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**Working Paper**

## Can the German Electricity Market Benefit from the EU Enlargement? Results of Scenario Calculations Using the EMELIE Model

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**Manfred Horn  
Claudia Kemfert  
Vitaly Kalashnikov**

**Can the German Electricity Market Benefit  
from the EU Enlargement? : Results of  
Scenario Calculations Using the EMELIE Model**

**Berlin, October 2006**





**Discussion Papers 632**

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**Can the German electricity market benefit from the EU  
Enlargement?**

Results of Scenario Calculations using the EMELIE Model

Berlin, October 2006

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## Abstract

This paper investigates the impacts of the eastern enlargement of the European Union in 2004 and the liberalisation of European electricity markets on Germany's electricity exchange with neighbouring countries and on electricity prices. Thus, electricity imports from Czech Republic have increased sharply in the last few years and have dampened German wholesale prices for electricity. In this paper the EMELIE simulation model, a game theoretic model for the European electricity market, is applied to analyse possible long-term effects of these changes. In the model calculations it is assumed that competition will prevail on the European electricity market in 2030, as far as possible with the existing transmission capacities. Primary energy prices are assumed to increase moderately from 2004 to 2030 (30 % for gas and 15 % for hard coal), and the price for CO<sub>2</sub>-certificates is assumed to remain high (€25/t). It is further assumed that Germany sticks to the aim to shut down nuclear power stations.

In the reference case (no increase of transport capacities, without CO<sub>2</sub> costs) model results show a clear increase in Germany's electricity imports from France and the Czech Republic. With rising CO<sub>2</sub> prices imports from France increase slightly, as do Germany's electricity exports to Poland. In the open-market case (transport capacities are increased and nuclear power stations are built in neighbouring eastern European countries), electricity imports from these countries increase if high energy and CO<sub>2</sub>-prices prevail. Wholesale prices for electricity in Germany are – according to the model results – higher than in the neighbouring countries with the exception of Austria and the Netherlands. Until 2030, the position of electricity consumers in Germany compared with those in all its neighbouring countries would improve; only in France and Sweden would these wholesale electricity prices be lower than in Germany.

## 1 Introduction

In Europe, all EU Member States must liberalise the electricity market according to the 1997 directive of the European Commission (Directive 96/92/EC). The directive provides that European electricity markets should already have been opened up to an average of 25% in 1999. With the opening of new accession countries, the harmonization of the European electricity market becomes even more challenging. An unequal distribution of market opening and libe-



ralisation of the electricity markets in Europe involves some competition distortions – some utilities already face complete competition, whereas others can continue operating in a monopolistic position. Since utilities have to compete with each other after the opening of the market, providers need to alter their behaviour in order to survive. In Germany, for example, utilities reacted very dynamically after the liberalisation of the electricity market in 1999 by firm mergers and strategic behaviour. A rise in the market shares of certain producers might lead to a rather uncompetitive market structure, which will increase rather than reduce electricity tariffs.

Furthermore, electricity trading options can offer additional incentives for the practice of market power, unless uniform price structuring for tradable electricity is created. In Germany, for example, a federation agreement regulates prices for the energy sector. However, it has been observed in the past that due to strategic market behaviour, the market entry of providers with third-party access to surplus electricity was delayed or refused. A regulatory authority will soon observe these effects and regulate prices. In its second benchmark report, the European Commission criticises that competition distortions and market power can arise through utilities' strategic behaviour, such as charging net access fees that are too high, thus obstructing the entry of new providers. The different degrees of market opening diminish the advantages for the customer. Therefore, future European electricity policy will try to decrease market distortions and harmonise the market opening processes in all European countries.

European climate policy has one main intention: to reduce greenhouse gas emissions. Two main policy directives are important in this context: the implementation of the European emissions trading system (the first planning phase runs from 2005 until 2007 and the real phase starts in 2008 and lasts until 2012) and the directive to increase the share of renewable energy in electricity production. For electricity providers, this means that they have to produce electricity in a cost-effective and environmentally friendly way. Newbery (2000, 2002a, 2002b) studied potentials and opportunities for European utilities in a liberalised market. Day and Bunn (1999) investigated these aspects by a game theoretic model of market power and firms' strategic actions in the UK. Bower and Bunn (1999) assessed trade opportunities within a pool versus a bilateral trade system in the UK electricity market. Experiences in Scandinavia and the UK suggest that a uniform tariff is preferred over distance-related charges. Moreover, market opportunities and grid owners significantly influence trade. Dawson and Shuttleworth (1997) studied transmission pricing in Norway and Sweden. Green (1997) examined this

effect for the UK. Cardell et al. (1996) investigated the negative effects of market power and transmission constraints on trading using an imperfect competition model for North American electricity suppliers.

Jing-Yuan and Smeers (1999) have modelled an oligopolistic electricity market with a sophisticated game theoretic model for Europe, calculating the Nash equilibria. More generally, Helman et al. (1999) investigated different kinds of trade options and strategic price setting within the electricity market. Hauch (2004) studied the impacts of electricity market liberalisation and emissions reduction targets for the Nordic countries.

Bower et al. (2001) simulated the liberalised German electricity market using an agent-based model. They concluded that mergers increase market power, increasing electricity prices. Their model is very sensitive to the out-phasing of expensive oil-fired plants, to increasing use of nuclear energy and to borders being closed against imports of (cheap) electricity. In all these instances, prices rise considerably.

We apply a game theoretic model for the European electricity market, EMELIE (Electricity Market Liberalisation In Europe).<sup>1</sup> EMELIE is calibrated to the main European energy suppliers, which are linked by capital flows. The main aim of this paper is to assess whether the Eastern European market opening offers advantages or disadvantages when both the liberalization of the energy market and climate policy play a major role.

## **2 The EMELIE Model for the enlarged European market**

German electricity exchange with neighbouring countries is currently experiencing the effects of the eastern enlargement of the European Union in 2004 and the liberalisation of European electricity markets. Thus, electricity imports from Czech Republic have increased sharply in the last few years and have probably dampened German wholesale prices for electricity. In this paper the EMELIE simulation model is used to analyse possible long-term effects of these changes. It is based on a study conducted by the German Institute for Economic re-

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<sup>1</sup> A first version of EMELIE is applied to study the economic impacts of the German and European electricity markets in Lise et al. (2006). The first application to the European market is given by Kemfert (2005). See also Kemfert (2006).

search for the Ministry of Economics and Labour about the German energy situation after the EU enlargement.<sup>2</sup>

EMELIE (Electricity market liberalisation in Europe) was developed for the European Commission in order to analyse the effects of strategic behaviour by electricity suppliers on electricity prices and trade flows in western Europe (Kemfert 2004, Lise et al. 2006 and Kemfert 2006). Germany, Belgium, Denmark, Norway, Sweden, Austria, France and Britain were first considered in the model.<sup>3</sup> To enable the effects on electricity exchange and prices in Germany of the enlargement of the EU by the central and eastern European countries to be considered the model was extended to include Poland, the Czech Republic, Slovakia, Hungary, and Bulgaria and Romania. With certain assumptions on framework data in the electricity industry and the behaviour of suppliers on the electricity market it enables statements to be made on the development in electricity trading and prices in Europe.

The creation of a European electricity market will ideally increase pressure of competition and reduce the scope for strategic behaviour. In the model calculations it is assumed that there will be competition on the European electricity market in 2030, as far as is possible with the existing transmission capacities. In competition prices will be determined by the costs to the marginal suppliers. In the ideal case of unlimited transmission capacities prices would be largely aligned.<sup>4</sup> In reality bottlenecks in transmission capacities are hardly likely to be fully removed by 2030, and in that case differences in marginal costs and so in national electricity prices will persist.<sup>5</sup> Here, for the sake of simplicity, only the information and results for Germany's immediate neighbours are given (without Luxemburg, which is not included in the EMELIE model).

### 3 Data and Scenarios

The intensity of electricity trading between Germany and the new member states will depend on the generating capacities available for export, on differences in the variable costs of elec-

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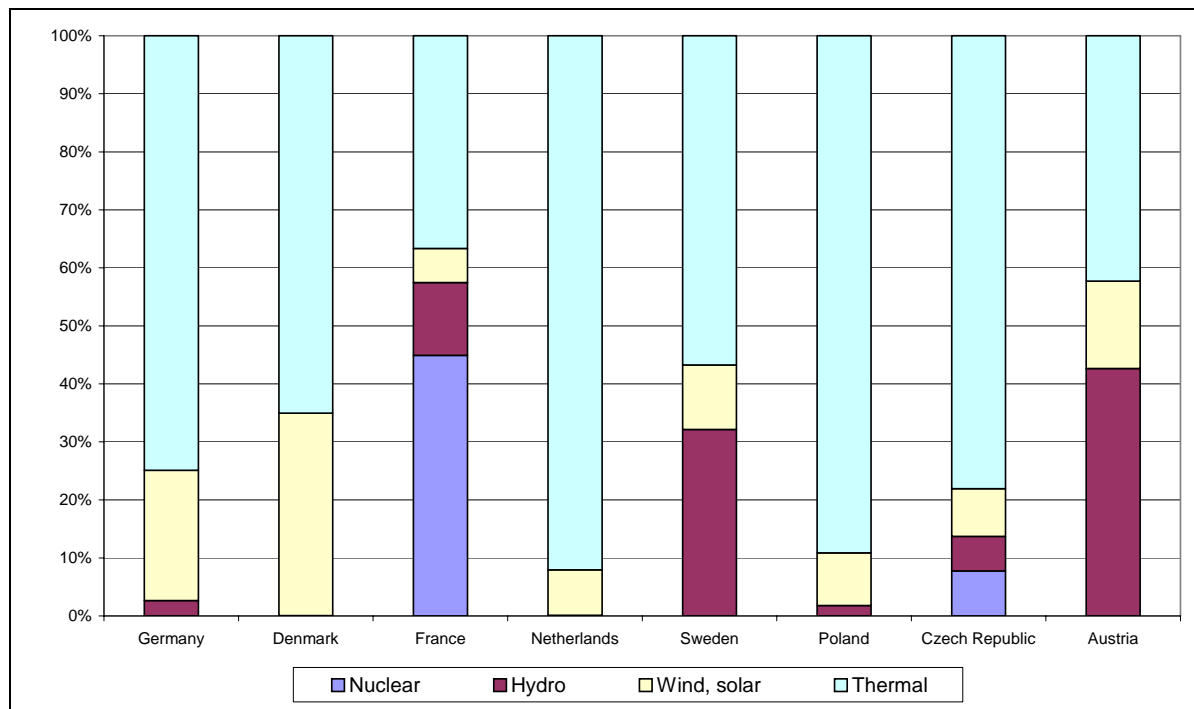
<sup>2</sup> Horn 2006.

<sup>3</sup> The model also differentiates according to the biggest electricity generating companies in a country that maximise their profits by input technology costs. Electricity can be traded within a country and between neighbouring states, see Lise et al. (2006).

<sup>4</sup> Prices would only differ where there were differences in transmission costs.

tricity generation and on the size of the available transmission capacities. The data base for electricity consumption and generation, and the development of capacities by technologies, is based on current scenarios by the European Commission.<sup>6</sup> In the European Commission's reference scenario only France and the Czech Republic of the countries considered here will still be using nuclear power by the year 2030. Germany, Sweden and Holland will cease to use nuclear power entirely by 2030.

Figure 1:  
**Electricity Generating Capacities by Energy Sources in 2030 in % of Each Country's Total Capacity – Reference scenario of EU, 2005.**



Source: European Commission (2005): European energy and transport scenarios on key drivers. Brussels.

In 2030 conventional thermal power stations (without nuclear power) will account for the greatest share of electricity generating capacities in all the countries considered here except France and Austria. In France nuclear power will predominate, while in Austria hydro power will have a similarly large output to conventional thermal power stations at more than 40%. In

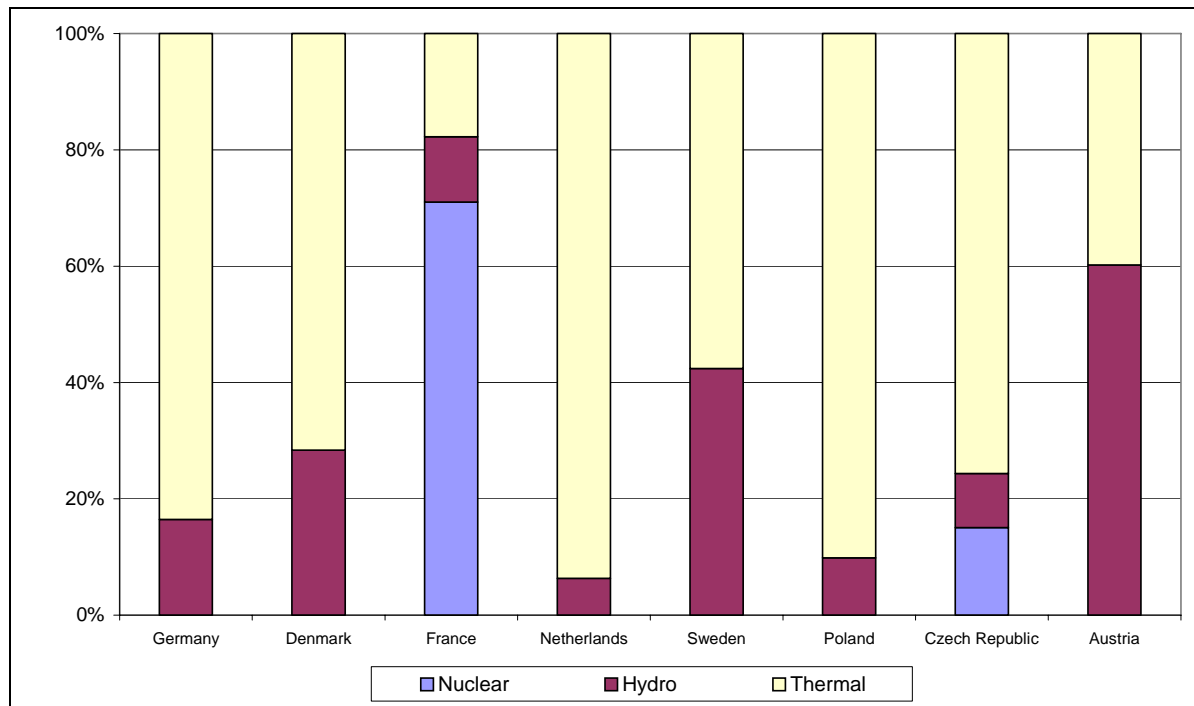
<sup>5</sup> The EMELIE model differentiates according to techniques and energy sources for which - differentiated by countries - average degrees of efficiency are assumed. Further differentiation of these plants, e.g. by age, is not made.

<sup>6</sup> European Commission, 2005.

Sweden hydro power and in Denmark wind and solar power will have shares of more than 30% of output.

The contribution of thermal power stations (incl. nuclear power stations) to electricity generation will generally be greater than their share of output in the countries considered here, owing to the relatively high utilisation, particularly of plants running on the base load. However, in Sweden and Austria the utilisation rate of hydro power stations will be similar to that of conventional thermal power stations.

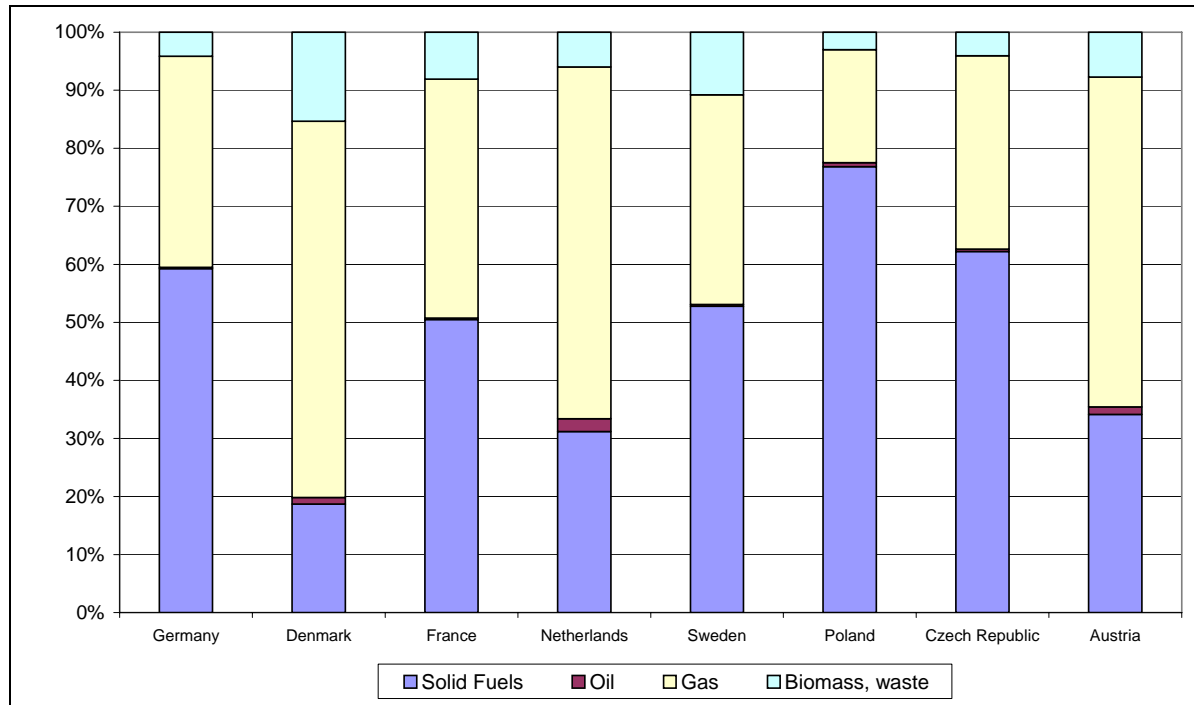
Figure 2:  
**Electricity Generation by Energy Sources in 2030 in % of Each Country's Total Electricity Generation**



Source: European Commission (2005): European energy and transport scenarios on key drivers. Brussels.

If the fuel consumption of conventional thermal power stations in 2030 is differentiated by energy sources marked differences appear. Whereas in Poland just under four fifths and in the Czech Republic just under two thirds of the fuel consumed is hard coal, in Denmark, Netherlands and Austria natural gas will be the main source. In Germany, France and Sweden hard coal will have a share of 50% to 60% of fuel consumption, and natural gas a good 30% to 40%.

Figure 3:  
**Fuel Consumption in Thermal Power Stations in 2030 in % of Each Country's Total Fuel Consumption**



Source: European Commission (2005): European energy and transport scenarios on key drivers. Brussels:

The assumptions on primary energy costs - which account for a large part of the variable costs - are largely based on EWI/Prognos (2005). The following real price changes for the period 2004 to 2030 are assumed for the individual fuels:

Oil	45%
Natural gas	30%
Hard coal	15%
Lignite	10%

Of considerable importance for the competitiveness of the different types of power station and for the direction and size of the trade flows in Europe is the development of the prices for CO<sub>2</sub> emission certificates. Hence this cost component is also taken into account in the model calculations for the year 2030. Independent of the allocation of emission certificates it is assumed that the prices of the certificates fixed for emission trading will be incorporated in the variable electricity generating costs and affect the use of the existing plant.

EWI/Prognos<sup>7</sup> expects a price of €15/t CO<sub>2</sub> in real terms for 2030. Owing to the many factors that will influence it (e.g. future reduction targets, number of countries included, number of emission certificates issued, intensity of competition on emission trading markets) this price is a more or less arbitrary assumption to which considerable uncertainty attaches. In the model calculations made here a price of €25/t CO<sub>2</sub> was used for 2030. Should such a price really evolve (in 2005 prices were even higher), e.g. owing to strategic behaviour by suppliers on the emission certificates market, then expanding high voltage transmission lines between the countries considered here would be profitable.<sup>8</sup>

The future development of electricity trading depends not least on what transmission capacities are available. Although in the EU scenarios Germany's surpluses or shortages in electricity trade with most of its neighbours in the initial situation (2000, 2005) are clearly reduced by 2030, it is not certain that the existing transmission capacities will suffice in the long term. For the growing share of fluctuating energy sources in electricity generation will cause the net transfer capacities for commercial deliveries available in the existing lines to fall. That rather suggests that the transmission capacities will have to be expanded, even if the present level of electricity trading should not be increased.

For our own model calculations we differentiated between a **reference scenario** and an **“open markets” scenario** (each with data for 2030). The **reference scenario** is based on the framework data for the electricity industry in the EU scenarios and the price assumptions by EWI/Prognos (2005). It was also assumed that the net transfer capacities<sup>9</sup> of the transmission lines will be the same in 2030 as in the initial situation in 2004/2005. The **reference scenario** is also subdivided into one case without and one with the costs of CO<sub>2</sub> emission certificates (€25/t CO<sub>2</sub>). To promote the integration of the European electricity markets and improve the conditions for competition on these markets the transmission lines would need to be expanded, particularly those between the old and the new EU member states. However, the plans published by UCTE do not indicate any noticeable increase in transmission capacities between the UCTE core, to which Germany also belongs, and the Central states<sup>10</sup> before

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<sup>7</sup> EWI/Prognos 2005.

<sup>8</sup> Cost differences between electricity produced with nuclear power and coal or gas would be higher than transport costs which result even in the case that new high voltage lines have to be built. Manfred Horn et al.: Auswirkungen der EU-Integration auf die deutsche Energieversorgung. Study on behalf of the German Ministry of Economics and Labour. Berlin 2006.

<sup>9</sup> In the EMELIE model these capacities are represented by the electricity flows of each year.

<sup>10</sup> Czech Republic, Hungary, Poland and Slovakia.

2015. In the “**open markets**” scenario it is assumed that the electricity transmission capacities between Germany and its neighbours will be doubled by 2030. Only those between Germany and France will remain at the present level.<sup>11</sup> This scenario is also subdivided into two cases. In the first production capacities are the same size as in the reference scenario. In the second nuclear power stations are built in Poland and the Czech Republic with a total output of 3.2 GW in each country, and as a consequence correspondingly fewer natural gas power stations are built in Germany. In both cases the costs of CO<sub>2</sub> emission certificates are taken into account.

## 4 Model Results

We applied the EMELIE model for the base year 2004 and for 2030. For the base year a satisfactory approximation to the UCTE data was achieved. There are greater deviations between the current data on electricity flows according to UCTE and the figures for German electricity trade with France and Holland estimated using the EMELIE model. As model results show that German net imports from France are lower by the same amount as German net deliveries to the Netherlands, the reason for these deviations is probably the greatly simplified modelling of the European high voltage network in the EMELIE model. For the rest the UCTE data on electricity trading in Table 1 is physical electricity flows, while the EMELIE model calculates commercial deliveries. So complete uniformity of the data would hardly be plausible.

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<sup>11</sup> On principle Germany could also import more nuclear power from France, but as the effects of EU integration are to be examined in this study that option has not been included.



Table 1:

**Germany's Trade in Electricity with its Neighbours according to the EMELIE model calculations (+ = imports, - = exports) in TWh**

	2004		2030			
	UCTE	EMELIE	Reference scenario		Open markets scenario	
			without CO <sub>2</sub> -costs	with CO <sub>2</sub> -price 25-€/t	+ increased transmission-capacities	+ Shift of generation capacities
Denmark <sup>1</sup>	2,00	7,30	8,00	8,00	8,26	7,61
France	15,09	10,87	31,33	33,57	34,83	34,98
Netherlands	-16,80	-12,24	-6,60	-6,60	-12,60	-12,60
Sweden	-0,18	1,11	1,11	1,11	2,11	2,11
Poland	-2,71	-0,57	-0,94	-2,42	-4,48	25,46
Czech Republic	12,97	15,11	20,35	20,35	25,36	40,00
Austria	-4,46	-6,00	-6,00	-6,00	-8,77	-7,06

<sup>1</sup> Including East Denmark, whose electricity grid is in the Nordel system.

Source: UCTE 2006, DIW Berlin calculations using the EMELIE model.

In the reference case (without CO<sub>2</sub> costs) the EMELIE model results show Germany's imports of electricity from France rising strongly up to 2030, as well as from the Czech Republic. Electricity trade with the other countries shown only slightly changes. With rising CO<sub>2</sub> prices and transmission capacities unchanged imports from France increase slightly, while Germany sells rather more electricity to Poland. Electricity trade with the other countries does not change, because the transmission capacities are fully utilised in the reference case without CO<sub>2</sub> costs, so no further increase in electricity trade is possible.

In the **"open markets" scenario** - based on the reference case with CO<sub>2</sub> costs – we assume that the capacities of the international electricity connections are doubled, with the exception of those between France and Germany. In this case Germany imports more electricity from the Czech Republic and France, and to a lesser extent from Sweden and Denmark as well. But Germany's exports to Holland rise strongly, and its exports to Poland and Austria increase to a lesser extent. As net imports decline slightly as a whole, while electricity consumption remains about the same, the German power stations should also have become more competitive on the domestic market.

If, in addition to the prognoses by the EU, nuclear power stations were built in Poland and the Czech Republic with a total output of 3.2 GW in each country, and with correspondingly fewer natural gas power stations built in Germany, there would be a massive increase in electricity imports from Poland and the Czech Republic, however, that is to assume that, in the Czech Republic at least, transmission capacities would be increased again. There would be only slight changes in electricity trading with the other countries.

In the initial year wholesale electricity prices in Germany are higher than in most of the countries considered here. Only Holland and Austria have even higher prices. In 2030 Germany only has cost disadvantages against France and Sweden, although their price advantage increases markedly - particularly that of France. The German position vis-à-vis the other countries improves clearly in some cases. Taking CO<sub>2</sub> emission costs of €25/t into account Sweden become by far the most cost-favourable supplier, with France in second place. Of the other countries the positions of Denmark and Austria improve owing to their large share of regenerative energy sources, while the cost disadvantage of the Netherlands increases less strongly compared with 2004 on account of the high share of natural gas fired plant.

Table 2:  
**Wholesale Prices for Electricity by Scenario Calculations using the EMELIE Model**

	2004	2030			
		Reference scenario		Open markets scenario	
		without CO <sub>2</sub> -costs	with CO <sub>2</sub> -price 25-€/t	+ increased transmission-capacities	+ Shift of generation capacities
		Price in €/MWh			
Germany	16,85	16,08	24,22	21,41	18,98
Denmark <sup>1</sup>	16,36	21,02	24,23	25,79	25,79
France	16,53	13,93	18,94	19,94	17,75
Netherlands	20,26	25,93	30,22	28,08	27,46
Sweden	13,80	12,25	15,78	15,89	13,19
Poland	14,26	16,36	26,74	25,91	26,08
Czech Republic	14,43	17,35	27,66	26,97	24,30
Austria	22,18	24,46	26,97	26,88	26,71
		Price difference to Germany in €/MWh			
Denmark <sup>1</sup>	-0,49	4,94	0,01	4,38	6,81
France	-0,32	-2,15	-5,28	-1,47	-1,23
Netherlands	3,41	9,85	6,00	6,67	8,48
Sweden	-3,05	-3,83	-8,44	-5,52	-5,79
Poland	-2,59	0,28	2,52	4,50	7,10
Czech Republic	-2,42	1,27	3,44	5,56	5,32
Austria	5,33	8,38	2,75	5,47	7,73

Source: calculations using the EMELIE model.

The competitive position of the German electricity supplies only improves against Poland and the Czech Republic through the introduction of CO<sub>2</sub> trading. However, open electricity markets with increased transmission capacities dampen costs for the German electricity industry and improve the position of electricity consumers in Germany compared with those in all its neighbouring countries. This effect against most other countries could be even further increased by the use of nuclear power capacities in neighbouring countries, although job losses in the power stations thus displaced in Germany would have to be expected.

## 5 Conclusions

More than other countries, Germany can benefit from the enlargement of the European Union and the liberalisation of electricity markets in Europe. Because of its geographical position in central Europe German electricity companies profit from cost differences compared to numerous companies in neighbouring countries through increased electricity trade. Even if primary energy prices and CO<sub>2</sub>-prices substantially increase compared to 2004, and if Germany phase out nuclear power entirely by 2030, price increases for electricity in Germany will be dampened substantially. However, most of the additional imports that contribute to the dampening of electricity prices are from countries which will still be using nuclear power in the year 2030 or may start doing so by that date. This means that Germany benefits from different energy policies in Europe.

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