs for individual RES-Heat systems in the range of about 4,000 € and 18,000 €, the share of the tax reduction on the investment costs can reach a maximum range of 4.2% and 15.4%. The estimated average is about 1% and 5%. Hence, the share of tax reduction in the investment costs in individual RES-Heat systems is quite low and thus the instrument has only a negligible impact.

11.2.7
Key factors for the further deployment of renewable energy in Austria

Formerly offered feed-in tariffs (in the “ kostromgesetz 200x”) combined with reasonable investment incentives generated important growth rates until passed legislation (“ kostromnovelle 2006”) set a lower tariff level. In particular the yearly budget restriction created high insecurity for investors in RES-E projects in 2005 and 2006. The annual tariff adjustment also might have had an impact on investor decisions. The proposed shortening of the payment duration and tariff level reduction within the proposal of the new amendment (“ kostromnovelle 2008”) may represent further obstacles for strong growth of RES-E. Appliances of rejected projects are only valid for the following

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year, afterwards the appliance expires and a new application has to be done, which is ranked behind the others, in the meantime applied projects, and are therefore served afterwards.

11.3 Development of renewable energy sources and corresponding policies in the Czech Republic

11.3.1 Background

No major changes have occurred in the support scheme for RES-E projects in the Czech Republic since the beginning of 2008. The logic of the support scheme remains the same and is based on choice between feed-in tariffs and green bonuses. Energy Regulatory Office's (ERO) notice 150/2007 Col. extended assured period of feed-in tariffs to the whole lifetime of projects (20 years, for small hydro 30 years). Support of RES-E projects within three Operational programs (EU structural funds) has started. Even though that the (economic) support scheme is set up in a consistent way and creates a stable platform for investor decision-making there still are some imperfections in it. Other significant (non-economic) barriers for the further development of RES-E projects still exist (e.g., complicated land and construction permission, negative attitude of some municipalities, lack of suitable locations, etc.), causing the development of RES-E projects to still be moderate as can be seen with the low share of power generation based on RES utilization that reached only 4.7% in the year 2007. Wind power plants are the quickest developing type of RES-E projects at the moment. In contrary, biomass that is understood as the decisive RES both for power generation and heat production, in the mid- and longer perspective is stagnating.

The currently valid State Energy Policy was approved in 2004 and defines also targets for RES both in the structure of primary energy sources used and power generated. At the end of 2007, the Czech government established a special committee led by head of Academy of Sciences Mr. Paces to submit proposals to revise the State Energy Policy. The final version of "Paces" commission proposal will be was presented at the end of November 2008. Based on currently available information this proposal highlight role of RES, but will not change dramatically expected shares of RES.

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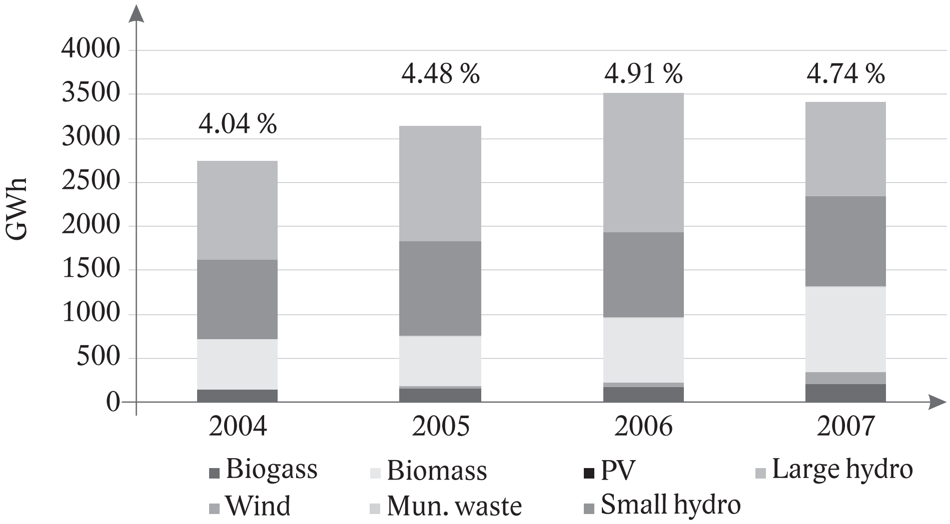
11.3.2
RES targets

The RES-E target to be achieved by the Czech Republic in 2010 is 8% of gross electricity consumption. Biofuels: National indicative targets for biofuels are: 2.5% in 2005; 4.3% in 2007 and 5.75% in 2008. With respect to 20% RES by 2020 EU target, the Czech Republic (based on currently available proposal) has to generate about 13.2% of its final energy demand in 2020 using renewable energy sources.

Progress in RES-E share on gross domestic consumption of electricity is documented in the following figure.

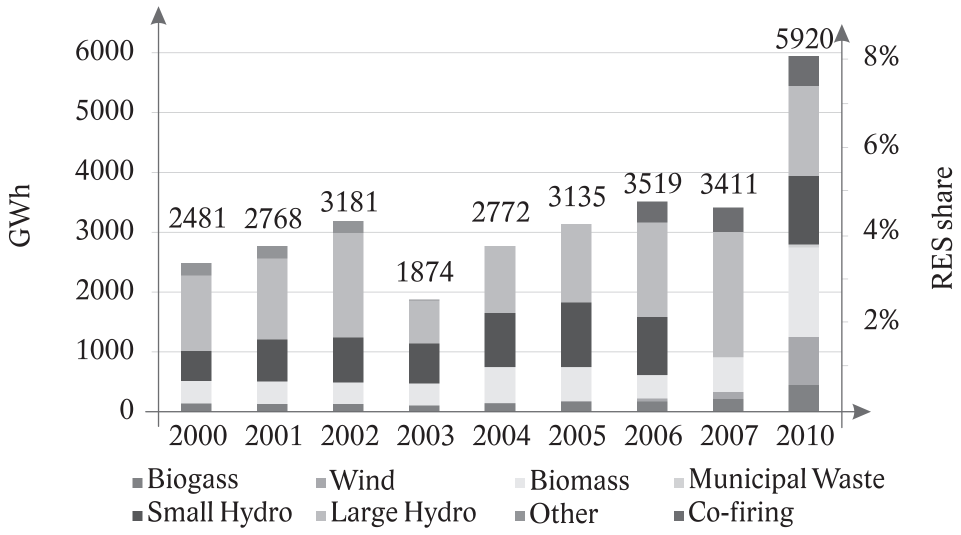


Source: MPO

Fig. 11.7: Power generation based on RES in 2004–7, Czech Republic

Development of power generation based on RES utilization from the year 2000 is documented in the next figure where assumption of power generation needed to meet national indicative target is included.

Support of power generation based on RES started in 2002 with a feed-in tariff system (similar to the current system), but only on a one-year basis (feed-in tariffs were defined by ERO price decision for a given year)—in fact these tariffs were kept on the same level until the end of 2005 (and for older plants they continued also after 2005). Systematic support started at the beginning of 2006, when investors had an assured value of feed-in tariffs for 15 years (since 2008 for 20 years). But it is obvious that definition of system



Note: Power generation in 2007 does not include small hydro in the large hydro category

Source: MPO

Fig. 11.8: Development of power generation based on RES, Czech Republic

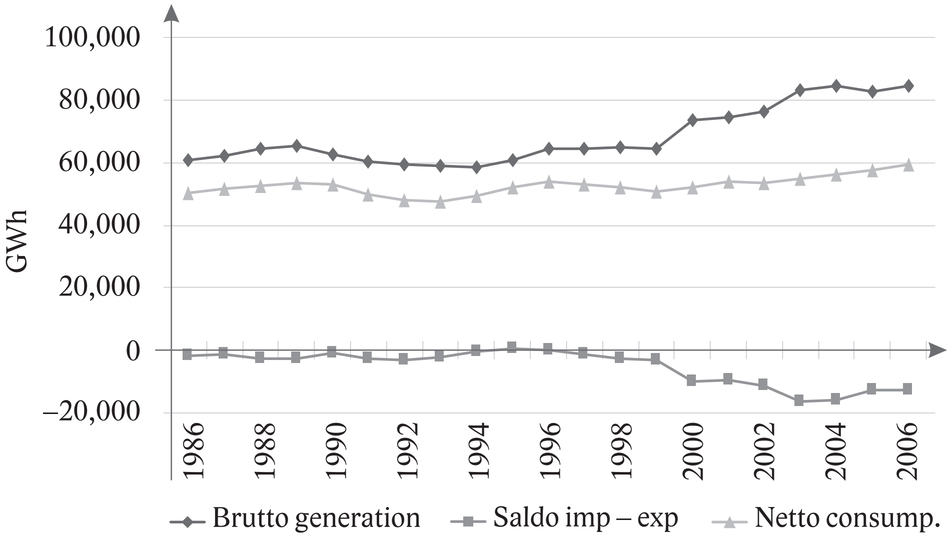
basis for RES-E projects support is not accompanied by quick development of RES-E projects.

At the moment is seems that the National indicative target to the year 2010 (8%) will not be met. Meeting the National indicative target is also, to some extent complicated by continuously increasing power consumption in the Czech Republic—see the following figure 11.9.

The average growth rate of electricity net consumption is 2.3% for 2000–06. If the year 2002[2] is excluded from the figures, the average growth rate is 2.7% in this period. Continuation of electricity net consumption is expected for the upcoming years, mainly thanks to expected growth of industry[3].

[2] *Year 2002 was the "flood" year. Extensive floods in August affected a significant part of country with negative impacts to industrial production.*

[3] *Thanks to the "financial crisis". expectation of power consumption will probably be to the some extent revised, but at the moment (official figure for 3 Q of 2008 is growth of GDP 4.8%)*



Source: ERO statistics

Fig. 11.9: Power generation and consumption in the Czech Republic

11.3.3 Status renewable energy market

Current contribution of RES used in primary energy used is documented in the following two figures 11.10 and 11.11.

Both figures documented that biomass plays a dominant role in contribution of RES to PES. RES share on installed capacity of power plants is significantly higher that their contribution to total power generation—see the next two figures. This is mainly because Czech hydro power plants (currently dominant RES-E source) have a rather lower load factor caused by lower water availability in the Czech rivers. Large hydro power stations are typically used for dynamic services.

A more detailed look at the structure power generation based on RES utilization is given in the following figure 11.13.

Stagnating biomass

Despite that biomass has the biggest potential to contribute to RES utilization (both from power generation and contribution to primary energy sources) its utilization shows only limited progress. The highest increase of biomass utilization is from household consumption as the result of relatively quick increase of energy commodities in last few years (biomass utilization increases

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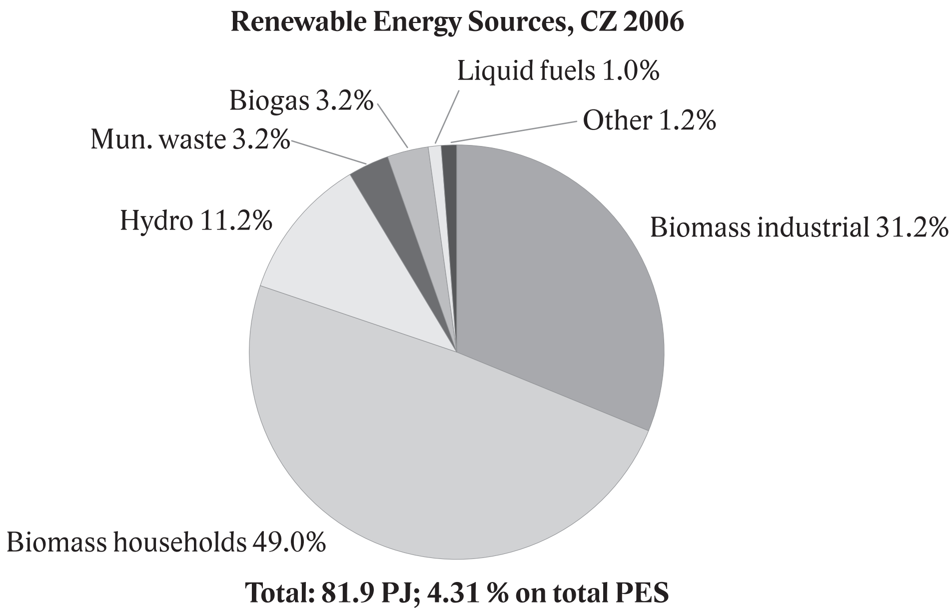
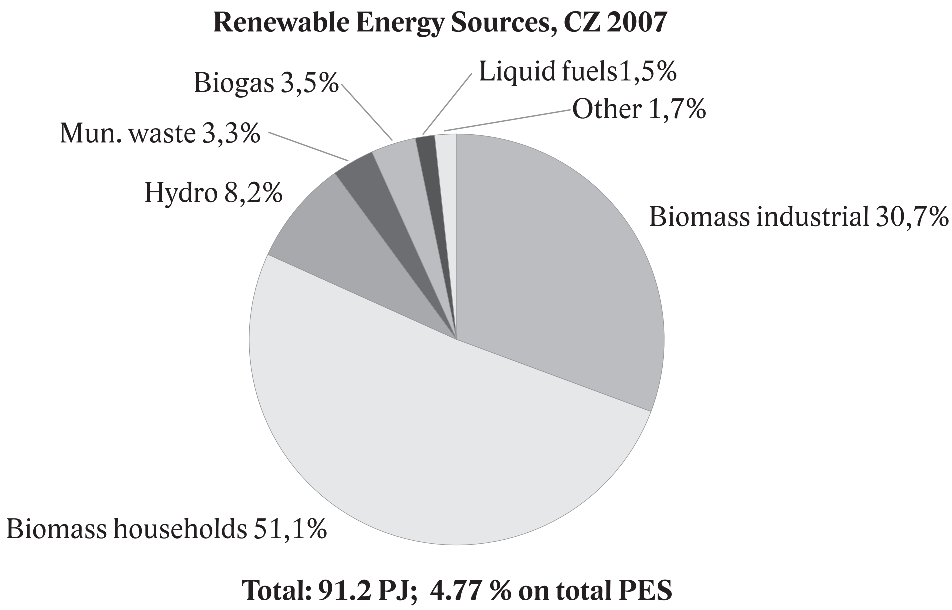
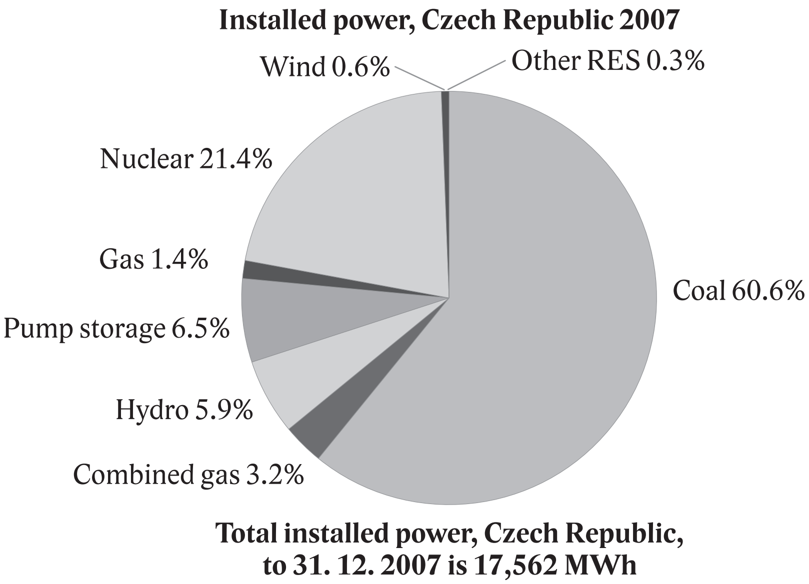




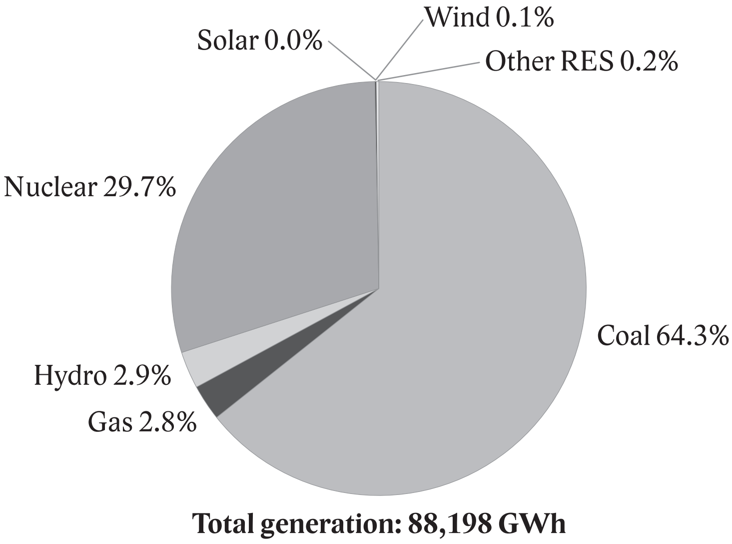
Source: MPO statistics

Fig. 11.10: RES in primary energy sources used—structure and total contribution for 2006 and 2007



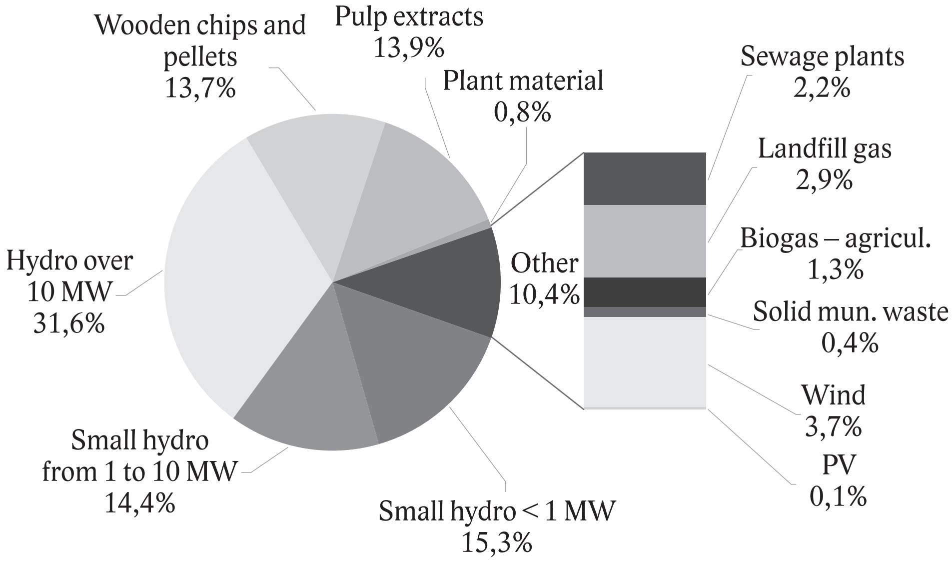
Source: MPO

Fig. 11.11: Structure of installed power, Czech Rep. 2007



Source: MPO

Fig. 11.12: Structure of power generation, Czech Rep. 2007



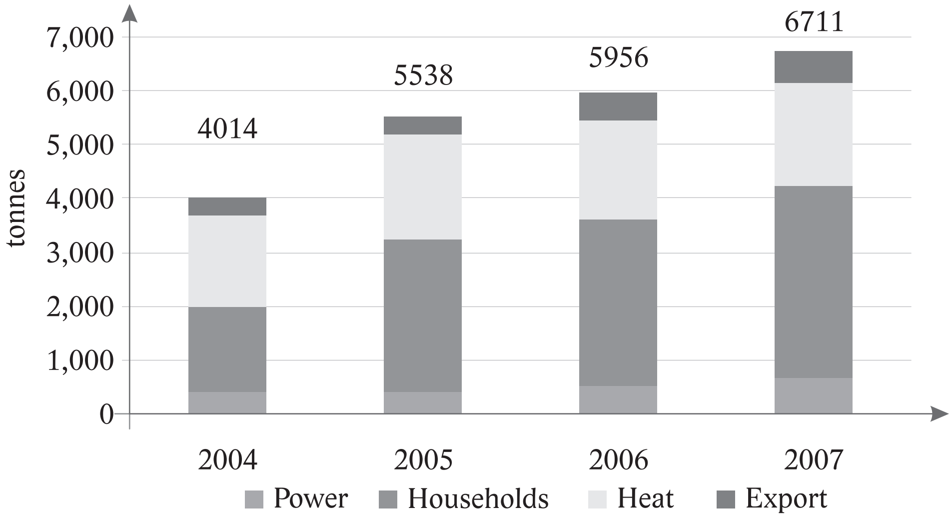
Source: ERO

Fig. 11.13: Structure of power generation from RES, Czech Rep. 2007

esp. in rural areas). Current biomass utilization for energy purposes can be documented in the following figures 11.14 and 11.15.

Power generation from (solid) biomass (burning processes) increased from 731 GWh in the year 2006 to 968 GWh in the year 2007. Structure of power generation from biomass documents next figure 11.15.

About 420 GWh of power was generated in so-called co-firing in 2007. Co-firing means that solid biomass is added into coal burnt in large coal-fired power and cogeneration stations. This technology has many advantages: very limited investment cost (just investment related to the biomass logistics at the power plant site, power plants already exist), stable burning process with high temperature (reduction of adverse pollutants), flexible range of biomass content (from several % up to app. 20%), flexible range of biomass types that can be used, etc. Biomass co-firing has been assumed as the most important contributor to meeting National indicative target to the year 2010. Faster development of biomass utilization is blocked to some extent esp. by the luck of suitable biomass—sources of residual and waste biomass are quickly being exhausted and power companies face problems with finding long-term contractors for biomass delivery



Source: MPO

Fig. 11.14: Biomass utilization for energy purposes, Czech Rep. 2004–7

Quick development of wind applications

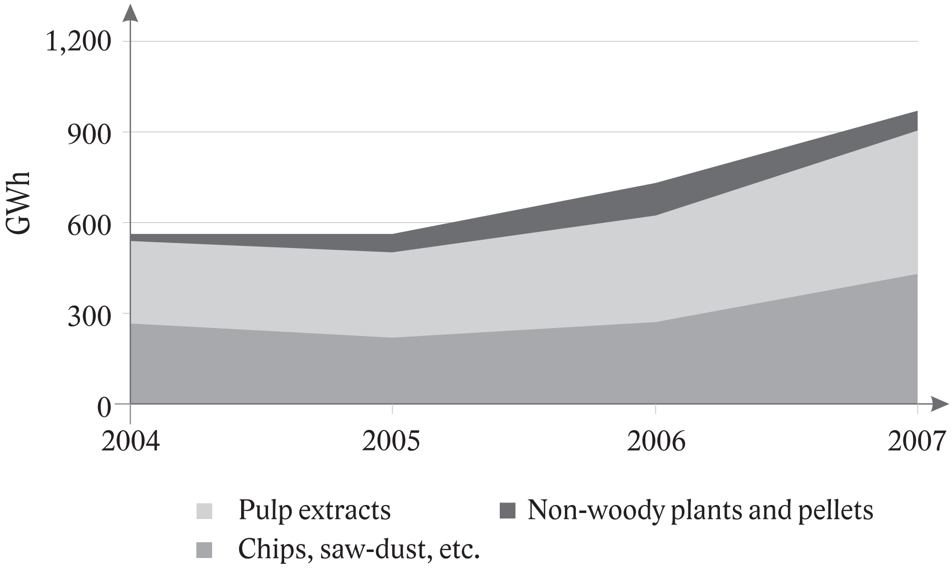
Wind power plants are at the moment the quickest developing RES used for electricity generation. Development of wind power projects is shown in following table 11.4.

	1. 1. 2002	1. 1. 2003	1. 1. 2004	1. 1. 2005	1. 1. 2006	1. 1. 2007	1. 1. 2008	14. 3. 2008
Inst. power in MW	3.39	6.97	8.18	11.49	34.41	44.5	117.52	124.12
Number of premises	7	14	17	26	42	57	69	71

Tab. 11.4: Wind power plants installed and projects in the CR

Total installed capacity of the wind project that currently under preparation is (in outlook to the year 2013) up to 1700 MW of installed capacity, app. in the following structure:

- connected to transmission grid: 510 MW



Source: MPO

Fig. 11.15: Power generation from biomass, Czech Rep. 2004–7

- connected to 110 kV grid: 695 MW
- connected to HV grid: 475 MW

11.3.4
Overview of support scheme for RES-E projects in the Czech Republic

Support directly related to the RES-E projects can be divided into the following 4 groups:

Systematic support of power generation based on RES utilization

- Support is based on feed-in tariff and green bonuses paid by distribution companies that have obligation to purchase this electricity. Feed-in tariffs are assured for the whole technical lifetime of power plant (for given type of RES) and are annually adjusted for inflation. Basic Act 180/2005 Col. on support of renewable energy sources and related notices of Energy Regulatory Office and Ministry of Environment defines scheme for power generation.

Tax incentives of RES utilization

- All RES-E projects have income tax breaks (starting year and 5 consecutive years). Exemptions to the rule are small hydro power plants where tax breaks are applicable only to plants with less than 1 MW installed capacity. A similar arrangement exists for land and property tax.

Support of decentralized power production

- All power plants included to voltage levels 110 kV, high voltage and low voltage get extra support in the form of special extra payment (paid by distribution company). Value of support is annually defined by ERO in price decision. Values of this support in 2088 were: 20/27/65 CZK/MWh (plant connected to 110 kV/high voltage/low voltage grid).

Support from state funds and EU structural funds

- At the moment operational programmes (EU structural funds) are exclusive source of this support. In last years also funds of Czech Energy Agency and State Environmental Funds were used. Czech Energy Agency has been liquidated to beg. of 2008. Operational programmes of three ministries cover this field (Ministry of Agriculture—biogas stations, Ministry of Industry and Trade—other entrepreneurial RES-E projects, Ministry of Environment—other non-entrepreneurial projects). Investment subsidies are typical support here.

Indirect support includes support of grass production in LFA regions (but the maintenance of land is the primary target here) and Carbon credit for intentionally planted biomass for energy purposes (45 EUR/ha). There is no systematic policy of support for intentionally planted biomass for energy purposes.

Introduction of ecological taxes (special kind of consumer taxes imposed on fossil fuels and electricity for final consumption) also indirectly influence the competitiveness of renewables.

By far the most important is the obligatory support of RES-E projects based on Act 180/2005 Col. Increased cost from obligatory power purchase from RES are transferred to the final power consumers via a special item added to the cost of distribution. The value of this item (Support of renewable power generation and cogeneration) is 40.75 CZK/MWh (plus value added tax), in the year 2006 only 28.26 CZK/MWh. Total value of support (transfer from power consumers to the power producers) can be estimated to be 2–2.5 bil. CZK in 2007.

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Tax breaks are assumed in the methodology of feed-in tariffs and green bonuses calculation. If this exemption would not be applied it would cause an increase of feed-in tariffs by about 1%–3% only (depending on type of RES because different RES-E projects have a different proportion of investment cost on total cost in present value). Application of this exemption creates some complications in tax system because effective utilization of exemption needs postponing of tax depreciation of investment. Interpretation of how to apply this exemption (depreciation postponing) might differ among regional tax offices. This exemption is now being discussed as one that could be cut from the year 2010.

Support of decentralized production is based on the logic of power producers participating in power losses savings-power plants connected to the lower grid voltages save part of power losses in the grid assuming typical power flows from big power stations via transmission grid to distribution grid and its voltage levels. Total value of this support (that is not included in feed-in tariffs calculation) was up to 60 mil. CZK in 2007.

A more complicated situation exists with (non-obligatory) support from operational programmes. As mentioned above three different operation programmes explicitly support RES-E projects (but also utilization of RES for heat production):

- OP¦P (Operational programme of environment): part "Sustainable utilization of energy sources" (construction and reconstruction of plants using RES for power and/or heat production)—responsible ministry is Ministry of Environment.
- Operational programme "Development of country-side", axis III, part "Diversification of agriculture activities and activities close to the agriculture" (construction and reconstruction of biogas stations is assumed here)—responsible ministry is Ministry of Agriculture.
- Operational programme Entrepreneurship and Innovation, part Eco-energy (currently valid 2nd call announced 1. 10. 2008).

The total amount of allocated sources in OP¦P for construction and reconstruction of plants using RES for power and/or heat production is 362.5 mil. EUR (years 2007–2013). Maximum support is 20% of qualified project expenditures, but 50 mil. CZK at max. Biogas stations cannot qualify for support here. Support for RES-E project (part 3,1 of programme) can be used by non-entrepreneurial subjects (e.g., municipalities, NGO's, confederation of towns and villages, foundations, etc.).

Support of biogas stations is available within the operational programme of Ministry of Agriculture. Support exclusively targets entrepreneurs (farmers or farming companies) in agriculture. Projects here can get investment subsidy of up to 40%–60% (depending on region). It is assumed that app. 120 biogas stations projects will be supported under this program (total investment cost app. 290 mil. EUR) and power generation from these biogas stations will be 470 GWh.

Ministry of Industry and Trade manages the Operational programme Entrepreneurship and Innovation, part Eco-Energy. Eco-Energy includes in general support of RES utilization both for power and heat generation. Support targets business companies. The currently valid call for project submission assumes support of small hydro power plants and biomass and biogas application with combined power and heat production (investment support of up to 30%). Support of other RES (e.g., PV or wind projects) is not assumed in this 2nd call. Projects targeted to increase energy efficiency and utilization of the so-called secondary energy sources are preferred against RES-E projects.

Despite that feed-in tariffs and green bonuses are calculated based on the assumption that there is no other support (i.e., they should create adequate economic motivation with any other support) feed-in tariffs and green bonuses are not influenced by fact of investment support obtaining.

11.3.4.1
Feed-in tariffs and green bonus system.

The following legislation creates the core of the support scheme:

- Act 180/2005 Col. on support of renewable energy sources for power generation
- ERO notice 364/2007 (that amends original notice 475/2005) on some specifications to the Act 180/2005 Col.
- ERO notice 150/2007 on regulation
- Ministry of environment notice 482/2005 on biomass categories

Act 180/2005 Col. defines the logic of the scheme. ERO notice 364/2007 among others presents indicative values for investment cost, power generation etc. for different kind of RES plants. Notice 482/2005 defines categorization of biomass into three major categories, values of feed-in tariffs and green bonuses are individually set for each category. Biomass types not included in the notice are not eligible for support. Notice 150/2007 significantly “improve” the conditions defined by the act 180/2005—it extends the validity of feed-in tariffs for the whole lifetime of technology (typically 20 years) and also defines the range of inflation used for annual feed-in tariff adjustment.

Main principles of this support scheme are:

- Each year the producer can select the type of support—feed-in tariff or green bonus.

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- Feed-in tariff choice: distribution (or transmission) companies (to which the producer is connected) has obligation to purchase "green" electricity for price specified by ERU Price decision. Distribution company is also responsible for power deviations. Cost related to power deviations are valid (eligible) cost related to distribution (transmission).
- Green bonus option: GB is supplement to market price of electricity. Producer sells electricity on a free electricity market (to chosen customer, based on contract). Act 180/2005 defines that GB option includes higher risk for producer that should be reflected in GB values.

- Green bonuses and feed-in tariffs are differentiated by RES type.
- Green bonuses and feed-in tariffs are paid to producer by distribution (transmission) company to which the producer is connected. These extra costs are included as a separate item into distribution (transmission) fee and and charged to the final customers as a separate fee imposed to any consumed MWh.[4].
- Feed-in tariffs and green bonuses should be set up so that investors can reach at least 15 years of payback time.
- Level of support (feed-in tariffs) **is assured during the whole (technical) lifetime of the given technology (e.g., 20 years for wind power) with a 2%–4% annual adjustment according to the producers' price index (PPI) of.** Later ERO notice 150/2007 Col. defined assured support for the lifetime of the given technology and introduced the level of inflation adjustment into the support scheme
- The principle of "time matrix" is used, i.e., for power plants put into operation in different years and which can have different feed-in tariffs. The **producer has for the whole assured period a feed-in tariff that was valid at the year of beginning operation.**
- Feed-in tariffs for new plants in the following year can be reduced only by 5% (reduction from year to year to reduce risk of investment into new plants for investors).
- ERO is responsible for setting feed-in tariff and green bonuses so that the indicative goal for the Czech Republic (8% of RES share on gross consumption of electricity at 2010) would be met.

In practice, the methodology applied by ERU when setting up feed-in tariffs and green bonuses is based on applying the so-called minimum price of production. Minimum price means such a price of electricity (for given type of

[4] Final consumer pays separate item in his electricity bill that is dedicated to cover cost increase resulting from RES-E support, cogeneration and non-traditional energy source utilization. For the year 2008 this item is equal to 40.75 CZK/MWh—defined by ERU Price decision 9/2007.

RES) that assures net present value of a project equal to zero. In this case rate of return on capital invested is equal to discount rate used for NPV calculation. Discount rate has meaning of WACC.

ERU respects the risk of business in case of RES-E projects. Business risks are significantly reduced by obligation of purchases, and assured support for the project's whole lifetime with PPI (inflation) adjustment.

Assumption on discount rate plays a crucial role in setting feed-in tariffs (i.e., in minimum price calculations). As mentioned above discount has the meaning of WACC. It means that a discount rate equal to 7% (that is currently used for the calculation) does not mean that the rate of return for the investor is also 7%. WACC defines rate of return on total capital employed (i.e., sum of equity and debt capital). The rate of return on capital invested by the investor depends on share of equity capital on total capital (or on E/D ratio), "price" of debt capital (interest rate) and value of income tax.

The big investors (namely big power companies) have far better access to debt capital and lower interest rates than the small and middle size investors (e.g., Czech dominant power producer that is also one of the major players in the field of RES-E projects has interest rates on the level of 3.5%–4%; see annual report 2007). In the case that interest rates range from 4%–5% the rate of return on equity capital is near 15%.

Calculations of FT and GB are done based on reference projects for each type of RES. To define reference projects for each type of RES ERU uses information on new, currently running projects or planned projects. Selected information on reference projects are published in ERU Notice 475/2005 amended by Notice 364/2007. The logic of these figures (called technical and economic parametres of RES) is that if investors are within the range of parametres, then feed-in tariffs and green bonuses should assure adequate rate of return. But it is not obligatory to meet them.

Green bonuses are supplement to (expected) market price. The producer sells generated electricity on a free market and should solve responsibility for power deviation. Value of green bonuses should correspond with feed-in tariffs for a given type of RES but should also reflect higher business risk. Green bonuses are derived from the basic equation:

$$Gb_i > Ft_i^* - Mp_i$$

where

Gb_i ... green bonus for i type of RES

Ft_i^* ... feed-in tariff for i type of RES recalculated with corresponding higher discount rate (i.e., risk premium)

Mp_i ... expected market price of electricity from i type of RES

Estimation on expected electricity market price is based on technical features of delivered electricity from given RES type and competitive possibilities of electricity purchase on the power market. Different technical features of delivered electricity from different RES types lead to different estimation of electricity market price.

Feed-in tariffs and green bonuses valid for the power plant put into operation after 1. 1. 2008 are indicated in following table 11.5.

	FT [CZK/MWh]	GB [CZK/MWh]
Small hydro	2,600	1,400
Biomass	4,210/3,270/2,520	2,930/1,990/1,240
Co-firing	—	1,390/790/240
Biogas 1	3,900	2,620
Biogas 2	3,300	2,020
Wind	2,460	1,870
PV	13,460	12,650

Note: Green bonuses for co-firing are differentiated by biomass used—S1, S2, S3. The first category S1 (and highest green bonus) includes the intentionally planted biomass, the second one forestry residuals and agricultural waste, the last number other types of biomass (wood chips, etc.). Similarly, feed-in tariffs and green bonuses are differentiated in case of exclusive biomass burning (item "biomass"—construction of new power plant and only biomass burning are assumed here).

Tab. 11.5: Feed-in tariffs and green bonuses valid for the power plant put into operation after 1. 1. 2008 in the CR

The logic of the time-matrix (see above) means that there are different feed-in tariffs and green bonuses for wind power plants put into operation before the year 2008 (applicable for the year 2008)—see following table 11.6.

Differences between FT and GB

- ↗ FT are assured for lifetime period and adjusted by PPI
- ↗ GB can be changed from year to year—no limit on change

A producer can choose the type of support freely for each year (he should decide until the end of November and he should announce it to ERU).

From the list of FT and GB for 2008 it is obvious that for different RES, a different assumption of (expected) market price of electricity is taken. The

Wind power plant put into operation	FT [CZK/MWh]	GB [CZK/MWh]
after 1. 1. 2008	2,460	1,870
in 1. 1. 2007–31. 12. 2007	2,520	1,930
in 1. 1. 2006–31. 12. 2006	2,570	1,980
in 1. 1. 2005–31. 12. 2005	2,820	2,230
in 1. 1. 2004–31. 12. 2004	2,960	2,370
before 1. 1. 2004	3,280	2,960

Note: already existing power plants have assigned FT valid in year of operation start. They are adjusted by PPI, i.e., "each next year" they have a new (PPI adjusted) price.

Tab. 11.6: Wind power plant put into operation and Feed-in tariffs and green bonuses valid in the CR

lowest expected electricity price is assumed for power from wind. This can be another source of economic benefits—if a producer will be able to sell power for higher than the expected price.

11.3.4.2 Barriers and imperfections of Czech support scheme

Despite the existence of the (economic) support scheme based on feed-in tariffs and green bonuses, the development of RES utilization for power generation is still slow.

Stagnation or rather slow development of RES-E projects is caused by several reasons that can be categorized as follows:

- imperfections or "gaps" in the economic support scheme,
- subjective barriers on the side of investors,
- worse conditions for RES utilization and lack of suitable sites for construction of RES power plant,
- legal barriers,
- opposition of some municipalities against RES-E projects (namely against wind power plants).

Imperfections in economic support scheme

Problems related to support scheme can be divided into two major groups:

- ↗ still missing systematic strategy for intentionally planted biomass,
- ↗ uniform support scheme for RES-E projects has different impacts to different types of investors.

As discussed in the previous chapter, biomass is expected to play the decisive role in the development of RES-E projects. Progress in biomass utilization for power generation, however, is inhibited by the lack of suitable biomass. Effective programmes of intentionally planted biomass (e.g., SRC plantations or non-woody plants) are still at the beginning. Investors in biomass utilization for power generation cannot find contracts for long-term delivery of planted biomass mainly because of the following:

- ↗ there is no long term strategy for intentionally planted biomass (and utilization of agriculture land),
- ↗ bio fuel programmes compete with biomass planting for energy purposes—it is more effective and less risky for farmers to be oriented to the standard agriculture production (on annual basis) than to sign long-term contracts for biomass delivery (that are requested by investors in power plants) at the moment,
- ↗ planting biomass for power generation is supported via green bonuses and feed-in tariffs—i.e., via money transfer from power producers to primary biomass producers; this scheme is not fully effective and does not assure that adequate "money" are transferred to primary biomass producers,
- ↗ conservatism of farmers and lack of experience in growing new types of crop.

Another imperfection in the economic support scheme results from the basic logic of the support scheme. As discussed above, feed-in tariffs are based on the regulated rate of return. The typical payback period is 9–11 years (for small hydro rather longer). The Czech support scheme does not distinguish the type of producer (small, middle or big companies) or the volume of the project. Feed-in tariffs and green bonuses are the same in all cases for a given type of RES. The logic of a discount rate as WACC leads to a rate of return on equity capital different (in some cases significantly) for small and big investors (as a result of different access to debt capital and differences in paid interest rate—see Fig. 11.5). The WACC formula also assumes continuous reinvestment—i.e., stable E/D ratio. This, however, is realized in the case of big power companies not in the case of small companies running a few RES power plants. It results in a smaller rate of return (for the same project) in case of small size (e.g., one project) companies compared with the big power companies with stable E/D ratio.

Small—typically under capitalized investors also face the threat of negative cash flows at the beginning of project operation. These investors would need a different scheme that would reflect their conditions better—e.g., degressive scheme with higher initial feed-in tariffs decreasing in time. This would enable managing (i.e., "surviviing") the starting years of project realization when bank loans are being repaid.

Problem of under capitalization of small investors is to some extent solved with investment support from EU structural funds where only small- and middle-size companies are eligible for support (but no legal claim to get the subsidy). This solution, however, is not consistent with the equality of all types of RES used and of all investors from the point of view of rate of return. Investment support of this type is not taken in feed-in tariffs values calculations and supported investors finally get higher rate of return than the others. The problem is not the rate of return, but threat of negative CF at the beginning of the projects. This problem is one of the most important (economic) barriers for small—local projects.

Subjective barriers on the side of investors

Most investors waited for full legal constitution of a support system. Despite that the same logic of support has been applied since 2002 (but in 2002–5 not covered by Act on support of RES) the development of RES-E projects started only after the beginning of 2006. Before 2006 the Czech banks evaluated these types of projects as high risk activity.

The Czech support scheme significantly reduces the business risk of RES-E projects, and there is no business risk in the case of feed-in tariff scheme. Business risk, however, is also reflected in the discount rate used for derivation of feed-in tariffs and green bonuses. Some investors (typically small companies) argue that payback time is too long. Some other (typically financial) investors argue that rate of return should be higher (not taking into account relation between rate of return and risk). Much higher interest of big power companies has been visible after 2006. It seems it is the validation of basically favourable feed-in tariffs and green bonuses for the investors (esp. "boom" of wind power and PV project is visible).

Lack of suitable sites

The Czech Republic, thanks to its location in Central Europe, has objectively worse conditions for utilization of RES for power generation. Faster development of RES-E projects (namely wind and PV projects) is blocked by the lack of suitable locations. Suitable (good) conditions are limited to a small part of the republic. The best wind conditions are typically in upper part of mountains, but the requirements for environmental protection block their construction here. In some cases the utilization of good sites is blocked by problems with grid connection (too long and too expensive connection). Investors preparing RES projects have already reserved good sites for wind and PV projects. This creates barrier for entrance of new investors from abroad.

Legal barriers

Legal barriers are typically connected with the process of obtaining the construction permission as can be seen with wind power plant projects. The construction of a wind power plant should be in compliance with the regional land plan, but this plan usually does not include plans for the construction of a wind power plant. This means that regional plans should be changed. The process of construction permission can start only after its change and "regional/area approval". Also EIA evaluation is needed (based on Act 100/2001 Col), which esp. in the case of wind parks can be time consuming. The processes of obtaining regional approval and construction permission can significantly affect time plans—the total time for wind power plant project preparation can be two years or more. At the moment this type of barrier seems to be one of the most important barriers to RES-E project development.

Attitude of municipalities

The preparation of wind power projects in some locations is slowed down by the negative attitude of municipalities to these projects. Investors have often got negative references from a municipality in the region in which the project is planned. Arguments like negative impact on landscape, noise, vibration, etc. have arisen.

11.3.5
Support of RES utilization for heat production

Support of RES utilization for power generation is, despite some (minor) imperfections set in a systematic way and creates transparent, stable and motivating conditions for RES-E project development. A completely different situation is utilization of RES for heat production—either for decentralized or centralized applications. At the moment only financial sources from Operational programmes—all three above mentioned programmes—support utilization of RES for heat production.

Heat production based on RES utilization can be divided into several different groups of problems:

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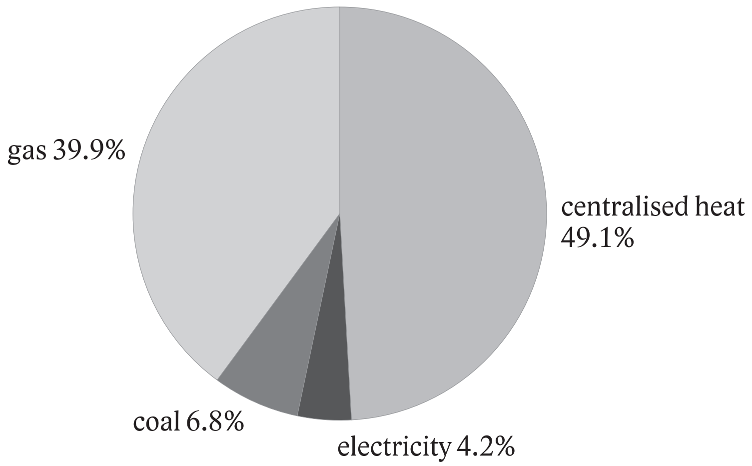
- individual household heating and substitution of currently used sorted brown coal with biomass,
- development of utilization of thermal solar collector for space heating,
- centralized systems of heat production and delivery and possible substitution of widely used brown coal—biomass here is one of the options
- support of utilization of the heat originating in relation to power generation (biomass burning, biogas stations, landfill and sewage gas applications),
- definition of system strategy (i.e., optimisation) for the most effective biomass utilization (biomass for power generation in co-firing, biomass for heating and cogeneration plants, biomass for (liquid) biofuels production.

Financial support from Operational programmes (i.e., EU funds) plays a significant (sometimes even decisive) role in financing projects targeted to heat production based on RES utilization. Total amount of these sources for this type of project is on the level of hundreds of million EUR, but these sources are limited to 2007–2013 and are mainly targeted at either construction of power and heating plants or other activities in agriculture fields rather than supporting intentionally planted biomass for energy purposes.

Utilization of domestic brown coal is a special Czech problem. Structure of space household heating is shown in the following figure 11.16.



Source: www.tscr.cz

Fig. 11.16: Structure of household space heating by type, 2005 Czech Republic

The share of brown coal is by far higher in the countryside and in the year 2005 reached 24.4%. Utilization of brown coal in individual heating devices is one of the sources of bad air quality (esp. in winter time) in many villages in the Czech Republic. App. 3–4 mil. tons of sorted coal is produced by coal mining companies and most of it is used for individual space heating. Only a part of this consumption can be covered by natural gas (probably not more than 1/3). This situation will probably lead to the effort to process residual (wood) biomass from wood processing industry into higher quality products (pellets and briquettes) than for it to be used for space heating.

Meeting Czech obligations in the share of power generated based on RES (esp. expected target to the year 2020) will call inevitably for significantly higher biomass utilization for power generation, mainly in co-firing that is the most effective way of "green" electricity generation.

Also heating and cogeneration plants using domestic brown coal at the moment will look for substitution of—at least partly—domestic brown coal. This is caused by the fact that without changing of regional limits the Czech power sector will face—at least to the some extent—shortage of domestic (relatively cheap) brown coal. This situation is expected esp. after horizon of 2015. Changes on the Czech coal market can be also documented by currently new plans of coal mining company MUS, a. s. that announced plans for coal auctions.

All of the above will lead—inevitably—to a significant increase of biomass demand or demand for agriculture land for "energy biomass" production. Biomass is in the Czech condition one of the most important substitutes of domestic brown coal. This situation finally will call of definition of system approach to the biomass utilization—finding he most effective ways of biomass utilization taking into account Czech strategic targets and internal needs.

Conclusions

Specific Czech conclusions

The support scheme for RES-E projects in the Czech Republic is basically defined in a transparent, consistent and economically effective way. The support scheme is defined by the Act 180/2005 and is targeted to minimize investors' risk and to create adequate economic motivation for the investors. Investors in RES-E projects have assured feed-in tariffs for the whole technical lifetime of the power plant including annual adjustment for inflation. The support scheme does not differentiate among investors based on their size and capital power. Thanks to the support scheme's logic (derivation of feed-in tariffs based on regulated rate of return and WACC logic) small and mid-sized companies (with worse access to capital) can have problems with possible negative CF at the beginning of the project and lower rate of return. This problem can be solved with adequate utilization of financial sources from Operational programmes (EU structural funds).

Faster development of RES-E projects is slowed down esp. by different kind of barriers—esp. complicated process of obtaining construction permission and land approval, lack of suitable locations and in some cases small support from regional councils or municipalities (sometimes even resulting in the rejection of some types of projects—e.g., wind power projects). Here central government and ministries can play a better role—esp. in spreading information, simplification of official procedures, etc.

In contrary to support of RES-E projects there is no systematic support of RES utilization for heat production. On one hand biomass is taken as the Czech decisive RES source but the system strategy for "energy" biomass production and utilization is missing. Biomass is expected to play a significant role in substitution of domestic brown coal, esp. in household space heating in the countryside, but several different potential consumers compete and will compete for biomass—big power plants doing co-firing, heating and cogeneration stations, individual biomass users, etc. Without definition of priorities and creation of suitable conditions for intentionally planting biomass on agriculture land and for effective utilization of wooden residuals from timber feeling Czech mid-and longer term targets in RES field probably cannot be met.

Specific Austrian conclusions

Support scheme for RES-E in Austria are targeted to minimize overall specific support costs. Since 2003 when favourable FIT were introduced, there was an important growth in capacity in the wind, biomass and biogas but after the new legislation was passed in parliament, less favourable and partly insecure investment conditions implicated a stagnation of the RES-E development. However, the target of the new RES-E supporting scheme is among others to extend the capacity of hydropower and wind power each by 700 MW until 2015.

However, investors in RES-E projects whose projects have been approved have assured feed-in tariffs for the whole technical lifetime of the power plant.

For the future it is important to strive for efficient support policies that take into account full customers WTP.

In contrary to support of RES-E projects there is no harmonised support of RES utilization for heat production. There is a broad range of subsidies in provinces and local towns and villages. Here it would be necessary to examine which support is still necessary and justified and to provide more detailed legal instruments.

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PART

D

TRANSPORT

12

Energy consumption for passenger transport —a comparison of “East” and “West” applied to CZ and AT

12.1 Introduction

Transport energy demand continues to increase at high rates in most countries. Growth rates, however, are different for mode and countries. Hence it is of interest what are differences in drivers (like GDP, decreasing prices, ...) and slowers like taxes, efficiency increases (of vehicles).

12.1.1 Objective of this chapter

This chapter’s objective is to analyze the differences in energy consumption in passenger transport in typically (former) Eastern and Western countries by comparing development in the Czech Republic and Austria, focusing mainly on passenger travel by car.

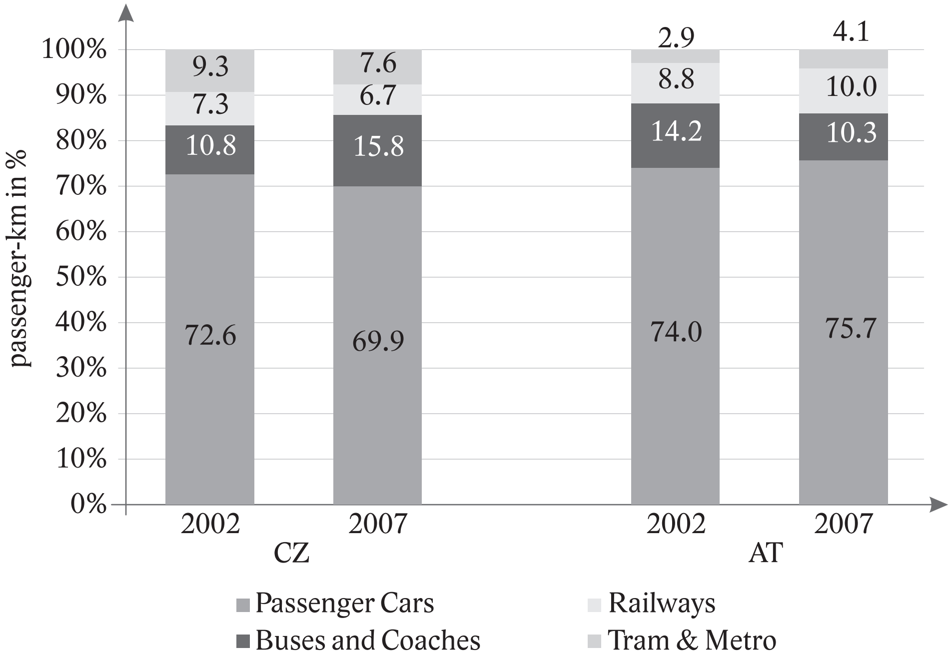
More specifically, the following will be addressed:

- Documentation and comparison of the historical development and the current state of transport energy consumption in the CZ and AT for passenger transport;
- Analyses of differences of the share of transport modes;
- Development of fuel costs;
- Documentation and analysis of structural parameters (size, car stock, automotive power, number of cars per capita ...);
- Documentation, comparison and analysis of some intensity/efficiency parameters (e.g., gasoline consumption per car ...);
- In the CZ: what were the changes in the transport system in the “free” market compared to the communist system?

12.2 Background

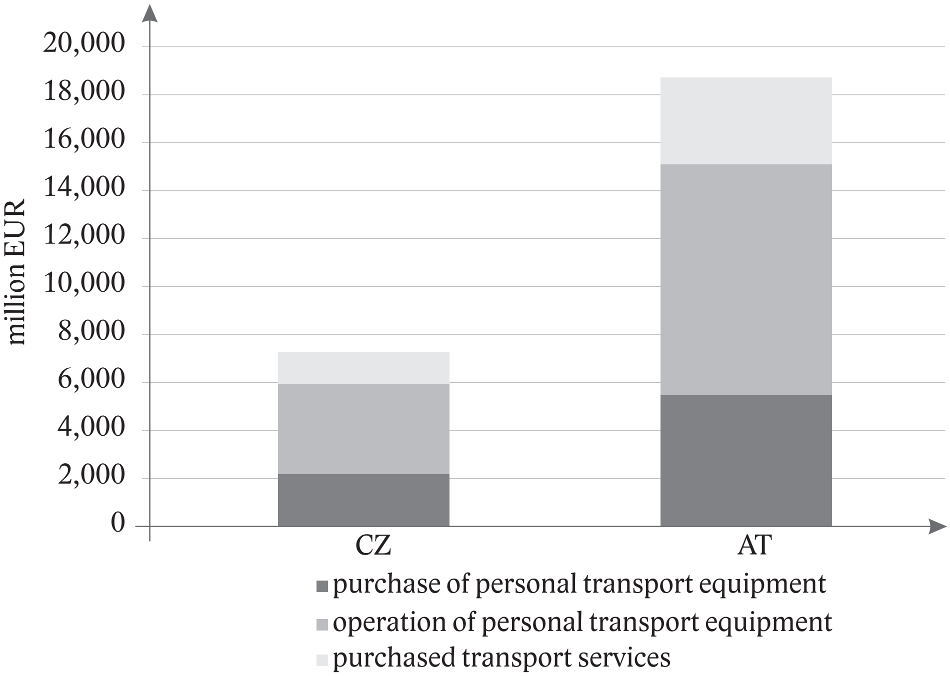
Fig. 12.1 depicts the modal split of passenger travel in the Czech Republic and Austria in 2005. Of the different modes, passenger cars contributed by far the most with about 70% in the CZ and slightly higher at about 74% in AT. Of special interest is the different trend. While in the CZ the share of cars decreased from 72.6% in 2002 to 69.9% in 2007, it increased in AT from 74.0% in 2002 to 75.7% in 2007. This will be addressed in more detail later in the chapter.

Total household expenditures for transport by type in the Czech Republic and Austria in 2005 are shown in Fig. 12.2. Overall expenses in AT are more than three times higher than in CZ.



Source: EU (2004), EU (2009)

Fig. 12.1: Modal split of passenger travel in the Czech Republic and Austria in 2002 and 2007



Source: EU (2009)

Fig. 12.2: Total household expenditures for transport by type in the Czech Republic and Austria in 2007

12.3 Development of fuel energy consumption in the transport sector

This chapter gives a short, comparative overview of the development of total fuel energy consumption in the transport sector in the Czech Republic and Austria as is depicted in Fig. 12.3 and more specifically of this development for passenger cars (Fig. 12.4). As can be seen in Fig. 12.3, both countries interestinglyshow similar trends with energy consumption increasing tremendously between about 1998 and 2005. Some signs of stagnation can be seen, but are probably due to higher prices in recent years. A similar picture is revealed if only car passenger transport is analyzed. Fig. 12.4 shows that since 1995 energy consumption in the CZ virtually skyrocketed. However, in recent years the increase is at least a bit lower.

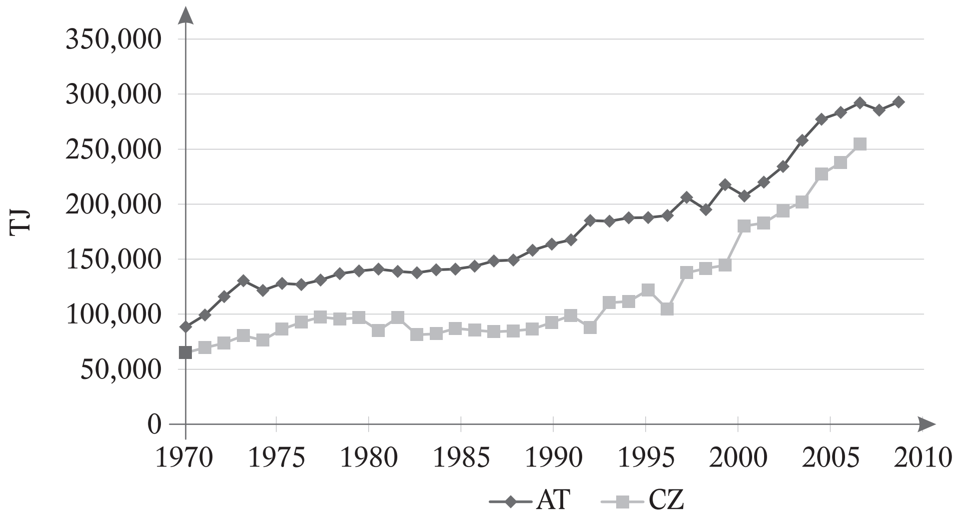


Fig. 12.3: Development of fuel energy consumption in the transport sector in the Czech Republic and Austria

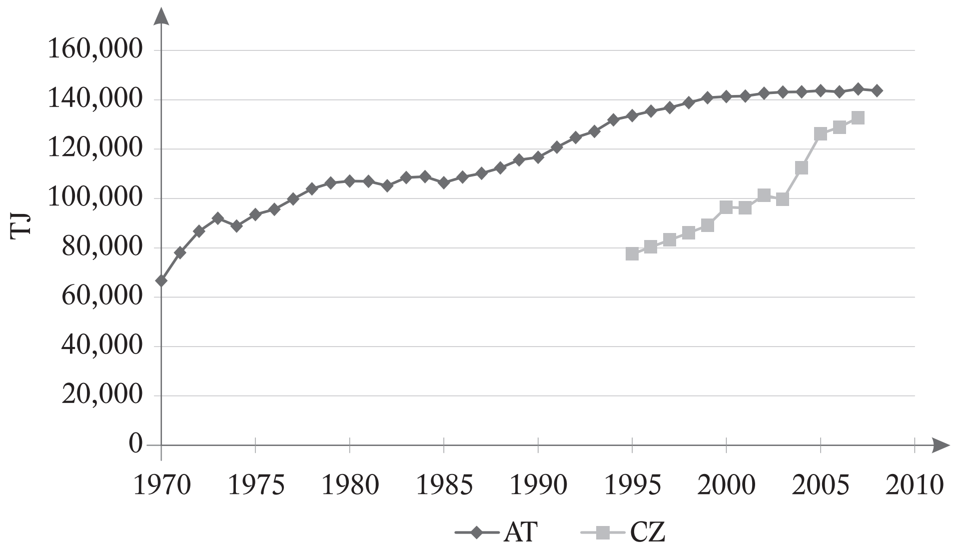


Fig. 12.4: Development of fuel energy consumption of passenger car transport in the Czech Republic and Austria

12.4 An overview of energy consumption, car stock and new registrations and kilometres driven in the Czech Republic and Austria in road passenger transport

This chapter provides a survey on the historical developments and the current situation in road passenger transport in the Czech Republic and Austria. The documentation focuses on the development of energy consumption as well as of car stock, vehicle km driven, fuel intensities as well as the most important energy policies for individual passenger transport in both countries.

12.4.1 Czech Republic

Energy consumption by fuel

The total energy consumption of passenger transport in the Czech Republic has grown continuously from 77 PJ in 1995 to 133 PJ in 2007. As is depicted in Fig. 12.5, energy consumption of gasoline grew the least, whereas that of diesel and biofuels was significant.

Car stock and new registered vehicles by type

The number of passenger vehicles in the Czech Republic has increased from 2.75 million in 1993 to 4.28 million in 2007, see Fig. 12.6. Whereas the number of alternative vehicles is experiencing a downward trend, the number of gasoline cars peaked at 3.19 million in 1998 before falling and gradually increasing again. The number of diesel cars has continuously increased throughout the period.

Development of kilometres driven over time

The total amount of kilometres driven in the Czech Republic did not vary dramatically during the 1995–2007 period. The average number of driven kilometres fluctuate around the mean value of 10000 km per year and car, Fig. 12.7.

Energy policies for individual passenger transport

National policies for individual passenger transport in the Czech Republic include the following:

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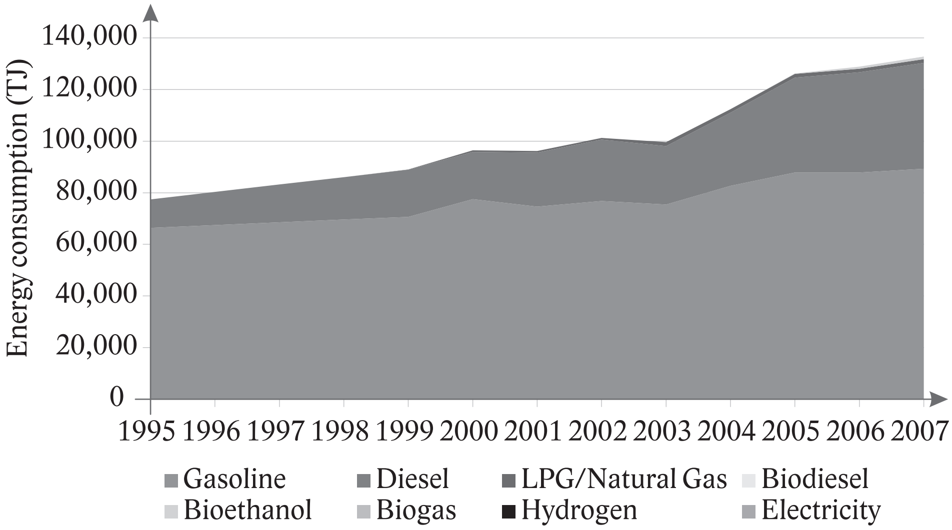

Fig. 12.5: Development of energy consumption in road passenger transport in Czech Republic by fuel 1995–2007

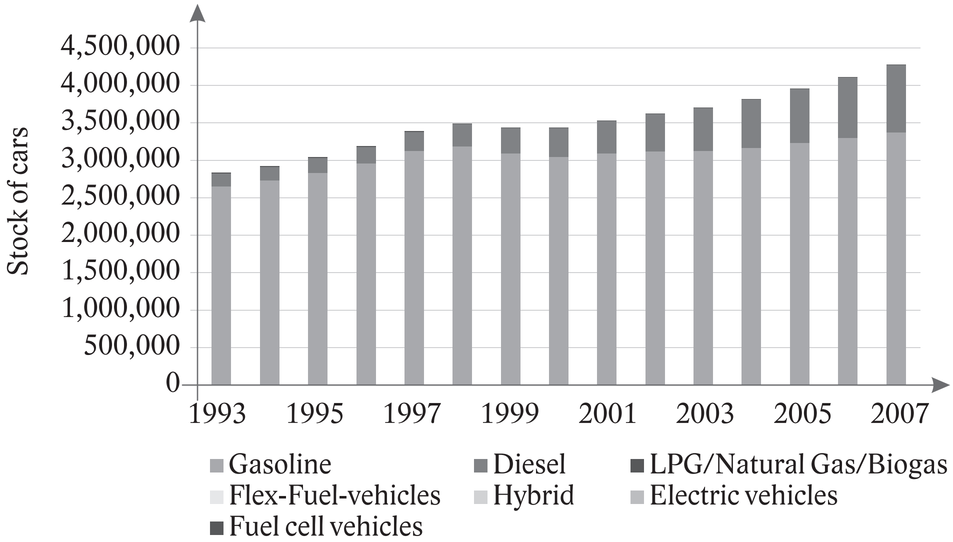

Fig. 12.6: Development of car stock in passenger transport in the Czech Republic by fuel 1993–2007

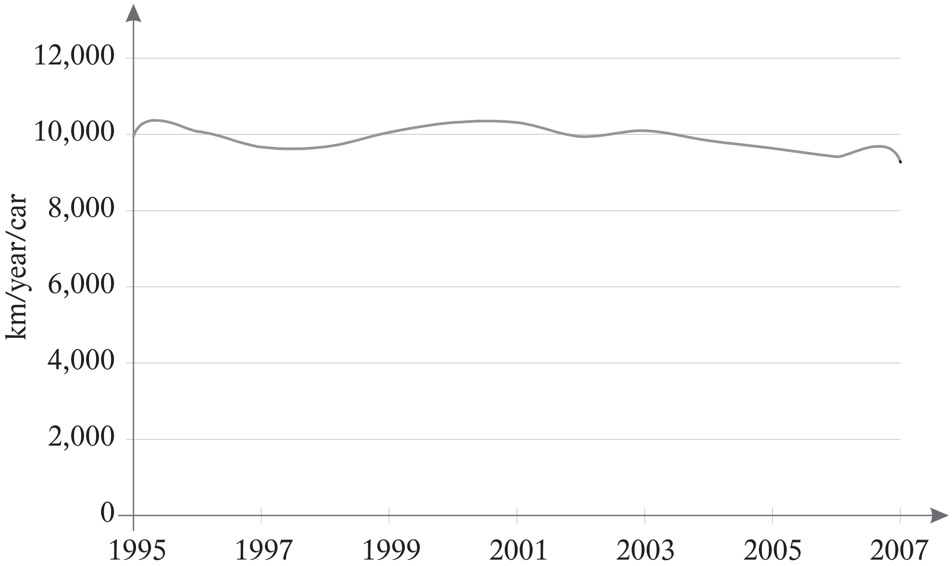

Fig. 12.7: Development of specific vehicle km driven in Czech Republic for gasoline and diesel cars 1995–2007

Taxes/tax exemptions on fuels:

There is a 19% VAT on all fuel types. There is an excise tax of 0.43697 EUR/litre of gasoline, 0.36815 EUR/litre of automotive diesel, 0.07992 EUR/litre of LPG/natural gas and 1.0471 EUR/MWh of electricity.

Quotas/Legal instruments:

An exemption from road taxes that already exists for electric cars will be extended to vehicles powered by liquified petroleum gas (LPG), compressed natural gas or fuel blends with high biofuel content. Purchasers of new cars will be eligible for a tax reduction of 48% in the first three years after purchase and 40% in the following three years. In addition, cars more than 18 years of age will attract a premium of 25%.

In line with EU policy to replace 5.75% of its fossil fuels with biofuels by 2010, Czech regulation will allow grain alcohol to be added to petrol and rapeseed oil methyl ester to diesel from 2007. Ranging between 2 to 5 percent, the concentration of biofuels to be added to diesel will follow production capacities.

The excise duty on diesel containing at least 31% (by volume) biodiesel from rapeseed methyl ester is granted a rebate of 3.08 CZK per litre of blended fuel.

12.4.2
Austria

Energy consumption by fuel

Total energy consumption in road passenger transport in Austria has grown from 66 PJ in 1970 to 142 PJ in the year 2000 and finally to 150 PJ in 2008. As can be seen in Fig. 12.8 the highest growth rates were in the very early 1970s and from 1986–2002—both periods of low oil prices. A major feature of road passenger transport in Austria is the continuous increase of the market share of diesel, which reached its peak in 2007.

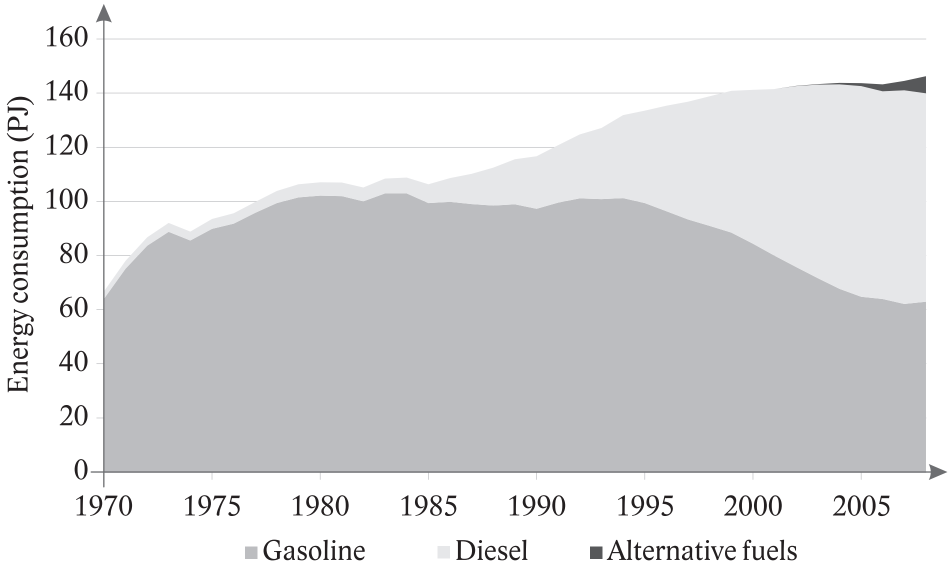

Fig. 12.8: Development of energy consumption in passenger transport in Austria by fuel 1970–2008

Car stock and new registered vehicles by type

The number of passenger cars in Austria has grown from about 1.2 million in 1970 to more than 4 million in 2007, see Fig. 12.9. The number of diesel cars also increased continuously and currently represents more than 50% of the vehicle stock.

The number of alternative car types in recent years has also increased to about 700 gas-powered cars and about 550 hybrids in 2007. The number of electric cars has remained at about 180 since the mid-1990s.

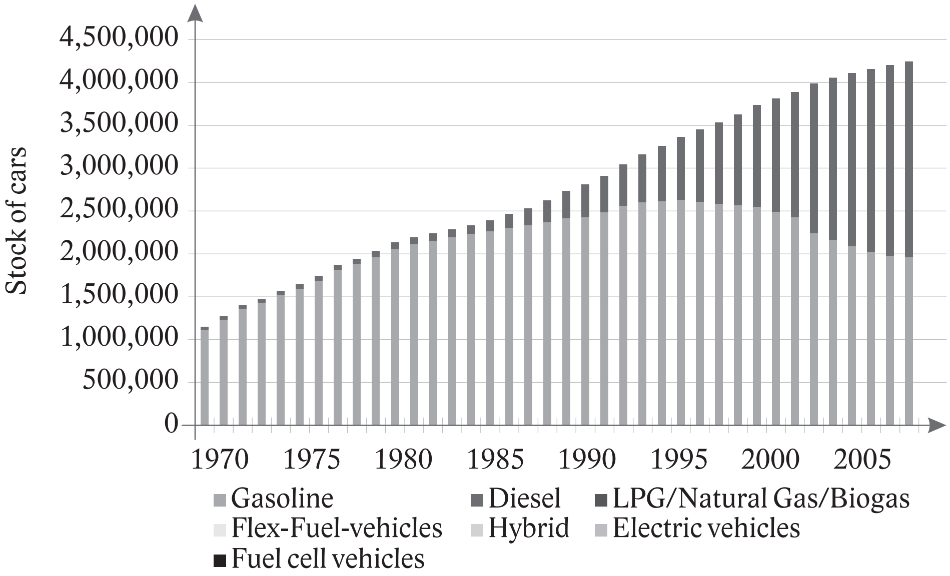

Fig. 12.9: Development of car stock in passenger transport in Austria by fuel 1970–2007

Development of kilometre driven over time

Total vehicle km driven in Austria has grown continuously since 1985, see Fig. 12.11. Just as the number of diesel cars has increased so has the overall amount of km driven with diesel cars increased considerably since about 1985. Since the early 1990s the overall amount of km driven with gasoline cars has decreased. Specific km driven—Fig. 12.10—are still highest for diesel cars—about 17000 km/yr—while gasoline cars drive about 12000 km/yr. Since the 1990s slight decreases can be observed.

Energy policies for individual passenger transport

National policies for individual passenger transport in Austria include the following:

Taxes/tax exemptions on fuels:

There is a 20% VAT on all fuel types. There is an excise tax of 0.425 EUR/litre of gasoline since 2004 (it was 0.415 EUR/litre between 1995 and 2003), and of 0.325 EUR/litre on diesel since 2004 (it was 0.295 EUR/litre between 1995 and 2003).

Natural gas is exempted from the excise tax.

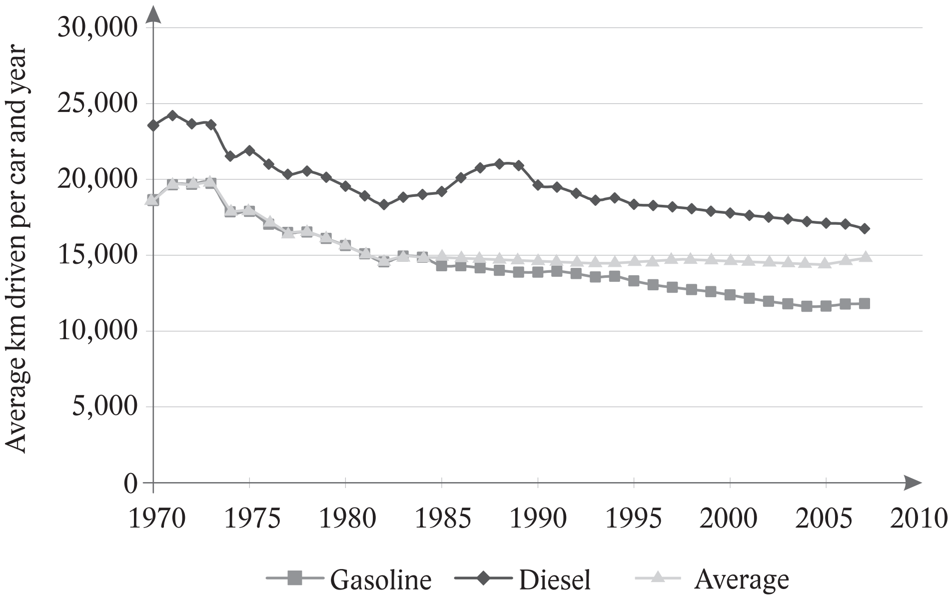

*Fig. 12.10: Development of **specific** vehicle km driven in Austria for gasoline and diesel cars 1970–2008*

Biofuels are almost fully exempted from the fossil fuel taxes that were introduced in 1995 (tax reduction of approximately 95%).

Taxes/tax exemptions on vehicles:

There is a registration tax on new cars depending on the car's fuel intensity. Since 2008 this tax also depends on CO_2 emissions. From 1993 to 2008 this tax was 3% of the investment costs on new gasoline cars and 2% on new diesel cars.

Subsidies:

Subsidies are only available for electric vehicles (500 EUR per new registered car)

Standards:

Up to 2008 no standards existed for any type of car.

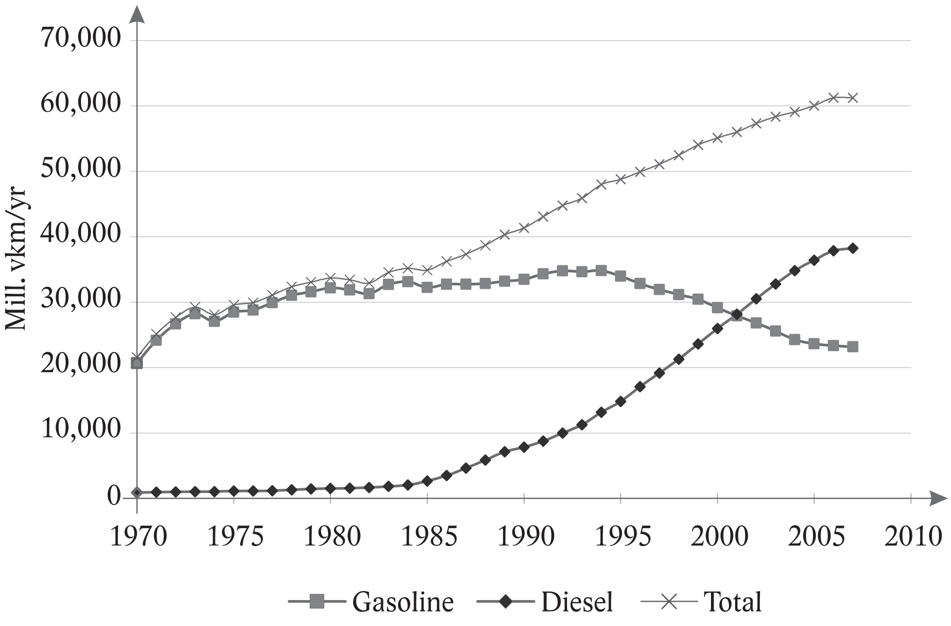

*Fig. 12.11: Development of **total** vehicle km driven in Austria for gasoline and diesel cars 1970–2008*

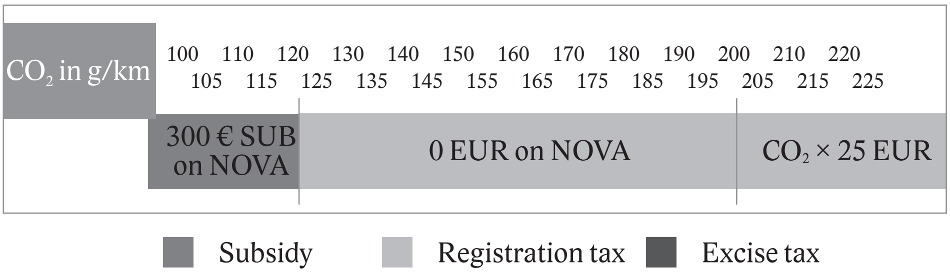

Fig. 12.12: CO_2-dependent subsidies/taxes for passenger vehicles in Austria in 2008

Quotas/Legal instruments:

A quota exists for biofuels: Austrian national indicative targets for biofuels are: 2.5% in 2005; 4.3% in 2007 and 5.75% in 2008.

12.5 Comparison: Development of passenger car stock and new car registrations in the CZ and AT

The development of the stock of passenger cars in the Czech Republic and Austria is depicted in Fig. 12.13. The most interesting perception from this figure is that in recent years the car stock in CZ has grown much steeper than in Austria and will probably this year (2009) surpass it.

Fig. 12.14 depicts the development of specific passenger car ownership in the Czech Republic and Austria. While in Austria a sort of stagnation at about 500 cars per 1000 inhabitants has occurred since about 2003, in the CZ specific passenger car ownership is continuously growing.

As can be seen in Fig. 12.15 about two times more registrations were completed for Austria than the Czech Republic. Moreover in AT the number of registrations stagnated in 1990. No clear statement can be made for the CZ because data were available only since 2003.

The development of the car stock by cylinder category (= size equivalent) in Austria is depicted in Fig. 12.16. Up to 2006 the share of large car categories in the stock was growing continuously. For the CZ no similar comparison is possible because no data were available.

An analysis of the number of passenger vehicles per amount of GDP leads to the interesting result depicted in Fig. 12.17: Firstly, the numbers are more than two times higher in the CZ than in AT; Secondly, it has been decreasing in the CZ since about 1998; and thirdly, it has been virtually constant in AT since 1990.

12.6 Development of service demand in passenger transport

Of further interest is of course a comparison of the underlying development of service demand in passenger transport in the Czech Republic and Austria. The increase in total person km driven is depicted in Fig. 12.18. Of course, due to higher GDP and a much higher income level these numbers are higher in AT than in the CZ.

However, it is difficult to determine whether there are signs of stagnation in AT, or if the rounding off is only due to the short-term volatility or higher recent prices.

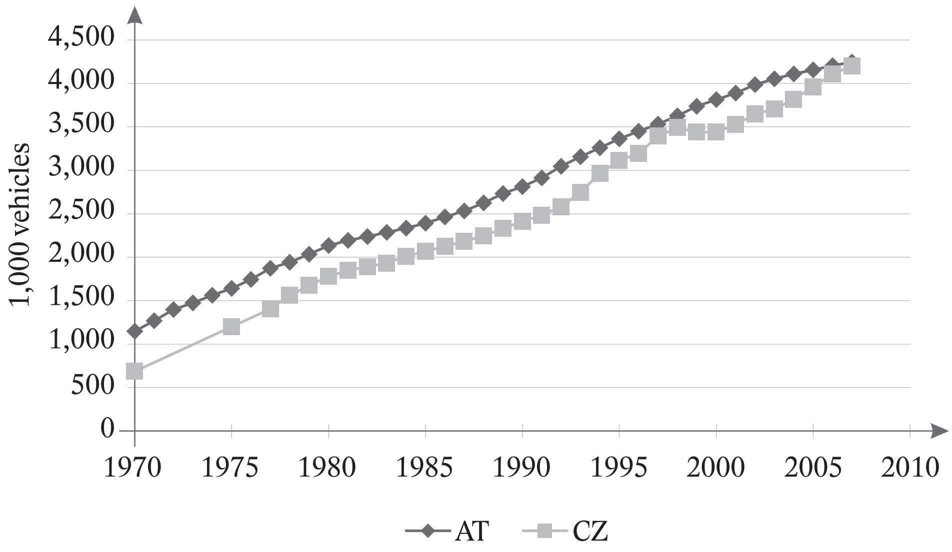

Fig. 12.13: Development of stock of passenger cars in the Czech Republic and Austria

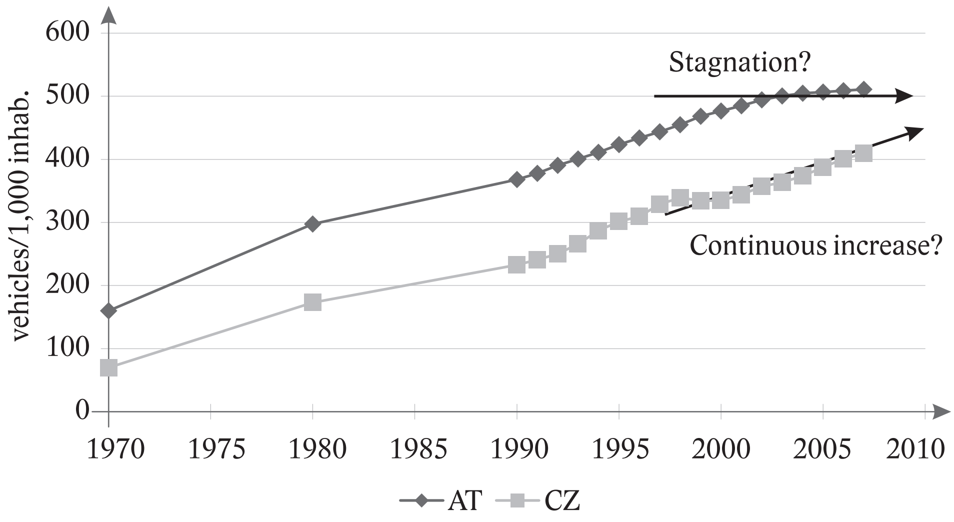

Fig. 12.14: Development of specific passenger car ownership in the Czech Republic and Austria

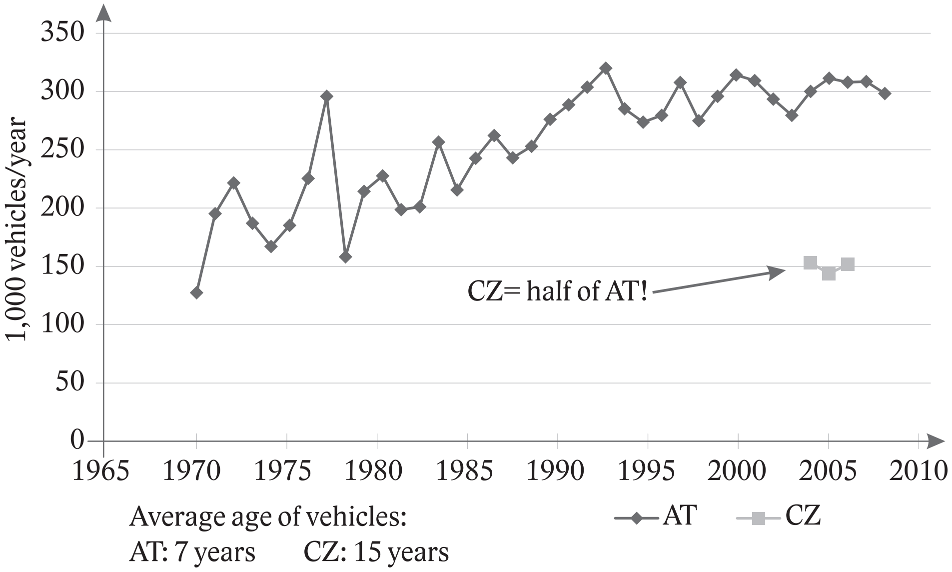

Fig. 12.15: Development of new registrations of passenger cars in the Czech Republic and Austria

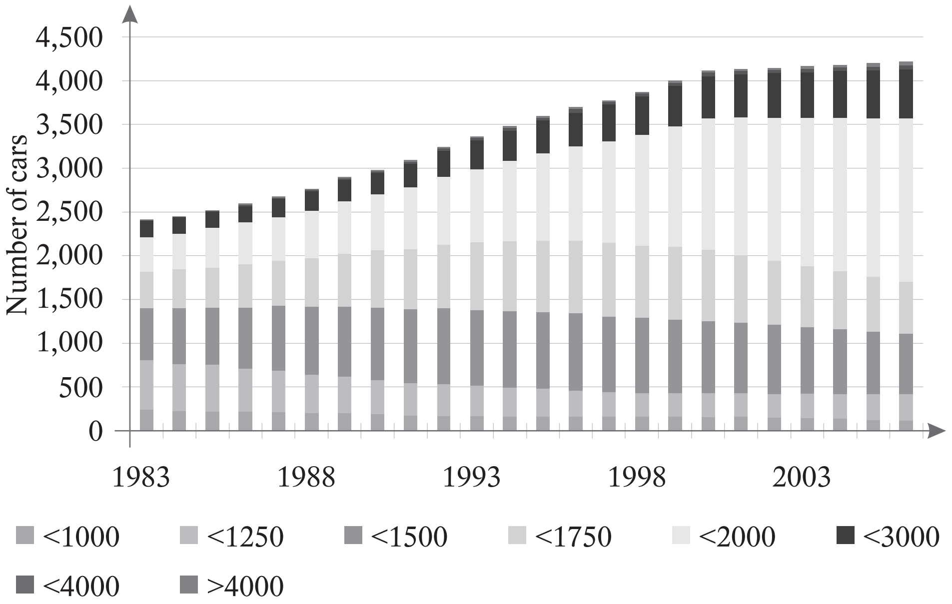

Fig. 12.16: Development of car stock by cylinder category (= size equivalent) in Austria

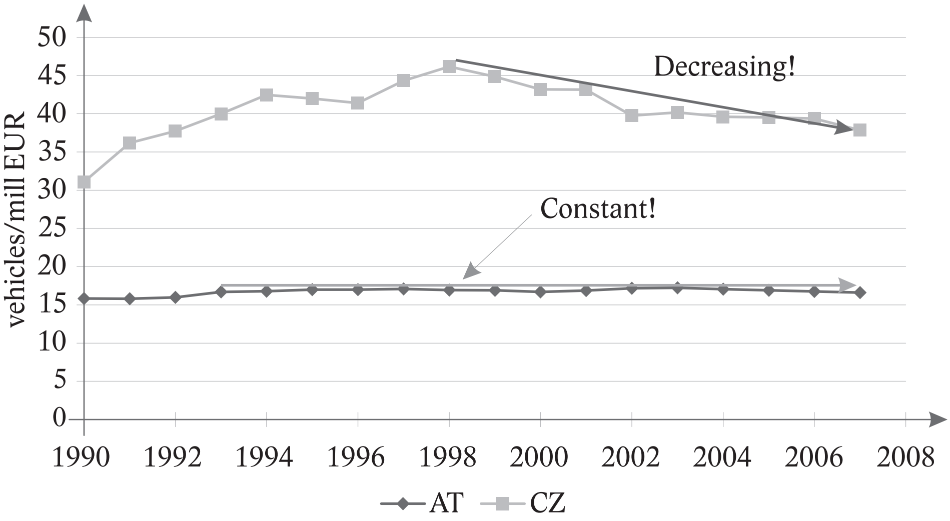

Fig. 12.17: Development of vehicle stock per Mill. EUR of GDP in the Czech Republic and Austria

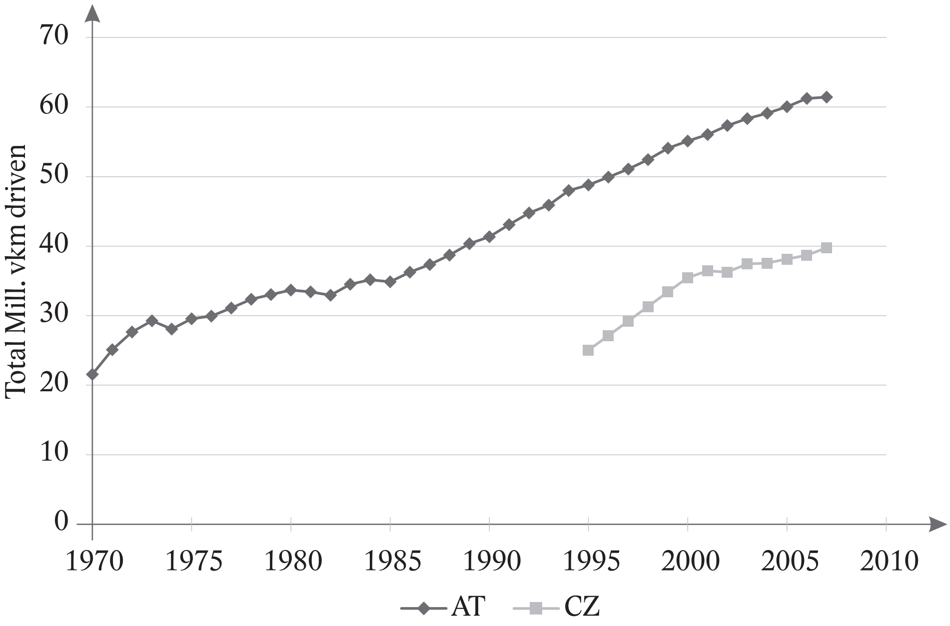

Fig. 12.18: Development of total person km driven in the Czech Republic and Austria

12.7 Fuel price development in the transport sector

In this chapter the development of fuel prices in the transport sector in the Czech Republic and Austria is analyzed.

12.7.1 Diesel and gasoline prices

Fig. 12.19 and 12.20 depict the development of current as well as real (of 2005) diesel and gasoline prices in AT and CZ from 1980 to 2007. The most impressing feature in this figure is that the current prices of diesel and gasoline in the Czech Republic **decreased** after 2000. **Why** did this decrease occur? The major reason as seen in Figures 12.21, 12.22 and 12.23 is because of how the exchange rates developed and the tax structures changed (à tax decreases).

A more detailed look at the development of diesel and gasoline prices for households is presented in Figures 12.21, 12.22, and 12.23. Figures for gasoline and diesel prices presented in EUR or USD are in the CZ case significantly affected by changes in exchange rates CZ-USD and CZ-EUR. Impact of exchange rate changes and fluctuation in the years around the year 2000 caused different curve behaviour that uses CZK and USD or EUR.

The difference in the behaviour of the curve given in CZK compared to that of the curve given in USD can be explained by the way in which the gasoline and diesel market prices were created. The CZ prices basically follow the prices on the Rotterdam commodity exchange given in USD. The continuous strengthening of the CZK to a significant extent halts the price increase.

12.8 Development of fuel intensities in transport

In this Section the development of different types of fuel intensities in transport in the CZ and AT is compared. Technical bottom-up intensities—litres per kilometre driven—as well as economic top-down intensities are analyzed.

The historical development of diesel and gasoline fuel intensities in CZ are nearly constant between small ranges, see Fig. 12.24. Over the period of 1999 to 2004 we can observe a slightly upward trend for gasoline cars.

Fuel intensities for gasoline and diesel cars in Austria have both decreased since the late 1970s, see Fig. 12.25. The strongest decrease can be observed

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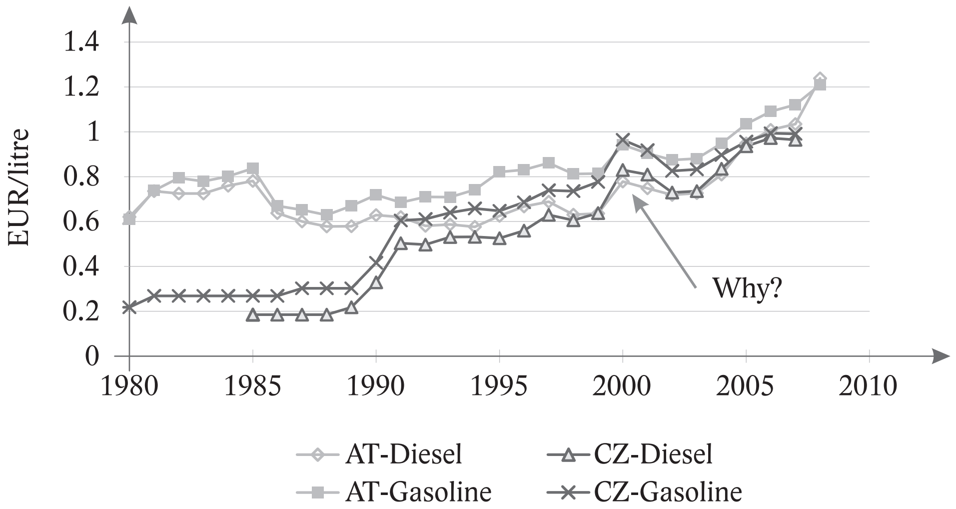


Fig. 12.19: Development of current diesel and gasoline prices in AT and the CZ from 1980 to 2007

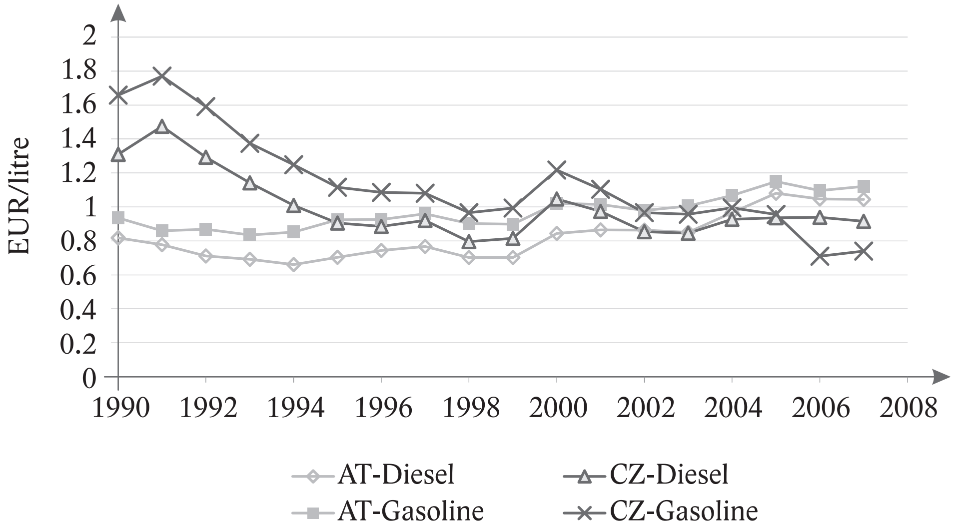
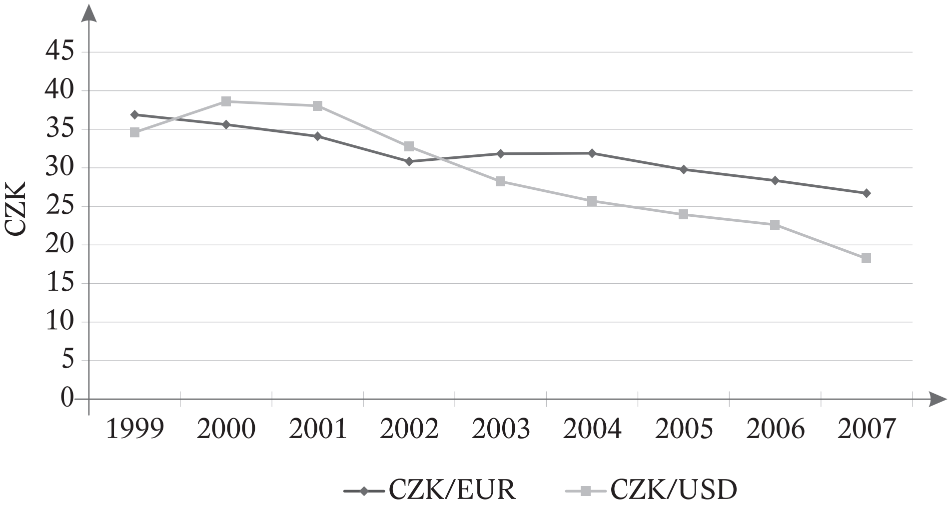
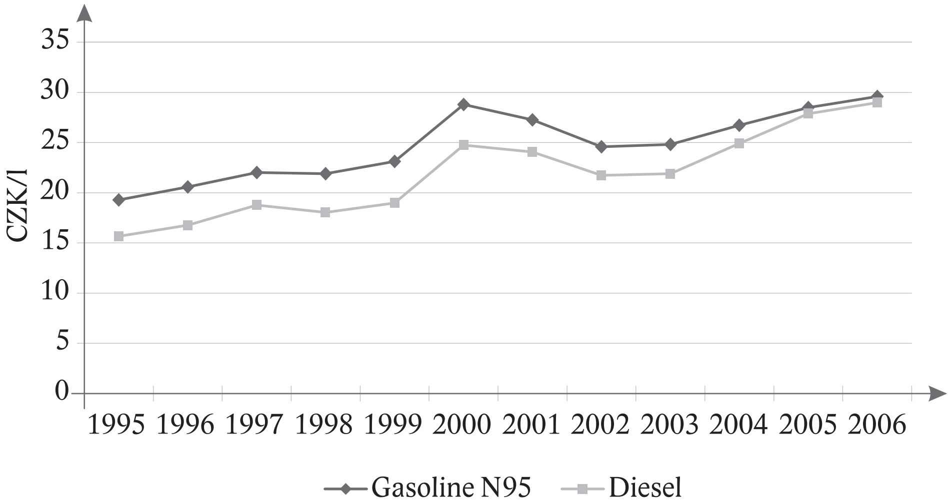


Fig. 12.20: Development of (real) diesel and gasoline prices of 2005 in AT and the CZ from 1980 to 2007



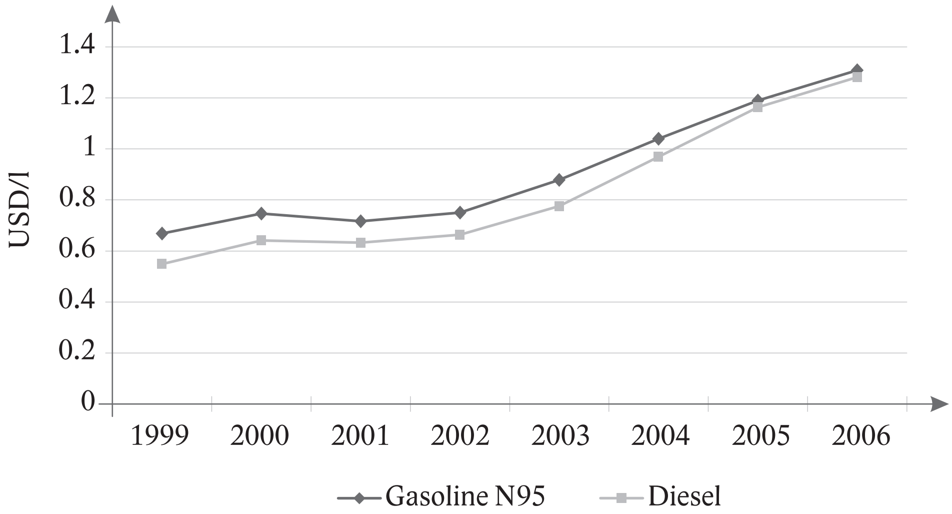
Source: Czech National Bank 2007

Fig. 12.21: Development of CZK/US$ exchange rates



Source: CZ transportation yearbook 2006, 2007

Fig. 12.22: Development of gasoline and diesel prices in the Czech Republic in CZK/l, nominal values, VAT included



Source: CZ transportation yearbook 2006, 2007

Fig. 12.23: Development of gasoline and diesel prices in the Czech Republic in USD/liter

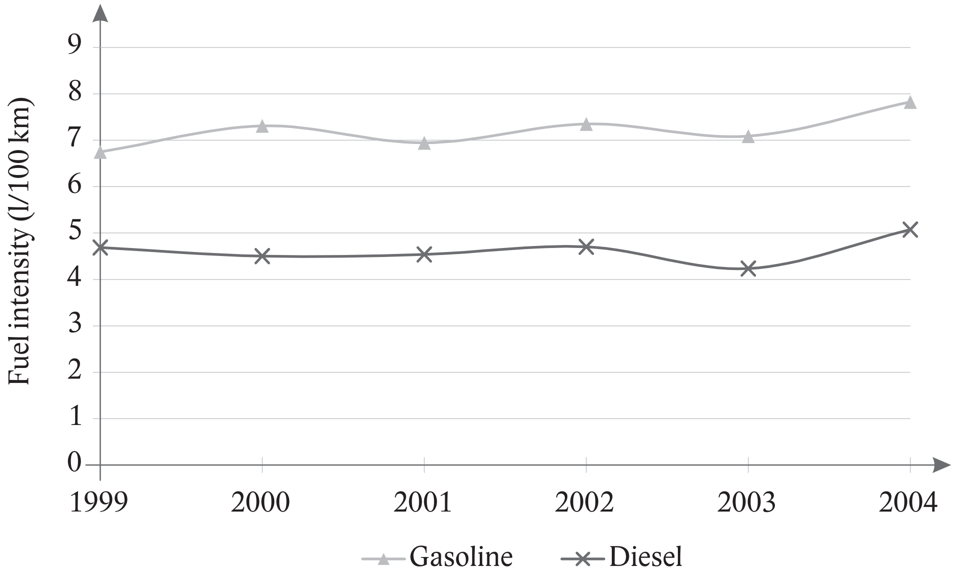


Fig. 12.24: Development of fuel intensities for gasoline and diesel cars in Czech Republic 1999–2004

for diesel cars between 1982 and 1988. Part of the efficiency gains were compensated by a switch to larger cars.

In Fig. 12.26 the development of technical bottom-up fuel intensities in passenger transport in Austria is depicted for three different size categories and the aggregates as well. The most interesting perception from this figure is that for all size categories fuel intensities decreased more than the average. This is due to the significant switch to larger cars, see also Fig. 12.16. Moreover, fuel intensities decreased the most in the period of very high oil prices—1980 to 1985—and decreased much more moderately afterwards when prices were low.

The economic top-down intensities development in overall transport in the CZ and AT (1990–2006) is depicted in Fig. 12.27. Similar to the pattern for vehicle stock per GDP—see Fig. 12.18—also the energy consumption per Mill. EUR is virtually constant in AT. Again the feature is almost twice as high in the CZ as in AT. In Figure 12.18 there is a clear decrease of the feature vehicles per Mill EUR. On contrary in Fig. 12.26 for energy consumption per Mill. EUR since 1995 no decreasing trend has been observed.

Conclusions

The development of energy consumption in passenger transport in the Czech Republic and Austria show similar trends. In both countries energy consumption increased tremendously between about 1998 and 2005. Since then there are some signs of stagnation probably due to higher prices in recent years.

Regarding the development of the stock of passenger cars in the Czech Republic and Austria it is most interesting that in recent years the car stock in CZ has grown much steeper than in Austria and will probably this year (2008) surpass it.

The development of specific passenger car ownership in Austria shows already kind of a stagnation since about 2003 at a figure of about 500 cars per 1000 inhabitants while in the CZ specific passenger car ownership is growing continuously.

Analysis of the intensity of passenger vehicles per amount of GDP provides an interesting conclusion: Firstly, this intensity is more than twice as high in the CZ than in AT; Secondly, it is continuously decreasing in the CZ since about 1998 and virtually constant in AT since 1990.

New registrations of passenger cars are in the Czech Republic on a level that is half of that in Austria. Moreover in AT it has stagnated since about 1990.

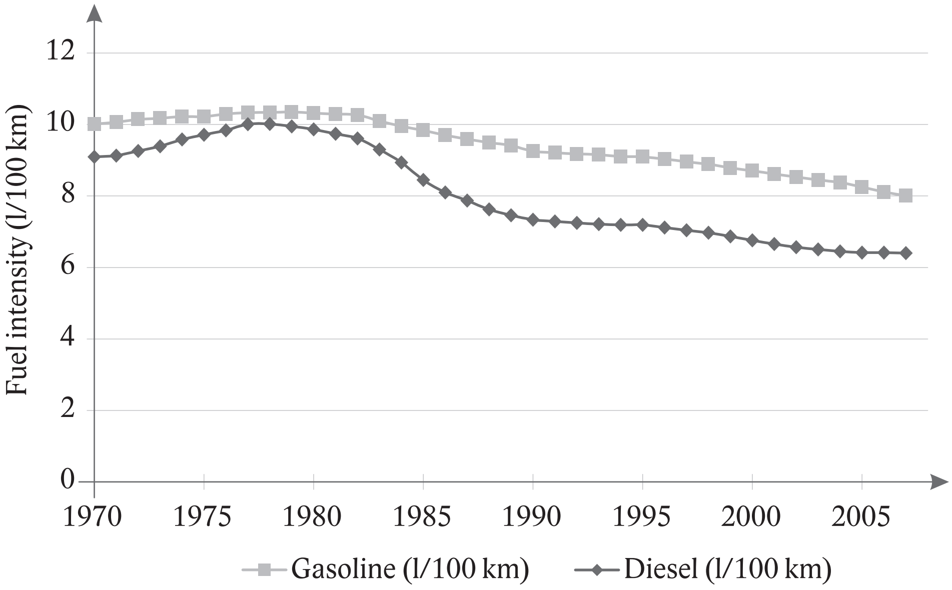


Fig. 12.25: Development of fuel intensities for gasoline and diesel cars in Austria 1970–2007

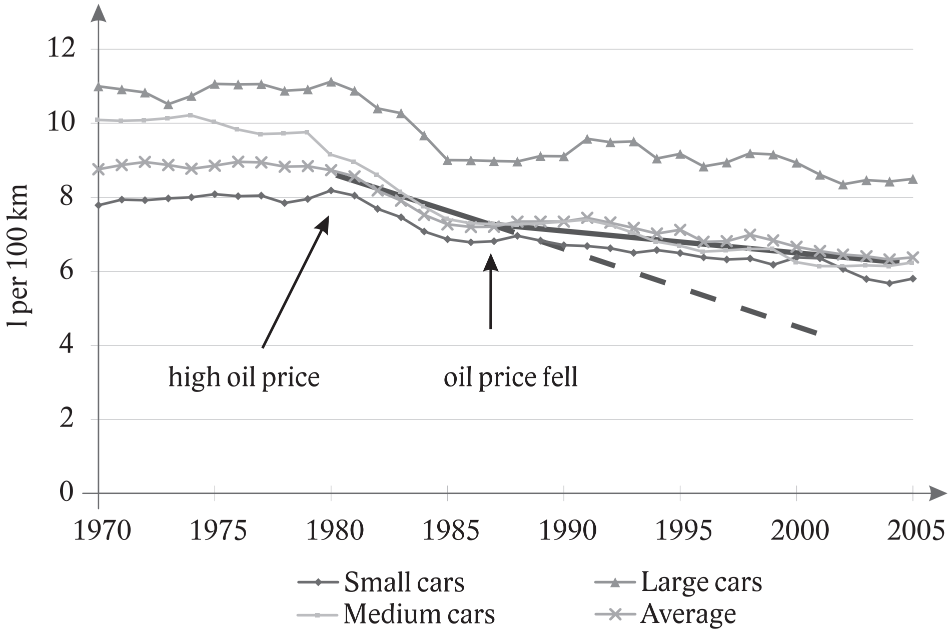


Fig. 12.26: Fuel intensity development in passenger transport in AT

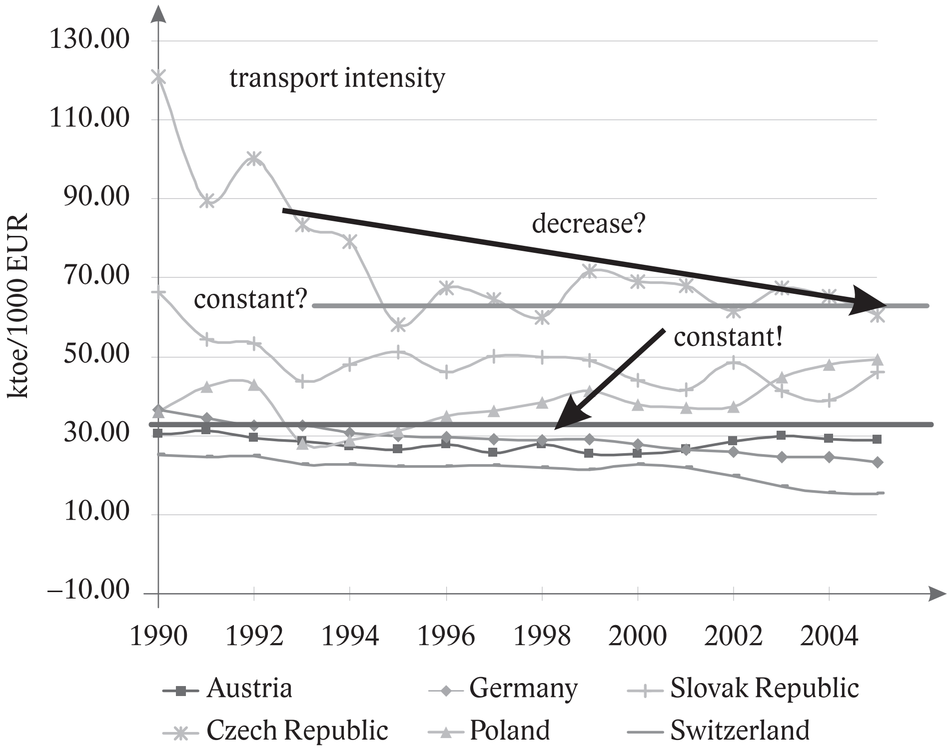


Fig. 12.27: Economic top-down intensities development in overall transport in the CZ and AT (1990–2006)

Regarding service demand in total person-kilometer driven, from the data analyzed it is hard to say whether there are some signs of stagnation—especially for AT one could interpret stagnation from this figure—or whether this is only due to short-term volatility or higher recent prices.

With respect to fuel prices in transport in recent years CZ prices have been stagnating while they have increased in Austria. All in all, in Austria energy prices are still significantly higher than in the CZ.

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PART

E

ENERGY EFFICIENCY IN BUILDINGS

13

Energy efficiency of buildings—a win-win-strategy

13.1 Introduction

With the Kyoto Protocol Austria has agreed to reduce its greenhouse gas emissions by 13% by 2012, compared to the base year 1990. To fulfill this commitment and to avoid possible payments for international CO_2-Certificates, amounting from 1.5 to 5 Billion Euros (depending on the current market value), financial subsidies for energy efficient houses (e. g., Passive-Houses) should be harmonized and optimized throughout Austria. This is especially relevant in regard to residential buildings, for refurbishments of old as well as construction of new buildings, because of the long-term impact of the building structure.

The general application of the Passive-House technology, particularly in the field of refurbishments, would create a clear win-win situation. Advantages include:

- enhancement of living and working conditions,
- reduction in demand for fossil fuels, which in turn would decrease import dependency for energy. This would boost security of supply while reducing the reliance on non-renewable energy sources,
- favorable effect on the trade balance,
- investments into the local economy,
- improvements of the employment situation in the building sector and renewable energy supply sector,
- profits from developing worldwide leadership in know-how and technology,
- positive impact on the ecology and climate.

The enormous energy savings potential is a very important point for the European Union because of its deep dependency on foreign energy imports. In December 2002, the European Community approved an EU Directive on the energy performance of buildings (EPBD-directive 2002/91/EC). According to this Directive, an energy performance certificate of an apartment or building has to be provided to potential tenants in the case of buying or renting a property. This should inform the user about the estimated heating demand and should be used as a marketing instrument to improve the value of energy-efficient buildings. The Directive is going to be revised to establish a harmonized calculation methodology and harmonized energy performance indicators.

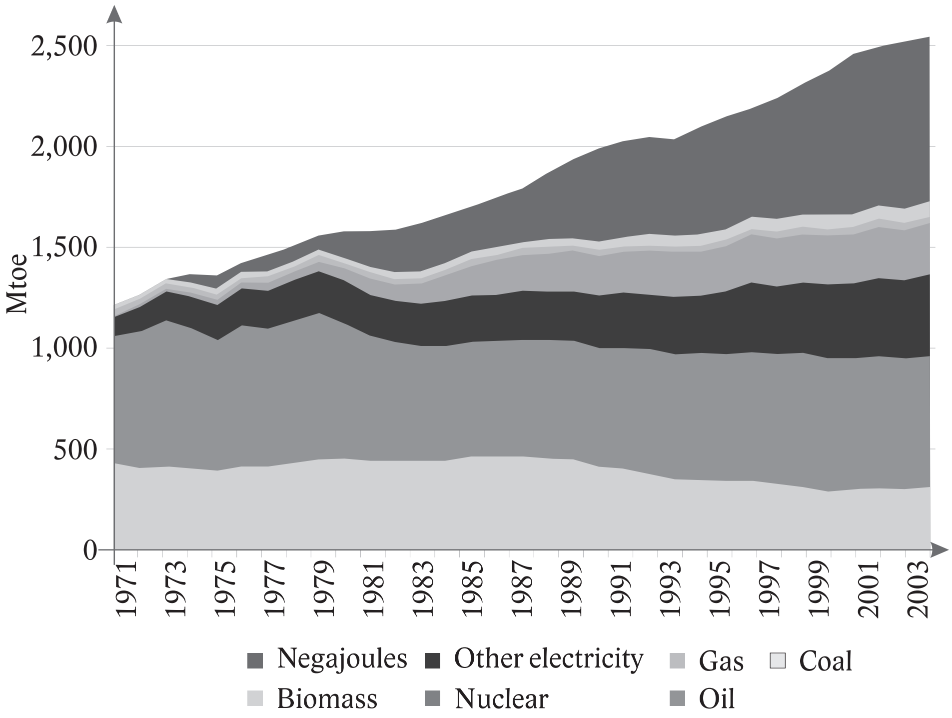
The energy efficiency of buildings is hardly visible. Only experts can recognize the differences between Passive-Houses and conventional buildings. To raise the awareness with the public it is necessary to make energy efficiency clearly visible. This can be done easily by posting an information board with relevant energy performance indicators outside the building, which all people passing by can notice.

13.2 The path to a sustainable future

The goal of Sustainable Development is to meet the needs of the present generation without compromising the ability of future generations to meet their own needs. This means that we have to provide enough energy and material resources for the next generations, an objective that can be achieved using two parallel measures: increasing our resource efficiency and making the transition to renewable resources. The following figure shows the total primary energy demand of the EU. The “Negajoules” band on top indicates energy savings from efficiency measures, based on 1971 energy usage. The basic messages are:

- Energy demand is rising and without efficiency measures the increase would be even higher. This has occurred in spite of the remarkable energy savings made by efficiency measures, as total overall energy demand has increased sharply.
- The rising energy demand makes the withdrawal of fossil and nuclear power stations unfeasible. Therefore the share of renewable energy resources remains negligible.
- A significant increase in energy efficiency is needed. This would be the driving force for a transition to renewable energy sources. This is also of particular importance for the protection of the climate.

The concept for a drastic increase of energy efficiency in the building sector already exists within the Passive-House concept of Wolfgang Feist.



"Mtoe" = Megatons of oil equivalent, "Negajoules" = energy savings by efficiency measures, based on 1971 energy usage

Source: EC 2005; Data-Source: Enerdata

Fig. 13.1: Impact of efficiency measures on the development of the primary energy demand of EU-25

13.2.1
How do building activities influence Sustainable Development?

Buildings are of crucial importance for social and environment related politics. On the one hand, we spend about 93% of our time inside buildings. On the other hand, the life cycle of building construction has an important impact on the environmental performance of a region. Buildings in Central Europe cause:

- nearly half of the primary energy demand (BMWA 2004),
- nearly half of the greenhouse gas emissions (BMWA 2004),
- approx. 25% of the mineral material demand (BAWP 2001),
- approx. 60% of the annual waste production (BAWP 2001).

Due to their long lifespan, most buildings have long-term impacts on the environment and on future generations. Responsible architecture seeks to significantly reduce the total energy demand of buildings, which is feasible with innovative building technology.

A Passive-House requires only 5%–10% of the useful heating energy of an average Austrian house. Meanwhile, more than 1000 new buildings in Austria meet the Passive-House Standard and existing buildings have also been refurbished to reach the Passive-House Standard.

13.2.2 Passive-House standard

The Passive-House concept was developed in the late 1980s by Prof. Bo Adamson from Lund University in Sweden and by the German physicist Wolfgang Feist, founder of the Passive-House Institute in Darmstadt. The concept could be implemented at this time because of the new development of energy efficient windows. The first Passive-House was built in 1991 in Darmstadt, Germany, where Wolfgang Feist and three other families are still living.

A Passive-House is a super-insulated green building with a comfortable and healthy interior climate that can be maintained without active heating and cooling systems (Energeticky pasivní dům—Energetic Passive-House). Thermal comfort can be achieved exclusively by post-heating or post-cooling of the fresh air mass required for adequate indoor air quality. Hence, an efficient ventilation system, required within energy efficient and airtight buildings, is sufficient to both heat and cool the building.

Ventilation systems of Passive-Houses are very different from air-based heating and cooling systems used most widely in America. Air conditioning systems mainly recirculate indoor air at a very high rate (10 air changes per hour (ach)). In Passive-Houses, the air is not recirculated but is replaced by external air to maintain good air quality (0.3 to 0.6 ach).

A common misunderstanding is the fear that the windows in Passive-Houses cannot be opened. Of course they can, but they don't need to be opened, because fresh air is continuously supplied via the ventilating system. Unlike window ventilation, fine filters in the ventilating system keep out dust and pollen. Hence, a Passive-House enables greater living comfort, especially for people sensitive to dust, allergens, or traffic noise.

The Passive-House concept is not a construction method or a building style. It is a building standard that is defined by a heating load per treated floor area of less than 10 W/m^2 per heated floor area. This limiting value is derived from the maximal temperature of preheated fresh air of 50 °C (to avoid smoldering of dust). The annual heating demand in a Passive-House depends on the climate. In Austria typically 15 kWh/(m·a) are needed per heated floor area.

In Stockholm this value could be as much as 20 kWh/(m·a), and in Rome perhaps 10 kWh/(m·a).

To achieve the Passive-House criteria, three major aspects must be considered: super-insulated building without relevant heat bridges, airtight building, and solar inputs. Thus, a precondition for energy efficient buildings is a sophisticated building envelope.

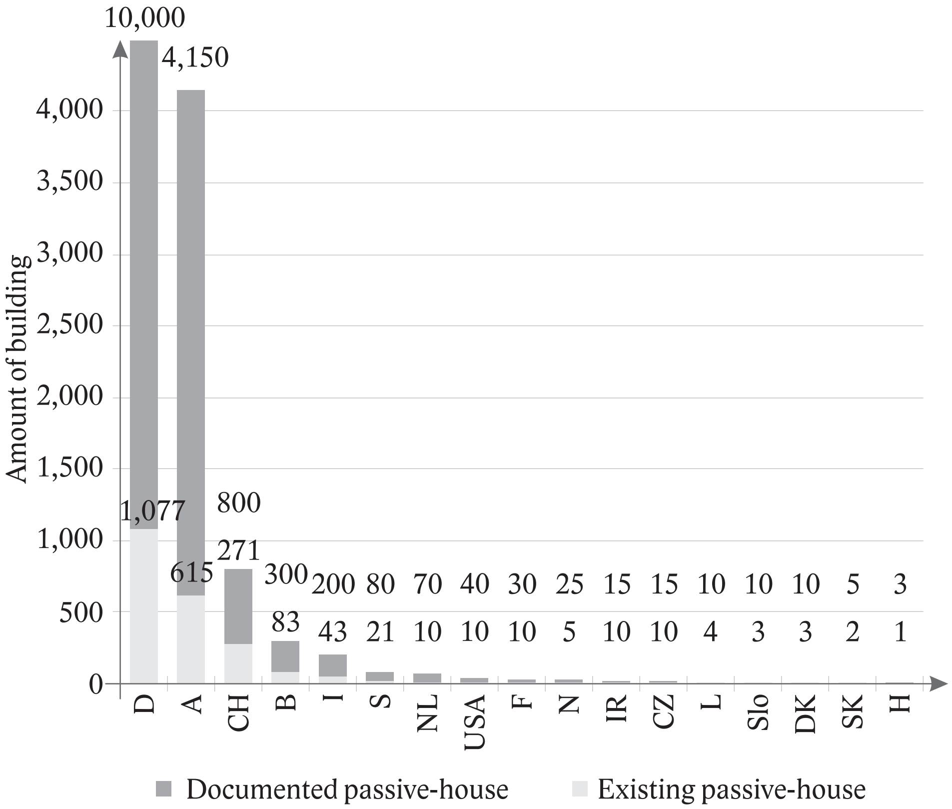
The heating energy demand of buildings is usually dominated by thermal transmission losses. Therefore the best option for minimizing the heating energy demand is intensive thermal insulation. To avoid further thermal losses the air change rate through unsealed joints must be less than 0.6 times the house volume per hour at a pressure difference of 50 Pa. The quality assurance should be performed by Blower-Door tests and thermal imaging.

The Passive-House concept is applicable to all types of buildings. In Austria, many passive residential buildings and office buildings are already in use, as well as several examples of other buildings: administration buildings, schools, kindergartens, student residence halls, and supermarkets. An attractive example of a Passive-House in an extremely cold climate is the Schiestlhaus in the Austrian Hochschwab region. This Alpine refuge is located 2154 m (7067 ft) above sea level in an “island location” and was designed to be self-sufficient and eco-friendly with respect to energy and water usage.

13.3 The role of Austria in technology transfer and the promotion of the passive house concept

During recent decades, Austria has accumulated substantial practical experience concerning Passive-Houses, solar heating systems, and biomass energy production systems, and has been a pioneer in the promotion of eco-friendly and energy efficient houses. By 2015 the passive house standard is aimed to be the target criteria for all subsidized residential buildings (Bund/Länder 2008). As of July 2009 there were 6.5 million m^2 of passive-house floor area in Europe, of which 2.5 million m^2 are in Austria (5,000 buildings) and 2.4 million m^2 in Germany (Daxböck 2009). That means Austria has a passive-house density of 300 m^2 per 1000 residents, which is 10 times greater than Germany.

In 2008, 7% of all new buildings in Austria were constructed to the Passive-House standard. At the end of 2008, there are existing 4,150 buildings with around 7,000 residential units and ca. 20,000 Passive-House residents according to Lang (2009). This is remarkable considering that no additional financial subsidies are provided throughout Austria. In some Austrian federal

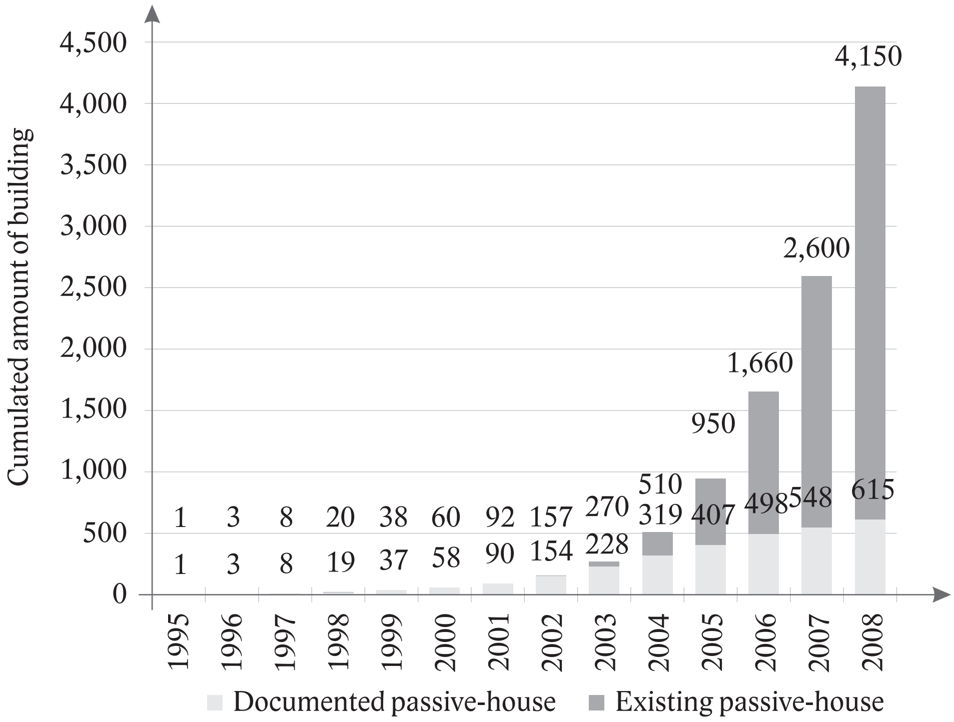


Quoted from Lang, 2009

Fig. 13.2: Overview of documented and existing Passive-Houses worldwide

states subsidies for Passive-Houses are provided. The state of Vorarlberg is an intense Know-How region for sustainable buildings and has taken the lead to demand at least Passive-House standard for all subsidized multifamily houses since the beginning of 2006. Since January 2009 the state of Vienna has been providing a very attractive subsidy for reaching the Passive-House standard with thermal retrofit measures. Now these pioneering trends should be encouraged and harmonized in all other federal states in Austria.

Special subsidies for research & development of passive houses came from the Austrian Federal Ministry of Transport, Innovation and Technology (BMVIT). The impulse-program "Buildings of Tomorrow" (www.hausderzukunft.at) has supported more than 300 projects since 1999 that are all documented on the website. The BOKU-Division for Sustainable Construction together with partners analyzed most of the projects and transferred them into lectures at BOKU-Vienna, TU-Vienna, TU-Graz, TU-Bratislava and other universities and

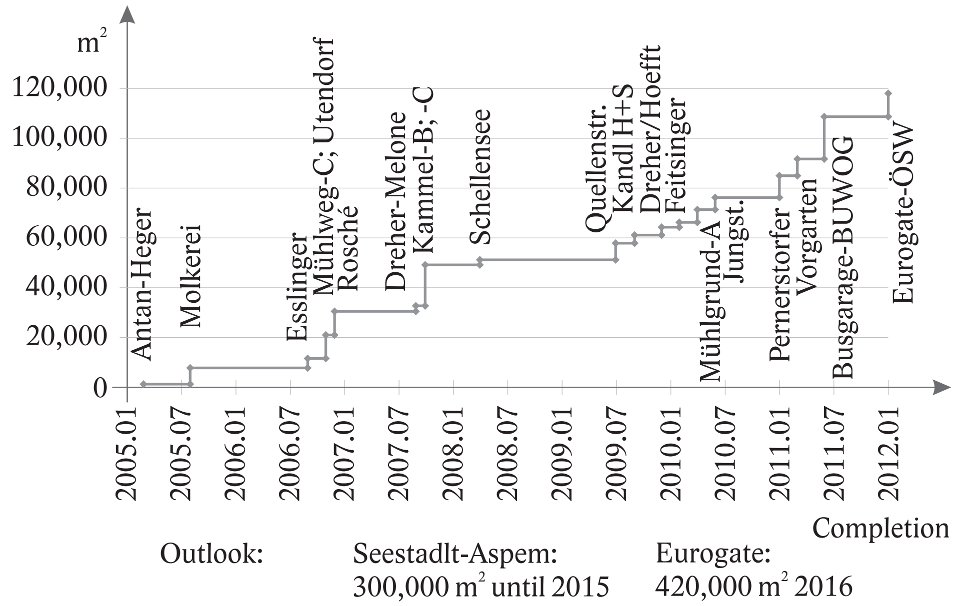


Quoted from Lang, 2009

Fig. 13.3: Overview of the development of documented and existing Passive-Houses in Austria

technical colleges (Treberspurg et al., 2008a). The collected material includes detailed research results for timber constructions in passive house standard (Schöberl et al., 2001, Ambrozy/Lange 2007, Kogler 2008), for additional costs of multifamily passive houses (Schöberl et al., 2004), for building services / HVACR (Streicher et al., 2004) and many more. The realizations of the first passive housing estates in Vienna—Anton-Heger-Platz, Esslinger Hauptstraße, Mühlweg-C and Utendorfgasse—have also been supported by this program. As figure 13.2 shows this was an essential and sustainable stimulus for Vienna.

Further development in Vienna was driven by special competitions for housing developers. These competitions have a long history in Vienna and each competition focuses on a different innovative topic. The passive house competition for the Kammelweg site resulted in a major increase in the useful floor area meeting the Passive-House standard in Vienna. Further competitions have been executed for the area of Nordbahnhof (project Vorgarten-Leystrasse



Source: Treberspurg et al. 2009

Fig. 13.4: Passive housing estates in Vienna—Recent developments and prospects

and Busgarage in figure 13.2) and the area Eurogate. Beside the competitions there exists a special advisory committee for housing estates. The submitted plans are evaluated in terms of ecology, economy, aesthetic and social aspects.

In comparison to other Austrian federal states, Vienna could thereby reach first place in regard to the number of residential units built to meet the Passive-House standard. By 2005–2007, some 637 residential units were built to meet the passive-house standard (3.9% of all residential units built within that period). Currently 884 residential units are inhabited with overall construction costs of € 85.7 million (subsidies: € 30.5 million) and 16 housing estates are planned or under construction with approx. 1,800 residential units and estimated overall construction costs of € 232 million (subsidies: € 83 million). (Daxböck 2009)

Vienna was the place where the first student hostel (dormitory) to meet the passive-house standard in Austria was built—the Molkereistrasse in 2005. It was planned by Baumschlager-Eberle P.ARC Architects and at that time the largest passive-house worldwide with 10,527 m^2 gross floor area (Treberspurg et al., 2008b). One year later, in 2006 the residential building Roschégasse 20 was completed—planned by Treberspurg & Partners Architects—and with its 13,234 m^2 gross floor area took the lead as the largest passive-house (see section 13.4.1–2 of this article).

The consistent pursuit of energy-efficient and solar architecture in theory and practice has been the aim of the work of the Treberspurg architect's office since 1982. A great deal of personal commitment and an awareness of the ethical responsibility of the architect to plan buildings that fulfill requirements in this field for more than the next hundred years power these efforts. Treberspurg was honored with the UIA-award in 1999 in Beijing "For the Improvement of the Quality of Human Settlements". He occupies the Chair of Sustainable Construction at the University of Natural Resources and Applied Life Sciences in Vienna and also holds lectures at the TU Vienna and the TU Bratislava. He is author of the publication 'Neues Bauen mit der Sonne' (English: New Buildings with the Sun) (Treberspurg 1999) and 'solarCity—Linz Pichling' (Treberspurg 2007).

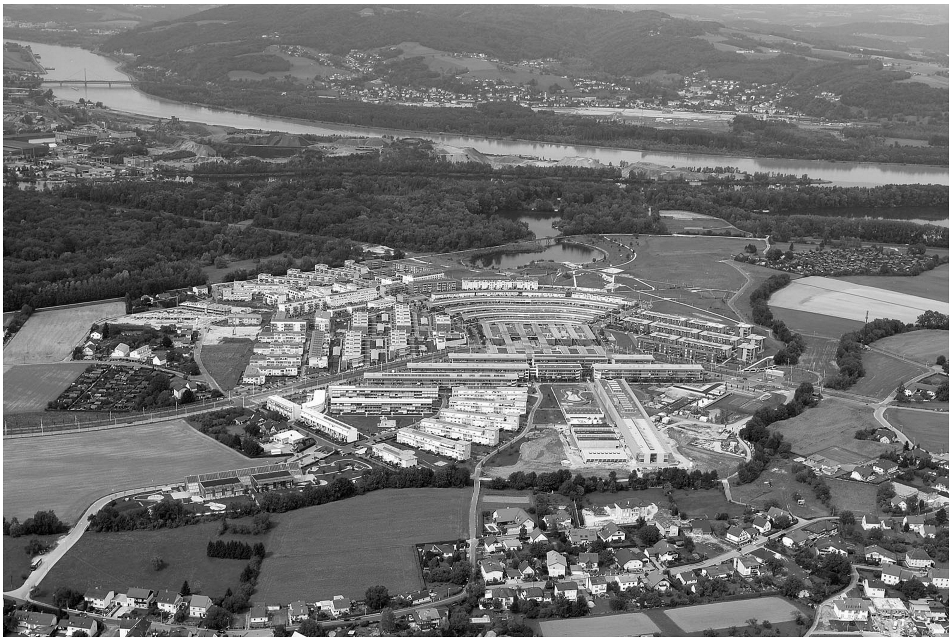
In cooperation with the organization Ekobydleni in Brno, an exhibition named 'Austrian Solar Architecture' was organized where the projects of Treberspurg & Partner architecture office and Reinberg architecture office were presented. The exhibition was shown in different cities—Prague, Brno and Bratislava, and was also a part of a Green Architecture exhibition, together with a lecture at the Austrian Cultural Forum in Prague in November 2008.

13.3.1
Sustainable urban development—the example of solarCity Linz Pichling

During the years 2001 to 2005, twelve housing developers in Linz built a total of 1 300 residential units on a 36-hectare site in Linz Pichling. The main objective was to realize a European exemplary model of future-oriented urban development. The motivation for this project came from the problematic population developments and settlement trends in the region of Linz. It was necessary to take strategic measures to counteract the migration of the resident population, the increasing number of commuters and the development of suburbanization around the city of Linz.

The main focus of this urban development project was:

- Low-energy housing regarding solar criteria;
- Future-oriented power supply and drainage and sanitation;
- Building biology;
- Local recreation and nature facilities;
- Modern socio-cultural and family-oriented infrastructure;
- Efficient public transport connection.



Source: Magistrat der Stadt Linz, Stadtplanung

Fig. 13.5: Solarcity Linz Pichling

Another central objective was to realize a target market-oriented marketing concept to achieve complete occupancy of the residential units. The concrete planning objectives had already been defined in 1999, with the property purchase agreements, which were binding for the housing developers.

The first building phase of the solarCity included 630 residential units and was planned by the READ group (Renewable Energies in Architecture and Design) consisting of well-known architects like Foster and Partners, Richard Rogers Partnership, Herzog + Partner and Renzo Piano Building Workshop, working together with the engineer Norbert Kaiser. In 1995 further non-profit-making housing associations could be found for the second building phase to build a total of 1,300 residential units in the solarCity. In 1996 an international architecture competition was set up for the urban planning of the second construction phase. Architect Martin Treberspurg emerged from this competition as the clear winner for the planning of the second development area. Additionally he and his architectural office Treberspurg and Partner Architects could realize a housing development project with the housing association EBS, including 93 residential units in Passive-House and low energy standard.

In March of 2007, the University of Natural Resources and Applied Life Sciences in Vienna began conducting a three-year sustainability check. This

Source: Treberspurg & Partner Architects

Fig. 13.6: Residential Building EBS

sustainability monitoring and reporting project, supported by the Province of Upper Austria, the City of Linz and the housing developers, is based on quantitative quality indicators and involves intensive interviewing of the residents. The social analysis is being carried out by Dr. Josef Lins of the Johannes Keppler University of Linz. The goal of the post-occupancy evaluation is to provide factual documentation of the quality of the solarCity and a clear presentation of its sustainability performance, focusing particularly on the areas of urban development, architecture, energy management, climate protection, material management and user satisfaction. An additional part of the project consists in developing an easily applicable orientation and decision-making tool that can be used for future urban development projects and new residential buildings in Upper Austria.

13.4
Sustainable buildings in Austria

13.4.1
Alpine mountain refugee Schiestlhaus

The Schiestlhaus of the Austrian Tourist Club (ÖTK) is situated at an altitude of 2154 m above sea level on a plateau directly under the main summit of the Hochschwab. As the existing 120-year-old building was in very poor condition, the owner decided for a replacement. ÖTK agreed to realize a pilot project: The first large mountain refuge built to Passive-House standards. The new refuge accommodates 70 people. The Schiestlhaus is currently used from the beginning of May until the end of October. However, positive experience and popular demand from visitors to the Schiestlhaus has led ÖTK to consider extending this period.

As the refuge is at a great distance from any kind of infrastructure, planners aimed to develop a self-sufficient building, which uses an integrated package of thermal collectors, photovoltaic elements, and sufficient storage capacities for power and heat supply.

In addition, the special conditions of this location with a view to nature and environment conservation (the main sources for the second water supply pipeline to Vienna are situated in the Hochschwab area) as well as the requirements resulting from the special use of the building as a hostel had to be taken into account.

What was needed was a system that met the complex requirements of building construction in an alpine environment. The design should be able to withstand the extreme loads resulting from wind and snow pressure. At the same time, the difficult conditions for transportation and assembly and the associated costs called for special solutions. As the Schiestlhaus can neither be accessed via road nor freight cable car all building material had to be transported by helicopter. Drinking water supply required the development of a complex system of rainwater capture because there are no water sources at this height.

The development of an overall integrated system that meets these manifold specifications requires close cooperation between designers, planners, and professionals as well as networking between research and practice. The realization of the Schiestlhaus has created a prototype for solar and ecological building construction in alpine island locations. The project partners are testing a number of sustainable technologies and a sophisticated concept for the floor plan under extreme conditions. The solutions and findings resulting from this

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Source: DI Wilhelm Hofbauer

Fig. 13.7: Schiestlhaus—mountain refuge. Design and realization: arge solar4alpin, pos architects, Treberspurg & Partner Architects

project may be used—with slight modifications—for other building projects in similar alpine conditions.

13.4.2 Housing estate Roschégasse

The residential building complex meets Passive-House standards and is situated at the south-eastern outskirts of Vienna, in between the center of Vienna and Vienna Airport. Although this part of the city is a rather quiet residential area, an efficient public link to the centre is given with tramway line 71.

Four-story buildings with an attic linked back are situated alongside the two streets to the north and west. They contain apartments facing both sides (south and north / west and east). No flat is oriented solely to the street. Inside the site the development reaches an altitude of only two stories with also an attic linked back. Two bars border the court in the south and the east and

Source: Treberspurg & Partner Architects

*Fig. 13.8: Roschégasse—One of the largest passive housing estates in Vienna, Austria with 114 dwellings.
Design and realization: Treberspurg & Partner Architects*

enclose another building structure in the center. They contain two-story units (maisonettes) with one-story apartments on top, which can be accessed over access balconies. Some have roof gardens with access to internal stairs and galleries.

The architecture concentrates on a few design elements, such as the bays along Pantucekgasse, the strongly accented and partly overhanging ends of the attic), or the framework of the balconies facing the court. Particular attention was drawn to well-designed apartments and the high quality of open space areas.

At the time of its completion this project was the largest Passive-House in the world. It represents optimal quality of housing and comfort. The apartments are equipped with a decentralized, compact ventilation unit with an integrated, high efficient heat exchanger (90% heat recovery rate). The remaining heating demand is covered by heated supply air. Heating of supply air and hot water preparation are done by a small heat pump using the exhaust air as heat source. The fresh air is preheated by deep geothermal heat exchanger: 11 units with 100 m depth. The geothermal heat is transferred to the fresh air on the rooftop by a heater battery.

The imbedding of the PV-system as an integrated component of the facade marks a visible symbol for sustainability and the supply of the building with renewable energy.

13.4.3
Further passive housing estates in Vienna

Currently the BOKU and partners are evaluating the sustainability of Viennese passive housing estates compared with conventional housing estates of the same construction period through research project NaMAP (Treberspurg et al., 2009). This Facility-Performance-Evaluation focuses on multifamily houses, because they have the highest share (approx. 45%) of the existing useable floor area of all documented passive houses in Austria (Lang 2009). All of the buildings under study have been occupied for more than one year. This is necessary to obtain significant results for the energy performance and the living comfort.

The social aspects are evaluated by Alexander Keul (Salzburg University) and the economic aspects by Andreas Oberhuber (FGW—Forschungsgesellschaft für Wohnen, Bauen und Planen). For the evaluation of the energy-performance the final energy consumption, the primary energy demand and the greenhouse gas emissions are taken into account and compared with expectations at the planning stage.

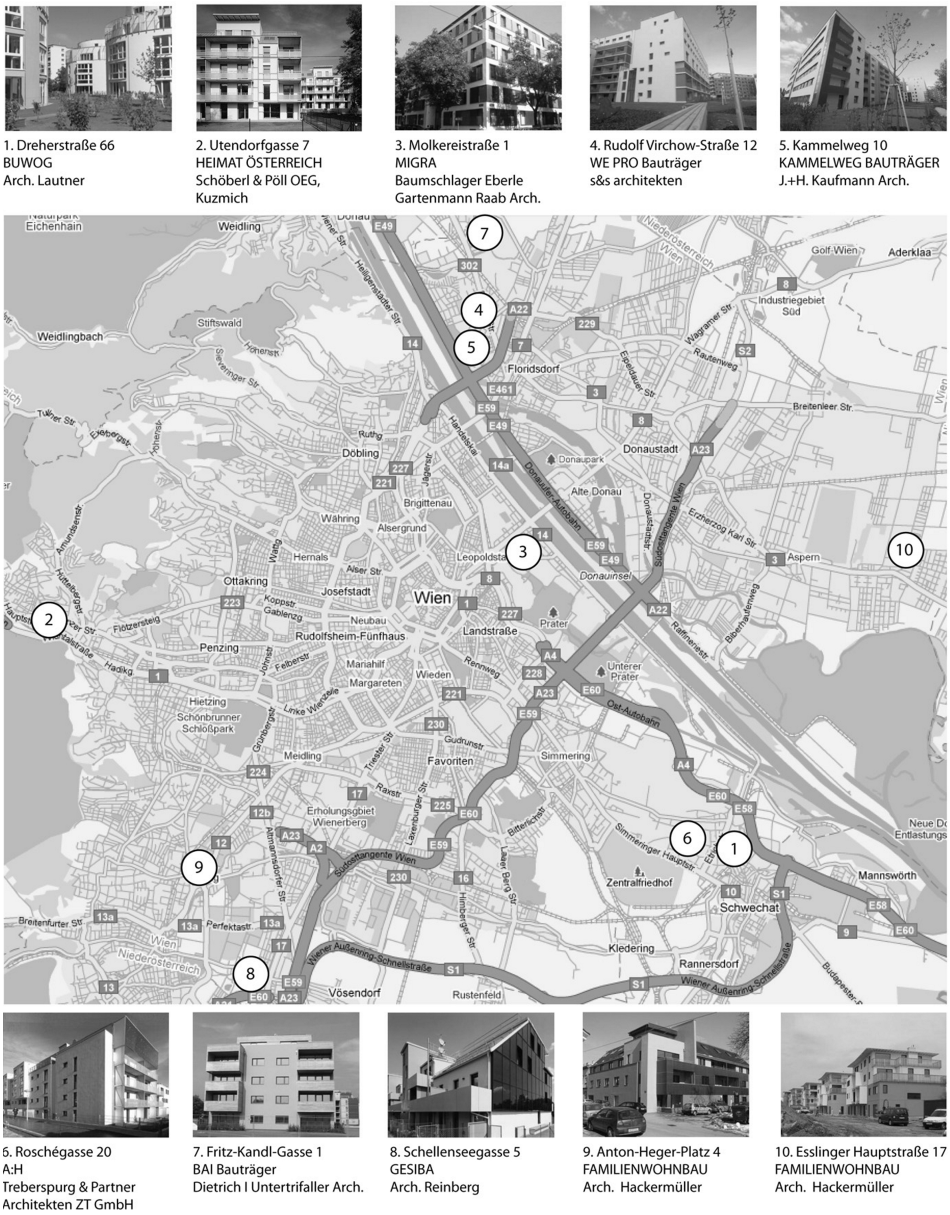
Figure 13.2 shows the selected passive house buildings and the building developers and architects involved. All of these buildings use geothermal energy to preheat the fresh air used for ventilation, but they vary in energy supply, technical details, building construction and the thermal envelope.

The preliminary results of the study are:

- The measured heating energy consumption of all investigated passive houses is very low compared to conventional housing estates built in the same building period.
- Living comfort in passive houses is higher than the Viennese baseline.
- Useful space heating energy demands are about 80% less than similar Viennese housing estates built in the period 1980–2000. The reference value for these buildings was taken from a study of Viennese housing estates supplied by district heating (Hofbauer 1998). The savings in heating energy compared to housing estates of the same construction period are still to be analyzed in detail.
- Fine-tuning of the regulating system is necessary to reach the design targets.

	Passive housing estates	Flats	Construction	Energy supply — space heating	Space heat emission	Ventilation system
1	Dreherstraße 66	27	Concrete	District heating	Heater battery (register)	Central
2	Utendorfgasse 7	39	Concrete	Gas	Heater battery for incoming air	Semi-central
3	Molkerei-straße 1	133	Concrete	District heating	Mini-Radiator	Decentral
4	Rudolf Virchow-Str. 12, (Kammel-weg Site-B)	92	Concrete	District heating	Mini-Radiator	Central with decentral regulation
5	Kammelweg 10 (Site-C)	80	Light-weight timber	District heating	Mini-Radiator	Decentral with central support
6	Roschégasse 20	114	Concrete	Geothermal energy, photovoltaic	Heater battery + E-Radiator	Decentral
7	Fritz-Kandl-Gasse 1	70	Massive timber	Gas, thermal solar energy	Mini-Radiator	Central
8	Schellen-seegasse 5	22	Concrete	Gas, thermal solar energy	Mini-Radiator	Central
9	Anton-Heger-Platz 4	15	Light-weight timber	Gas	underfloor + heater battery (incoming air)	Decentral
10	Esslinger Hauptstraße 17	46	Light weight timber	7 Variations: geothermal energy + electricity	underfloor + heater battery (incoming air)	Decentral

Tab. 13.1: Overview of analyzed multifamily passive houses—energy system and construction



Source: Vienna-GIS stadtplan.wien.at 15. 08. 2009, edited; Photos from the noted building developers and architects

Fig. 13.9: Passive housing estates in Vienna analyzed by BOKU

The final results will be published online (www.wohnbauforschung.at) by the end of 2009 by MA 50—Vienna housing research.

13.4.4 Austrian Passive-Houses within the EU-R & D-project CEPHEUS

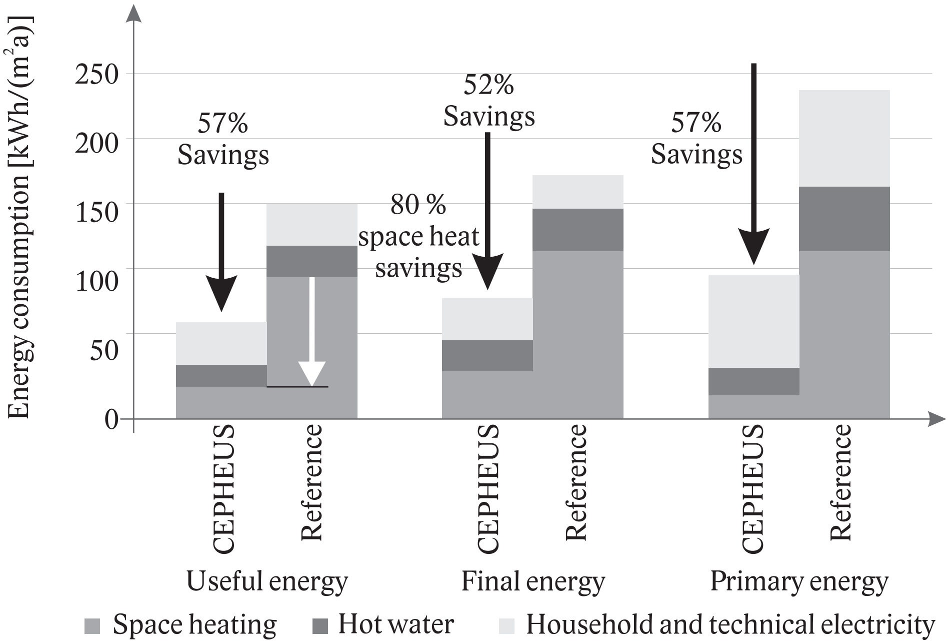
The European CEPHEUS project (Cost Efficient Passive-Houses as European Standards) was the first EU-Research project for analyzing the Passive-House standard. It served to examine and prove the sustainability of the Passive-House Concept in Europe. Fourteen Passive-Houses with a total of 221 residential units were built and analyzed for their living quality, environmental performance and construction costs. Nine buildings with 84 residential units are located in Austria, two in Germany, one in Switzerland, one in France and one in Sweden. Austrian Passive-Houses were built in Lower Austria (1), Upper Austria (1), Salzburg (3) and Vorarlberg (4). These included freestanding single-family houses, terraced houses and multi-floor apartment buildings built both in conventional on-site construction buildings and with prefabricated elements.

Average space heating savings of 80% compared to conventional buildings were confirmed. The research project showed that the additional costs were between 0% and 17%, and on average 8% higher. It can be concluded that Passive-Houses are economically reasonable due to decreased operating costs, higher thermal comfort and healthier indoor air conditions. (Krapmeier, 2001).

One of the buildings of the CEPHEUS project was the Passive-House in Horn designed by Treberspurg & Partner Architects. Building physics and Passive-House consulting was performed by Ingenieurbüro Wilhelm Hofbauer, Vienna and the construction was planned by Buhl GmbH, Gars am Kamp.

The building is a construction prototype of a prefabricated house development. The development is oriented around the following basic principles. In a compact structure, the main living areas are situated in a zone on the south side of the building with a large window area; separated by an interior wall, access areas and side rooms are situated on the north side. Regarding roof shapes, monopitch and gabled roofs are possible, among others. At the customer's request, the gabled roof variant was used. As a consequence, two skylights meeting Passive-House standards had to be installed for natural lighting of the hallway in the upper level.

A cellar was excavated beneath the entire house. Due to the interior descending stairway it was necessary to insulate the structural elements separating the house and cellar appropriately. However, the temperature in the cellar



Source: Krapmeier, 2001, Datasource: Jürgen Schneiders, Passivhaus-Institut Darmstadt

Fig. 13.10: Energy Savings of CEPHEUS Passive-Houses

is influenced by moderate thermal insulation and somewhat through heat dissipated from the technical room; this results in only minimal temperature differences with the living rooms.

The building was designed as a combination of solid and lightweight elements. Because ecological concerns were of great importance to the owners, care was taken to use particularly environmentally friendly materials in addition to meeting the high structural requirements. Therefore, the east, west and north walls were constructed with recycled brick and the interior wall surfaces plastered with loam. On the outside, vapor diffusion open panels were bolted onto a supporting frame and the remaining cavity was insulated with cellulose. Finally, a rear ventilated larch siding was attached to part of the wall surfaces. The other part was plastered after attachment of a plaster base. For the lightweight south wall and roof, support frames with OSB board mounted on the inside were again used and the cavity filled with cellulose. Autoclaved aerated concrete was used for thermal separation of the solid elements between the ground and cellar levels. Flax was used as the insulating material in the floor above the cellar. All-wood window frames with a frame

Source: Treberspurg & Partner Architects

Fig. 13.11: Single Family House Horn

depth of 13 cm and meeting Passive-House standards were developed for this project, and the edges were sealed with coconut fibre (free of PU foam). A box design was used for the skylight, and two wooden casements with double heat-insulating glass were installed. The balcony, which shades the ground floor, and a fixed wooden lamella in the upper level serve to ensure sun protection for the large, south-side facing windows.

13.4.5 Austrian Passive-Houses within the impulse-programme "Building of Tomorrow"

The R & D-impulse-programme "Building of Tomorrow" of the Austrian Federal Ministry of Transport, Innovation and Technology (BMVIT) on "technologies for sustainable development" (at:sd) has a focus on sustainable buildings and has supported approximately 300 projects. Core projects are innovative building and reconstruction concepts and their realization. The following pictures provide an overview on selected Austrian Passive-Houses that have been subsidized by this program:

13.4.6
Thermal retrofit of buildings reaching Passive-House standard

In the year 2000 in Austria there were 3.4 million residential units in total. Of these, 2.9 million units were built before 1995 (85%) and 0.5 million units after 1995 (15%). Therefore many old buildings with low levels of energy efficiency exist, presenting a huge potential for energy savings.

In Austria there are some examples of refurbishing existing buildings into Passive-Houses. The renovation of Makartstrasse, a 50-unit housing block in Linz, used a super-insulated passive solar façade and decentralized ventilation systems. This resulted in 90% savings in useful heating energy and operational costs.

13.5
Renewable energy supply for buildings

13.5.1
Solar thermal collectors

Austria currently has one of the highest rates of solar thermal collectors per resident in Europe (besides Cyprus). The total area of installed solar collectors is 3.1 million m^2 and is increasing by approximately 0.2 million m^2 per year. To grasp these figures, let's compare with Australia. Even with Austria's much smaller population and less solar radiation, the annual sales of solar collector area are 50% higher than in Australia. This is also an important factor for the economy: More jobs are generated by the solar heating industry than by the Austrian ski producers.

Solar thermal energy concepts have been optimized by simulation with TRNSYS and successfully tested in practice. Online monitoring of solar systems has proved to be valuable for owners and occupants, providing safeguards against failure and malfunction and helping to adjust the control settings and thereby increase solar gains. Experience and planning competence are available especially for large volume houses—housing estates, office buildings, hotels, and business/industrial facilities.

Mühlweg-Vienna (Source: Bruno Klomfar, Dietrich I Untertrifaller Architects)

EBS-solarCity-Linz (Source: Treberspurg & Partner Architects, EBS Linz)

Roschégasse-Vienna (Source: Treberspurg & Partner Architects)

Fig. 13.12: Housing estates in Passive-House standard

SOL4, Mödling (Source: Thomas Kirschner, SOL4)

Adobe-Passive-House Tattendorf (Source: Meingast, natur & lehm, Reinberg Architects)

Christophorushaus, Stadl-Paura (Source: BBM)

Fig. 13.13: Office buildings in Passive-House standard

S-house (Wimmer, 2005) (Source: GrAt, Schleicher Architects)

Gemeindezentrum Ludesch (Source: Gebhard Bertsch, Hermann Kaufmann Architects)

Schiestl House alpine refuge at Hochschwab 2154 m above see level (Source: Treberspurg & Partner Architects, pos Architects)

Fig. 13.14: Special buildings in Passive-House standard

Housing estate Makartstrasse-Linz (Source: Robert Freund, Arch+More Architects)

School Schwanenstadt (Source: PAUAT Architects)

Fig. 13.15: Buildings with thermal retrofit measures that meet the Passive-House standard

Solar Heat Worldwide	Collector Yield 2005 [GWh/a]		Total capacity installed at the end of 2005 [MW_{th}]		Annual installed capacity 2005 [MWth]	
	Hot water, space heating	Total (incl. pools)	Glazed collectors	All collectors	Glazed collectors	All collectors
Austria	860	995	1690	2106	163	168
Australia	701	1971	1192	3605	114	385

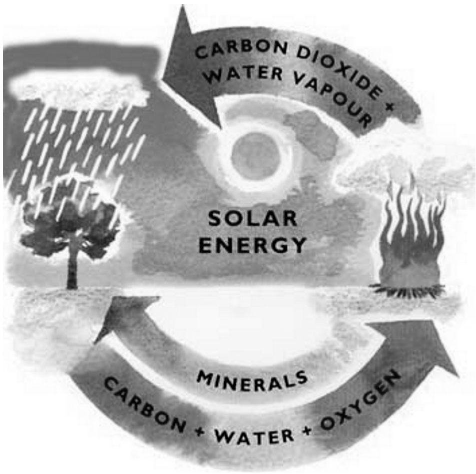
Source: Weiss et al., 2007

Tab. 13.2: Solar heat markets in Austria and Australia according to IEA

13.5.2 Bioenergy

Biomass is also an important energy source for heating. About 43% of the land area in Austria is forest. Biomass resources are used from forestry, agriculture, food industry, timber industry and paper industries. Since biomass heating has been continuously supported, the regional economy has been strengthened. Meanwhile, Austria is one of the technology leaders in the production of boilers for split logs, wood chips, and pellets.

The energy conversion of biofuels is similar to fossil fuels. Biological energy sources are transformed into heat and/or electricity in power plants. The highest energy efficiency can be achieved with combined heat and power (CHP) processes.



Source: Bioenergy Technology Ltd

Fig. 13.16: Biomass—Wood Renewable Energy Cycle

In 2005, the European Union produced 10.7 TWh of electricity, representing 6.7% growth year-on-year. European electricity production from biological energy sources is also growing, with an increase of around 16% between 2004 and 2005 (+6.1 TWh, i. e., a total of 44 TWh/a). This rise originates mainly from new CHP plants in Germany and the Netherlands as well as from biomass co-combustion in conventional electric power plants in the United Kingdom. CHP is the principal technology used to produce electricity from solid biomass, because it accounts for more than three-quarters of this total production (Biopact team, 2006).

Sustainable use of bioenergy has to consider factors that are derived from the concept of a sustainable development. The concept has roots in the European forestry of the 12th century. The forestry rules of the Alsatian monastery Mauermünster in 1144 include limits for the usage rate of wood: The amount of wood harvested must not exceed the amount that grows again. The catalyst for the development of a sustainable forestry was the enormous wood consumption for metal and salt production that resulted in forests becoming severely depleted. Since then—or even earlier in other areas of the world—the natural limitations of the usage rate of wood were obvious and a sustainable management of forests has been a major goal in many areas of Europe. Today these rules are of crucial importance for future generations. In order to protect environmental resources for future generations it is necessary to consider the natural growth rate especially for imports of bioenergy and biomass. The social dimension of a sustainable development also has to be taken into account. This concerns in particular alternative utilization of biomass (as building material or as food) that might be more valuable for the local people.

13.5.2.1 Cogeneration of heat and electricity—Example "Sunmachine"

The "Sunmachine" is the most innovative and eco-friendly system for cogeneration of heating energy and electricity. The basic principle has been tested for decades and is very simple: pellets are transformed into gas in a combustion chamber (almost residue-free) and then a Stirling engine drives a generator by transforming the temperature gradient between burner flames and heating water into action. The produced heat is used for space heating and domestic hot water. The kinetic energy is transformed into electricity. The costs for the pellets can be covered by the income for production and feed-in of electricity.

The "Sunmachine" can be operated with pellets or bio-gas and a further type is to be introduced in 2011 that is going to be operated with solar energy. A further possibility of cogenerated heat and electricity by solar radiation are combined solar thermal and photovoltaic collectors (PVT-collectors).

13.6 Success factors for the realization of sustainable buildings in Austria

- Austria has an effective housing subsidy scheme. High income taxes (30%–45%) enable several steering mechanisms. About 1.3% of the gross domestic product is used for housing subsidies. This stabilizes the building industry and has positive impact on social integration, the overall quality of buildings, and especially the ecological building performance. For example, in early 2006, the housing subsidy scheme in the federal state Vorarlberg was revised. Passive-House Standards are now mandatory for subsidized housing estates. As of October 1, 2006, a solar heating system is mandatory for subsidized housing estates in the federal state Styria.
- Building laws have mandatory values for thermal insulation. Thermal resistance limits for the building envelope have been increased several times during recent decades and will be further increased.
- A law banning nuclear power plants (Atomsperrgesetz, BGBl. Nr. 676/1978): The use of nuclear power as an energy supply was prohibited after

Öko- Energiemaschinen Vertriebs GmbH, 2009

Fig. 13.17: Sunmachine schematics, size $1160 \times 760 \times 1590$ *[mm]*

a referendum in 1978. This has been an early success on the road to a sustainable energy supply.

- The Initiative of individuals had a relevant impact on the development of green buildings. The Passive-House movement in Austria started in the federal state Vorarlberg because of the commitment of individuals. In the federal state Styria the use of solar collectors has began in the 1970s. Individuals who provided guidance in building the first solar collectors for private homes formed the AEE INTEC, now one of the leading R & D companies for solar heating systems in the world. Since their establishment in 1988, they have conducted research, demonstration and know-how transfer projects in the field of solar thermal components and systems, sustainable buildings as well as sustainable water management.
- The R & D-impulse-program "Buildings of Tomorrow" of the Austrian Federal Ministry of Transport, Innovation and Technology (BMVIT) on "technologies for sustainable development" (at:sd) has a focus on sustainable buildings and has supported approximately 300 projects. Core

projects are innovative building and renovation concepts and their realization.

- Energy performance certificate for buildings: Documentation of the planned energy performance is mandatory for new buildings since the 1990s in some parts of Austria. With the implementation of the European Directive for the energy performance of buildings (EPBD, Directive, 2002/91/EC) an energy certificate will be mandatory for new and existing buildings. The certificate includes key figures for energy flows and characteristics of the building service equipment, comparable to a technical certificate for a car or a refrigerator. This will be an important source of information for residents and investors. Furthermore, it is expected that this information will be integrated into the calculation of the market value of buildings, which is not yet the case. Currently the calculated market value of Passive-Houses is not higher than that of conventional houses.

13.7 Forecast

Currently an EU-Directive on the resource efficiency of buildings is being drawn up, and the European Committee for Standardization (CEN) has been commissioned to prepare the relevant standards. It is expected that the Directive will lead to an upgrade of the energy certificate into a resource certificate for buildings.

Product stewardship: The International Union of Architects (UIA) has set up a list of criteria to promote the spread of sustainable buildings. One issue was the liability of building developers and owners of a building. If they take on this responsibility, they must provide plans and instructions for disassembling the building and recycling the building materials. An estimation of the costs is also necessary. These documents, together with necessary funds, should be provided before completion of the building. This idea is not feasible at present, but other initiatives are working in the same direction: Product stewardship is consistent with the aim of the EU initiative for Integrated Product Policy (IPP), which has identified housing as one of the products with the greatest potential for environmental improvement.

Ecological building materials: It is expected that the use of sustainable building materials will increase. Austria's best practice example for the use of straw is the “S-house” in Böheimkirchen (prizes: Global 100 ECO-TECH Award, see: www.s-house.at) and for the use of loam and adobe, the “Lehm-Passivhaus” in Tattendorf.

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Ecological building refurbishment: There is a vast potential for the thermal renovation of building envelopes. Savings of up to 90% in energy and operating costs are possible.

Currently there is extremely low public demand for sustainable buildings. It is likely that the demand for a higher living comfort will raise the demand for Passive-Houses. This will be supported by increasing prices for fossil fuels. Presumably the prices will continue to rise as availability of cheap fossil fuel resources become scarce and emerging economies develop and increase demand. Prof. Kenneth Deffeys of Princeton University claimed that the world's peak oil production already occurred in 2005. From this date on, oil production will decrease, first slowly and then more and more rapidly.

The atmosphere has served as a free "sanitary landfill" for greenhouse gas emissions. The follow-up costs of this "dumping" are not assigned to the polluter. Political steering instruments to reduce greenhouse gas emissions are starting to show (small) effects (e. g., the Kyoto protocol) but still must be improved and implemented all over the world.

Conclusions—Promotion of Passive-Houses

General requirements

Further education in Passive-House technology should be made available for planners as well as executors. The topic should be also be further integrated into the university education system and training of architects.

Research programs and funds, especially in the field of refurbishments, should be guaranteed in the long term to assure an adequate amount of support to scientific research as well as the realization of pioneer projects. Without the financial subsidies made available to this date for the program "Haus der Zukunft" from the Austrian Federal Ministry of Transport, Innovation and Technology, approx. 60% of the passive housing units realized in Vienna and Lower Austria would not have been able to be completed.

Incentives for architects and planners

Passive houses should receive the highest possible financial subsidies. In Lower Austria only severely reduced subsidies and in Vienna no subsidies for Passive-House projects are available at present.

Subsidies for the initial phase of Passive-House projects should be guaranteed through a subsidy fund to cover the extra planning costs. The tender must include a two-stage procedure, which evaluates the projects according to formal criteria and content.

A Passive-House consultant who can be chosen from a pool should be involved from the first phases of Passive-House projects. The costs should be mainly covered by federal subsidies. The resulting integral planning is crucial for a successful realization of Passive-House projects.

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