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PROSPECTS FOR COAL AND COAL-BASED ELECTRICITY IN LIBERALIZED ENERGY MARKETS IN THE ECE REGION

Highlights

Note by the secretariat

I. INTRODUCTION

1. A combination of technological and regulatory changes in the energy markets in the ECE region since the mid-1980s has brought substantial changes in the structure of its electricity sector. While those changes are related both to developed and markets in transition, their speed is uncomparably higher in the former than in the latter. Energy market liberalization with a focus on electricity and natural gas has already changed the energy pricing structure and transformed the way the individual energy sectors are organised.

2. In the above framework, the future of energy mix for electricity generation in the ECE region has been one of the most controversial issues. While it seems that new technological and regulatory factors favour an increasing use of natural gas in electricity generation, the immediate future of nuclear energy does not appear to be very bright. Among those two possible extremes, the future of coal for power generation is positioned with not yet clear views on how it might

evolve. Given that currently coal-based power plants contribute more than 30% and 50% to the total electricity generation in Europe and the United States of America respectively, the development of related trends is being closely monitored by both the electricity and coal industries in the region (Charts 1-4). At the same time, between 80 and 90% of the coal consumed in the region is burnt in the power generation sector (Annex 1). It is also often felt that the expected slow down of electricity demand in developed markets (below 2%) and markets in transition (with no growth if the countries of former Soviet Union are included) and often fierce attacks on the environmental performance of coal are additional factors that might complicate the future of the coal as a dominant fuel for power generation.

3. This paper aims at analysing the possible evolution of the role of coal for electricity generation in the ECE region in the light of underlying market, technological and regulatory trends. While being well aware of the controversies related to this important topic, the ECE secretariat felt that there was sufficient information and knowledge to provide at least initial leads on the issue with substantial benefits for all energy market participants.

II. CURRENT STATE OF THE ELECTRICITY MARKETS AND INTER-FUEL COMPETITION

4. Electricity generation in the ECE region in 1998/1999 amounted to close to 9,000 TWh per year with approximately 50/50% split between North America and Europe. On average, the coal-fired power plants (CPP) contributed 31% of the generation. The USA is on the higher end of the range with 52% while the countries of the former Soviet Union produced only 21% of electricity in CPP.

5. The structure of installed electricity generation capacity does not necessarily correspond to the structure of the produced electricity. In principle, being base-load generators, CPP and nuclear power plants (NPP) deliver regularly to electricity consumers a larger share of electricity compared to their share in installed capacity. This discrepancy could be further deepened if petroleum and natural gas prices are relatively high as was the case in 2000. For example, in the USA CPP had 40% of the total installed generation capacity while they produced 52% of electricity in 1998 (Chart 4).

6. The total CPP share in the electricity generation in western Europe has been decreasing steadily over the last thirty years (Chart 5). A combination of factors such as the development of a vast nuclear programme in selected countries, generous availability of natural gas in the Russian Federation, subsidies to domestic natural gas use and substantial advances in thermal efficiency when using combined-cycle gas-fired power plants (CCGPP) reduced substantially the importance of coal in the sector. Certainly, the situation in individual countries varies considerably from France, Austria and Sweden with less than 10% of the share of CPP to Germany and USA with more than 50% of electricity produced in CPP. There are also a few countries, such as Poland, where CPP are almost exclusive electricity generators.

7. Fuel consumption for electricity production is clearly still dominated by coal. For example, in western Europe in 2000 coal had more than 50% share in the total fuel consumption in the

electricity sector (Chart 6). However, its share has been steadily decreasing since 1970 with the expectation of further declines in the years to come (Chart 7). The main reason is the penetration of natural gas that is fast becoming the fuel-of-choice for incremental capacity additions and is favoured by the dynamics of deregulated markets.

8. The inter-fuel competition in the power generation sector is taking place against a background of considerable differences in efficiency of selected types of generators (Chart 8), unit capital cost, unit operating cost and various environmental constraints.

9. While certainly gas-fired combined cycle units have efficiencies higher than 50%, the thermal efficiency of fossil-fuelled steam-electric plants in selected economies in transition is well below 30%. Although further advances in thermal efficiency are expected in the years to come it is not always easy to predict which segments of the power plant sector will be affected most. 1/

10. Inter-fuel cost competition is often mentioned not only as one of the most important parameters for the short-term optimization of the use of a pool of power plants but also as a guide for the future mix of power plants. While clearly there are short-term changes in relative prices among coal, crude oil and natural gas that would justify short-term pool optimization, the coordinated medium-term and long-term price movement of the major fossil fuel competitors does not provide a solid argument for relative prices as a guide for the future mix of power plants (Chart 9).

11. Relative coal price competitiveness in western Europe, although fairly volatile in the last 15 years or so, have practically not changed at all (Chart 10). The price competitiveness relative to crude oil has been subject to wider swings than natural gas. The reason is simple: while crude oil prices are set in the daily market, most of the natural gas pricing is based on crude oil indexing. The indexing is not automatic but includes delays, floors and ceilings as well as various baskets that smooth actual natural gas prices.

12. Wholesale fuel prices which are very close to the actual prices charged to electricity generators in the 1987-2000 period were subject to substantial volatility. Understandably, the highest price volatility was detected in crude oil followed by natural gas. On the other hand, the cost-plus nature of coal production and the absence of standardized and centralized market transactions made the volatility for coal much lower when compared to its competitors (Chart 11).

13. Since the mid-1980s an intensive energy liberalisation effort has started, first in the USA and after that in the United Kingdom and continental Europe. With some differences, the liberalization focussed on natural gas and electricity. While in the ECE region as a whole the main target of the energy market liberalization and deregulation has been the development of a more competitive market with downward pressures on wholesale and retail electricity and natural gas prices, its implementation has not been uniform.

1/ For example, power plants based on clean coal technologies to be commissioned in the year 2005 are supposed to have a higher thermal efficiency than today and reach 40-45% with the average unit capital cost between US$ 1200-1300 per one kW. Source IEA Newsletter 3/1999.

14. On the electricity side, the US reform was initiated by the passage of the 1978 Public Utility Regulatory Policies Act (PURPA) and the 1992 Energy Policy Act (EPACT) with subsequent orders 888 and 2000 by the Federal Energy Regulatory Commission. While on the wholesale level, the deregulations has been applied equally among the individual States, the retail competition is a different case. As of October 2000, 24 States and the District of Columbia had enacted legislation or passed regulatory orders to restructure their power industries. However, a number of other States such as Kentucky and Idaho, with the lowest electricity rates in the country did not promote retail competition at all. The FERC order 2000, probably the most ambitious effort to make liberalization work, calls upon electric utilities to form regional transmission organisations (RTO) which will operate, control and possibly own the US transmission power networks.

15. As a result of the liberalization and deregulation efforts, a number of wholesale electricity trading hubs and centralised power markets appeared in the USA (Chart 12). While in principle the hubs cover the trades executed in that particular location, centralised power markets, either in the form of an independent system operator (ISO) or transmission company (Transco), aim at covering the electricity market of one or more individual states**.**

16. Such a more dynamic market structure coupled with certain technological development, made the power generators increase their flexibility, reduce specific capital expenditures and rely partially on market volatility in achieving desired rates of return on assets and equity. Thus, gas-fired combined cycle power plants of different sizes, with comparatively low specific investments per MW, low maintenance cost and modest requests for land, began to appear as the prime choice for electricity generation of the operators**.** The power plants with higher capital investments and a larger portion of fixed costs in the total operational cost, such as coal-fired and nuclear plants, lost their attractiveness (See Chart 18 for the total long-term marginal cost), despite the fact that CPP still dominate electricity production in the USA with 52% share.

17. The electricity market deregulation and liberalisation in western Europe has been a much more challenging task. While the EU electricity liberalisation Directive came into force in February 1997, aiming at 33% market opening by February 2003, the competition has arrived on a limited basis and with somewhat protracted timetables. There are many reasons why it has proceeded less evenly and more slowly than expected, one of them certainly being the unwillingness of individual EU Member States to leave it up to the market to decide on electricity generation fuel and power plant mix. The “nominal” market opening in individual EU Member States varies greatly from less than 30% to an almost complete opening for a number of leading countries (Chart 13). However, a “nominal” market opening should not be confused with an actual opening since many required technical and regulatory pieces are missing.

18. The “single“ European electricity market is currently a set of a number of regional sub-markets such as United Kingdom, Iberian Peninsula, North of Europe and North and South of Germany with surrounding countries. A number of imperfect electricity exchanges and “hubs” emerged whose efficiency has been severely limited by relatively low volumes, lack of adequate transmission capacity and omnipresent government intervention in various forms. In the end, an increasing uncertainty with regard to the intended or real shape of the European liberalised

electricity market has emerged. It has been further reinforced by uncertainties in the European gas market liberalization.

19. The conflicting regulatory and market messages has not allowed the electricity generators in Europe, compared to their US counterparts, to pursue an optimal investment and structural policy. A substantial excess capacity emerged with almost 30% reserve capacity margin at the end of the last decade (Chart 14). Thus a massive programme of plant closures had to be announced, in particular in Germany where there is almost 10,000 MW of excess capacity. Almost exclusively, the closures relate to the coal-fired power plants. 2/ At the same time, investment uncertainty has not been favourable for the planning and building of new power plants in Europe since the liberalisation started (Chart 15). It remains to be seen what market and price consequences for end users, if any, will follow from such capacity developments.

20. Regardless of the problems encountered in electricity deregulation and liberalization both in the USA and in western Europe, it seems that competitive pressures, removal of some barriers to entry and some electricity trade flows have resulted in the convergence of retail and wholesale electricity prices (Chart 16).

21. While the differences in retail electricity prices are still significant within the European Union, they are a bit less pronounced than 5 years ago. On the contrary and with the exception of Italy, the levels of electricity prices for large industrial consumers within the European Union and in the US on average are very similar - somewhere between 3.5 and 4 US cents per kWh. However, it should be noted that there are wide variations in electricity prices in the individual US States behind the reported US averages. Given the regional character of the US electricity markets, it should not be surprising to find the actual industrial price range in from US cents 2.64 in the State of Washington to US cents 8.18 in Massachusetts.

22. Economies in transition were rather slow to embrace electricity market liberalization and deregulation. Given considerable market inefficiencies and structural problems in those countries, it would be unreasonable to expect a quick fix to the sector including setting prices at economic levels for all consumers. While certainly selected countries in central and eastern Europe, such as Hungary, attracted sizeable foreign investments, it is not yet completely clear in which directions related electricity market structures might evolve.

23. Apart from a lack of the liberalization drive, it appears that the electricity sector in Russia and Ukraine, in particular, have been in distress. It has been estimated for Russia, for example, that due to the low collection rate (below 30%) and low investments (20% of required levels), the United Energy Systems electricity company's network is worn-out and faces possible serious operational problems. 3/

2/ Source: CW International, 5 March 2001

3/ Energy Economist, #233, March 2001

III. DEFINING THE KEY VARIABLES FOR THE FUTURE OF COAL IN THE ELECTRICITY GENERATION IN THE ECE REGION

24. The future of coal use in the electricity generation should be judged in a comprehensive framework that includes a number of relevant factors (Table 1).

25. Alternative fuel price levels are not sufficient as the criteria for the choice of the future power plant and fuel mix in the ECE region as a whole or in its main individual countries (Chart 17). While coal has recently been the cheapest fuel measured in price per thermal equivalents, it has certainly influenced only the structure of the short-term plant operations and not long-term decisions. Thus, it is not a paradox that, for example, in Germany in 2000/2001 many gas-fired power plants were not in use while coal-fired plants were employed at their maximum. At the same time, plans on the near-term closure of more than 6,000 MW of coal-fed power plants were announced. There are probably more to come.

26. Structure of the long term marginal cost of electricity production might be critical for the understanding of the possible future of the use of coal in the electricity sector. While fixed costs comprise about 75% of the total cost for nuclear and hydro power, it is exactly the opposite case for natural gas fired combined cycle (chart 18). Coal is somewhere in between but again with the domination of fixed costs. In the short term, however, a high price of natural gas regularly makes operators shut down gas-fired power plants temporarily and rely on those with lower short marginal costs. The level of fuel costs per produced kWh in 2000/2001 in market economies was, thus, favourable for relatively increased short-term use of nuclear and coal power plants (Chart 19).

27. Combined cycle gas-fired power plants enjoy important advantages in terms of specific investment costs per one kW of installed capacity, use of space, staging and timing of construction, duration of lead times and overhead costs. Specific investment costs (investment per one kW) are 60% lower than in the case of coal-fired power plants and more than 70% lower when compared with the EPR nuclear power plants (Chart 20). In a liberalised market which requires a high degree of supply and operational flexibility coupled with the advantage of being closer to the main customers, such low investment requirements with options to increase installed capacity are difficult to ignore. At the same time, combined cycle gas-fired power plants have much higher variable costs so they might not be competitive in the short-term when the natural gas price is relatively high, as happened in continental Europe in 2000.

28. With the above framework and given the current structure of the power plants it is possible to make an estimation of comparative generation costs in the sector. The case in point is Germany, the biggest continental European energy, electricity and natural gas market (Chart 21). The estimate is given at different load factors: from 4000 to 8000 per year, thus for the power plants serving base-load and mid-load purposes in the system. A number of other necessary assumptions including an acceptable rate of return were also made.

29. There is a striking difference between the generation costs of the existing and proposed power plants. Being largely depreciated, the existing nuclear power plants apparently are able to deliver the cheapest electricity along the whole load range: from US cents 2.22 for a load of 4000

hours per year to US cents 1.33 for a load of 8,000 hours per year. The electricity price delivered by the hard coal electricity units, also depreciated to a certain extent, moves in the range of 2.08 and 2.44 US cents as the load factor decreases. None of the proposed power plants, regardless of the technology and under reasonable assumptions on costs of capital and relative and absolute fuel prices, would be able to match those low generation costs.

30. If a new power plant is going to be selected in the market conditions typical for Germany that include public non-acceptance of new nuclear energy generation, gas-fired combined cycle power plants are clearly superior to an alternative hard coal facility. Its unit electricity costs are estimated to be in the range of 2.22 to 2.75 US cents as the load increases. In particular at low load factors, any new hard coal power plant would not be competitive on the basis of long term marginal costs.

31. An important issue in today's debates on the achievement of a sustainable energy sector is the internalization of external costs. While it is certainly not possible to achieve a sensible internalization with the property rights in place both in market economies and economies in transition, an insight into the external costs of generating electricity might prove to be highly interesting both for decision makers and the business sector (Chart 22). According to the calculation, the average external cost of electricity production in the existing hard coal and lignite-fired power plants is almost higher than direct production costs**.** On the other hand, it appears that among the fossil fuel-fired power stations, the nuclear ones have a clear lead.

Table 1. Selected factors of importance for the future of the use of coal in the power plant sector in the immediate future

Factor	What is the issue	Degree of uncertainty
Technological developments	- Thermal efficiency - Appearance of combined cycle	Low, gas-fired plants superior
Regulatory developments	- Progress in market liberalisation including natural gas - Design of market institutions - Federal (EU) versus state actions - Security of supply definition and implementation	High in Western Europe Medium to low in United States Very high in economies in transition
Regulatory profile & goals	- Regulatory goals: low risk versus market return - Equity / debt structure	Low in the USA High in western Europe Very high in economies in transition
Energy policy	- Subsidies - National energy goals - Protective legislation	Medium in western Europe Medium to high in economies in transition Not applicable to the USA
Environmental compliance	- Kyoto protocol - National legislation	Risk difficult to specify

Factor	What is the issue	Degree of uncertainty
Energy taxation	- Energy tax - CO_2 tax	Risk difficult to specify, probably lowest in the USA
Nominal versus real market opening	- transmission access - efficient hubs - access to trade	Medium in western Europe Very high in economies in transition Low to medium in the USA
Overall competitiveness of various power plants	- fixed cost - variable cost - land use - pollution	Low uncertainty at least in medium term: gas-fired and existing, depreciated nuclear plants superior to other power plants
Overall	a complexity of interrelated factors	Significant uncertainty although with selected unfavourable factors for coal use in electricity generation

Source: ECE secretariat

32. Another issue is in which way those externalities could be captured and dealt with efficiently. Unfortunately, with some exceptions in market economies, there is currently no efficient system in place that would address the problem in the appropriate way. The debate and action mostly focus on energy and CO2 tax while a possible coherent international emission trading system is far from being constructed (Chart 23).

IV. PRELIMINARY CONCLUSIONS ON THE POSSIBLE FUTURE OF COAL IN THE ELECTRICITY GENERATION

33. The future of coal in the electricity sector appears at present to be in a delicate balance**.** While coal reserves are abundant worldwide including in the ECE region, the current stock of coal-fired power plants is considerable and there is a problem with the acceptance of new nuclear energy plants in the region, the above-mentioned regulatory and technological shocks coupled with serious environmental concerns are not necessarily favouring an increasing use of coal in the power plant sector. This is so despite expected possibly substantial increases in the thermal efficiency of the coal-fired power plants in the long-term.

34. Despite the fact that the coal industry is working on the development of clean coal technologies for power generation, there are major barriers inhibiting their wider use, such as:

- persistent public and political resistance to coal-fired power plants;
- uncertainty associated with the future regulation of CO_2 emissions;
- lack of transparent information about the costs of new technologies;
- lack of incentives for their development and implementation;
- lack of incentives to encourage R&D projects on CO_2 sequestration.

35. Available estimates of the probable additions to the electricity generation capacity both in the USA and western Europe in the next 5 to 20 years indicate a dominant position of combined

cycle gas-fired power plants. So for example, in a period from 1997 to 2005 it is estimated that about 60% of all net plant commissioning in western Europe will be based on gas-fired generating capacity. Practically there would be no additions of coal-fired power stations (Chart 24). The combined cycle also appears to lead the additions to the electricity generation in the USA (Chart 25). About 45% of all new commissioned power plants in the next twenty years are expected to be combined-cycle gas-fired driven.

36. Despite the expected decrease in the importance of steam power plants in the installed power plant capacity in the world for the years to come, from 54% in 1995 to 46% in 2010, coal will most probably remain the most important fuel for power generation in the ECE region as well. But its dominance, based on the available estimates on the power plant stock evolution in the next 20 years, could be threatened by natural gas by the year 2020 at least in western Europe and possibly in the USA. At the same time, related future developments in selected economies in transition, Russia and Ukraine in particular, are difficult to assess. While, for example, Russia has announced that it would like to switch a part of gas-fired power plants to coal it is not clear whether sufficient investments will be in place to follow-up on that target. A difficult economic and energy situation in Ukraine does not permit any forecast on the long-term future of its electricity sector.

37. Along with a continuous assessment of changes in technological, market and regulatory conditions in the energy market in the ECE region and their impact on the use of coal in power plants, further research on the issue might be beneficial both to the governments and private sector in the region. ECE will maintain its role in this important activity.

ANNEX I

BASIC DATA ON COAL USE FOR ELECTRICITY IN THE ECE REGION, 1998-2000

Table A-1
Deliveries of hard coal to power plants in the ECE Region (Mt)

Main countries	Actual 1998	Estimates 1999	Forecast 2000
Belgium	5	3.7	3.7
Denmark	8.9	7.5	5.6
Finland	2.1	2.2	2.2
France	12.6	11.6	8.9
Germany	51.1	49.9	50.1
Italy	8.0	8.4	8.4
Netherlands	9.3	7.0	6.9
Portugal	5.0	5.2	4.0
Spain	24.9	29.9	29.9
United Kingdom	46.6	39.4	35.0
European Union	**177.5**	**168.1**	**158.2**
Israel	9	10	10
Turkey	2	2	2
Western Europe	**189**	**180**	**170**
Canada	14	13	
United States	811	845	
North America	**825**	**858**	
Czech Republic	2	3	Na
Hungary	1	1	1
Poland	55	48	na
Romania	4	2	3
Kazakhstan	34	32	30
Russian Fed.	88	90	na
Ukraine	22	22	na
Central Europe and FSU	**206**	**198**	
ECE TOTAL	**1220**	**1236**	

Source : European Commission, IEA and UN/ECE.

Table A-2
Deliveries of Brown coal to power plants in central/eastern Europe and the CIS (Mt)

Main countries	Actual 1998	Provisional 1999	Forecast 2000
Bulgaria	27	24	Na
Czech Republic	31	32	Na
Hungary	14	14	13
Poland	63	60	61
Romania	22	20	22
Slovakia	3	3	3
Russian Fed.	50	63	64
Central Europe and FSU	**210**	**216**	

Source : UN/ECE

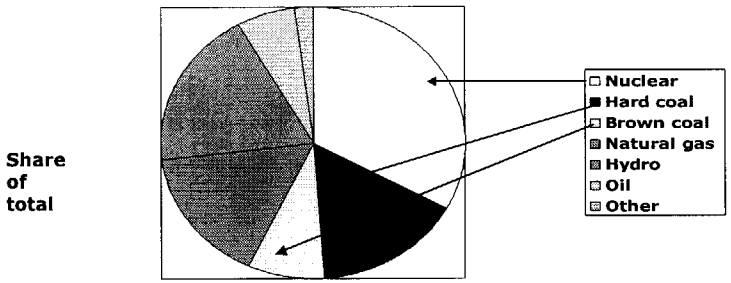
Table A-3

Gross electricity production in 1998 and Coal share in selected UN/ECE countries

	Production (TWh)	Coal Share (%)
OECD Europe	3032	31
Non-OECD Europe	205	38
FSU	1 224.48	21
UN/ECE	**8 833**	**31**
Canada	561.69	19
USA	3 803.71	53
Austria	55.89	9
Belgium	82.13	21
Denmark	41.08	58
Finland	70.17	19
France	506.93	7
Germany	552.38	54
Greece	46.18	70
Italy	253.64	11
Netherlands	91.17	30
Portugal	38.91	31
Spain	193.53	33
Sweden	158.23	2
United Kingdom	356.62	35
Belarus	25.3	0
Bulgaria	41.5	45
Czech Republic	64.62	72
F. Rep. Yugoslavia	40.7	64
Hungary	37.19	26
Poland	140.77	96
Romania	53.5	28
Russian Federation	826.1	19
Kazakhstan	49.1	72
Slovakia	25.2	23
Slovenia	13.7	35
Turkey	111.02	32
Ukraine	172.8	26
Uzbekistan	45.9	4
WORLD	**14 330**	**38**

Source : IEA/OECD

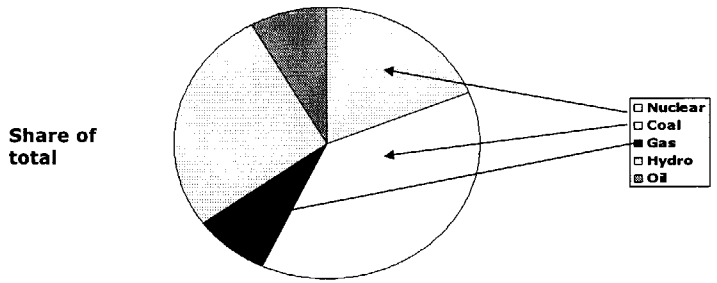
1. Electricity production by fuel type, Western Europe, 2000, estimate



Source: Own estimate based on initial Eurelectric data

Note: shares from nuclear on clockwise

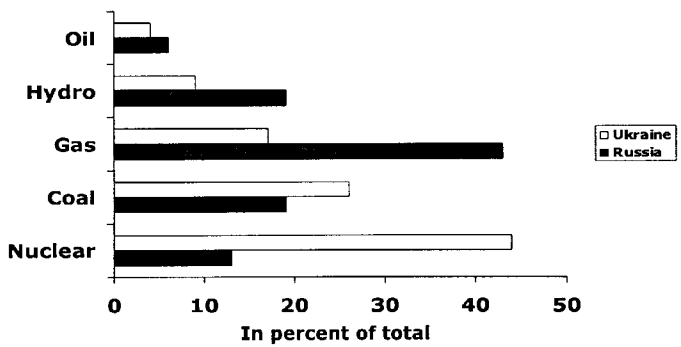
2. Electricity production by fuel type, Central & Eastern Europe, 1999



Source: ECE, IEA / OECD

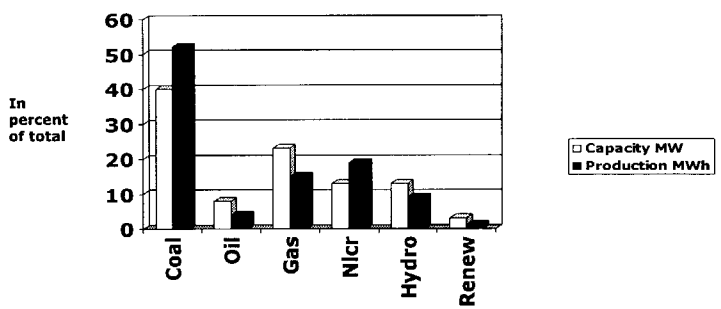
Note: shares from nuclear on clockwise

3. Electricity production by fuel type, Russia & Ukraine, 1999



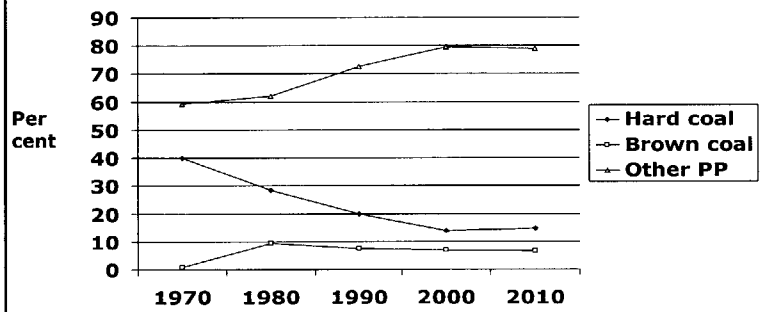
Source: ECE

4. Installed capacity & generation, by energy source, USA, 1998



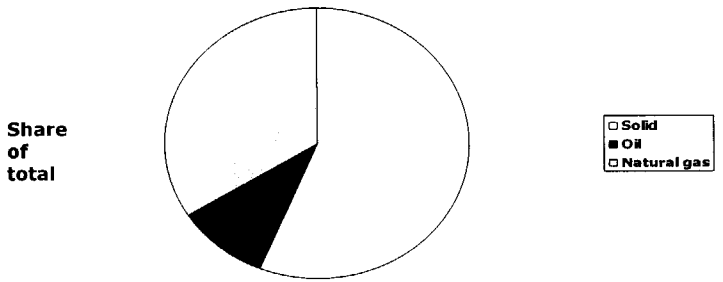
Source: Own construction based on initial EIA data

5. Coal-based PP share in electricity generation, W. Europe, 1970-2010



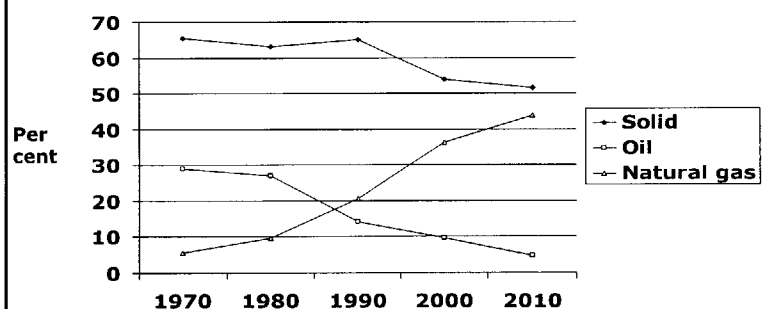
Source: Eurelectric 1998

6. Fuel use for electricity production, Western Europe, 2000, estimate



Source: Own estimate based on initial Eurelectric data

7. Share of solid fuels in the total fuel consumption for electricity generation, W. Europe, 1970-2010



Source: Own construction with Eurelectric data 1998

8. Thermal efficiency of selected types of generators, status, 2000

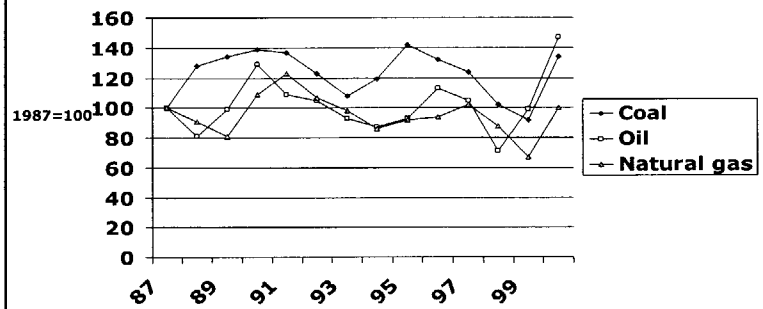
1. Fossil-fuelled steam-electric plants	33-35 per cent[1,2]
2. Gas turbines	30-34 per cent
3. Natural gas combined cycle units	50-60 per cent
4. New advanced coal technology	38-45 per cent

1) Reportedly 28% in China and 38% in Germany

2) Targeted increase to 50%

Source: Industry and government experts

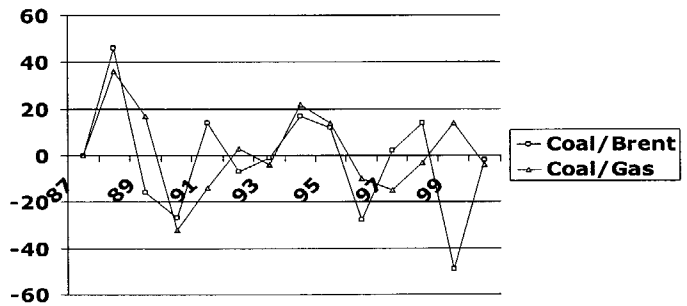
9. Crude oil, coal & gas wholesale prices, W. Europe, 1987-2000



Source: BP and ECE

Prices: Brent for oil, NW Europe for coal and WE border price for gas; 1987=100

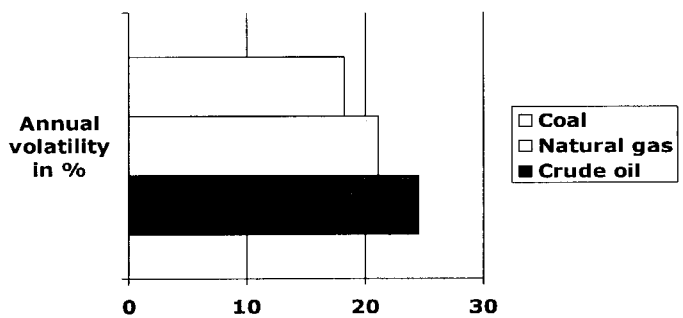
10. Relative wholesale price competitiveness of coal to crude oil and gas, W. Europe, 1987-2000



Source: Our calculation

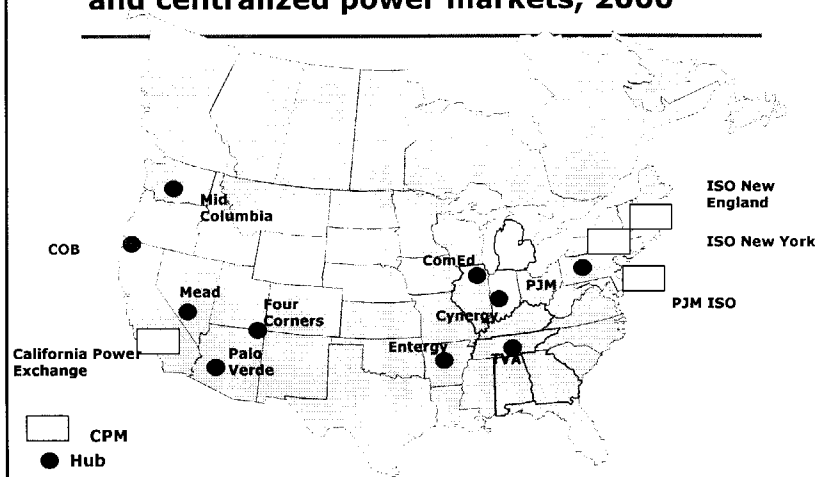
Prices: Brent for oil, NW Europe for coal and WE border price for gas; 1987=0

11. Wholesale fuel price volatility, Western Europe, 1987-2000

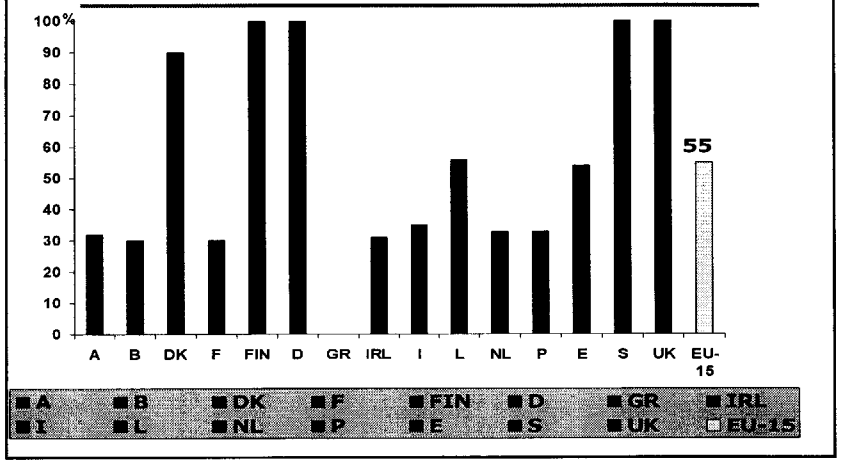


Source: ECE secretariat

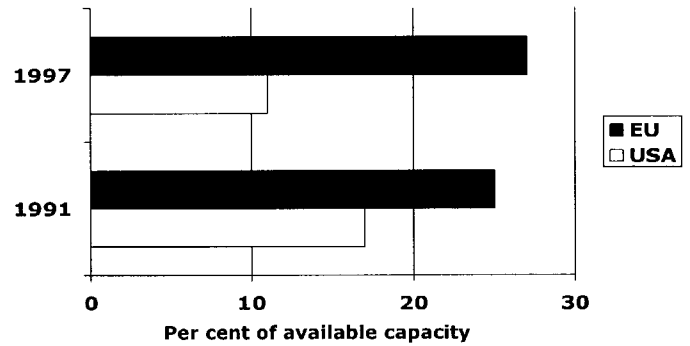
12. USA wholesale electricity trading hubs and centralized power markets, 2000



13. Electricity market opening in EU, estimate 2001, in percent

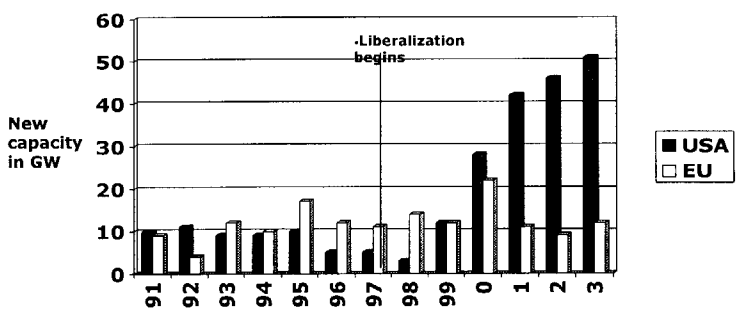


14. Reserve capacity margin, USA vs EU, 1991 and 1997, in per cent



Source: SIEMENS & ECE secretariat

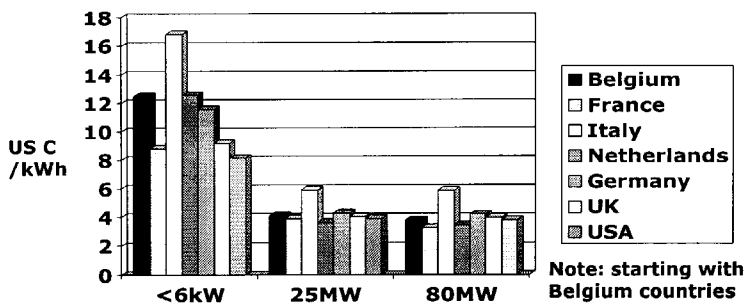
15. Construction of new PP and liberalization, USA and EU-15



Total added:
USA 241 GW,
EU 155 GW

Source: ECE, Siemens, 2001

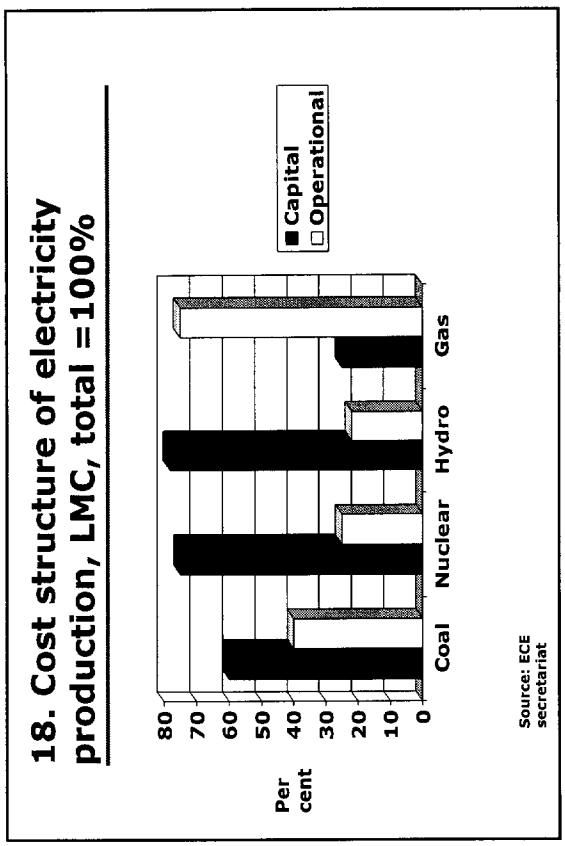
16. Electricity prices, Europe & USA, 1/1/2001 in US cents /kWh

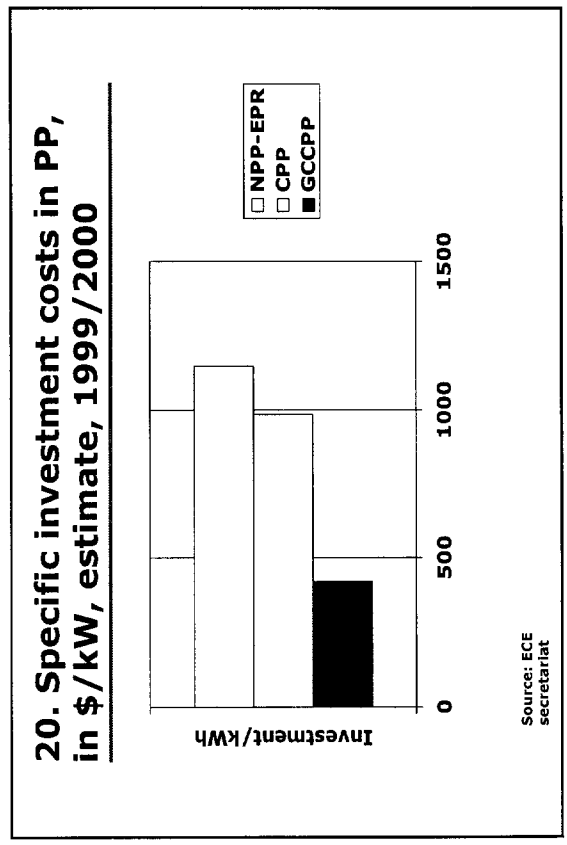


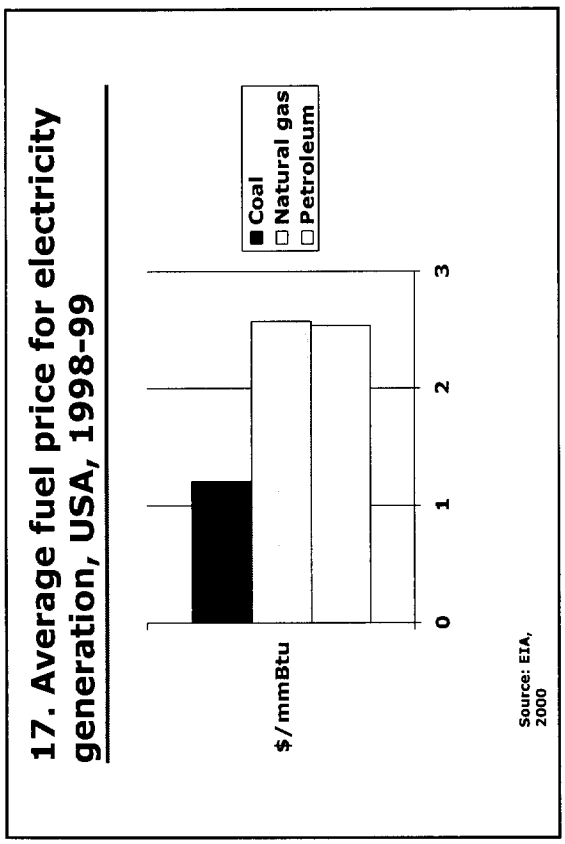
Note: starting with Belgium countries follow from left to right

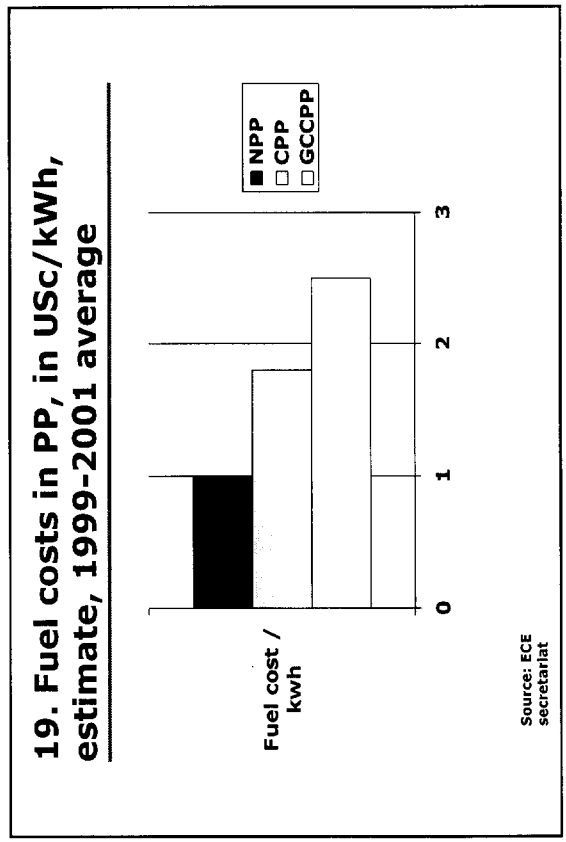
Source: ECE secretariat

Load factor 60% where applicable, w/o VAT

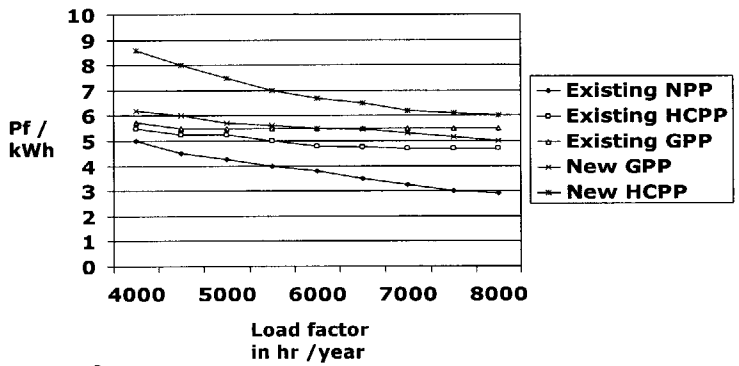

18. Cost structure of electricity production, LMC, total =100%
Capital
Operational
Per cent
80
70
60
50
40
30
20
10
0
Coal
Nuclear
Hydro
Gas
Source: ECE secretariat


20. Specific investment costs in PP, in $/kW, estimate, 1999/2000
NPP-EPR
CPP
GCCPP
Investment/kWh
0
500
1000
1500
Source: ECE secretariat


17. Average fuel price for electricity generation, USA, 1998-99
Coal
Natural gas
Petroleum
$/mmBtu
0
1
2
3
Source: EIA, 2000

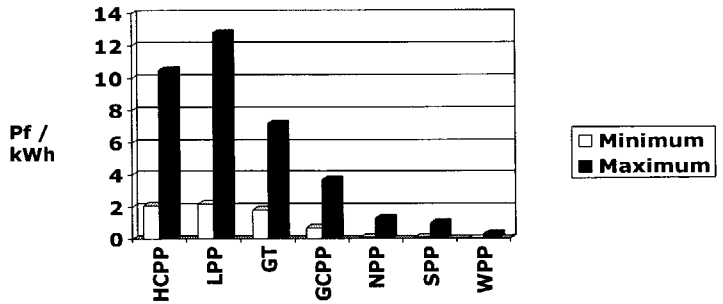

19. Fuel costs in PP, in USc/kWh, estimate, 1999-2001 average
NPP
CPP
GCCPP
Fuel cost / kwh
0
1
2
3
Source: ECE secretariat

21. Generation cost of various PP, example of Germany, Pf/kWh,1999



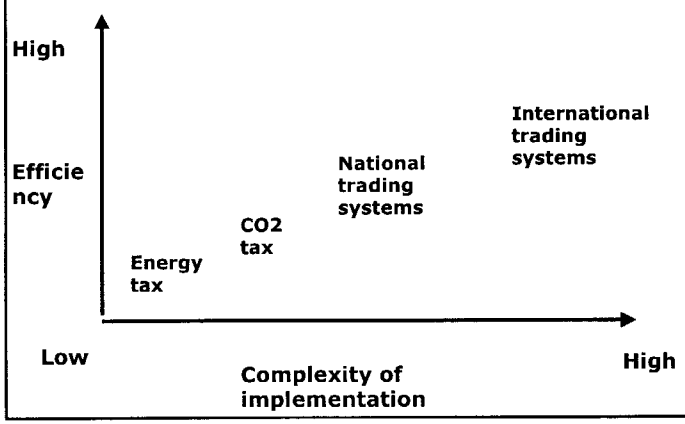
Source: Bayernwerk, 1999

22. External cost of generating electricity, Pf/kWh, EU, 1999



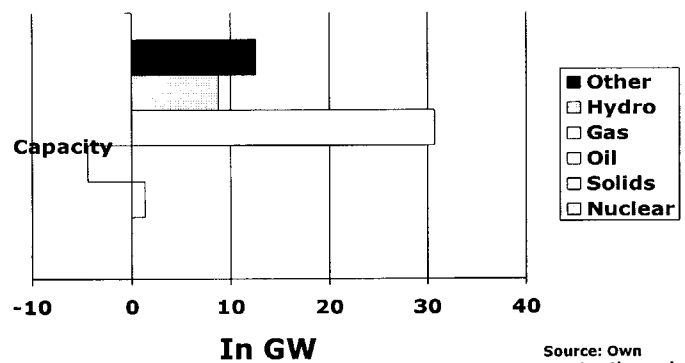
Source: EU

23. Alternative ways of capturing a part of external electricity generation costs: case in point - emissions



Source: BE

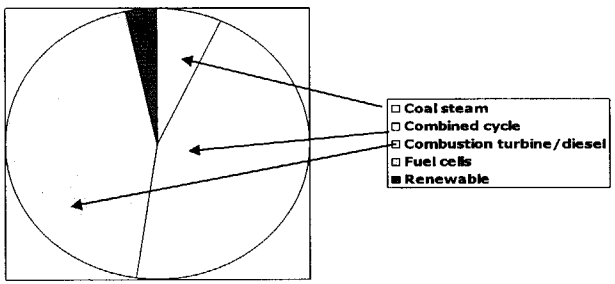
24. Expected PP net commissioning, W Europe, 1997-2005, in GW



Source: Own construction on initial Eurelectric data

25. Projected additions to electricity generation capacity, by technology type, USA, 1999-2020

In GW - total 299.9



Source: Own construction based on EIA data