“Capacity Building and Strengthening Institutional Arrangement”

Workshop: Quantitative risk assessment of oil and gas plants

Oil and gas Integrated Pollution and Prevention Control (IPPC) and relative Best Available Technologies (BAT)

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Oil and gas environmental impacts

- ***Refineries*** generate emission to the air, discharges to water and also waste.
- Most pollutants are emitted to streams that are transboundary in nature.
- As consequence many of the environmental policies and regulations with respect to oil refining are to a large extent influenced by international developments (EU-directives and other international regulations).
- These regulations focus on product quality, refinery emissions and, more recently, on environmental reporting.
- The issue of emergency procedures is normally included in the external safety report and in the permit for the location.

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- **Legislation affecting emissions to air:**
  - National Emission Ceiling Directive;
  - Air Pollution Protocol (Gothenburg Protocol, 1 December 1999);
  - VOC prevention during transfer of liquids;
  - Air Quality Directive (AQD);
  - EC Large Combustion Plant Directive.

Oil and gas environmental impacts

- **Legislation affecting emissions to water**

There is an OSPARCOM Decision (89/5) which sets an oil limit for refinery discharges.

- **Legislation affecting other issues**

- Environmental Impact Assessment (EIA);
- External safety (post-Seveso guideline, EU (82/501));
- Some EU and international emission limit values:
    - SO_2 for existing plants in the refinery:
      overall limit to 1.700 mg/Nm3(bubble);
      new refinery plants limit to 1.000 mg/Nm3;
      new refinery installations (proposed limit) to 450 mg/Nm3.
    - Particulates (PM) 50 mg/Nm3.

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Italy

- ***MTD***- Guidelines for identification of BAT, October 2005.
- The maximum allowable SO2 refinery emission concentration (as bubble) permitted in 2000 will be 1.700 mg/Nm3.

Oil and gas environmental impacts

World Bank

- The following guidelines present emission levels normally acceptable to the World Bank Group in making decisions regarding provision of World Bank Group assistance; any deviations from these levels must be described in the World Bank Group project documentation.
- The guidelines are expressed as concentrations to facilitate monitoring.
- Dilution of air emissions or effluents to achieve these guidelines is unacceptable.
- All the maximum levels should be achieved for at least
- 95 % of the time that the plant or unit is operating, to be calculated as a proportion of annual operating hours. [World Bank, 1998].

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Air Emissions - World Bank

Parameter (mg/Nm3)	Maximum value
Particulate matter (PM)	50
Nitrogen oxide (NOx)* (as NO2)	460
Sulphur oxide (SOx) (as SO2)	50 for sulphur recovery units and 500 for other units
Nickel and vanadium (combined)	2
Hydrogen sulphide	15

- Excluding NOx emissions from catalytic units.

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Liquid effluents - World Bank

Parameter	Maximum value milligrams per litre (mg/l)
pH	6 - 9
BOD	30
COD	150
Total suspended solids	30
Oil and grease	10
Chromium (hexavalent)	0.1
Chromium (total)	0.5
Lead	0.1
Phenol	0.5
Benzene	0.05
Benzo(a)pyrene	0.05
Sulphide	1
Nitrogen (total)	10
ΔT (ºC)	Less than or equal to 3

Oil and gas environmental impacts

Solid Wastes and Sludges - World Bank

- Generation of sludges should be minimised to 0.3 kg/tonne of crude processed with a maximum of 0.5 kg/tonne;

- Sludges must be treated and stabilised to reduce concentrations of toxics (such as benzene and lead) in leachate to acceptable levels (such as levels below 0.05 mg/kg).

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Ambient Noise - World Bank

- Noise abatement measures should achieve either the following levels or a maximum increase in background levels of 3 dB(A).
- Measurements are to be taken at noise receptors located outside the project property boundary.

Receptor	Maximum dB(A)
- Residential; institutional; educational	Ldn 55
- Industrial; commercial	Leq (24) 70

- The emission requirements given here can be consistently achieved by well designed, well operated and well maintained pollution control systems.

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Examples

1. *Calculation of the cost-effectiveness of the implementation of a technique in a hypothetical case:*

- Most studies on environmental technologies, present the cost and effectiveness (percent of emission reduction or tonnes of emissions reduced) of installing a technology or implementing a technique against an uncontrolled baseline operation.
- In this case it is easy to calculate the cost effectiveness of an environmental technology versus an otherwise uncontrolled facility by simply dividing the cost of the technique by the emissions reduction achieved.

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Technology	Percentage of reduction (%)	Remaining Emission (tonnes)	Technology cost for a new installation (kEUR)
A	0	10000	0
B	20	8000	1000
C	50	5000	2000
D	60	4000	3000
E	90	1000	4500
F	95	500	7000
G	99	100	12000

This table shows a series of various hypothetical controls capable of reaching various percentage emission reductions.

For example, Technology C would provide a 50% reduction for a cost of 2.000 k EUR while Technology G would provide 99% reduction for 12.000 k EUR.

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- As can be seen in the table, if technology C is already in place at a location, the additional emissions reduction for going to technology G would be only 49%.
- The cost of implementing technology G therefore becomes:

12.000 kEUR/4.900 t = 2.45 kEUR/tonne

for the incremental emissions reductions, rather than:

12.000 kEUR/9.900 t = 1.21 kEUR/tonne

when going to 99% control from 0%.

- In the case of implementing technology G in a location where technology E was in place, the incremental cost would be:

12.000 kEUR/900 t = 13.3 kEUR/tonne.

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- The actual cost for going to the 99% level in these situations, if done incrementally, would effectively be the cost of implementing Technology C plus E, plus G, to get the 99% reduction.
- This Table shows the resultant cost of applying various technologies starting from different levels of existing control.

Actual level of control Targeted level of control	0%	20%	50%	60%	90%	95%
20%	0.5	-	-	-	-	-
50%	0.4	0.67	-	-	-	-
60%	0.5	0.75	3	-	-	-
90%	0.5	0.64	1.12	1.5	-	-
95%	0.74	0.93	1.55	2	14	-
99%	1.21	1.52	2.45	3.07	13.3	30

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2. *Cost-effectiveness data for Sulphur Recovery Unit (SRU):*

Name of the technique	Specific cost (1) EUR/tonne SO_2	Specific cost (2) EUR/tonne SO_2
3rd reactor		32
Stand Alone Scot	321-538	32
Cascade Scot Common regenerator		32
Super Claus	155-228	32-161
Super Claus + Claus Stage		32-160
Clauspol	198-330	32
Sulfreen	174-288	32-160
Hydro-sulfreen	253-417	32-160
CBA/AMOCO cold real absorption	169-300	-

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(1) [TWG, 2001]

Calculations for this column have been performed based on the following hypothesis:

- The TGCU selling costs include license fee, catalyst and chemical first loads. These investments are financed by a full reimbursable loan.
This loan is based on a 10 years basis, with a yearly 6% interest rate.

- The catalyst life-time is 3 years (part of the operating costs). The related investment every 3 years is financed by a full reimbursable loan.
This loan is based on a 3 years basis, with a yearly 6% interest rate.

- The solvent and chemical make-up (part of the operating costs) have been calculated on a yearly basis as a cash expense.

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- The utilities consumption and production as well as the supervision manpower costs have been considered constant over the time.
- The sulphur selling price has also been considered constant over the time.

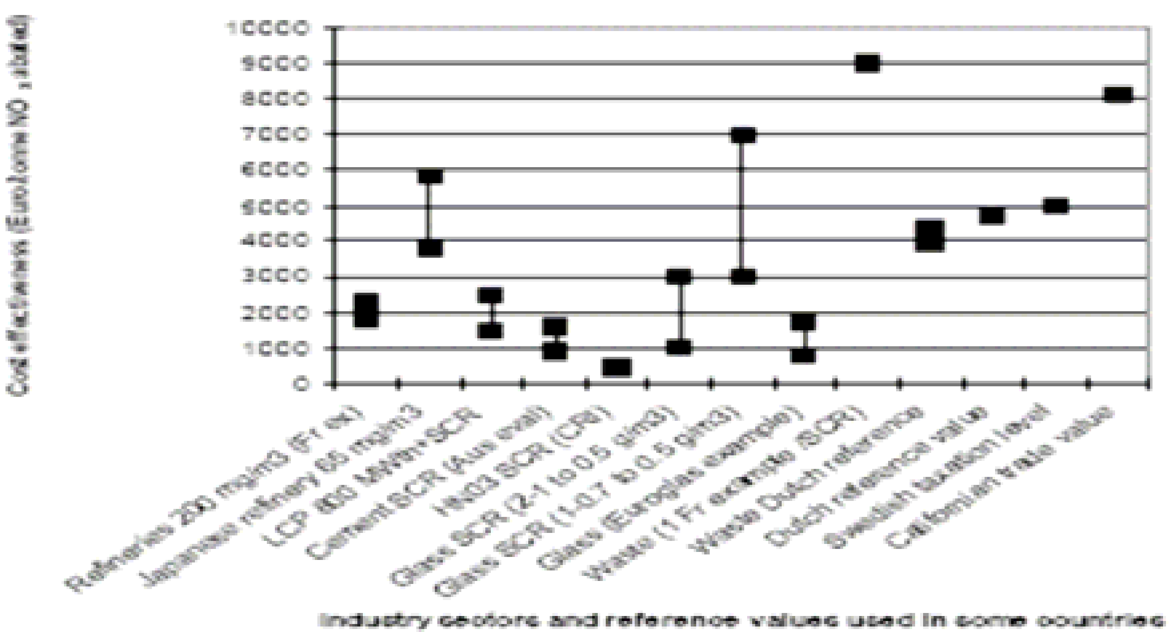
(2) [CONCAWE, 1999]

Claus plant with a capacity of 30.000 t/yr sulphur production (sulphur recovery efficiency 94-96% for a two stage unit), a volume of gas treated of 60 million m3/yr, and pollutant initial concentration:
34.000 mg SO2/m3

Oil and gas environmental impacts

3. Cost-effectiveness data for some NOx abatement techniques:

- The following graph shows the cost to abate a tonne of NOx in industry sectors as well as some reference values used in some countries [Ademe, 2001]



Oil and gas environmental impacts

4. NOx Control for Fired Heaters and Boilers Firing Refinery Blend Gas:

- Basis: 100 Giga joules/hr installation;

Retrofit of existing unit; Refinery blend gas firing;

Uncontrolled NOx emissions of 150 ppm at 3% oxygen (300 mg/Nm3)

Exchange rate of 1 EUR = 1.25 U.S. dollar and capital and operating costs escalation of 4%/yr have been used in this analysis.

	Flue Gas Recirculation plus Low NO_x Burner [4]	Ultra Low NO_x Burners	SNCR	SCR	Ultra Low NO_x Burner plus SCR
Cost Effectiveness EUR/tonne NO_x Removed (incl. capital charge @ 15%)	2000-4300 [6]	650 [1] 600-700 [2] 1700-5000 [3]	2000-2500 [3] 1800-4300 [4]	8300-9800 [2] 12000 [3] 4200-9000 [4]	9100-10500 [3] 9000 [5]
NOx reduced (%)	*70*	*75*	*60*	*90*	*90+*

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5. *NOx Control for Fired Heaters / Boilers Firing Residual Fuel Oil*

Basis: 100 Giga joules/hr installation

Retrofit of existing unit; Residual Oil firing;

Uncontrolled NOx emissions of 250 ppm at 3% oxygen (500 mg/Nm3)

Exchange rate of 1 EUR = 1.25 U.S. dollar and capital and operating costs escalation of 4%/yr have been used in this analysis

	Boilers			Heaters
	Low NO_x Burners (2)	SNCR	SCR	Low NO_x Burners (1)
Cost Effectiveness		1500-2800	5000-8000	
EUR per tonne NO_x Removed	500-1800	1500-4300 (2)	4500-10200 (2)	500-1800
(Incl. capital charge @ 15%)				
NOx reduced (%)	*40*	*60*	*75*	*40*

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6. NOx Control for Gas Turbines Firing Natural or Refinery Blend Gas

Basis: 85 MW output turbine (representative of a GE Frame 7 size unit) (electrical output); Natural gas or refinery blend gas firing; Uncontrolled NOx emissions of 250 ppm at 15% oxygen (350 g/GJ)

Exchange rate of 1 EUR = 1.25 U.S. dollar and capital and operating costs escalation of 4%/yr have been used in this analysis.

	Dry Low NO_x Combustors	Steam Injection	SCR	Steam Injection plus SCR	Dry Low NO Combustors plus SCR
Cost Effectiveness EUR/tonne NO_x Removed (includes capital charge @ 15%)	350 [4]	1500 [1]	1700-8000 [2]	3800 [illegible] 3600 [illegible]	7600 [illegible]
NOx reduced (%)	*90*	*80-90*	*90*	*98-99*	*98*

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7. *NOx Control for Fluid Catalytic Cracking Units*

Basis: 30 k bbl/day FCCU with CO Boiler;
800 mg/Nm3 uncontrolled NOx emission

Exchange rate of 1 EUR = 1.25 U.S. dollar and capital and operating costs escalation of 4%/yr used in this analysis.

	SNCR	SCR	Feedstock Hydrotreating
Cost Effectiveness EUR/tonne NO_x Removed (includes capital charge @ 15%)	1900	2800-3300	28000 [3]
NOx reduced (%)	*60*	*85*	*until 85*

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8. Cost Effectiveness of some already applied NOx abatement techniques in USA refineries.

	Low-NO_x Burners (LNB)	Selective Catalytic Reduction (SCR)	Selective Non-Catalytic Reduction (SNCR)
Cost Effectiveness EUR/tonne NO_x Removed	1260-4500	6300-21600 (for process heaters and boilers) Approx. 5940 for the FCCU described in the report	2070-6030 (for process heaters)

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9. Feasibility study on the applicability of NOx environmental measures in two different refinery sites

- Combined scenarios of the potential applicability of these BAT are presented for the both sites and for similar environmental objectives based on a global NOx bubble concentration.
- Cost impact is different for each existing site to be retrofitted and is very expensive according to the environmental objectives to be reached.
- This technical feasibility and economic considerations have to be remembered in the context of the BAT associated emissions levels to be proposed, taking into account the complexity of retrofitting due to the difference in the current European existing refinery sites.

Oil and gas environmental impacts

Site A	Objectives	400 mg/Nm^3	300 mg/Nm^3	200 mg/Nm^3
Investment	kEuro	3000	6800	13000
Annual Cost	kEuro	1070	2150	4150
Cost/t NO_x abatted /yr	Euro	1170	1680	1860
	techniques	LNB - SNCR	LNB - 1 SCR	LNB - 3 SCR

Site B	Objectives	400 mg/Nm^3	300 mg/Nm^3	200 mg/Nm^3
Investment	kEuro	3800	8620	17900
Annual Cost	kEuro	930	2600	5350
Cost/t NO_x abatted /yr	Euro	1100	1770	2350
	techniques	LNB - recircul.	reburn - SCR	SCR with exch.

Oil and gas environmental impacts

References

- Integrated Pollution Prevention and Control (IPPC).
  Reference Document on Best Available Techniques for Mineral Oil and Gas Refineries - February 2003.