

PETROLEUM INDUSTRY: FLUID CATALYTIC CRACKING UNIT

SYNOPSIS SHEET

PREPARED IN THE FRAMEWORK OF EGTEI

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1 Activity description and EGTEI contribution – summary

Within a refining complex, one of the sources with major potential for atmospheric emissions is the catalytic cracking unit. Emissions from an FCC can be 20-30 % of total refinery SO₂ emissions, 15-30 % for NO_x and 30-40 % of particulates. [1]

This sector was not considered as an individual sector in the previous NO_x and SO₂ version of RAINS [3, 4], and **EGTEI has been able to develop an approach for representing this sector and to estimate costs of reduction techniques. The methodology for this sector was developed in close cooperation with CONCAWE and with experts from TOTAL, SHELL and ADEME.**

The representative unit used is the ton of oil throughput. One reference installation (RI) has been defined. EGTEI defines different abatement measures. However, as for dust, the group of experts defines as first abatement measures **higher stage cyclones** and agreed that it would not be relevant to distinguish between bag filters and ESP. A **“deduster”** was defined. For NO_x abatement measures, **only secondary measure** may be implemented. For SO₂ abatement measures, the DeSO_x catalyst additive option and the wet scrubber option have been defined.

EGTEI provides default emission factors (EF) with abatement efficiencies, investments and variable and fixed operating costs (OC) as well as unit costs (€/t pollutant abated and €/activity unit) for the different abatement measures.

National experts only need to collect **6 country specific parameters** (wages, electricity, ammonia price, catalyst cost, limestone cost and zeolithe cost) and **5 country and sector specific parameters** (activity level, the different pollutant emissions and the application rate of one DeSO_x abatement technique). EGTEI provides default costs for country and specific parameters which can be used if no better data exist. Knowing the sector specific parameters then allows to properly describe the sector and to calculate the application rate of each abatement technique.

Recently, this specific sector doesn't properly exist in the RAINS modules. In the future however, new technological developments should be considered by EGTEI to continuously update the background document and hence the representation of the sector.

2 Representation of the sector in RAINS¹

In the RAINS model of the year 2003, which has been used for elaborating the background document, the sector of FCC Unit was part of the RAINS sector “PR_REF” (Other industrial Processes – Petroleum Refining) [2, 3, 4].

3 Status of EGTEI

EGTEI has developed an approach for representing the FCC Unit sector and estimating costs of reduction techniques. The methodology used for this sector was developed in close cooperation with CONCAWE and with experts from TOTAL, SHELL and ADEME.

4 Methodology developed within EGTEI to represent the sector

4.1 Definition of reference installation

According statistics from CONCAWE (average capacity of FCC in European refineries = 40,331 bpsd), one Fluid Catalytic Cracking Units (FCC U) with a capacity of 2,000 kt/a is proposed as reference installation for the activity of “processes in oil refining”.

Table 4.1: Reference Installations

Reference Code	Technique	Fuel	Capacity [MWth]
01	Combustion unit	Heavy fuel oil	50

¹The latest modified versions of the RAINS modules have not been considered. Here we refer to the RAINS model of the year 2003

02	Combustion unit	Gas	50
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4.2 Definition of emission abatement techniques and proposed techno-economic data

4.2.1 Dust abatement techniques

Concerning dust, different configurations of **cyclones** may be used. The performance range may be greatly variable but as average an efficiency of 80% could be taken. The second option is an end of pipe technology like bag filters and ESP with much better performances. This option could be named "deduster".

Table 4.2.1.1: Abatement Measures for dust

Description	PM abatement efficiency [%]	TSP emission factor (mg/Nm ³)	TSP emission factor (kg/t feed)
None (two stage cyclone)	-	600	0.36
Higher stage cyclones	80	120	0.072
Deduster(EP and bag filter)	97.5	15	0.009

Table 4.2.1.2: Investments and Operating costs for dust abatement

Description	Investment (k€)	Fixed Operating costs (%/a)	Variable Operating costs (€/t)	Total Operating costs (€/t)	Cost per tonne TSP abated (€/t) ⁽¹⁾	Cost per tonne of feed (€/t) ⁽¹⁾
None	-	-	-	-	-	-
Higher stage cyclones	2,000	4	0.039	0.16	702	0.202
Deduster(EP and bag filter)	3,500	4	0.094	0.286	6,020	0.38

⁽¹⁾: Case of France

4.2.2 NO_x abatement techniques

No primary measures are installed but the SCR and SNCR (in very few plants) technologies may be implemented.

Table 4.2.2.1: NO_x abatement measures for each reference installation

Description	NO _x abatement efficiency [%]	NO _x emission factor (mg/Nm ³)	NO _x emission factor (kg/t feed)
None	-	500	0.3
Secondary technology	80	100	0.06

Table 4.2.2.2: Investments and Operating costs for NO_x abatement measures

Description	Investment (k€)	Fixed Operating costs (%/a)	Variable Operating costs (€/t)	Total Operating costs (€/t)	Cost per tonne of NO _x abated (€/t) ⁽¹⁾	Cost per tonne of feed (€/t) ⁽¹⁾
None	-	-	-	-	-	-
Secondary technologies	4,815	4	0.177	0.27	2,100	0.59

⁽¹⁾: Case of France

4.2.3 SO₂ abatement techniques

For SO_x abatement techniques, the **DeSO_x catalyst additive option** may be considered as a measure (efficiency of 40 to 50%).

The most performing options (**Wet scrubbing**...) could be considered in another category.

Table 4.2.3.1: SO₂ abatement measures

Measure Code	Abatement technique	Efficiency (%)	Emission factor (mg/Nm ³)	Emission factor (kg/t feed)
00	-	-	3,500	0,0021
01	DeSO _x catalyst additive option	45	1,900	0,0012
02	Wet scrubber	90	350	0,00021

Table 4.2.3.2: Investments and Operating costs for SO₂ abatement measures

Description	Investment (k€)	Fixed Operating costs (%/a)	Variable Operating costs (€/t)	Total Operating costs (€/t)	Cost per tonne of SO ₂ abated (€/t) ⁽¹⁾	Cost per tonne of feed (€/t) ⁽¹⁾
None	-	-	-	-	-	-
DeSO _x catalyst additive option	500	4	1.25	1.25	1,366	1.29
Wet scrubber	8,000	4	0.93	1.9	837	1.58

⁽¹⁾: Case of France

5 Country specific data to be collected

Different types of country specific data have to be collected to give a clear picture of the situation in each Party. EGTEI proposes default values for the economic parameters which can be modified by the national expert if better data are available.

For the sector, country specific economic parameters are used to calculate variable operating costs. They are presented in table 5.1 as default costs proposed by EGTEI (these costs are entered only once in the ECODAT database tool).

Table 5.1: Country specific costs

Parameters	Default costs provided by EGTEI	Country specific costs
Electricity [€/kWh]	0.0569	To be provided by national experts
Wages [€/h]	37,234	To be provided by national experts
Ammonia price [€/t _{NH3}]	400	To be provided by national experts
Catalyst cost [k€/m ³]	15	To be provided by national experts
Limestone cost [€/t _{lime}]	20	To be provided by national experts
Zeolithe cost [€/t _{zeolithe}]	18,300	To be provided by national experts

Default data have been used to calculate variable and annual abatement costs presented in tables 4.2.1.2; 4.2.2.2, 4.2.3.2.

Information concerning activity levels from 2000 to 2020 as well as the description of the control strategy is also necessary (these data can be directly entered in the database ECODAT). A full specification of the work to be done by national experts is provided in the general EGTEI methodology.

Table 5.2: Activity level for Reference Installation (t feed / year)

RIC	2000	2005	2010	2015	2020
01					

National experts can also modify - in a range of ± 10% - the default unabated emission factor proposed by EGTEI to represent the reference situation of the sector for all Parties.

Table 5.3: Unabated emission factor [kg/ t feed]

Pollutants	Default data mean	User input mean
EF NO _x	0.48	To be provided by national

		expert
EF PM _{TSP}	0.36	To be provided by national expert
EF SO ₂	2.4	To be provided by national expert

6 Application rate and applicability of each abatement technique

The national experts are kindly asked to provide for each abatement technique its application rate and its applicability in 2000, 2005, 2010, 2015, 2020. If a national expert has this information at hand, he can fill in the different tables described in paragraphs 6.1, 6.2 and 6.3. If not, a methodology is described in the background document [5].

Table 6: Input parameters needed to calculate application rates

PARAMETER	2000	2005	2010	2015	2020
E _{NOx} Emission of NO _x [t]					
E _{SOx} Emission of SO ₂ [t]					
E _{dust} Emission of Dust [t]					
Na: Activity level (t feed per year)					
Application rate of one DeSO _x abatement technique					

6.1 Dust abatement measures

Table 6.1: Application rate and applicability for dust abatement measures

Description	Application rate in 2000 [%]	Application rate in 2005 [%]	Applicability [%]	Application rate in 2010 [%]	Applicability [%]	Application rate in 2015 [%]	Applicability [%]	Application rate 2020 [%]	Applicability [%]
None (two stage cyclone)									
Higher stage cyclones			100		100		100		100
Deduster(after a cyclone)			100		100		100		100

6.2 NO_x abatement measures

Table 6.2: Application rate and applicability for NO_x abatement measures

Description	Application rate in 2000 [%]	Application rate in 2005 [%]	Applicability [%]	Application rate in 2010 [%]	Applicability [%]	Application rate in 2015 [%]	Applicability [%]	Application rate in 2020 [%]	Applicability [%]
None									
Secondary technology			Cyclone application rate		Cyclone application rate		Cyclone application rate		Cyclone application rate

6.3 SO₂ abatement measures

Table 6.3: Application rate and applicability for SO₂ abatement measures

Description	Application rate in 2000 [%]	Application rate in 2005 [%]	Applicability [%]	Application rate in 2010 [%]	Applicability [%]	Application rate in 2015 [%]	Applicability [%]	Application rate in 2020 [%]	Applicability [%]
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None									
DeSOx catalyst additive option									
Wet scrubber									

7 Relevance of EGTEI information for Integrated Assessment Modelling (IAM)

In the RAINS model of the year 2003, which has been used for elaborating the background document, the sector of FCC Unit was part of the RAINS sector "PR_REF" (Other industrial Processes – Petroleum Refining) [2, 3, 4]. Thus, emission factors, abatement techniques and costs considered were not specific to this sector and it was very difficult to define a reduction scenario.

EGTEI now provides an approach to specifically consider the sector. The approach has been developed in close cooperation with industry.

8 Perspective for the future

In the future, new production technologies which could gain relevant market shares should be considered by EGTEI in the background document to continuously develop the representation of the sector.

9 Bibliography

- [1] Reference document on best available techniques for mineral oil and gas refineries, IPPC, Sevilla, 2001.
- [2] Nitrogen oxides emissions, abatement technologies and related cost for Europe in the RAINS model database, IIASA, 1998. <http://www.iiasa.ac.at/~rains/reports/noxpap.pdf>
- [3] Sulfur emissions, abatement technologies and related cost for Europe in the RAINS model database, IIASA, 1998. <http://www.iiasa.ac.at/~rains/reports/so2-1.pdf>
- [4] Modelling Particulate Emissions in Europe, A framework to Estimate Reduction Potential and Control Costs, IIASA, 2002. <http://www.iiasa.ac.at/rains/reports/ir-02-076.pdf>
- [5] Draft Background document on the sector of the petroleum industry prepared in the framework of EGTEI

ANNEXE: Example of data collection and use of EGTEI data – Case of France
A. Country specific data collection and scenarios developed

For the moment, no French data has been collected for this sector.