

REMARKS ON THE DRAFT BACKGROUND DOCUMENTS OF THE COMBUSTION SECTOR

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Red text shows the paragraphs of the Draft Document, to which the Dutch remarks refer.
Blue text indicates the elements of response given by EGTEI.

1. REMARKS (THE NETHERLANDS)

1.1 General

Not clear in the report is which year is related to the costs. This can be found in the methodology document : Euro 2000 (EGTEI, 2003).

In the Netherlands, we have mainly convention coal power plants, all with FGD and two with SCR (a third SCR is planned) and power plants based on gas turbines. Emission factors, based on information collected by ECN, can be found in Table 1.1.

Table 1.1 Emission factors of Dutch power plants (year 2000)

	MWe	PJ fuel	Ton NO _x /PJ fuel	Ton SO ₂ /PJ fuel
Coal with MP and SCR	1247	54.3	56	76
Coal with MP	2694	152.1	127	65
Coal gasification combined cycle	253	122.3	25	10
Gas power plants	8609	181.3	38	0

Values shown in above table are

1. national (Dutch) data
2. reflect probably already “controlled” emissions and thus the current situation in the Netherlands.

One has to bear in mind that the EGTEI-Drafts indicates possible default values for uncontrolled emissions (unabated emission factors), and then apply control options with certain efficiencies.

Each country has the possibility to propose other values which could suit more to its own framework.

For France, the proposed values are the following :

Table 1.2: Unabated NO_x emission factor in kt/PJ for new and existing plants in France

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

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Leading when applying primary and secondary measures to existing plants to the following Nox emission levels in kt/PJ :

Fuel	1990-2030
HC1	0.045
HC2	0.058
HC3	0.055
HF1	0.048
GAS	0.012

Table 1.3: Unabated SO_x emission factor in kt/PJ in France

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

Leading when applying secondary measures to existing plants to the following Sox emission levels in kt/PJ :

Fuel	1990-2030
HC1	0.111
HC2	0.094
HC3	0.141
HF	0.213

The French values seem to remain in coherence with the Dutch situation which may nevertheless be described in the slight different way concerning unabated emission levels especially for Sox for which the initial sulphur content is of main importance.

The EGTEI proposal gives more flexibility on this issue allowing to combine low sulphur fuels and scrubbing which is not the case of the RAINS model applying scrubbing only to 1990 fuel characteristics.

It does mean that scrubbing is only applied in RAINS on fuels of very high sulphur content.

The EGTEI flexibility allowing also to change the fuel characteristics for each given year is necessary but due to this change proposal we have to be cautious on abatement performances.

EGTEI documents further cover not only EU15 situation (like NL), but also EU25 and even beyond (Belarus, Turkey,...). Therefore, we have also to take into account some very specific frameworks and not only the best performances obtained in particular plants, but the documents with their reference installations need to reflect average situations for the whole spectrum of countries covered.

§ Page 9 A description of the current content of the RAINS model.

Table 1.4: Fuel categories RAINS

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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

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.

The fuel LF (Light Fraction) is replaced by 6 other fuels. One of them is leaded gasoline. In the EU-15 the sale of this fuel, has ended in certain countries and will legally end in 2007 for countries, which have asked for delay because of special circumstances (only max 0,5% may be sold after that date for old vehicles) (ECMT, 2001). So is it still relevant to put it in the RAINS model?

In EU-25 (other than EU-15), but certainly beyond EU-25 leaded gasoline still is used and will be used for years. Therefore this fuel is unlikely to disappear from the RAINS model already now.

§ Page 32:

An average conversion factor (F_{conv}) between concentrations of pollutants (in mg/Nm^3) and specific mass flows of pollutants (emission factor, in g per **GJ fuel input**)
Concentration of pollutant emitted (in mg/Nm^3) x F_{conv} = Specific mass flow of pollutant emitted (in mg/GJ fuel input)

For solid fuels: $F_{conv} = 350 Nm^3/GJ$ (6 % O_2 , dry)

For liquid fuels: $F_{conv} = 280 Nm^3/GJ$ (3 % O_2 , dry)

For gaseous fuels: $F_{conv} = 270 Nm^3/GJ$ (3 % O_2 , dry)

The F_{conv} factors for the different fuels are 3% lower than the figures I calculated from the fuel compositions:

For solid fuels (coal) I calculates $360 Nm^3/GJ$.

For liquid fuels about $285 Nm^3/GJ$ (gasoline/diesel) and $290 Nm^3/GJ$ for heavy oil.

For gaseous fuels $280 Nm^3/GJ$ (Dutch natural gas).

The EGTEI proposals are default values to allow expert to convert easily concentrations in specific mass flows.

We do not have stronger arguments in hand against 350-280-270 than for these values, which again reflect a medium situation over the 49 parties covered. But NL is free to use a slightly

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different set of data (360-285-280) to propose national specific mass flows (unabated emission factors for example). It could for example be justified by the specificities of the Dutch natural gas.

Anyway, the difference does not seem very important. Other uncertainties in the assessments are probably much higher but again it is up to a given country to use more appropriate hypotheses to describe its own situation.

1.2 Technologies

STEGs and gas turbines.

In the Netherlands, gas turbines are the main technology used in gas fired power plants, most of them being combined cycle plants (steam and gas turbine). To us, it is not clear whether this technology is taken into account or not. The definition of Main groups of emission control technologies within the Power Plant sector, seems not to consider the existence of STEG Power Plants, as commonly used in the Netherlands and most commonly used technology for all recently build power plants in Western Europe. Without their presence, and without the controlling option for the efficiency of the coupled gas turbines during the STEG process, it seems that the current Dutch situation will not be approximated correctly. This may lead to divergent results for the emissions and for the costs of adapting techniques of gas-fired power plants.

This could be implemented in the RAINS model by implementing data for STEG power plants as well, and asking countries to give the percentage (for different years) of the gas use in the two main types.

Gasification process.

Although not widely used, at least three countries within Europe also make use of gasification techniques (coal, refinery waste, biomass, etc.) for the production of electricity. Considering the aim of the EGTEI, the Gasification process and also the IGCC process should be considered as valid options within the model.

Malfunctioning of emission abating measures.

When considering the high efficiencies of abatement technologies all along the document, the RAINS model should include a controlling option for malfunctioning of emission controlling techniques, because malfunctioning of techniques will decrease the overall efficiency dramatically. A solution could be to include a parameter called "Availability" which multiplied by the technique efficiency would give the "Overall efficiency" of the considered technique.

It is correct that for the time being STEGs and GT are specifically represented in the EGTEI-draft. An expert has been recently appointed to cover STEGs and GT.

In the future, there will be a framework to cover STEGs and GT.

In the meantime and if necessary, it is possible using one or more specific fuels for this kind of plants to propose specific unabated emission factors.

Then, the abatement techniques defined for gaseous fuels may be used.

It is thus an opportunity to make quickly raw assessments.

Gasification process (incl. IGCC) should indeed be considered as valid options within EGTEI and IAM. BREF working groups are supposed to elaborate on these technologies in more detail.

Transient working conditions of control measures (beyond the nominal working point) do without any doubt have an important (negative) impact on the overall performance. Depending on base load functioning on one hand and peak load on the other, the nominal efficiency should be lowered to a more realistic average value. For the time being, the RAINS model can not take this aspect into account.

EGTEI has tried to do it proposing abatement efficiencies taking into account this aspect.

This is also why the efficiencies provided by EGTEI as default values may be lower than those you have collected on your own : values provided by EGTEI are 'industrial' ones, i.e. values that are representative of industrial operating conditions (so to say average values over the full cycle of operating conditions of an installation).

1.3 NO_x emission factors and reduction options

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Techniques	EURELECTRIC LCP 115-116	LCP BREF 2 nd Draft*
Low NO _x Burner (LNB)	<u>Solid fuels</u> Air staged: 25-35% Fuel staged: 50-60% <u>Liquid fuels: 20%, up to 50%</u>	<u>Solid fuels</u> Air staged: 25-35% Fuel staged: 50-60% <u>Liquid fuels: up to 50% for modern design</u>

From some publications, current available technology data are put in a table. According to information of Babcock-Hitachi, their HT-NR3 burner (www.bhk.co.jp) can reduce NO_x with 60% (since 1998), from 300 ppm (6% O₂: 220 g NO_x/GJ coal) to 125 ppm (93 g/GJ). A reduction of NO_x from a solid fuel with 60% by applying (only) a low NO_x burner is realistic. (The LNB figure for Fuel staged: 50-60% in the report looks correct).

So the sentence in brackets seems to further support the values presented by EGTEI as a result of information collection.

But indeed, also here one has to distinguish between particular equipment supplier's data, "real life" european (> EU-25) average situation and what can be proposed to fit to the current modelling framework.

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Description	EURELECTRIC LCP 115-116	LCP BREF 2 nd Draft*
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

It is stated: No secondary NO_x abatement measure needed for grate combustion and lignite fired boilers and CFBC. But the text in the BREF says (pag 258): "The SCR technique is regarded as part of BAT for the reduction of NO_x emission, but on account of the relative low NO_x emissions of lignite-fired plants compared with hard coal plants, SCR has not been considered as BAT in the general sense for combustion of lignite". Thus, the conclusion they don't need it, is only one way of looking at it. Another conclusion could be: they don't need it legally yet.

In the Netherlands, no lignite is used in power plants. Dutch grate fired waste combustion plants have all SCR. The report does not mentions new technologies like for instance NO_x absorption.

Data presented does not correspond to EGTEI proposal but is a synthesis of collected information. The second draft BREF is one of the sources.

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Table 1.5: NO_x 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

The effect of MP on new plants of 30 to 50% is low. According to information of Babcock-Hitachi, their HT-NR3 coal burner (www.bhk.co.jp) can reduce NO_x with 60% (since 1998). Experiences in the Netherlands between 1987 and 1990 with a conventional gas and oil power plant with low NO_x burners, flue gas re-circulation and In-Furnace NO_x Reduction resulted already in higher reductions. A reduction of 94% was found for gas (from 218 to 13 g/GJ) and of 62% for oil from (145 to 46 g/GJ) (Witikamp, 1991). In the evaluation of the experience some special circumstances are reported (so it can't be used in all existing plants) and some efficiency loss (maximum loss from 40% to 39.6% in case of gas; oil 4 times more). The oldest SCR in the Netherlands had already a removal efficiency of 80%.

Conclusion: proposed abatement efficiencies are very low.

Concerning this issue, we have at first to come back to the current RAINS situation.

In fact, the RAINS model proposes often very efficient primary measures (between 50 and 65%) which is not realistic as an average especially concerning existing plants (liquid fuels for example).

On top of this, secondary measures of the RAINS model increase only slightly the overall performance level (between 15 and 30% for existing plants) which is not realistic at all and lead to very high abatement costs.

On the contrary, EGTEI has tried to set up a logical and realistic approach proposing simple and low cost primary measures which can be combined with secondary measures.

The overall efficiency proposed by EGTEI is for example often higher and never lower concerning existing plants than the current RAINS hypotheses (best overall efficiency 80% for all fuels).

Concerning new plants, there are only slight differences :

Fuel	RAINS overall performance level	EGTEI proposal
BC	93	91
HC	90	91
HF	93	89,5
Gas	93	92,5

which can be easily understood, as the efficiency can not be for example the same for liquid and gaseous fuels.

Anyway, this approach will allow to consider reasonable and realistic costs for primary and secondary techniques.

Table 1.6: Remind of main groups of NOx emission control technologies considered in RAINS for the power plant sector

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

The same remark as on [page 21, see above]: also here one has to distinguish between particular equipment suppliers' data and "real life" european (> EU-25) average situation.

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Table 1.7 : Currently available figures NOx abatement techniques [EURELECTRIC, BREF, Manufacturers]

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		Investments [10 ⁶ Euro] 800 MWth	Investments [10 ⁶ Euro] 1800 MWth
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]

Catalyst cost	kEuro/m ³	12.1	26 for liquid fuels 6 solid fuels 20 gas
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Cost data of MP and SCR are compared with Dutch figures, for instance (Bakema, 1998), (Kroon, 1996). Within the normal range (see for instance the ranges in table 3.24) they seem to be correct. Striking is the high costs of the catalyst for gas and liquid fuels (per m³) which is

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compensated by the low catalyst volume. The 6 k€/m³ for solid fuels is low compared to other information sources (10-20 k\$/m³)¹ but this can be related to the type and volume of the catalyst needed.

More country-related cost data in this context may be proposed by NL and is very welcomed. Thanks a lot for this support in this difficult exercise.

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Remark: For new plant, the investment for Primary measures is considered as zero because new boilers inherently comprise low NO_x burners as standard design.

This way, the real cost for existing plants already include retrofiting.

The remark under table 3.25 is somewhat strange. Why use a high unabated level of NO_x emission and also say there are no reduction costs? If the costs (the cost of a low NO_x burner and boiler design, compared to an old design) would be implemented, the retrofit factor of MP of zero would change also.

It is worthwhile to discuss whether RAINS in 2005 has still to start with unabated emission factors of 1990, and why not change the basis to power plants with already some abatement options (why not start with a coal power plant with PM and dedusting 4)?

Following RAINS reports, no additional costs are attributed in the case of fuel switch (structural changes).

Whether to start with different (more recent) unabated emission factors is a general remark to be discussed with IIASA. NL is invited to integrate its comments into the data base but keeping in mind that the model has to consider the situation in 40 countries.

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The data for the factor $c_{i_{cat}}$ seems to be missing. Probably it is referred to Catalyst cost in table 3.27.

The information is, as you said, in table 3.27.

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¹ <http://www.worldbank.org/html/fpd/em/power/EA/mitigatn/aqnoscr.stm>

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

Total options for NO_x reduction in France in 2010 reduce emissions from about 116 kton to 53 kton. A reduction of 55%. This is strange, one would expect a reduction possibility above 80%. If all plants directly use SCR with an efficiency of 80% (which technically can be implemented at almost all places) emissions would be reduced with at least 80% (also MP can be used). Probably this figure shows only one control strategy and not a complete picture of reduction possibilities. In the RAINS model a complete picture of possibilities should be implemented. In table 4.46 the costs of SCR on HF (both existing and new) are very (extremely) high. I could not find a reason for this in the report. It could be caused by a small size of the HF combustion installations, but this size distribution is not in the report. If they are small, they might be out of the reliability range of the investment cost (and other cost) functions. For instance: for small installations in the Netherlands we use urea and not ammonia as a reduction agent. Urea has a higher price per ton NO_x reduced, but much lower storage investment cost. It should be stated that the high costs could also be caused by a low number of working hours per year or by a low remaining lifetime.

The above table reflects the French situation, given here only as an illustration, leading to the application rates and applicability following specific technical constraints. Very high costs for SCR on HF occur due to extremely low yearly operating hours of the plants.

This part of the document is just given to show how the EGTEI approach could be used. The French power plant sector is very specific (electricity is mainly produced in France by nuclear plants).

Some French plants have low operating hours or will be closed in the near future. The result is that the Nox emission level can reasonably be lowered in 2010 only by 54% according to the climate policy scenario.

The situation is different the following years :

- 2015 (71%),
- 2020 (84%),
- 2025 (86,5%)
- etc...

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Table 1.8: NOx total emissions in France for the CP scenario in kt

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

1.4 SO₂ emission factors and reduction options

§ Page 9 A description of the current content of the RAINS model.

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]

Country specific figures can be used for the different fuels. This is very useful because we use in the Netherlands low sulfur coals in power plants. From Table 1.10 it appears the differences between two years can be substantial. The difference in sulfur content can change for individual power plants over 0.2% between two years. The removal efficiency can vary more than 3% between two years (due to malfunction).

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Agreed, supports the approach which is new and not yet considered in RAINS.

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Table 1.9: Main groups of SO₂ 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

Limestone injection 50%, existing FGD 90%, new FGD 95% en high eff FGD 98%. The publication of (DePriest, 2003) mentions also 98% for wet FGD. For dry FGD it mentions 93-95% just like (Hitachi 2002). However, dry FGD is not an option in EGTEI data. The 98% reduction possibility is also not an option in the EGTEI document.

Table 1.10: Coal in power plants in the Netherlands

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	mean value 2000	Mean value 2001	Individual range
Sulphur content [Weight %]	0.88	0.72	0.59-0.95

Heating value [MJ/kg]	24.2	24.5	24-25
FGD Removal efficiency [%]	90	89	87.6-92.7
Emission factor [g SO ₂ /GJ coal]	71	63	54-101

Dry FGD (spray dry scrubber) is not supposed to be an option for large plants. This is why EGTEI has chosen not to consider this option for power plants with a capacity higher than 500 MWth. The situation will be different for smaller plants which will be covered in other documents.

The 98% reduction efficiency value is related to regenerative processes which are not so common in the power plant sector. To use this kind of process require to be connected to a refinery. More common processes used in the power plant sector have lower performance levels.

Table 1.6 underlines the usefulness of country specific data, and is in line with the approach proposed by EGTEI.

Techniques	EURELECTRIC LCP 115-116	LCP BREF 2 nd Draft*
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

A reduction with 50-70% by dry sorbent injection is realistic. It looks from information of (U.S. DOE, 2003), 70% reduction needs some additional measures like water injection in a separate tower or sorbent recycling (LIFAC project). According to (Muzio, 1987) there is a relation between sulfur content and removal efficiency. If the same ratio between S:Ca is used removal efficiency at higher sulfur concentrations is higher. Thus, removal efficiency can differ between countries depending on the mean sulfur content.

It may be the case, but the RAINS model does not offer this opportunity to change the abatement efficiencies. It would be anyway extremely difficult to take this kind of option into account in a modelling framework.

Techniques	LCP BREF 2 nd Draft*
Low Sulfur content fuel	<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 ³

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It is strange that low sulfur fuels can only be used in <100 MWth. In bigger power plants, combined with FGD, they can also lead to lower SO₂ emissions.

This information is presented as it is in the draft BREF document.
The EGTEI approach gives the opportunity to use low sulphur fuels for large power plants.

Techniques	BREF 2 nd Draft*
Spray dry scrubber	<u>Solid fuels</u> 80 % - 92 % For plant<100MWth <u>Liquid fuels</u> For plant<300MWth 85 % - 92 %

Spray dryer: Babcock-Hitachi (Hitachi, 2002) mentions several (advanced) spray dryers with efficiencies between 90 and 94% (in the report the efficiency is 80-92%).

This information is presented as it is in the draft BREF document.

Table 1.11: Options proposed for DeSOx 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

Options proposed for DeSOx technologies. Table 3.29 (page 38) of document "Combustion Sector" shows a maximum of 85% efficiency for existing power plants. The actual Dutch situation is that existing plants achieve 90% efficiency due to optimised O&M techniques (and reduction of malfunction time). Further studies on the subject show preliminary results of even better efficiencies for existing plants (up to 95%). A higher efficiency for existent plants is coupled to extra investments and operational costs. For instance, by adding redistribution rings in the wash tower and by adding absorbent improvers to the washing liquid and/or leakage reduction in the heat exchangers between WFGD gas input and output. These options are not only applicable to the Netherlands. Other European countries could also achieve these efficiencies by optimising their O&M techniques. Therefore, we propose to include two extra options for existing plants already fitted with WFGD: WFGD technology with efficiencies of

90% (by improved O&M techniques) and WFGD technology with efficiencies of 95% (by improved O&M techniques and additional investments). The costs of application of additional options on existing WFGD plants should be an input to the RAINS-model in such a way that, during the cost optimisation, also for other European countries these techniques could be applied. Because the SO₂ emission of plants already fitted with WFGD is still very high, implementing of those two options in the Rains model, will have a substantial effect on the relevant part (options for further reduction compared to the current situation) of de SO₂ reduction cost curve

As EGTEI proposes to combine the use of low sulphur fuels and wet scrubbing (it is not the case at the moment with RAINS), we need in a first step to be cautious and perhaps a little bit conservative.

You have to keep in mind that the current situation is that the RAINS model apply scrubbing on 1990 fuel characteristics leading to consider sulphur content between 3 and 4% for liquid fuels for example.

If problems are faced by the Netherlands, they could be solved using a sulphur content slightly lower than the reality but allowing to match current emission levels.

As a second step, the request to have additional categories (WFGD with improved efficiency for existing plants) could be considered.

But before we would like to get assessments combining the use of low sulphur fuels and wet scrubbing for several countries...

It may already change to a great extend the modelling results.

Table 1.12: Options and investments proposed by EGTEI for DeSO_x technologies applied to two calculation examples (Power plants of 800 and 1800 MWth) [EURELECTRIC, BREF, Manufacturers]

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

Cost data of FGD are compared to Dutch figures. Within the normal range they seem to be correct. Investment costs for the Dutch coal power plants, transferred into euro 2000 are 0.05 mln euro/MWth

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(about 40 mln euro for a 800 MWth plant, compared to 35 mln euro in table 3.31). Electricity demand looks with 0.44 up to 0.85 GWh/PJ fuel some what low.

Figure of 40Mio instead of 35Mio for the HC existing plant may be taken if supplementary evidence is provided by other countries.

What would NL propose as electricity demand (“...0.44 up to 0.85 GWh/PJ fuel some what low ?”) ? EGTEI proposal is between 1,22 and 2,36 GWh/PJ fuel input.

1.5 Dust emissions factor and reduction options

§ Page 25	
Description	LCP BREF 2 nd Draft*
ESP	<p>< 1 µm: > 96.5% 2 µm: > 98.3% 5 µm: > 99.95% > 10 µm: > 99.95%</p> <p><u>Solid fuels</u> 85% - 98% 90% maximum value in specific cases</p> <p><u>Liquid fuels</u> 92-98%</p>
Fabric filter	<p>< 1 µm: > 99.6% 2 µm: > 99.6% 5 µm: > 99.9% > 10 µm: > 99.95%</p> <p><u>Solid fuels</u></p> <p><u>Liquid fuels</u></p>

The reduction of dust has been put in removal efficiencies. This does not say much about emission factors. See for emission factors for instance [Table 1.13](#) and [Table 1.14](#) from the best available technology study on combustion installations of Vito (Goovaerts, 2002)

Again, this information does not correspond to EGTEI proposals but to available information provided by EGTEI.

Table 1.13: Emission factors of dust for a “medium emission” large combustion plants

Type of dust	diesel	heavy oil	coal	gas
TSP	5 g/GJ	20 g/GJ	25 g/GJ	200 mg/GJ
PM10	5 g/GJ	15 g/GJ	25 g/GJ	200 mg/GJ
PM2.5	5 g/GJ	9 g/GJ	12 g/GJ	200 mg/GJ

Table 1.14: Emission factors of dust for “medium emission” middle and small combustion plants

Type of dust	diesel	heavy oil	coal	gas
TSP	5 g/GJ	50 g/GJ	100g/GJ	200 mg/GJ
PM10	5 g/GJ	40 g/GJ	60 g/GJ	200 mg/GJ
PM2.5	5 g/GJ	35 g/GJ	35 g/GJ	200 mg/GJ

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The type of coal (the specific properties of the fine dust) influences the efficiency of ESP filters. Mentioned efficiencies are in line with (15 year old) Dutch information (Weier, 1989).

The emission of Dust (PM10) of several Dutch power plants is presented in [Table 1.15](#). Each number is the figure of one power plant in one year. The figures are calculated from environmental reports. As can be seen the emission for coal power plants with an wet FGD varies between 0.1 and 1.7 g/GJ². In the Netherlands, we have one coal gasification power plant. **The emission of this plant is about 0.8 g/GJ; but only 0.2 is from flue gas emissions. 80% of the emission of PM10 is from other sources like coal storage and fly ash handling.** It is not clear whether those emissions are included in the figures from the other coal power plants.

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Diffuse emissions (other than stack emissions) are not taken into account so far.

One gas power plant uses a small amount of oil and bio-oil. The dust emission factor is substantial higher compared to the coal power plants [7-16 g/GJ oil] but related to the total energy input it is low (0.14 g PM10/GJ oil and gas)

Table 1.15 Emission factors for Dutch power plants [g PM10/GJ fuel]

Particulates (PM10)	2000	2001	2002	2003
Coal power plant with wet FGD	0.5/1.7	0.4/1.6	1.0/0.9/0.1/0.5	0.2/0.2/0.7
Coal Gasification (80% storage and not combustion)	0.7	0.9		
Conventional gas and oil plant (emission related to oil and bio-oil burning)			16	7 (0.14 total input)

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IGCC is an inherently “clean” technology, but seems still to be more costly then a conventional PP which meets actual LCP constraints.

§ Page 41 BREF document.

Table 1.16: Options proposed for dedusters

Fuel	Technology	Achieved abated emission factor [mg/Nm ³]
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

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Although the documents makes reference to BREF, not all latest figures from the BREF document seem to be used as reference values in the EGTEI document. Page 41, for instance, shows 4 Deduster options for each Hard and Brown coal, with an achieved abated emission factor of 20 mg/Nm³ as a minimum. The latest (draft) version of the BREF document, shows at

² The variation in one power plant can be substantial. One plant reported three measurements 9.8, <1.0 and 7.0 mg/Nm³ (mean value 5.6 mg/Nm³). Because one electric field (of five) in the ESP was temporary out of order during the test, the mean value was set on 1.89 mg/Nm³.

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page 255 that an emission factor of 5 to 10 mg/Nm³ should be used as a norm for new and for retrofitted plants larger than 300 MW. (for a combination of deduster and WFGD)
 Again, we are very close to the BAT associated emission levels and have in this exercise to take into account the availability of the treatment plant.

It is therefore questionable whether there is a need to formulate 4 dedusters (page 43), of which only one (deduster 4) is BAT (or worse than BAT). Why are there no options to reduce the dust emission further? In this way, even common practice can hardly be simulated, and additional options for pm10 and pm2.5 reduction cannot be evaluated.

Again, we have to take into account the situation in 40 countries and the objectives proposed are drivers for the majority of these countries.
 In addition, other preliminary steps of improvement are necessary for some countries.

These hypotheses lead to drastic emission reduction for France (99,3 to 99,36% in 2010).

Table 1.17: 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

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We would also be very interested by a collection of input data by the Netherlands.
 Could you describe the additional options which could be taken into account for PM10 and PM2.5 ?

Table 1.18: Alternative proposal figures for solid fuels [EURELECTRIC, Manufacturers]

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

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Table 1.19: Proposed figures for liquid fuels [EURELECTRIC, Manufacturers]

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

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Cost figures are checked and most figures are within normal range. Only the labor demand in table 3.42 is set on 5 person year. Other sources report only minor labor demand. We think that 5 person year very is high.

Synergy effect(s).

It is known that in Wet FGD, in addition to SO₂ removal, removes also 90% of the remaining particulate matter after dedusting (see for instance the Dutch emission data in [Table 1.15](#)). Is this taken into account? We could not find it in the document. If not, the emission factor in RAINS for PM may end up a factor 10 larger than in practice. This kind of synergy effects may be a general point of attention.

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EGTEI has tried to take this aspect into account considering that no additional cost has to be considered from 45 mg/Nm³ to 20 mg/Nm³ if a wet FGD has already been installed (see page 40 – 3.4.3.1).

1.6 Conclusions

- The cost figures in the report are within range of Dutch figures.
- The NO_x reduction effect of the options is lower than usual. If this is put in the RAINS model, the effect will be: higher NO_x reduction costs or/and higher remaining NO_x emissions. EGTEI comment : this is not true especially if you compare the EGTEI proposals with the current RAINS hypotheses.
- Upgrading of the SO₂ removal efficiency of existing FGD installation is a missing option. (EGTEI comment : it will have to be considered after implementing in the RAINS model an option allowing to combine the use of low sulphur fuels and scrubbing)
- Non combustion dust emission from coal storage or fly ash handling at combustion locations looks missing. (EGTEI comment : agreed, but difficult to implement at the moment)
- The removal effect is missing of particulates from a wet FGD after a deduster (EGTEI comment : EGTEI has tried to take this aspect into account considering that no additional cost has to be considered from 45 mg/Nm³ to 20 mg/Nm³ if a wet FGD has already been installed (see page 40 – 3.4.3.1)
- It looks there are no data on gas turbine power plants in this document. Because this is the main new technology, they should be added. To use this in the RAINS model a country could specify the percentage of the gas used in a conventional power plant and in a gas turbine power plant. (EGTEI comment : the current approach using a specific and identified fuel may be used but EGTEI will examine this technology in the future in order to better take it into account)
- The data does not give a good overview of the emission reduction options in the total calculation period of RAINS. At this moment, only conventional reduction options are in the report. For use in the RAINS model additional options should be added as well. For the period after 2010 options, which are now in the demonstration phase, are relevant. In addition, improved conventional options with a higher efficiency (and higher cost) should be formulated. (EGTEI comment : emerging (future) technological options will need to be addressed at a later stage. EGTEI begins with the current state of the art as it is not yet fully accurately described in the RAINS model).
Another group deal with emerging technologies. Its final report will be soon available on the EU DG environment web-site and may be used to improve some modelling aspects.

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