Final Background Document
on the sector

Fat, Edible and Non-Edible Oil Extraction

Prepared in the framework of EGTEI

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5. Definition of abatement techniques and costs (p. 5)

Two primary and three secondary measures are defined.

If a measure is missing in the document, national experts have to contact the Secretariat to add it in the background document.

As emission factors can differ widely from one installation to another and from one kind of seed treated to another, they are defined as country specific. The unabated emission factor has to be provided by national experts. Only efficiencies are defined in this document.

6. Data to be provided by national experts for the completion of the database for their own country (p. 8)

Tables to be filled in by national experts are:

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Sector: Fat, Edible and Non-Edible Oil Extraction

SNAP: 06 04 04 or NFR 3C Chemical products, manufacture and processing

This sector covers the extraction of oil from seeds for various end uses.

ACTIVITY: tonnes of seeds treated / year.
POLLUTANT CONSIDRED: VOC

1 Data from the bibliography

Following data are just displayed for comparison reasons

1.1 Data currently used in RAINS [1]

Currently, this sub-sector is studied in “Other Industrial Use of Solvents” in RAINS.
Being considered separately in the EU Directive 1999/13/EC, this sector will be studied separately in the future.
In the majority of countries, the most important single activity of “Other Industrial Use of Solvents” is “Fat edible and non-edible oil extraction”.

1.1.1 Control options

According to [1], emissions from this sector can be controlled by improving the efficiency of the solvent extraction and by adding abatement equipment like water scrubbers at the drying plant.
Two control options are specifically considered in RAINS for “Fat edible and non-edible oil extraction”:

- NoC: Reference case;
- PRM: Primary measure (efficiency: about 70%);
- PRM+BIO: Combination of primary measures and add-on technology (biofiltration; efficiency: 75%).

1.1.1 Abatement costs

Examples for three countries are displayed below (activity is in kt of VOC) :

Table 1.1.2.1: French situation

Measure	Emission factor [kt VOC / kt of VOC]	Efficiency [%]	Technical Eff. [%]	Applicability [%]	Unit cost [€$_{1990}$/t VOC]
NoC	1,0000	0	0	0	0
PRM	0,5740	43	71	60	550
PRM+BIO	0,5500	45	75	60	600

Table 1.1.2.2: German situation

Measure	Emission factor [kt VOC / kt of VOC]	Efficiency [%]	Technical Eff. [%]	Applicability [%]	Unit cost [€$_{1990}$/t VOC]
NoC	1,0000	0	0	0	0
PRM	0,5740	43	71	60	550
PRM+BIO	0,5500	45	75	60	600

Table 1.1.2.3: Hungarian situation

Measure	Emission factor [kt VOC / kt of VOC]	Efficiency [%]	Technical Eff. [%]	Applicability [%]	Unit cost [€$_{1990}$/t VOC]
NoC	1,0000	0	0	0	0
PRM	0,3255	67	71	95	550
PRM+BIO	0,2875	71	75	95	600

1.2 Situation in the UK [2]

There are two distinct manufacturing sectors covered by this part of the Directive:

- Continuous process seed and cereal crushing,
- Batch process vegetable matter oil extraction.

According to the Seed Crushers and oil Processors, the seed crushers operating continuous processes will be below the Directive limits as the process are already covered by the UK regulation. Containment and recovery of solvents is the favoured compliance technique of the continuous processors. It appears that similar techniques are used to a lesser extent by the batch processors.

The net cost of containing and recovering the solvents from continuous processes is estimated to be low with much of the required equipment already installed or due to be installed as natural investment in new plant over the next 10 years.

As compliance with the UK regulation for both continuous and batch processes should ensure compliance with the Directive, no over-costs are considered in [2].

2 Short technology description [3]

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

- ➢ 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.
- ➢ 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.

3 EU regulation : Directive 1999/13/EC of 11 March 1999 [4]

Operators concerned can conform to the Directive:

- By introducing a reduction scheme to comply with the total emission limit value.

Directive applies to installations with a solvent consumption above 10 t per year.

Emission limits for application of the Directive are presented in table 3.1.

Table 3.1: Emission limits

Matter treated	Total emissions [kg VOC/ t]
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

All obligations of the Directive are not described in this chapter.

4 Definition of Reference Installations [5]

Reference installations presented in table 4.1 are defined according to their annual production of seeds.

Table 4.1: Reference installations

Reference Installation Code RIC	Description
01	Small Reference Installation: quantity of seeds to be treated : 100 000 t/y (< 200 000)
02	Medium Reference Installation: quantity of seeds to be treated : 400 000 t/y (200 000 - 600 000)
03	Large Reference Installation: quantity of seeds to be treated : 1 200 000 t/y (> 600 000)

5 Definition of abatement measures and costs [3], [6], [7], [8]

5.1 Measures

According to [3], 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 are applied in an interconnected way.

According to [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 made on a survey among FEDIOL's members.

However, according to [7], 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.

- BAT description

Four techniques are described in reference [6] : the counter current flow Desolventizer-Toaster (DT) allowing to minimize the solvent losses and steam consumption, the heat integration of DT vapour stream with miscella distillation in the extraction process leading to an optimisation of the energy consumption, the mineral oil scrubbing system to reduce VOC emissions and the reboiler minimising solvent losses.

- Process optimisations

Process optimisation includes better control of deviations from normal operating conditions and avoiding of start-ups and shut-downs are assumed to cause no additional costs. With proper operation and maintenance, the oilseed extraction facilities will be able to meet the emission values as set in Directive 1999/13/CE [3].

Table 5.1.1: Primary measures

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

- Condensation/Physical Separation/Distillation

The hexane and steam vapours coming from the meal desolventising/toasting, from the miscella (crude vegetable oil and hexane) distillation, from the reboiler and from the stripping column of the mineral oil system, all pass through a condenser system.

The condensed vapours (hexane-water condensate) go to the hexane-water separator where the undissolved hexane is separated by means of gravitational phase separation. The hexane is re-circulated to the extraction process.

Any residual solvent content in the aqueous phase of the hexane/water separator is distilled off in the so-called re-boiler. The resulting hexane/water vapours from the reboiler are condensed together with the vapours from the distillation stage.

After boiling the almost hexane-free water is fed to the waste water system. This technology also ensures the explosion safety of this downstream system.

- Absorption/Desorption

The components that cannot be condensed by the condenser are treated further by an absorption technique, the so-called mineral oil scrubbing system, where residual hexane is absorbed.

The mineral oil system consists of an absorption column, where the hexane is absorbed by cold, food grade mineral oil. The hexane is then recovered by steam stripping the hexane laden mineral oil in a stripping column. The stripped mineral oil is cooled down and reused in the absorption column.

The final emissions from the mineral oil system consist of the non-condensables with traces of hexane. The hexane and steam vapour from the mineral oil stripping column are condensed in the condenser system. The hexane-water condensate then goes to the hexane-water separator (see above).

The total recovered hexane is reused in the extraction process.

Table 5.1.2: 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...)

- Add-on abatement techniques

According to [3], the only relatively relevant point source is the outlet of the mineral oil absorption system. Due to the specific process characteristics, in practice additional add-on techniques such as thermal oxidation or biofiltration have no application potential.
Thermal oxidation is considered not feasible for safety reasons (ensuring plant safety by avoiding ignition sources considering risks of explosion).
Biofiltration is not feasible due to the very limited water solubility of the hexane. In order to become available for biodegradation the hexane has to diffuse into the biofilm first. The biofilm is the water layer (biofilm) around individual particles of the filter material where the micro organisms are present. Due to the water-insolubility of hexane the transfer of the water-insoluble hexane across the phase boundary into the biofilm is hampered. Hence, the second step of biodegradation cannot take place.

5.2 Efficiencies and costs data for the different combinations

Only reliable combinations are presented in table 5.2.1 [7], [8].

Table 5.2.1: Efficiency, investments, variable and fixed costs, savings

RIC PMC SMC	Eff. [%]	Q	CI %	Invest. [k€]	Q	CI %	Variable OC [k€ / year]	Q	CI %	Fixed OC [k€ / year]	Savings [k€/y]
01 00 00	0	-	-	0	-	-	398,7	-	-	-	Will be calculated at a country level
01 00 01	73	3		40	2	40	414,7			2	
01 01 01	80	3	-	715	3	25	408,4	3	20	2	
01 01 02	83	3		735	4	20	408,4			3	
02 00 00	0	-	-	0	-	-	1 428,3	-	-	-	
02 00 01	73	3		75	2	40	1 463,3			3,8	
02 01 01	80	3	-	1 475	3	25	1 323,8	3	20	3,8	
02 01 02	83	3	-	1 509	4	20	1 323,8	3	20	5,5	
03 00 00	0	-	-	0	-	-	4 015	-	-	-	
03 00 01	73	3		165	2	40	4 069			8,3	
03 01 01	80	3		3 665	3	25	3 661,3			8,3	
03 01 02	83	3	-	3 745	4	20	3 661,3	3	20	12,3	

6 Data to be provided by national experts for the completion of the database for their own country

The following tasks are required:

6.1 Validation work

For representing costs in this sector, the national expert is invited to comment the methodology defined by the Secretariat.

- Validate investments provided and,
- Validate the method of derivation of operating costs.

Or

- Provide other costs for the same combination of techniques and justify them.

Comments have to be sent to the Secretariat in the two weeks after having received the document.

6.2 Provision of specific data

Tables to be filled in by national experts

- Determination of sector & country specific data to calculate variable costs.

Table 6.2.1: Sector specific data

Parameters	Default parameter	Country specific costs
Electricity cost [€ / kWh]	0,0686	
Steam cost[€ / kg]	0,016	
Labor cost [€ / h]	25,9	

Table 6.2.2: Sector and country-specific data

Parameters	Default parameter	Country specific costs
Hexane cost [€ / kg]	0,87 [7]	

Table 6.2.3: Default value according to [8]

Parameters	Default parameter
Hexane cost [€ / kg]	0,5 [8]

- Total activity (t of seed / y) in 2000, 2005, 2010, 2015, 2020. Some default values for the confidence interval are given. They can be used by the Parties if no data are available.

Table 6.2.4: Total Activity level (t of seeds used / year)

RIC	2000	CI%	2005	CI%	2010	CI%	2015	CI%	2020	CI%
01										
02										
03										
Default values		10		20		50		100		100
Total	Calculated automatically by the tool									

Total activity (t of seeds / y) has to be estimated from 2000 to 2020. It should evolve.

- Country specific unabated emission factor (kg VOC / t of seeds).

Table 6.2.5: Unabated EF for the combination of measures PMC SMC 00 00

Unabated EF [kg VOC / tonne of seeds]	**CI [%]**

- Respective percentage of combinations of reduction measures in 2000 as well as if possible, the percentage of use in 2005, 2010, 2015, 2020 due to the VOC Directive or national regulations and applicability according to the definition used in the RAINS model.

Table 6.2.6: Application rate and Applicability for each combination of reduction measures

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									
01 00 01									
01 01 01									
01 01 02									
Total RIC 01	**100**	**100**		**100**		**100**		**100**	
02 00 00									
02 00 01									
02 01 01									
02 01 02									
Total RIC 02	**100**	**100**		**100**		**100**		**100**	
03 00 00									
03 00 01									
03 01 01									
03 01 02									
Total RIC 03	**100**	**100**		**100**		**100**		**100**	

Two cases can be encountered :
Case 1: if detailed information is available, table 6.2.6 can be filled-in.
Case 2: if information is sparser, the expert fills-in table 6.2.7 on his own judgment.

Table 6.2.7: Aggregated table

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. [%]**
Aggreg. 00 00									
Aggreg. 00 01									
Aggreg. 01 01									
Aggreg. 01 02									
Total aggreg.	**100**	**100**		**100**		**100**		**100**	

Aggreg. : Aggregation

7 Explanatory notes

7.1 Derivation of Consumption and Emission Factors

Consumption and emission factors are dependent on the types of seeds being treated. Each case being specific, this is very difficult to assess average emission factors representative for all countries. Thus we propose to have country specific emission factors.

In 2000, the shares of techniques correspond to an average emission factor. In 2007, all plants will have to be in compliance with the Directive requirements. New emission factors can thus be calculated from emission limits presented in table 3.1.

Default emission factors from Belgium [8] are defined in table 7.1.1 hereafter. Efficiencies of the measures defined in table 5.2.1 have been back calculated from these emissions factors. Even if emission factors are country specific, it is assessed that efficiencies of the measures are similar for all countries.

Table 7.1.1: Default emission factors [8]

PMC SMC	Emission Factor [kg VOC / t of seed]	Efficiency [%]
00 00	3,0	0
00 01	0,8	73
01 01	0,6	80
01 02	0,5	83

7.2 Derivation of Cost Data [5]

7.2.1 Investments

Solvent recovery is an integral part of solvent extraction plants. The economics of a plant may be finely balanced on the proportion of solvent that is recovered. The efficiency of recovery is usually high, but is dictated by economic considerations, and will be limited to recovery plant on which the capital investment can be paid for by reduction in expenditure on new solvent.

Investments are reported from reference [7]: the study is based on the treatment of soybeans seeds. As three different sizes of installations are defined, we have assumed that these costs are representative of the whole sector (costs are size's dependent).

Table 7.2.1.1: Investments of primary measures

RIC PMC SMC	Investment [k€]	Q	CI [%]	Lifetime [y]
01 00 00	0	-	-	20
01 01 00	675	4	20	20
02 00 00	0	-	-	20
02 01 00	1 400	4	20	20
03 00 00	0	-	-	20
03 01 00	3 500	4	20	20

No investment for "Old Hexane Recovery Section" has been provided. Investments given in table 7.2.1.2 are just guess. Investments for "New Hexane Recovery Section" are derived from reference [7].

Table 7.2.1.2: Investments of secondary measures

RIC PMC SMC	Investment [k€]	Q	CI [%]	Lifetime [y]
01 00 01	40	2	40	20
01 01 01	40	4	20	20
01 01 02	60	4	20	20
02 00 01	75	2	40	20
02 01 01	75	4	20	20
02 01 02	109	4	20	20
03 00 01	165	2	40	20
03 01 01	465	4	20	20
03 01 02	245	4	20	20

According to [8], investment for combination 03 01 02 is 4 300 k€ (i.e. 3000 k€ for PMC 01 and 1300 k€ for SMC 02). In this document an overall investment of 3 745 k€ is used [7] as presented in table 5.2.1. The difference between both figures is in the range of uncertainty defined in the document. Source [7] has been chosen so costs are all based on the same reference.

7.2.2 Operating costs and savings

Operating costs take steam and electricity consumptions into account [7]. Savings (hexane consumptions) will be calculated at a country level from the emission factors provided by national experts. No extra cost is taken into account for labour [7].

Table 7.2.2.1: Operating costs of primary measures

RIC PMC SMC	Steam consumption [t / year]	Electricity consumption [kWh / y]	Steam cost [k€ / year]	Electricity cost [k€ / year]	Savings [k€ / y]	Lifetime [y]
01 00 00	21 420	816 000	342,7	56	Will be calculated at a country level	20
01 01 00	21 183	780 100	338,9	53,5		20
02 00 00	77 520	2 741 760	1 240,3	188		20
02 01 00	69 360	2 611 200	1 109,8	179		20
03 00 00	220 150	7 180 800	3 522,4	492,6		20
03 01 00	196 350	6 789 120	3 141,6	465,7		20

As no variable operating cost is available for secondary measures, they are derived from the equations developed for adsorption (http://citepa.org/forums/egtei/adsorption_costs_170603.pdf). These costs are considered to be similar for SMC 01 and 02 (they have been rounded up).
Fixed operating costs are assumed to be 5% of the total investment per year (as in other sectors) for abatement techniques (secondary measures).

Table 7.2.2.2: Operating costs of secondary measures

RIC PMC SMC	Variable OC [k€ / year]	Fixed OC [k€ / year]	Lifetime [y]
01 00 01	16	2	20
01 01 01	16	2	20
01 01 02	16	3	20
02 00 01	35	3,8	20
02 01 01	35	3,8	20
02 01 02	35	5,5	20
03 00 01	54	8,3	20
03 01 01	54	8,3	20
03 01 02	54	12,3	20

8 References

[1] RAINS-VOC model, September 1998. http://www.iiasa.ac.at/~rains/databases.html

[2] Regulatory and Environmental Impact Assessment for the Implementation of the EC Solvent Emissions Directive. Final Report. Entec UK Limited. 20 December 1999.

[3] Mrs. BECHERT. Letter from FEDIOL (EC Seed Crushers' and Oil Processors' Federation).16/07/03. clbechert@fediol.be

[4] 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

[5] Task force on the assessment of abatement options and techniques for VOC from stationary sources. Draft background document – Prepared by IFARE for UN/ECE-May 1999.

[6] Extract of the best Available techniques reference document – prevention and reduction of VOC emissions. FEDIOL. 02/06/03.

[7] Anonymous contact from the Industry. 03/10/2003.

[8] Mr. PLAISIER. Ministerie v/d Vlaame Gemeenschap. Belgium. 30/10/03.

9 Modifications compared to the draft background document

p. 7: Variable operating costs for combinations 010101, 020101 and 030101 have been corrected.

p.10: In table 7.2.1.1, costs are in k€ and not in €.