UNITED NATIONS

E

Economic and Social Council

Distr.
GENERAL

ENERGY/GE.1/1999/7
25 June 1999

ORIGINAL : ENGLISH

ECONOMIC COMMISSION FOR EUROPE

COMMITTEE ON SUSTAINABLE ENERGY

Ad Hoc Group of Experts on Coal and Thermal Power
Second session, 8-9 November 1999
(Item 6 of the provisional agenda)

STATUS OF CLEAN COAL TECHNOLOGIES IN CENTRAL EUROPE AND THE CIS

(Transmitted by the World Energy Council) */

I. POLLUTION CONTROL: THE PROMISE OF CLEAN COAL TECHNOLOGIES

1. Heavily polluted (the “black triangle” between northern Bohemia, Saxony and Upper Silesia may serve as a reminder) and under strong international pressure to reduce transboundary air and water pollution, the economies in transition have comparatively rapidly conceptualized pollution control policies, developed the necessary national legislation and institutions and adhered to international instruments such as the UN/ECE Convention on Long-Range Transboundary Air Pollution of 1979 and its Protocols, the Convention on the Protection and Use of Transboundary Watercourses and International Lakes of 1992, the UN Framework Convention on Climate Change of 1992 and the Kyoto Protocol of 1997.

*/ Prepared by Mr. Klaus Brendow, WEC Regional Coordinator - Central Europe/CIS, Geneva

Clean coal technologies (CCT)

Definition:	"Technologies designed to enhance both the efficiency and environmental acceptability of coal extraction, preparation and use"
Extraction:	geophysical and seismic exploration
	selective mining techniques
	mine methane drainage
	reduction of ground water contamination
	recultivation
Preparation:	increased share of washed coal
	improved reduction of ash and sulphur
	waste water treatment
Combustion:	sub-critical (<248 bar/560^0 C) pulverized coal combustion combined with electro-static and/or fabric filters, flue gas desulphurisation, low-NO_x burners, selective catalytic NO_x reduction
	advanced pulverized coal combustion with higher efficiencies due to high-strength alloy steels enabling supra-critical and ultra-supra-critical pressures (>248 bar) and temperatures (>560^0 C)
	fluidized bed combustion, - atmospheric or pressurized
	integrated coal gasification combined cycles (IGCC)
	hybrid systems
	IGCC co-firing of coal and biomass, waste

Source: World Coal Institute, Coal - power for progress, London 1999, pp.22-24; IEA Coal Research, Air pollution control for coal-fired power stations in eastern Europe, London 1996

2. Without going into detail, suffice it to say that the countries of central and eastern Europe (CEE) and the CIS countries have fully integrated the international mainstream in this regard. In CEE, much of this commitment can be attributed to the desire to accede the EU as early as possible and to conform with various EU directives, of which the Directive on Large Combustion Plants. 1/

3. These policies and instruments affected also, and particularly, coal mining and combustion as coal was a major source of pollution and had no long-term future unless clean. Improved management and clean coal technologies (CCT) were at hand to respond to the challenge, but needed to be applied to the specific circumstances prevailing in the economies in transition. However, this proved technically more difficult, financially more demanding and more time consuming than had been anticipated.

4. Three “applications” of CCT need to be distinguished:
   - in power generation and co-generation
   - for direct use in small industrial and residential boilers,
   - in mining proper

II. CLEAN COMBUSTION: POWER AND CO-GENERATION PLANTS

5. Coal is a most important fuel for power generation in the economies in transition: 30% of electricity generation is based on coal 2/. Vice versa, power plants absorb a high and ever increasing share of coal production: 66% in CEE and 50% in CIS (1995) 3/ (see Table 1). This interdependence explains the mutual interest of both industries in the successful application of clean technologies.

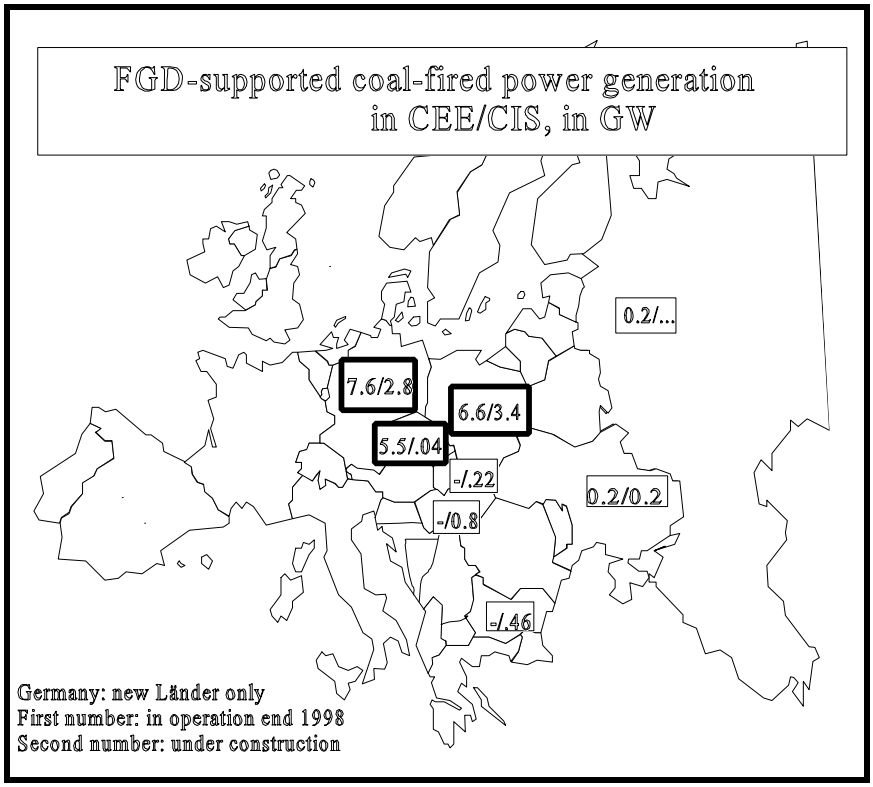
A. The situation in the various countries

6. Yet, progress in applying these technologies has been slow and uneven so far. CCT has been systematically introduced only in the new German Länder, the Czech Republic and Poland; Hungary will have followed by 2003/2004; the other countries are either undertaking ad hoc projects or are still in the planning stage; the small and energy-importing CIS countries (Belarus, Republic of Moldova, Georgia ...) are not able to even begin the process of investing in depollution:

- in Bulgaria, the first two flue gas desulphurisation facilities (2 x 230 MW) with wet limestone technology will be in operation in Maritza-East by 2001; further 2 x 230 MW are planned to be in operation by 2010; there will also be a test facility using ammonia to remove sulphur and NO_x 4/

- in the Czech Republic, the law required that existing generating units be equipped with desulphurisation by the end of 1998; subsequently, CEZ - the national power company - invested $2.2 bill. in desulphurisation, denitrification and repowering of its coal-fired plants; 5510 MW are in operation and desulphurisation of another 400 MW is planned 5/. The application of CCT depends entirely on the resources of the coal-using companies, even though the law requires them to use CCT; the absence of Czech-designed CCT proved a difficulty as it implied cooperation with foreign financial institutions and technology providers; also, the large size of boilers (>250 MW) and uncertainty about the long-term functioning of CCT for low-grade coal was an impediment; as a result, preference was given to low-cost, proven CCT with flue gas desulphurisation and circulating fluidized bed combustion; more advanced CCT are envisaged for 2000-2010, with IGCC using heat from nuclear reactors emerging after 2020 6/.
- in Estonia, circulating fluidized bed technology is the preferred CCT for future application to shale combustion 7/.

- in the new German Länder, the updating of lignite-fired power stations was successfully concluded; by the end of 1998, 7580 MW were equipped with wet flue gas desulphurisation, 2770 MW are under construction and will have been commissioned by 2000 8/; new electro-static precipitators updated boiler-fired system to reduce NO_x, replacement of turbines, process controls and other components rendered the updating expensive; in some cases, it would have been cheaper to build a new plant 9/



- in Hungary, coal-fired plants that will not conform with stricter environmental regulations would have to be closed down by 2003, 2004; plants using coal from underground mines may not be sufficiently profitable to finance CCT; by contrast opencast-supported power generation will be expanded: thus, RWE/EVS will refurbish its 800 MW Matra plant ($253 million, of which $70 million for environmental protection) and build a new 2 x 500 MW plant near Miskolc ($1.48 billion, of which $0.48 billion for mine expansion) 10/

- in Poland, the Government adopted in 1996 a plan entitled "SO_2 emission reduction in the Polish energy sector" implying a cost of $2 billion; by 1997, 6600 MW had been equipped with flue gas desulphurisation and 3400 MW were under construction; various CCT are used: wet limestone, semi-dry, dry sorbent SO_2 reduction and atmospheric circulating fluidized bed combustion; NO_x reduction is achieved through low-NO_x burners and

staged combustion; fly ash is reduced by electrostatic and fabric filters; fluidized bed boilers are in operation in several plants 11/

- in Romania, power plants use mostly pulverized coal combustion with low efficiency and without denoxification and desulphurisation; a "Programme of refurbishing and modernization of power plants within the national power system" directs the refurbishment of the entire thermal power sector which relies 44% on coal; investments are estimated at $2.5 billion; for lack of funding, low- and medium-level measures (improved burning process control, low NO_x burners, improved electrostatic precipitators, pollution measurement) have been applied to four units (1140 MW) of the lignite-fired Turceni and Rovinari power plants; CCT will be applied at a later stage to existing plants, but have to be applied from the outset to new plants. 12/

- in the Russian Federation, coals from Kuzbas, Kansk-Achinsk, eastern Siberia, the north-east and far-east are low-sulphur and can be burnt without or with minimum sulphur cleaning; these mining regions accounted in 1993 for 78% of production; in other cases, CCT are required: since 1995 200 MW operate with flue gas desulphurisation at the Dorogobush cogeneration plant 13/; at present, desulphurisation tests are run with anthracite culm and coals from Kansk-Achinsk and Ekibastuz; demonstration projects are undertaken:
  by Rostovenergy, the combustion of anthracite screenings in melted slag at the Nesvetai power plant, the circulating fluidized bed combustion of anthracite screenings in large boilers in the new Rostov power plant, and the circulating fluidized bed combustion of coal preparation wastes in smaller boilers,
  by Krasnoyarskenergo, staged combustion in a traditional pulverized coal furnace with high temperature preheating, fabric filters and removal of sulphur from the flue gas with activated ash,
  by the Ryasan State District power plant, with a German partner, to undertake desulphurisation of a 300 MW unit 14/.

- in Slovakia, two units of the Vojany Power Plant were equipped with facilities for desulphurisation/denitrification and two units of the Novaky Power Plant with desulphurization facilities. The latter plant was also equipped with a fluidized bed boiler.

- in Ukraine, (only) one unit (250 MW) of the Dobrotvorsk Power Plant is equipped with wet limestone flue gas desulphurization 15/; an agreement signed in early 1999 foresees the replacement of boilers, turbine, processing techniques and electrostatic filters at the coal power plant of Smijev (300 MW, 1965); this project is said to be the first joint CCT venture between western and Ukrainian partners 16/.

B. Regional overview

(a) The policy:

7. Except for low-sulphur coals (Russian Federation), CCT is a necessity for the survival of coal as a power generation fuel in CEE/CIS. This has been recognized as a policy objective in all countries.

Table 1: Coal in power generation

Country/region	coal-firing capacity in MW	of which operating with FGD in 1998	additional FGD capacities under construction	share of 1998 coal production delivered to power stations, in%
Albania	35	-	-	-
Bulgaria	5000	-	460	45
Czech Republic	8500	5510	400	75
Estonia (shale)	1647	-	-	98
ex-GDR	9000	7600	2770	86
Hungary	1750	-	800	91
Poland	31718	6600	3400	96
Romania	7694	-	-	44
Slovakia	2000	-	220	48
Slovenia	1020	-	-	95
The former Yugoslav Republic of Macedonia	800	-	-	77
CEE	69100	19700	8050	66
Kazakhstan	13900	-	...	..
Russian Federation	39000	200	...	50
Ukraine	23000	215	...	50
CIS	75900	645	...	50*
CEE/CIS	145000	20345	...	59
Sources: see country notes/quotations; FGD = flue gas desulphurisation				

(b) The facts:

8. At present, about 20 GW or 14% of coal-firing capacities in CEE/CIS are equipped with flue gas desulphurisation; they are almost exclusively located in CEE, where they represent 29% of installed capacities; if the new German Länder were excluded, about 13 GW or 9% of CEE/CIS capacities are equipped with FGD.

9. Further desulphurisation units for 8 to 9 GW are under construction and will be operational by 2001-2003; by then, about 29 GW will be equipped with such facilities. This is 20% of CEE/CIS and 40% of CEE coal-fired capacities, including the new German Länder. Fluidized bed boilers are also increasingly installed. Their capacity is not documented.

(c) The perspectives beyond 2003:

10. For CEE, the aim should certainly be to push the share of FGD-supported coal combustion from the anticipated 40% by 2001-2003 to close to 100%; this is also true for Ukraine, but not for the Russian Federation, where low-sulphur coals account for close to 80% of production (and more in power generation).

11. This means that beyond 2003, 65-75 GW of coal-based power generation in the economies in transition need to be equipped with FGD.

(d) The obstacles:

12. Coal properties as such are not the obstacle to introducing CCT as evidenced by the experience in the former GDR, the Czech Republic and Poland. However, low-rank coal - predominant in CEE/CIS - requires highly site- and coal-specific solutions which increase cost and add uncertainty as to the reliability of operations; hence the tendency to apply proven and low-cost CCT; large-size units (>250 MW) can be an obstacle.

13. The apparent bottleneck is finance, the real bottleneck delays in restructuring the coal and electric power industries in those countries, that have not liberalized those industries. If the Czech experience (CTT investment cost of $/kW 260) 17/ were representative of the region as a whole, repowering and compliance with SO_2, NO_x and particulate standards for power stations and co-generation would require $18 billion in CEE and $20 billion in CIS, i.e. $38 billion for the region as a whole. Out of this sum $8 billion have already been spent, $4 billion are being invested and the remainder, $26 billion, has still to be mobilized; if advanced super-critical and ultra-super-critical CTT were applied, the bill would be (only) 5% and 10% higher 18/.

14. It is evident that the bulk of CCT funding has to come from domestic sources. External funding can play an important stimulating role; such funds have been forthcoming from multilateral banks such as the EBRD and the World Bank, but also bilaterally (e. g. from Germany to the Czech Republic, from Austria to Slovenia), from equipment manufacturers and from individual companies (e. g. the Dutch SEP which generated “activities implemented jointly”- projects under the Kyoto Protocol in Poland and Romania).

(e) The opportunities:

15. But there are also the opportunities offered by multilateral project finance and business. The transfer of technology and capital depended clearly on progress in restructuring of the coal industries: where this was accomplished or a near-time perspective, technology and capital transfer proved sufficiently attractive for foreign investors and involved increasingly CEE/CIS design institutes and manufacturers.

16. Multilateral project finance was available particularly for refurbishing coal-based power plants:

- Azerbaijan: an EBRD loan of $26.7 million for Mingechaur
- Bulgaria: an EBRD loan of $75 million for power sector refurbishment
- Kazakhstan: an EBRD loan of $ 85 million for Ekibastuz
- Poland: a World Bank loan of $215 for Dolna Odra and of $140 million for Rybnik
- Romania: World Bank and EBRD support for refurbishing the power sector
- Russian Federation: a World Bank loan of $510 for Krasnodar
- Slovakia: an EBRD loan for Vojany
- Ukraine: a World Bank loan of $160 million for Krivoy Rog

17. Apart from pre-financing equipment supplies, private foreign capital began to acquire equity:

- power generators acquired equity in the former GDR (MIBRAG), Hungary (RWE/EVS, AES ...), Poland (EDF - CHP Cracow-Lek) and Kazakhstan (Ispat-Karmet, AES, Access Industries, Sverdloenergo, Samsung, NTD, US Global Mineral Reserves, Ormat/National Power)
- in Romania and Poland, SEP (NL) initiated “activities implemented jointly” according to the Kyoto-Protocol
- joint ventures in equipment manufacturing for power plants were formed in most CEE/CIS countries, involving western partners such as SIEMENS and ABB
- in the Czech Republic, for flue gas desulphurization, occasionally joint ventures were concluded between Czech companies and foreign suppliers Bischoff, Mitsubishi, SHL (Germany), Marubeni-Chiyoda-Burmeister, Hoogovens, Steinmüller, IVO and Austrian Energy & Environment; for fluidized bed combustion with ABB-PBS Brno, ACC, Vitkovice-Lurgi-Babcock, Lurgi-Tlmace and Austrian Energy & Environment 19/
- in Poland, for flue gas desulphurisation, occasionally joint ventures were formed between Polish companies and foreign suppliers: HTS (NL), Rafako (Pl)-Steinmüller (G), FLS Miljo (DK), Holter Industrie Beteiligung (G), ABB-Flakt (Pl), Foster Wheeler (US); fluidized bed boilers by Rafako (Pl), Babcock, Stork Boilers, Rolls Royce, IVO, Burmeister-Wain Energi, Ecoenergia-Institute of Power Engineering; circulating fluidized bed boilers by Foster Wheeler and Rafako 20/

- in Romania, IPROMIN seeks foreign partners to develop its CCT for small and medium-sized enterprises and domestic uses 21/
- in Slovakia, foreign and domestic investors financed the desulphurisation of 2 units of the Vojany Power Plant (2 x 210 MW) and the first fluidized bed boiler at the Novaky Power Plant; the main contractor for Vojany was Austrian Energy & Environment, for Novaky: Tlmace-Lurgi 22/

III. CLEAN DIRECT USES: DISTRICT HEATING AND INDUSTRIAL AND RESIDENTIAL BOILERS

18. Compared with power stations and co-generation, international attention and regulation has been considerably less for district heating and briquetting plants, and for direct use under industrial boilers (under 50 MW_{th}) or in houses. A draft EU Directive on Small Combustion Plant has been considered for some time, but is dormant 23/. National legislation applies which - while different - systematically allows higher emissions for “smaller” boilers.

19. Yet these plants and boilers need attention for three reasons: for their huge number, for the difficulty of auditing their performance, and - in case low-grade coal is used - for the need to apply CCT technologies suitable to their size. This is particularly true in the economies in transition, where energy-intensive industries, district heating, briquettes and direct use of solid fuel by industry and households play a much bigger role than anywhere else in the world: customers other than power and coking plants absorb 40% of total coal supplies. Plants and equipment are outdated, polluting and inefficient:

- in Albania, where pollution from coal burning by end-users is high, the future of coal use depends also on the application of low-NO_x burners and fluidized bed technology in small industrial boilers 24/
- in Bulgaria, 20% of the population is linked to district heating systems and 9% of coal production is earmarked for briquetting; industrial coal-fed boilers are a major polluter 25/
- in the Czech Republic, emissions from small combustion plants were 412 kt of SO_2 compared with 636 kt from power stations, and 138 kt of NO_x compared with 79 kt from power stations 26/
- in Estonia, there are over 4000 boilers below 1 MW and 815 between 1 and 15 MW; 40% of all boilers run on coal, shale, peat or wood 27/
- in Romania, CCT for small and medium-sized enterprises and for residential use have been evaluated but implementation rests on foreign partnerships and support 28/

IV. CLEAN MINING

20. Coal mining has serious environmental effects: pollution of rivers (acid mine drainage, saline discharges), lowering of water tables and pollution of ground water, special and hazardous wastes, subsidence, land disturbance,

dust, spoil heap fires, methane accumulation. The coal industry also has the answers: back-filling, selective mining, improved coal preparation, closed water systems, re-use as construction materials, recultivation, soil decontamination, methane drainage.

21. The apparent issue in CEE/CIS is funding. If the experience with clean-up of mining damage in the new German Länder was representative for the region, between $35 and 40 billion (or 27 $/t of 1990 production) would be needed to restore water systems and land surfaces. While this amount corresponds to only 5.5% of one year of GDP in CEE/CIS, it is simply not available: funding is insufficient in the more advanced reforming countries, symbolic in the others. State funds are increasingly re-directed towards social protection, community needs and environmental damage generated before privatization and restructuring. The new owners have either not internalised the environmental cost of their activities or view those as a target for cost reduction:

- in Bulgaria, for lack of funding, waste waters from mining activities are a serious problem; hundreds of hectares of land around mines and power stations are contaminated by waste; only 10% of the opencast mining area has been recultivated 29/
- in the Czech Republic, during 1993-95, CZK 4.575 ($140 million or 1.8 $/t of 1990 production) were allocated to “rehabilitation”; the original deadlines for undertaking recultivation were not met because of reduced state funding 30/
- in the new German Länder, between 1990 and 1997, about half of the required recultivation had been undertaken at a cost of DM 8 bill ($4.5 billion or 18 $/t of 1990 production); for 1998-2001, every year another DM 1.2 billion ($670 million) are forthcoming from state funds to conclude recultivation, on the whole 20.7 $/t of 1990 production 31/
- in Hungary, land reclamation in conjunction with the closure of mines is almost completed 32/
- in Poland, funding aimed at improving coal quality and addressing the environmental legacy is considered inefficient 33/; still, 14 new coal preparation plants have been put into operation, with another 14 planned
- in the Russian Federation, the environmental performance of mining depends on mining regions, - the newer ones operating “close to best international practices” (World Bank); restoration is estimated to cost $100 - 150 million in the Kuzbass and perhaps $10 million in each of the other surface mining areas 34/

V. DEPOLLUTION: THE RESULTS THUS FAR

22. Environmental measures focus on air pollution control from large stationary sources. In countries that have introduced CCT, emissions have fallen considerably:

- in the Czech Republic, emissions of the power sector have fallen between 1993 and 1998 by 92% (SO_2),53% (NO_x), 44% (CO) and 89% (fly-ash) 35/

- in the new German Länder, emissions of SO_2 from power stations fell between 1990 and 1997 by 79%, of NO_x by 58% and of dust by 99% 36/
- in Poland, 14 coal preparation plants have been refurbished and another 14 commissioned; emissions from energy sources are expected to fall between 1980 and 2000 as follows: SO_2 - 41%, NO_x - 37%, dust - 77%, CO_2 - 12% 37/

Table 2: Emission limits for new plant, mg/m^3

Country	Particulates	SO_2	NO_x
Bulgaria	50-100	400-2000	650-1300
Czech Republic	100-150	500-2500	650-1100
Germany	50-150	400-2000	200-500
Hungary	50-100	400-2000	200-600
Poland	190-3700	540-1755	95-460
Romania	100	400-2000	400-500
Slovakia	50-150	400-2500	550-650
Slovenia	50-150	400-2000	200-500
European Union	50-100	400-2000	650-1300
Source: IEA Coal Research, Bulgaria, op. cit., p. 31			

23. In the other countries, emissions stabilized or decreased under the impact of the recession:

- in Bulgaria, emissions from power stations stabilized under the impact of decreasing demand and a higher share of nuclear power 38/
- in Estonia, pollution from all stationary sources fell between 1990 and 1996 as follows: CO - 50%, SO_2 - 52%, NO_x - 29% 39/
- in Hungary, emissions from power plants stabilized during 1990-1997, with a slight increase of SO_2 emissions 40/
- in Slovakia, emissions from the national power company, Slovenske Elektrarne, developed between 1993 and 1997 as follows: ash - 16%, SO_2 - 33%, - 4%, + 51% 41/

24. A comparison between the two groups of countries shows that the correlation between declining GDP and depollution observed in the earlier 1990s has recently been broken in CEE: with GDP rising again in this region, depollution nevertheless continues. What really mattered were specific CCT measures applied to coal combustion. This lesson might also apply to the issue of reducing CO_2 emissions by either general or specific measures: indeed, compared to the more general (and hence more drastic) methods of reducing carbon dioxide emission by carbon taxes, CCT offers a cheaper and faster alternative for the economies in transition. It offers additional advantages

in terms of local depollution, increased efficiency and revitalization of the coal industry, hence of social and regional revival.

VI. THE TASK AHEAD

25. The status of CCT deployment in the economies in transition requires continued attention by all actors:

- Governments: to pursue restructuring
  to assume liability for past damage
  to support CCT test and demonstration projects
- Environmental agencies: to pay greater attention to direct burning of coal
  to adopt international standards for small industrial and residential boilers
  to tighten emission standards and calendars for existing installations
- Industry: the new owners: to internalize environmental obligations
  national CCT designers and manufacturers: to enlarge their CCT knowledge and business base including through joint ventures
  suppliers of CCT: to become aware of the emerging CCT market for small boilers below 50 MW but also of the need to offer financing packages
- UN/FCCC, IEA, ... to realize the merits of CCT compared with more general, hence more drastic means with uncertain side effects such as carbon taxes

NOTES

1. For a survey of these agreements, see: J. Topper and A. Botting, Developments in environmental legislation and regulation relating to coal-fired plants, CRE Group Ltd, Cheltenham, UK, manuscript 1998

2. Data base of WEC/IIASA, Global energy perspectives, Cambridge 1998

3. UN/ECE, Coal demand and supply in the ECE region in 1997 and prospects, with particular attention to thermal power generation, ENERGY/GE.1/1998/4, Table 8, CEE augmented to include the ex-GDR

4. UN/ECE Seminar on restructuring of the coal industry and coal-fired power sector in the economies in transition, Varna, 25-27 May 1998, ENERGY/GE.1/SEM.1/2, p.8

5. IEA Coal Research, Coal in the Czech Republic, draft of September 1998, p. 23

6. Recent developments and preconditions for further implementation of clean coal technologies in the Czech Republic, ENERGY/WP.1/R.73/Add.4 (1997)

7. N. N., Long-term development plan for the Estonian fuel and energy sector, p.13

8. H.-W. Schiffer, Deutscher Energiemarkt ‘98, in Energiewirtschaftliche Tagesfragen, March 1999, pp.159, 160

9. ENERGY/GE.1/SEM.1/2, p.8

10. Communication by the Hungarian delegation to the UN/ECE Ad Hoc Group of Experts on Coal and Thermal Power, October 1998; Power Economics, nr. 8/1997

11. J. Rakowski, Polish power industry in 1997, lecture given at the WEC Conference “Prospects for clean fossil fuels systems in sustainable development”, Ankara, 26-29 May 1999

12. Restructuring of the coal industry and thermal power sector in south-eastern Europe, ENERGY/1998/16, p.10; Rehabilitation of coal-fired power plants strategy in Romania, ENERGY/WP.1/R.73/Add.2 (1997)

13. G. G. Olkhovsky, Coal in Russian power industry, paper 1.2.22 of the 17th World Energy Congress, Houston, September 1998; IEA Coal Research, Air pollution control for coal-fired power stations in eastern Europe, London, 1995, p.41

14. Prospects for coal utilization in the electric power sector of the Russian Federation, ENERGY/WP.1/R.73/Add 3, pp.3-4; A.G. Tumanovskii, V.P. Glebov, Promising air protection technologies in power engineering, and A.G. Tumanovsky et al., Improvement of fuel combustion technologies, papers submitted to the 60th American Power Conference, April 1998, Chicago

15. IEA Coal Research, Air pollution control ..., op. cit. p. 47

16. Frankfurter Allgemeine Zeitung, 9 March 1999

17. According to IEA Coal Research, Air pollution control..., op. cit. p.39 ff, in 1995 typical capital cost ($/kW) were 160-240 for wet scrubbing, 140-170 for spray dry scubbers, 80-90 for sorbent injection and (as regards NO_x control through selective catalytic reduction) 60-80 for new and 80-110 for old plants

18. A 1997 survey of the IEA Coal Industry Advisory Board identified capital costs of CCT as follows: sub-critical or conventional pulverized fuel technology (166 bar/538^0 C) 294 $/kW, super-critical (240/538)310 $/kW and ultra-super-critical PF (311/593 with wet flue gas desulphurisation and scrubbers) 323 $/kW

19. ENERGY/WP.1/R.73/Add.4, p.6

20. UN/ECE, Clean coal programmes in Poland, ENERGY/WP.1/R.73 (1997), p.4-5

21. I. Stanciu, op. cit., p.4

22. Slovenske Elektrarne, Annual Report 1997, Bratislava 1998, p.77

23. J. Topper, A. Botting, Developments in environmental legislation and regulation relating to coal-fired plants, op. cit. p.4

24. National Committee of Energy, Energy report of Albania, Ankara 1996, p.18

25. IEA Coal Research, Coal in Bulgaria, London 1998, p. 21

26. IEA Coal Research, Coal in the Czech Republic, manuscript, London 1999 p.25

27. EESTI Energeetika 1994-1996, p.15

28. I. Stanciu, J. Stratulat, Difficulties and achievements in the field of environment protection in the coal mining sector of Romania, manuscript

29. IEA Coal Research, Coal in Bulgaria, op. cit., p.29

30. UN/ECE, Restructuring of the coal industry and thermal power sector in central European economies in transition, ENERGY/1998/20, p.9

31. Der Kohlenbergbau in der Energiewirtschaft der Bundesrepublik Deutschland, op. cit., p. 26

32. ENERGY/1998/20, p. 9

33. UN/ECE, Clean coal technology in Polish hard coal mining, ENERGY/WP.1/R.73/Add.1 (1997), p.4

34. IEA Coal Research, Coal prospects in Russia, London 1996, p.44

35. M. Vlcek, T. Spilkova, The environmental programme of the Czech power industry, in “Energy in the Czech Republic”, publication of the WEC National Committee of the Czech Republic, 1998

36. Communication by VDEW - Vereinigung Deutscher Elektrizitätswerke

37. Ministry of Industry and Trade, Energy policy guidelines for Poland until 2010, Warsaw 1995, p. 54

38. Black Sea Regional Energy Centre, Bulgaria, op. cit. p.27

39. EESTI Energeetika 1994-1996, op. cit., p.28

40. MVM Statistical Data 1997, Budapest 1998, p.40

41. Slovenske Elektrarne, Annual Report 1997, op. cit., p.81