FAT, EDIBLE AND NON-EDIBLE OIL EXTRACTION

SYNOPSIS SHEET

Prepared in the framework of EGTEI

1. Activity description and EGTEI contribution - summary

The production of crude vegetable oil from oilseeds (e.g. soya beans, sunflowerseeds or rapeseed) is a two-stage process:

Ø The first process step is the cleaning, preparation (i.e. drying) and in some cases dehulling, flaking and conditioning and pressing of the oilseeds. Pressing takes place in one or two steps, resulting in crude pressed oil and a cake. Beans (with 20% oil or less) are not pressed, because of the lower fat content, but are extracted directly after cleaning and preparation.

Ø The second process step is the extraction of oil from the pressed cake or flaked beans using hexane as a solvent. Extraction takes place in counter-current flow.

The mixture of hexane and oil, called miscella, is further processed in a distillation process, to recover the hexane from the vegetable oil. The solvent is re-used in the extraction process.

The hexane remaining in the cake is recovered by a stripping process, using steam. This desolventising-toasting process also reduces the enzyme and micro organism activity in the meal. The meal is dried and cooled by air before storage in silos or before loading.

This activity emits NMVOC originating from the use of hexane. NMVOC emissions from this sector may vary significantly from country to country. At a EU25 level for the year 2000 (according according to the RAINS model: version CP_CLE_Aug04(Nov04)), NMVOC emissions were 49.8 kt representing 0.5% of total NMVOC emissions. Average European emission factor (EF) in 2000 is 3 kg/t of seed (according to CIAM, the variation is high from country to country and in some cases, EF is as high as 18 kg/t; very few countries have EF below 2 kg/t of seed).

Vegetable oil activities are addressed by the European Directive 1999/13/EC (SED) [1] related to the reduction of NMVOC emissions from the use of solvents in some industrial activities. In order to be able to better represent the impact of this Directive in terms of emission reduction and costs, **fat oil has been considered as an individual activity by EGTEI [2]**. This sector was not considered separately in the previous RAINS version [5] and **EGTEI has been able to develop an approach for representing this sector and estimate costs of reduction techniques**. **The methodology was developed in cooperation with the European Federation (FEDIOL) [3].** As information provided was not sufficient to cover all situations (FEDIOL's adherents are already well equipped), an anonymous industrial contact developing processes [4] has also been involved in this work. **Data provided by EGTEI have been used in the new RAINS version [7] for the modelling work carried out in the scope of the CAFÉ programme and the revision of the Gothenburg Protocol and national emission ceiling Directive. However, country specific emission factors vary greatly between countries: this specificity is considered within RAINS.**

The representative unit used is the amount of seeds treated annually (t/year). Three reference installations (RI) are defined as costs of technologies are size dependant.

The standard techniques are a combination of on the one hand condensation/physical separation/distillation and on the other hand absorption/desorption. These techniques are not applied as independent techniques but in an interconnected way.

Two primary measures are considered based on different processes: two types of desolventiser can be used (i.e. the traditional one and the Schumacher type desolventiser-toaster-dryer-cooler).

Hexane recovery unit is the unique secondary measure considered for this sector. This technique is indeed very well adapted to recover the hexane used. Its use allows installations being in compliance with the SED requirements.

EGTEI provides default emission factors (EF) with abatement efficiencies, investments and variable and fixed operating costs (OC) as well as unit costs (€/t NMVOC abated and €/activity unit) for all the combinations of measures according to the size of the installation. As emissions are very dependant on the type of seeds treated, emission factors are only provided as default values. They can be easily modified in RAINS if national experts have specific figures. However, abatement measure efficiencies are considered to remain the same even if the no control emission factor is modified.

Unit costs of the different measures are negative. This can be explained because the uncontrolled case is an extreme situation where no hexane is recovered. When a recovery unit is installed, variable costs are reduced dramatically as well as NMVOC emissions.

National experts have to collect 3 country specific parameters (wages, electricity and steam costs) and 1 country and sector specific parameter (cost of hexane recovered). The first ones can be very easily known. The second one can be defined with the help of national federations. EGTEI provides default costs for country and specific parameters which can be used if no better data exist. National experts have also to provide the trends in activity level from 2000 to 2020, the activity shares according to the different RI as well as the application and applicability rates of each abatement technique.

As the representation of this sector in RAINS [7] is now based on the EGTEI proposal, it is recommended to national experts to complete ECODAT with country specific parameters which are not known from CIAM.

In the future however, any new technology which could be developed should be considered by EGTEI in the background document to continuously improve the representation of the sector and the capacity of EGTEI to describe new technologies.

2. European regulation

As mentioned above, the European Directive 99/13/EC [1] applies to this sector (annex IIA, n°19).

Operators can conform to the Directive by introducing a reduction scheme to comply with the total emission limit values as defined in table bellow. The SED applies to installations with a solvent consumption above 10 t per year.

Table 2.1: Emission limit values for fat-oil

Matter treated	Total emission limit values [kg NMVOC / t matter]
Rapeseed / sunflower seed	1.0
Soya beans (normal crush)	0.8
Soya beans (white flakes)	1.2
Animal fat	1.5
Olives	2.5
Castor / other seed and other vegetable matter	3.0

3. Methodology developed within EGTEI to represent the sector

3.1 Definition of reference installations

Three reference installations (RI) are defined according to the quantity of seed to be treated (t/year). This level of detail is important to take into account the differences in costs.

Table 3.1.1: Reference installations

Reference Installation Code RIC	Description	Technical characteristics
01	Small Installation: Quantity of seeds to be treated: 100,000 t/y (< 200,000 t/y)	Solvent input (I*): 300 t/y
02	Medium Installation: Quantity of seeds to be treated: 400,000 t/y (200,000 – 600,000 t/y)	Solvent input (I): 1,200 t/y
03	Large Installation: Quantity of seeds to be treated: 1,200,000 t/y (> 600,000 t/y)	Solvent input (I): 3,600 t/y

* As mentioned in the Solvent Management Plan implemented by the SED [2], inputs of organic solvents (I) equal the quantity of organic solvents or their quantity in preparations purchased (I1) + the quantity of organic solvents recovered and reused as solvent input into the process (I2).Definition of emission abatement techniques

3.2 Definition of measures

According to FEDIOL [3], as the standard combination of control techniques based on Best Available Techniques (BAT) is being used across the whole sector, the only possibility for these installations to further reduce VOC emissions and be in line with the Directive is improved process control, process optimisation and autonomous minor process modifications, and proper maintenance of the existing installations. This remark is based on a survey among FEDIOL's members.

However, according to [4], some installations still use old hexane recovery units. Two secondary measures are then defined in the document: the use of an old recovery unit and the use of a new recovery unit. Efficiencies of both techniques are very different.

Table 3.2.1: Primary measures

Primary Measure Code (PMC)	Description
00	Traditional desolventiser
01	Schumacher type desolventiser-toaster-dryer-cooler

Only hexane recovery sections are defined as these are the most appropriate techniques for this sector.

Table 3.2.2: Secondary measures

Secondary Measure Code (SMC)	Description
00	Without hexane recovery section
01	With Old hexane recovery section
02	With New hexane recovery section + Process optimisations (better control of deviations from normal operating conditions, avoiding of start-ups and shut-downs...)

The combination of PMC01 / SMC02 can be defined as BAT.

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 the economical parameters which can be modified by the national expert if better data are available.

For this activity as for all NMVOC sectors, country specific economical parameters are used to calculate variable operating costs. They are presented in table 4.1 as the default costs proposed by EGTEI (these costs are entered only once in ECODAT).

Table 4.1: Country specific costs

Parameters	Default costs provided by EGTEI	Country specific costs
Electricity [€/kWh] (net of taxes)	0.0686	To be provided by national experts
Steam [€/kg] (net of taxes)	0.016	To be provided by national experts
Wages [€/h]	25.9	To be provided by national experts

For this sector, an additional country and sector specific parameter is necessary to calculate variable operating costs. It corresponds to cost of hexane which is used in the process. A default figure is given in table 4.2.

Table 4.2: Country and sector specific economic parameter

Parameter	Default cost provided by EGTEI [€/kg]	Country and sector specific cost [€/kg]
Hexane [€/kg] (net of taxes)	0.5	To be provided by national experts

The best source of information for the determination of hexane cost is the national seed and oil processor federation.

Default data have been used to calculate variable and annual unit costs presented in table 5.1.

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 definition of the work to be done by national experts is provided in the general EGTEI methodology [9].

In this sector, emission factors are dependant on the type of seeds being treated. Each case being specific, it is very difficult to determine average emission factors representative for all countries. The unabated emission factor should then be country specific. However, EGTEI proposes the following one:

Table 4.3: Unabated emission factor [kg of NMVOC / t of seed]

Default emission factor	User specific emission factor
3.0	To be provided by national expert

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

Table 5.1 gives an overview of all data provided by EGTEI for this sector: default emission factors (EF) with abatement efficiencies, investments, and variable and fixed operating costs (OC) as well as unit costs per t NMVOC abated and per unit of activity.

Variable costs account for electricity, steam and labour used for secondary measures and savings from hexane recovery. Fixed operating costs are only considered for secondary measures and correspond to 5% of the hexane recovery section (for maintenance and insurance). As no economic data are available, it is assumed that fixed operating costs are the same for all primary measures (that is why fixed operating costs appear as 0 costs for primary measures).

Solvent recovery is an integral part of solvent extraction plants. Investments are reported from reference [4]. As no variable operating cost was available for secondary measures, they have been derived from the equations developed in the EGTEI document for adsorption [6].

Table 5.1: Default emission factors (EF), abatement efficiencies and costs for each combination

RIC PMC SMC	NMVOC EF [kg NMVOC / t seed]	Abatement efficiency [%]	Investment [k€]	Variable Operating Cost [k€ / year]	Fixed Operating Cost [k€/y]	Unit cost [€/t NMVOC abated]	Unit cost [€/t seed]
01 00 00	3.0	0	0	0	-	0	0
01 00 01	0.8	73	40	-94	2	-405	-0.89
01 01 01	0.6	80	715	-110.3	2	-240	-0.58
01 01 02	0.5	83	735	-115.3	3	-245	-0.61
02 00 00	3.0	0	0	0	-	0	0.00
02 00 01	0.8	73	75	-405	3.8	-450	-0.99
02 01 01	0.6	80	1,475	-584.5	3.8	-496	-1.19
02 01 02	0.5	83	1,509	-604.5	5.5	-493	-1.23
03 00 00	3.0	0	0	0	-	0	0.00
03 00 01	0.8	73	165	-1,266	8.3	-472	-1.04
03 01 01	0.6	80	3,665	-1,793.7	8.3	-529	-1.27
03 01 02	0.5	83	3,745	-1,853.7	12.3	-526	-1.32

Unit costs [€/t of NMVOC abated] are obtained by dividing the annual total additional cost of a measure by the amount of NMVOC abated (costs and emissions are compared to the uncontrolled measure PMC 00/SMC 00).

As shown in table 5.1, the cheapest way of reducing NMVOC emissions is the use of a traditional desolventiser. This technique is less and less used and, as noticed in paragraph 3.2, the standard combination of control techniques based on Best Available Techniques (BAT) is being used in a lot of cases. However, some installations do still use no or old hexane recovery with traditional desolventiser.

6. Relevance of EGTEI information for Integrated Assessment Modelling (IAM)

In the previous RAINS version [5], vegetable oil activities were not studied as a separate sector. It was considered as part of "Other use of solvents" (but for most of the countries, it was the most important sub-sector). Activity was defined as total VOC emissions. Abatement techniques were not specific to this sector: that is why it was identified as a priority sector at the beginning of the work.

EGTEI provides now an approach to consider this sector and test the impact of the current legislation as well as the maximum achievable reduction. The approach was developed in close cooperation with the European industry.

Data provided by EGTEI (emission factors and costs) have been implemented in the new RAINS version [7] for the modelling work carried out in the scope of the CAFÉ programme and the revision of the Gothenburg protocol.

For this activity, data provided by national experts through ECODAT can then be directly used by CIAM for introduction in RAINS.

7. Perspective for the future

In the future, any new technology which could be developed should be considered by EGTEI in the background document to continuously improve the representation of the sector and the capacity of EGTEI to describe new technologies.

8. Bibliography

[1] Council Directive 1999/13/EC of 11 March 1999 on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain activities and installations.
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[5] KLIMONT; M. AMANN; J. COFALA. Estimating costs for Controlling Emissions of Volatile Organic Compounds (NMVOC) from Stationary Sources in Europe. Interim Report IR-00-51. IIASA. August 1. 2000. http://www.iiasa.ac.at/~rains/voc_review/voc_ir-00-51.pdf
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[8] Rapport d'inventaire national au format UNECE/NFR et NEC
Rapport d'étude du CITEPA - Décembre 2003
[9] Methodology http://citepa.org/forums/egtei/egtei_index.htm
[10] CITEPA: National reference centre for emission inventories

ANNEXE: Example of data collection and use of EGTEI data – Case of France

A. Country specific data collection and scenario CLE developed

The French national expert has been able to complete ECODAT for this sector with the help of CITEPA [10].

All data have been provided to CIAM for the bilateral consultation France – CIAM in March 2004.

Country and sector specific economic parameters

Country specific parameter costs have been defined from costs encountered in the medium size industry which are monthly published by official French statistic organizations.

Table A.1: French specific costs

Parameters	French specific costs
Electricity [€/kWh] (net of taxes)	0.05
Steam [€/kg] (net of taxes)	0.0131
Wages [€/h]	23.4

As no better hexane cost is available, the default one is used for describing the French situation.

Table A.2: French and sector specific data (net of taxes)

Parameter	Default cost [€/kg]	French and sector specific cost [€/kg]
Hexane	0.5	0.5

Activity level

The activity trend from 2000 to 2020 comes from data developed by the French expert: activity is assumed to increase by 2.78%/year based on the added value for the branch “agricultural and food industry”. Activity level in 2000 is derived from annual emission reports of each installation.

Respective shares (kt seeds/y) of total activity level carried out on each reference installation in 2000, 2005, 2010, 2015, 2020 are derived from the same annual reports.

Table A.3: Activity levels on Reference Installations (kt of seeds / year)

RIC	2000	2005	2010	2015	2020
01	228.45	262.02	300.523	344.683	395.333
02	1,720.99	1,973.883	2,263.937	2,596.615	2,978.178
03	1,096.56	1,257.695	1,442.509	1,654.48	1,897.6
Total (kt)	3,046	3,494	4,007	4,596	5,271

Current legislation control scenario (CLE)

In the current legislation control scenario (CLE), the application rates of the different abatement techniques depend on the regulation implemented and on the dates of compliance.

For 2000, the rates of use of the different reduction techniques were known by CITEPA which, in the scope of the French emission inventory (carried out for the French ministry of Ecology), gathers this type of information [10]. For this sector, as the number of installations is rather low (around 10 installations considered in France), emissions are directly derived from the annual industrial reports. In 2000, some of the installations were still equipped with a traditional desolventiser and no hexane recovery section

From 2005 to 2020, all installations are considered to be equipped with an hexane recovery unit to be in compliance with the European emission limit values. The bigger the installation, the more advanced the technology. That is why, for RIC01, only the use of PMC00/SMC01 is assumed when for the largest installations, only BATs should be installed.

The application rates and applicability factors for the CLE scenario are presented in table A.4.

Table A.4: Definition of the CLE scenario

RIC PMC SMC	Application rate in 2000 [%]	Application rate in 2005 [%]	Appl. [%]	Application rate in 2010 [%]	Appl. [%]	Application rate in 2015 [%]	Appl. [%]	Application rate in 2020 [%]	Appl. [%]
01 00 00	11	0	100	0	100	0	100	0	100
01 00 01	89	100	100	100	100	100	100	100	100
01 01 01	0	0	100	0	100	0	100	0	100
01 01 02	0	0	100	0	100	0	100	0	100
Total RIC 01	**100**	**100**	**-**	**100**	**-**	**100**	**-**	**100**	**-**
02 00 00	25.6	0	100	0	100	0	100	0	100
02 00 01	43.4	19	100	0	100	0	100	0	100
02 01 01	0	50	100	50	100	25	100	0	100
02 01 02	31	31	100	50	100	75	100	100	100
Total RIC 02	**100**	**100**	**-**	**100**	**-**	**100**	**-**	**100**	**-**
03 00 00	10.3	0	100	0	100	0	100	0	100
03 00 01	44	0	100	0	100	0	100	0	100
03 01 01	0	0	100	0	100	0	100	0	100
03 01 02	45.7	100	100	100	100	100	100	100	100
Total RIC 03	**100**	**100**	**-**	**100**	**-**	**100**	**-**	**100**	**-**

Appl.: applicability factor

B. Trends in emissions and total costs of the CLE scenario

Data shown in the table below are directly provided by ECODAT and based on input parameters defined in chapter A.

Table B.1 presents NMVOC emissions from 2000 to 2020 and total annual costs of emissions reduction for the CLE scenario.

Table B.1: Trends in emissions and total annual costs of emission reductions in the CLE

	2000	**2005**	**2010**	**2015**	**2020**
NMVOC emissions	**t NMVOC**	**t NMVOC**	**t NMVOC**	**t NMVOC**	**t NMVOC**
CLE scenario	3,424	2,062	2,236	2,506	2,807
Annual total costs	**k€/year**	**k€/year**	**k€/year**	**k€/year**	**k€/year**
CLE scenario	-2,738	-4,188	-4,908	-5,658	-6,522