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DEVELOPMENT OF CLEAN COAL TECHNOLOGY IN THE CZECH REPUBLIC

(Submitted by the Government of the Czech Republic) */

A. INTRODUCTION

1. Czech Republic as a country with an economy in transition is characterized by high specific energy consumption, limited reserves of fossil fuels and with a small chance for exploitation of renewable energy resources.

2. Coal is the only locally available raw material for production of energy and there is a chance that it will keep its importance also in the future. But possibilities for mining are limited and increasing demand for electricity must be supplemented with other resources, such as nuclear energy and natural gas and the import of electricity must also be taken into consideration.

3. Out of numerous factors and conditions affecting the use of coal, the development of clean coal technologies holds an important position. Within the period 1980-1990 all existing power plants were retrofitted with the main

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objective of satisfying emission limits of the main contaminants - SO_2, NO_x and particulates - but for the future it will be necessary to ensure a satisfactory competitiveness of electricity produced on the basis of coal versus other sources. This can be achieved by reducing the costs of coal mining, high efficiency of conversion e.g. by the use of CCT and by reducing investment costs.

4. It is possible to conclude that in the first phase of the introduction of CCT in the Czech Republic significant success was achieved in reducing emissions of contaminating compounds. In the period after the year 2000 it is possible to expect the spread of processes of a higher technical level with higher efficiency and savings of fuel.

B. COAL RESERVES AND THEIR MINING

Brown coal

5. Geological reserves of brown coal in the Czech Republic are considerable and are estimated at 9.6 billion tons, of which the recoverable reserves are 5 billion tons where 1.5 billion tons are assigned for exploitation. Other recoverable reserves are located in prospective or blocked sites where their future possible mining depends on the use of CCT with higher efficiency. Most of the brown coal has a low calorific value which is within the range of 9.5 to 12.0 MJ/kg with high ash content (up to 40% Ad, S up to 2.5% Sd which is characterized by difficult beneficiation. Only a limited part has a higher calorific value - up to 16 MJ/kg with good beneficiation. This fact is limiting possibilities of using CCT.

Table 1: **Mining of Brown Coal and its Prospects (million tons)**

Year	Actual	Prospects	
		Case 1	Case 2
1990	81		
1995	59		
1997	54		
2000		48	48
2005		43	45
2010		41	44
2020		36	43
2030		29	42
2040		3	40
2050		-	30

6. It can be seen from this table that due to restructuring of the coal industry and its accommodation to market conditions within the period 1990-2000, a reduction of mining outputs is taking place. For the future two cases may be taken into consideration:

- case 1 (reduced) with the continuous reduction of mining rates up to recovery of all coal of the existing mines up to about the year 2030.

- case 2 (expanded) with removed blocking according to present day mining legislation and with the opening of new sites whose reserves could cover the need for coal in the Czech Republic up to the year 2060.

Bituminous coal

7. Geological reserves of bituminous coal in the OKD (region of Ostrava-North Bohemia) are about 8.5 billion tons: due to restructuring and dumping , recoverable reserves of mines in operation account for only about 400 million tons and prospective sites to about 1.3 billion tons. Calorific value of this coal is about 20-28 MJ/kg, sulphur content about 0.6% S^d. About 30% of these reserves are coking coal.

Table 2: **Mining of Bituminous Coal and its Prospects (million tons)**

Year	Actual	Prospects	
		Case 1	Case 2
1990	22.4		
1995	16.6		
2000		15	16
2010		12	12
2020		8	10
2030		3.5	7
2040		2	7
2050		-	7

8. According to the first case (reduced) complete exploitation of the sites currently mined is assumed around the year 2040. According to the second case (expanded) the opening of some of prospective sites is assumed with the possibility of mining beyond the year 2060.

9. At present the ratio of mining of coal for energy to total mining of black coal is estimated to be about 40% and this ratio should rise to about 60% with the reduction in coking coal whose utilization will be difficult.

C. PRODUCTION OF ELECTRICITY BASED ON COAL

10. As a result of the restructuring of industry of the Czech Republic and the temporary reduction in industrial production, consumption of electricity in the period 1990-1994 has decreased. Several forecasts hint that consumption of coal will systematically increase as is demonstrated in Table 3 [TWh].

Table 3: **Contributions of Various Fuels to Production of Electricity and their Prediction**

Year	Actual	Prognosis		
	Consumption **	Production *	Consumption **	Production *
1990	53.0			
1993	47.8			
1997	53.4	59.9		
1998			54.4	60.8
2000			57.5	62.2
2005			63.7	70.2

* production without self consumption of power plant
** production without self consumption of power plant - network losses - PS - pumping

Note: Prognosis of the company ÈEZ, s.c., 1998

11. The contribution of individual energy resources to the production of electricity and their prospects is given in Table 4, from which it is obvious that the highest contributors are power plants based on coal. According to this prognosis this ratio will decrease due to the introduction into operation of the Nuclear Power Plant (NPP) Temelín, but in the case of the forecast increase of the use of coal, its share should not decrease below 50%.

12. If the NPP Temelín were not brought into operation or in the case of a reduction of coal mining it would be necessary to provide for a larger share of electricity based on natural gas or to cover it by importing electricity.

13. The installed power output of resources for the production of electricity in the Czech Republic represents at present about 15,000 MW of which 11,000 MW is owned by the electric power plant and distributing company ÈEZ. The contribution of coal firing plants to this output is 60%. The necessary rise in power outputs to the year 2010 should be secured first of all by nuclear energy (Temelín - 2000 MW) and on a smaller scale by the construction of several new blocks based on natural gas or coal.

Table 4: **Contributions of Various Energy Resources to Production of Electricity and their Prognosis**

Year	1997		2000		2005		2010	
	TWh	%	TWh	%	TWh	%	Twh	%
Total production	59.9	100	62.2	100	70.2	100	78	100
Of which various resources:								
• nuclear	12	20	*22.0	35	23.3	33	24	31
• hydro	2.3	4	2.3	4	2.3	3	2	3
• coal(steam)	44.3	74	35.9	58	40.6	58	45	57
• gas	1.3	2	2.0	3	4.0	6	7	9

* On the assumption that the NPP Temelín is brought into operation

14. Most Czech coal firing electric power plants use brown coal. The contribution of bituminous coal to total electricity production is about 10%.

D. PRESENT STATE OF CLEAN COAL TECHNOLOGIES IN THE CZECH REPUBLIC

15. Around the year 1900 CCT started to be brought into operation. Its application was oriented to reduction of emissions of pollutants – SO_2, NO_x and particulates - with the aim of satisfying the legal limits of the Czech Republic and the emission load prescribed by international conventions. It is possible to state that the ecological legislation of the Czech Republic is quite strict and that its aim is to reach in the near future the levels of respective EU legislation.

16. Emission limits of the Czech Republic are given in Table 5 for boilers firing brown coal with outputs which are frequent for retrofitted boilers which should satisfy emission limits. The given limits are compulsory for new units. For older units the deadline for satisfying the emission limits is 31 December 1998.

17. Reconstruction of existing boilers or their substitution by fluidized bed boilers was started in the Czech Republic with the aim of satisfying the specified emission limits. The company CEZ alone (accounting for 75% of the production of electricity in the Czech Republic) desulphurizes about 6300 MWe.

18. In total, emissions will be reduced by the year 2000 in comparison with the year 1993 as concerns SO_2 by 90%, NO_x by 50% and particulates by 80% due to retrofitting and introduction of fluidized bed boilers.

Table 5: **Emission Limits for Boilers Firing Coal [mg/nm³]**

Thermal output (MWt)	Particulates	SO_2	No_x
Pulverized coal boilers			
5- 50	150	2500	650
50-300	100	1700	650
>300	100	500	650
Fluidized bed boilers			
5- 50	100	800	400
> 50	50	500	400

19. Machine works in the Czech Republic do not have locally available CCT and thus their introduction is dependent on the transfer of know-how from western states. High investment costs and their slow returns assume the presence of foreign capital - of international organizations or investment companies.

20. All installations of CCT are subject to strict selective procedures - tenders mostly in accordance with international rules. Usually prestigious foreign companies enter into these tenders, mostly in cooperation with local companies.

21. Czech end user companies mostly require processes with excellent recommendations and thus require their worldwide use. Participation of several foreign companies and competition in tenders lead to a considerable reduction in the price of CCT. On the other hand foreign companies get the chance to expand their activities in the Czech Republic.

22. The following CCTs are at present operated in the Czech Republic:

(a) Desulphurization of flue gas by secondary methods mostly by the use of wet lime-limestone non-regenerative processes

(b) Reduction of emissions of NO_x by primary methods, first of all by application of low-emission burners,

(c) Reduction of emission of particulates by substitution of less effective filtration units by progressive processes, first of all by ESP,

(d) Substitution of pulverized coal boilers by fluidized bed boilers in the circulating atmospheric variant,

(e) IGCC electric power plant 2x200 MW (Vøesová) whose reconstruction was based on retrofitting of the original pressurized gas plant with Lurgi generators to production of energogas and its use in the combined cycle.

23. Solid waste produced during desulphurization of reconstructed electric power plants is dumped or reused. Both these approaches contribute to improvement of the quality of underground waters. Tables 6 and 7 give the most important power plants with desulphurization of flue gas and with fluidized bed boilers in the Czech Republic.

Table 6: **Desulphurization of Flue Gas in Power Plants of ÈEZ**

Power plant	Output MWe	Supplier	Year (start)
Prunéøov 1	4x110	Bischof (BRD)	1995
Prunéøov 2	5x210	Mitsubishi (Jap.)	1996
Poèerady 1	3x200	Hoogovens (Neth.)	1996
Poèerady 2	2x200	SHL (BRD)	1994
Tušimice 1	3x110	Bischoff (BRD)	prep.
Tušimice 2	4x200	Marubeni-(Jap.)-Chivoda	1997
Ledvice	3x110	Austrian Energy Env.(Aus.)	1996
Tisová	1x100	Steinmuller(BRD)	1997
Chvaletice	4x200	IVO Int. (Fin.)	1998
Dìtmarovice	4x200	Mitsubishi (Jap.)	1998
Mìlník 2	2x110	Austrian Energy Env.(Aus.)	1998
Mìlník 3	1x500	Austrian Energy Env.(Aus.)	1998

Table 7: **Construction of Higher Output Fluidized Bed Boilers**

Site	Output t/hr	Supplier	Year (start)
EPP[x] Ledvice	350	ABB (CR)	1998
EPP Poøíèí	250	ACC-Cons.(Fr.-Fin.)	1996
EPP Tisová	350	Vítkovice (CR)	1996
	350	Lurgi (BRD)	1997
MW[+] Tøinec	160	Lurgi-Tlmaèe	1995
HP* Zlín	150	ABB (CR)	1996
EPP Hodonín	2x170	Austrian Energy Env. (Aus.)	1996

[x] EPP-Electric Power Plant,
* MW-Mechanical Works
[+] HP-Heat Plant

E. PROSPECTS

24. The outlook for the construction of CCT in the Czech Republic for the period after the year 2000 depends on numerous conditions, the most important being the possibility of utilization of coal reserves in the long-time horizon, i.e. for the expanded case of coal.

25. While the present period (1990-2000) is oriented to ecological retrofitting of existing units and construction of units with atmospheric fluidized bed combustion, in the future the application of processes with higher efficiency and with minimized emissions of polluting compounds inclusive of CO_2 is assumed. Besides the necessity of arranging for the necessary rise in demand for electricity by construction of new capacities around the year 2010, it will be necessary to compensate for the aging units which were retrofitted in the 1990s by new and more effective units.

26. Technologies suitable for processing coal with properties typical for the Czech Republic are evaluated in Table 8 for various time horizons. With regard to the evaluation given in the table, it is possible to predict the future of CCT in the Czech Republic:

Table 8: **Evaluation of Different Technologies Suitable for Production of Electricity Based on Coal**

Technology	Present state	2000-2010	After 2010
Combustion of pulverized coal with desulphurization and denitrification	1	1	1
• supercritical brown coal	3	2	1
• bituminous coal	1	1	1
Fluidized bed combustion			
• atmospheric	1	1	1
• pressurized	2	1	1
IGCC			
• brown coal	2	1	1
• bituminous coal	3	2	?

Note:
1. Commercialized, widely used processes,
2. demonstration units, larger reference units are not secure,
3. without significant references for large units.

Medium-time horizon (2000-2010)

27. On the assumption that the NPP Temelín will be brought into operation and the operation of existing power plants which are already desulphurized, expansion of CCT will be oriented so as to cover the necessary demand for new capacities or for substitution of obsolete units. Here must be taken into consideration first of all PC-combustion of bituminous coal with supercritical parameters or of brown coal if sufficient references were available for these processes which would be suitable for coals with higher ash content. Wider possibilities could be seen for the transfer of atmospheric and especially pressurized fluidized bed combustion units if sufficiently reliable references were available for combustion of low quality brown coal.

28. Consideration is also given to the IGCC production of electricity based on bituminous coal. Use of brown coal for this process is limited both by its quality and opening of the mining sites which are at present blocked.

Long-time horizon (after the year 2010)

29. Application of CCT in this horizon is greatly limited by removing the mining limits for brown coal and opening of reserve localities.

30. Regarding physical termination of existing power plants with desulphurization of flue gases, their substitution and construction of new units will be inevitable. In this period, when sufficiently reliable reference units would exist even with the use of high ash-content brown coals, the prospects of transfer of CCT units in the Czech Republic are quite large - especially of highly efficient processes. Another prospective direction is progressive processes of beneficiation which could reduce the ash content in brown coal in the Czech Republic and increase quality of its utilization in combustion or gasification processes. In the more distant horizon (after the year 2020) other processes could become of interest - the developed CCTs, pressurized combustion and new generation of gasification processes (topping process), allothermic gasification or use of coal gas from gasification for direct conversion to electricity.

Table 9: **Prospects of CCT in the Czech Republic**

Period	Construction of CCT
Present	Desulphurization and denitrification of existing power and heating plants, Atmospheric fluidized beds of higher outputs
2000-2010	Meeting the rising demand for electricity: • atmospheric fluidized bed combustion, • PC combustion with supercritical parameters, • lower output pressurized fluidized bed combustion, • IGCC
2010-2020	Substitution of the existing electric power plants, meeting the rising demand for electricity: • PC combustion with supercritical parameters, - fluidized bed combustion with high efficiency, • IGCC with gasification, New beneficiation coal processes
After the year 2020	IGCC cycle with gasification and with new generation of pressurized fluidized bed combustion (topping cycle), Allothermic gasification, Direct conversion of coal gas from gasification to energy

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