PROCESSES IN REFINERIES AND EMISSIONS OF NMVOC

SYNOPSIS SHEET

Prepared in the frame work of EGTEI

1. Activity description and EGTEI contribution

NMVOC emissions from refineries originate from 4 main sources:

- fugitive emissions from piping associated with nearly all process steps, scattered throughout a refinery,
- the flare system: flares are used for safety and environmental control of discharges of undesired or excess combustibles and for surges of gases in emergency situation or upsets [2],
- the waste water treatment plant: waste water treatment systems employed in refineries include neutralisers, oil/water separators, settling chambers, clarifiers, dissolved air flotation systems and activated sludge ponds.
- storage tanks and refinery dispatch stations.

This synopsis sheet refers only to the three first sources. Emissions from storage tanks and refinery dispatch stations might perhaps covered by EGTEI in the future if priority is given to those sectors. With the first three emission sources, EGTEI is in coherence with the present RAINS structure for this sector.

In RAINS, NMVOC emissions from refineries are considered under REF-PROC. At a EU25 level for the year 2000 (according to the RAINS model: version CP_CLE_Aug04(Nov04)), NMVOC emissions were 203 kt representing 3.8 % of total NMVOC emissions [6] for 699.5 Mt crude processed. These estimations could be modified in a near future due to information delivered by national experts during the bilateral consultations scheduled in 2005.

Refineries are addressed by the EC Directive 96/61/EC of council of 1996, September 24th related to Integrated Pollution Prevention and Control (IPPC) [7]. No direct emission limits are introduced by this directive. Nevertheless permit emission limit values have to be based on BAT performances.

Processes in refineries and NMVOC emissions were considered as a unique sector in the previous RAINS [5] version. EGTEI provides no real new approach to tackle this complex sector but attempt to update emission factors and costs of emission reduction techniques. On contrary to what has been provided for the development of an EGTEI proposal for steam cracking and down stream units in the chemical industry [9], there is a lack of data on NMVOC emissions from refineries especially in Europe. This has to be highlighted. For the time being, costs of reduction measures are associated with considerable uncertainties. Data provided by EGTEI, emission factors, efficiencies and costs of reduction techniques have to be considered as a first attempt of definition. The work should be updated and improved with more robust information. However some EGTEI proposals have been considered in the new RAINS version [6].
The methodology for this sector has been prepared on the basis of information provided by CONCAWE experts [12] or administration experts [14] and literature information such as [1], [2], [3], [4], [10], [11] and using the same methodology for estimation of fugitive emission reduction costs as those developed for the chemical industry in cooperation with UIC and CEFIC [9].

Only one reference installation is considered.
Five combinations of primary measures based on two different leak and detection and repair programmes (LDAR1 and LDAR2) and treatment of waste water system emissions are considered.

EGTEI provides default emission factors (EF) with abatement efficiencies, investments, variable and fixed operating costs (OC) as well as unit costs expressed in €/t NMVOC and €/kt crude oil throughput for the five reduction combinations.

Unit default costs range from 129 to 523 €/t NMVOC abated according to the reduction measure considered and from 16 to 54 €/kt crude oil.
National experts have to collect only one country specific economic parameter (wage costs) and one country and sector specific economic parameter (crude oil cost). This last parameter can be very easily known through the petroleum industry. National experts have also to provide the trend in crude oil throughput from 2000 to 2020 as well as the application and applicability rates of each abatement measure in refineries.

As mentioned above the background document needs updates and completion for reducing uncertainties on emission factors and costs. In the future, any new technology which could be

developed should be considered by EGTEI in the background document to continuously improve the sector representation and the EGTEI capacity to describe new technologies. It should be necessary to review the considered efficiencies regularly to update them and perhaps define an additional reduction technique if necessary.

2. European regulation

Processes in refineries are addressed by the EC Directive 96/61/EC of council of 1996, September 24th related to Integrated Pollution Prevention and Control (IPPC) [7]. The directive does not introduce emission limit values but permit emission limit values have to be based on BAT performances. BATs are described in the BREF document [2].

3. Methodology developed within EGTEI to represent the sector

3.1 Definition of the reference installation

For simplification reason and due to the lack of data which could enable to link costs to the complexity of the refinery, only one reference installation is taken into account. Its size is defined by the crude oil input. Its capacity is 5 Mt/y of crude oil.

A flare system equips the reference installation. It can be indeed considered that flare systems are present in all refineries in Europe. Flare systems are mainly used for safety reasons (during start up period, shutdowns and emergency).

Table 3.1.1: Definition of the reference installation

Reference Installation Code (RIC)	Description
01	Medium refinery type II – crude oil processed: 5.0 Mt per year Configuration 2 – catalytic cracker [2]. Number of points: 100 000 [12]. Elevated flare system present.

The number of points is derived from information provided by CONCAWE [17] (In fact the number of points depends on the borders of the installation considered).

It has to be outlined that the measurement techniques used in Europe to estimate fugitive emissions from processes in refineries are not yet well defined. Emissions depend on the methodology used. The EPA 21 method [8] can be used sometimes. Other methods exist and give different results [11], [10].
The EPA 21 method presents several estimation techniques (emission factors, generic correlations for refineries). Each of these techniques gives different results and this has consequences on the cost effectiveness of the LDAR programmes. Total emissions from the sources considered under this activity are assumed to be 310 t NMVOC/Mt crude oil when no control measure is used. Fugitive emissions are estimated to 250 t/Mt but this emission factor is associated with high uncertainties.

The number of leaks in different leak ranges of the reference installation has been estimated to be in coherence with the emission factor presented above and with the use of correlation equations provided by the US EPA for refineries [8]. From a monitoring result expressed in ppm of NMVOC around a leaking point, the generic EPA correlations give a quantity of VOC emitted in kg/point/hour. No monitoring results have been obtained.
It has to be kept in mind that the use of specific correlations which can be derived by industry for some processes gives lower emissions than the use of generic equations provided by EPA. The CEN [13] is presently working on the redaction of a standard for the determination of NMVOC leaks from process equipment. In this document, the use of EPA correlations is recommended if user defined correlations are not available.

3.2 Definition of emission abatement techniques

3.2.1 Primary measures

Fugitive emissions can be reduced through a Leak Detection And Repair programme (LDAR) [8].

The technique for LDAR consists in measuring the VOC concentrations in the atmosphere around the potential leaking point, then selecting equipments leaking over a defined threshold value and finally operating a repair on those leaking items.

A LDAR programme is established according to the following principles:
- The definition of what constitutes a leak and fixation of corresponding thresholds,
- The fixation of the frequency of inspections,
- The listing and identification of components included,
- The procedures concerning repair of leaking components depending on the leak category.

2 LDAR programmes are considered for cost estimation. They differ from the leak thresholds considered and type of maintenance carried out. Repair procedures related to leak category considered in primary measures are indicated in table 3.2.1.1.

Covers on the oil water separators with good oil removal facilities reduce evaporation. Efficiency ranges from 80 to 90 % according to reference [2].
An efficiency of 90 % is taken into account or 4 g NMVOC / t crude oil.

Table 3.2.1.1: Measures of reduction considered

Primary Measure Code PMC	Description
00	• No control of fugitive emissions • Basic waste water collection and treatment system control (housekeeping improvements to minimise hydrocarbons and solids entering the waste water system, installation and optimisation of stripper plus installation of water seals (traps) on sewage systems and process drains and separation of drain systems for process areas from storm sewer systems).
01	• No control of fugitive emissions • Completely closed waste water collection and treatment system (fixed roof and vapour collection or floating roof and vapour recovery or floating cover on primary separator)
02	• Establishment of the LDAR1 programme Inventory of all components and establishment of a database. First survey of all potential leak points of the plant (100 % of accessible points are considered and controlled), analysis of the first results of the survey. Tightening for points > 5 000 ppm Basic maintenance for 100 % points > 100 000 ppm during first shut down. Intermediate campaign before shutdown: 20 % of accessible points are controlled each year (in five years all points are controlled). Tightening each year for 100 % controlled points > 5 000 ppm. Next Shutdown. Basic maintenance for 100 % measured points (during the 5 years) > 100 000 ppm. • Basic waste water collection and treatment system control (housekeeping improvements to minimise hydrocarbons and solids entering the waste water system, installation and optimisation of stripper plus installation of water seals (traps) on sewage systems and process drains and separation of drain systems for process areas from storm sewer systems).
03	• Establishment of the LDAR1 programme • Completely closed waste water collection and treatment system (fixed roof and vapour collection or floating roof and vapour recovery or floating cover on primary separator)

04	• Establishment of the LDAR2 programme Inventory of all components and establishment of a database. First survey of all potential leak points of the plant (100 % of accessible points are considered and controlled), analysis of the first results of the survey. Tightening for points > 5 000 ppm Basic maintenance for 100 % points > 5 000 ppm during first shut down. Intermediate campaign before shutdown: 20 % of accessible points are controlled each year (in five years all points are controlled). Tightening each year for 100 % controlled points > 5 000 ppm. Next Shutdown. Basic maintenance for 100 % measured points (during the 5 years) > 5 000 ppm. • Basic waste water collection and treatment system control (housekeeping improvements to minimise hydrocarbons and solids entering the waste water system, installation and optimisation of stripper plus installation of water seals (traps) on sewage systems and process drains and separation of drain systems for process areas from storm sewer systems).
05	• Establishment of the LDAR2 programme • Completely closed waste water collection and treatment system (fixed roof and vapour collection or floating roof and vapour recovery or floating cover on primary separator)

3.2.2 Secondary measure

No secondary measure is considered.

4. 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 these economical parameters which can be modified by the national expert if better data are available.
For processes in refineries, only one country and sector specific economic parameter and one country specific economic parameter are required. They are presented in tables 4.1 and 4.2 as the default costs proposed by EGTEI for this activity.

Table 4.1: Country specific economic parameter cost

Parameter	Default costs provided by EGTEI	Country specific cost
Wages [€/h]	24.3	to be provided by national experts

Table 4.2: Activity and country specific economic parameter cost

Parameter	Default cost provided by EGTEI	Country specific cost
Crude oil €/t	250	to be provided by national experts

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 ECODAT). A full definition of the work to be done by national experts is provided in the general EGTEI methodology [15].

The national expert can also modify the default unabated emission factor proposed by EGTEI to represent the reference situation of refining and NMVOC emissions for all Parties in a range of ± 10% with appropriate explanations.

Table 4.2: Unabated emission factor [t NMVOC emitted / Mt crude oil]

Default emission factor	Country specific emission factor
310	To be provided by national experts

Remark: This activity is not yet in ECODAT to estimate costs. For the time being, for estimating country specific costs the EXCEL sheet "refinery-costs" has to be used.

5. Default emission factors and cost data defined with the EGTEI methodology

Table 5.1 presents an overview of all data provided by the EGTEI methodology for the reference installation: default emission factors with abatement efficiencies, investments, variable and fixed operating costs as well as unit costs.

Table 5.1: Emission factors (EF), abatement efficiencies, investments, variable operating costs (OC) for each combination and unit costs

RIC PMC SMC	NMVOC EF [t NMVOC/Mt crude oil]	Abatement efficiency [%]	Investment [€]	Operating costs [€/y]	Product recovery [€/y]	Unit cost [€/t NMVOC abated]	Unit cost [€/kt crude oil]
01 00 00	310						
01 01 00	274	11.6	450000	38700		523.2	18.8
01 02 00	185	40.3	888000	126930	155790	129.0	16.1
01 03 00	149	51.9	1330000	165630	155790	215.9	34.8
01 04 00	160	48.4	1760000	144800	185970	205.1	30.8
01 05 00	124	60.0	2221000	183500	185970	291.8	54.3

It has to be kept in mind that NMVOC fugitive emissions depend on the method used for estimating them. EGTEI data are based on the use of the EPA 21 method considering only generic correlations provided (the use of specific correlations could give lower emissions). The use of other types of estimation methods could lead to other unit costs.

6. Relevance of EGTEI information for integrated assessment modelling (IAM)

In the RAINS model [6], the sector REF-PROC represents the processes in refineries and their emissions on NMVOC as a whole. Storage of chemical products is considered under sector ORG_STORE.

EGTEI proposal is built in a coherent structure with RAINS. The RAINS model however, still considers the blow down system.

Some information provided by EGTEI has been used in RAINS new version [6] for the modelling work carried out in the scope of the CAFÉ programme and the revision of the Gothenburg protocol. Costs are not yet available on the web site.

7. Perspective for the future

The EGTEI proposal for the refinery processes is not yet completely satisfying due to high uncertainties of emission factors and costs provided. Additional work would be useful, but this is linked to the availability of new information. For the time being this information has not been found.

8. Bibliography

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Annexe A - Example of data collection and use of EGTEI data – Case of France

A. Country specific data collection and scenarios developed by the national expert

Not yet developed by the French national expert.

Country and sector specific economic parameters

For refineries and NMVOC emissions, only one country and sector specific economic parameter and one country specific economic parameter are required. There are presented in table A.1 and 4.2.

Table A.1: Country specific economic parameter cost

Parameter	French specific cost
Wages [€/h]	**23.4**

Table A.2: Activity and country specific economic parameter cost

Parameter	Default cost provided by EGTEI	French specific cost
Crude oil € [net of taxes]/t	250	To be defined by national expert

Activity level

The activity level from 2000 to 2020 will depend on the energy scenario selected.

Table A.3: Activity levels on the reference Installation (kt NMVOC / year)

RIC	2000	2005	2010	2015	2020
01					

Emission factor

The French emission factor used is equal to the default emission factor provided by EGTEI.

Table A.4: Unabated emission factor

Default unabated emission factor [t NMVOC emitted /Mt crude oil]	French unabated emission factor [t NMVOC/Mt crude oil]
310	310

Current legislation control (CLE) scenario

Not yet developed.