

EGTEI

PLANT COSTS INCREASINGS

Precautions to take when talking about plant costs

It is always difficult to talk about costs and to compare costs, because a lot of parameters impact plant costs; following are some parameters which have to be taken into account:

-New plant or existing plant

Investment costs are not the same for a new plant and an existing plant: for instance, a lack of space in an existing plant can completely change the investment cost of FGD or SCR

The performances of a similar depollution system will not be the same down stream an ancient boiler as a new boiler because of the imbalance of the gas flue, cold points...

-Different kinds of costs

It is necessary to distinguish the various kinds of costs to be sure to compare them correctly: equipment costs, foundations and connections costs, engineering costs, capital costs...

Generally a manufacturer gives costs without site costs (foundations, connection, site engineering...) A problem of ground work can increase the cost of a depollution system by 30% (especially in case of retrofitting).

-Conditions and performances of depollution

The costs are obviously dependant on the concentration of pollutants and the performances of the depollution: FGD costs are not the same with a coal sulphur content of 3% or 1, 2% and if the FGD desulfuration is 95% or 99%.

-Size effect

The depollution specific cost is not the same for a unit of 1000MWe and a unit of 100MWe.

-Series effect

Generally, if several depollution systems are ordered at the same time, there is a reduction in price

Evolutions of costs

Boiler costs (and depollution systems) have multiplied by 1, 5 to 2 between 2003 and 2007; these are two main reasons for the increase:

-Increasing of steel costs

For example, the increase of the cost of steel was +54% between 2000 and 2007. (+58% during year 2007). This steel price is correlated with ferrous scrap prices and energy prices. The lowest recent price was in January 2002 (price index 80). The price index in January 2008 is 160; steel price has doubled.

Considering that a large part of the cost of a plant is dependant on steel prices, this shows how difficult it is to compare depollution prices at different periods.

An other example of cost increase is the SCR catalyst price which has grown in 2 years at least by +20%.

-Market tension

The small number of depollution manufacturers and the proximity of the regulatory term (2015) to apply LCP Directive regulation increase the market tension on the prices of the depollution systems and also on the new plant prices.

This market tension explains together with the steel cost increase the global increase of costs of plants and depollution systems at present.

This market tension is felt by different ways: the classical price revision formula are no longer representative; there is no longer reduction in price if you buy several units in series; there is a market saturation until 2014 and even beyond because new countries of the European union are granted a delay in applying the European regulation. The delays to build a plant are becoming very long. Manufacturers are at present free to choose the tenders they wish to answer.

Conclusion

Costs can only be meanfull when fixed in the real context. The costs given in the following tables have to be considered estimated.



Chiffres-clefs

[Acier brut](#)[Commerce extérieur](#)[Marché](#)[Prix de l'acier](#)[Ferrailles](#)

Les chiffres clefs

Production d'acier brut				
(en Kt par mois)	Janvier 2008	1 mois 2008	var. % mois (*)	var. % cumul (*)
Monde	113 039	113 039	+4,9%	+4,9%
Union européenne (27 pays)	17 920	17 920	-0,4%	-0,4%
France	1 610	1 610	-7,0%	-7,0%
Importations en provenance des pays tiers				
(en Kt par mois)	Décembre 2007	12 mois 2007	var. % mois	var. % cumul
Union européenne (27 pays)	2 303	3 589	-22,1%	+21,8%
France	35	69	-50,0%	+21,1%
Exportations à destination des pays tiers				
Union européenne (27 pays)	2 380	2 220	+25,9%	+0,9%
France	157	145	-1,9%	-1,4%
Approvisionnement des marchés				
(en Kt par mois)	Novembre 2007	11 mois 2007	var. % mois	var. % cumul
Union européenne (25 pays)	14 623	15 672	-7,5%	+4,9%
France	1 194	1 244	-4,4%	-0,6%
Evolution des prix de l'acier				
Année 2000 = 100	décembre 2007	12 mois 2007	var. % mois	var. % cumul
Tous aciers, tous produits confondus	153,6	158,4	+3,6%	+13,2%
Prix des ferrailles d'origine régionale				
Année 2003 = 100	janvier 2008	1 mois 2008	var. % mois	var. % cumul
Toutes qualités confondues	215,4	215,4	+23,7%	+23,7%
Autres matières premières				
(en Euros par tonne)	novembre 2007	11 mois 2007	var. % mois	var. % cumul
Coke (prix à l'importation dans l'UE 15)	218	173	+43,9%	+14,7%
Minerai de fer (prix à l'importation dans l'UE 15)	53	50	+12,3%	+13,0%
(en US dollar par tonne)	janvier 2008	1 mois 2008	var. % mois	var. % cumul
Nickel (LME cash)	27 680	27 680	-24,8%	-24,8%
Etain (LME 3 months-midday)	16 420	16 420	+45,9%	+45,9%
Zinc (LME 3 months-midday)	2 356	2 356	-36,9%	-36,9%

Sources : FFA , IISI, EUROFER, EUROSTAT, INSEE, UCFF, LME

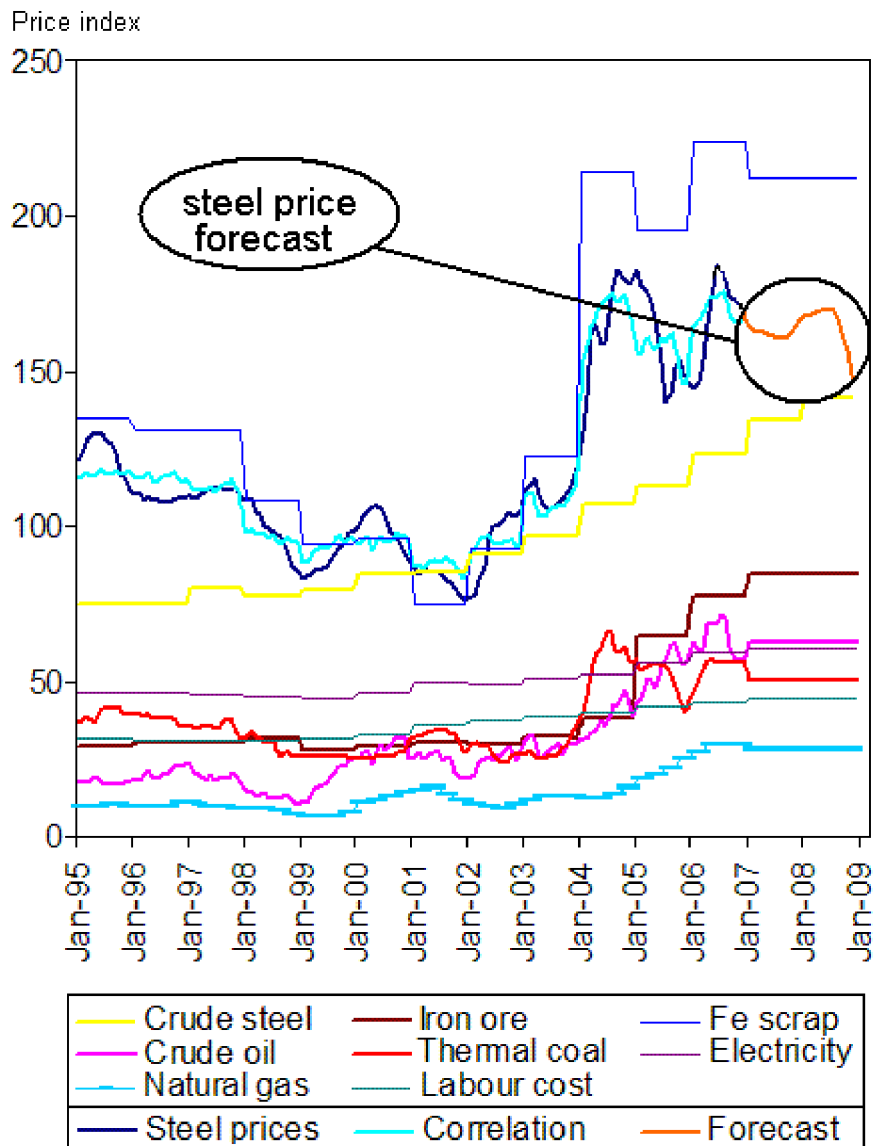
(*) variation en % par rapport à la même période de l'année précédente

Chiffres-clefs

[Acier brut](#)[Commerce extérieur](#)[Marché](#)[Prix de l'acier](#)[Ferrailles](#)

Pages optimisées pour une résolution d'écran 1024X768

World Steel Price Forecast 2007-2008



COMMENTS

EDF comments (Christine Lecuyer; EDF engineering Paris La défense, meeting on 26 February 2008)

Oil units

For a 600MWe oil existing unit (Porcheville for instance), the cost of depollution systems are estimated in 2007 as follows:

SCR: 40 MEuros (44 with engineering costs)

ESP: 15 MEuros (16 with engineering)

Units 2, 3, 4 of Porcheville oil plant are already equipped with cyclones which limit dust emissions below 50 mg/Nm³

These oil units used in peak conditions are operated 400 or 500 hours per year. It means that the depollution costs are often unbearable for a small gain on pollution emissions.

Generally bag filters are not used on oil unit because of clogging problems

ESP are generally used on oil units, even if clogging may occur sometimes.

BOOS technique has been used with success in Porcheville to lower NO_x emissions. BOOS technique consists of no longer using the higher burners of the boiler.

On this kind of oil unit, the SO₂ emissions are lowered by lowering sulphur content in the oil (0, 5 or 0, 3%). FGD, even Flowpac, is not economically acceptable.

Coal units

All the French coal units which will be operated after 2015 are completely depolluted (FGD, SCR, and ESP)

All the FGD manufacturers are improving their FGD technology.

For some EDF experts, for the future, the most performing wet FGD technology could be the Double-Contact-Flow Scrubber (DCFS) developed by Mitsubishi, with a fountain double-contact which allows reaching desulphurisation rate above 99%. With such FGD, the SO₂ emission can be below 30 mg/Nm³.

EDF comments on dust capture (Veronique Arrondel, Michel Halmil EDF research Centre Chatou, meeting on 22sd February 2008)

It is recommended to read the book « Les polluants et les techniques d'épuration des fumées » edited in 1998 by the RE.CO.RD. Association (Environmental Ministry, ADEME, EDF, GDF, Solvay, French cement manufacturers, French car manufacturers...). This book explains the different depollution systems when burning wastes. But in fact, this book is also applicable for the Large Combustion Plants

At the same time, in 1998, the RE.CO.RD association also created a cost data base, but this data basis, property of the RE.CO.RD association, has not been edited. It could be interesting to get this cost basis as a 1998 reference. Write to Nicolas Caraman (EDF Chatou) who is the RE.CO.RD correspondent for EDF.

All the precipitator manufacturers try to improve the 2 main systems used for large combustion plants: electrostatic precipitators and filter bag precipitators. For instance, Alstom has developed a High Frequency Transformer Rectifier which consummates less

electrical energy and lower counter-emissions. There are no revolutionary new techniques for capturing dusts.

However, EDF recommend following 2 innovative dust capture systems for fine particles but these techniques are not really suitable when wet FGD are used because wet FGD captures also the fine particles. These advanced technologies seem to be used to capture fines particles when there is no wet FGD in USA or Australia:

-COHPAC process

-INDIGO process

EMERGING TECHNOLOGIES COHPAC FINE PARTICLE COLLECTOR TECHNOLOGY

Description

COHPAC is an EPRI licensed technology which is centred around combination of an existing or new electrostatic precipitator with a baghouse precipitator.

The baghouse precipitator is placed in a separate casing downstream of the ESP (known as COHPAC I) or within the existing ESP's casing by replacing one or more fields of collecting plates with baghouse modules (COHPAC II)

The technology is based on the fact that a baghouse collects higher levels of particulates and finer particulate than ESP of equivalent size; the baghouse acts as a "polishing device". By using dry additives, COHPAC in combination with TOXECON offers the ability to significantly reduce mercury, sulphur dioxide and others toxics (dioxins) emissions than an ESP alone could not economically collect.

TOXECON is an EPRI licensed technology involving the introduction of a sorbent between a primary particulate collector such as either an ESP or mechanical collector. The dry sorbent additives could be activated carbon, sodium or calcium compounds.

References

HRC internet site

"Effective use of both COHPAC and TOXECON technologies as the technologies of the future for particulate and mercury control on coal-fired boilers" (by Richard Miller...)

HRC has installed over 1700 MW of COHPAC technology on both coal-fired and waste-to-energy combustors

Full scale demonstration of TOXECON is currently underway at Alabama Power, E.C.

Gaston Steam Plant. (USA). This long-term demonstration, DOE funded project is the second phase in a program begun in 2001. HRC is a co-contributor in this program designed to demonstrate the ability to control mercury emissions utilizing both COHPAC and TOXECON technologies. Testing in 2004.

Performances

-High collection efficiencies (> 99, 9%)

-Low capital cost (much lower than competing systems to achieve comparable particulate control levels)

Manufacturer

Hamon Research-Cottrell (HRC) is the only experienced licensed supplier of EPRI's COHPAC & TOXECON particulate and mercury reduction technologies on both coal-fired and waste-to-energy fired boilers

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Comments (Veronique Arrondel , Michel Halmil EDF)

These technologies have been developed to capture in USA toxic emissions (mercury and dioxins...)

Europe is perhaps less concerned by these technologies

However the combination of ESP and baghouse is interesting because this combination seems more performant for extract fine particles at a lower investment costs. The interest of this technology has to be demonstrated when there is FGD.

EMERGING TECHNOLOGIES INDIGO FINE PARTICLES AGGLOMERATOR

Description of the Indigo Technology

The Indigo Agglomerator utilizes a combination of two patented processes that cause the fines particles to attach to the large particles, which are easily captured by electrostatic precipitator.

-Fluidic Agglomeration Process (FAP), a physical process that occurs without the need for electrical energisation

-Bipolar Electrostatic Agglomeration Process (BEAP) which uses 2 key processes to reduce fine particle emissions: a bi-polar charger used to charge in an alternating way half of the dust with a positive charge and half negatively and an especially size designed size selective mixing system.

Agglomerator is located in front of an electrostatic precipitator (up-stream ESP)

Indigo technology references

Tests at full load were carried out at the Mississippi Power's Plant Watson on Indigo agglomerator trial installation on unit 4 in January 2004 (a 250 MW wall fired pulverized coal boiler with 2 air-heaters connected to 2 separate electrostatic precipitators). Tests have been also implemented on Tarong Power Station (4x350MWe coal units; boilers Babcock Hitachi), 180 Km west of Brisbane, Australia.

Fine particles health context

Fine particles, in particular PM2.5, are an acknowledged health hazard. Electrostatic precipitators are poor collectors of fines particles, particularly between 0,5 and 2 micrometer. The electrostatic precipitator collection efficiency, normally around 99,9% for larger particles, is generally less than 90% in this particle size range and can fall below 50% in worst case condition

Indigo Agglomerator Performances

The Indigo Agglomerator provides a significant reduction in fine particle emissions by attaching the fine particles to the large particles, which are easily collected in the electrostatic precipitator.

Particles size	10 micrometers	0,1 micrometer	PM2,5
Agglomerator reduction	60%	90%	80%
	About a factor 2	About a factor 10	

Tests in Tarong Power station show that the capture of arsenic in the ashes is significantly increased. Tests in Watson power Station show that mercury emissions are divided by 4. Recent regulations in the US require Mercury emission control on coal fired power stations. Mercury is considered a major health hazard because it concentrates in the food chain. The Indigo Agglomerator enhances Mercury collection by increasing the interaction between the Mercury and the adsorbent, either injected Activated Carbon or using the LOI from the combustion process.

Manufacturer

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Comments (Veronique Arrondel, Michel Hamlil EDF)

It seems that the agglomerator is only used in plants not equipped with wet FGD. In Europe, this kind of technology could be less useful than in USA or Australia for 2 reasons:
-generally coals burned in Europe are without mercury (except perhaps for some local coals, especially in Central Europe)
-at the end of 2015, almost all the LCP of the European union will be equipped with wet FGD which are efficient to capture fine particles.

Reference

ICESP X – Australia 2006 Paper 6A2

VGB document comparison
 Jean-Pierre RIVRON
 22 November 2007
 Revision 1: 1st march 2008

EMERGING TECHNOLOGIES SUB-GROUP
ESTIMATION OF DENOX AND DESOX COSTS FOR A 300 MWel HARD COAL UNIT
ACCORDING VGB POWERTECH DOCUMENTS
 Date of the estimation: 2006

Reference documents

DENOX-kosten var,1,2,4,5 HtKr, entw1,entw2, entw Heit and Heit.K
 Rea kosten O.xls original word document
 FGD overall costs VGB PowerTech E.doc
 Ermittlung der REA kosten Heit/Heit Kr.doc

Power unit characteristics

LCP capacity: 300 MWel / 726,4 MWth
 Efficiency (net caloric value): 41,3%
 Net caloric value of coal: 25000KJ/Kg
 Effective full load operation hours per year: 6000h
 Electrical production per year: 1,8TWh
 Coal consumption: 104,6 t/h
 Primary energy input per year: 15690 TJ
 Flue gas emission per coal Kg: 10 m3/Kg
 Flue gas flow: 1 046 005 m3/h
 Specific energy consumption: 0,9%
 Internal costs of electricity: 0,03 Euro/KWh
 NO2 concentration at DENOX inlet: 700 mg/m3
 NO2 concentration at DENOX outlet: 200 mg/m3
 S content of coal: 1%

COMPARISON OF DATA FOR EMERGING TECHNOLOGIES SUB-GROUP

	DENOX (SCR)	DESOX (wet FGD)
Abatement efficiency	71,5%	88%
Abated emission factor	185 g/GJ fuel input	641 g/GJ fuel input
Electrical consumption	0,19 KWh/GJ	1 KWh/GJ
CO2 impact (from energy consumption)	0,00016 t CO2/ GJ fuel input	0,0009 t CO2/GJ fuel input
Equipment life time	30 years	30 years
Specific depollution invest costs	25,2 Euro/KWth	41 Euro/KWth
Fixed operating costs	0,0014 MEuro/a/MWth	0,0023 MEuro/a/MWth
Variable operating costs	NH3 0,0011 MEuro/a/MWth NH4OH 0,0022 MEuro/a/MWth	0,0014 MEuro/a/MWth

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RELATION OF THE FGD COSTS TO THE UNIT CAPACITY

REA-Investitionskosten ohne Eigenleistung

(REA kosten 0.xls)

Efficiency 41,3%

Electrical capacity of the unit MWel	Thermal capacity of the unit MWth	Investment MEuro	Investment+10% for additional investor costs: engineering, foudation, connections... MEuro	FGD specific cost MEuro/MWel	FGD specific cost MEuro/MWth
Leitung in MWel					
1000	2421	60	66	0,066	0,027
800	1937	52	57,2	0,072	0,030
600	1453	43	47,3	0,079	0,033
400	968,5	32,5	35,8	0,090	0,037
300	726	27,5	30,3	0,101	0,042
200	484	20	22	0,110	0,045
100	242	12,5	13,8	0,138	0,057

RELATION OF THE SCR COSTS TO THE UNIT CAPACITY

DENOX kosten var.xls

Efficiency 41,3%

Electrical capacity of the unit MWel	Thermal capacity of the unit MWth	Investment MEuro	SCR specific cost MEuro/MWel	SCRspecific cost MEuro/MWth
Leitung in MWel				
1000	2421	58,5	0,059	0,024
800	1937	47	0,059	0,024
600	1453	35,5	0,059	0,024
400	968,5	24,1	0,060	0,025
300	726	18,3	0,061	0,025
200	484	12,6	0,063	0,026
100	242	6,8	0,068	0,028

Size effect

Electrical capacity MWel	Thermal capacity MWth	SCR investment MEuro	FGD investment MEuro	SCR specific cost MEuro/MWth	FGD specific cost MEuro/MWth	SCR size effect	FGD size effect
1000	2421	58,5	66	0,024	0,027	0,86	0,47
800	1937	47	57,2	0,024	0,030	0,86	0,53
600	1453	35,5	47,3	0,024	0,033	0,86	0,58
400	968,5	24,1	35,8	0,025	0,037	0,89	0,65
300	726	18,3	30,3	0,025	0,042	0,89	0,74
200	484	12,6	22	0,026	0,045	0,93	0,79
100	242	6,8	13,8	0,028	0,057	1	1

REFERENCE POWER PLANT RPP NRW

This document is composed with cost extracts of the VGB document « Concept study Reference Power Plant North Rhine-Westphalia (RPP NRW) (February 2004)

Brief overview

The concept of the “Reference Power Plant North Rhine-Westphalia” (RPP NRW) is based on a hard coal fired 600 MW plant with optimised plant technology and efficiency of 45,9%. Efficiency of over 48% could also be achieved with certain technical measures. However, that would require different site conditions and also different economic boundary conditions than can currently assume. With efficiency of 45,9%, the NRW reference power plant is clearly above the average of hard coal power plants currently in operation in Germany (average efficiency around 38%). Thus, its use can make a considerable contribution to attaining targets for the reduction of CO₂.

This NRW Reference Power Plant study was produced with the aim of developing a concept for a sustainable hard coal-fired power plant that takes these challenges into account.

A number of innovative proposals have been included in the plant design.

The building of the RPP NRW will involve a total order volume of around Euros 480 million.

Results for the reference case (§3.5)

The RPP NRW in the reference case is clearly superior economically to the other hard coal technologies, the 700°C plant and the IGCC plant. The RPP NRW also proved to have the advantage over a combined cycle plant operating on natural gas. Only modern lignite power plant proved to be more cost effective.

Figure 3.1

Price basis 2003	Fixed cost ct/KWh	Variable cost ct/KWh	Cost of electricity ct/KWh
RPP NRW Reference case	1,9	1,45	3,35
CCPP gas Combined cycle	1	2,5	3,5
MLP Modern Lignite Plant	2,3	1	3,3
700°C Plant	2,5	1,3	3,8
IGCC	2,8	1,3	4,1

Cost of generating power

No CO₂ cost impact

Gas price 1,2 ct/KWh

Price of hard coal 48 euros/t

Lignite price 31 euros/t

The volume of investments in the reference power plant

Aspect	Unit	Amount
Price of the plant	Euro/KW (gross)	798
Installed gross capacity	MW	600
Order volume	Million euros	478,8
Period of use	Years	35
Owner's own contribution (5% of the order volume)	Million euros	23,9
Flat rate for imponderables (3% of the order volume)	Million euros	14,4
Total sum of investment	Million euros	517,1
Specific sum of investment	Euros/KW	798x1,08=861,8

Basic data for the determination of the operating costs of the reference power plant (table 5.6)

Cost category	Unit	Amount
Installed gross power	MW	600
Specific plant price	Euros/KW (gross)	798
Absolute plant price	Million euros	478,8
Aux. station power requirement	% of gross installed power	7,4
Aux. station power requirement	MW	44,4
Maintenance	%/a	1,5
Operating personnel	Persons	70
Payroll costs for each employee	Euros/a	70000
Fuel price	Euros/t	41
Fuel price	Euros/t hard coal units (tce)	48
Consumables and operating supplies	Euros/MWh	1

Quality of coal (§ 6.2)

		Guarantee design coal	Fuel band
Lower heating value	MJ/Kg	25	21 to 29
Water	%	7,5	7 to 18
Ash	%	14	5 to 22
Volatile matter (daf)	%	30	23 to 47
Nitrogen	%	1,5	<2
Sulphur	%	0,6	<1,5
Chlorine	%	<0,01	<0,3

Project duration: 36 months+ two months trial operation

Thermodynamic design: overview summarizing the findings (§6.6)

1	Utilization of hot mill air or flue gas waste heat by transferring the heat to the HP feed water heating line
2	Use of an external desuperheater to increase final feed water temperature up to 320°C
3	Reduction of pressure drop in the extraction lines for HP feed water heaters
4	Reduction in terminal temperature differences for HP feed water heaters
5	Consideration of use of an additional LP feed water heater (9 th feed water heater)
6	Thermo compression in the area of the area of the LP feed water heaters
7	Concepts for reheat temperature control (control within boiler or spray attemperation or by allowing reheat temperature to slide)
8	Consideration of use of an HP feed water heater bypass for mobilization of short-term peak output
9	Study of a feed water pump drive concept (turbine drive vs. electric drives with various designs)
10	Optimization of the cold end (LP turbine exhaust cross-section and size of cooling tower)

Power plant concept (§6.6)

Gross capacity	600MW
Type of boiler	Tower-type boiler with vertical tubes and steam coil air heater
Heat recovery	Utilization of mill air heat recuperation
Flue gas discharge	Discharge via cooling tower
Turbine model	H30-40/M30-63/N30-2x16m2
Main steam parameters	285 bar/600°C/620°C
Condenser pressure	45 mbar
Generator	Water/hydrogen cooling
Feed water heating stages	8 feed water heaters+external desuperheater
Feed water final temperature	303,4°C
Feed water pump concept	3x50% electric motor-driven feed water pumps, variable-speed drive with planetary gearing

Operating concept (§12)

The following major boundary conditions have been specified for the operating concept:

- Service life: 200 000 operating hours
- Base load for the first 15 years at 7500 h/year, then intermediate load at 5500 full load operating hours per year
- 2860 starts over the entire period of usage

Preferred variant(§13 and14)

A total power plant price of 798 Euros/ KW (gross) was offered for the preferred variant (45,9% of net efficiency) (861,8 Euros/KW in taking into account +8% for owner contribution and imponderables)

	Preferred variant
Gross installed capacity	600MW
Net installed capacity	555,5MW
Net efficiency	45,9%
Main steam parameters	285bar/600°C/620°C
Feed water end temperature	303,4°C
Price of the plant	478,5 MEuros
Boiler type	Benson tower boiler with vertical tubes
Utilization of waste heat	Use of mill air heat
Flue gas cleaning	SRC-DENOX, electrostatic precipitator, flue flue gas desulphurisation using limestone
Flue gas discharge	Discharge via cooling tower
Steam turbine	Three-casing steam turbine with simple intermediate heating and low-pressure stages made of titanium alloy
Generator stages	Cooled by water/hydrogen
Economiser stages	Eight economisers+external desuperheater
Feed water pump concept	3x50% electric motor-driven feed water pumps , variable-speed drive with planetary gearing
Condenser pressure	45 mbar, wet closed-circuit coming via natural-draft cooling tower
Price of the plant	478,5 MEuros
Specific plant price	798 Euros/KWgross

Increasing of cost in relation with net efficiency.

Net efficiency	Total power plant price
Preferred Variant 45,9%	798 Euro/KWbrutto
45,9 to 46,1%	798 Euro/KWbrutto + Appr. 20 Euro/KWbrutto per % pt
46,1 to 46,2%	798 Euro/KWbrutto + Appr. 25 Euro/KWbrutto per % pt
46,2 to 46,5%	798 Euro/KWbrutto + Appr. 30 Euro/KWbrutto per % pt
46,5 to 47,3%	798 Euro/KWbrutto + Appr. 35 Euro/KWbrutto per % pt

Efficiency	Calculation	Specific power price	Total specific power price x1,08	600 MWe1 plant total price
45,9%		798 Euro/KW	861,8 Euro/KW	517 MEuros
46,1%	+20 Euro/KWx0,2%= +4 Euro/KW	802 Euro/KW	866,2 Euro/KW	520 MEuros
46,2%	+25 Euro/KWx0,1%= +2,5 Euro/KW	804,7 Euro/KW	868,ç Euro/KW	521 MEuros
46,5%	+30 Euro/KWx0,3%= + 9 Euro/KW	903,7 Euro/KW	878,6 Euro/KW	527 MEuros
47,3%	+ 35 Euro/KWx0,8%= + 28 Euro/KW	931,7 Euro/KW	908,8 Euro/KW	545,3 MEuros

Innovations (§8.2.3)

The greatest improvement in efficiency is achieved by raising the steam parameters to the high steam conditions at boiler outlet (600°C/620°C/292,5 bar). A further improvement in plant efficiency has been achieved by optimising the economiser section and raising the feed water temperature. These temperature and pressure increases make it necessary to use new materials for the walls and new super heater materials.

The efficiency of the boiler is improved to 95% by keeping to the very low excess air coefficients of 1,15 and exhaust gas temperatures of 115°C. The distance to the dew point temperature for flue gas ducts and the electrostatic precipitator is achieved by specified guaranteed coal with a sulphur content of only 0,6%.

Flue gas cleaning (§9)

Flue gas cleaning consists of plant components for denitrification, dust collection and desulphurisation.

Emission limits:-SO_x and NO_x< 200 mg/Nm³

Dust<30 mg/Nm³ (<20 mg/Nm³ with German requirements)

SCR

Ammonia (NH₃) liquefied under pressure is used as the reducing agent. It is taken from the liquid ammonia tank, dry, at 6% by volume O₂

The maximum NH₃ slip at the end of the life of the catalyst (24000 hours of operation) is 2 vpm. The design of the reactor for an NH₃ slip of only 2 vpm is required in order to limit the ammonia content of the fly ash to a maximum of 100 mg/Kg, even if the ash content of the coal is very low.

The reactor is not fitted with a bypass.

So-called “acoustic horns» are used in addition to the steam operated soot-blowers for cleaning the catalysts

Dedusting; Electrostatic precipitator

The use of a fabric filter has been ruled out because the higher pressure losses and higher maintenance costs.

FGD

The absorber is optimised in 3 areas:

-the absorber diameter was selected so that the maximum velocity of the flue gas is around 4 m/s

-Nozzle levels were optimised with help of a numerical simulation program

-A frequency controlled drive is used for one recirculating pump

The required availability for FGD is >98%.

Cooling water systems

The cooling water systems essentially consist of the natural-draft cooling tower...

EMERGING TECHNOLOGIES SUB-GROUP

Dust emission reduction by installation of SO₃ injection upstream precipitator EDF Le Havre 4 coal power station (600 MWe)

Reference document

EDF document “Installation de conditionnement des fumées par injection de SO₃ en amont du dépollueur de la tranche 4 du Havre » (Mathieu INSA)

Dust problem characteristics in Le Havre 4

Le Havre 4 is a coal-fired power unit commissioned in 1983. Generally the dust emission was 30 or 40 mg/m³, always below the regulatory limit of 50 mg/m³. From 2000, the imported coal combustion gives ashes with high resistivity (> 10¹¹ ohm.cm, 2x10¹¹ with some low sulphur content south-African coals) which prevents to have a good dust captation in the electrostatic precipitator. With this kind of coal, the dust emissions could reach 110 mg/m³ or even theoretically 200 mg/m³, with necessity to stop because flue gas desulfuration operational limit.

SO₃ injection upstream precipitator

The SO₃ injection system includes:

- a liquid sulphur stockage and pumping
- a combustion chamber to oxidise sulphur to SO₂
- a catalytic convertisseur to transform SO₂ to SO₃
- Injection nozzles to inject SO₃ in the flue gas upstream precipitator

The SO₃ system has been implemented on Le Havre 4 unit in 2005. With this system, dust emissions are below the required limit 50 mg/m³ for any kind of coal used.

DATA CONTRIBUTION FOR EMERGING TECHNOLOGIES SUB-GROUP

Short description: SO₃ injection to lower particles emissions in case of combustion of high resistivity coal ashes (Le Havre 4 600MWe/1580 MWth coal fired unit in 2006)

Dust abatement efficiency: average 50% with possibility of 75 to 85%

Dust: abated factor: 6, 2 g/GJ fuel input

Electricity consumption: 0,013 KWh/GJ fuel input

SO₃ equipment investment (engineering included): 0, 0007 MEuro/MWth (1, 1 MEuro)

Fixed operating costs: not significant: 0, 0012 Euro/GJ

Variable operating cost: not really significant; 0, 001 Euro/GJ

Some Calculations

References:

Le Havre 4 in 2004

2563 GWh (gross)

5737 operation hours

4202 full capacity equivalent operational hours

279 tons dust emissions

68 mg/m³ yearly average dust emission

918899 tons of coal

24405 KJ/Kg heating value

22426 TJ primary fuel input/ year 2004

Dust abated emission factor

50% average abatement due to SO₃ injection

139500 Kg/year

$139500000/22426000=6, 2$ g/GJ fuel input

SO₃ system electrical consumption: 50 KW

$50KW \times 5737$ hours= 286850 KWh

$286850/22426000=0,013$ KWh/GJ

Fixed costs

Maintenance: 2, 5% investment cost (estimation)

$1, 1MEuro \times 0, 025=27500$ Euros/year

$27500/22426000GJ=0, 0012$ Euro/GJ

Variable costs (sulphur cost)

5100 Euros/1000 full equivalent capacity operational hours

21400 Euros for 4202 full capacity equivalent hours (2004)

$21400/22426000GJ=0,001$ Euro/GJ

ALSTOM'S TURBULENT BED DESULPHURISATION SCRUBBER FLOWPAC

Description

Flowpac process is a wet desulphurisation process developed by ALSTOM. It is a turbulent bubble bed reactor. The flue-gas is injected into a slurry through numerous submerged pipes while limestone slurry is fed into the turbulent bubbled bed reactor and air for oxidation is blown into slurry. The absorber type is a good example of a simplified FGD process. It eliminates the need for recycle pumps, spray nozzles and headers, separate oxidation tanks and thickeners, thereby minimising difficulties as well as power consumption.

Performances

The process has a compact design and allows to reach high desulphurisation rates (> 99%) with high sulphur content fuels (>1, 5%).

The electrical consumption is lower in the Flowpac (1, 3% of the power capacity in Karlshamm) than in the classical wet FGD (1, 7 /1, 75%)

According Alstom, the yearly maintenance costs are lower for Flowpac (1, 2% of the investment costs) than for the classical wet FGD (1, 5%) due to a better accessibility.

References

Few Flowpac absorbers are built in the world. The prototype was built in 1996 on unit 3 of the Karlshamm power station in Sweden (3 x 340 MWe oil plant). The gas flow is 1080000 Nm³/h the design oil sulphur content is 3, 5%.

3 other Flowpac (3x150 MWe) have been built recently at Lietuvos Elektrine Power Plant (Lituany) and forecast to start in 2008 (according to Alstom references). The gas flow is 1800000 Nm³/h and the design sulphur content is 3, 5%

Lietuvos plant: 4x150MWe+4x300MWe=1800MWe: 5 FGD have been implemented in Lietuvos : boilers 1+ 2 (2x150 MWe);boilers 5A+5B (300MWe); boilers 6A+6B(300MWe); boilers 7A+7B (300MWe); boiler 8A(300MWe); fuel:natural gas, heavy oil(sulphur content up to 3,5%),orimulsion (sulphur content up to 3%)

An other Flowpac will be started in 2009 at Amagervaerket plant in Copenhagen (owner/operator Energi E2) (150MW; 540000 Nm³/h; 1, 3% sulphur content)

There is no reference for capacity > 340 MWe and no operational reference for coal unit. A prototype of 15 MW is in test in Sweden. For a unit of 600 MWe, Alstom proposes 2x300 Flowpac in parallel without reference.

From the expert point of view, this kind of process is to be advised for oil units < 340 MWe until more experiences.

Costs

The investments costs desulphurisation of 2 coal units of 600 MWe were estimated in 2003: Flowpac: 58 Euros/kWe (70 MEuros for 2x600MWe coal units), 6% lower than Classical wet desulphurisation: 61 Euros/KWe (74 MEuros for 2x600MWe coal units)

Sources:

EDF: "Procédé de désulfuration humide innovant Flowpac: état des connaissances" (C.Derousseau, I.Gasquet)

EGTEI – LCP 2030 – Consideration on costs – 17 March 2008

Alstom internet documentation

IPPC draft reference Document on Best Available Techniques for LCP