

**Draft Background Document**  
**on**

**Combustion sector**

(part 1: plants greater than 500 MW<sub>th</sub>)

Prepared in the framework of EGTEI

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# 1 Description of hypothesis in the different RAINS models

This paragraph describes the various hypotheses applied in the RAINS modules. These hypotheses are compared to the hypotheses proposed by EGTEI throughout the next paragraphs.

## 1.1 Fuel categories in RAINS

Table 1.1: Fuel categories RAINS

Brown coal/lignite, grade 1	BC1
Brown coal/lignite, grade 2	BC2
Hard coal, grade 1	HC1
Hard coal, grade 2	HC2
Hard coal, grade 3	HC3
Derived coal (coke, briquettes)	DC
Other solid-low S (biomass, waste, wood)	OS1
Other solid-high S (incl. high S waste)	OS2
Heavy fuel oil	HF
Medium distillates (diesel, light fuel oil)	MD
Light fractions (gasoline, kerosene, naphtha, LPG)	LF
Natural gas (incl. other gases)	GAS
Renewable (solar, wind, small hydro)	REN
Hydro	HYD
Nuclear	NUC
Electricity	ELE
Heat (steam, hot water)	HT
No Fuel use	NOF

For solid fuels (hard coal, lignite) RAINS offers an opportunity to distinguish –within each sector - different quality parameters (grades) such as calorific value, sulfur content or sulfur retained in ash.

The characteristics of each fuel are country and sector specific. The different parameters to describe each of them are the following:

- Low heating value [GJ/t]
- Sulfur content [%S]
- Sulfur retained in ash [fraction]
- Ash content for solid fuels [percentage]
- Dust retained by the boiler for solid fuels [fraction]

In the RAINS PM module, the category “LF - light fraction” disappears and the model introduces some new fuel categories such as:

GSL: Gasoline; LPG: Liquefied petroleum gas; MTH: Methanol; ETH: Ethanol; H2: Hydrogen; LFL: Leaded gasoline.

## 1.2 Emission calculation in RAINS

The RAINS model calculates present and future sectoral emissions as a product of activity level (e.g., fuel consumption) and an emission factor:

$$S_i(t) = \sum_j \sum_k act_{i,j}(t) \cdot ef_{i,j} \cdot af_{i,j,k}(t) \cdot (1 - p_{j,k})$$

with:

$S_i(t)$ : SO<sub>2</sub>; NO<sub>x</sub> or PM emissions in country  $i$  in time step  $t$

$act_{i,j}(t)$ : activity level of sector  $j$  in time step  $t$

$ef_{i,j}$ : (unabated) emission factor per unit of activity for country  $i$  and sector  $j$

$p_{j,k}$ : removal efficiency of technology  $k$  in sector  $j$

$af_{i,j,k}(t)$ : application factor of technology  $k$  in country  $i$  for sector  $j$  in time step  $t$ .

The country- and sector-specific emission factor  $ef_{i,j}$  is calculated taking into account the most important fuel characteristics in the case of SO<sub>2</sub> emissions:

$$ef_{i,j} = 2 \cdot \frac{sc_{i,j,l}}{hv_{i,j,l}} \cdot (1 - sr_{i,j,l})$$

with:

$sc_{i,j,l}$ : sulfur content (per weight) of fuel  $l$  used in sector  $j$  in country  $i$

$hv_{i,j,l}$ : heat value of fuel  $l$  used in sector  $j$  in country  $i$

$sr_{i,j,l}$ : sulfur retention in ash (fraction) of fuel  $l$  used in sector  $j$  in country  $i$ .

It is important to mention that the unabated emission factor reflects the hypothetical situation as if no control measures were applied and is derived from information of the CORINAIR'90 inventory (if, in a particular situation, in the year 1990 emission controls were applied, they are reflected in the application factor  $af$ ). Any change in emission factors over time (e.g., caused by a changed sulfur content) is interpreted as an emission control measure and reflected via a modified application factor  $f$  of a control technology  $k$  with the efficiency (e.g., by assuming the use of low-sulfur fuels). This approach implies that all changes in fuel quality, even those occurring 'autonomously' due to other reasons, are credited as emission abatement efforts with costs attributed to them.

## 1.3 Sectors considered in RAINS

Five main sectors are considered:

1. Power generation PP (SNAP code 01: distinguishing New boilers (PP new), Existing boilers, wet bottom (PP\_EX\_WB) and Existing boilers, dry bottom (PP\_EX\_OTH))
2. CON COMB fuel conversion other than power plants Combustion (CON\_COMB) 05
3. DOMESTIC domestic, commercial and agriculture use (SNAP code 02)
4. IN BO industrial boilers 0301
5. Other combustion 03 excluding 0301 IN OC

Table 1.2: RAINS sectors related to stationary sources with energy combustion.

RAINS sector	RAINS code	NFR category	SNAP sector
<b>Centralized power plants and district heating</b>			
New power plants	PP_NEW		
New power plants, grate combustion	PP_NEW1		
New power plants, fluidized bed combustion	PP_NEW2		
New power plants, pulverized fuel combustion	PP_NEW3		
Existing plants <sup>(1)</sup> , wet bottom boilers	PP_EX_WB	1A1a	0101, 0102, 020101, 020102, 020201, 020301
Existing plants <sup>(1)</sup> , other types (of boilers)	PP_EX_OTH		
Other types, grate combustion	PP_EX_OTH1		
Other types, fluidized bed combustion	PP_EX_OTH2		
Other types, pulverized fuel combustion	PP_EX_OTH3		
<b>Fuel conversion</b>			
Energy consumed in fuel conversion process	CON_COMB		
Fuel conversion, grate combustion	CON_COMB1		
Fuel conversion, fluidized bed combustion	CON_COMB2	1A1c	0104
Fuel conversion, pulverized fuel combustion	CON_COMB3		
<b>Residential, commercial, institutional, agricultural use</b>			
Combustion of liquid fuels	DOM	1A4a	
Fireplaces	DOM_FPLACE		
Stoves	DOM_STOVE	1A4b	020103-06, 020202-03, 020302-05
Single house boilers (<50 kW) - manual	DOM_SHB_M		
Single house boilers (<50 kW) - automatic	DOM_SHB_A		
Medium boilers (<1 MW) - manual	DOM_MB_M	1A4a	
Medium boilers (<50 MW) - automatic	DOM_MB_A		
<b>Fuel combustion in industrial boilers</b>			
Combustion in boilers	IN_BO		
Combustion in boilers, grate combustion	IN_BO1		010301-03, 010501-03, 0301
Comb. in boilers, fluidized bed combustion	IN_BO2		
Comb. in boilers, pulverized fuel combustion	IN_BO3	1A2	
Other combustion	IN_OC		
Other combustion, grate combustion	IN_OC1		010304-06, 010504-06, 0302, 0303
Other combustion, fluidized bed combustion	IN_OC2		
Other combustion, pulverized fuel combustion	IN_OC3		

Plants having a capacity higher than 500 MW<sub>th</sub> are covered in PP.

## 1.4 SO<sub>2</sub> module

### 1.4.1 Main groups of SO<sub>2</sub> emission control technologies considered in RAINS

Table 1.3: Main groups of SO<sub>2</sub> emission control technologies considered in RAINS for the power plant sector

Technology name	RAINS abbreviation	Removal efficiency %
Use of low sulfur fuels (coal, and heavy fuel oil)		(*)
Limestone injection Industry	LINJ	50
Power plants, Wet FGD, already retrofitted	PRWFGD	90
Power plants, Wet FGD	PWFGD	95
High efficiency FGD	RFGD	98

(\*) The control efficiency is a function of the initial sulfur content of the fuel to be replaced.

## 1.4.2 Investment function

Investment function is given by Equation:

$$I = (ci^f + \frac{ci^v}{bs}) \cdot v \cdot (1+r)$$

where  
 $ci^f, ci^v$ : coefficients of the investment function  
 $bs$ : boiler size  
 $v$ : relative flue gas volume

$r$ : retrofit factor.

Table 1.4: Coefficients of the investment function for add-on control technologies in RAINS

Technology		Coefficient Capacity class (MW <sub>th</sub> )		
		<20	20-300	>300
Limestone Injection	ci <sub>f</sub> , EURO/kW <sub>th</sub>	64	32	22
	ci <sub>v</sub> , 10 <sup>3</sup> EURO	0	638	3630
Wet FGD	ci <sub>f</sub> , EURO/kW <sub>th</sub>	97	83	44
	ci <sub>v</sub> , 10 <sup>3</sup> EURO	0	294	12,101
Advanced FGD	ci <sub>f</sub> , EURO/kW <sub>th</sub>	373	182	113
	ci <sub>v</sub> , 10 <sup>3</sup> EURO	0	3823	24,079

Table 1.5: Relative flue gas volume  $v$  for different fuel categories used in RAINS (hard coal=1)

Item	Value
Brown coal	1.2
Hard coal	1.0
Other solid fuels	1.0
Heavy fuel oil and gas	0.9

### Retrofit factor

Retrofit coefficient $r$	%/100	0.3
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The investment is annualised over the technical life of the plant  $lt$  by using real interest rate  $q$  (as %/100). The result is given by this equation:

$$I^{an} = I \cdot \frac{(1+q)^{lt} \cdot q}{(1+q)^{lt} - 1}$$

A 4% interest rate is taken into account in the RAINS model. The rate of 4% is regarded as a societal parameter and not as a business parameter.

## 1.4.3 Operating costs

### 1.4.3.1 Fixed expenditures

The annual **fixed expenditures**  $OM^{fix}$  cover the costs of maintenance and administrative overhead. These cost items are not related to the actual use of the plant. As a rough estimate for the annual fixed expenditures, a standard percentage  $f$  of the total investments is used:

$$OM^{fix} = I \cdot f$$

### 1.4.3.2 Variable operating costs

The **variable operating costs**  $OM^{var}$  related to the actual operation of the plant take into account:

- additional labor demand
- increased energy demand for operating the device (e.g., for the fans and pumps),
- sorbent material demand (e.g., limestone),
- byproducts / waste disposal.

These cost items are calculated based on the specific demand  $\lambda^x$  of a certain control technology and its (country-specific) price  $c^x$ .

$$OM^{var} = \left( \frac{\lambda^l \cdot c^l}{pf} + \lambda^e \cdot c^e \right) + ef \cdot \eta \cdot (\lambda^s \cdot c^s + \lambda^d \cdot c^d)$$

$$ef = 2 \cdot \frac{sc}{hv} \cdot (1 - sr)$$

where:

- $\eta$ : removal efficiency,
- $\lambda^l$ : labor demand,
- $\lambda^e$ : additional energy demand,
- $\lambda^s$ : sorbents demand,
- $\lambda^d$ : demand for waste disposal,
- $c^l$ : labor cost,
- $c^e$ : electricity price,
- $c^s$ : sorbent cost,
- $c^d$ : byproduct/waste disposal cost,
- $pf$ : load factor (annual operating hours at full load)
- $ef$ : unabated emission factor,
- $sc$ : sulfur contents,
- $hv$ : lower heat value
- $sr$ : sulfur retention in ash.

### Names and units of technology-specific parameters for the cost calculation of add-on control technologies

- $I$ : Investment function [EURO/kWth]
- $ci f$ : Intercept of the investment function [EURO/kWth]
- $ci v$ : Slope of the investment function [ $10^3$  EURO]
- $v$ : Flue gas volume (relative to that of hard coal)
- $r$ : Retrofit cost factor [%/100]
- $\eta$ : Sulfur removal efficiency [%/100]
- $f$ : Maintenance costs and overheads [%/100/year]
- $\lambda^e$ : Specific demand for electricity [kWh/GJth]
- $\lambda^l$ : Specific demand for labor [man-year/MWth]
- $\lambda^s, \lambda^d$ : Specific demand for sorbents and byproducts/waste disposal [ton/t of SO<sub>2</sub> removed]

Table 1.6: Technology-specific parameters for add-on control technologies in RAINS

Parameter	Unit	Limestone injection	Wet FGD	Advanced FGD
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Removal efficiency $\eta$	%	50	95	98
Retrofit coefficient $r$	%/100	0.3	0.3	0.3
Fixed O+M cost $f$	%/100/yr	0.04	0.04	0.04
Labor demand	man-yr/GWth	10.8	10.8	25.2
Electricity demand	GWh/PJ fuel inp.	0.5	1	2.2
Sorbent demand	t/tSO <sub>2</sub>	4.68	1.56	0.01
Byproducts	t/tSO <sub>2</sub>	7.8	2.6	0.5

## Costs of low sulfur fuels

Table 1.7: Options for low-sulfur fuels considered in RAINS and their costs

Fuel type	Price difference (million EURO/PJ/%S)	Cost per ton of SO <sub>2</sub> removed (EURO/t SO <sub>2</sub> )
Hard coal (HC), 0.6%	0.28	370
Derived coal (coke - DC), 0.6 %	0.28	370
Heavy fuel oil, 0.6% S	0.20	410
Gasoil	0.68	1440
- reduction to 0.2 %S		
- reduction from 0.2% S to 0.045% S	2.04	4330
- reduction from 0.045% S to 0.003% S	6.69	14,200

## Country-specific parameters for calculating costs of add-on technologies

<p><math>sc</math>: sulfur contents [%/100]  <math>hv</math>: lower heat value [GJ/t]  <math>sr</math>: Sulfur retained in ash [%/100]  <math>ef</math>: unabated emission factor [ktonSO<sub>2</sub>/PJ]  <math>bs</math>: Average boiler size [MWth]  <math>pf</math>: load factor (annual operating hours at full load) [hours/year]  <math>c^e</math>: electricity price [Euro/kWh]  <math>c^s</math>: sorbent cost [Euro/person-year]  <math>c^d</math>: byproduct/waste disposal cost [Euro/ton]  <math>c^l</math>: labor cost [Euro/ton]  <math>lt</math>: Control equipment lifetime [years]  <math>q</math>: Real interest rate [%/100]</p>
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For detailed values of the country-specific parameters, see the annexes of the RAINS model.

## 1.5 NO<sub>x</sub> module

### 1.5.1 Main groups of NO<sub>x</sub> emission control technologies considered in RAINS

Table 1.8: Main groups of NO<sub>x</sub> emission control technologies considered in RAINS for Power plant sector

RAINS Sector/Technology	Technology abbreviation	Removal efficiency, %
<b>Power plant sector (PP):</b>		
Brown Coal - Combustion modification (CM) –	PBCCM	65

existing plant		
Brown Coal - Selective catalytic reduction (SCR) – new plant	PBCSCR	80
Brown Coal - CM + SCR – existing plant	PBCCSC	80
Hard Coal - CM – existing plant	PHCCM	50
Hard Coal - SCR – new plant	PHCSCR	80
Hard Coal - CM + SCR – existing plant	PHCCSC	80
Oil and Gas - CM – existing plant	POGCM	65
Oil and Gas - SCR – new plant	POGSCR	80
Oil and Gas - CM + SCR – existing plant	POGCSC	80

### 1.5.2 Investment function

The investment function is given by equation:

$$I = (ci_1^f + \frac{ci_1^v}{bs}) + (ci_2^f + \frac{ci_2^v}{bs}) \cdot (1+r) + \lambda_{cat} \cdot ci_{cat}$$

where

$ci_1^f, ci_1^v, ci_2^f, ci_2^v$ : coefficients of investment function;  $ci_1$  have non-zero values only for combinations of technologies (e.g., CM plus SCR)

$bs$ : boiler size

$\lambda_{cat}$ : catalyst volume (per unit of installed capacity)

$ci_{cat}$ : unit cost of catalysts

$r$ : retrofit cost factor

Table 1.9: Coefficients of the investment function for 'combustion modification' technologies used in boilers and furnaces

Technology abbreviation	$ci f2$ EURO/kW <sub>th</sub>	$ci v2$ 10 <sup>3</sup> EURO	Capacity range MW <sub>th</sub>
PBCCM	12.34	0.00	<20
	10.02	46.46	20-300
	6.4	1128.93	>300
PHCCM	7.62	0.00	<20
	6.27	27.23	20-300
	2.82	1060.57	300
POGCM	4.63	0.00	<20
	3.75	17.42	20-300
	2.41	967.58	>300

Table 1.10: Coefficients of the investment function for add-on technologies and combined measures used in boilers and furnaces

Technology abbreviation	$ci f1$ EURO/kW <sub>th</sub>	$ci v1$ 10 <sup>3</sup> EURO	$ci f2$ EURO/kW <sub>th</sub>	$ci v2$ 10 <sup>3</sup> EURO	Capacity range MW <sub>th</sub>
PBCSCR	0.00	0.00	28.46	0.00	<20
	0.00	0.00	21.2	148.1	20-300
	0.00	0.00	7.4	4283.4	>300
PBCCSC	12.34	0.00	28.46	0.00	<20
	10.02	46.46	21.2	148.1	20-300
	6.4	1128.93	7.4	4283.4	>300
PHCSCR	0.00	0.00	23.72	0.00	<20
	0.00	0.00	17.67	123.42	20-300

	0.00	0.00	6.17	3569.5	>300
PHCCSC	7.62	0.00	23.72	0.00	<20
	6.27	27.23	17.67	123.42	20-300
	2.82	1060.57	6.17	3569.5	>300
POGSCR	0.00	0.00	17.7	0.00	<20
	0.00	0.00	13.62	83.31	20-300
	0.00	0.00	5.72	2409.42	>300
POGCSC	4.63	0.00	17.7	0.00	<20
	3.75	17.42	13.62	83.31	20-300
	2.41	967.58	5.72	2409.42	>300

### Retrofit factor

Retrofit coefficient $r$	%/100	0.5
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### 1.5.3 Operating costs

#### 1.5.3.1 Fixed expenditures

The annual **fixed expenditures**  $OM_{fix}$  cover the costs of maintenance and administrative overhead. These cost items are not related to the actual use of the plant. As a rough estimate for the annual fixed expenditures, a standard percentage  $f$  of the total investments is used:

$$OM^{fix} = I \cdot f$$

#### 1.5.3.2 Variable operating costs

$$OM^{var} = \lambda^e \cdot c^e + ef \cdot \eta \cdot \lambda^s \cdot c^s$$

where:

$\lambda^e$ : additional electricity demand

$\lambda^s$ : sorbents demand

$c^s$ : sorbents price

$c^e$ : energy price

$ef$ : unabated NOx emission factor

$\eta$ : removal efficiency

If a control technology makes use of catalyst, the periodical replacement costs for this equipment (depending on the real operation time of the plant) is also included in this cost category:

$$OM^{cat} = \frac{pf}{l_{cat}} \cdot \frac{\lambda_{cat}}{ci_{cat}} \cdot \frac{1}{pf}$$

$pf$ : capacity utilization (operating hours/year)

$l_{cat}$ : lifetime of catalyst.

Table 1.11: Other technology-specific parameters for add-on control technologies (secondary and combined measures)

Parameter	Unit	Value
Retrofit coefficient $r$	%/100	0.5
Fixed O+M cost $f$	%/100/yr	0.06
Catalyst cost $ci_{cat}$	kEURO/m <sup>3</sup>	10
Electricity demand $\lambda_e$		

- coal boilers	GW <sub>h</sub> /PJ fuel input	0.36
- oil and gas boilers		0.30
Catalyst volume $\lambda_{cat}$	m <sup>3</sup> /MW <sub>th</sub>	
Brown coal boilers		0.41
Hard coal, dry bottom boilers		0.34
Hard coal, wet bottom boilers		0.46
Oil and gas boilers		0.11
Sorbent demand $\lambda_s$ , technology:	t/t NO <sub>x</sub>	
PBCSCR, PHCSCR, POGSCR		0.390
PBCCSC, POGCSC		0.117
PHCCSC,		0.173

## Country-specific parameters for calculating costs of measures on boilers and furnaces

<i>ef<sub>NOx</sub></i> : Unabated NO <sub>x</sub> emission factor [kt NO <sub>x</sub> /PJ]
<i>bs</i> : Average boiler size [MW <sub>th</sub> ]
<i>pf</i> : Capacity utilization hours/year
<i>ce</i> : Electricity price EURO/kWh
<i>cs</i> : Sorbent (ammonia) cost EURO/ton
<i>lt</i> : Control equipment lifetime years
<i>q</i> : Real interest rate %/100

For detailed values on the country-specific parameters, see the annexes of the RAINS model.

## 1.6 The PM module

### 1.6.1 Source categories

Table 1.12: RAINS sectors related to stationary sources with energy combustion

RAINS sector	RAINS code	NFR category	SNAP sector
<b>Centralized power plants and district</b>			
New power plants	PP_NEW	1A1a	0101, 0102, 020101, 020102, 020201, 020301
New power plants, grate combustion	PP_NEW1		
New power plants, fluidized bed combustion	PP_NEW2		
New power plants, pulverized fuel combustion	PP_NEW3		
Existing plants (1), wet bottom boilers	PP_EX_WB		
Existing plants (1), other types (of boilers)	PP_EX_OTH		
Other types, grate combustion	PP_EX_OTH1		
Other types, fluidized bed combustion	PP_EX_OTH2		
Other types, pulverized fuel combustion	PP_EX_OTH3		

(1) Refers to all sources that came on line before or in 1990.

### 1.6.2 Emission factors for solid fuels

Estimation in a first step:

$ef_{TSP} = \frac{ac}{hv} \cdot (1 - ar) \cdot 10$ <p>where:</p>
--

*ef*: unabated emission factor [g/MJ],  
*ac*: ash content [%],  
*hv*: lower heat value [GJ/t],  
*ar*: fraction of ash retained in boiler .

In a second step, the emissions of fine particulate matter (for two size fractions: PM10 and PM2.5) are calculated from the TSP estimates by using typical size profiles available in the literature (e.g., Ahuja *et al.*, 1989; Houck *et al.*, 1989; EPA, 1998a; AWMA, 2000; Kakareka *et al.*, 1999). The order of magnitude of the emission factors obtained with this method was checked against values reported in the literature, e.g., TA Luft, 1986; Soud, 1995, and summarized by Dreiseidler *et al.* (1999).

### Size fraction

Table 1.13: Size fractions used in RAINS for solid fuel combustion in power plants, 'raw gas' [%]

Fuel [installation type]	PM <sub>2.5</sub>	Coarse	PM <sub>10</sub>	>PM <sub>10</sub>	TSP
Coal [grate]	14	23	37	63	100
Coal [fluidized]	5	21	26	74	100
Brown coal [pulverized]	10	25	35	65	100
Hard coal [pulverized]	6	17	23	77	100
Hard coal [wet bottom]	21	2	23	77	100
Derived coal	45	34	79	21	100
Biomass	77	12	89	11	100
Waste	23	15	38	62	100

### 1.6.3 Emission factors for other fuels

For liquid fuels, biomass, solid fuels used in small residential installations, industrial processes, mining, storage and handling of bulk materials, waste incineration, agriculture<sup>1</sup>, and transport TSP emission factors are taken from the literature.

Table 1.14: Emission factors used in the RAINS model for stationary combustion of heavy fuel oil [kt/PJ]

Fuel [installation type]	PM <sub>2.5</sub>	Coarse	PM <sub>10</sub>	>PM <sub>10</sub>	TSP	TSP mg/Nm <sup>3</sup>
Power plants PP_NEW, PP_EX	0.0093	0.0039	0.0132	0.0023	0.0155	55

Table 1.15: Emission factors used in the RAINS model for stationary combustion of natural gas [kt/PJ]

Fuel [installation type]	PM <sub>2.5</sub>	Coarse	PM <sub>10</sub>	>PM <sub>10</sub>	TSP	TSP mg/Nm <sup>3</sup>
Power plants PP_NEW, PP_EX	0.0001	0	0.0001	0	0.0001	0.35

### 1.6.4 Control techniques

Table 1.16: Control techniques

Control technology	RAINS code	Removal efficiency		
		> PM <sub>10</sub>	Coarse <sup>(1)</sup>	Fine <sup>(2)</sup>
Cyclone	CYC, _CYC	90 %	70 %	30 %
Wet scrubber	WSCRB, _WSCRB	99.9 %	99 %	96 %
Electrostatic precipitator, 1 field	ESP1, _ESP1	97 %	95 %	93 %
Electrostatic precipitator, 2 fields	ESP2, _ESP2	99.9 %	99 %	96 %
Electrostatic precipitator, 3 fields and more	ESP3P, _ESP3P	99.95 %	99.9 %	99 %
Wet electrostatic precipitator	PR_WESP	99.95 %	99.9 %	99 %
Fabric filters	FF, _FF	99.98 %	99.9 %	99 %
Regular maintenance, oil fired boilers	GHIND	30 %	30 %	30 %

(1): coarse particles: (> 2.5 and < 10 microns)

(2): fine particles (< 2.5 microns)

Source: *Modelling particulate emissions in Europe. A framework to estimate reduction potential and control costs*. IIASA. 2002.

## 1.6.5 Costs

### 1.6.5.1 Investment

The Investment function is given by the equation:

$$I = (ci^f + \frac{ci^v}{bs}) \cdot v \cdot (1+r)$$

where:

$ci^f$ ,  $ci^v$ : coefficients of investment function

$bs$ : boiler size

$r$ : retrofit cost factor

$v$ : relative flue gas volume

Table 1.17: Relative flue gas volume  $v$  for different fuel categories used in RAINS (hard coal=1)

Item	Value
Brown coal	1.2
Hard coal	1.0
Other solid fuels	1.0
Heavy fuel oil and gas	0.9

### 1.6.5.2 Fixed Operating Costs

The annual **fixed expenditures**  $OM^{fix}$  cover the costs of repairs, maintenance and administrative overhead. These cost items are not related to the actual use of the plant. As a rough estimate for annual fixed expenditures, a standard percentage  $f$  of the total investments is used:

$$OM^{fix} = I \cdot f$$

### 1.6.5.3 Variable Operating Costs

$$OM^{var} = \frac{\lambda^l \cdot c^l}{pf} + \lambda^e \cdot c^e + ef_{TSP} \cdot \eta_{TSP} \cdot \lambda^d \cdot c^d$$

where

- $\eta_{TSP}$  dust (TSP) removal efficiency,  
 $\lambda^l$  labor demand (per thermal capacity unit),  
 $\lambda^e$  additional electricity demand (per unit of fuel used),  
 $\lambda^d$  demand for waste disposal (per unit of dust reduced),  
 $c^l$  labor cost,  
 $c^e$  electricity price,  
 $c^d$  waste disposal cost,  
 $pf$  plant factor (annual operating hours at full load),  
 $ef_{TSP}$  unabated TSP emission factor

### Cost parameters for technologies used to control emissions from stationary combustion sources in power plants and industry

Table 1.18: Cost parameters for technologies used to control emissions from stationary combustion sources in power plants and industry

Technology	INV_C Euro/kWth	INV_V kEuro	Fixed O+M, %	Electricity kWh/GJ fuel	Capacity range, MWth	
					from	to
ESP1 (1 field)	26.0	0.0	0.5	0.11	0	5
	6.9	95.9	0.5	0.11	5	50
	3.7	254.6	0.5	0.11	>50	
ESP2 (2 fields)	32.5	0.0	0.5	0.13	0	5
	8.6	119.9	0.5	0.13	5	50
	4.6	318.2	0.5	0.13	>50	
ESP3 (3 and more fields)	35.4	0.0	0.5	0.15	0	5
	10.2	126.4	0.5	0.15	5	50
	5.6	353.6	0.5	0.15	>50	
CYC (cyclones)	10.4	0.0	0.5	0.15	0	5
	2.7	38.4	0.5	0.15	5	50
	1.5	101.8	0.5	0.15	>50	
FF (fabric filters)	21.5	0.0	1.0	0.20	0	5
	11.0	52.3	1.0	0.20	5	50
	7.9	212.1	1.0	0.20	>50	
Wet scrubbers	31.9	0.0	1.0	1.50	0	5
	9.1	113.8	1.0	1.50	5	50
	5.0	318.2	1.0	1.50	>50	
Good housekeeping oil boilers	2.0	0.0	4.0	0.00	>0	

## 2 Overview: Analysis of pollutant abatement efficiencies from various data sources

### 2.1 Primary measures for NO<sub>x</sub> abatement

Table 2.1: Primary measures for NO<sub>x</sub> abatement: comparison of existing data

Techniques	EURELECTRIC LCP 115-116	LCP BREF 2 <sup>nd</sup> Draft*	RAINS
Low NO <sub>x</sub> Burner (LNB)	<u>Solid fuels</u> Air staged: 25-35% Fuel staged: 50-60% <u>Liquid fuels</u> : 20%, up to 50%	<u>Solid fuels</u> Air staged: 25-35% Fuel staged: 50-60% <u>Liquid fuels</u> : up to 50% for modern design	Does not distinguish primary measures: only one category (Combustion Modification).  Only considers primary measures for existing plants: Lignite: 65% Hard Coal: 50%
Over Fire Air (OFA)	<u>Solid fuels</u> : 40-50% OFA is the most often used primary for coal <u>Liquid fuels</u> : up to 60%	<u>Solid fuels</u> : 40-50% Old plant design do not allow for installation <u>Liquid fuels</u> : Up to 60% in specific cases	
Flue Gas Recirculation (FGR)	<u>Solid fuels</u> FGR is <b>often</b> used, except in wet bottom boilers 15% (coal) <u>Liquid fuels</u> : FGR mainly used with LNB &/or OFA	FGR more often used for oil than coal <u>Solid fuels</u> FGR is <b>not often</b> used, except in wet bottom boilers 15-20% <u>Liquid fuels</u> : FGR mainly used with LNB: it adds 20% to LNB efficiency	
Low Excess Air (LEA)	<u>Solid fuels</u> LEA: better for wet bottom, for coal than lignite 20%-40% <u>Liquid fuels</u>	<u>Solid fuels</u> 10-40% <u>Liquid fuels</u> LEA rarely used alone, but in combination with LNB &/or OFA.	
Reburning	Never used alone & Better suited for new plants <u>Solid fuels</u> : Always with LNB and/or OFA. <u>Liquid fuels</u> always with OFA+FGR, if not even with LNB	Never used alone & Better suited for new plants <u>Solid fuels</u> : Always with LNB and/or OFA. <u>Liquid fuels</u> only with OFA+FGR and/or LNB: than 55%- 80%	
LNB & OFA	<u>Solid fuels</u> Air staged LNB+OFA: 55% Fuel staged LNB+OFA: 60% New design LNB+OFA: up to 70% <u>Liquid fuels</u> ?	<u>Solid fuels</u> LNB+OFA: up to 70% <u>Liquid fuels</u> LNB+FGR: 60-75% LNB+OFA: 60-75%	
LNB & Reburning &/or OFA	<u>Solid fuels</u> : 65%-75%	<u>Solid fuels</u> : 65%-75% <u>Liquid fuels</u> : 55-80%	

LNB & FGR&/or OFA		<u>Liquid fuels:</u> 60-75%	
		<u>General comment:</u> primary measures for Nox reduction reduce efficiency of plants by 0.1-0.3%, may increase electricity consumption (OFA) and may have impact on waste (LNB, LEA)	

\*:still under development within BREF working group

## 2.2 Secondary measures for NO<sub>x</sub> abatement

Table 2.2: Secondary measures for NO<sub>x</sub> abatement: comparison of existing data

Description	EURELECTRIC LCP 115-116	LCP BREF 2 <sup>nd</sup> Draft*	RAINS (present figures)
SCR	No figure	<u>General:</u> 80-95% Energy consumption: 0.5 to 2% of electric capacity <u>Solid fuels</u> For plants over 300MWth Not applicable to lignite fired plants Catalyst lifetime: 4-5 years Catalyst lifetime reduced for wet bottom <u>Liquid fuels:</u> Catalyst lifetime: 7-10 years	Lignite, new plant: 80% Hard Coal, new plant: 80% Oil&Gas, new plant: 80%  For existing plants, only combination of primary and secondary measures are considered
SNCR	Better suited for small units Not suited for gas turbines	30-50% Not suited for gas turbines Energy consumption: 0.1 to 0.3% of electric capacity	SNCR is presently not considered for the power plant sector
	General comment: No secondary NO <sub>x</sub> abatement measures needed for grate combustion, lignite fired boilers and CFBC	General comment: No need for secondary measures for NO <sub>x</sub> for lignite fired plants	

\*:still under development within BREF working group

## 2.3 Primary measures for SO<sub>2</sub> abatement

Table 2.3: Primary measures for SO<sub>2</sub> abatement: comparison of existing data

Techniques	EURELECTRIC LCP 115-116	LCP BREF 2 <sup>nd</sup> Draft*	RAINS
Low Sulfur content fuel	<u>Solid fuels</u> No figure  <u>Liquid fuels</u> A decrease S by 0.5% reduces emissions by 800mg/Nm <sup>3</sup>	<u>Solid fuels</u> Can be used alone for boilers < 100MWth (combined with dry sorbent injection) No figure  <u>Liquid fuels</u> A decrease of 0.5% in S content leads to a decrease in emissions by 800 mg/Nm <sup>3</sup>	Considers use of low sulfur fuels  Do not consider limestone injection for power plants (only for industrial boilers, 50%)
Injection of dry sorbent	<u>Solid fuels</u> <i>Pulverized combustion boilers:</i> mainly used for lignite 50-70%  <i>Fluidized bed combustion:</i> 80-90% for BFBC, 90-95% for CFBC  <u>Liquid fuels</u> Not relevant	<u>Solid fuels</u> <i>Pulverized combustion boilers:</i> For boilers < 250 MWth (combined with Fabric Filters) 40-50%, up to 70% <i>Fluidized bed combustion:</i> 55% - 65% for BFBC, 80% - 95% for CFBC  <u>Liquid fuels</u> Not relevant	
Fuel cleaning	Not addressed	Not addressed	

\*:still under development within BREF working group

## 2.4 Secondary measures for SO<sub>2</sub> abatement

Table 2.4: Secondary measures for SO<sub>2</sub> abatement: comparison of existing data

Description	EURELECTRIC LCP 115-116	LCP BREF 2 <sup>nd</sup> Draft*	RAINS (present figures)
Wet scrubber	<u>Solid fuels</u> Not suited for small plants (<100MWth) and low operating factors (<2200 FLH/a) No figure <u>Liquid fuels</u> No figure	80% of installed FGD are wet scrubbers For plants > 100 MWth <u>Solid fuels</u> 85% - 98% 90% maximum value in specific cases  <u>Liquid fuels</u> 92-98%	Retrofitted plants: 90% New plants: 95% High efficiency FGD: 98%
Spray dry scrubber	<u>Solid fuels</u> No figure Better suited for small units or low load factors <u>Liquid fuels</u> Not mentioned	<u>Solid fuels</u> 80 % - 92 % For plant<100MWth  <u>Liquid fuels</u> For plant<300MWth 85 % - 92 %	Not considered
	General comment: No secondary SO <sub>2</sub> abatement measures needed for grate combustion, lignite fired boilers and FBC		

\*:still under development within BREF working group

## 2.5 Secondary measures for PM abatement

Table 2.5: Secondary measures for PM abatement: comparison of existing data

Description	EURELECTRIC LCP 115-116	LCP BREF 2 <sup>nd</sup> Draft*	RAINS (present figures)
ESP	<p><u>Solid fuels</u> 99.5 to 99.9%</p> <p><u>Liquid fuels</u> Only for oil with high ash content (&gt; 1%)</p>	<p>&lt; 1 μ m: &gt; 96.5%</p> <p>2 μ m: &gt; 98.3%</p> <p>5 μ m: &gt; 99.95%</p> <p>&gt; 10 μ m: &gt; 99.95%</p> <p><u>Solid fuels</u> 85% - 98%</p> <p>90% maximum value in specific cases</p> <p><u>Liquid fuels</u> 92-98%</p>	<p>ESP 1 field:</p> <ul style="list-style-type: none"> <li>Ø PM10: 97%</li> <li>Ø Coarse: 95%</li> <li>Ø Fine: 93%</li> </ul> <p>ESP 2 fields:</p> <ul style="list-style-type: none"> <li>Ø PM10: 99.9%</li> <li>Ø Coarse: 99%</li> <li>Ø Fine: 96%</li> </ul> <p>ESP 2 fields and more:</p> <ul style="list-style-type: none"> <li>Ø PM10: 99.95%</li> <li>Ø Coarse: 99.9%</li> <li>Ø Fine: 99%</li> </ul>
Fabric filter	<p><u>Solid fuels</u> Higher O&amp;M than ESP:</p> <ul style="list-style-type: none"> <li>- compensation of pressure drop,</li> <li>- pre-heating during start-up</li> <li>- cleaning the bags</li> <li>- replacement of filters (10% of total investment, every 3 to 4 years)</li> </ul> <p><u>Liquid fuels</u> Not used in oil fired boilers, for safety reasons</p>	<p>&lt; 1 μ m: &gt; 99.6%</p> <p>2 μ m: &gt; 99.6%</p> <p>5 μ m: &gt; 99.9%</p> <p>&gt; 10 μ m: &gt; 99.95%</p> <p><u>Solid fuels</u></p> <p><u>Liquid fuels</u></p>	<ul style="list-style-type: none"> <li>Ø PM10: 99.98%</li> <li>Ø Coarse: 99.9%</li> <li>Ø Fine: 99%</li> </ul>
Cyclone		<p>85 – 90 %</p> <p>Smallest diameter trapped: 5 to 10 μ</p>	<ul style="list-style-type: none"> <li>Ø PM10: 90%</li> <li>Ø Coarse: 70%</li> <li>Ø Fine: 30%</li> </ul>
Wet scrubber		<p>&lt; 1 μ m: &gt; 98.5%</p> <p>2 μ m: &gt; 99.5%</p> <p>5 μ m: &gt; 99.9%</p> <p>&gt; 10 μ m: &gt; 99.9%</p>	<ul style="list-style-type: none"> <li>Ø PM10: 99.9%</li> <li>Ø Coarse: 99%</li> <li>Ø Fine: 96%</li> </ul>
		<p>General comment</p> <p>Deduster is not needed for wet bottom boilers</p> <p>Most used: ESP (90%) and Fabric filters (10%)</p>	

\*:still under development within BREF working group

### 3 EGTEI approach concerning plants having capacities higher than 500 MW<sub>th</sub>

To consider the plants having a capacity greater than 500 MW<sub>th</sub>, the following approach has been developed by EGTEI.

#### 3.1 Energy scenarios

It is important to know and estimate the energy consumption for the years 1990 until 2030 for the scenarios BL and CP for plants having a capacity greater than 500 MW<sub>th</sub> in a country.

BL scenario: Baseline energy scenario

CP scenario: Climate Policy scenario

The PRIMES model can be used as help to determine the different consumption.

Table 3.1: Energy scenarios for plants having a capacity greater than 500 MW<sub>th</sub> (data required as input from national experts for each country)

Unit PJ	1990	1995	2000	2005	2010	2015	2020	2025	2030
<b>BL Cons tot PP</b>									
<b>CP Cons tot PP</b>									

##### 3.1.1 Fuels considered

For each scenario, the energy consumption will be split following the fuels used. The expert has the possibility to introduce additional fuels, different from the fuels predefined in the RAINS models. But as the abatement techniques are depending from the fuel burned, the introduction of new fuels must be accompanied by a description of the abatement techniques (name, abatement efficiency, investments, operating costs, ...), which are used with this fuel or the difference in the exhaust gas flow observed in comparison with a conventional fuel.

Table 3.2: Fuel consumption for scenario BL for the years 1990 until 2030 (data required as input from national experts for each country)

Fuel	1990	1995	2000	2005	2010	2015	2020	2025	2030
<b>BC1</b>									
<b>BC2</b>									
<b>HC1</b>									
<b>HC2</b>									
<b>HC3</b>									
<b>DC</b>									
<b>OS1</b>									
<b>OS2</b>									
<b>HF1</b>									
<b>HF2</b>									
<b>HF3</b>									
<b>MD</b>									
<b>Natural gas</b>									
<b>Coke oven gas</b>									
<b>LPG</b>									
<b>Others ?</b>									

Table 3.3: Fuel consumption for scenario CP for the years 1990 until 2030 (data required as input from national experts for each country)

Fuel	1990	1995	2000	2005	2010	2015	2020	2025	2030
BC1									
...									

### 3.1.2 New and existing plants

First we need to distinguish between new and existing plants.

**New plants:** plants permitted after 27-11-2002 or started after 27-11-2003.

**Existing plants:** plants permitted before 27-11-2002.

It is important to point out that the definition of new/existing plants is different in the LCP directive:

- “**existing plants**”: licensed before 1 July 1987;
- “**new plants**”: licensed after 1 July 1987 and before one year after the entry into force of the directive.

But this new classification proposed by EGTEI is important because of the influence of the regulation of emissions considering the LCP directive and because of the influence of a retrofit factor for the calculation of the abatement costs. For new installations, the abatement efficiency could be also higher.

Then the tables 3.2 and 3.3 are split into two other tables: one for new plants (tables 3.4 and 3.6) and the second for existing plants (tables 3.5 and 3.7).

Table 3.4: Energy consumption for new plants for different fuels between 1990 and 2030 for the BL scenario (data required as input from national experts for each country)

Fuel	2000	2005	2010	2015	2020	2025	2030
BC1							
BC2							
HC1							
...							

Table 3.5: Energy consumption for existing plants for different fuels between 1990 and 2030 for the BL scenario (data required as input from national experts for each country)

Fuel	1990	1995	2000	2005	2010	2015	2020	2025	2030
BC1									
BC2									
HC1									
...									

Table 3.6: Energy consumption for new plants for different fuels between 2000 and 2030 for the CP scenario (data required as input from national experts for each country)

Fuel	2000	2005	2010	2015	2020	2025	2030
BC1							
BC2							

<b>HC1</b>								
...								

Table 3.7: Energy consumption for existing plants for different fuels between 1990 and 2030 for the CP scenario (data required as input from national experts for each country)

<b>Fuel</b>	<b>1990</b>	<b>1995</b>	<b>2000</b>	<b>2005</b>	<b>2010</b>	<b>2015</b>	<b>2020</b>	<b>2025</b>	<b>2030</b>
<b>BC1</b>									
<b>BC2</b>									
<b>HC1</b>									
...									

### 3.1.3 Distinction of regulatory classes

The energy consumption will be distinguished according to the following regulatory classes described by the LCP directive:

1. New Plants (permitted after 27-11-2002 or started after 27-11-2003)

Emission limit value to fulfil (see paragraph 3.5.1)

2. Plants closed until 31/12/2015 and operating less than 20,000 hours between 01/01/2008 and 31/12/2015

No emission limit value to fulfil.

3. Low operated plants, burning solid fuels and permitted before 01-07-87, which do not operate more than 2000 h/year (rolling average over 5 years) from 01-01-2008 to 31-12-2015, and more than 1500 h/year (rolling average over 5 years) after 01-01-2016

Emission limit value to fulfil (see paragraph 3.5.1)

4. Plants authorized between 01/07/1987 and 27/11/2002

Emission limit value to fulfil (see paragraph 3.5.1)

5. Plants authorized before 01/07/1987. Classes 4 and 5 have the same emissions limit.

Only the implementation dateline of the application is different.

6. Plants submitted to a National Emission Reduction Plan

Countries prepared national emission reduction plans to limit pollutants from large combustion plants. These plans contain detailed information on existing plants including capacity, annual operating time and emissions history and they specify total emissions targets with a timetable for compliance.

## 3.2 Fuel characteristics

Each fuel is described with different characteristics for each year between 1990 and 2030.

### 3.2.1 Lower heat values

Table 3.8: Lower heat values for each fuel and for each year (example of France)[GJ/t] (data required as input from national experts for each country)

<b>Fuel</b>	<b>1990</b>	<b>1995</b>	<b>....</b>	<b>2030</b>
-------------	-------------	-------------	-------------	-------------

<b>HC1</b>	24	24		24
<b>HC2</b>	24.9	24.9		24.9
<b>HC3</b>	24.9	24.9		24.9
<b>HF</b>	39.2	39.2		39.2
...				

*If no data for each year is available. the same characteristics can be used.*

### 3.2.2 Sulfur content

Table 3.9: Sulfur content for each fuel and for each year (example of France) [%S] (data required as input from national experts for each country)

<b>Fuel</b>	<b>1990</b>	<b>1995</b>	<b>....</b>	<b>2030</b>
<b>HC1</b>	0.9	0.9		0.9
<b>HC2</b>	0.8	0.8		0.8
<b>HC3</b>	1.2	1.2		1.2
<b>HF</b>	2.79	2.79		2.79
...				

*If no data for each year is available. the same characteristics can be used.*

### 3.2.3 Sulfur retained in ash (solid fuels)

Table 3.10: Sulfur retained in ash for each solid fuel and for each year (example of France) [fraction] (data required as input from national experts for each country)

<b>Fuel</b>	<b>1990</b>	<b>1995</b>	<b>....</b>	<b>2030</b>
<b>HC1</b>	0.02	0.02		0.02
<b>HC2</b>	0.024	0.024		0.024
<b>HC3</b>	0.024	0.024		0.024
<b>BC1</b>				
...				

*If no data for each year is available. the same characteristics can be used.*

### 3.2.4 Ash retained by the boiler

Table 3.11: Ash retained by the boiler for each solid fuel and for each year (example of France) [fraction] (data required as input from national experts for each country)

<b>Fuel</b>	<b>1990</b>	<b>1995</b>	<b>....</b>	<b>2030</b>
<b>HC1</b>	0.1	0.1		0.1
<b>HC2</b>	0.1	0.1		0.1
<b>HC3</b>	0.1	0.1		0.1
<b>BC1</b>				
...				

*If no data for each year is available. the same characteristics can be used.*

### 3.2.5 Ash content of solid fuels

Table 3.12: Ash content for each solid fuel and for each year (example of France) [%] (data required as input from national experts for each country)

Fuel	1990	1995	....	2030
HC1	12	12		12
HC2	12	12		12
HC3	12	12		12
BC1				
...				

If no data for each year is available, the same characteristics can be used.

### 3.3 Unabated Emission factors

#### 3.3.1 Unabated NO<sub>x</sub> emission factor

The unabated NO<sub>x</sub> emission factor is depending on the fuel used in the combustion process and on the combustion process itself, which is not accounted for here.

Table 3.13: Unabated NO<sub>x</sub> emission factor for each solid fuel and for each year (example of France) [kt NO<sub>2</sub>/PJ] (data required as input from national experts for each country)

Fuel	1990	1995	....	2030
HC1	0.26	0.26		0.26
HC2	0.333	0.333		0.333
HC3	0.315	0.315		0.315
HF	0.238	0.238		0.238
...				

If no information for each year is available, the same values can be used.

Table 3.14: Unabated NO<sub>x</sub> emission factor for each solid fuel and for each year (example of France) as concentration [mg/Nm<sup>3</sup>]

Fuel	1990	1995	....	2030
HC1	743	743		743
HC2	950	950		950
HC3	900	900		900
HF1	850	850		850
...				

If no information for each year is available, the same values can be used.

**Remark** on the relationship between the pollutant concentration (C) in mg/Nm<sup>3</sup> and pollutant emission expressed as specific mass flow (F<sub>s</sub>) in mg per PJ fuel consumed.

A conversion factor  $F_{conv}$  can be introduced on the basis of:

$$C \cdot F_{conv} = F_s$$

#### 3.3.2 Unabated SO<sub>2</sub> emission factor

The unabated SO<sub>2</sub> emission factor is calculated taking into account the most important fuel characteristics :

$$ef = 2 \cdot \frac{sc}{hv} \cdot (1 - sr)$$

with:

$sc_{i,j,l}$ : sulfur content (per weight) of fuel  $l$  used in sector  $j$  in country  $i$

$h_{v,i,j,l}$ : heat value of fuel  $l$  used in sector  $j$  in country  $i$

$sr_{i,j,l}$ : sulfur retention in ash (fraction) of fuel  $l$  used in sector  $j$  in country  $i$ .

If this information is available, the emission factor can be calculated for each year.

Table 3.15: Unabated SO<sub>2</sub> emission factor for each solid fuel and for each year (example of France) [kt SO<sub>2</sub>/PJ]

Fuel	1990	1995	....	2030
HC1	0.74	0.74		0.74
HC2	0.63	0.63		0.63
HC3	0.94	0.94		0.94
HF1	1.42	1.42		1.42
...				

If no information for each year is available, the same values can be used.

Table 3.16: Unabated SO<sub>2</sub> emission factor for each solid fuel and for each year (example of France) as concentration [mg/Nm<sup>3</sup>]

Fuel	1990	1995	....	2030
HC1	2590	2590		2590
HC2	2200	2200		2200
HC3	3290	3290		3290
HF1	3980	3980		3980
...				

If no information for each year is available, the same values can be used.

### 3.3.3 Unabated dust emission factor

For **solid fuels**, the unabated TSP emission factor is calculated:

$$ef_{TSP} = \frac{ac}{h_v} \cdot (1 - ar) \cdot 10$$

where:

$ef_{TSP}$ : unabated TSP emission factor [g/MJ],

$ac$ : ash content [%],

$h_v$ : lower heat value [GJ/t],

$ar$ : fraction of ash retained in boiler .

Table 3.17: Unabated TSP emission factor for solid fuels and for each year (example of France) [t PM/PJ]

Fuel	1990	1995	...	2030
HC1	4500	4500		4500
HC2	4337	4337		4337
HC3	4337	4337		4337

Table 3.18: Unabated TSP emission factor for solid fuels and for each year (example of France) [mg/Nm<sup>3</sup>]

Fuel	1990	1995	...	2030
HC1	12,857	12,857		12,857

<b>HC2</b>	12,392	12,392		12,392
<b>HC3</b>	12,392	12,392		12,392

For **non-solid fuels**, the unabated TSP emission factor has to be given.

Table 3.19: Unabated TSP emission factor for non-solid fuels and for each year (example of France) [kt PM/PJ] (data required as input from national experts for each country)

<b>Fuel</b>	<b>1990</b>	<b>1995</b>	<b>....</b>	<b>2030</b>
<b>HF</b>	15.5	15.5		15.5
<b>Natural gas</b>	0.1	0.1		0.1
<b>...</b>				

*If no information for each year is available. the same values can be used.*

Table 3.20: Unabated TSP emission factor for non-solid fuels and for each year (example of France) [mg/Nm<sup>3</sup>]

<b>Fuel</b>	<b>1990</b>	<b>1995</b>	<b>....</b>	<b>2030</b>
<b>HF</b>	55.4	55.4		55.4
<b>Natural gas</b>	0.4	0.4		0.4
<b>...</b>				

*If no information for each year is available. the same values can be used.*

Remarks: 1. In case of use low NO<sub>x</sub> burners, the TSP emission factors for HF is two times bigger.

2. on the relationship between the pollutant concentration (C) in mg/Nm<sup>3</sup> and the pollutant emission expressed in specific mass flow (F<sub>s</sub>) in mg per PJ fuel consumed.

A conversion factor  $F_{conv}$  can be introduced on the basis of:

$$C \times F_{conv} = F_s$$

The emissions of fine particulate matter (for two size fractions: PM10 and PM2.5) will be calculated after the treatment because the type of abatement measure has a big influence on the repartition of the size fractioning and EGTEI has considered that it was the easiest way to tackle the problem.

### 3.3.4 Conversion factor $F_{conv}$

An average conversion factor ( $F_{conv}$ ) between concentrations of pollutants (in mg/Nm<sup>3</sup>) and specific mass flows of pollutants (emission factor, in g per **GJ fuel input**)

Concentration of pollutant emitted (in mg/Nm<sup>3</sup>) x  $F_{conv}$  = Specific mass flow of pollutant emitted (in mg/GJ fuel input)

For solid fuels:  $F_{conv} = 350 \text{ Nm}^3/\text{GJ} (6 \% \text{ O}_2, \text{ dry})$

For liquid fuels:  $F_{conv} = 280 \text{ Nm}^3/\text{GJ} (3 \% \text{ O}_2, \text{ dry})$

For gaseous fuels:  $F_{conv} = 270 \text{ Nm}^3/\text{GJ} (3 \% \text{ O}_2, \text{ dry})$

### 3.4 Abatement techniques

#### 3.4.1 NO<sub>x</sub> emission

##### 3.4.1.1 NO<sub>x</sub> emission control technologies

Two important options are supposed to be possible: as primary measure MP and as secondary measures SCR. RAINS actually doesn't really combine both but the expert group suggests to combine them.

Table 3.21: NO<sub>x</sub> emission control technologies proposed with their abatement efficiency

Control Technology Description	Technology	Abatement efficiency %
HC existing plant	MP	30
BC existing plant	MP	30
HF existing plant	MP	20
Gas existing plant	MP	40
HC new plant	MP	40
BC new plant	MP	40
HF new plant	MP	30
Gas new plant	MP	50
HC existing plant	MP + SCR	82.5
BC existing plant	MP + SCR	82.5
HF existing plant	MP + SCR	80
Gas existing plant	MP + SCR	85
HC new plant	MP + SCR	91
BC new plant	MP + SCR	91
HF new plant	MP + SCR	89.5
Gas new plant	MP + SCR	92.5

Remark : the chosen abatement efficiency for SCR is 75 % for existing plants and 85% for new plants.

For others categories of fuels, the average efficiency of all abatement techniques described above is taken into account.

Table 3.22: NO<sub>x</sub> emission control technologies proposed with their abatement efficiency for other fuels

Control Technology Description	Technology	Abatement efficiency %
--------------------------------	------------	------------------------

Existing plant	MP	30
New plant	MP	40
Existing plant	MP + SCR	82.5
New plant	MP + SCR	91

The lifetime of all these control equipments is taken as 10 years for new and existing plants. For catalyst the approach is different.

### 3.4.1.2 Investments

The Investment function is given by the following equation:

$I = I_{\text{principal}} + I_{\text{catalyst}}$

$$I = \left( ci_1^f + \frac{ci_1^v}{bs} \right) + \left( ci_2^f + \frac{ci_2^v}{bs} \right) \cdot (1+r) + \lambda_{\text{cat}} \cdot ci_{\text{cat}}$$

where

$ci_1^f, ci_1^v, ci_2^f, ci_2^v$ : coefficients of investment function;  $ci_i$  have non-zero values only for combinations of technologies (e.g., CM plus SCR)

$bs$ : boiler size

$\lambda_{\text{cat}}$ : catalyst volume (per unit of installed capacity)

$ci_{\text{cat}}$ : unit cost of catalysts

$r$ : retrofit cost factor

Considering the investment functions in RAINS, the investments for Primary measures and for SCR without any primary measure already installed have been calculated for two different capacities 800 and 1800 MW<sub>th</sub>.

Table 3.23: RAINS Investment function applied on two capacities 800 and 1800 MW<sub>th</sub> for primary measure and for SCR without any primary measures already installed

Fuel	Technology	RETRO [%]	INV_C1 [Euro/kW <sub>th</sub> input]	INV_V1 [kEuro]	INV_C2 [Euro/kW <sub>th</sub> input]	INV_V2 [kEuro]	Investment 800 MW <sub>th</sub> [Euro]	Investment 1800 MW <sub>th</sub> [Euro]
HC existing plant	MP	0	0	0	2.82	1060.57	3,316,570	6,136,570
BC existing plant	MP	0	0	0	6.4	1128.93	6,248,930	12,648,930
HF existing plant	MP	0	0	0	2.41	967.58	2,895,580	5,305,580
Gas existing plant	MP	0	0	0	2.41	967.58	2,895,580	5,305,580
HC new plant	MP							
BC new plant	MP							
HF new plant	MP							
Gas new plant	MP							

HC existing plant	MP + SCR	50	2.82	1060.57	6.17	3569.5	16,074,820	28,149,820
BC existing plant	MP + SCR	50	6.4	1128.93	7.4	4283.4	21,554,030	39,054,030
HF existing plant	MP + SCR	50	2.41	967.58	5.72	2409.42	13,373,710	24,363,710
Gas existing plant	MP + SCR	50	2.41	967.58	5.72	2409.42	13,373,710	24,363,710
HC new plant	MP + SCR	0	2.82	1060.57	6.17	3569.5	11,822,070	20,812,070
BC new plant	MP + SCR	0	6.4	1128.93	7.4	4283.4	16,452,330	30,252,330
HF new plant	MP + SCR	0	2.41	967.58	5.72	2409.42	9,881,000	18,011,000
Gas new plant	MP + SCR	0	2.41	967.58	5.72	2409.42	9,881,000	18,011,000

Currently available figures:

Table 3.24 : Currently available figures NO<sub>x</sub> abatement techniques [EURELECTRIC, BREF, Manufacturers]

		<b>Investments [10<sup>6</sup> Euro] 800 MW<sub>th</sub></b>	<b>Investments [10<sup>6</sup> Euro] 1800 MW<sub>th</sub></b>
Hard Coal	SCR	[9.9-16.2]	[17-33]
Brown Coal	SCR	[12.4-20]	[21-34.6]
HF	SCR	[8.5-13.8]	[14.5-23.5]
Gas	SCR	[8.5-18]	[14.5-36]
HF	MP	[3.7-7]	[4.1-8.6]

Thus considering all these figures:

Table 3.25 : Investments applied on two capacities 800 and 1800 MW<sub>th</sub> for primary measure and for SCR

		<b>Investment Euro 800 MW<sub>th</sub></b>	<b>Investment Euro 1800 MW<sub>th</sub></b>	<b>Retrofit factor</b>
Hard Coal <i>existing plant</i>	SCR	16,200,000	28,000,000	40 %
Brown Coal <i>existing plant</i>	SCR	20,250,000	35,000,000	
HF <i>existing plant</i>	SCR	14,000,000	24,000,000	
Gas <i>existing plant</i>	SCR	13,000,000	22,000,000	
Hard Coal <i>existing plant</i>	MP	2,500,000	4,650,000	0 %
Brown Coal <i>existing plant</i>	MP	3,750,000	7,000,000	
HF <i>existing plant</i>	MP	2,200,000	4,200,000	
Gas <i>existing plant</i>	MP	2,000,000	3,800,000	
Hard Coal <i>new plant</i>	MP	0	0	
Brown Coal <i>new plant</i>	MP	0	0	
HF <i>new plant</i>	MP	0	0	
Gas <i>new plant</i>	MP	0	0	

**Remark:** For new plant, the investment for Primary measures is considering as zero because a new boiler is always built with low NO<sub>x</sub> burners.

Table 3.26: Coefficients of the investment function

Fuel - type of plant	Technology	ci <sub>1</sub> <sup>f</sup> Euro/kW <sub>th</sub>	ci <sub>1</sub> <sup>v</sup> 10 <sup>3</sup> Euro	ci <sub>2</sub> <sup>f</sup> Euro/kW <sub>th</sub>	ci <sub>2</sub> <sup>v</sup> 10 <sup>3</sup> Euro
Hard Coal <i>existing plant</i>	MP	-	-	2.15	780
Brown Coal <i>existing plant</i>	MP	-	-	3.25	1,000
HF <i>existing plant</i>	MP	-	-	2	600
Gas <i>existing plant</i>	MP			1.8	560
Other fuels <i>existing plant</i>	MP	-	-	2.3	735
Hard Coal <i>new plant</i>	MP			0	0
Brown Coal <i>new plant</i>	MP			0	0
HF <i>new plant</i>	MP			0	0
Gas <i>new plant</i>	MP	-	-	0	0
Other fuels <i>new plant</i>	MP	-	-	0	0
Hard Coal <i>existing plant</i>	MP + SCR	2.15	780	6.28	5,000
Brown Coal <i>existing plant</i>	MP + SCR	3.25	1,000	8.39	5,700
HF <i>existing plant</i>	MP + SCR	2	600	5.1	4,300
Gas <i>existing plant</i>	MP + SCR	1.8	560	4.8	4,300
Other fuels <i>existing plant</i>	MP + SCR	2.3	735	6.14	4,825

**Remark:** for the other fuels, to calculate the investment, a relative flue gas volume  $v$  is used, taking into account that for hard coal it is 1.

Then the investment for other fuels is the following:

$$I = (ci_1^f + \frac{ci_1^v}{bs}) + (ci_2^f + \frac{ci_2^v}{bs}) \cdot (1+r) \cdot v + \lambda_{cat} \cdot ci_{cat}$$

The investments are annualised over the technical lifetime of the plant for the principal investment and for the catalyst investment using the catalyst lifetime, on the real interest rate  $q$  (as %/100):

$$A = I_{princ} \cdot \frac{(1+p)^{lt}}{(1+p)^{lt} - 1} \cdot p + I_{cata} \cdot \frac{(1+p)^{lcat}}{(1+p)^{lcat} - 1} \cdot p$$

### 3.4.1.3 Operating cost

The same methodology as for RAINS has been used (see the report: "Nitrogen oxides emissions, abatement technologies and related costs for Europe in the RAINS model database")

### 3.4.1.4 Technology-specific parameters for the cost calculation of add-on control technologies

Table 3.27: Other technology-specific parameters for add-on control technologies (secondary measures for NO<sub>x</sub>) [EURELECTRIC, BREF, Manufacturers]

Parameter	Unit	Value RAINS	Value EGTEI
-----------	------	-------------	-------------

Retrofit coefficient $r$	%/100	0.5	0.4
Fixed O+M cost $f$	%/100/yr	0.06	0.04
Electricity demand $\lambda_e$	GWh/PJ fuel input		
brown coal boilers		0.36	0.36
hard coal boilers		0.36	0.36
oil boilers		0.30	0.30
gas boilers		0.30	0.30
Electricity demand	% of thermal capacity		
brown coal boilers		0.13	0.13
hard coal boilers		0.13	0.13
oil boilers		0.11	0.11
gas boilers		0.11	0.11
Catalyst volume $\lambda_{cat}$	$m^3/MW_{th}$		
brown coal boilers		0.41	0.5
hard coal boilers		0.34	0.5
oil boilers		0.11	0.11
gas boilers		0.11	0.11
Catalyst lifetime	$10^3$ h		
brown coal boilers		24	56
hard coal boilers		24	56
oil boilers		36	80
gas boilers		36	120
Sorbent demand $\lambda_s$ , for SCR 80% defined in RAINS for SCR 75% for SCR 85%	$t/t_{NO_x}$	0.39	
			0.34
			0.39
Labour demand	person-year/ $GW_{th}$	0	1.2
Catalyst cost	kEuro/ $m^3$	12.1	26 for liquid fuels 6 solid fuels 20 gas
Catalyst cost	kEuro/ $MW_{th}$		
brown coal boilers		4.96	3
hard coal boilers		4.11	3
oil boilers		1.33	2.9
gas boilers		1.33	2.2

### 3.4.2 SO<sub>2</sub> emission

Two options are proposed: the use of low sulfur fuels or the use of wet scrubbers.

#### 3.4.2.1 Low sulfur fuels

The costs for low-sulfur fuels are represented through the price difference between high- and low-sulfur alternatives.

Table 3.28: Options proposed for low-sulfur fuels and their costs

	Sulfur content [%]	Price difference [Meuro/PJ/%S]	Cost per tonne of SO <sub>2</sub> avoided [euros]	Additional cost per tonne compared to the previous fuel category [euros]
HC	1	-		
HC - LSCO	0.6	0.33	412.5	3.3

HF	3	-	-	
HF - LSHF	1	0.28	560	22.4
HF - LSHF	0.5	1.5	3160	30
HF - LSHF	0.25	2.5	5000	25

Compared to the approach in RAINS, the EGTEI approach is a little different. For hard coal, one type of low sulfur coal is defined and for heavy fuel oil HF 3 types of low sulfur heavy fuel (see table 3.22) (in RAINS, only one is defined). In accordance with the paragraph 3.2, the strategy to use fuels with low sulphur fuels is left to the initiative of the country.

To calculate the cost of low-sulphur fuel [M€/PJ], the following equation is used:

$$\text{Extra cost of low S fuel oil (MEuro/PJ/\%S)} \cdot (\text{sulphur content of the old fuel} - \text{sulphur content of the new fuel})$$

### 3.4.2.2 Wet Flue Gas Desulphurisation

Wet limestone flue gas desulphurisation (WFGD) is the most commonly used desulphurisation technique in Europe.

#### 3.4.2.2.1 Technology

For existing plants, EGTEI proposes an abatement efficiency of 85 % and for new plants of 90 %. A high efficiency wet flue gas desulphurisation HEFGD could be installed for new plants with an efficiency of 95 %.

Table 3.29: Options proposed for DeSO<sub>x</sub> technologies

Control Technology Description	Technology	Abatement efficiency %
HC existing plant	WFGD	85
BC existing plant	WFGD	85
HF existing plant	WFGD	85
Other fuels existing plant	WFGD	85
HC new plant	WFGD	90
BC new plant	WFGD	90
HF new plant	WFGD	90
Other fuels new plant	WFGD	90
HC new plant	HEWFGD	95
BC new plant	HEWFGD	95
HF new plant	HEWFGD	95
Other fuels new plant	HEWFGD	95

The lifetime of all these control equipments is taken as 10 years for new and existing plants.

### 3.4.2.2.2 Investment

The Investment function is given by the following equation:

$$I = (ci^f + \frac{ci^v}{bs}) \cdot v \cdot (1+r)$$

where  
 $ci^f$ ,  $ci^v$ : coefficients of the investment function  
 $bs$ : boiler size  
 $v$ : relative flue gas volume  
 $r$ : retrofit factor.

Table 3.30: Options and investments proposed for DeSOx technologies in RAINS applied on two examples of calculation (Power plants of 800 and 1800 MW<sub>th</sub>)

Fuel	Technique	Retrofit factor [%]	INV_C [Euro/kW <sub>th</sub> input]	INV_V [kEuro]	Abatement efficiency [%]	Investment for 800 MW <sub>th</sub> [Euro]	Investment for 1800 MW <sub>th</sub> [Euro]
All existing	PWFGD	30	44	12101	95	61,491,300	118,691,300
All new	PWFGD	0	44	12101	95	47,301,000	91,301,000
All existing	PRWFGD	30	44	12101	90	61,491,300	118,691,300

Table 3.31: Options and investments proposed by EGTEI for DeSOx technologies applied to two calculation examples (Power plants of 800 and 1800 MW<sub>th</sub>) [EURELECTRIC, BREF, Manufacturers]

Fuel - type of plant	Technology	No. of spray levels	Abatement efficiency %	Investment [Euro] for 800 MW <sub>th</sub>	Investment [Euro] for 1800 MW <sub>th</sub>
Hard Coal <i>existing plant</i>	Wet Flue Gas Desulphurisation	3 - 4	85	35,000,000	78,750,000
Brown Coal <i>existing plant</i>	Wet Flue Gas Desulphurisation	3 - 4	85	44,000,000	99,000,000
HF <i>existing plant</i>	Wet Flue Gas Desulphurisation	3 - 4	85	30,000,000	67,500,000
Hard Coal <i>new plant</i>	Wet Flue Gas Desulphurisation	4 - 5	90	31,200,000	70,200,000
Brown Coal <i>new plant</i>	Wet Flue Gas Desulphurisation	4 - 5	90	39,000,000	87,750,000
HF <i>new plant</i>	Wet Flue Gas Desulphurisation	4 - 5	90	26,520,000	59,670,000
Hard Coal <i>new plant</i>	High Efficiency FGD	6 - 7	95	36,200,000	81,450,000
Brown Coal <i>new plant</i>	High Efficiency FGD	6 - 7	95	44,000,000	99,000,000
HF <i>new plant</i>	High Efficiency FGD	6 - 7	95	31,520,000	70,920,000

In RAINS, the investment function is a linear function. As we defined two points (800 and 1800 MW<sub>th</sub>), it is possible to determine the coefficient of the investment function.

Table 3.32: Coefficients of the investment function (for power plants with capacity higher than 500 MWth)

Fuel - type of plant	Technology	ci <sup>f</sup> , Euro/kWth	ci <sup>v</sup> , 10 <sup>3</sup> Euro
Hard Coal <i>existing plant</i>	Wet Flue Gas Desulphurisation	33.65	0
Brown Coal <i>existing plant</i>	Wet Flue Gas Desulphurisation	42.30	0
HF <i>existing plant</i>	Wet Flue Gas Desulphurisation	28.85	0
Other fuels <i>existing plants</i>	Wet Flue Gas Desulphurisation	34.92	0
Hard Coal <i>new plant</i>	Wet Flue Gas Desulphurisation	39	0
Brown Coal <i>new plant</i>	Wet Flue Gas Desulphurisation	48.75	0
HF <i>new plant</i>	Wet Flue Gas Desulphurisation	33.15	0
Other fuels <i>new plants</i>	Wet Flue Gas Desulphurisation	40.3	0
Hard Coal <i>new plant</i>	High Efficiency FGD	45.25	0
Brown Coal <i>new plant</i>	High Efficiency FGD	55	0
HF <i>new plant</i>	High Efficiency FGD	39.4	0
Other fuels <i>new plants</i>	High Efficiency FGD	46.55	0

Remark: for the other fuels, to calculate the investment, a relative flue gas volume  $v$  is used, taking into account that for hard coal it is 1.

The Investment function is given by the following equation:

$$I = (ci^f + \frac{ci^v}{bs}) \cdot v \cdot (1+r)$$

#### 3.4.2.2.3 Technology parameters for the different FGD technologies

Table 3.33: Technology-specific parameters for add-on control technologies in EGTEI

Parameter	Unit	Wet FGD	Wet FGD	High efficiency FGD
Removal efficiency $\eta$	%	85	90	95
Retrofit coefficient $r$	%/100	0.3	0	0
Fixed O+M cost $f$	%/100/yr	0.04	0.04	0.04
Labour demand	person-yr/GW <sub>th</sub>	3.33	3.33	3.33
Labour demand	person-yr	10	10	10
Electricity demand	GWh/PJ fuel inp.	1.22	1.60	2.36
Electricity demand	% of thermal capacity	0.44	0.58	0.85
Sorbent demand	t/tSO <sub>2</sub> input	1.41	1.48	1.59
Byproducts	t/tSO <sub>2</sub> input	2.3	2.4	2.5

### 3.4.3 PM emission

The RAINS model defines a lot of different deduster types. EGTEI proposes to simplify the approach.

#### 3.4.3.1 Technologies

For solid fuels (HC and BC for example) four different dedusters are defined according to the emission factor achieved with these techniques. Deduster 1 achieves the emission level of 300

mg/Nm<sup>3</sup>, deduster 2 100 mg/Nm<sup>3</sup>, the third 45 mg/Nm<sup>3</sup> and the fourth 20 mg/Nm<sup>3</sup>. For the fourth deduster, if a wet FGD has been already installed, no additional cost will be added.

For liquid fuels, only one deduster is defined, which achieves a emission level of 10 mg/Nm<sup>3</sup>.

Table 3.34: Options proposed for dedusters

Fuel	Technology	Achieved abated emission factor [mg/Nm <sup>3</sup> ]
Hard Coal	Deduster 1	300
	Deduster 2	100
	Deduster 3	45
	Deduster 4	20
Brown Coal	Deduster 1	300
	Deduster 2	100
	Deduster 3	45
	Deduster 4	20
Heavy fuel oil	Deduster 1	10

Concerning heavy fuel oil firing, it will be considered that the use of low NO<sub>x</sub> burners increases the unabated emission factor by a factor 2.

The lifetime of all these control equipments is taken as 10 years for new and existing plants.

### 3.4.3.2 Investments

The Investment function is given by the following equation:

$$I = (ci^f + \frac{ci^v}{bs}) \cdot (1+r)$$

where:

$ci^f$ ,  $ci^v$ : coefficients of investment function

$bs$ : boiler size

$r$ : retrofit cost factor

RAINS defines for the combustion sector the following abatement techniques

Table 3.35: Options defined by RAINS with their TSP abatement efficiencies for the example of France

		Cyclones	Ghkeep	ESP1	ESP2	ESP3	FF	WSCRb
BC1/BC2	PP EX OTH1/NEW1	77.00		95.98	99.15	99.81	99.82	99.15
	PP EX OTH2/NEW2			96.38	99.52	99.89	99.91	
	PP EX OTH3			96.10	99.28	99.84	99.86	99.28
	PP NEW 3			96.10	99.28	99.84	99.86	
DC	PP EX OTH	56.20		94.52	97.84	99.51	99.51	
HC1/HC2/HC3	PP EX OTH1/NEW1	77.00		95.98	99.15	99.81	99.82	99.15
	PP EX OTH2/NEW2			96.38	99.52	99.89	99.91	
	PP EX OTH3			96.42	99.51	99.88	99.91	99.51
	PP EX WB			95.84	98.94	99.74	99.76	
	PP NEW 3			96.42	99.51	99.88	99.91	

HF	PP EX OTH		30.00				99.37	
	PP NEW		30.00				99.37	
MD	PP EX OTH		30.00				99.76	
	PP NEW		30.00				99.76	
OS1	PP EX OTH	41.40		93.68	96.79	99.21	99.22	
	PP NEW	41.40		93.68	96.79	99.21	99.22	
OS2	PP EX OTH	72.00		95.72	98.78	99.70	99.72	
	PP NEW	72.00		95.72	98.78	99.70	99.72	

Table 3.36: RAINS cost parameters for technologies used to control emissions from stationary combustion sources in power plants for capacity greater than 50 MWth

Technology	INV_C Euro/kW <sub>th</sub>	INV_V kEuro	Fixed O+M, %	Electricity kWh/GJ fuel
<b>ESP1 (1 field)</b>	4.07	280.06	0.5	0.11
<b>ESP2 (2 fields)</b>	5.06	350.02	0.5	0.13
<b>ESP3 (3 and more fields)</b>	6.16	388.96	0.5	0.15
<b>CYC (cyclones)</b>	1.65	111.98	0.5	0.15
<b>FF (fabric filters)</b>	8.69	233.31	1.0	0.20
<b>Wet scrubbers</b>	5.5	350.02	1.0	1.50
<b>Good housekeeping oil boilers</b>	2.2	0.0	4.0	0.00

Currently available figures:

Table 3.37 : Currently available figures for solid fuels considering the cost functions of RAINS

	Achieved concentration mg/Nm <sup>3</sup>	Investment RAINS 800 MWth [10 <sup>6</sup> Euro]	Investment RAINS 1800 MWth [10 <sup>6</sup> Euro]
Deduster 1	252	3.5	7.6
Deduster 2	84	5.3	11.47
Deduster 3	37	7.2	15.88

Table 3.38 : Alternative proposal figures for solid fuels [EURELECTRIC, Manufacturers]

	Achieved concentration mg/Nm <sup>3</sup>	Investment 800 MWth [10 <sup>6</sup> Euro]	Investment 1800 MWth [10 <sup>6</sup> Euro]
Deduster 1	300	5.4	10.9
Deduster 2	100	6.7	13.9
Deduster 3	45	8.6	16.8
Deduster 4	20	10	20

Table 3.39 : Proposal figures for liquid fuels [EURELECTRIC, Manufacturers]

	Achieved concentration mg/Nm <sup>3</sup>	Investment 800 MWth [10 <sup>6</sup> Euro]	Investment 1800 MWth [10 <sup>6</sup> Euro]
Deduster 1	10	4.8	9.6

According to these figures the coefficients of the investment function can be determined for each deduster.

Table 3.40: Coefficients of the investment function

Fuel	Technology	INV_C [Euro/kWth]	INV_V [kEuro]
Hard Coal	Deduster 1	5.5	1,000
	Deduster 2	7.15	1,000
	Deduster 3	8.25	2,000
	Deduster 4	10	2,000
Brown Coal	Deduster 1	5.5	1,000
	Deduster 2	7.15	1,000
	Deduster 3	8.25	2,000
	Deduster 4	10	2,000
Heavy Fuel oil	Deduster 1	4.8	960
Other fuels	Deduster 1	5.5	1,000
	Deduster 2	7.15	1,000
	Deduster 3	8.25	2,000
	Deduster 4	10	2,000

Remark: for the other fuels, to calculate the investment, a relative flue gas volume  $v$  is used, taking into account that for hard coal it is 1.

The Investment function is given by the following equation:

$$I = (ci^f + \frac{ci^v}{bs}) \cdot v \cdot (1+r)$$

### 3.4.3.3 Cost parameters

Table 3.41: Cost parameters for dedusters for solid fuels by RAINS

	Achieved concentration [mg/Nm <sup>3</sup> ]	Electricity consumption [GWh/PJ] RAINS	Fixed OM [%] RAINS	Labour demand [person-yr/GWth] RAINS	Waste byproduct disposal [t/t TSP reduced] RAINS
<b>Deduster 1</b>	252	0.11	0.5	0	1
<b>Deduster 2</b>	84	0.15	0.5	0	1
<b>Deduster 3</b>	37	0.20	1	0	1

Table 3.42 : Alternative proposal figures for solid fuels [EURELECTRIC, Manufacturers]

	<b>Achieved concentration [mg/Nm<sup>3</sup>]</b>	<b>Electricity consumption [GWh/PJ]</b>	<b>Fixed OM [%]</b>	<b>Labour demand [Person-year]</b>	<b>Waste byproduct disposal [t/t TSP reduced]</b>
<b>Deduster 1</b>	300	0.11	4	5	1
<b>Deduster 2</b>	100	0.15	4	5	1
<b>Deduster 3</b>	45	0.18	4	5	1
<b>Deduster 4</b>	20	0.2	4	5	1

Table 3.43 : Proposed figures for liquid fuels [EURELECTRIC, Manufacturers]

	<b>Achieved concentration [mg/Nm<sup>3</sup>]</b>	<b>Electricity consumption [GWh/PJ]</b>	<b>Fixed OM [%]</b>	<b>Labour demand [man-yr]</b>	<b>Waste byproduct disposal [t/t TSP reduced]</b>
Deduster 1	5	0.1	4	3	1

#### 3.4.3.4 PM<sub>10</sub> and PM<sub>2.5</sub>

The emissions of fine particulate matter (for two size fractions: PM10 and PM2.5) will be calculated after the treatment because the type of abatement measure has a big influence of the repartition of the size fraction.

It is a particularly difficult subject which requires more information to validate the information which is in this document.

Table 3.44: Size fraction for PM<sub>10</sub> and PM<sub>2.5</sub> depending of the deduster

<b>Fuel</b>	<b>Technology</b>	<b>Size fraction of PM 10 in TSP [%]</b>	<b>Size fraction of PM 2.5 in TSP [%]</b>
Hard Coal	Deduster 1	40	15
	Deduster 2	65	40
	Deduster 3	75	50
	Deduster 4	90	60
Brown Coal	Deduster 1	45	17
	Deduster 2	70	45
	Deduster 3	80	50
	Deduster 4	90	60
Heavy Fuel oil	Deduster 1	98	95

Table 3.45: Size fraction for PM<sub>10</sub> and PM<sub>2.5</sub> before deduster

<b>Fuel</b>	<b>Size fraction of PM 10 in TSP [%]</b>	<b>Size fraction of PM 2.5 in TSP [%]</b>
Hard Coal	23	12

Fuel	Size fraction of PM 10 in TSP [%]	Size fraction of PM 2.5 in TSP [%]
Hard Coal	23	12
Brown Coal	32	10
Heavy Fuel oil	85	60
Natural Gas	100	100

### 3.5 Control strategy

The application rates will be recalculated considering the integration of the LCP directive for regulation of the emissions.

The different cases are:

- Uncontrolled
- Scenario CLE taking into account the LCP directive
- Maximum feasible

#### 3.5.1 LCP Directive

The LCP directive provides the following distinctions:

1. New Plants (permitted after 27-11-2002 or started after 27-11-2003)

		mg/Nm <sup>3</sup>	
Solid fuel	SO <sub>2</sub>	200	
	NO <sub>x</sub>	200	
	Dust	30	
Liquid fuel	SO <sub>2</sub>	200	
	NO <sub>x</sub>	200	
	Dust	30	
Gaseous fuel	SO <sub>2</sub>	general	35
		LPG	5
		Coke oven gas	400
		HF	200
	NO <sub>x</sub>	general	100
		Iron and steel industry gases	200
	Dust	general	5
		Coke oven gas	30
		Blast furnace gas	10

2. Plants closed until 31/12/2015 and operating less than 2000 hours between 01/01/2008 and 31/12/2015

No emission limit value to fulfil.

3. Low operated plants, burning solid fuels and permitted before 01-07-87, which do not operate more than 2000 h/year (rolling average over 5 years) from 01-01-2008 to 31-12-2015, and more than 1500 h/year (rolling average over 5 years) after 01-01-2016.

	mg/Nm <sup>3</sup>
SO <sub>2</sub>	800
NO <sub>x</sub>	600 (until 31/12/2015)
	450 (from 01/01/2016)

4. Plants authorized between 01/07/1987 and 27/11/2002

		mg/Nm <sup>3</sup>	
Solid fuel	SO <sub>2</sub>	400	
	NO <sub>x</sub>	500 until 31/12/2015 200 from 01/01/2016	
	Dust	50	
Liquid fuel	SO <sub>2</sub>	400	
	NO <sub>x</sub>	400	
	Dust	50	
Gaseous fuel	SO <sub>2</sub>	general	35
		LPG	5
		Iron and steel industry gases	800
	NO <sub>x</sub>	200	
	Dust	general	5
		Coke oven gas	50
		Blast furnace gas	10

5. Plants permitted before 01/07/1987

The same values as above are considered from the 1<sup>st</sup> of January 2008.

6. Plants submitted to a National Emission Reduction Plan (the national expert will have the possibility to provide in the tool the different limit values per pollutant)

### 3.5.2 Calculation of application rates for the scenario CLE

The methodology to calculate the application rate for each technique will be laid out in the following. To illustrate this, the case of NO<sub>x</sub> emissions is chosen.

#### **First method:**

The different input parameters to determine the application rates can be:

- $E_{NO_x}$ : Emission of NO<sub>x</sub> in a country (t per year) for one fuel and considering a regulatory class (see below how to calculate the emission level)

ü  $N_a$ : Activity level (PJ fuel per year) for “each specific case” (the regulatory class for example) (already given in the tables of paragraph 3.1.3)

Then, the (sector) specific case (one fuel, one regulatory class) situation may be defined by:

$$F_{s\ a\ NO_x} = (E_{NO_x}/N_a)$$

Using this result, it is then possible to calculate the different application rates.

The following different parameters are already known:

$F_{S1NO_x}$ : Uncontrolled  $NO_x$  emission level

$F_{S2NO_x}$ :  $NO_x$  emission level implementing the De $NO_x$  stage 1 technical option (primary measures – PM)

$F_{S3NO_x}$ :  $NO_x$  emission level implementing the De $NO_x$  stage 2 technical option (secondary measures – SM)

*First case:*  $F_{s\ a\ NO_x}$  has a value lower than the emission limit value of the LCP directive:

ü If  $F_{S1NO_x} < F_{s\ a\ NO_x} < F_{S2NO_x}$ , it can be considered that some primary measures may still be implemented to a given percentage of the production capacity.

The virtual application rate of primary measures  $T_{1,NO_x}$  then is obtained by:

$$T_{1,NO_x} = (F_{s\ a\ NO_x} - F_{S1NO_x}) / (F_{S2NO_x} - F_{S1NO_x})$$

ü If  $F_{s\ a\ NO_x} < F_{S2NO_x}$  it may be considered that some secondary measures have already been implemented. In this case, it can be considered that the application rate concerning  $NO_x$  primary measures is 100%.

The virtual application rate of secondary measures  $T_{2,NO_x}$  then is obtained by:

$$T_{2,NO_x} = (F_{s\ a\ NO_x} - F_{S2NO_x}) / (F_{S3NO_x} - F_{S2NO_x})$$

*Second case:*  $F_{s\ a\ NO_x}$  has a value higher than the emission limit value of the LCP directive.

Then the emission limit value of the LCP must be considered from the implementation date.

$F_{s\ a\ NO_x}$  = Emission of the LCP directive (see the different values presented in the tables above)

ü If  $F_{S1NO_x} < F_{s\ a\ NO_x} < F_{S2NO_x}$ , it can be considered that some primary measures may still be implemented to a given percentage of the production capacity.

The virtual application rate of primary measures  $T_{1,NO_x}$  then is obtained by:

$$T_{1,NO_x} = (F_{s\ a\ NO_x} - F_{S1NO_x}) / (F_{S2NO_x} - F_{S1NO_x})$$

ü If  $F_{s\ a\ NO_x} < F_{S2NO_x}$  it may be considered that some secondary measures have already been implemented. In this case, it can be considered that the application rate concerning  $NO_x$  primary measures is 100%.

The virtual application rate of secondary measures  $T_{2,NO_x}$  then is obtained by:

$$T_{2,NO_x} = (F_{s\ a\ NO_x} - F_{S2NO_x}) / (F_{S3NO_x} - F_{S2NO_x})$$

### Second method:

If the national expert does not know the different emission levels, then the second case is automatically applied, because the plant must fulfil the directive from the implementation deadline.

Before the implementation deadline, application rates have to be fixed considering the unabated level, the emission limit value and the corresponding application rate.

### Third method:

The national expert has always the possibility to check the calculated application rates among technical options and to give other values allowing nevertheless to fulfil the LCP directive. Then with these new values, the influence on the total emissions of the sector will be calculated and shown in the tool. The tool calculates sectoral emissions as a product of activity level (fuel consumption) and an emission factor, considering the removal efficiency of the technical options and the application rates of these techniques in the country.

$$S_i(t) = \sum_j \sum_k act_{i,j}(t) \cdot af_{i,j,k}(t) \cdot ef_{i,j} \cdot (1 - p_{j,k})$$

with:

$S_i(t)$ : SO<sub>2</sub>; NO<sub>x</sub> or PM emissions in country  $i$  in time step  $t$

$act_{i,j}(t)$ : activity level of sector  $j$  in time step  $t$

$ef_{i,j}$ : (unabated) emission factor per unit of activity for country  $i$  and sector  $j$

$p_{j,k}$ : removal efficiency of technology  $k$  in sector  $j$

$af_{i,j,k}(t)$ : application factor of technology  $k$  in country  $i$  for sector  $j$  in time step  $t$ .

Table 3.46 : Application rates for NO<sub>x</sub> abatement techniques – scenario CLE – for each regulatory class 1 to 5 and for the national emission reduction plan (data required as input from national experts for each country)

Control Technology Description	Technology	1990	1995	2000	2005	2010	2015	2020	2025	2030
<b>New plants</b>										
HC new plant	MP									
BC new plant	MP									
HF new plant	MP									
Gas new plant	MP									
HC new plant	MP + SCR									
BC new plant	MP + SCR									
HF new plant	MP + SCR									
Gas new plant	MP + SCR									
<b>Regulatory class X (2 to 5) and national emission reduction plan</b>										
HC existing plant	MP									
BC existing plant	MP									
HF existing plant	MP									

Gas existing plant	MP										
HC existing plant	MP + SCR										
BC existing plant	MP + SCR										
HF existing plant	MP + SCR										
Gas existing plant	MP + SCR										

Table 3.47 : Application rates for low sulfur fuels for each regulatory class 1 to 5 and for the national emission reduction plan. Have to be fixed by the experts and not by the model (data required as input from national experts for each country)

	1990	1995	2000	2005	2010	2015	2020	2025	2030
<b>Regulatory class X (1 to 5) and national emission reduction plan</b>									
HC1 – LSCO									
HC2 - LSCO									
HF1 – LSHF1									
HF1 – LSHF2									
HF2 – LSHF1									
HF2 – LSHF2									

Table 3.48 : Application rates for SO2 abatement techniques – scenario CLE – for each regulatory class 1 to 5 and for the national emission reduction plan (data required as input from national experts for each country)

<b>Control Technology Description</b>	<b>Technology</b>	1990	1995	2000	2005	2010	2015	2020	2025	2030
<b>New plants</b>										
HC new plant	WFGD									
BC new plant	WFGD									
HF new plant	WFGD									
HC new plant	HEWFGD									
BC new plant	HEWFGD									
HF new plant	HEWFGD									
<b>Regulatory class X (2 to 5) and national emission reduction plan</b>										
HC existing plant	WFGD									
BC existing plant	WFGD									
HF existing plant	WFGD									

Table 3.49 : Application rates for Dedusters– scenario CLE – for each regulatory class and for the national emission reduction plan (data required as input from national experts for each country)

<b>Fuel</b>	<b>Technology</b>	1990	1995	2000	2005	2010	2015	2020	2025	2030
<b>Regulatory class X (1 to 5) and national emission reduction plan</b>										
Hard Coal	Deduster 1									

	Deduster 2										
	Deduster 3										
	Deduster 4										
Brown Coal	Deduster 1										
	Deduster 2										
	Deduster 3										
	Deduster 4										
Heavy fuel oil	Deduster 1										

### 3.6 Applicability

For each technique, an applicability has to be introduced. This rate allows to reach emissions lower than those given under legal requirements. To help the national expert, some default values will be already introduced.

Table 3.50 : Applicability for NO<sub>x</sub> abatement techniques for each regulatory class and for the national emission reduction plan

Control Technology Description	Technology	1990	1995	2000	2005	2010	2015	2020	2025	2030
<b>New plants</b>										
HC new plant	MP									
BC new plant	MP									
HF new plant	MP									
Gas new plant	MP									
HC new plant	MP + SCR									
BC new plant	MP + SCR									
HF new plant	MP + SCR									
Gas new plant	MP + SCR									
<b>Regulatory class X (2 to 5) and national emission reduction plan</b>										
HC existing plant	MP									
BC existing plant	MP									
HF existing plant	MP									
Gas existing plant	MP									
HC existing plant	MP + SCR									
BC existing plant	MP + SCR									
HF existing plant	MP + SCR									
Gas existing plant	MP + SCR									

Table 3.51 : Applicability for low sulfur fuels. They are the same as application rates.

Table 3.52 : Applicability for SO2 abatement techniques for each regulatory class and for the national emission reduction plan

Control Technology Description	Technology	1990	1995	2000	2005	2010	2015	2020	2025	2030
<b>New plants</b>										
HC new plant	WFGD									
BC new plant	WFGD									
HF new plant	WFGD									
HC new plant	HEWFGD									
BC new plant	HEWFGD									
HF new plant	HEWFGD									
<b>Regulatory class X (2 to 5) and national emission reduction plan</b>										
HC existing plant	WFGD									
BC existing plant	WFGD									
HF existing plant	WFGD									

Table 3.53 : Applicability for dedusters for each regulatory class and for the national emission reduction plan

Fuel	Technology	1990	1995	2000	2005	2010	2015	2020	2025	2030
<b>Regulatory class X (1 to 5) and national emission reduction plan</b>										
Hard Coal	Deduster 1									
	Deduster 2									
	Deduster 3									
	Deduster 4									
Brown Coal	Deduster 1									
	Deduster 2									
	Deduster 3									
	Deduster 4									
Heavy fuel oil	Deduster 1									

Knowing the applicability, it is possible to calculate the possible profit by using the technique until their applicability.

$$P_i(t) = \sum_j \sum_k act_{i,j}(t) \cdot af_{i,j,k}(t) \cdot ef_{i,j} \cdot (1 - p_{j,k}) - \sum_j \sum_k act_{i,j}(t) \cdot bf_{i,j,k}(t) \cdot ef_{i,j} \cdot (1 - p_{j,k})$$

with:

$S_i(t)$ : SO<sub>2</sub>; NO<sub>x</sub> or PM emissions in country  $i$  in time step  $t$

$act_{i,j}(t)$ : activity level of sector  $j$  in time step  $t$

$ef_{i,j}$ : (unabated) emission factor per unit of activity for country  $i$  and sector  $j$

$p_{j,k}$ : removal efficiency of technology  $k$  in sector  $j$

$af_{i,j,k}(t)$ : application factor of technology  $k$  in country  $i$  for specific case  $j$  in time step  $t$

$b_{f,i,j,k}(t)$ : applicability factor of technology  $k$  in country  $i$  for specific case  $j$  in time step  $t$

The result gives the minimum achievable for each pollutant.

### 3.7 Cost calculation for each technical option in all different case

For each technical option and each specific case, the cost and marginal cost per ton of pollutant avoided and per unit of production has to be calculated. To realize these calculations, some input parameters are needed:

- Capacities installed for each specific case (fuels and regulatory classes)

Table 3.54 : Installed capacities for each specific case (fuels and regulatory classes) in MWth

Fuel	Regulatory class 1	Regulatory class 2	Regulatory class 3	Regulatory class 4	Regulatory class 5	National Emission Reduction Plan
HC1						
HC2						
...						

- Operating hours at full load

Table 3.55 : Average operating hours at full load for each specific case (fuels and each regulatory class) in hours

Fuel	Regulatory class 1	Regulatory class 2	Regulatory class 3	Regulatory class 4	Regulatory class 5	National Emission Reduction Plan
HC1						
HC2						
...						

- Number of plants in the country for each specific case.

Table 3.56 : Number of plants for each specific case (fuel and each regulatory class)

Fuel	Regulatory class 1	Regulatory class 2	Regulatory class 3	Regulatory class 4	Regulatory class 5	National Emission Reduction Plan
HC1						
HC2						
...						

These values will allow to check the consistency of the energy consumption with the average capacity, the number of plants and the operating hours at full load.

Energy consumption in PJ = Number of plants · Average capacity in MWth · Operating hours /  $10^6 \cdot 3600$ .

**Results:**

**(For each specific case)**

Table 3.57 : Cost per PJ fuel input, per ton of NOx abated and marginal cost for NOx abatement techniques for each regulatory class and for the national emission reduction plan

Control Technology Description	Technology	Cost per PJ fuel input [Euro/PJ fuel input]	Cost per t of NOx abated [Euro/t NOx abated]	Marginal cost [Euro/t NOx abated]
<b>New plants</b>				
HC new plant	MP			
BC new plant	MP			
HF new plant	MP			
Gas new plant	MP			
HC new plant	MP + SCR			
BC new plant	MP + SCR			
HF new plant	MP + SCR			
Gas new plant	MP + SCR			
<b>Regulatory class X (2 to 5) and national emission reduction plan</b>				
HC existing plant	MP			
BC existing plant	MP			
HF existing plant	MP			
Gas existing plant	MP			
HC existing plant	MP + SCR			
BC existing plant	MP + SCR			
HF existing plant	MP + SCR			
Gas existing plant	MP + SCR			

Table 3.58 : Cost per PJ fuel input, per ton of SOx abated and marginal cost for low sulfur fuels for each regulatory class and for the national emission reduction plan

	Cost per PJ fuel input [Euro/PJ fuel input]	Cost per t of SOx abated [Euro/t SOx abated]	Marginal cost [Euro/t SOx abated]
<b>Regulatory class X (1 to 5) and national emission reduction plan</b>			
HC1 – LSCO			
HC2 - LSCO			

HF1 – LSHF1			
HF1 – LSHF2			
HF2 – LSHF1			
HF2 – LSHF2			

Table 3.59 Cost per PJ fuel input, per ton of SO<sub>x</sub> abated and marginal cost for SO<sub>2</sub> abatement techniques for each regulatory class and for the national emission reduction plan

Control Technology Description	Technology	Cost per PJ fuel input [Euro/PJ fuel input]	Cost per t of SO <sub>x</sub> abated [Euro/t SO <sub>x</sub> abated]	Marginal cost [Euro/t SO <sub>x</sub> abated]
<b>New plants</b>				
HC new plant	WFGD			
BC new plant	WFGD			
HF new plant	WFGD			
HC new plant	HEWFGD			
BC new plant	HEWFGD			
HF new plant	HEWFGD			
<b>Regulatory class X (2 to 5) and national emission reduction plan</b>				
HC existing plant	WFGD			
BC existing plant	WFGD			
HF existing plant	WFGD			

Table 3.60 : Cost per PJ fuel input, per ton of TSP abated and marginal cost for dedusters for each regulatory class and for the national emission reduction plan

Fuel	Technology	Cost per PJ fuel input [Euro/PJ fuel input]	Cost per t of TSP abated [Euro/t TSP abated]	Marginal cost [Euro/t TSP abated]
<b>Regulatory class X (1 to 5) and national emission reduction plan</b>				
Hard Coal	Deduster 1			
	Deduster 2			
	Deduster 3			
	Deduster 4			
Brown Coal	Deduster 1			
	Deduster 2			
	Deduster 3			
	Deduster 4			
Heavy fuel oil	Deduster 1			

The same table is to be given for PM<sub>10</sub> and PM<sub>2.5</sub>.

Knowing all the costs and potential reduction, it is possible to generate the **cost curve** for the scenario CLE. Such cost curve defines - for each country and year - the potential for further emission reductions beyond a selected initial level of control and provide the minimum costs of achieving such reductions. For a given abatement level a cost-optimal combination of abatement measures is defined.

Table 3.61: NOx abatement cost curve for each specific case (fuels and each regulatory class)

Fuel – Technology - Abatement technique	Application rate [%]	Applicability rate [%]	Unit cost [Euro/t NOx abated]	Marginal cost [Euro/t NOx abated]	NOx removed [kt/a]	Remaining NOx [kt/a]	Total cost Mio Euro/a
<b>Regulatory class X</b>							
HC1-Ex plant-MP							
...							

Table 3.62: SO<sub>2</sub> abatement cost curve for each specific case (fuels and each regulatory class)

Fuel – Technology - Abatement technique	Application rate [%]	Applicability rate [%]	Unit cost [Euro/t SO <sub>2</sub> abated]	Marginal cost [Euro/t SO <sub>2</sub> abated]	SO <sub>2</sub> removed [kt/a]	Remaining SO <sub>2</sub> [kt/a]	Total cost Mio Euro/a
<b>Regulatory class X</b>							
HC1-Ex plant-WFGD							
...							

Table 3.63: TSP abatement cost curve for each specific case (fuels and each regulatory class)

Fuel – Technology - Abatement technique	Application rate [%]	Applicability rate [%]	Unit cost [Euro/t TSP abated]	Marginal cost [Euro/t TSP abated]	SO <sub>2</sub> removed [kt/a]	Remaining SO <sub>2</sub> [kt/a]	Total cost Mio Euro/a
<b>Regulatory class X</b>							
HC1-Ex plant-Deduster 2							
...							

### Calculation of the total emission in the sector

Table 3.64: Total emissions for each regulatory class

<b>Scenario</b>	<b>NO<sub>x</sub></b>	<b>SO<sub>2</sub></b>	<b>TSP</b>	<b>PM10</b>	<b>PM2.5</b>
<b>Without treatment</b>					
<b>Scenario CLE</b>					
<b>Maximum feasible</b>					

Table 3.65: Total emissions for the sector

<b>Scenario</b>	<b>NO<sub>x</sub></b>	<b>SO<sub>2</sub></b>	<b>TSP</b>	<b>PM10</b>	<b>PM2.5</b>
<b>Without treatment</b>					
<b>Scenario CLE</b>					
<b>Maximum feasible</b>					

## 4 Example of France

The number of plants > 500 MW<sub>th</sub> for FRANCE is around 30 (number of units: 49). The biggest part of information has been found in the *GIC inventory* and has been completed with enquiries or with input from experts

The study will be structured following the different fuels and status of plant (new and existing plants) and regulatory constraints.

### 4.1 Energy scenarios for France

Table 4.1: Energy scenarios

Unité PJ	1990	1995	2000	2005	2010	2015	2020	2025	2030
<b>BL CLE Cons tot PP</b>	374	263	309	388.2	436	442	647.07	747.86	848.65
<b>CP CLE Cons tot PP</b>	374	263	309	406	488	486	737.66	845.08	942.00

#### 4.1.1 Fuels considered for existing and new plants

Table 4.2: Fuel consumption for existing and new plants in France for the two scenarios CP and BL

CP

Existing:	1990	1995	2000	2005	2010	2015	2020	2025	2030
HC1	38.1	27.2	31.3	47.7	33.1	12.7	32.67	0	0
HC2	124	88	101	101	76	52	0	0	0
HC3	133.9	94.8	109.7	129.3	144.9	120.3	175.1	217.2	0
HF	49	31	39	42.2	64	57	32.7	24.8	0
Gas	29	22	28	18	18	0	0	0	0
Total	374	263	309	338.2	336	242	240.47	242	0

New:	1990	1995	2000	2005	2010	2015	2020	2025	2030
HC1				0	0	0	0.00	0.00	0.00
HC2				0	0	0	0.00	0.00	0.00
HC3				0	0	0	180.00	245.86	536.70
HF				0	0	0	10.60	18.00	43.60
Gas				50	100	200	216.00	242.00	268.35
Total				50	100	200	406.60	505.86	848.65

Total existing + new	374	263	309	388.2	436	442	647.07	747.86	848.65
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BL

Existing:	1990	1995	2000	2005	2010	2015	2020	2025	2030
HC1	38.1	27.2	31.3	49	37	14	37.24	0.00	0.00
HC2	124	88	101	106	85	57	0.00	0.00	0.00
HC3	133.9	94.8	109.7	136	162	132	199.62	245.44	0.00
HF	49	31	39	44	72	63	37.28	28.02	0.00
Gas	29	22	28	19	20	0	0.00	0.00	0.00
Total	374	263	309	354	376	266	274.14	273.46	0.00

New:	1990	1995	2000	2005	2010	2015	2020	2025	2030

HC1							0.00	0.00	0.00
HC2							0.00	0.00	0.00
HC3							205.20	277.82	595.74
HF							12.08	20.34	48.40
Gas				52	112	220	246.24	273.46	297.86
Total				52	112	220	463.52	571.62	942.00

Total existing + new	374	263	309	406	488	486	737.66	845.08	942.00
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#### 4.1.2 Distinction of the regulatory classes

1. New Plants (permitted after 27-11-2002 or started after 27-11-2003)

Table 4.3: Fuel consumption for regulatory class 1 in France for the two scenarios CP and BL

CP	1990	1995	2000	2005	2010	2015	2020	2025	2030
HC1				0	0	0	0.00	0.00	0.00
HC2				0	0	0	0.00	0.00	0.00
HC3				0	0	0	180.00	245.86	536.70
HF				0	0	0	10.60	18.00	43.60
Gas				50	100	200	216.00	242.00	268.35
Total				50	100	200	406.60	505.86	848.65

BL	1990	1995	2000	2005	2010	2015	2020	2025	2030
HC1							0.00	0.00	0.00
HC2							0.00	0.00	0.00
HC3							205.20	277.82	595.74
HF							12.08	20.34	48.40
Gas				52	112	220	246.24	273.46	297.86
Total				52	112	220	463.52	571.62	942.00

2. Plants closed until 31/12/2015 and operating less than 20.000 hours between 01/01/2008 and 31/12/2015

Table 4.3: Fuel consumption for regulatory class 2 in France for the two scenarios CP and BL

CP	1990	1995	2000	2005	2010	2015	2020	2025	2030
HC1									
HC2	124	88	101	101	76	52	0	0	0
HC3									
HF									
Gas									
Total									

BL	1990	1995	2000	2005	2010	2015	2020	2025	2030
HC1									
HC2	124	88	101	106	85	57	0.00	0.00	0.00
HC3									
HF									
Gas									

Total									
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3. Low operated plants. burning solid fuels and permitted before 01-07-87, which do not operate more than 2000 h/year (rolling average over 5 years) from 01-01-2008 to 31-12-2015, and more than 1500 h/year (rolling average over 5 years) after 01-01-2016.

Table 4.3: Fuel consumption for regulatory class 3 in France for the two scenarios CP and BL

CP	1990	1995	2000	2005	2010	2015	2020	2025	2030
HC1	24.1	13.2	17.3	33.7	19.1	12.7	32.67		
HC2									
HC3									
HF									
Gas									
Total									

BL	1990	1995	2000	2005	2010	2015	2020	2025	2030
HC1	24.1	13.2	17.3	35	23	14	37.24		
HC2									
HC3									
HF									
Gas									
Total									

4. Plants authorized between 01/07/1987 and 27/11/2002

Table 4.3: Fuel consumption for regulatory class 4 in France for the two scenarios CP and BL

CP	1990	1995	2000	2005	2010	2015	2020	2025	2030
HC1									
HC2									
HC3									
HF									
Gas									
Total									

BL	1990	1995	2000	2005	2010	2015	2020	2025	2030
HC1									
HC2									
HC3									
HF									
Gas									
Total									

5. Plants authorized before 01/07/1987

Table 4.3: Fuel consumption for regulatory class 5 in France for the two scenarios CP and BL

CP	1990	1995	2000	2005	2010	2015	2020	2025	2030
HC1	14	14	14	14	14	0	0	0	0

HC2									
HC3	133.9	94.8	109.7	129.3	144.9	120.3	175.1	217.2	0
HF	49	31	39	42.2	64	57	32.7	24.8	0
Gas	29	22	28	18	18	0	0	0	0
Total									

BL	1990	1995	2000	2005	2010	2015	2020	2025	2030
HC1	14	14	14	14	14	0	0	0	0
HC2									
HC3	133.9	94.8	109.7	136	162	132	199.61	245.44	0
HF	49	31	39	44	72	63	37.28	28.02	0
Gas	29	22	28	19	20	0	0	0	0
Total									

## 4.2 Fuel characteristics

### 1.6.1 Heat values

Table 4.4: Fuel heat values in France [GJ/t]

Fuel	1990-2030
HC1	24
HC2	24.9
HC3	24.9
HF	39.2
GAS	4.02

### 1.6.2 Sulfur content

Table 4.5: Sulfur content in France [%S]

Fuel	1990	1995	2000	2005	2010	2015	2020	2025	2030
HC1	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
HC2	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
HC3	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
HF	2.79	2.79	2.79	2.79	2.79	2.79	2.79	2.79	2.79
GAS	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
HF regulatory class 1				2.10	2.10	2.10	2.10	2.10	2.10
HC3 regulatory class 5	1.20	1.20	1.20	1.20	1.15	1.15	1.15	1.15	1.15
HF regulatory class 5	2.79	2.00	0.60	0.60	1.46	1.46	1.46	1.46	1.46

### 1.6.3 Sulfur retained in ash

Table 4.6: Sulfur retained in ash in France [fraction]

Fuel	1990-2030
HC1	0.02
HC2	0.024
HC3	0.024

#### 4.2.4 Ash retained by the boiler

Table 4.7: Ash retained by the boiler in France [fraction]

Fuel	1990-2030
HC1	0.3
HC2	0.1
HC3	0.1

#### 4.2.5 Ash contents of solid fuels

Table 4.8: Ash content of solid fuels in France [percentage]

Fuel	1990-2030
HC1	12
HC2	12
HC3	12

### 4.3 Unabated Emission factors

#### 4.3.1 Unabated NO<sub>x</sub> emission factor

Table 4.9: Unabated NO<sub>x</sub> emission factor in kt/PJ for new and existing plants in France

Fuel	1990-2030
HC1	0.26
HC2	0.333
HC3	0.315
HF1	0.238
GAS	0.08

In concentration mg/Nm<sup>3</sup> (3% of O<sub>2</sub> gas and liquids – 6% solids):

Table 4.10: Unabated NO<sub>x</sub> emission factor in concentration for new and existing plants in France

Fuel	1990-2030
HC1	743
HC2	950
HC3	900
HF1	850
GAS	296

#### 4.3.2 Unabated SO<sub>x</sub> emission factor

Table 4.11: Unabated SO<sub>x</sub> emission factor in kt/PJ in France

Fuel	1990-2030
HC1	0.74
HC2	0.63
HC3	0.94
HF	1.42

GAS	0.05
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### 4.3.3 Unabated dust emission factor

Table 4.12: Unabated TSP emission factor in t/PJ in France

Fuel	1990-2030
HC1	3500
HC2	4337
HC3	4337
HF	15.5
GAS	0.1

Table 4.13: Unabated TSP emission factor in mg/Nm<sup>3</sup> in France

Fuel	1990-2030
HC1	12.857
HC2	12.392
HC3	12.392
HF	55.4
GAS	0.4

### 4.4 Control strategy

Table 4.14 : Application rates for NO<sub>x</sub> abatement techniques – scenario CLE – for each regulatory class 1 to 5 for France

Control Technology Description	Technology	1990	1995	2000	2005	2010	2015	2020	2025	2030
<b>New plants</b>										
HC3 new plant	MP				25.93	25.93	25.93	25.93	25.93	25.93
HF new plant	MP				21.90	21.90	21.90	21.90	21.90	21.90
Gas new plant	MP				61.76	61.76	61.76	61.76	61.76	61.76
HC3 new plant	MP + SCR				74.07	74.07	74.07	74.07	74.07	74.07
HF new plant	MP + SCR				78.10	78.10	78.10	78.10	78.10	78.10
Gas new plant	MP + SCR				38.24	38.24	38.24	38.24	38.24	38.24
<b>Regulatory class 2</b>										
HC2 existing plant	MP	0	0	0	0	0	0	0	0	0
HC2 existing plant	MP + SCR	0	0	0	0	0	0	0	0	0
<b>Regulatory class 3</b>										
HC1 existing plant	MP	0	0	35	64	64.10	64.10	82.05	82.05	82.05
HC1 existing plant	MP + SCR	0	0	0	0	0	0	17.95	17.95	17.95
<b>Regulatory class 4</b>										
No plants in France										
<b>Regulatory class 5</b>										

HC1 existing plant	MP	0	0	34.62	70.51	94.87	94.87	17.95	17.95	17.95
HC3 existing plant	MP	0	0	34.92	69.84	72.49	72.49	8.99	8.99	8.99
HF existing plant	MP	0	0	0	0	45.10	45.10	45.10	45.10	45.10
Gas existing plant	MP	0	0	0	0	81.25	81.25	81.25	81.25	81.25
HC1 existing plant	MP + SCR	0	0	0	0	5.13	5.13	82.05	82.05	82.05
HC3 existing plant	MP + SCR	0	0	0	0	27.51	27.51	91.01	91.01	91.01
HF existing plant	MP + SCR	0	0	0	0	54.90	54.90	54.90	54.90	54.90
Gas existing plant	MP + SCR	0	0	0	0	0	0	0	0	0

Table 4.15 : Application rates for SO<sub>2</sub> abatement techniques – scenario CLE – for each regulatory class 1 to 5 for France

Control Technology Description	Technology	1990	1995	2000	2005	2010	2015	2020	2025	2030
<b>New plants</b>										
HC3 new plant	WFGD				48.82	48.82	48.82	48.82	48.82	48.82
HF new plant	WFGD				4.53	4.53	4.53	4.53	4.53	4.53
HC3 new plant	HEWFGD				51.18	51.18	51.18	51.18	51.18	51.18
HF new plant	HEWFGD				95.47	95.47	95.47	95.47	95.47	95.47
<b>Regulatory class 2</b>										
HC2 existing plant	WFGD	0	0	0	0	0	0	0	0	0
<b>Regulatory class 3</b>										
HC1 existing plant	WFGD	0	0	0	0	72.83	72.83	72.83	72.83	72.83
<b>Regulatory class 4</b>										
No plants in France										
<b>Regulatory class 5</b>										
HC1 existing plant	WFGD	100	100	100	100	100	100	100	100	100
HC3 existing plant	WFGD	0	80	80	80	99.38	99.38	99.38	99.38	99.38
HF existing plant	WFGD	0	0	0	0	99.96	99.96	99.96	99.96	99.96

Table 4.16 : Application rates for Dedusters– scenario CLE – for each regulatory class for France

Fuel	Technology	1990	1995	2000	2005	2010	2015	2020	2025	2030
<b>Regulatory class 1</b>										
HC3	Deduster 1				0	0	0	0	0	0
	Deduster 2				0	0	0	0	0	0
	Deduster 3				40	40	40	40	40	40
	Deduster 4				60	60	60	60	60	60
Heavy fuel oil	Deduster 1				80.14	80.14	80.14	80.14	80.14	80.14

Regulatory class 2										
HC2	Deduster 1	98.76	98.76	98.76	25	25	25	25	25	25
	Deduster 2	0	0	0	75	75	75	75	75	75
	Deduster 3	0	0	0	0	0	0	0	0	0
	Deduster 4	0	0	0	0	0	0	0	0	0
Regulatory class 3										
Hard Coal	Deduster 1	0	0	0	0	0	0	0	0	0
	Deduster 2	63.64	63.64	63.64	63.64	0	0	0	0	0
	Deduster 3	36.36	36.36	36.36	36.36	100	100	100	100	100
	Deduster 4	0	0	0	0	0	0	0	0	0
Regulatory class 4										
Regulatory class 5										
HC1	Deduster 1	0	0	0	0	0	0	0	0	0
	Deduster 2	63.64	63.64	63.64	63.64	0	0	0	0	0
	Deduster 3	36.36	36.36	36.36	36.36	100	100	100	100	100
	Deduster 4	0	0	0	0	0	0	0	0	0
HC3	Deduster 1	0	0	0	0	0	0	0	0	0
	Deduster 2	63.64	63.64	63.64	63.64	0	0	0	0	0
	Deduster 3	36.36	36.36	36.36	36.36	100	100	100	100	100
	Deduster 4	0	0	0	0	0	0	0	0	0
Heavy fuel oil	Deduster 1	0	0	0	0	11.81	11.81	11.81	11.81	11.81

#### 4.5 Applicability

Table 4.17 : Applicability for NO<sub>x</sub> abatement techniques for each regulatory class for France

Control Technology Description	Technology	1990	1995	2000	2005	2010	2015	2020	2025	2030
New plants										
HC3 new plant	MP				0	0	0	0	0	0
HF new plant	MP				0	0	0	0	0	0
Gas new plant	MP				0	0	0	0	0	0
HC3 new plant	MP + SCR				100	100	100	100	100	100
HF new plant	MP + SCR				100	100	100	100	100	100
Gas new plant	MP + SCR				100	100	100	100	100	100
Regulatory class 2										
HC2 existing plant	MP	0	0	0	0	0	0	0	0	0
HC2 existing plant	MP + SCR	0	0	0	0	0	0	0	0	0
Regulatory class 3										
HC1 existing plant	MP	82.05	82.05	82.05	82.05	82.05	82.05	82.05	82.05	82.05
HC1 existing plant	MP + SCR	17.95	17.95	17.95	17.95	17.95	17.95	17.95	17.95	17.95

<b>Regulatory class 4</b>										
No plants in France										
<b>Regulatory class 5</b>										
HC1 existing plant	MP	94.87	94.87	94.87	94.87	94.87	0	0	0	0
HC3 existing plant	MP	0	0	0	0	0	0	0	0	0
HF existing plant	MP	45.10	45.10	45.10	45.10	45.10	45.10	45.10	45.10	45.10
Gas existing plant	MP	100	100	100	100	100	100	100	100	100
HC1 existing plant	MP + SCR	5.13	5.13	5.13	5.13	5.13	0	0	0	0
HC3 existing plant	MP + SCR	100	100	100	100	100	100	100	100	100
HF existing plant	MP + SCR	54.90	54.90	54.90	54.90	54.90	54.90	54.90	54.90	54.90
Gas existing plant	MP + SCR	0	0	0	0	0	0	0	0	0

Table 4.18 : Applicability for SO<sub>2</sub> abatement techniques for each regulatory class for France

<b>Control Technology Description</b>	<b>Technology</b>	<b>1990</b>	<b>1995</b>	<b>2000</b>	<b>2005</b>	<b>2010</b>	<b>2015</b>	<b>2020</b>	<b>2025</b>	<b>2030</b>
<b>New plants</b>										
HC3 new plant	WFGD				0	0	0	0	0	0
HF new plant	WFGD				0	0	0	0	0	0
HC3 new plant	HEWFGD				100	100	100	100	100	100
HF new plant	HEWFGD				100	100	100	100	100	100
<b>Regulatory class 2</b>										
HC2 existing plant	WFGD	0	0	0	0	0	0	0	0	0
<b>Regulatory class 3</b>										
HC1 existing plant	WFGD	100	100	100	100	100	100	100	100	100
<b>Regulatory class 4</b>										
No plants in France										
<b>Regulatory class 5</b>										
HC1 existing plant	WFGD	100	100	100	100	100	100	100	100	100
HC3 existing plant	WFGD	100	100	100	100	100	100	100	100	100
HF existing plant	WFGD	100	100	100	100	100	100	100	100	100

Table 4.19 : Applicability for dedusters for each regulatory class for France

<b>Fuel</b>	<b>Technology</b>	<b>1990</b>	<b>1995</b>	<b>2000</b>	<b>2005</b>	<b>2010</b>	<b>2015</b>	<b>2020</b>	<b>2025</b>	<b>2030</b>
<b>Regulatory class 1</b>										
HC3	Deduster 1				0	0	0	0	0	0
	Deduster 2				0	0	0	0	0	0
	Deduster 3				0	0	0	0	0	0

	Deduster 4				100	100	100	100	100	100
Heavy fuel oil	Deduster 1				100	100	100	100	100	100
<b>Regulatory class 2</b>										
HC2	Deduster 1	25	25	25	25	25	25	25	25	25
	Deduster 2	75	75	75	75	75	75	75	75	75
	Deduster 3	0	0	0	0	0	0	0	0	0
	Deduster 4	0	0	0	0	0	0	0	0	0
<b>Regulatory class 3</b>										
HC1	Deduster 1	0	0	0	0	0	0	0	0	0
	Deduster 2	0	0	0	0	0	0	0	0	0
	Deduster 3	0	0	0	0	0	0	0	0	0
	Deduster 4	100	100	100	100	100	100	100	100	100
<b>Regulatory class 4</b>										
<b>Regulatory class 5</b>										
HC1	Deduster 1	0	0	0	0	0	0	0	0	0
	Deduster 2	0	0	0	0	0	0	0	0	0
	Deduster 3	0	0	0	0	0	0	0	0	0
	Deduster 4	100	100	100	100	100	100	100	100	100
HC3	Deduster 1	0	0	0	0	0	0	0	0	0
	Deduster 2	0	0	0	0	0	0	0	0	0
	Deduster 3	0	0	0	0	0	0	0	0	0
	Deduster 4	100	100	100	100	100	100	100	100	100
Heavy fuel oil	Deduster 1	11.81	11.81	11.81	11.81	11.81	11.81	11.81	11.81	11.81

#### 4.6 Calculation of the total emission in the sector

##### 4.6.1 NOx emissions

Table 4.20 : NOx total emissions in kt for each regulatory class and for the BL energy scenario

Scenario	1990	1995	2000	2005	2010	2015	2020	2025	2030
<b>Class regulatory 1</b>									
<b>BL - Without treatment</b>				4.16	8.96	17.60	87.21	114.23	223.01
<b>BL - Scenario CLE</b>				1.40	3.02	5.94	21.69	27.97	52.45
<b>BL - Minimum achievable</b>				0.31	0.67	1.32	7.60	10.03	19.89
<b>Class regulatory 2</b>									
<b>BL - Without treatment</b>	41.29	29.30	33.63	35.30	28.31	18.98	0	0	0
<b>BL - Scenario CLE</b>	41.29	29.30	33.63	35.30	28.31	18.98	0	0	0
<b>BL - Minimum achievable</b>	41.29	29.30	33.63	35.30	28.31	18.98	0	0	0
<b>Class regulatory 3</b>									
<b>BL - Without treatment</b>	6.27	3.43	4.50	9.10	5.98	3.64	9.68	0	0

<b>BL - Scenario CLE</b>	6.27	3.43	4.03	7.35	4.83	2.94	5.87	0	0
<b>BL - Minimum achievable</b>	3.80	2.08	2.72	5.51	3.62	2.21	5.87	0	0
<b>Class regulatory 4</b>									
<b>BL - Without treatment</b>									
<b>BL - Scenario CLE</b>									
<b>BL - Minimum achievable</b>									
<b>Class regulatory 5</b>									
<b>BL - Without treatment</b>	59.80	42.64	49.72	58.47	73.41	56.57	71.75	83.98	0
<b>BL - Scenario CLE</b>	59.80	42.64	45.72	48.73	39.94	30.16	18.15	20.32	0
<b>BL - Minimum achievable</b>	16.71	12.20	14.21	15.79	20.40	14.33	15.18	16.67	0

Table 4.21 : NOx total emissions in kt for each regulatory class and for the CP energy scenario

Scenario	1990	1995	2000	2005	2010	2015	2020	2025	2030
<b>Class regulatory 1</b>									
<b>CP - Without treatment</b>				4.00	8.00	16.00	76.50	101.09	200.91
<b>CP - Scenario CLE</b>				1.35	2.70	5.40	19.03	24.75	47.26
<b>CP - Minimum achievable</b>				0.30	0.60	1.20	6.66	8.87	17.92
<b>Class regulatory 2</b>									
<b>CP - Without treatment</b>	41.29	29.30	33.63	33.63	25.31	17.32	0	0	0
<b>CP - Scenario CLE</b>	41.29	29.30	33.63	35.30	28.31	18.98	0	0	0
<b>CP - Minimum achievable</b>	41.29	29.30	33.63	35.30	28.31	18.98	0	0	0
<b>Class regulatory 3</b>									
<b>CP - Without treatment</b>	6.27	3.43	4.50	8.76	4.97	3.30	8.49	0	0
<b>CP - Scenario CLE</b>	6.27	3.43	4.03	7.08	4.01	2.67	5.15	0	0
<b>CP - Minimum achievable</b>	3.80	2.08	2.72	5.31	3.01	2.00	5.15	0	0
<b>Class regulatory 4</b>									
<b>CP - Without treatment</b>									
<b>CP - Scenario CLE</b>									
<b>CP - Minimum achievable</b>									
<b>Class regulatory 5</b>									
<b>CP - Without treatment</b>	59.80	42.64	49.72	55.85	65.96	51.46	62.94	74.32	0
<b>CP - Scenario CLE</b>	59.80	42.64	45.72	46.55	35.95	27.44	15.92	17.98	0
<b>CP - Minimum achievable</b>	16.71	12.20	14.21	15.17	18.47	13.02	13.31	14.75	0

Table 4.22 : NOx total emissions in France for the BL scenario in kt

Scenario	1990	1995	2000	2005	2010	2015	2020	2025	2030
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<b>Without treatment</b>	107.36	75.38	87.85	107.03	116.65	96.80	168.64	198.21	223.01
<b>Scenario CLE</b>	107.36	75.38	83.38	92.78	76.10	58.02	45.70	48.29	52.45
<b>Minimum achievable</b>	61.80	43.59	50.57	56.91	53.00	36.84	28.64	26.69	19.89

Table 4.23 : NO<sub>x</sub> total emissions in France for the CP scenario in kt

<b>Scenario</b>	<b>1990</b>	<b>1995</b>	<b>2000</b>	<b>2005</b>	<b>2010</b>	<b>2015</b>	<b>2020</b>	<b>2025</b>	<b>2030</b>
<b>Without treatment</b>	107.36	75.38	87.85	102.25	104.23	88.08	147.94	175.41	200.91
<b>Scenario CLE</b>	107.36	75.38	83.38	88.61	67.97	52.82	40.09	42.73	47.26
<b>Minimum achievable</b>	61.80	43.59	50.57	54.41	47.39	33.53	25.12	23.62	17.92

#### 4.6.2 SO<sub>2</sub> Emissions

Table 4.24 : SO<sub>2</sub> total emissions in kt for each regulatory class and for the BL energy scenario

<b>Scenario</b>	<b>1990</b>	<b>1995</b>	<b>2000</b>	<b>2005</b>	<b>2010</b>	<b>2015</b>	<b>2020</b>	<b>2025</b>	<b>2030</b>
<b>Class regulatory 1</b>									
<b>BL - Without treatment</b>	0	0	0	0	0	1.10	211.33	291.41	630.42
<b>BL - Scenario CLE</b>	0	0	0	0	0	1.10	16.14	21.69	45.51
<b>BL - Minimum achievable</b>	0	0	0	0	0	1.10	11.40	15.26	31.71
<b>Class regulatory 2</b>									
<b>BL - Without treatment</b>	77.77	55.19	63.34	66.48	53.31	35.75	0	0	0
<b>BL - Scenario CLE</b>	77.77	55.19	63.34	66.48	53.31	35.75	0	0	0
<b>BL - Minimum achievable</b>	77.77	55.19	63.34	66.48	53.31	35.75	0	0	0
<b>Class regulatory 3</b>									
<b>BL - Without treatment</b>	17.71	9.70	12.72	25.73	16.91	10.29	27.37	0	0
<b>BL - Scenario CLE</b>	17.71	9.70	12.72	25.73	6.44	3.92	10.43	0	0
<b>BL - Minimum achievable</b>	2.66	1.46	1.91	3.86	2.54	1.54	4.11	0	0
<b>Class regulatory 4</b>									
<b>BL - Without treatment</b>									
<b>BL - Scenario CLE</b>									
<b>BL - Minimum achievable</b>									
<b>Class regulatory 5</b>									
<b>BL - Without treatment</b>	207.45	144.70	170.40	201.81	266.18	213.85	240.84	270.78	0
<b>BL - Scenario CLE</b>	198.71	62.81	47.91	56.90	33.29	25.54	32.12	37.50	0
<b>BL - Minimum achievable</b>	32.35	20.77	20.21	23.70	32.50	24.89	31.16	36.32	0

Table 4.25 : SO<sub>2</sub> total emissions in kt for each regulatory class and for the CP energy scenario

<b>Scenario</b>	<b>1990</b>	<b>1995</b>	<b>2000</b>	<b>2005</b>	<b>2010</b>	<b>2015</b>	<b>2020</b>	<b>2025</b>	<b>2030</b>
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Class regulatory 1									
CP - Without treatment	0	0	0	0	0	1.00	185.42	257.91	567.95
CP - Scenario CLE	0	0	0	0	0	1.00	14.19	19.22	41.01
CP - Minimum achievable	0	0	0	0	0	1.00	10.03	13.53	28.58
Class regulatory 2									
CP - Without treatment	77.77	55.19	63.34	66.48	53.31	35.75	0	0	0
CP - Scenario CLE	77.77	55.19	63.34	66.48	53.31	35.75	0	0	0
CP - Minimum achievable	77.77	55.19	63.34	66.48	53.31	35.75	0	0	0
Class regulatory 3									
CP - Without treatment	17.71	9.70	12.72	24.77	14.04	9.33	24.01	0	0
CP - Scenario CLE	17.71	9.70	12.72	24.77	5.35	3.56	9.15	0	0
CP - Minimum achievable	2.66	1.46	1.91	3.72	2.11	1.40	3.60	0	0
Class regulatory 4									
CP - Without treatment									
CP - Scenario CLE									
CP - Minimum achievable									
Class regulatory 5									
CP - Without treatment	207.45	144.70	170.40	192.90	238.60	194.31	211.27	239.63	0
CP - Scenario CLE	198.71	62.81	47.91	54.29	29.90	23.23	28.18	33.19	0
CP - Minimum achievable	32.35	20.77	20.21	22.63	29.19	22.64	27.33	32.14	0

Table 4.26 : SO<sub>2</sub> total emissions in France for the BL scenario in kt

Scenario	1990	1995	2000	2005	2010	2015	2020	2025	2030
Without treatment	302.93	209.59	246.46	294.01	336.39	260.99	479.55	562.18	630.42
Scenario CLE	294.19	127.70	123.96	149.11	93.04	66.30	58.69	59.19	45.51
Minimum achievable	112.77	77.41	85.46	94.04	88.34	63.28	46.66	51.58	31.71

Table 4.27 : SO<sub>2</sub> total emissions in France for the CP scenario in kt

Scenario	1990	1995	2000	2005	2010	2015	2020	2025	2030
Without treatment	302.93	209.59	246.46	281.01	300.30	237.25	420.70	497.54	567.95
Scenario CLE	294.19	127.70	123.96	142.40	82.91	60.39	51.52	52.40	41.01
Minimum achievable	112.77	77.41	85.46	89.68	78.96	57.65	40.97	45.67	28.58

### 4.6.3 Dust Emission

#### 4.6.3.1 TSP Emission

Table 4.28 : TSP total emissions in kt for each regulatory class and for the BL energy scenario

Scenario	1990	1995	2000	2005	2010	2015	2020	2025	2030
<b>Class regulatory 1</b>									
<b>BL - Without treatment</b>	0	0	0	0.01	0.01	0.02	890.42	1205.66	2585.46
<b>BL - Scenario CLE</b>	0	0	0	0.01	0.01	0.02	2.28	3.12	6.69
<b>BL - Minimum achievable</b>	0	0	0	0.01	0.01	0.02	1.49	2.03	4.34
<b>Class regulatory 2</b>									
<b>BL - Without treatment</b>	537.83	381.69	438.07	459.76	368.67	247.23	0	0	0
<b>BL - Scenario CLE</b>	19.53	13.86	15.91	5.57	4.46	2.99	0	0	0
<b>BL - Minimum achievable</b>	6.51	4.62	5.30	5.57	4.46	2.99	0	0	0
<b>Class regulatory 3</b>									
<b>BL - Without treatment</b>	24.94	13.66	17.91	36.23	23.81	14.49	38.54	0	0
<b>BL - Scenario CLE</b>	0.45	0.25	0.32	0.66	0.27	0.17	0.44	0	0
<b>BL - Minimum achievable</b>	0.15	0.08	0.11	0.22	0.14	0.09	0.23	0	0
<b>Class regulatory 4</b>									
<b>BL - Without treatment</b>									
<b>BL - Scenario CLE</b>									
<b>BL - Minimum achievable</b>									
<b>Class regulatory 5</b>									
<b>BL - Without treatment</b>	630.53	460.66	525.41	639.56	752.77	573.51	866.36	1064.99	0
<b>BL - Scenario CLE</b>	4.90	3.53	4.07	4.88	3.78	2.96	3.67	4.26	0
<b>BL - Minimum achievable</b>	2.39	1.62	1.95	2.27	3.23	2.67	2.43	2.49	0

Table 4.29 : TSP total emissions in kt for each regulatory class and for the CP energy scenario

Scenario	1990	1995	2000	2005	2010	2015	2020	2025	2030
<b>Class regulatory 1</b>									
<b>CP - Without treatment</b>	0	0	0	0.01	0.01	0.02	781.07	1066.96	2329.23
<b>CP - Scenario CLE</b>	0	0	0	0.01	0.01	0.02	2.00	2.76	6.03
<b>CP - Minimum achievable</b>	0	0	0	0.01	0.01	0.02	1.31	1.80	3.91
<b>Class regulatory 2</b>									
<b>CP - Without treatment</b>	537.83	381.69	438.07	438.07	329.64	225.54	0	0	0
<b>CP - Scenario CLE</b>	19.53	13.86	15.91	5.30	3.99	2.73	0	0	0
<b>CP - Minimum achievable</b>	6.51	4.62	5.30	5.30	3.99	2.73	0	0	0
<b>Class regulatory 3</b>									
<b>CP - Without treatment</b>	108.45	59.40	77.85	151.65	85.95	57.15	147.02	0	0
<b>CP - Scenario CLE</b>	0.67	0.37	0.48	0.94	0.30	0.20	0.51	0	0
<b>CP - Minimum achievable</b>	0.17	0.09	0.12	0.24	0.13	0.09	0.23	0	0

Class regulatory 4									
CP - Without treatment									
CP - Scenario CLE									
CP - Minimum achievable									
Class regulatory 5									
CP - Without treatment	630.53	460.66	525.41	610.48	678.48	522.67	759.98	942.46	0
CP - Scenario CLE	4.90	3.53	4.07	4.67	3.40	2.69	3.22	3.77	0
CP - Minimum achievable	2.39	1.62	1.95	2.17	2.88	2.42	2.13	2.21	0

Table 4.30 : TSP total emissions in France for the BL scenario in kt

Scenario	1990	1995	2000	2005	2010	2015	2020	2025	2030
Without treatment	1276.81	901.75	1041.34	1256.83	1224.95	883.76	1924.36	2270.65	2585.46
Scenario CLE	25.11	17.76	20.46	11.43	8.62	6.20	6.53	7.37	6.69
Minimum achievable	9.07	6.33	7.37	8.08	7.86	5.78	4.18	4.52	4.34

Table 4.31 : TSP total emissions in France for the CP scenario in kt

Scenario	1990	1995	2000	2005	2010	2015	2020	2025	2030
Without treatment	1276.81	901.75	1041.34	1200.20	1094.07	805.38	1688.06	2009.42	2329.23
Scenario CLE	25.11	17.76	20.46	10.92	7.70	5.64	5.73	6.53	6.03
Minimum achievable	9.07	6.33	7.37	7.72	7.02	5.26	3.67	4.00	3.91

#### 4.6.3.2 PM10 Emission

Table 4.32 : PM10 total emissions in kt for each regulatory class and for the BL energy scenario

Scenario	1990	1995	2000	2005	2010	2015	2020	2025	2030
Class regulatory 1									
BL - Without treatment	0	0	0	0.01	0.01	0.02	205.05	277.71	595.61
BL - Scenario CLE	0	0	0	0.01	0.01	0.02	1.83	2.49	5.33
BL - Minimum achievable	0	0	0	0.01	0.01	0.02	1.35	1.83	3.92
Class regulatory 2									
BL - Without treatment	123.70	87.79	100.76	105.74	84.80	56.86	0	0	0
BL - Scenario CLE	6.68	4.74	5.44	2.92	2.34	1.57	0	0	0
BL - Minimum achievable	3.42	2.43	2.78	2.92	2.34	1.57	0	0	0
Class regulatory 3									
BL - Without treatment	24.94	13.66	17.91	36.23	23.81	14.49	38.54	0	0
BL - Scenario CLE	0.45	0.25	0.32	0.66	0.27	0.17	0.44	0	0
BL - Minimum achievable	0.15	0.08	0.11	0.22	0.14	0.09	0.23	0	0

Class regulatory 4									
BL - Without treatment									
BL - Scenario CLE									
BL - Minimum achievable									
Class regulatory 5									
BL - Without treatment	145.50	106.25	121.22	147.52	173.83	132.51	199.62	245.22	0
BL - Scenario CLE	3.42	2.45	2.84	3.40	2.94	2.31	2.80	3.23	0
BL - Minimum achievable	2.09	1.42	1.70	1.98	2.81	2.32	2.14	2.21	0

Table 4.33 : PM10 total emissions in kt for each regulatory class and for the CP energy scenario

Scenario	1990	1995	2000	2005	2010	2015	2020	2025	2030
Class regulatory 1									
CP - Without treatment	0	0	0	0.01	0.01	0.02	179.87	245.77	536.58
CP - Scenario CLE	0	0	0	0.01	0.00	0.00	1.66	2.28	5.00
CP - Minimum achievable	0	0	0	0.01	0.01	0.02	1.18	1.62	3.53
Class regulatory 2									
CP - Without treatment	123.70	87.79	100.76	100.76	75.82	51.87	0	0	0
CP - Scenario CLE	6.68	4.74	5.44	2.78	2.09	1.43	0	0	0
CP - Minimum achievable	3.42	2.43	2.78	2.78	2.09	1.43	0	0	0
Class regulatory 3									
CP - Without treatment	24.94	13.66	17.91	34.88	19.77	13.14	33.81	0	0
CP - Scenario CLE	0.45	0.25	0.32	0.63	0.23	0.15	0.39	0	0
CP - Minimum achievable	0.15	0.08	0.11	0.21	0.12	0.08	0.21	0	0
Class regulatory 4									
CP - Without treatment									
CP - Scenario CLE									
CP - Minimum achievable									
Class regulatory 5									
CP - Without treatment	145.50	106.25	121.22	140.82	156.67	120.76	175.11	217.00	0
CP - Scenario CLE	3.42	2.45	2.84	3.25	2.64	2.10	2.46	2.86	0
CP - Minimum achievable	2.09	1.42	1.70	1.90	2.51	2.10	1.87	1.95	0

Table 4.34 : PM10 total emissions in France for the BL scenario in kt

Scenario	1990	1995	2000	2005	2010	2015	2020	2025	2030
Without treatment	294.14	207.70	239.88	289.50	282.44	203.89	443.21	522.93	595.61

<b>Scenario CLE</b>	10.56	7.44	8.60	6.98	5.57	4.07	5.07	5.72	5.33
<b>Minimum achievable</b>	5.66	3.93	4.59	5.13	5.31	4.00	3.72	4.04	3.92

Table 4.35 : PM10 total emissions in France for the CP scenario in kt

<b>Scenario</b>	<b>1990</b>	<b>1995</b>	<b>2000</b>	<b>2005</b>	<b>2010</b>	<b>2015</b>	<b>2020</b>	<b>2025</b>	<b>2030</b>
<b>Without treatment</b>	294.14	207.70	239.88	276.46	252.26	185.80	388.79	462.77	536.58
<b>Scenario CLE</b>	10.56	7.44	8.60	6.67	4.96	3.69	4.50	5.14	5.00
<b>Minimum achievable</b>	5.66	3.93	4.59	4.90	4.74	3.63	3.26	3.58	3.53

#### 4.6.3.3 PM2.5 Emission

Table 4.36 : PM2.5 total emissions in kt for each regulatory class and for the BL energy scenario

<b>Scenario</b>	<b>1990</b>	<b>1995</b>	<b>2000</b>	<b>2005</b>	<b>2010</b>	<b>2015</b>	<b>2020</b>	<b>2025</b>	<b>2030</b>
<b>Class regulatory 1</b>									
<b>BL - Without treatment</b>	0	0	0	0.01	0.01	0.02	107.05	145.01	311.00
<b>BL - Scenario CLE</b>	0	0	0	0.01	0.01	0.02	1.26	1.72	3.69
<b>BL - Minimum achievable</b>	0	0	0	0.01	0.01	0.02	0.92	1.25	2.66
<b>Class regulatory 2</b>									
<b>BL - Without treatment</b>	64.54	45.80	52.57	55.17	44.24	29.67	0	0	0
<b>BL - Scenario CLE</b>	2.73	1.94	2.22	1.53	1.23	0.82	0	0	0
<b>BL - Minimum achievable</b>	1.79	1.27	1.46	1.53	1.23	0.82	0	0	0
<b>Class regulatory 3</b>									
<b>BL - Without treatment</b>	13.01	7.13	9.34	18.90	12.42	7.56	20.11	0	0
<b>BL - Scenario CLE</b>	0.28	0.16	0.20	0.41	0.18	0.11	0.29	0	0
<b>BL - Minimum achievable</b>	0.10	0.06	0.07	0.15	0.10	0.06	0.16	0	0
<b>Class regulatory 4</b>									
<b>BL - Without treatment</b>									
<b>BL - Scenario CLE</b>									
<b>BL - Minimum achievable</b>									
<b>Class regulatory 5</b>									
<b>BL - Without treatment</b>	76.03	55.51	63.34	77.08	90.87	69.29	104.24	128.01	0
<b>BL - Scenario CLE</b>	2.20	1.57	1.82	2.18	2.00	1.58	1.89	2.17	0
<b>BL - Minimum achievable</b>	1.44	0.98	1.17	1.37	1.94	1.61	1.46	1.50	0

Table 4.37 : PM2.5 total emissions in kt for each regulatory class and for the CP energy scenario

Scenario	1990	1995	2000	2005	2010	2015	2020	2025	2030
<b>Class regulatory 1</b>									
CP - Without treatment	0	0	0	0.01	0.01	0.02	93.91	128.32	280.18
CP - Scenario CLE	0	0	0	0.01	0.01	0.02	1.41	1.94	4.23
CP - Minimum achievable	0	0	0	0.01	0.01	0.02	0.81	1.10	2.40
<b>Class regulatory 2</b>									
CP - Without treatment	64.54	45.80	52.57	52.57	39.56	27.07	0	0	0
CP - Scenario CLE	2.73	1.94	2.22	1.46	1.10	0.75	0	0	0
CP - Minimum achievable	1.79	1.27	1.46	1.46	1.10	0.75	0	0	0
<b>Class regulatory 3</b>									
CP - Without treatment	13.01	7.13	9.34	18.20	10.31	6.86	17.64	0	0
CP - Scenario CLE	0.28	0.16	0.20	0.40	0.15	0.10	0.26	0	0
CP - Minimum achievable	0.10	0.06	0.07	0.14	0.08	0.05	0.14	0	0
<b>Class regulatory 4</b>									
CP - Without treatment									
CP - Scenario CLE									
CP - Minimum achievable									
<b>Class regulatory 5</b>									
CP - Without treatment	76.03	55.51	63.34	73.57	81.89	63.14	91.44	113.28	0
CP - Scenario CLE	2.20	1.57	1.82	2.08	1.80	1.43	1.66	1.92	0
CP - Minimum achievable	1.44	0.98	1.17	1.31	1.74	1.46	1.28	1.33	0

Table 4.38 : PM2.5 total emissions in France for the BL scenario in kt

Scenario	1990	1995	2000	2005	2010	2015	2020	2025	2030
Without treatment	153.58	108.44	125.25	151.15	147.54	106.54	231.40	273.01	311.00
Scenario CLE	5.21	3.66	4.25	4.12	3.42	2.53	3.44	3.89	3.69
Minimum achievable	3.33	2.30	2.71	3.05	3.28	2.51	2.54	2.75	2.66

Table 4.39 : PM2.5 total emissions in France for the CP scenario in kt

Scenario	1990	1995	2000	2005	2010	2015	2020	2025	2030
Without treatment	153.58	108.44	125.25	144.34	131.78	97.09	202.99	241.60	280.18
Scenario CLE	5.21	3.66	4.25	3.94	3.05	2.30	3.32	3.86	4.23
Minimum achievable	3.33	2.30	2.71	2.91	2.93	2.28	2.23	2.43	2.40

## 4.7 Costs for each technical option in all different case

### 4.7.1 Costs per PJ fuel input, per ton of pollutant abated and marginal costs

Table 4.40 : Cost per PJ fuel input, per ton of NOx abated and marginal cost for NOx abatement techniques for each regulatory class

Control Technology Description	Technology	Cost per PJ fuel input [Euro/PJ fuel input]	Cost per t of NOx abated [Euro/t NOx abated]	Marginal cost [Euro/t NOx abated]
<b>New plants</b>				
HC3 new plant	MP	0	0	0
HF new plant	MP	0	0	0
Gas new plant	MP	0	0	0
HC3 new plant	MP + SCR	167,541	969	1,729
HF new plant	MP + SCR	622,184	5,793	8,714
Gas new plant	MP + SCR	135,502	2,930	6,377
<b>Regulatory class 2</b>				
HC2 existing plant	MP	43,348	434	434
HC2 existing plant	MP + SCR	515,312	1,876	2,700
<b>Regulatory class 3</b>				
HC1 existing plant	MP	43,700	560	560
HC1 existing plant	MP + SCR	646,486	2,322	3,329
<b>Regulatory class 4</b>				
No plants in France				
<b>Regulatory class 5</b>				
HC1 existing plant	MP	24,620	316	316
HC3 existing plant	MP	15,017	159	159
HF existing plant	MP	205,485	4,317	4,317
Gas existing plant	MP	14,781	462	462
HC1 existing plant	MP + SCR	324,750	1,514	2,199
HC3 existing plant	MP + SCR	214,896	827	1,209
HF existing plant	MP + SCR	1,859,220	9,765	11,581
Gas existing plant	MP + SCR	176,200	2,591	4,484

Table 4.41 : Cost per PJ fuel input, per ton of SOx abated and marginal cost for low sulfur fuels for each regulatory class

	<b>Cost per PJ fuel input</b> [Euro/PJ fuel input]	<b>Cost per t of SOx abated</b> [Euro/t SOx abated]	<b>Marginal cost</b> [Euro/t SOx abated]
HC1 – LSCO	99,000	404	404
HC2 - LSCO	66,000	421	421
HC3 - LSCO	198,000	421	421
HF – LSHF1	501,200	549	549
HF – LSHF2	3,435,000	2,940	13,465
HF – LSHF3	6,350,000	4,900	49,784

Table 4.42 Cost per PJ fuel input, per ton of SOx abated and marginal cost for SO2 abatement techniques for each regulatory class

<b>Control Technology Description</b>	<b>Technology</b>	<b>Cost per PJ fuel input</b> [Euro/PJ fuel input]	<b>Cost per t of SOx abated</b> [Euro/t SOx abated]	<b>Marginal cost</b> [Euro/t SOx abated]
<b>New plants</b>				
HC3 new plant	WFGD	422,424	499	499
HF new plant	WFGD	1,701,551	1,328	1,328
HC3 new plant	HEWFGD	516,275	578	1,995
HF new plant	HEWFGD	2,033,368	1,504	4,662
<b>Regulatory class 2</b>				
HC2 existing plant	WFGD	931,934	1,748	1,748
<b>Regulatory class 3</b>				
HC1 existing plant	WFGD	902,896	1,445	1,445
<b>Regulatory class 4</b>				
No plants in France				
<b>Regulatory class 5</b>				
HC1 existing plant	WFGD	522,185	836	836
HC3 existing plant	WFGD	433,297	542	542
HF existing plant	WFGD	4,528,854	3,743	3,743

Table 4.43 : Cost per PJ fuel input, per ton of TSP abated and marginal cost for dedusters for each regulatory class

Fuel	Technology	Cost per PJ fuel input [Euro/PJ fuel input]	Cost per t of TSP abated [Euro/t TSP abated]	Marginal cost [Euro/t TSP abated]
<b>New plants</b>				
HC3	Deduster 1	57,812	13.66	13.66
	Deduster 2	72,561	16.87	210
	Deduster 3	97,245	20.19	763
	Deduster 4	101,603	22.47	1,640
Heavy fuel oil	Deduster 1	674,281	53,093	53,093
Heavy fuel oil	Deduster 1 after low NOx burner	674,281	23,911	23,911
<b>Regulatory class 2</b>				
HC2	Deduster 1	156,541	36.99	36.99
	Deduster 2	188,753	43.87	460
	Deduster 3	234,012	54.15	2,351
	Deduster 4	266,900	61.63	3,760
<b>Regulatory class 3</b>				
HC1	Deduster 1	175,064	51.57	51.57
	Deduster 2	210,086	60.63	500
	Deduster 3	260,955	74.90	2,642
	Deduster 4	296,823	84.98	4,100
<b>Regulatory class 4</b>				
<b>Regulatory class 5</b>				
HC1	Deduster 1	86,489	25.48	25.48
	Deduster 2	103,733	29.94	246
	Deduster 3	129,593	37.19	1,343
	Deduster 4	146,607	41.97	1,944
HC3	Deduster 1	57,812	13.66	13.66
	Deduster 2	72,561	16.87	210
	Deduster 3	97,245	20.19	763
	Deduster 4	101,603	22.47	1,640
Heavy fuel oil	Deduster 1	674,281	53,093	53,093
Heavy fuel oil	Deduster 1 after low NOx burner	674,281	23,911	23,911

Table 4.44 : Cost per PJ fuel input, per ton of PM10 abated and marginal cost for dedusters for each regulatory class

<b>Fuel</b>	<b>Technology</b>	<b>Cost per PJ fuel input</b> [Euro/PJ fuel input]	<b>Cost per t of PM 10 abated</b> [Euro/t TSP abated]	<b>Marginal cost</b> [Euro/t TSP abated]
<b>New plants</b>				
HC3	Deduster 1	57,812	60	60
	Deduster 2	72,561	74	766
	Deduster 3	97,245	88	1,342
	Deduster 4	101,603	102	2,600
Heavy fuel oil	Deduster 1	674,281	64,642	64,642
Heavy fuel oil	Deduster 1 after low NOx burner	674,281	28,564	28,564
<b>Regulatory class 2</b>				
HC2	Deduster 1	156,541	164	164
	Deduster 2	188,753	194	1,673
	Deduster 3	234,012	237	4,138
	Deduster 4	266,900	269	5,966
<b>Regulatory class 3</b>				
HC1	Deduster 1	175,064	229	229
	Deduster 2	210,086	269	1,819
	Deduster 3	260,955	329	4,651
	Deduster 4	296,823	371	6,506
<b>Regulatory class 4</b>				
No plants in France				
<b>Regulatory class 5</b>				
HC1	Deduster 1	86,489	113	113
	Deduster 2	103,733	133	896
	Deduster 3	129,593	163	2,634
	Deduster 4	146,607	184	3,086
HC3	Deduster 1	57,812	60	60
	Deduster 2	72,561	74	766
	Deduster 3	97,245	88	1,342
	Deduster 4	101,603	102	2,600
Heavy fuel oil	Deduster 1	674,281	64,642	64,642
Heavy fuel oil	Deduster 1 after low NOx burner	674,281	28,564	28,564

Table 4.45 : Cost per PJ fuel input, per ton of PM2.5 abated and marginal cost for dedusters for each regulatory class

Fuel	Technology	Cost per PJ fuel input [Euro/PJ fuel input]	Cost per t of PM 2.5 abated [Euro/t TSP abated]	Marginal cost [Euro/t TSP abated]
<b>New plants</b>				
HC3	Deduster 1	57,812	114	114
	Deduster 2	72,561	143	875
	Deduster 3	97,245	170	1,396
	Deduster 4	101,603	199	2,653
Heavy fuel oil	Deduster 1	674,281	101,548	101,548
Heavy fuel oil	Deduster 1 after low NOx burner	674,281	42,301	42,301
<b>Regulatory class 2</b>				
HC2	Deduster 1	156,541	310	310
	Deduster 2	188,753	373	1,927
	Deduster 3	234,012	457	4,272
	Deduster 4	266,900	517	6,095
<b>Regulatory class 3</b>				
HC1	Deduster 1	175,064	433	433
	Deduster 2	210,086	517	2,175
	Deduster 3	260,955	633	4,837
	Deduster 4	296,823	714	6,687
<b>Regulatory class 4</b>				
No plants in France				
<b>Regulatory class 5</b>				
HC1	Deduster 1	86,489	214	214
	Deduster 2	103,733	255	1,071
	Deduster 3	129,593	314	2,455
	Deduster 4	146,607	353	3,176
HC3	Deduster 1	57,812	114	114
	Deduster 2	72,561	143	875
	Deduster 3	97,245	170	1,396
	Deduster 4	101,603	199	2,653
Heavy fuel oil	Deduster 1	674,281	101,548	101,548
Heavy fuel oil	Deduster 1 after low NOx burner	674,281	42,301	42,301

#### 4.7.2 Cost curves

Knowing all the costs and potential reduction, it is possible to generate **cost curves** for the scenario CLE. It is not the work of EGTEI to elaborate them, that is why only one example is shown in this document.

Table 4.46 : Example of NOx abatement cost curve for combustion sector in France in 2010

Fuel-Sector-Technology	Unit cost (Euro/t NOx abated)	Marginal cost (Euro/t NOx abated)	Removed emissions (kt)	Remaining emissions (kt)	Total cost (kEuro)	Application rate (%)	Applicability (%)
Initial emissions				116.65			
HC3 new-MP	0	0	0.00	116.65	0	54.59	0.00
HF new-MP	0	0	0.00	116.65	0	60.78	60.78
Gaz new-MP	0	0	0.00	116.65	0	92.00	100.00
HC3 existing-MP	159	159	0.00	116.65	0	72.49	0.00
HC1 (LFC) existing-MP	316	316	1.04	115.61	327	94.87	94.87
HC2 existing -MP	434	434	0.00	115.61	327	0.00	0.00
Gaz existing-MP	462	462	0.64	114.97	623	81.25	100.00
HC1 (hors LFC) existing-MP	560	560	1.47	113.50	1447	64.10	82.05
HC3 existing-MP+SCR	1102	1641	42.10	71.40	70533	27.51	100.00
HC3 new-MP+SCR	1323	2361	0.00	71.40	70533	45.41	100.00
HC1 (LFC) existing-MP+SCR	2060	3057	0.15	71.25	71004	5.13	5.13
HC2 existing-MP+SCR	2627	3880	0.00	71.25	71004	0.00	0.00
HF existing-MP	4317	4317	1.55	69.70	77676	45.10	45.10
HC1 (hors LFC) existing-MP+SCR	3247	4782	0.89	68.82	81911	0.00	17.95
Gaz existing-MP+SCR	3690	6559	0.00	68.82	81911	0.00	0.00
Gaz new-MP+SCR	3964	8627	8.28	60.54	153342	0.00	0.00
HF new-MP+SCR	8341	12547	0.00	60.54	153342	39.22	39.22
HF existing-MP+SCR	14829	18334	7.53	53.01	291397	54.90	54.90

Example of NOx abatement cost curve for combustion sector in France in 2010

