Eco-profile

of Category 1 and 2 Hydrocarbon solvents

December 2024

1 SUMMARY

This Eco-profile report has been prepared according to the **Eco-profiles program and methodology – PlasticsEurope – V3.1 (2022)** with regards to the report layout, general structure and the chapters covered. As it is mentioned on several occasions later within chapter 2.10, the rules of the underlying LCA model are defined by and according to the **Guide for EF compliant data sets – V2.0 (2020)**

It provides average environmental performance data of a representative European market mix of 1 kg of **Category 1 and Category 2 solvents**[1] analysed from cradle to gate (from crude oil extraction to liquid solvent production at plant).

Please keep in mind that comparisons <u>cannot</u> be made on the level of the solvent material alone: it is necessary to consider the full life cycle of an application in order to compare the performance of different materials and the effects of relevant life cycle parameters.

It is intended to be used by the member companies, to support product-orientated environmental management; by users of solvents, as a building block of life cycle assessment (LCA) studies of individual products; and by other interested parties, as a source of life cycle information.

The underlying developed, aggregated LCI datasets are compiled following the EF standard [JRC 2020] and therefore can be used for the creation and modelling for future (product) environmental footprint (EF) studies/profiles according the official (P)EF guidance document [PEF GUIDE 2013].

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[1] For more information on the categories please refer to HSPA Naming Convention [HSPA 2022]

1.1 META DATA

Data Owner	Hydrocarbon Solvent Producers Association (HSPA)
LCA Practitioner	Sphera Solutions GmbH
Programme Owner	PlasticsEurope
Reviewer	DEKRA Assurance Services GmbH, Angela Schindler
Number of plants included in data collection	4
Representativeness	about 70% of European production
Reference year	2021/2022
Year of data collection and calculation	2023/2024
Expected temporal validity	Revision should be considered in 2029
Cut-offs	No significant cut-offs
Data Quality	Very good
Allocation method	Mass allocation for multi-functional systems

1.2 DESCRIPTION OF THE PRODUCT AND THE PRODUCTION PROCESS

This Eco-profile combines both the hydrocarbon solvents categories 1 and 2 (contained substances are listed in sec. 2.2).

Hydrocarbon solvent substances are commonly derived from petroleum feedstocks and contain one or more hydrocarbon classes (e.g. aromatics). The difference between the types of hydrocarbon solvents is mainly due to their different hydrocarbon classes and their carbon chain length distribution. The carbon chain length distribution depends on the targeted distillation range of the final product. The hydrocarbon solvent carbon chain lengths for Category 1 and Category 2 (Cat.1 & Cat.2) solvents are typically narrow cuts of hydrocarbon lengths over C8 and below C13.

The reference flow, to which all data given in this Eco-profile refer, is 1 kg of Cat.1 & Cat.2 solvents.

Production Process

The major process for transforming petroleum feedstocks into hydrocarbon solvent substances is a combination of various process steps that may include distillation of the feedstock, mild or heavy hydrogenation.

Use Phase and End-of-Life Management

Hydrocarbon solvents are petroleum derivatives used for cleaning and or dissolving substances and are used in a variety of industrial and consumer products. Cat.1 & Cat.2 solvents are typically function as fuel additives, agrochemicals, oilfield chemicals and coatings.

With regards to the End-of-Life (EoL) treatment of this solvent, of course, no general statements can be made as it is clearly depending on its specific application.

The following parameters for example do influence the consideration of potential EoL treatment options:

- Industrial or non- industrial/end-consumer applications
- Concentration of solvent/ degree of impurity
- Hazardousness/ toxicity of solvent/potential risks in solvent handling
- Price of solvent
- Environmental burden of solvent production
- Calorific value of solvent but also the related CO_2 emissions of its incineration – both being mainly influenced by the solvent specific carbon content
- Physical/ chemical properties (e.g. boiling range)

Only for industrial solvent uses a controlled treatment of solvent wastes can be assumed – apart from that, emission to air or municipal waste (water) treatment will be the common fate.

In an industrial context, usually solvent recycling (either open or closed loop) via mostly rectification/ distillation and/or (ultimately) specific waste solvent incineration are the preferred options. The latter one can also be combined with energy recovery as organic solvents show a high calorific value.

1.3 Data Sources and Allocation

The main data source was a data collection from three European producers: 4 plants from 4 different countries.

For the solvent in scope of this study, primary production data covers about 70% of the European Cat.1 & Cat.2 solvent production capacity, according to qualified expert judgement by HSPA.

The data for the upstream supply chain until the precursors, as well as all relevant background data such as energy and auxiliary material are taken from EF 3.1 compliant datastock [EF DATABASE 2022], whenever applicable. Sphera's managed LCA Content (MLC) databases (formerly, GaBi database) [SPHERA 2023] were used to close the gap for those relevant background dataset which are not available from the EF compliant database. Most of the background data used is publicly available and public documentation exists.

Mass allocation was applied in the foreground systems of the products in scope for the plants with valuable multi-outputs.

1.4 ENVIRONMENTAL PERFORMANCE

The tables below show the environmental performance indicators associated with the production of 1 kg of Cat.1 & Cat.2 solvents. Please refer to chapter 4 for a complete overview of all EF 3.1 indicator results of the solvents in scope.

1.4.1 Input Parameters

Indicator	Unit	Value	Impact method ref.
Non-renewable energy resources[1)]			
• Fuel energy	MJ	16.63	-
• Feedstock energy	MJ	44[2]	Gross calorific value
Renewable energy resources (biomass)[1)]			
• Fuel energy	MJ	0.55	-
• Feedstock energy	MJ	0.00	Gross calorific value
Resource use			
• Minerals and Metals	kg Sb eq.	6.25E-08	EF 3.1
• Energy Carriers	MJ	56.38	EF 3.1
Renewable materials (biomass)	kg	0	-
Water use	m^3 world eq.	0.03	EF 3.1
[1)] Calculated as upper heating value (UHV)			

1.4.2 Output Parameters

Indicator	Unit	Value	Impact method ref.
Climate change, total	kg CO_2 eq.	0.91	EF 3.1
Ozone depletion	kg CFC-11 eq.	2.85E-12	EF 3.1
Acidification	Mole of H^+ eq.	3.02E-03	EF 3.1
Photochemical ozone formation	kg NMVOC eq.	2.30E-03	EF 3.1
Eutrophication, freshwater	kg P eq.	2.67E-06	EF 3.1
Respiratory Inorganics	Disease incidences	2.45E-08	EF 3.1
Waste			
• Non-hazardous	kg	0.18	-
• Hazardous	kg	7.83E-05	-

[2] Value taken from GaBi database, using Benzene-Toluene-Xylene as reference [SPHERA 2023]

1.5 PROGRAMME OWNER

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1.6 DATA OWNER

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1.8 REVIEWER

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2 ECO-PROFILE REPORT

2.1 FUNCTIONAL UNIT AND DECLARED UNIT

1 kg of primary Cat.1 & Cat.2 solvents »at gate« (production site output) representing the average of the participating companies

2.2 PRODUCT DESCRIPTION

As not every producer covered in this study is offering each of the distinct substances mentioned below in this chapter (which have been grouped and categorized following a naming convention for REACH registration), the participants have collected data for one or several representative substances (in terms of production volume and/or economic importance) falling under these categories.

Chapter 2.3 describes the manufacturing of solvent naphtha (petroleum), light (Cat.1) and heavy (Cat.2) aromatic, which are both mixtures of several substances of category specific substances itself.

The production process and the herewith related environmental burden for all distinct products falling under a specific solvents' category is considered to be very similar.

The following sub-chapters show all current products contained in the defined categories together with their EC number. For an overview of the relationship CAS to EC number, please consult [HSPA 2022].

Category 1 solvents: C9 Aromatics

The C9 Aromatic Hydrocarbons Solvents Category (Cat.1) is comprised of a petroleum naphtha refinery stream, "Solvent naphtha, (petroleum), light aromatic," (CAS NR 64742-95-6). The solvents are described as UVCBs (Unknown or Variable Composition, Complex Reaction Products and Biological Materials) because they are composed of a defined, progressive carbon number range that includes various types of hydrocarbons. UVCB substances containing aromatic molecules (one-ring) composed of carbon and hydrogen and consisting of C9 aromatic hydrocarbons(approximately 90%). The category only includes substances with boiling ranges between ~160°C to ~175°C [OECD 2012].

The substances and their identifiers are listed below:

HSPA Substance Name	CAS Number	EC Number
Hydrocarbons, C9, aromatics	(64742-95-6)	918-668-5
Hydrocarbons, C9-C10, aromatics >1% naphthalene	(64742-95-6)	946-365-8

Category 2 solvents: C9-C12 Aromatics

The C9-C12 Aromatic Hydrocarbons Solvents Category (Cat.2) is comprised of a petroleum naphtha refinery stream, “Solvent naphtha, (petroleum), heavy aromatic,” (CAS NR 64742-94-5). UVCB substances containing aromatic (one-ring or two-ring) molecules of carbon and hydrogen. They consist of aromatic hydrocarbons having carbon numbers predominantly (approximately 80%) in the C10 to C13 range. The category only includes substances that have boiling ranges falling within approximately ~182 °C to ~288°C. The substances in this category contain >98% aromatic hydrocarbons [OECD 2012].

The substances and their identifiers are listed below:

HSPA Substance Name	CAS Number	EC Number
Hydrocarbons, C10, aromatics, >1% naphthalene	(64742-94-5)	919-284-0
Hydrocarbons, C10, aromatics, <1% naphthalene	(64742-94-5)	918-811-1
Hydrocarbons, C10-C13, aromatics, <1% naphthalene	(64742-94-5)	922-153-0
Hydrocarbons, C10-C13, aromatics, >1% naphthalene	(64742-94-5)	926-273-4

2.3 MANUFACTURING DESCRIPTION

The production of the Cat.1 & Cat.2 solvents typically involves several steps starting from refinery of crude oil in the upstream. Petroleum refinery activities begin with the reception of crude oil which is first desalted. The crude oil then undergoes atmospheric distillation, separating it into fraction based on boiling points, with naphtha being the key precursor to aromatics. The straight-run naphtha is subjected to hydrotreatment. Finally, the treated naphtha processed in the catalytic reformer to produce an intermediate aromatic rich stream, by transforming non-aromatic hydrocarbons to aromatic compounds such as benzene, toluene and xylenes, and other heavier aromatics. This intermediate aromatic rich stream is then received by the solvent producers and further processed through a fractionation via distillation to produce the hydrocarbon aromatic solvents within the desired ranges of carbon atoms.

2.4 PRODUCER DESCRIPTION

Eco-profiles represent European industry averages within the scope of ESIG as the issuing trade federation. Hence, they are not attributed to any single producer, but rather to the European solvents industry as represented by ESIG's membership and the production sites participating in the Eco-profile data collection. The following companies contributed data to this Eco-profile:

Company	**Address**	**Contribution to Cat.1 & Cat.2**
ExxonMobil	ExxonMobil Petroleum and Chemical B.V.B.A Hermeslaan 2 1831 Machelen Belgium	X
DHC	DHC Solvent Chemie GmbH Timmerhellstraße 28 45478 Mülheim an der Ruhr Germany	X
Haltermann Carless	Haltermann Carless UK Ltd Refinery Rd Harwich CO12 4QG England	X[3]
Shell	Shell Global Solutions GmbH Hohe-Schaar-Str. 36 21107 Hamburg Germany	X

[3] Contribution to Cat.2 only

2.5 SYSTEM BOUNDARIES

The Eco-profile refers to the production of Cat.1 & Cat.2 solvents as a cradle-to-gate system (see Figure 1). The diagram shows the common foreground and background system.

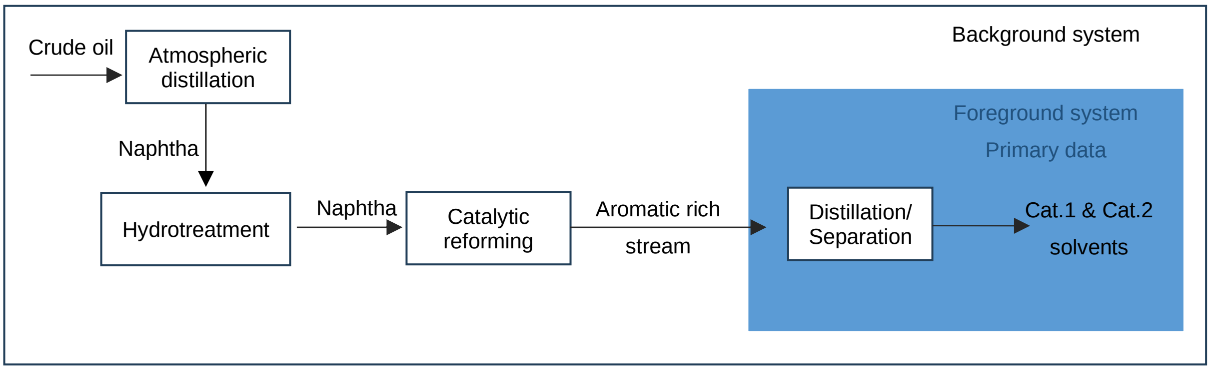

Figure 1:Cradle-to-gate system boundaries (Cat.1 & Cat.2 solvents)

2.6 TECHNOLOGICAL REFERENCE

The production processes were modelled using specific values from primary data collection at site, representing the specific technology for the data reporting companies. The LCI data represent technology in the defined production region of the participating producers. The considered participants cover about 70% of European production in 2022 (according to qualified expert judgement by HSPA) in the reference year mentioned above.

Primary data were used for all foreground processes (under operational control) complemented with secondary data from background processes (under indirect management control).

2.7 TEMPORAL REFERENCE

The LCI data for production was collected as 12-month averages representing the year 2022.

Background data have reference year from 2019-2022 (Sphera data), and 2012-2017 regarding the EF 3.1 datasets.

The average datasets are considered to be valid until substantial technological changes in the production chain occur. Having the latest technology development in mind, the companies participating in this Eco-profile define as temporal reference: the overall reference year for this Eco-profile is 2022 with a recommended temporal validity until 2029.

2.8 GEOGRAPHICAL REFERENCE

Primary production data have been reported from production sites within EU. Fuel and energy inputs in the system reflect whenever applicable and possible, site specific conditions – otherwise average European conditions were applied – to reflect representative situations. Therefore, the study results are intended to be applicable within EU boundaries and in order to be applied in other regions adjustments might be required.

2.9 CUT-OFF RULES

In the foreground processes all reported flows were considered.

According to the Managed LCA Content MLC 2023 (formerly, GaBi database) [SPHERA 2023], and EF compliant datasets [EF DATABASE 2022] used in the background processes, at least 95% of mass and energy of the input and output flows were covered and 98% of their environmental relevance (according to expert judgment) was considered, hence an influence of cut-offs less than 1% on the total is expected.

2.10 DATA QUALITY REQUIREMENTS

Data Sources

Eco-profiles developed by ESIG (HSPA) use average data representative of the respective foreground production process, both in terms of technology and market share. The primary data are derived from site specific information for processes under operational control supplied by the participating member companies of ESIG (see 2.4).

The data for the upstream supply chain is taken from the MLC 2023 LCI database (formerly, GaBi database) [SPHERA 2023] of the software system Sphera LCA for Experts “LCA FE” (formerly, GaBi software) and the officially available EF compliant datasets [EF DATABASE 2022], if applicable[4].

The same applies for background data such as energy and auxiliaries. Most of the background data used is publicly available and public documentation exists.

Relevance

Regarding the goal and scope of this Eco-profile, the collected primary data of foreground processes are of high relevance, i.e. data was sourced from the most important solvents

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[4] Due to the project goal of developing EF 3.1 compliant datasets, the background datasets need to be taken from the current version of the EF Reference Package (v3) (with the reference year 2012-2015 for energy datasets).

producers in Europe in order to generate a European industry average. The environmental contributions of each process to the overall LCI results are included in the Chapter 'Dominance Analysis'.

Representativeness

The considered participants covered 70% of the European industry market (2022) regarding the solvent in scope of this assessment. The selected background data can be regarded as representative for the intended purpose, as it is average data.

Consistency

To ensure consistency, only primary data of the same level of detail and background data from the Managed LCA Content 2023 (formerly GaBi databases) [SPHERA 2023] and the officially available EF compliant datasets [EF DATABASE 2022] were used. While building up the model, cross-checks concerning the plausibility of mass and energy flows were continuously conducted. The methodological framework is consistent throughout the whole model as the same methodological principles are used both in foreground and background system.

Reliability

Data reliability ranges from measured to estimated data. Data of foreground processes provided directly by producers were predominantly measured. Data of relevant background processes were measured at several sites or determined by literature data or estimated for some flows, which have been reviewed and checked for its quality.

Completeness

Primary data used for the gate-to-gate production of the solvents in scope of this assessment all related flows in accordance with the cut off criteria. In this way all relevant flows were quantified, and data is considered complete.

Precision and Accuracy

As the relevant foreground data is primary data or modelled based on primary information sources of the owner of the technology, better precision is not reachable within this goal and scope. All background data is consistently MLC (formerly, GaBi) data or EF compliant data with related public documentation.

Reproducibility

All data and information used are either documented in this report or they are available from the processes and process plans designed within the LCA For Experts (formerly, GaBi software). The reproducibility is given for internal use since the owners of the technology provided the data and the models are stored and available in a database. Sub-systems are modelled by ´state of art´ technology using data from a publicly available and internationally used database. It is worth noting that for external audiences, it may be the case that full reproducibility in any degree of detail will not be available for confidentiality reasons. However, experienced experts would easily be able to recalculate and reproduce suitable parts of the system as well as key indicators in a certain confidence range.

Data Validation

The data on production collected from the project partners and the data providing companies was validated in an iterative process several times. The collected data was validated using existing data from published sources or expert knowledge.

The background information from the MLC database (formerly GaBi databases) [SPHERA 2023] is updated regularly and validated and benchmarked daily by its various users worldwide.

Life Cycle Model

The study has been performed with the LCA software LCA For Experts (formerly GaBi). The associated database integrates ISO 14040/44 requirements. LCA modelling has been carried out following the rules of EF compliant dataset modelling [JRC 2020].

Due to confidentiality reasons details on software modelling and methods used cannot be shown here. However, in principle the model can be reviewed in detail if the data owners agree. The calculation follows the vertical calculation methodology, i.e. that the averaging is done after modelling the specific processes.

2.11 Calculation Rules

Vertical Averaging

When modelling and calculating average Eco-profiles from the collected individual LCI datasets, vertical averages were calculated (Figure 2).

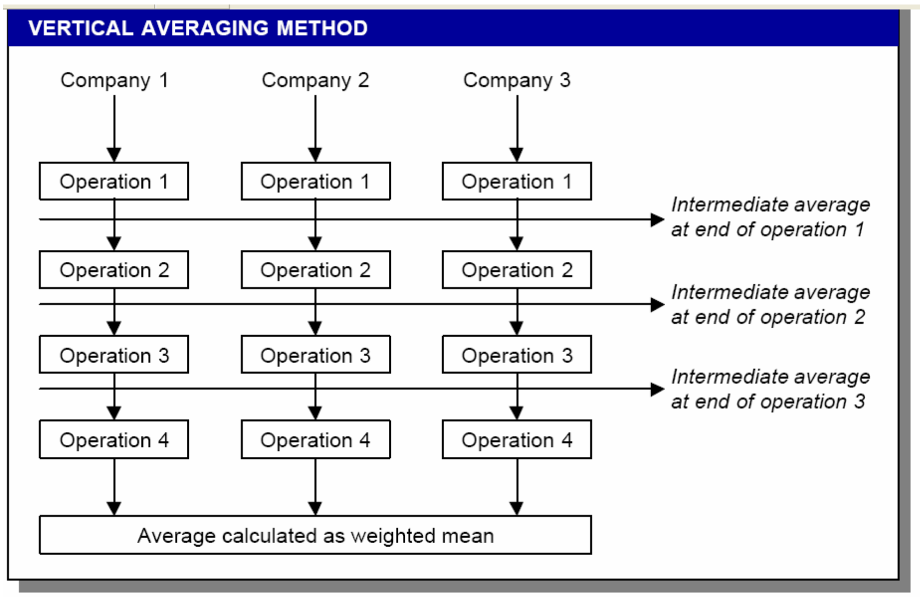

Figure 2: Vertical Averaging Method

Allocation Rules

Production processes in chemical and plastics industry are usually multi-functional systems, i.e. they have not one, but several valuable product and co-product outputs. Wherever possible, allocation should be avoided by expanding the system to include the additional functions related to the co-products. Often, however, avoiding allocation is not feasible in technical reality, as alternative stand-alone processes are not existing, or alternative technologies show completely different technical performance and product quality output or no clear dominant route is available for credit generation. In such cases, the aim of allocation is to find a suitable partitioning parameter so that the inputs and outputs of the system can be assigned to the specific product sub-system under consideration.

Foreground system:

Mass allocation has been applied as the method of choice in case of reported, valuable (and externally sold) by-products with an interdependent price ratio being below 20% (otherwise an economic allocation approach would have been followed, following the suggestion of [WBCSD 2014] and being in line with [JRC 2020]).

Background system:

Regarding the used background datasets from Sphera's MLC databases, in the refinery operations, co-production was addressed by applying allocation based on mass and net calorific value [SPHERA 2023] The chosen allocation in refinery is based on several sensitivity analyses, which was accompanied by petrochemical experts. The relevance and influence of possible other allocation keys in this context is small. In steam cracking, allocation according to net calorific value is applied. Relevance of other allocation rules (mass) is below 2 %.

2.12 Life Cycle Inventory (LCI) Results

Delivery and Formats of LCI Dataset

This eco-profile comprises

- One EF 3.1 compliant dataset per average solvent in ILCD/EF 3.1 format (https://eplca.jrc.ec.europa.eu/LCDN/developer.xhtml) according to the last version at the date of publication of the Eco-profile and including the reviewer (internal and external) input.
- LCA for experts format (.GabiDB)
- This report in pdf format

Energy Demand

The **primary energy demand** (system input) indicates the cumulative energy requirements at the resource level, accrued along the entire process chain (system boundaries), quantified as gross calorific value (upper heating value, UHV).

The **energy content in the solvent** indicates a measure of the share of primary energy incorporated in the product, and hence a recovery potential (system output), quantified as the gross calorific value (UHV).

The difference (Δ) between primary energy input and energy content in the solvent output is a measure of **process energy** which may be either dissipated as waste heat or recovered for use within the system boundaries.

Table 1 Primary energy demand (system boundary level) per 1kg Cat.1 & Cat.2 solvents

Primary Energy Demand	**Value [MJ]**
Energy content in solvent (energy recovery potential, quantified as gross calorific value of solvent)	44.00
Process energy (quantified as difference between primary energy demand and energy content of solvent)	17.18
Total primary energy demand	**61.18**

Water cradle to gate Use and Consumption

The cradle-to-gate[5] blue water **use** accounts for

- Cat.1 & Cat.2 solvents: 204.69 kg

The corresponding blue water **consumption** in the same system boundary shows as

- Cat.1 & Cat.2 solvents: 1.06 kg

Water foreground (gate to gate) Use and Consumption

The following tables show the weighted average values for water use of the solvents production process (gate-to-gate level). For each of the typical water applications the water sources are shown.

Table 2 Water use and source per 1kg of Cat.1 & Cat.2 solvents

Source	**Process water [kg]**	**Cooling water [kg]**	**Steam Water [kg]**	**Water in Raw Materials [kg]**	**Total [kg]**
From Tap	0.07	0.40	0.02	0.00	0.49
Deionized / Softened	0.00	0.00	0.02	0.00	0.02
Untreated (from river/lake)	6.21	0.00	0.00	0.00	6.21
Untreated (from sea)	0.00	0.00	0.00	0.00	0.00
Relooped	0.00	0.00	0.00	0.00	0.00
Totals	6.27	0.40	0.04	0.00	6.71

The following tables show the further handling/processing of the water output of the production processes of the solvents:

Table 3 Treatment of Water Output per 1kg of Cat.1 & Cat.2 solvents

Treatment	**Water Output [kg]**
To WWTP	0.16
Untreated (to river/lake)	0.07
Untreated (to sea)	0.00
Relooped	6.27
Water leaving with products	0.00
Water Vapour	0.21
Formed in reaction (to WWTP)	0.00
Totals	6.71

[5] This includes water use in the total upstream supply chain

Based on the water use and output figures above the **water consumption** can be calculated as:

Consumption = (water vapour + water lost to the sea) – (water generated by using water containing raw materials + water generated by the reaction + seawater used)

- Cat.1 & Cat.2 solvents = 0.21 kg

Dominance Analysis

Table 4 shows the contribution analysis for Cat.1 & Cat.2 solvents to those LCI and LCIA indicators which were considered most relevant (see chapter 1.4).

- It can be observed that the consumed raw materials show a major contribution (with at least 68% in each of the impact categories except for ozone depletion potential.
- The global warming potential shows a raw materials contribution of 68%, followed by thermal energy (18%) and direct process emissions (10%). Electricity and transport show relatively lower contributions to global warming potential results while all other processes can be neglected regarding this impact category.
- Transport of raw materials show relevant contribution in the other selected indicators such as acidification and photochemical ozone formation. In fact, these contributions are driven by long distance cargo ship transportation of the main precursor from suppliers located outside of the European Union.
- The category ozone depletion is highly (80%) dominated by the electricity consumed. Specifically, this is due to some dominating emissions related to the nuclear power consumption, which is still the main/ a relevant share in some of the European grid mixes (e.g. Belgium) applicable to the considered producers mix of Cat.1 & Cat.2 solvents.
- Other processes like infrastructure or utilities don´t show relevant contribution in any of the categories selected.

Table 4 Dominance analysis of impacts per 1kg Cat.1 & Cat.2 solvents

	Total Primary Energy	**Resource use, energy carriers**	**Resource use, minerals and metals**	**Climate change, total**	**Acidification**	**Eutrophication, freshwater**	**Photochemical ozone formation**	**Ozone depletion**
Production Process	0%	0%	0%	10%	0%	0%	0%	0%
Raw Materials	94%	95%	75%	68%	75%	84%	73%	17%
Thermal Energy	5%	4%	9%	18%	6%	5%	9%	1%
Electricity	1%	0%	9%	2%	1%	2%	1%	80%
Utilities	0%	0%	0%	0%	0%	0%	0%	1%
Process Waste Treatment	0%	0%	0%	0%	0%	9%	0%	0%
Infrastructure	0%	0%	1%	0%	0%	0%	0%	1%
Transports	0%	0%	6%	2%	17%	1%	17%	0%
Total	100%	100%	100%	100%	100%	100%	100%	100%

3 REVIEW

3.1 EXTERNAL INDEPENDENT REVIEW SUMMARY

DEKRA

Critical Review Statement

Eco-profile of Category 1 and 2 solvents

DEKRA Alles im grünen Bereich

Commissioned by:	Oxygenated Solvent Producers Association (OSPA) Hydrocarbon Solvent Producers Association (HSPA)
Version:	Eco-profile, November 2024
Prepared by:	Sphera Solutions GmbH, Abdessamad El Bahraoui
Reviewed by:	Angela Schindler Accredited partner of DEKRA Assurance Services GmbH
References:	▪ ISO 14071 (2016): Environmental management – Life cycle assessment – Critical review processes and reviewer competencies: Additional requirements and guidelines to ISO 14044:2006 ▪ ISO 14040 (2006): Environmental Management – Life Cycle Assessment – Principles and Framework ▪ ISO 14044 (2006): Environmental Management – Life Cycle Assessment – Requirements and Guidelines ▪ Eco-profiles program and methodology -PlasticsEurope v3.1 (2022) ▪ Guide for EF compliant data sets v2.0 (2020)

DEKRA Assurance Services GmbH Page 1 of 3 Date: December 2024

EXTERNAL INDEPENDENT REVIEW

This Eco-profile covers the declaration of the environmental performance of the average hydrocarbon solvent group Cat. 1 and 2 solvents.

The Eco-profile document was submitted in August 2024; the review process was finalized in November/December 2024.

In principle, this document is a supplement to Eco-profile of HSPA, published in November 2021.

The compliance of the document was reviewed according to the current requirements of the Eco-profiles program and methodology, version 3.1 (2022) of PlasticsEurope. Besides, the substantial intention of this Eco-profile is the generation of a life cycle inventory for the above-mentioned substance, according to the Guide for EF compliant data sets, version 2.0 (2020), to be used as background data for environmental footprint studies, according to the European Commission's PEF Guide (2013).

Thus, with this review statement it is confirmed, that the software modelling, applied data sets and the assessment follows the published rules of the European Platform on Life Cycle Assessment (EPLCA) and the Joint Research Centre (JRC).

The review process comprised the check of the Eco-profile document, a discussion of data input, software model and detailed assessment in a webmeeting with the LCA practitioner and the check of the obligatory files for generating the life cycle inventories to be provided for the PEF background database.

All comments of the reviewer could be solved in the webmeeting and by implementing respective adaptations to the Eco-profile report.

Main producers have taken part in this study. Regionalization of material and energy flows has been implemented as far as datasets were available. Thus, the Eco-profile can be seen as representative for the European market.

The data quality is assessed according to the DQR requirements. The details have been shown to the reviewer; the final result of the DQR procedure is published in the documentation of the life cycle inventory.

For unambiguous understanding the manufacturing description has been extended. The data collection for the activity data/primary data only refer to the final step of distillation and as an average of the two declared product groups (Category 1 and Category 2). In case electricity from renewable resources is applied and considered in the LCA calculation, the LCA practitioner received documents showing respective evidence.

The data collection contains an increased uncertainty. Even during the extended project time frame, it was not possible to solve a relevant open question on material and energy flows. The LCA practitioner decided to adapt the respective dataset by theoretical correction instead of neglecting this outlier information. The topic was a relevant aspect in the review process. The reviewer agreed to this approach, as the representativeness of the Eco-profile is not wanted to be restricted; at the same time this approach is estimated to deliver a more conservative result. As especially the climate change indicator shows higher uncertainty (estimated to at least 30%), the reviewer recommends updating this Eco-profile earlier than only after the typically 5 years' time frame.

Due to the intention to generate a PEF-conform LCI, the software model integrates only official background data of the EF database of the European Commission, as far as they are available, supplemented with datasets of the current MLC database. As the EF database was generated as a static database during the PEF pilot project, the applied background data are still valid, but refer to an older technological status, mainly 2012 – 2015. This compromise is necessary to meet all given requirements. This is valid especially regarding the dynamically changing electricity grid mixes; in the current study the contribution of electricity can be seen as a minor contributing factor.

The currently updated background data of the cracking process is controversially discussed in respect to scientific resilience. Thus, the present study integrates the background data of EF / MLC database.

Overall, the project is carried out very thoroughly. The structure and description of the Eco-profile is clear and transparent, thus displaying a reliable source of information.

Salem, 03.12.2024

Angela Schindler

Angela Schindler

Approved partner of DEKRA Assurance Services GmbH, Stuttgart, Germany

3.2 REVIEWER CONTACT DETAILS

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4 EF 3.1 INDICATOR RESULTS

The following table shows the full list of EF 3.1 indicator results for Cat.1 & Cat.2 solvents :

Table 5: EF 3.1 indicator results for Cat.1 & Cat.2 solvents

Indicator	**Unit**	**Value**
Climate change, total	kg CO_2 eq.	9.10E-01
Climate Change, biogenic	kg CO_2 eq.	3.69E-03
Climate Change, fossil	kg CO_2 eq.	9.05E-01
Climate Change, land use and land use change	kg CO_2 eq.	1.39E-03
Ozone depletion	kg CFC-11 eq.	2.85E-12
Acidification	Mole of H^+ eq.	3.02E-03
Photochemical ozone formation	kg NMVOC eq.	2.30E-03
Eutrophication, freshwater	kg P eq.	2.67E-06
Eutrophication, marine	kg N eq.	5.67E-04
Eutrophication, terrestrial	Mole of N eq.	6.30E-03
Respiratory Inorganics	Disease incidences	2.45E-08
Ionising radiation, human health	kBq U235 eq.	9.07E-03
Human toxicity, cancer – total	CTUh	6.37E-10
Human toxicity, cancer inorganics	CTUh	6.10E-10
Human toxicity, cancer organics	CTUh	2.74E-11
Human toxicity, non-cancer – total	CTUh	2.08E-08
Human toxicity, non-cancer inorganics	CTUh	2.05E-08
Human toxicity, non-cancer organics	CTUh	3.07E-10
Ecotoxicity, freshwater – total	CTUe	3.45E+01
Ecotoxicity, freshwater inorganics	CTUe	3.42E+01
Ecotoxicity, freshwater organics	CTUe	2.81E-01
Land Use	Pt	5.27E+00
Resource use, energy carriers	MJ	5.64E+01
Resource use, minerals and metals	kg Sb eq.	6.25E-08
Water use	m^3 world eq.	2.58E-02

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