POLYSTYRENE PROCESSING

SYNOPSIS SHEET

Prepared in the frame work of EGTEI

1. ACTIVITY DESCRIPTION AND EGTEI CONTRIBUTION 3

2. EUROPEAN REGULATION 4

3. METHODOLOGY DEVELOPED WITHIN EGTEI TO REPRESENT THE SECTOR 4

3.1 DEFINITION OF THE REFERENCE INSTALLATION 4
3.2 DEFINITION OF EMISSION ABATEMENT TECHNIQUES 4
3.2.1 Primary measures 4
3.2.2 Secondary measures 5

4. COUNTRY SPECIFIC DATA TO BE COLLECTED 5

5. DEFAULT EMISSION FACTORS AND COST DATA DEFINED WITH THE EGTEI METHODOLOGY 5

6. RELEVANCE OF EGTEI INFORMATION FOR INTEGRATED ASSESSMENT MODELLING (IAM) 6

7. PERSPECTIVE FOR THE FUTURE 6

8. BIBLIOGRAPHY 6

EXAMPLE OF DATA COLLECTION AND USE OF EGTEI DATA – CASE OF FRANCE 8

A. COUNTRY SPECIFIC DATA COLLECTION AND SCENARIO CLE DEVELOPED 8

B. TRENDS IN EMISSIONS AND TOTAL COSTS OF THE CLE SCENARIO 9

1. Activity description and EGTEI contribution

Polystyrene can be processed according to, at least, two routes:

- Expandable polystyrene bead process: expansion and moulding operations are involved from expandable polystyrene (EPS). Expandable polystyrene beads contain about 6 % w/w of pentane that acts as blowing agent during the process. Insulation panels and packages can be produced.
- Extruded polystyrene foam board process: polystyrene extrusion operations are involved for obtaining regular small and uniform cell sizes. CO_2 can act as blowing agent as well as HCFC. Mainly insulation panels are produced.

Only the expandable polystyrene bead process is treated by EGTEI since the extruded polystyrene foam board process is less used and NMVOC emissions very low due to the use of CO_2.

Pentane impregnated polystyrene beads contain about 6% w/w of pentane. They are processed as follows [1]:

- Heating and stirring in an expander with steam. Pentane acts as a blowing agent which, when heated with steam, expands the beads. Additives such as antistatic and mould release agents are also added to the vessel.
- Drying in a fluidised bed: the resulting “pre-expanded beads” are transferred to a fluidised bed dryer where they are dried and screened to remove the agglomerated beads.
- Storage: dried pre-expanded beads are stored in large volume hanging cloths or mesh sacks for between some hours to several days according to the final product density to be obtained. During this curing time, air permeates into the beads and restores their internal pressure.
- Moulding: cured pre-expanded beads are transferred into a mould where steam is admitted. Beads expand again but are constrained by the mould. They squeeze out all space and fuse to themselves to make an article of a shape determined by the mould.
- Storage of products. When insulation blocks are produced, the storage time depends again of the quality of insulation block to be obtained (density of these blocks).

When insulation boards are produced, EPS blocks are cut with electrically heated taut wires to the final dimensions desired.
According to products manufactured, one or two stages of pre-expansion and curing are required. Polystyrene wastes (polystyrene wastes from the production as recovered used polystyrene) can be recycled in the process during moulding.

All NMVOC emissions result from the release of blowing agent (pentane) from the beads during processing, curing, moulding and storage.

The Directive 1999/13/EC [2] (or SED) aiming at limiting NMVOC emissions from solvent uses in some activities does not cover the polystyrene processing.

The methodology for this sector was developed with information collected by CITEPA for a study carried out for SNPA (Syndicat des fabriquants de plastique alvéolaire) in 1998 [4] aimed at identifying reduction techniques and their costs. The background document has been discussed and improved following comments of industry [5].

This activity emits NMVOC. At a EU25 level for the year 2000 (according to the RAINS model: version CP_CLE_Aug04(Nov04)), NMVOC emissions were 36.6 kt representing 0.34% of total NMVOC emissions [10].These estimations could be modified in a near future due to information delivered by national experts during the bilateral consultation scheduled in 2005.

Polystyrene processing was not considered in the previous RAINS version [9]. Data provided by EGTEI, emission factors, efficiencies and costs of reduction techniques, are presently used in the last RAINS version (10] for the modelling work carried in the scope of the CAFÉ programme and the revision of the Gothenburg Protocol and national emission ceiling Directive.

The representative activity unit used is the annual consumption of expandable polystyrene expressed in kt PS/year. Only one reference installation is considered.
One primary measure is considered: recycling of polystyrene in the moulding step. It has not been possible to define costs of 4% pentane PS process.

Thermal oxidation can be used to treat a part of waste gases.

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 PS for the four reduction measures.

Unit costs range from 596 to 797 €/t NMVOC abated according to the reduction measure considered corresponding to 15.8 to 16.4 €/t PS.

National experts have to collect only three country specific parameters (wage cost, electricity cost and natural gas cost). National experts have also to provide the trends in activity level from 2000 to 2020 as well as the application and applicability rates of each abatement technique.
As the sector representation in RAINS [10] is presently 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 sector representation and the EGTEI capacity to describe new technologies. It would be necessary to follow the development of the use of polystyrene with 4% of pentane instead of 6%. EGTEI aims at considering this technique but it has not be possible to define its costs.

2. European regulation

As mentioned above, the European Directive 1999/13/EC [2] does not apply to this sector. However Member state regulation can exist for this sector on a case by case basis.

3. Methodology developed within EGTEI to represent the sector

3.1 Definition of the reference installation

Only one size of installation has been considered by EGTEI [6]. This installation has been determined based on information collected for SNPA in 1998 [4].

Table 3.1: Definition of the reference installation

Reference Installation Code (RIC)	Description
01	Medium Installation: annual polystyrene (new expandable polystyrene + recycled waste polystyrene) treated : 3 500 t/y

3.2 Definition of emission abatement techniques

3.2.1 Primary measures

Commonly, polystyrene beads have 6 % pentane content.

Expandable polystyrene beads with only 4% of pentane are presently available. However all product types cannot be produced with this 4% polystyrene. Low-density products that are the most common (< 20-25 kg/m^3) cannot be obtained. In France for example, this limitation reduces the use of 4% expandable polystyrene to only 25% of the total production of expanded polystyrene.

Waste polystyrene recycling (wastes from the site production as well as polystyrene wastes from outside recovery) is more and more frequently used. Wastes of expanded polystyrene are introduced in the process during moulding. In Netherlands for example, the total volume of recycled EPS in the production units (waste can be recycled in other type of activities) is 5% [7]. The use of recycled polystyrene is however limited for quality reason. A level of 15% is taken into account in this document.

Table 3.2.2.1: Measures of reduction considered

Primary Measure Code PMC	Description
00	Use of 100 % of 6 % pentane expandable beads
01	Use of 85 % of 6 % pentane expandable beads + 15 % of polystyrene wastes
02	Use of 100 % of 4 % pentane expandable beads

Due to unavailability of cost data for the primary measure 02, it cannot be used in the modelling work of RAINS.

3.2.2 Secondary measures

Thermal oxidation can be used to treat the pre-expander emissions. A gas collection system has to equip the pre-expander and the fluidised bed.
Another reduction technique consists in ducting waste gases into a boiler, but costs of this technique have not been estimated.

Table 3.2.2.1: Secondary measures

Secondary Measure Code	Description
00	No secondary measure
01	Thermal oxidation on the expander

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 this activity as for all VOC sectors, country specific economic parameters are used to calculate variable operating costs of reduction techniques. 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 economic parameter costs

Parameters	Default costs provided by EGTEI	Country specific costs
Electricity [€/kWh] (net of taxes)	0.0686	to be provided by national experts
Natural gas [€/kWh] (net of taxes)	0.0192	to be provided by national experts
Wages [€/h]	25.9	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 [8].

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

Table 4.2: Unabated emission factor [kg NMVOC / t polystyrene]

Default emission factor	Country specific emission factor
60	to be provided by national experts

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 and operating costs (OC) and unit costs for each combination

RIC PMC SMC	NMVOC EF [kg/t PS]	Abatement efficiency [%]	Investment [€]	Variable OC [€ / year]	Fixed OC [€/year]	Unit cost [€/t NMVOC abated]	Unit cost [€/t PS]
01 00 00	60	0	0	0	0	0	0
01 00 01	39.4	34.3	248650	14340	12430	797	16.4
01 01 00	51	15	0	0	0	0	0
01 01 01	33.5	44.2	248650	12200	12430	596	15.8
01 02 00	40	33.3	NA	NA	NA	NA	NA

NA not available.

Costs of polystyrene recovery have been assumed to counter balance polystyrene saving. Costs for PMC 01 are consequently zero.
Costs of PMC 02, EPS with 4% of pentane are not known.

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

In the previous RAINS version [9], the sector PNIS or Product Not Incorporating Solvents represented gathering polystyrene processing, polyester processing, PVC processing and polyurethane processing.
The EGTEI proposal has been considered. “PLSTYR-PR” represents now the polystyrene processing.
Reduction measure definitions and their efficiencies are based on EGTEI proposals:

- EPS-PLSTYR-PR+INC : 100 % of polystyrene with 6 % pentane + incineration
- EPS-PLSTYR-PR-LPB : 100 % of polystyrene with 4 % of pentane
- EPS-PLSTYR-PR+REC : 85 % of polystyrene with 6 % pentane + 15 % polystyrene recycled
- EPS-PLSTYR-PR+REC+INC : 85 % of polystyrene with 6 % pentane + 15 % polystyrene recycled + Incineration

Data provided in EGTEI approach (emission factors and costs) have been implemented in the new version of the RAINS model [10] for the modelling work carried out in the scope of the CAFÉ programme and the revision of the Gothenburg protocol.

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

7. Perspective for the future

Costs for the use of beads with only 4 % of pentane have not been determined in the scope of this study due to lack of information from industry. Other techniques could appear and should enable avoiding the pentane use.
In the future consequently, 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 would be necessary to follow the development of the use of polystyrene with 4% of pentane instead of 6%.

8. Bibliography

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[10] Review of data used in RAINS-VOC model http://www.iiasa.ac.at/web-apps/tap/RainsWeb/
[11] CITEPA. National reference centre for emissions inventories
[12] SPMP: syndicat des producteurs de matières plastiques

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 the polystyrene processing with help of CITEPA [11] and consultation of SPMP [12].
All data have been prepared by the French national expert for the bilateral consultation member state – CIAM which ended in March 2004.

Country and sector specific economic parameter

Country specific economic parameters used to calculate variable operating costs of reduction techniques are presented in table A.1.

Table A.1: Country specific economic parameter costs

Parameters	French country specific costs
Electricity [€/kWh] (net of taxes)	
Natural gas [€/kWh] (net of taxes)	
Wages [€/h]	

Activity level

The activity level from 2000 to 2020 has been defined by SPMP [12] and is assumed to increase by 3 % per year. These data have been approved by the French national expert.
The total polystyrene demand is assumed to increase as follows:

Table A.2: Activity level (kt polystyrene / year)

RIC	2000	2005	2010	2015	2020
01	121.0	140.3	162.6	188.5	218.5

Unabated emission factor

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

Table A.3: Unabated emission factor

Default unabated emission factor [kg/t polystyrene]	French unabated emission factor [kg/t polystyrene]
60	60

Current legislation control (CLE) scenario

In the current legislation control scenario (CLE), application rates of the different abatement techniques depend on regulation implemented and on dates of compliance required by this regulation but also internal development not driven by regulation.
In the CLE scenario, application rates of reduction techniques from 2005 to 2020 have been defined considering the requirement for compliance with the French regulation for this type of application (Arrêté du 02 February 1998 modified). NMVOC limits are implemented for this activity. The compliance date for existing installations is October 2005.
Application rates for the CLE scenario are presented in table A.4.

Table A.4: Application rates and applicability for each combination of reduction measures in 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	100	0	100	0	100	0	100	0	100
01 00 01	0	50	100	45	100	40	100	35	100
01 01 00	0	0	100	0	100	0	100	0	100
01 01 01	0	50	100	55	100	60	100	65	100
01 02 02	0	0	25	0	25	0	25	0	25
Total RIC 01	100	100	-	100	-	100	-	100	-

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

Data shown in the table B.1 are directly provided by ECODAT and based on input parameters defined in chapter A.

Table B.1: trends in emissions and total annual costs of emission reductions is NOC, CLE and MFR scenarios

	2000	**2005**	**2010**	**2015**	**2020**
NMVOC emissions	**t COV**	**t COV**	**t COV**	**t COV**	**t COV**
CLE scenario	7260	5113	5879	6760	7772
Total annual costs	**k€/year**	**k€/year**	**k€/year**	**k€/year**	**k€/year**
CLE scenario	0	2195	2541	2940	3403