



## ESA Database Project

– making existing and future LCI data available online at the CPM LCA Database website

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## Abstract/Summary

When assessing the environmental impact of technical systems for e.g. the purpose of technique or product development, system research and teaching or policy making, there is a need for environmental data on the technical processes of the systems. The purpose and goal of the ESA Database Project was to make LCI data produced at ESA, from 1990 to the present date, available online at the CPM LCA Database and to facilitate future online publishing. During the project, 162 process data sets have been published online, an increase of 30 % of processes in the database. Technical improvements of the software and the website interface have been made throughout the project and a start-up method for future documenting and publishing at ESA has been made, containing the ESA DBP Quality Criteria, relevance directions and the description of the documenting and reviewing procedure.



# Table of Contents

Introduction.....	1
Project purpose and goals .....	1
Project task descriptions .....	1
Project Task Results.....	2
Task 1 – Inventory of existing data.....	2
Publication and process inventory for ESA DBP .....	2
Task 2 - Definition of quality criteria and specification of nomenclatures .....	2
Mandatory requirements in the ESA DBP quality criteria.....	3
Optional guidelines in the ESA DBP quality criteria .....	3
Task 3 – Quality indication and prioritization of process data sets .....	9
Relevance directions for process data sets .....	9
Quality Indication .....	11
Task 4 – Documenting .....	11
Documenting, reviewing and publishing in the ESA Database Project .....	11
Process data sets published during the ESA Database Project .....	12
Future documenting, reviewing and publishing at ESA .....	12
Task 5 – Documenting procedure .....	13
Procedure in SPINE@CPM Data Tool .....	13
Procedure in the Microsoft Access database.....	15
Procedure for publishing.....	18
Task 6 – Technical improvements .....	19
CPM LCA Database end user web interface improvements .....	19
SPINE@CPM Data Tool functional improvements .....	19
SPINE@CPM Data Tool bugfixes .....	20
Unresolved technical issues .....	20
Concluding remarks.....	20
References.....	21
Appendix 1 – Published processes with publication references.....	I
Appendix 2 – Flowtype definitions and examples.....	I
Appendix 3 – Requirements for inventory data for the CPM LCA Database .....	I
Appendix 4 – Links.....	I





## **Introduction**

Using various assessment methodologies, environmental impact of technical systems can be assessed for the purpose of e.g. technology or product development, system research and teaching or policy making.

To be able to quantitatively measure the environmental impact of technical systems, there is a need for environmental data on the technical processes of the systems.

As process data is challenging to get hold of, a group of Swedish companies together with Chalmers University of Technology started their own network platform in 1996 for sharing knowledge of the Life Cycle Assessment (LCA) methodology; the CPM – Center for environmental assessment of Product and Material systems. The primary purpose of CPM was to share process data sets through their common database – the CPM LCA Database (initially named SPINE@CPM).

From 2008 the CPM LCA Database is publicly available on the internet and the process data sets are downloadable for free. The present host and maintainer of the database is the division of Environmental Systems Analysis (ESA) at Chalmers University of Technology. Since 1990, the staffs at ESA (former TEP – Technical Environmental Planning) have, in their research, used LCA to assess environmental impact of technical systems in their research and have consequently published numerous process data sets.

### ***Project purpose and goals***

The purpose of the ESA Database Project was to make LCI data produced at ESA available online at the CPM LCA Database website. The LCI data, in form of good quality data process sets, will be an appreciated contribution to future LCA use and research.

The goal was to make as many ESA process data sets as possible, with sufficient quality, available online, which included facilitating future online publishing at ESA. The goal was divided into six tasks. This report will go through the tasks one by one; how they were performed during the project and what results they led to.

### **Project task descriptions**

#### *Task 1 – Inventory of existing data*

Making an inventory of all publications, containing process data sets, generated at ESA (and previously from TEP) from 1991 to the present.

#### *Task 2 – Definition of quality criteria and specification of nomenclatures*

Defining the quality criteria for documentation in the ESA Database Project and for documentation of future process data sets generated at ESA. The quality criteria are divided

into mandatory requirement and optional guidelines. Specifying nomenclatures in the software tool.

*Task 3 – Quality indication and prioritisation of process data sets*

Prioritization of the process data sets according to relevance and to the quality criteria defined in task 2. Describing the prioritization process to enable future prioritization. Indicating the quality of the documented data when published online.

*Task 4 – Documentation and review of process data sets*

Documentation, using the software tool SPINE@CPM Data Tool, including interpreting and restructuring texts and tables of the original documents into well defined concepts and nomenclatures in the database format. The documentation work shall follow, and subsequently be reviewed according to, the quality criteria defined in task 2. Satisfactory process data sets will be made available for download at the CPM LCA Database website.

*Task 5 – Establishment of documentation procedure for new process data*

The documentation process used in this project will be evaluated, adjusted and described for continuous documentation of new data generated from future research.

*Task 6 – Technical improvements*

Handling, throughout the project, issues like software tool bugs and modifications in the CPM LCA Database web browser user interface.

## **Project Task Results**

### ***Task 1 – Inventory of existing data***

#### **Publication and process inventory for ESA DBP**

The search for processes to document in the CPM LCA Database was executed accordingly; all ESA-reports was hunted down via the online ESA-report library and the regular division library, and all division personnel were asked to recollect and list any of their own publications that might include LCI-data. When processes were found by the documenter in reports and publications, they were listed in the first version of the inventory list. As the processes were evaluated according to the quality and relevance criteria made in task 2 and 3 they were either documented in the CPM LCA Database or discarded from the list. The last version of the inventory list is reverted to a list of documented and online published processes; it can be found in Appendix 1.

### ***Task 2 - Definition of quality criteria and specification of nomenclatures***

The data quality demand depends on who is using the data and for what purpose, which means that one type of data can be of high quality for one user and of low quality for

another. Thus the quality affects how relevant the data is for the specific user. In order for the user to assess the quality (including the relevance) of the data it is therefore important to make the information about the data, the meta data, as transparent and accessible as possible. (Steen, 1997).

New quality criteria have been defined for ESA DBP, based on the earlier quality criteria for the CPM LCA Database; the CPM documentation criteria described by Pålsson (1999a and 1999b) and Flemström and Pålsson (2003). In ESA DBP the addition to the criteria is the definition of what meta data are important to include to get good data quality and transparency, i.e. which fields in the SPINE-format have to contain data or meta data and which ones are less important to fill. The importance is from a life cycle inventory perspective for as many data users as possible. The quality demands have been divided into mandatory requirements and optional guidelines.

Some of the fields in the database may only assume a word from a preset nomenclature, i.e. it is only possible to choose words from a table in the database. Nomenclature handling in the fields is included in the optional guidelines, as well as information about how many characters can be used in the field, what kind of information is wanted in the field, if there are suggested ESA standard texts that may be used, and other directions.

The ESA DBP quality criteria have been successfully used throughout the project and it is suggested that they are used continuously at the division of ESA when documenting process data in the CPM LCA database.

### **Mandatory requirements in the ESA DBP quality criteria**

- ✦ Use the English language when documenting.
- ✦ All SPINE-fields shall be filled, whether they are important or not (see explanation below in *Guidelines headline by headline*).
- ✦ When all SPINE fields are filled, the reviewer should grade how informative and extensive the documented process data set is with the grades U (unsatisfying), A (acceptable) and S (sufficient) (for procedure see Task 5).

### **Optional guidelines in the ESA DBP quality criteria**

*General guidelines (standard texts are underlined in the examples):*

- ✦ If the unimportant data is unknown – fill in the word Unknown.
- ✦ If the field is irrelevant for the process at hand – fill in the words Not applicable.
- ✦ When referring to a headline for another SPINE-field or referring to another process published in the CPM LCA Database, use single quotation-marks; e.g. ‘System Boundaries’.
- ✦ When inserting an excerpt from a report or publication use following standard text and then double quotation-marks; e.g. Excerpt from the report (see ‘Publication’):  
“Cultivated cotton is of the annual type, while the wild plant is perennial.”

- ✦ There is no demand for the flows to be complete, i.e. they do not have to equal out between input and output or include all imaginable resources or emissions for the process.
- ✦ When referring to a report or publication, the reference should be written in Harvard style.
- ✦ The publications that are linked to, must be placed in pdf-form in the Data references library at the CPM webpage, by a webpage manager.
- ✦ If there is a need to make the reader observant of, or comment, something, use the abbreviation NB (nota bene), e.g. NB: A flowchart for the system is given in the publication at page 7.

*Guidelines headline by headline:*

Below are all the headlines in the database listed, in order of appearance. A flag (🔒) is used to indicate which fields that are important to fill with descriptive metadata. In the headline list it is stated how many characters you can use in the field at hand, if you have to choose from a database table or if you can write free text, what kind of information is supposed to be in the field (partly from Steen et al. 1995), if there are any suggested ESA standard texts that may be used, and other directions. The ESA standard texts are underlined in the list.

🔒 Finished                      1 character.  
 Can be found under Data sets in the menu; Change active data set to 'Finished'. A data set is finished when it has been reviewed and approved by an authorized reviewer at ESA or CPM e.g. Johan Tivander (ESA), Emma Rex (CPM), Bengt Steen (ESA) or Anne-Marie Tillman (ESA).

**SPINE@CPM Data Tool – [Object Of Study]**

🔒 Name                              100 characters. Free text.  
 Write a suitable name for the process data set, finish with full stop, then write ESA-YYYY where YYYY is the year when the study was completed. E.g: Women's zipper manufacturing. ESA-2012

🔒 Sector                              40 characters. Choose from database table.  
 When needed, this entry can be enlarged with sectors according to the ISIC nomenclature, at e.g. <http://unstats.un.org/unsd/cr/registry/regs.asp?Lg=1>.

Site                                      30 + 30 characters. Choose from database table.  
 Used if the data is produced in a specific place, e.g. The Swedish Wool Factory in Borås. In case of confidentiality write Not applicable.

Owner                                      30 + 30 characters. Choose from database table.  
 Used if someone owns the data, e.g. ESA or the company that has produced the data.

🔒 Category                              20 characters. Choose from database table.  
 Technical scope, e.g. cradle-to-gate.

🔒 Function                              Unlimited number of characters. Free text.  
 - Brief description of the process and function of the product.

- Refer to the report at hand with following ESA standard text, followed by the whole report reference: This process is included in the system described in (e.g.)\_Dahlöf L, 2004, Methodological issues in the LCA procedure for the textile sector - a case study concerning fabrics for a sofa. Environmental Systems Analysis report 2004:7, Chalmers University of Technology, Gothenburg, Sweden
- Insert Link to publication: <a href=http://www.cpm.chalmers.se/CPMDatabase/DataReferences/ESA\_2004--7.pdf>http://www.cpm.chalmers.se/CPMDatabase/DataReferences/ESA\_2004--7.pdf</a>  
In the example above, the digital name of the document is “ESA\_2004--7”, mind changing this document name when inserting the above link.
- Refer to other processes published in the CPM LCA Database, from the same report, with following ESA standard text: Other processes in the CPM Database also included in the above publication: e.g 'Cotton cultivation. ESA-2004'.

#### SPINE@CPM Data Tool – [Activity/Flow Meta Data]

Direction	6 characters. Choose from database table.
FlowType	Input or Output. 20 characters. Choose from database table. E.g. Product, Bi-product, Emission, Resource. For more examples and definitions of flow types see Appendix 2.
Substance	40 characters. Choose from database table. It is possible to search if the substance at hand resides in the sharp database nomenclature by opening the nomenclature window and use the search engine at the top, or by using this link: <a href="http://www.cpm.chalmers.se/CPMDatabase/substancesearch.asp">http://www.cpm.chalmers.se/CPMDatabase/substancesearch.asp</a> which searches the database via the web. The program will display found items and the categories where they are placed. Substances that do not reside in the database must be inserted manually, for instruction see “Creating new choices in the nomenclature of ‘Substance’.” in Task 5.
Quantity	255 characters. Free text. When the quantity is given as an interval use ‘Min’ and ‘Max’ and give ‘Quantity’ the middle value.
Min	255 characters. Free text. Leave blank if they do not exist. When the quantity is given as e.g. >0.01 put ‘Min’ 0.01 instead.
Max	255 characters. Free text.

	Leave blank if they do not exist. When the quantity is given as e.g. <0.01 put 'Max' 0.01 instead.
SDev	255 characters. Free text.
	Leave blank if they do not exist.
Unit	50 characters. Choose from database table.
Environment	60 characters. Choose from database table.
	From what environment at input and to what environment at output, e.g. water, ground, technosphere.
Geography	30 characters. Choose from database table.
	Used if input or output can be related to a geographical spot. Otherwise, leave blank.
<i>QMeta Data – General/Specific</i>	QMetaData General – for the whole data set. QMetaData Specific – for single substance entries.
Date Conceived	23 characters. Free text.
	Time of data origin. YYYY-MM-DD, YYYY-MM or YYYY.
Data Type	100 characters. Choose from database table.
	E.g. derived, mixed, calculated, estimated.
Method	Unlimited number of characters. Free text.
	Method for fabricating the numerical value e.g. measuring or gathering data.
Represents	Unlimited number of characters. Free text.
	Used if the data is approximated with other data. If there is no information use the ESA standard text in 'QMetaData General': <u>See 'Function'</u> .
LitteratureRef	Unlimited number of characters. Free text.
	For 'QMetaData General' this is the literature reference where the flow data set was first documented. If the data set is first published in the ESA report it is the ESA report that is the reference, and if so - insert the link to the report on the webpage (mind changing the report number): <a href=http://www.cpm.chalmers.se/CPMDatabase/DataReferences/ESA_2004--7.pdf>http://www.cpm.chalmers.se/CPMDatabase/DataReferences/ESA_2004--7.pdf</a>
	For 'QMetaData Specific' this is the literature reference to the publication where the separate value was first documented.
Notes	Unlimited number of characters. Free text.
	If flow cutoffs have been done, this shall be noted here in 'QMetaData General'. If the documenter of data (to the CPM LCA database) suspects that a value is incorrect it should be noted here in 'QMetaData Specific', with the following ESA standard text: <u>Data documenter notes: Value reliability questioned. Value as reported in reference.</u>

## SPINE@CPM Data Tool – [Inventory]

### Scope

Intended User	200 characters. Free text. The person, organization or group of persons whom the study was made to serve. E.g. The Swedish Wool Factory and LCA practitioners.
General Purpose	Unlimited number of characters. Free text. The abstract idea or purpose that initiated the study, e.g. Master thesis report or climate change worries.
Detailed Purpose	Unlimited number of characters. Free text. The answer to a formulated question; the purpose of this particular study.
Commissioner	30 + 30 characters. Choose from database table. The person initiating the study. Commissioners that do not reside in the database must be inserted manually in the Juridical Person table, for instruction see “Creating new choices in the nomenclatures of JuridicalPerson” in Task 5. NB; it is only possible to put one row from the database as commissioner, thus when there are more than one commissioner these must be put in the same row in the Juridical Person table.
Practitioner	30 + 30 characters. Choose from database table. The person responsible for the study and the derivation of data. Practitioners that do not reside in the database must be inserted manually in the Juridical Person table, for instruction see “Creating new choices in the nomenclatures of JuridicalPerson” in Task 5.
Reviewer	30 + 30 characters. Choose from database table. A person representative to the review panel during the published study. Reviewers that do not reside in the database must be inserted manually in the Juridical Person table, for instruction see “Creating new choices in the nomenclatures of JuridicalPerson” in Task 5.
Functional Unit	200 characters. Free text.
FU Explanation	Unlimited number of characters. Free text. Brief, explaining text about the functional unit.

### System

Nature Boundary	Unlimited number of characters. Free text. Description of system boundaries bordering to nature e.g. flows that enter or leave the controlled technosphere.
Time boundary	Unlimited number of characters. Free text. Time horizon. Lifetime of the system/process/product. Applicable time of the system/process/product. Best before date. If the time boundary is not exactly stated in the report consider using the following ESA standard text: <u>Unknown. The documenter of data to the CPM Database makes a qualified guess that the average year of data is year YYYY, based on the publication years of the data literature references that are referred to in the report.</u>

<p>🔗 Geographical Boundary</p>	<p>Unlimited number of characters. Free text.</p> <p>Geographical horizon. Country, region or geographical extension (mostly for large technical systems).</p>
<p>Other Boundaries</p>	<p>Unlimited number of characters. Free text.</p> <p>Other assumptions. Notes of excluded subsystems.</p>
<p>🔗 Allocations</p>	<p>Unlimited number of characters. Free text.</p> <p>Applied allocation principle (if any), description.</p>
<p>🔗 Systems Expansions</p>	<p>Unlimited number of characters. Free text.</p>
<p><i>Data (1)</i></p>	
<p>🔗 Applicability</p>	<p>Unlimited number of characters. Free text.</p> <p>Under what circumstances the study is applicable, especially certain cautions. If there is no note about applicability in the report consider using following ESA standard text: <u>For applicability for the process see ‘Function’ and ‘System’.</u></p>
<p>🔗 About Data</p>	<p>Unlimited number of characters. Free text.</p> <p>Notes about the data set that does not fit in anywhere else.</p> <p>At the bottom of this field, include a full horizontal line followed by this ESA standard text (where YYYY is the year and Nnnn etc. are names):</p> <p style="margin-left: 40px;"><u>ESA-YYYY</u></p> <p style="margin-left: 40px;"><u>Documentation completed for this data set: YYYY-MM-DD</u></p> <p style="margin-left: 40px;"><u>Administering organization: Chalmers University of Technology, the division of Environmental Systems Analysis.</u></p> <p style="margin-left: 40px;"><u>Documenter of data: Nnnnn Nnn (ESA).</u></p> <p style="margin-left: 40px;"><u>Reviewer of data: Nn Nnnnnnn (ESA).</u></p>
<p><i>Data (2)</i></p>	
<p>🔗 Date Completed</p>	<p>10 characters. Free text.</p> <p>The date when the publication (for example the ESA report) was completed. YYYY-MM-DD.</p>
<p>🔗 Publication</p>	<p>Unlimited number of characters. Free text.</p> <p>The study where the data set and the meta data is found by the documenter.</p> <p>Insert link to the report on the webpage (see example from ‘Function’).</p>
<p>🔗 Availability</p>	<p>255 characters. Free text.</p> <p>Authorizations and confidentiality. Insert following ESA standard text: <u>Public.</u></p>
<p>🔗 Copyright</p>	<p>60 characters. Free text.</p> <p>Insert following ESA standard text: <u>Environmental Systems Analysis, Chalmers Univ. of Technology.</u></p>
<p>Notes</p>	<p>Unlimited number of characters. Free text.</p> <p>Notes that do not belong to any other field can be put here.</p>



### ***Task 3 – Quality indication and prioritization of process data sets***

Not all data may be useful for further studies for various reasons. Therefore the relevance of every process data set had to be evaluated before investing time in documenting it. In practice, the relevance of one process from a publication inventoried in ESA DBP was evaluated rather quickly by the documenters. The documenters considered the quality of the flow data, the quality of the meta data (both according to the ESA DBP quality criteria) and if the data would be useful for other LCA practitioners.

Still, the abundance of the number of processes made the task quite time consuming. Two thirds of the gone through processes had to be discarded, most often due to poor quality and rarely due to low relevance.

Relevance directions in future process documenting at ESA are suggested below. They are not to be followed strictly but with common sense, as relevance can be subjective. Base the relevance on the following question: “Is this data useful for other people; students, researchers, teachers, consultants etc?” and then prioritize accordingly.

#### **Relevance directions for process data sets**

##### *High relevance:*

- Process data sets that are representative for the process at hand, with clearly defined system boundaries and that have a wide applicability to other cases or systems. Both flow data and meta data are fulfilling the ESA DBP quality criteria.
- Data sets that have been produced for the study at hand are more relevant than data sets that have been extracted from literature.
- Inventory data in the category “cradle-to-gate” or “gate-to-gate” is more relevant than data in the category “cradle-to-grave”, since it has a wider potential application.
- Data sets from all years are relevant, though newer data has slightly higher relevance.
- In Table 1 you can see an example of a flow data set with high relevance, due to its applicability in other systems and the amount of flow information. This data set is for production of tire and is extracted from Boss (2005). If the meta data connected to this flow data fulfills the quality requirements the data set is considered of high relevance.

Table 1.(Table 2, p.11 in Boss (2005)) Inventory data for production of 5.47 kg tire.

	<b>Substance</b>	<b>Quantity [kg]</b>
Resources	Crude oil	6.01
	Hard coal	2.16
	Iron ore	1.17
	Latex	2.57
	Lignite	3.46
	Natural gas	5.41
	Sulphur	0.20
Emissions to air	CO	6.0E-3
	CO <sub>2</sub>	21.1
	Methane	1.47E-2
	N <sub>2</sub> O	2.62E-3
	NM VOC	1.61E-2
	NO <sub>x</sub>	1.10E-2
	SO <sub>2</sub>	1.15E-2
Emissions to water	BOD	7.78E-3
	Ca <sup>2+</sup>	1.75E-5
	Cl <sup>-</sup>	1.10
	COD	1.94E-2
	Na <sup>+</sup>	0.282
	SO <sub>4</sub> <sup>2-</sup>	0.467
Waste	Hazardous	5.25E-2
	Household	0.763
	Inert residues	13.5
	Ore dressing residue	2.08
	Rubber	0.181
	Slags & ashes	4.48E-2
	Sludge	7.73E-2
	Unspecified	1.27

*Low relevance:*

- Data sets that have limited applicability in other cases or systems due to very narrow system boundaries such as e.g. local and/or rare parameters.
- Data sets based on crude estimates and/or guesstimates are less relevant.
- In Table 2 you can see an example of a flow data set with low relevance, due to its lack of flow information. The data set is for cotton baling and is extracted from Dahllöf (2004). Even if the connected meta data would fulfill the quality requirements the data set would still be of low relevance.

Table 2. (Table 6, p.20 in Dahllöf (2004)) Inventory data for cotton baling.

Direction	FlowType	Substance	Quantity	Unit	Environment
Input	Non-elementary	Chlorinated phenol <sup>1</sup>		kg	Technosphere
Input	Non-elementary	Cotton fibers	2.18E+02	kg	Technosphere
Input	Non-elementary	Steel band <sup>1</sup>		kg	Technosphere
Input	Non-elementary	Woven jute <sup>1</sup>		kg	Technosphere
Output	Product	Cotton bale	2.18E+02	kg	Technosphere

1. Amount not known.

## Quality Indication

The quality indicators U (unsatisfying), A (acceptable) and S (sufficient) (can be seen in Appendix 1) are used to indicate the quality of the flow data and the meta data together; to which grade the documented data is informative and extensive. This is done when the documented process has been reviewed and is up for publishing online in the CPM LCA Database.

## Task 4 - Documenting

### Documenting, reviewing and publishing in the ESA Database Project

The inventoried publications stretched from 1990 to 2010 and some of them had been documented in the database as a part of the thesis work. So before starting the documentation process with relevance and quality assessment it was necessary in ESA DBP to control if the process was already documented in the database or not.

Processes, from ESA publications, that reached the demands for relevance and quality, both in flow data and meta data, was documented in a gateway database using SPINE@CPM Data Tool. The documenters in the ESA Database Project were Filippa Fuhrman (ESA) and Katarzyna Iwanek (ESA). (For detailed documenting procedure please look at Task 5.) When the documenters had finished the documentation it was time for review of the data. The reviewer in the ESA Database Project was mainly Johan Tivander (ESA) with occasional assistance of Filippa Fuhrman. The reviewer would make some changes or point out inconsistencies in the data for the documenters to take care of, and when the reviewer found the data set to be complete and have good quality the process was imported to the sharp CPM LCA Database, which is the version published on the web.

To recognize the process data sets published within the ESA Database Project the abbreviation ESA DBP is included at the end of every process name (e.g. 'Diocetyl phthalate (DOP) production. ESA-DBP'). Following informational text was added to the field 'About data' for every process:

“ESA Database Project.

Years: 2009-2011.

Documentation completed for this data set: YYYY-MM-DD

Administering organization: Chalmers University of Technology, the division of Environmental Systems Analysis.

Financier: The Swedish Research Council.

Documenter of data: Filipa Fuhrman (ESA)/ Katarzyna Iwanek (ESA), assisted by Johan Tivander (ESA).

Review committee for documented data: Johan Tivander (ESA), Emma Rex (CPM, Center for environmental assessment of Product and Material systems), Bengt Steen (ESA), Anne-Marie Tillman (ESA).”

### **Process data sets published during the ESA Database Project**

162 process data sets have been published in the CPM LCA Database during the ESA Database Project. The full list of processes is given in Appendix 1, together with the technical scope for each process.

### **Future documenting, reviewing and publishing at ESA**

When publishing process data sets in the CPM LCA Database at ESA in the future, it is suggested that the publication author (e.g. Master Thesis or PhD student) decides whether the process data is relevant and has good quality, using this report. It would be an advantage if someone who participated in the ESA Database Project is still working at the division. This person could then either document the process data set or guide the author of the publication (or other person) in the documenting procedure using this report. It is recommended that the data is documented, reviewed and published in the database as soon as possible after it has been acquired or published; the documenting process is less time consuming when the knowledge of the data is still fresh in the mind.

First choice for reviewer should be one of the following; Johan Tivander (ESA), Emma Rex (CPM), Bengt Steen (ESA) or Anne-Marie Tillman (ESA). If none of these persons is available the second choice should be among the future persons responsible for the CPM LCA Database, the CPM or other LCA research at the division of ESA.

It is suggested that the process name receives an addition that indicates that the process data set is published at ESA; ESA-YYYY. A process name can then for example look like this: 'Space ship manufacturing. ESA-2015'. It is also suggested that following informational text is added to the field 'About data';

“ESA-YYYY.

Documentation completed for this data set: YYYY-MM-DD.

Administering organisation: Chalmers University of Technology, the division of Environmental Systems Analysis.

Documentor of data: Nnnnn Nnnnnnnn (ESA).

Reviewer of data: Nnn Nn (ESA).”

### ***Task 5 – Documenting procedure***

The documenting procedure is a practical description of how to install the SPINE@CPM Data Tool and then use it to document process data. In ESA DBP one person already knew how to work with the program and thus taught the documenters. The description below is written for the future users of SPINE@CPM Data Tool and CPM LCA Database. For more information about the SPINE fields and documentation guidelines please read “Task 2- Definition of quality criteria and specification of nomenclatures” above.

### **Procedure in SPINE@CPM Data Tool**

- Installation:
  - o Install the SPINE@CPM Data Tool by following this link:  
<http://www.cpm.chalmers.se/CPMDatabase/datatool/spine@cpmv41.zip>  
The program is compatible with e.g. Windows 2007.
  - o You will receive a folder with installation material. The folder includes all the files you will need.
  - o Ensure that you have full administration rights on the computer you are installing to.
  - o Read the Read-me file and do exactly what it says.
  
- Opening a database with the SPINE@CPM Data Tool:
  - o When documenting, a gateway database is used. To create a gateway database copy the sharp database in the same way that you copy any file. When documented, the data is transferred from the gateway database to the sharp database as described further below.
  - o Click at the SPINE program icon – a sign comes up that says WELCOME.
  - o Select ‘A Microsoft Access database file’, with one click.
  - o Browse for your database and double-click at it. Up comes the SPINE@CPM Data Tool – [Search form].

- Creating a new activity:
  - o Open your database according to the directions above.
  - o In the SPINE@CPM Data Tool – [Search form], click on the eighth icon from the left (the white square with a grey square dot in the right lower corner). Up comes the sign SPINE@CPM New Dataset.
  - o Name your process (this name is possible to change later on). And select a process subtype. Click 'Ok'. Up comes the SPINE@CPM Data Tool – [Object of Study].
  - o Now create an 'Activity'. You can do it two ways:
    1. Choose 'Data sets' in the top menu and then 'New Activity'.
    2. Go to the 'Activities' window to the right, right-click and click on 'Add'.
  - o When you have created an 'Activity' you should in the 'Activities' window see a red book saying 'Not finished, Functional U...'. Double-click at the book. The book opens and you are free to feed data to your new activity.
  
- Opening an existing, but not finished, process data set:
  - o Open your database with SPINE@CPM Data Tool according to the directions above. Or; if you are already in the SPINE format, click the seventh icon from the left; SQL.
  - o In the SPINE@CPM Data Tool – [Search form], double-click at 'Object of Study not complete data sets' and then click at 'Not finished with activity' or 'With activity no flow' or 'Without activity' depending on how developed the existing process was. A list of processes will appear to the right.
  - o Choose your process from the list by double-clicking.
  - o If the process has an activity, double-click at the red book to the right. The book opens and you are free to feed data to the activity. Otherwise see the previous section 'Creating a new activity' in this report.
  
- Documenting data:
  - o In the ESA DBP Quality Criteria (see Task 2 in this report) it is stated whether the field is more or less important to fill, if you need to make a choice from a nomenclature, how many characters you can put in the field, what the field stands for, if there are any suggested ESA standard texts that you may or must put in the field and other information.
  - o The first icon to the left (a house with a red car in front of it) is the SPINE@CPM Data Tool – [Object of Study].
  - o The second icon from the left (a lightning) is the SPINE@CPM Data Tool – [Activity/Flow Meta Data].

- The third icon from the left (an eye) is the SPINE@CPM Data Tool – [Inventory]. Here you have four different sheets; 'Scope', 'System', 'Data (1)' and 'Data (2)'.
- In order to document the data in the SPINE fields, see '*Guidelines headline by headline*' in 'Task 2' where all the headlines are explained.
- Saving the page and the whole data set:
  - To save the page at hand, click the button 'Save Page' to the right. To save the whole data set click the ninth button from the left (a floppy disc).
  - If you have not saved when exiting, the program will ask you if you want to save the data set.
- Reloading page
  - To discard any changes made since the last saving click the button 'Reload page'.
  - The 'Reload and save' button reloads and saves. (This button is added to go round a bug where pushing the 'Reload page' button resulted in the ending of the program.)
- Explanation of all the icons that you can see in SPINE@CPM (from the left):
  - 1st. Opens Object of Study window.
  - 2nd. Opens Activity/Flow meta data window.
  - 3rd. Opens Inventory window.
  - 4th. Opens JuridicalPerson.
  - 5th. Opens Nomenclature of Substance.
  - 6th. Creates reports on active activity dataset – you can create a report in a format RTF, Excel, Text or Web format.
  - 7th. SQL - opens search form; a list of the processes in the database.
  - 8th. Creates a new object of the studied data set.
  - 9th. Saves the data set that is open.
  - 10th. Moves data to other database.
  - 11th. Opens aggregated activity.

### **Procedure in the Microsoft Access database**

- Creating new choices in the nomenclature of 'Sector':
  - Close the SPINE@CPM Data Tool.
  - Open your database in Microsoft Access view, i.e. directly from file (not with the SPINE@CPM Data Tool).
  - Double click on 'Sector' to the left. The list of sector categories comes up. Go to the bottom (empty) row.
  - Sectors are chosen according to the ISIC nomenclature (can be found at <http://unstats.un.org/unsd/cr/registry/regcst.asp?Cl=27&Lg=1> ). The categories are sorted with main categories and sub categories. Some of the names of the

categories are too long to fit in the Access database. Therefore you have to shorten them, but make sure they will not change in content. If the main category does not exist in the database, it has to be created before adding a new sub category. Put the name of the main category under 'Name' and then the word 'Sector' in the 'Superior' column. Add following ESA standard text under 'Notes'; ESA documenting YYYY . Sectors found within the ISIC nomenclature. This is how it can look:

'Name'	'Superior'	'Notes'
Agriculture	Sector	ESA docu...

- Changing row saves the entry and creates a new empty row.
- Add a new sub category by putting the name of the new sub category in the 'Name' column. In the 'Superior' column put the name of the existing main category. Add following ESA standard text under 'Notes'; ESA documenting YYYY . Sectors found within the ISIC nomenclature. This is how it can look:

'Name'	'Superior'	'Notes'
Forestry and logging	Agriculture	ESA docu...

- Changing row saves the entry and creates a new empty row.
- If new choices have been inserted in a gateway database remember to transport these choices to the sharp database when publishing the process that links to these choices (see also 'Transferring data from your gateway database to the sharp database' below).

- Creating new choices in the nomenclature of 'Substance':

- Close the SPINE@CPM Data Tool.
- Open your database in Microsoft Access view, i.e. directly from file (not with the SPINE@CPM Data Tool).
- Double click on Substance to the left. Go to the bottom row (empty) in the list that comes up. For 'Id' put ESA-NN\_YYYY-MM-DD\_x (where NN is the initials of the documenter, Y is year, M is month, D is day and x is 1 for the first entry in the Substance list that day, 2 for the second entry and so on). Then put the substance name in the 'DefaultName'. Under 'Notes', put the ESA standard text: ESA documenting YYYY. The rest of the fields are optional. This is how it can look:

'Id'	'DefaultName'	'Notes'
ESA -FF_2000-11-04_1	Cyanide	ESA documenting YYYY
ESA-KI_2013-02-10_1	Rubber tire	ESA documenting YYYY
ESA-KI_2013-02-10_2	NMVOC	ESA documenting YYYY



- Changing row saves the entry and creates a new empty row.
- Now double click on Substance Category to the left. Go to the bottom row (empty) in the list that comes up.
- Write the text ESA documenting in ‘Superior’ (ESA documenting is a super category already created for future documenting at ESA), and the substance id (given above in the Substance list) under ‘Subordinate’. This is how it can look:

‘Name’	‘Superior’	‘Subordinate’
Default	ESA documenting	ESA-FF_2000-11-04_1
Default	ESA documenting	ESA-KI_2013-02-10_1
Default	ESA documenting	ESA-KI_2013-02-10_2

- Changing row saves the entry and creates a new empty row.
  - If new choices have been inserted in a gateway database remember to transport these choices to the sharp database when publishing the process that links to these choices (see also ‘Transferring data from your gateway database to the sharp database’ below).
- Creating new choices in the nomenclature of JuridicalPerson (‘Site’, ‘Owner’, ‘Commissioner’, ‘Practitioner’ and ‘Reviewer’):

- Close the SPINE@CPM Data Tool.
- Open your database in Microsoft Access view, i.e. directly from file (not with the SPINE@CPM Data Tool).
- Double click on JuridicalPerson to the left. Go to the bottom row (empty) in the list that comes up. For ‘Id’ put ESA-FF\_YYYY-MM-DD\_x (where NN is the initials of the documenter, Y is year, M is month, D is day and x is 1 for the first entry in JuridicalPerson list that day, 2 for the second entry and so on). Then put your text under ‘Name’. The limit in this field is 60 characters. If there is a need for more space, you may use the ‘MailAddress’ column. These two fields will be merged later in SPINE@CPM Data Tool. The rest of the fields are optional. This is how it can look:

‘Id’	‘Name’	‘Mail Address’
ESA-FF_2010-05-04_1	CPM	Centre for Env. Assessment of Product and Material Systems
ESA-JT_2010-05-27_1	Marie Pascal	
ESA-JT_2010-05-27_2	Oliver Defoe	

- Changing row saves the entry and creates a new empty row.
- If new choices have been inserted in a gateway database remember to transport these choices to the sharp database (through copy and paste) when publishing

the process that links to these choices (see also 'Transferring data from your gateway database to the sharp database' below).

- Creating new choices in the nomenclature of 'Unit':
  - o Close the SPINE@CPM Data Tool.
  - o Open your database in Microsoft Access view, i.e. directly from file (not with the SPINE@CPM Data Tool).
  - o Double click on Unit to the left. Go to the bottom row (empty) in the list that comes up. Then put your text under 'Name'. The rest of the fields are optional. This is how it can look:  
'Name'  
g  
kg
  - o Changing row saves the entry and creates a new empty row:
  - o If new choices have been inserted in a gateway database remember to transport these choices to the sharp database (through copy and paste) when publishing the process that links to these choices (see also 'Transferring data from your gateway database to the sharp database' below).

### **Procedure for publishing**

- Transferring data from your gateway database to the sharp database
  - o If you have added choices in any nomenclature in your gateway database these must be copied manually to the sharp database.
  - o Close the SPINE@CPM Data Tool.
  - o Open your gateway and sharp databases in Microsoft Access view, i.e. directly from file (not with the SPINE@CPM Data Tool).
  - o If you have new records in the 'Sector' list, double click on 'Sector' in both databases. Go to your gateway database and copy the rows that were created by you. Then go to the bottom of 'Sector' list in the sharp database and paste the rows.
  - o Apply the above procedure for other lists, such as e.g. 'Substance', 'Substance category', 'JuridicalPerson' and 'Unit'.
- Grading the quality of documented processes in CPM LCA database:
  - o This should be done by the reviewer.
  - o Open sharp database in Microsoft Access view, i.e. directly from file (not with the SPINE@CPM Data Tool).
  - o Click on the bar above the list to the left and choose 'Queries'. Double-click on 'prettynessquery'. In the appearing window, click 'OK'.
  - o Find your processes by 'Id' or 'Name' (you can choose in which order they are presented).

- In the 'dDocument' column, type 'Unsatisfying', 'Acceptable' or 'Sufficient' depending on the quality of the documented process.
  - Changing row saves the entry.
  - After you have finished grading, change the displayed list to the left to 'Tables' again.
- Publication of the processes
- The publication can be done only by an authorized person – usually the reviewer of the data.
  - After you have copied the records from your gateway to sharp database, inform your reviewer about that.
  - If no corrections are needed, the reviewer or other authorized person will publish the processes at the CPM LCA Database website by placing the updated sharp Database on the website file area.

### ***Task 6 – Technical improvements***

During the ESA Database Project the following actions have been done when it comes to technical maintenance and improvements; normal maintenance of the system including security patching of web server, daily back-up of web site and database, aiding in installing the SPINE@CPM Data Tool onto documenters computers, etc. Due to security issues the web server was migrated to a new wm-ware platform in the end of 2009. This required reinstalling the specific CPM LCA Database web functions.

### **CPM LCA Database end user web interface improvements**

The web pages are programmed in Active Service Pages (ASP) using VB-script, javascript, and HTML. Microsoft Visual Interdev and direct editing in a standard Microsoft Windows text editor has mainly been used to edit the pages. The following main improvements have been made:

- A reference library has been added. Reference documentation to the process data sets (original reports, articles, etc.) can now be downloaded and linked directly from the documentation text.
- Security improvements by rewriting code to disable malicious SQL code to be sent as arguments to the web pages.
- The xfr formatted reporting function has been removed as it is no longer used.

### **SPINE@CPM Data Tool functional improvements**

The SPINE@CPM Data Tool is written in Visual Basic programming language. The programming and compiling is done in Microsoft Visual Studio 2005. Due to the relatively old coding (initially from 1998) a number of adjustments must be applied to enable compilation of the code. This includes backwards-compatibility with older versions of Access files, registering licences for SS-panel objects, etc. The main functionality improvements implemented in the tool is listed here:

- Update of program installation package: inclusion of necessary up to date .dll-files and update of appropriate installation instructions.
- Substance nomenclature search functionality implemented which reduces the time needed to document flow data.
- The requirements to fill data in fields in a flow entry row before saving the data has been reduced. This allows the documenter to add an arbitrary number of flow entries and choose what order data are to be entered before saving the work.

### **SPINE@CPM Data Tool bugfixes**

Bugfixes involves making sure the program behaves as intended as opposed to adding new functionality (see above). Microsoft Visual Studio 2005 is also used for tracing and correcting bugs.

- The save function does no longer crash the program after more than one flow has been added and the flow table has been reloaded.
- JuridicalPerson nomenclature can now be edited without program crashing.
- Trailing blank spaces are no longer unintentionally added to documentation fields upon loading and saving.

### **Unresolved technical issues**

The SPINE format is not yet totally compatible with Windows 7; the problem is related to registering of.dll files resulting in an incapability of opening the JuridicalPerson nomenclature in SPINE.

### **Concluding remarks**

162 additional process data sets have been published online at the CPM LCA Database website during the ESA DBP; this amounts to a 30 % increase of number of process data sets in the database.

The use of the software and the website interface has been facilitated through technical improvements.

A rigorous start-up method for future documenting and publishing at ESA has been made, containing the ESA DBP Quality Criteria, relevance directions and the description of the documenting and reviewing procedure.

A summarization of the process data requirements can be found in Appendix 3, addressing anyone who would want to publish a process data set in the CPM LCA Database, or to just make sure that the data is transparent enough for other people to use it when publishing in a publication or report.

## References

Boss A, 2005, Life cycle assessment of a gas-electric hybrid waste collection vehicle - comparison with conventional waste collection vehicles. Environmental Systems Analysis report 2005:7, Chalmers University of Technology, Gothenburg, Sweden

Dahllöf L, 2004, Methodological issues in the LCA procedure for the textile sector - a case study concerning fabrics for a sofa. Environmental Systems Analysis report 2004:7, Chalmers University of Technology, Gothenburg, Sweden

Flemström K, Pålsson A-C, 2003, Introduction and guide to LCA data documentation using the CPM documentation criteria and the ISO/TS 14048 data documentation format. CPM report 2003:3, Chalmers University of Technology, Gothenburg, Sweden

Pålsson A-C, 1999a, Review of LCI data at SPINE@CPM. CPM report 1999:8, Chalmers University of Technology, Gothenburg, Sweden

Pålsson A-C, 1999b, Introduction and guide to LCA data documentation - using the CPM documentation criteria and the SPINE format. CPM report 1999:1, Chalmers University of Technology, Gothenburg, Sweden

Steen B et al, 1995, SPINE – a relation database structure for life cycle assessments. Technical and Environmental Planning, Chalmers University of Technology, Gothenburg, Sweden

Steen B, 1997, Krav på datakvalitet - CPMs databas 1997. CPM-rapport 1:1997, Chalmers University of Technology, Gothenburg, Sweden

## Appendix 1 – Published processes with publication references

The processes below are published in the CPM LCA Database within the ESA Database Project.

**ESA** = Division of Environmental Systems Analysis, Chalmers University of Technology, Gothenburg, Sweden  
**TEP** = Division of Technical Environmental Planning, Chalmers University of Technology, Gothenburg, Sweden  
 TEP was converted into ESA in the year of 2000  
 Quality of the data; U (unsatisfying), A (acceptable) or S (sufficient)

No.	Publications and published processes	Technical scope	Quality
<b>R</b>	<b>ESA 2010:9. Gu S., Liu J. (2010). Life cycle assessment of Autoliv's Electronic Control Unit.</b>		
1	Electronic Control Unit's aluminium capacitor manufacturing. Autoliv ESA-DBP	Gate to gate	U
2	Electronic Control Unit's electronic connector manufacturing. Autoliv ESA-DBP	Gate to gate	U
3	Electronic Control Unit's housing manufacturing. Autoliv ESA-DBP	Gate to gate	U
4	Electronic Control Unit's inductor choke manufacturing. Autoliv ESA-DBP	Gate to gate	U
5	Electronic Control Unit's integrated circuit ASIC manufacturing. Autoliv ESA-DBP	Gate to gate	U
6	Electronic Control Unit's integrated circuit comparator manufacturing. Autoliv ESA-DBP	Gate to gate	U
7	Electronic Control Unit's integrated circuit interface manufacturing. Autoliv ESA-DBP	Gate to gate	U
8	Electronic Control Unit's integrated circuit MCU/memory manufacturing. Autoliv ESA-DBP	Gate to gate	U
9	Electronic Control Unit's label manufacturing. Autoliv ESA-DBP	Gate to gate	U
10	Electronic Control Unit's MEMS based sensor manufacturing. Autoliv ESA-DBP	Gate to gate	U
11	Electronic Control Unit's Printed Circuit Board (PCB) base manufacturing. Autoliv ESA-DBP	Gate to gate	U
12	Electronic Control Unit's rectifier diode manufacturing. Autoliv ESA-DBP	Gate to gate	U
13	Electronic Control Unit's resistor manufacturing. Autoliv ESA-DBP	Gate to gate	U
14	Electronic Control Unit's resonator manufacturing. Autoliv ESA-DBP	Gate to gate	U
15	Electronic Control Unit's Schottky diode manufacturing. Autoliv ESA-DBP	Gate to gate	U
16	Electronic Control Unit's screw manufacturing. Autoliv ESA-DBP	Gate to gate	U
17	Electronic Control Unit's signal diode manufacturing. Autoliv ESA-DBP	Gate to gate	U
18	Electronic Control Unit's transistor manufacturing. Autoliv ESA-DBP	Gate to gate	U
19	Electronic Control Unit's TVS diode manufacturing. Autoliv ESA-DBP	Gate to gate	U
<b>R</b>	<b>ESA 2010:8. Tengström J., Izurieta F. (2010). LCA of Stage Performances. Life Cycle Assessment of an Opera and a Theatre Stage Performance.</b>		
20	Stage performance in a theatre. ESA-DBP	Gate to gate	S

21	Stage performance in an opera. ESA-DBP	Gate to gate	S
<b>R</b>	<b>ESA 2010:7. Kuvalekar S., Hussain M. (2010). Life cycle assessment of Autoliv's night vision camera.</b>		
22	Night vision camera assembly. Autoliv ESA-DBP	Unit operation	S
23	Night vision camera's gasket manufacturing. Autoliv ESA-DBP	Gate to gate	A
24	Night vision camera's label manufacturing. Autoliv ESA-DBP	Gate to gate	S
25	Night vision camera's lens assembly. Autoliv ESA-DBP	Unit operation	S
26	Night vision camera's lens heater manufacturing. Autoliv ESA-DBP	Gate to gate	S
27	Night vision camera's motor manufacturing. Autoliv ESA-DBP	Unit operation	A
28	Night vision camera's rear enclosure manufacturing. Autoliv ESA-DBP	Gate to gate	S
29	Night vision camera's screw manufacturing. Autoliv ESA-DBP	Gate to gate	S
30	Night vision camera's sensor retainer manufacturing. Autoliv ESA-DBP	Gate to gate	A
31	Night vision camera's shutter assembly. Autoliv ESA-DBP	Unit operation	S
32	Night vision camera's spring extension. Autoliv ESA-DBP	Gate to gate	S
33	Night vision camera's thermistor manufacturing. Autoliv ESA-DBP	Gate to gate	S
<b>R</b>	<b>ESA 2010:4. Iwanek K., Samiee N. (2010). Life Cycle Assessment of Autoliv's front seatbelt.</b>		
34	Seatbelt assembly. Autoliv ESA-DBP	Unit operation	S
35	Seatbelt's bobbin manufacturing. Autoliv ESA-DBP	Gate to gate	S
36	Seatbelt's car sense ball manufacturing. Autoliv ESA-DBP	Gate to gate	S
37	Seatbelt's frame production. Autoliv ESA-DBP	Gate to gate	S
38	Seatbelt's gas generator assembly. Autoliv ESA-DBP	Unit operation	S
39	Seatbelt's header manufacturing. Autoliv ESA-DBP	Gate to gate	S
40	Seatbelt's initiator, serviceable assembly. Autoliv ESA-DBP	Unit operation	S
41	Seatbelt's label bam manufacturing. Autoliv ESA-DBP	Gate to gate	S
42	Seatbelt's pillar loop production. Autoliv ESA-DBP	Gate to gate	S
43	Seatbelt's polyamide granules production. Autoliv ESA-DBP	Unit operation	S
44	Seatbelt's pretensioner retractor assembly. Autoliv ESA-DBP	Unit operation	S
45	Seatbelt's rivet nut manufacturing. Autoliv ESA-DBP	Gate to gate	S
46	Seatbelt's short tube assembly. Autoliv ESA-DBP	Unit operation	S
47	Seatbelt's solder paste manufacturing. Autoliv ESA-DBP	Gate to gate	S
48	Seatbelt's spindle assembly. Autoliv ESA-DBP	Unit operation	S
49	Seatbelt's spring antiretour manufacturing. Autoliv ESA-DBP	Gate to gate	S
50	Seatbelt's spring, wire manufacturing. Autoliv ESA-DBP	Gate to gate	S
51	Seatbelt's synchronization ball manufacturing. Autoliv ESA-DBP	Gate to gate	S
52	Seatbelt's tongue production. Autoliv ESA-DBP	Gate to gate	S
53	Seatbelt's tube manufacturing. Autoliv ESA-DBP	Gate to gate	S
54	Seatbelt's web sensor manufacturing. Autoliv ESA-DBP	Gate to gate	S
55	Seatbelt's webbing manufacturing. Autoliv ESA-DBP	Gate to gate	S
<b>R</b>	<b>ESA 2010:1. Mujiyanto A., Priyojati S. (2010). Life cycle assessment of Autoliv's Driver Airbag.</b>		
56	Airbag's can production. Autoliv ESA-DBP	Gate to gate	S
57	Airbag's cushion manufacturing. Autoliv ESA-DBP	Gate to gate	S
58	Airbag's igniter granules manufacturing. Autoliv ESA-DBP	Unit operation	S
59	Airbag's inflator assembly. Autoliv ESA-DBP	Unit operation	S
60	Airbag's initiator assembly. Autoliv ESA-DBP	Unit operation	S

61	Airbag's label manufacturing. Autoliv ESA-DBP	Gate to gate	S
62	Airbag's nut manufacturing. Autoliv ESA-DBP	Gate to gate	S
63	Airbag's shunt ring. Autoliv ESA-DBP	Gate to gate	S
<b>R</b>	<b>ESA 2009:14. Liptow Ch., Tillman A.-M. (2009). Comparative life cycle assessment of polyethylene based on sugarcane and crude oil.</b>		
64	Ethylene production from cane based ethanol. ESA-DBP	Gate to gate	S
65	Polymerization in LDPE production process. ESA-DBP	Other	S
66	Refinery in crude oil based LDPE production process. ESA-DBP	Other	S
67	Sugarcane cultivation. ESA-DBP	Cradle to gate	S
68	Steam cracking in crude oil based LDPE production process. ESA-DBP	Other	S
<b>R</b>	<b>ESA 2008:1. Ljungkvist H. (2008). Miljö- och samhällsekonomisk analys av behandling av biologiskt avfall.</b>		
69	Anaerobic digestion of biological household waste. ESA-DBP	Gate to gate	S
70	Incineration of of biological household waste. ESA-DBP	Gate to grave	S
<b>R</b>	<b>D 2007:2. Heikkilä K. (2007). Environmental Assessment of Air-conditioning Systems. Design Considerations for Swedish Conditions. Building Services Engineering, Dep. Of Energy and Environment, Chalmers University of Technology, Göteborg, Sweden</b>		
71	Air-and-water air conditioning system. ESA-DBP	Cradle to gate	S
72	Air-conditioning system. ESA-DBP	Cradle to gate	S
73	All-Air handling unit with a cooling coil and vapour compression chiller with a refrigerant. ESA-DBP	Cradle to grave	S
74	All-Air desiccant cooling Air handling unit. ESA-DBP	Cradle to grave	S
75	Bore-hole based air-conditioning system. ESA-DBP	Cradle to grave	S
76	Operation on desiccant cooling system - a technology in Air conditioning. ESA-DBP	Gate to gate	S
77	Operation on vapour compression cooling system - a technology in Air conditioning. ESA-DBP	Gate to gate	S
<b>R</b>	<b>ESA 2006:14. Suomalainen K. (2006). Environmental life cycle assessment of a large-scale grid-connected PV power plant.</b>		
78	Wafer production, for photovoltaic cells. ESA-DBP	Cradle to gate	S
<b>R</b>	<b>ESA 2005:16. Kilgus D. (2005). Life Cycle Assessment of a Demonstration Project - Vehicle Use of Hydrogen - Blended Natural Gas</b>		
79	Extraction and processing of natural gas (NG). ESA-DBP	Gate to gate	A
80	Modified natural gas vehicle (NGV) operating on compressed natural gas (CNG). ESA-DBP	Gate to gate	A
81	Modified natural gas vehicle (NGV) operating on CNG wiith 15 % hydrogen (HCNG-15). ESA-DBP	Gate to gate	A
82	Modified natural gas vehicle (NGV) operating on CNG wiith 30 % hydrogen (HCNG-30). ESA-DBP	Gate to gate	A
83	Unmodified natural gas vehicle (NGV) operating on compressed natural gas (CNG). ESA-DBP	Gate to gate	A
84	Unmodified natural gas vehicle (NGV) operating on CNG with 15 % hydrogen (HCNG-15). ESA-DBP	Gate to gate	A
<b>R</b>	<b>ESA 2005:10. Abelmann A. (2005). Environmental Potential of Increased Human Consumption of Grain Legumes. An LCA of food products.</b>		



85	Operation of 'Hot Dogs' producing facility. ESA-DBP	Gate to gate	S
86	Pea cultivation. ESA-DBP	Gate to gate	S
87	Production of beef. ESA-DBP	Gate to gate	S
88	Production of pork. ESA-DBP	Gate to gate	S
89	Rape seed cultivation. ESA-DBP	Cradle to gate	A
90	Sausage (Hot-Dog) production. ESA-DBP	Gate to gate	S
91	Sausage (Pea-Dog) production. ESA-DBP	Gate to gate	S
92	Sausage (Soy-Dog) production. ESA-DBP	Gate to gate	S
93	Soy bean cultivation. ESA-DBP	Cradle to gate	S
94	Soy bean processing. ESA-DBP	Gate to gate	S
95	Sugar beet cultivation. ESA-DBP	Cradle to gate	A
96	Wheat cultivation. ESA-DBP	Gate to gate	S
<b>R</b>	<b>ESA 2005:7. Boss A. (2005). Life cycle assessment of a gas-electric hybrid waste collection vehicle - comparison with conventional waste collection vehicles.</b>		
97	Collection area driving, with diesel driven waste collection vehicle. ESA-DBP	Unit operation	A
98	Collection area driving, with gas driven waste collection vehicle. ESA-DBP	Unit operation	A
99	Collection area driving, with hybrid (gas-electric driven) waste collection vehicle. ESA-DBP	Unit operation	A
100	Collection stop, with diesel driven waste collection vehicle. ESA-DBP	Unit operation	A
101	Collection stop, with gas driven waste collection vehicle. ESA-DBP	Unit operation	A
102	Collection stop, with hybrid (gas-electric driven) waste collection vehicle. ESA-DBP	Unit operation	A
103	Transportation with diesel driven waste collection vehicle. ESA-DBP	Unit operation	A
104	Transportation with gas driven waste collection vehicle. ESA-DBP	Unit operation	A
105	Transportation with hybrid (gas-electric driven) waste collection vehicle. ESA-DBP	Unit operation	A
106	Truck chassi manufacturing. ESA-DBP	Gate to gate	S
107	Truck tire production. ESA-DBP	Gate to gate	S
108	Waste collection vehicle, diesel driven. ESA-DBP	Cradle to grave	S
109	Waste collection vehicle, driven by compressed natural gas. ESA-DBP	Cradle to grave	S
110	Waste collection vehicle, driven by electricity and compressed natural gas. ESA-DBP	Cradle to grave	S
<b>R</b>	<b>ESA 2004:7. Dahllöf L. (2004). Methodological issues in the LCA procedure for the textile sector - a case study concerning fabrics for a sofa.</b>		
111	Cotton (conventional) fibres production. ESA-DBP	Gate to gate	S
112	Cotton covering of sofa. ESA-DBP	Cradle to grave	S
113	Flame retardant polyester (Trevira CS) covering of sofa. ESA-DBP	Cradle to grave	S
114	Wool/polyamide covering of sofa. ESA-DBP	Cradle to grave	S
<b>R</b>	<b>ESA 2003:3. Jonasson K. (2003) Environmental aspects of the use-phase for bearings in trains.</b>		
115	Maintenance of train bearings - train type 'Regina'. ESA-DBP	Gate to gate	S
116	Maintenance of train bearings - train type 'X1'. ESA-DBP	Gate to gate	S
117	Maintenance of train bearings - train type 'X10'. ESA-DBP	Gate to gate	S
118	Operation on train bearings - train type 'Regina'. ESA-DBP	Gate to gate	S

119	Operation on train bearings - train type 'X1'. ESA-DBP	Gate to gate	S
120	Operation on train bearings - train type 'X10'. ESA-DBP	Gate to gate	S
121	Use phase of train bearings - train type 'Regina'. ESA-DBP	Gate to gate	S
122	Use phase of train bearings - train type 'X1'. ESA-DBP	Gate to gate	S
123	Use phase of train bearings - train type 'X10'. ESA-DBP	Gate to gate	S
<b>R</b>	<b>ESA 2002:14. Blanco-Rosette, S. (2002). LCA data structure and time series related to construction and maintenance in Sweden.</b>		
124	Clay roof tile manufacturing. ESA-DBP	Cradle to gate	A
125	Exterior coating (Swedish red paint) maintenance. ESA-DBP	Gate to gate	A
126	Floor maintenance. ESA-DBP	Gate to gate	A
127	Pine window production. ESA-DBP	Cradle to gate	A
128	Swedish red paint manufacturing and application. ESA-DBP	Gate to gate	S
<b>R</b>	<b>ESA 2002:10. Karlström M. (2002). Environmental technology assessment of introducing fuel cell city buses - a case study of fuel cell buses in Göteborg .</b>		
129	Transport with a fuel cell bus run on hydrogen produced in steam reforming process. ESA-DBP	Gate to gate	S
130	Hydrogen fuel production by steam reforming of natural gas. ESA-DBP	Cradle to gate	S
131	Hydrogen fuel production from on-site electrolysis. ESA-DBP	Gate to gate	S
132	Transport with a fuel cell bus run on hydrogen produced in electrolysis process. ESA-DBP	Gate to gate	S
133	Transport with a diesel bus. ESA-DBP	Gate to gate	S
134	Transport with a compressed natural gas bus. ESA-DBP	Gate to gate	S
<b>R</b>	<b>TEP 1997:9. Bengtsson M, Lundin M, Molander S. (1997). Life cycle assessment of wastewater systems - case studies of conventional treatment, urine sorting and liquid composting in three Swedish municipalities.</b>		
135	Construction of liquid composting batch system. ESA-DBP	Gate to gate	S
136	Construction of liquid composting continuous system. ESA-DBP	Gate to gate	S
137	Construction of small-scale waste water treatment plant. ESA-DBP	Gate to gate	S
138	Operation of large scale waste water treatment plant. ESA-DBP	Gate to grave	S
139	Operation of liquid composting batch process. ESA-DBP	Gate to grave	S
140	Operation of liquid composting continuous system. ESA-DBP	Gate to grave	S
141	Operation of small-scale waste water treatment plant. ESA-DBP	Gate to grave	S
142	Operation of the sewage sludge and septage treatment system - central treatment option. ESA-DBP	Gate to grave	S
143	Operation of the sewage sludge and septage treatment system - local treatment option. ESA-DBP	Gate to grave	S
144	Operation of waste water treatment plant with urine and sludge separation . ESA-DBP	Gate to grave	S
<b>R</b>	<b>TEP 1997:3. Beckman T. (1997). Gutenberg versus IT - a life cycle assessment of printed and CD-stored information.</b>		
145	Cardboard production (MDF based). ESA-DBP	Gate to gate	A
146	Cultivation and felling of trees for papermaking. ESA-DBP	Gate to gate	A
147	Diocetyl phthalate (DOP) production. ESA-DBP	Gate to gate	A

148	Manufacturing of CD-R (Compact Disc-Recordable). ESA-DBP	Gate to gate	S
149	Manufacturing of CD-ROM (Compact Disc - Read Only Memory). ESA-DBP	Gate to gate	S
150	Production of copypaper. ESA-DBP	Other	S
151	Production of orthoxylene. ESA-DBP	Gate to gate	A
<b>R</b>	<b>TEP 1996:11. Thuresson J. (1996). Life cycle assessment of water pumps.</b>		
152	Cast iron production. ESA-DBP	Gate to gate	S
153	Coal mining and cleaning. ESA-DBP	Gate to gate	S
154	Limestone quarrying. ESA-DBP	Gate to gate	S
155	Production of pig iron - blast furnace process. ESA-DBP	Gate to gate	S
156	Sand extraction and processing. ESA-DBP	Cradle to gate	S
157	Sinter plant's process ESA-DBP	Gate to gate	S
158	Uranium ore extraction and enrichment. ESA-DBP	Gate to gate	S
<b>R</b>	<b>TEP 1995:3. Jönsson Å, Tillman A-M, Svensson T. (1995). Life cycle assessment of flooring materials. A case study and methodological considerations.</b>		
159	Dioctyl phthalate (DOP) production. ESA-DBP	Gate to gate	A
160	Linoleum flooring. ESA-DBP	Cradle to grave	S
161	Solid wood flooring. ESA-DBP	Cradle to grave	S
162	Vinyl flooring. ESA-DBP	Cradle to grave	S

## Appendix 2 – Flowtype definitions and examples

Flow type	Short definition	Examples
By-product	A product which is a result of the studied process but in comparison to the 'Product' it has secondary meaning and/or was unexpected.	Grape seed oil as a result of a wine production process.
Cargo	Goods or merchandise which is transported either by ship, train, aircraft or truck.	Four tons of oranges.
Co-product	A result of the studied process together with other product(s) where all of them have similar importance.	Fuel oils and vehicle fuels from a refinery process.
Emission	Outputs of the process which cross the technosphere boundary into the environment and are out of our control. They can be emitted to air, ground or water.	CO2, dust, noise, BOD, oil.
Input product	A ready component, which has been produced in a previous process in the studied system of processes.	Screw in seatbelt production.
Natural resource	A resource that comes from the environment. Could be derived from the biosphere or as non-living resource.	Air, wind, flora, animals, coal, fossil fuels, mineral resources, soil, water, water reserves.
Product	An output of the process and the main reason for carrying out the process.	Seatbelt in seatbelt assembly process.
Refined resource	A resource which was processed and consequently comes from the technosphere.	Electricity, fuel, ethanol, alloy, biogas, cotton fabric, ink, paste, polymer.
Residue	A not wanted output of the process that remains in the technosphere.	Hazardous waste, ash, radioactive waste, waste water, used oil.
Resource	Can be physical or virtual and it is used in the process to create a value. If it is doubtful whether the resource should be qualified as 'natural' or 'refined', it can be put in this category.	Service, fuel.



## **Appendix 3 – Requirements for inventory data for the CPM LCA Database**

### **Requirements for inventory data for the CPM LCA Database**

The data you are gathering and the study you perform can, when published, be a useful source of data and information for other LCA practitioners, students, teachers, supervisors, researchers etc. Therefore please remember that any process data you collect should be transparent, understandable for others and presented including the following data. The data from LCA studies done at the division of ESA that fulfills these data quality requirements will be extracted and published in the CPM LCA Database.

#### **Quantitative flow data**

- Direction of the flow (indicates if the flow is an input or output).
- Substance (what the flow consists of, e.g. name of chemical substance, component, or product).
- Quantity and Unit (the quantity of the flow).
- Flow type (the type of the flow, e.g. product, by-product, emission, refined resource, resource, waste).
- Environment (what environmental compartment the flow originates from or enters into, e.g. air, water, ground, or technosphere).
- Reference to the original data source.

#### **Qualitative process description**

- A descriptive name of the process (e.g. manufacturing of cotton fabric).
- Technical scope (cradle-to-gate, gate-to-gate etc.).
- **Functional unit** (or other quantitative reference) very important! It must be clear to what all flows are normalized.
- Short description of the technical aspects considered for the process and the function of the product.
- Reference(s) (literature, database, name of the supplier, etc.).
- Short information about system boundaries; natural, time-span, geographical and technical.
- Short information about allocations and/or system expansions.



## Appendix 4 – Links

CPM homepage:

<http://www.cpm.chalmers.se>

CPM LCA Database website:

<http://www.cpm.database.cpm.chalmers.se>

ESA homepage:

<http://www.chalmers.se/ee/SV/forskning/forskargrupper/miljosystemanalys>

ESA publications website:

<http://www.chalmers.se/ee/SV/forskning/forskargrupper/miljosystemanalys/publikationer>