Center for
Environmental Assessment
of Product and Material Systems

Introduction and guide to LCA data documentation

using
the CPM documentation criteria and
the SPINE format

Ann-Christin Pålsson

CPM report 1999:1

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Introduction

During the first phase of CPM (Centre for Environmental Assessment of Product and Material Systems) at Chalmers University of Technology a project was run, with the aim of establishing a Swedish national database. During the work, it was necessary to reach an agreement regarding requirements of data quality for data the database, to form a platform from which to work with in data acquisition for the database. As a result, a set of requirements was formulated in co-operation with industry and university on how data should be documented[1]. It was concluded that data quality could only be assessed if the data is sufficiently documented, and that data quality may in many respects correspond to data documentation quality.

These documentation criteria have been developed into a general methodology for data handling to be used at all stages of data handling in LCA. The CPM data documentation criteria are based on the SPINE-format, and are a specification on how the format should be used and interpreted. The CPM data documentation criteria may be applied for any type of technical system that are studied in LCA, regardless of the type of system or the original source of data.

This report is an adaptation and a revision of an earlier handbook in Swedish describing how to work documentation according to the CPM data documentation criteria and the SPINE format[2]. It is the result from experiences when working with data documentation, and teaching how to work with documentation of LCI-data and LCI-studies using the CPM data documentation criteria and the SPINE format.

The report is focused on LCA applications. The CPM documentation criteria and the SPINE format may however be used in all areas where data on a technical system needs to be handled, reported and communicated, such as for example within environmental management systems (EMS), and have thus a wider range of application than just within the field of LCA.

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[1] Arvidsson P. ed. (1997)*Krav på datakvalitet CPMs databas*, CPM report 1:1997, Chalmers University of Technology, Göteborg, Sweden
[2] Pålsson A-C. (1997) *Handbok vid arbete med datakvalitet och SPINE,* CPM report 6:1997, Chalmers University of Technology, Göteborg, Sweden

LCI-data, a model of a technical system

LCI-data is data that describes environmentally relevant in- and outflows of a defined model of a technical system. Matter and energy is used in the technical system in order to fulfil a function, expressed by a functional unit or a functional flow.

The function of a technical system may for example be the production of a certain product, and the functional unit may have been chosen as for example 1 kg of that material. Examples of inflows considered relevant are natural resources, raw materials, energyware, ancillary material etc. Examples of outflows are products and by-products, emissions to air, water and soil, waste etc.

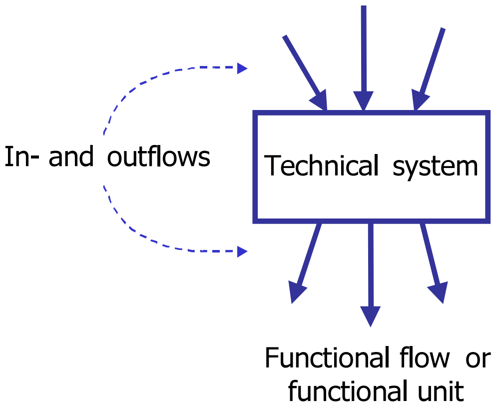

Figure 1. A model of a technical system

Examples of models of technical systems that are studied in LCA is individual process steps or production lines within a site, entire plants, transports and transportation routes, and complex composite systems such as production systems for specific products from cradle to gate.

A model of a technical system may have an inner structure, i.e. be composed of models of technical subsystems. For example, when performing an LCA, a flow model of the studied production system is accomplished by linking models of smaller technical systems together in a flow chart. Thus, the complete LCI may be seen as LCI-data. Also, other types of flow models may be constructed and used in LCA. For example, a model of a production line within a site may be composed of models of the included process steps.

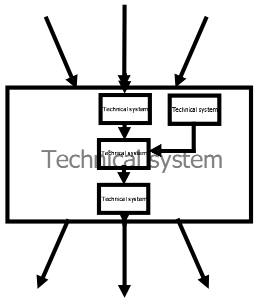

Figure 2. A model of a technical system, composed of models of technical systems

LCI-data acquisition, i.e. modelling a technical system

The acquisition of LCI-data involves the modelling of a technical system and quantification of in- and outflows of the system. Models of technical systems that are used in LCA is defined to as closely as possible describe the real technical system that is to be represented by the model. Every model is uniquely designed for a specific purpose and intended application. In some cases the model may have a wide applicability (has been designed for a wide area of application) whereas in other cases the model is only applicable for the specific application for which it was designed. For the applicability of the model to be correctly assessed, the model and the choices made in the design of the model needs to be carefully described.

When accomplishing a model of a technical system, i.e. when modelling a technical system, many different subjective choices are made; all of which has a large influence on the result. Depending on the purpose for which the model is intended, the system content is defined and system boundaries are chosen to as truly as possible represent the technical system that is desired. If the system performs more than one function (e.g. a plant that produces more than one product) it may be necessary to perform an allocation to allocate the environmental load between the functions. Criteria for determining what flows that are considered environmentally relevant are also established in the choice of system boundaries.

Examples of choices made in the modelling, i.e. in the data acquisition, is the choice of functional unit, what to include within the model and what can be excluded from the model, what in- and outflows that are considered environmentally relevant and therefore should be quantified etc.

In order to obtain quantitative data for the model, different types of sources are used such as statistically interpreted measured data, theoretical models, estimations etc. Measured data may have been acquired by several different methods, all of which results in data with different precision. The measurements have been performed using a specific measurement system, with an inherent precision and range. In some cases the measurement system that measures a specific quantity does not correspond to the system that is modelled. This is often the case when e.g. modelling a production line for a specific product within an industrial site that produces several products. For instance if the desired model describes a production line within a plant, but the measured quantity describes the entire site. Then a model mapping or an allocation needs to be performed to allocate an appropriate share of the measured quantity to the studied system, i.e. the share of the measured quantity that may be accounted for the production line and the product.

In order for the models to be used correctly and the right conclusions to be drawn from the use of the model, the model should be supplied with sufficient information describing the model and the choices that have been made in the design. This is done through documentation of the model, of relevant aspects of the modelling and the choices and assumptions that have been made regarding the purpose of the model, the system, the system boundaries and methods applied to retrieve the numerical data for the modelled system.

Also, when the model is to be communicated, the information needs to be adapted to the context in which it will be communicated, in order for it to be correctly understood and used by the receiver. For example, additional information regarding the applicability of the model may be given for guidance for the data user on how to use the model. This is especially important when the information is communicated to parties with little or no experience regarding the technical system that the model describes. A description of a system intended for an expert in the field, in which the system operates, is generally not sufficient if the model is to be communicated to a layman with no prior experience of the system. This is often is the case in LCA, since it is impossible for an LCA practitioner to hold a thorough knowledge of every system that is included in an LCA application.

PHASETS

This report focuses on how to document and communicate complete models of technical systems. How to perform the actual modelling of the technical system will not be described in detail.

For guidance in the modelling, however, a procedural approach for the design of model of a technical system has been developed at CPM. The approach is called PHASETS (PHASEs in the modelling of a Technical System) and can be used to structure the work when accomplishing a model of a technical system. The modelling of a technical system may be considered to consist of six distinct phases, through which data and information passes. Information is communicated from simple to more aggregated concepts. Every phase is equally important for the quality of the result in any given phase:

0. *Setting up the measurement system,*
   the measurement system for parameters considered environmentally relevant are established and maintained.
1. *The sampling*,
   a sample is taken from the measurement system, following the routines defined by the measurement system in phase 0
2. *Form a frequency function from individual sample sets*,
   samples from phase 1 is statistically interpreted and analysed
3. *Systems synthesis; modelling of the technical system,*
   a model of a technical system is synthesised. Choices are made regarding functional unit, system content and system boundaries. The frequency function from phase 2 is used to quantify the inflows and outflows of the model.
4. *Aggregation of models of technical systems,*
   models of technical systems is used to form an aggregate model, such as an average or a process or product flow chart.
5. *Contextual transfer,*
   between any two phases information is communicated, and the communication is generally done between different contextual environments. In order for the data and information to be correctly interpreted, the communicating parties should consider differences in contextual environment.

A more detailed description of PHASETS can be found in Carlson&Pålsson[3].

Note:
In general, aspects of modelling "smaller" technical systems such as individual process steps or plants (i.e. LCI-data acquisition) have been overlooked in LCA. The modelling performed

[3] Carlson R., Pålsson A-C. (1999) *A procedural approach to the design of a model of a technical system* (under preparation), CPM, Chalmers University of Technology, Göteborg, Sweden

when acquiring LCI-data is not recognised, and is often not done consciously. Guidelines for such modelling are rarely available in LCA literature and manuals. However, issues regarding e.g. choice of system boundaries and inclusions and exclusions of system components are equally important regardless of the size or extension of the technical system; whether describing individual processes or plants as when describing complex composite systems such as complete production systems. The modelling when acquiring LCI-data should therefore be equally carefully documented as the modelling done when performing an LCA.

Aspects of data quality

In most LCAs, data describing many different technical systems is acquired. Depending on the purpose of the study, varying requirements is put on data quality and what type of data that can be used in the LCA. Assessment of data quality concerns both qualitative and quantitative aspects such as e.g. to what extent the data describes the studied technology, the precision of the data etc., and is thus a complex task, where a multitude of aspects must be considered. The quality of a specific LCI-data set is therefore very much dependent on the context in which it is used. A data set representing a technical system that may be relevant in one application may be irrelevant or even wrong in a different application, even though certain aspects of the system would apply equally well in both applications. For instance, both systems may deliver the same product but be different in all other aspects.

Therefore, the quality of any given LCI-data set in a specific application may only be determined through a thorough knowledge of the system and of the data. Sufficient documentation of the data is fundamental to avoid misuse and misinterpretation of the data. The possibility to assess the quality can thus be considered as a measure of the quality of the data, i.e. the quality of the documentation of the data is in itself a quality aspect. A transparent documentation of the data implies a good basis to judge both the qualitative and quantitative aspects of data quality. This is the only feasible approach to consider and ensure that data quality requirements are met.

The different aspects that should be considered in data quality assessment can be categorised into the concepts *reliability*, *accessibility* and *relevance*.

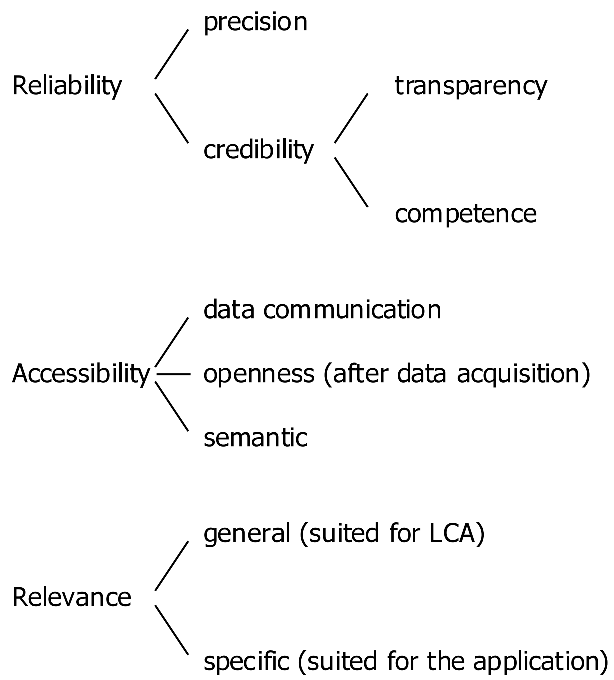

Figure 3. Aspects of data quality (from Carlson & Pålsson[4])

[4] Carlson R., Pålsson A-C. (1999) *Fundamental aspects of environmental data quality* (under preparation), CPM, Chalmers University of Technology, Göteborg, Sweden

Reliability

To be able to draw conclusions from the result when using the data, the data should be reliable. The reliability of data depends on the *precision* of data and the *credibility* of the origin of the data.

The *precision* of data concerns the numerical accuracy and the uncertainty of data. This quality aspect, though important, is not sufficient if all other aspects of data quality are not known.

The *credibility* of the origin of the data concerns how credible the data may be considered. For example, any statement regarding precision is useless, unless the data origin may be considered credible. Credibility may be achieved through *transparency* and *competence.* A data set may be considered more credible if the data may be transparently reviewed. Also, credibility may only be reached if the data has been acquired by someone with competence regarding the technology and the system that is described by the data. For instance, a data set describing a specific plant would generally be considered more credible if the data is acquired by someone working within the plant, who are well familiar with the process, than if the data is acquired by an LCA-practitioner, who is not situated at the plant.

Accessibility

Accessibility of data has generally not been considered as a quality aspect, but more as a general problem in LCA. However, if the data is not accessible for the data users, the data reviewers etc., no other quality aspects can be considered. The accessibility of data concerns *data communication*, *openness* after data acquisition and *semantic*.

Data communication is an important aspect of accessibility. In order for data to be useful, it needs to be efficiently communicated between the data suppliers and the data users. This may be done in many different forms such as via mail, questionnaires, specific formats etc. Data communication may however only be done depending on the *openness* after data acquisition. If aspects regarding openness, e.g. secrecy, is not solved or handled adequately, the accessibility of data will be obstructed.

The *semantic* aspect of data is also a vital component of the accessibility of data. Data are generally acquired within a specific context, for instance within a site. Terminology and other aspects regarding e.g. the technology are implicit and do not need explanation as long as the data is communicated within this specific context. However, if the data is to be communicated to someone who operates in a different context, the terminology and other implicit aspects must be explicitly explained, for the data to be understood and accessible.

Relevance

Regardless of all other aspects of data quality, if the data is not relevant for the context in which it will be used it is not useful. For any specific data set there are two aspects of relevance; the *general* (suited for LCA) and the *specific* (suited for a specific application). The general issue, i.e. that the data is suited for LCA, regards that the data really describes a model of a technical system relevant for LCA in accordance with the definition in section “LCI-data, a model of a technical system”. The specific issue, i.e. that the data is suited for the specific application, regards whether or not the data is relevant for the application in which it is used.

Data quality requirements according to ISO 14 041:1998(E)

According to ISO 14041:1998(E) the following data quality requirements should be considered when performing an LCA:

- time related coverage
- geographical coverage
- technology coverage

Also, further descriptors to define the nature of the data should be given, and the following parameters should be considered at an appropriate level of detail:

- precision
- completeness
- representativeness
- consistency
- reproducibility

These requirements may all be grouped into the quality aspects relevance, reliability and accessibility described above:
Relevance: time related coverage, geographical coverage, technology coverage, completeness representativeness
Reliability: Precision, consistency.
Accessibility: Reproducibility, consistency
The relevance aspect is thus considered as an important aspect of data quality according to ISO 14 041.

A full description on how the data quality requirements in ISO 14041 are interpreted in terms of the CPM data documentation criteria and the SPINE-format can be found in "An interpretation of the CPM use of SPINE in terms of the ISO 14041 standard"[5]

[5] "An interpretation of the CPM use of SPINE in terms of the ISO 14041 standard", CPM-report X:1999,

Documentation of LCI-data, i.e. models of technical systems
The CPM documentation criteria and the SPINE-format

In order for LCI-data to be assessed with regard to the qualitative and quantitative aspects of data quality as described in the previous chapter, the LCI-data i.e. the model of the technical system needs to be sufficiently documented. Documentation of the model is facilitated by a common understanding and agreement of what aspects that are considered relevant to document. The CPM documentation criteria, together with the SPINE-format constitutes such a common language for how to document and interpret LCI-data, and provide a *structured documentation format for LCI-data*. This means that data may easily be communicated between two parties sharing this common language. All relevant information to enable an assessment of the data is communicated together with the data.

The CPM documentation criteria can be used to document data for any type of technical system that is studied in LCA; individual processes, plants, cradle to gate production systems for specific materials etc.. The documentation criteria can also be used to document models of technical systems with an inner structure, i.e. models of technical systems that are composed of models of technical subsystems. Then the documentation of the aggregate model consists of the documentation of the technical subsystems and the documentation of the modelling of the aggregate model. The CPM documentation criteria may thus be seen as a report template for describing any model of a technical system, both LCI-data and study report.

The description of models of technical systems may be considered to consist of 6 separate, but closely integrated sections. The types of information covered within each section regards very different choices made during the data acquisition, i.e. the modelling. Section 1 and 2 describes the model in qualitative terms regarding how the model was the designed, whereas section 3 and 4 describes the quantitative data for inflows and outflows and information regarding how the numerical data was obtained. Section 5 and 6 describes more general aspects e.g. how the model should be used and how the information may be distributed.

1. Description of the model of the technical system, where the content of the system is described, with regards to e.g. the included processes etc.

2. Description of choices made during the data acquisition and the objective for the choices, e.g. the purpose, the choice of functional unit and system boundaries etc.

3. Inflows and outflows to the system, i.e. quantitative data on flows together with information on the origin and destination of the flows.

4. Description on methods and assumptions used to acquire the numerical data.

5. Description on recommendations on the use of the model and the data, e.g. areas of application and a general description on the quality of the sources that has been used.

6. General and administrative information regarding e.g. how data may be distributed.

In each section a number of fields are specified, with the SPINE format, as will be described below. The division into sections is only a suggestion for how to easily document and interpret data documented in the format. Data documented according to the CPM documentation criteria using the SPINE format need not however be presented using this suggested structure when e.g. published, as long as the fields in the SPINE format are specified.

The following is a description on the documentation criteria implemented in the SPINE format. The text is written for guidance both when documenting data and when interpreting data documented according to the CPM documentation criteria.

1. Description of the technical system

The description of the technical system should provide a clear account of the scope of the system, i.e. what is included in the system, with regard to included activities or processes, equipment and technology used etc. Equipment that has a large influence on the in- and outflows to the technical system should be stated especially, for instance cleaning equipment, details regarding technical performance (e.g. degree of efficiency) and the state of the technology (e.g. new old etc.). It should be clearly stated where the process starts and ends and the transformations that takes place within the system.

The technical system is described by a name, the type, the geographical location, the sector to which it belongs and a detailed description of the contents of the system. Also, when applicable, the owner of the technical system can be specified.

Name

The most prevalent name of the technical system. The name is preferably descriptive, since it should give a first identification on what technical system that is described.

Type of technical system (Category)

The type or the scope of the technical system that is studied e.g. unit operation, "gate to gate", ”cradle to gate” etc.

In the SPINE-format, this nomenclature is called *ProcessType*. A general structure for the ProcessType nomenclature has been developed within CPM for this purpose based on the different types of technical systems that are studied in LCA.

Note: The specification of the type or the scope of the system is valuable to get a first indication of what is included in the system.

Sector

The sector within which the technical system operates.

If the data describes a large aggregate technical system, the sector is specified by the last process in the chain, or in accordance with the general function of the system.

In the SPINE format the nomenclature is called *Sector*. There are several statistical classification systems that may be used to specify the sector, for example the EU statistical classification or the ISIC classification. Within CPM, a simplified version of the ISIC classification was developed for the Sector nomenclature.

Note: The specification of the sector is useful e.g. when searching for data stored in a database.

Geographical location (Site)

The geographical location where the system is situated, i.e. address or geographical area.

If the studied technical system is a specific process or plant, the address is given. For general or complex systems such as averages or geographically extended systems, where the activities included in the system takes place in several geographical places, a geographical region is given, e.g. the country within which the activities take place.

Addresses are specified by name, mailing address, phone number, facsimile number and e-mail address. In the SPINE format, the information is handled in the JuridicalPerson address register.

See also: Geographical system boundaries in section “2. Description of choices made in the data acquisition and the objective for the choices”

Description of system content (Function)

Detailed description of the system content and the scope of the technical system that are studied with regard to the included process steps and activities, technology etc.. The description should ideally provide an understanding on how reported inflows are transformed into the reported outflows.

All process steps that are included in the system should be described, e.g. administration, internal recycling loops, preparation, sewage treatment, scrubber technology etc. Activities within the system that has a large influence on the flows that are reported should especially be stated, since the description should enable an identification of technology that may have a large influence on e.g. emissions, energy consumption etc.

To structure a complex description; a brief abstract may be given of the main process steps that are included, followed by a more detailed description, where the included process steps is described in detail.

See also: the description of system boundaries in section “ 2. Description of choices made in the data acquisition and the objective for the choices”

Owner

The owner of the technical system.

This is generally only applicable when the owner can be easily identified, such as when the system describes individual processes or plants.

Addresses are specified by name, mailing address, phone number, facsimile number and e-mail address. In the SPINE format, the information is handled in the JuridicalPerson address register.

Note: Owner refers to the owner of the system, not the owner of the data.

Aspects to consider in the documentation

The description of the technical system should only concern information on what is included within the system. Related information regarding e.g. technical subsystems that have been excluded should be described in the section describing choices made during the data acquisition. Example of such information is information on transports to and from a studied technical system that are not included within the system, but may still be valuable for the data user.

Information that is not directly relevant in the description of the technical system should also be avoided, such as e.g. details about how the product or service delivered by the system is used when it leaves the studied technical system. Such information may however be important for the data user, and should preferably be stated in the section describing recommendations on how the information may be used.

2. Description of choices made during the data acquisition and the objective for the choices

The objective or the purpose for the data acquisition, and the intended user of the data generally has a large influence of the resulting data. The scope of the system and the choice of functional unit and system boundaries are based on the purpose. Therefore, the purpose and the choices that have been made to fulfil the purpose, with regard to e.g. system boundaries should be carefully described. Also the persons responsible for the data acquisition should be specified.

Objective and intended user of data

The objective and the intended user of data is described by the intended audience or user of the information, and the purpose for the data or the study, e.g. details regarding the background to why the data acquisition or study was initiated and what question explicitly the work aimed at answering. The organisation or person responsible for initiating or funding the data acquisition or the study generally has a large influence on the purpose that is described, and should therefore also be specified.

Intended User

The intended target group for the information.

General Purpose

The background to why the data acquisition or the study was initiated.

Detailed Purpose

The specific objective to why data was acquired or the study was performed.

Commissioner

The person or organisation responsible for initiating or funding the data acquisition or study.

The Commissioner is specified by name, mailing address, phone number, facsimile number and e-mail address. In the SPINE format this type of information is handled in the JuridicalPerson address register.

Persons responsible for the data acquisition

In the modelling, i.e. the data acquisition, several different persons may have been involved. The person or persons that are may be identified as responsible for the information that is presented should therefore be specified.

Practitioner

The person or persons responsible for the modelling and main part of the information that is presented, with compilation and interpretation.

The practitioner/s is specified by name, mailing address, phone number, facsimile number and e-mail address. In the SPINE format this type of information is handled in the JuridicalPerson address register.

Note: Since several persons may be involved with the data acquisition, the practitioner's role should preferably be specified. For example, the data may not have been documented by the person who is responsible for the data acquisition.

Reviewer

The person or persons responsible for reviewing the data or the data acquisition.

The reviewer/s is specified by name, mailing address, phone number, facsimile number and e-mail address. In the SPINE format this type of information is handled in the JuridicalPerson address register.

Note: Different types of review may have been performed of the data. Therefore, whenever stating a reviewer; also state with regard to what the review was performed.

Choice of functional unit

Functional Unit

The functional unit is the reference to which all numerical data on inflows and outflows are presented.

Explanation of the Functional Unit (FUExplanation):

Explanation and motivation of the choice of the functional unit.

Choice of system boundaries

The description of the choice of system boundaries are done by describing the motives to why a specific set of system boundaries have been chosen. This provides an understanding for how the model was designed and why a specific scope has been chosen. A system boundary is defined by what is communicated between the system and its surroundings, i.e. in LCA by emissions and waste and the resources extracted from the environmental system, and material and energy from other technical systems.

The description of the system boundaries supplements the description of the technical system in section "1. The description of the technical system", where the content of the system is described.

The description of system boundaries is divided into system boundaries towards the environmental system, system boundaries in time, geographical system boundaries and other system boundaries.

System boundaries towards the environmental system (NatureBoundary)

Description of system boundaries towards the environmental system. The description is primarily done by a description of the criteria that have been used in the choice of parameters that are considered environmentally relevant, i.e. the motive for including or excluding flows that originate in or end up in the environmental system should be explained.

For instance, the choice of parameters that are reported for emissions to air may be based on legislature for the studied process. Some parameters that may have a potential influence on the environment may therefore have been excluded.

System boundaries in time (TimeBoundary)

System boundaries in time describe different time related aspects of the studied technical system, such as the time period during which the process or the technology can be considered valid.

Examples of such descriptions are an estimation of the "best before date" for the system, together with a description and motivation. The motivation may be done through a description of the technology level of the process or plans for investments or alterations of the process that will have a significant effect on the process and consequently the data. With such descriptions it is possible to form an opinion on whether the data still is representative or not

Geographical system boundaries (GeographyBoundary)

The geographical extension or geographical limitations of the studied process or system.

The motives for choosing the geographical system boundaries should be described. Also, if subsystems that are included in the technical system operates in different geographical places, a description should be given to where geographically each included subsystem operates

See also: geographical location in section “1. Description of the technical system”

Other system boundaries (OtherBoundary)

Description of other system boundaries, such as boundaries towards other technical systems and cut-offs.

The description is primarily done by describing motives for exclusions of technical subsystems and the criteria that has been used as a basis for the choice of flows to and from other technical systems.

Description of allocations (Allocations)

Description of allocations that have been performed to obtain the numerical data that are presented (when applicable).

The basis for the allocation, a motivation of the choice of allocation method and the rules and assumptions that have been used in the allocation should be carefully described, since different allocation methods give very different result.

Description of system expansions (LateralExpansion)

If a system expansion or system enlargement has been done, the motives and the details for the system expansion should be described, regarding for instance what technical subsystems that have been included in the system.

System expansion is done in order to model the full effects of a change or to avoid allocation.

Note: the subsystems that have been included as a result of the system expansion are also described in section “1. Description of the technical system, since they are part of the technical system that is studied. The description of system expansions is then very important to alert the user that a system expansion has been done.

Aspects to consider in the documentation

This section complements the description of the scope and the content of the technical system in section “1. Description of the technical system”. They should together give an account of the choices made in the modelling of the technical system, and the result of the modelling. It is therefore important that these two sections are consistent and that for example, the description of system boundaries does not contradict what is described as included in the system in the description of the technical system.

3. Inflows and outflows to the system

The inflows and outflows of the system that are considered environmentally relevant are quantified, in relation to the chosen functional unit. Depending on how the flows are considered they may be grouped into different categories such as e.g. resources, raw materials, emissions, products, by-products etc. Also, information of the origin and destination of the flows are important in order to allow for impact assessment to be made, since a flow may have very different impact on the environment depending on the emitting or receiving body.

Each flow that enters or leaves the technical system should therefore be specified by the direction and the category of the flow, the substance name and the amount per functional unit, together with corresponding minimum and maximum values or standard deviation (if available). The origin or the destination of each flow is specified by the environmental type or media and the geographical location. The specification of the origin or the destination of the flow concerns the origin at the point where the flow enters the studied system or the destination at the point where the flow leaves the system. Local considerations in impact assessment may thus be made.

See also: The choice of functional unit in section “2. Description of choices made during the data acquisition and the objective for the choices”

The following information should be given for each in- and outflow to the technical system:

Direction (SubType)

The direction of the flow i.e. input or output

Type of flow (Category)

Categorisation to distinguish between different flows e.g. Resource, Emission, Product etc.

In the SPINE format the nomenclature is called FlowType. A limited nomenclature has been developed within CPM for this purpose. The reason for the limited nomenclature was that the categorisation of flows is often used for program control in calculation software. One should therefore take care before introducing new flow types, since this may lead to difficulties when the data is communicated or used in different software.

Substance (SubstanceName)

Name of the flow, i.e. the substance entering or leaving the technical system

In the SPINE format this nomenclature is called *Substance*. A suggestion for the Substance nomenclature has been developed within CPM. However, a common nomenclature for names of substances are almost impossible to achieve, except within specific contexts such as within a company or an industrial sector. A specific substance may be known under several synonym names such as trade name, chemical formulae etc.

When introducing new substances in the substance nomenclature, the name should be clearly defined and explained. The following rules of thumb for the naming should also be used

- British English
- Established notation

- If two notations can be considered to be equally established, use the shortest notation.

Quantity

The size of the flow, normalised to the functional unit

QuantityMin

The corresponding minimum value for the flow, normalised to the functional unit

QuantityMax

The corresponding maximum value for the flow, normalised to the functional unit

StandardDev

The corresponding standard deviation of the flow, normalised to the functional unit

Unit

The unit for the given quantity for the flow

Origin or destination of flow – environmental type or media (Impact Media)

Type of environment where the flow originated when entering the technical system (e.g. technosphere) or end up when leaving the technical system (e.g. Air water, ground).

In the SPINE format this nomenclature is called *Environment*. A general structure, with a suggested detailed structure has been developed at CPM for the Environment nomenclature.

.

Origin or destination of flow – geographical (Impact Region)

Description of the geographical location where the flow originated when entering the technical system or end up when leaving the technical system

In the SPINE format this nomenclature is called *Geography*. A nomenclature has been developed within CPM for this purpose.

Aspects to consider in the documentation Often the defined functional unit is a inflow or outflow to the system, for example a functional unit may be defined as 1 kg of product A. When that is the case, it is important that the functional unit also is specified as a flow in the flow table. Otherwise it will not be possible to link systems together in a flow chart.

4. Description of methods used to acquire the numerical data

The numerical data for the inflows and outflows of a technical system has generally been acquired using several different methods, e.g. different measurement techniques, theoretical models, estimations etc. In general a combination of several different methods is used, for example, a measured value may be used together with certain assumptions to calculate the value for a specific flow. In some cases, data describing a similar technical system may have been used to represent the studied technical system

The following information should be specified for how the numerical data was retrieved. If different methods have been used for different flows (which generally is the case) this type of information should be given for both the entire data set and for specific.

Time period during which data was acquired (DateConcieved)

The time period during which the data and the numerical basis for the data was acquired.

For example, the basis for the data may be measurements performed during a specific time period, such as a month or a year and the value that is presented is an average of the measurements. The time period that should be specified is then from the time of the first measurements that are included within the average to the time of the averaging.

The following format should be used:

YYYY-MM-DD - YYYY-MM-DD

If only the year is known: YYYY-01-01

If only the year and the month is known: YYYY-MM-01

Type of Method (DataType)

The type of method that has been used to obtain the data, e.g. Derived, unspecified.

In the SPINE format the nomenclature is called QMetaDataType. A general nomenclature for QMetaDataType has been developed within CPM, which should cover the most commonly used methods to obtain data. New types may be added to this nomenclature, but the “predefined” types should be used if possible

Description of Method (Method)

The description of method includes a clear account of the methods that have been used and the assumptions and calculations that have been performed to obtain the numerical data that are presented. Ideally, the description should be thorough enough to enable a check of the calculations etc. that have been performed from the original source.

Naturally it should also be described how well the statistical information has coverage in the basis for the data, i.e. if minimum and maximum values or standard deviations have been given, the basis for the values should be described. This is extremely important in order for the data user to be able to interpret the data. For instance, a minimum value may be an extreme value, or a calculated minimum value.

Literature and other sources that have been used should be referenced and specified in References below.

Represents

In some cases, data describing a similar technical system is used to represent the studied technical system. For example, the value for a specific parameter of the studied system may be estimated using an average value describing several similar systems. This may be done in order to avoid data gaps for a specific parameter for the studied process.

If this has been done, a description should be given of relevant aspects of the original conditions for the data, i.e. what system the data originally represents. It should also be argued for how well the assumed value may be considered to correspond to the true value.

Literature and other sources that have been used should be referenced and specified in References below.

References (LiteratureRef)

References that have been used in the data acquisition (literature or personal contacts), and that are referred to in Method or Represents.

Further notes (Notes)

Further information of the data or the flows that are not related to how the numerical data for the flows was acquired. For instance, information on how the substances are handled before entering or after leaving the studied system can be given, such as information on how transportation of raw materials etc. is done.

5. Recommendations on the use of the model and the data and other relevant information

The description of the technical system and the choices and methods that have been used in the data acquisition, supplied in the previous sections constitute a good basis to assess the reliability and the relevance of the data that is presented. However, there may be certain aspects that the data user should be especially aware of, regarding for instance limitations for the applicability of the data or special circumstances when the data should not be used.

Also, if the expected data user has little or no prior experience of the technical system and the business that is described, some further information may be needed in order for the data user to handle the data correctly. This may for example concern the representativeness of a plant or manufacturing process compared to other similar plants or processes regarding the technology used etc. Therefore, some recommendations or guidelines and other relevant information should be given.

Applicability

Description of an assumed area of application for the described technical system regarding e.g. geographical, technology or other trade specific applicability. Also, other general cautions and recommendations may be given regarding how data can be used.

AboutData

General description of numerical and other qualities, or quality deficiencies in the overall documentation and numerical basis for the data.

Notes

Other relevant information about the technical system and the data that are not appropriate in any of the other fields.

Aspects to consider in the documentation Since data generally is communicated between different contextual environments in LCA, the recommendations on how to use the data are important. Generally, a more detailed description is needed when the data is to be communicated to someone that does hold specific knowledge of the technical system that is described. There is otherwise a risk that the data is misinterpreted and consequently not used correctly.

6. General and administrative information

In addition to the description of the technical system and the data some general and administrative information should be supplied regarding when the work was completed, if the information is published in some type of publication. Also general information regarding how the data may be distributed should be given.

Date Completed

The date when complete data set or the study that is presented was final reported.

Date completed does not necessarily correspond to the time during which data was acquired (c.f. Time period during which the data was acquired in section “4. Description of methods used to acquire the numerical data”). For example, the final reporting of the complete data set may have been done in 1993, but the numerical basis for the data set may have been acquired from 1992 or earlier. Data completed in that case is then 1993-01-01.

The following format should be used:

YYYY-MM-DD

If only the year is known: YYYY-01-01

If only the year and the month is known: YYYY-MM-01

Publication

Literature reference to where the complete data set or the study has been published (when applicable), or contact person.

Note: This reference refers to the complete data set, with the compilation and interpretation (cf. References in “4. Description of methods used to acquire the numerical data”)

Availability

Conditions or agreements regarding how data may be distributed.

For instance, details in secrecy agreements or restrictions regarding the data should be described.

Copyright

Holder of copyright.

Generally only applicable when the data has been published.

Working with documentation during an LCA project

During an LCA project, there is a lot to gain by working consistently with documentation of the data and the study from the beginning of the project.

Inventory

During the inventory part of an LCA-project, there are several reasons to why the data, and the modelling choices made in the construction of the flow chart, should be documented according to the CPM documentation criteria:

- *Consistent knowledge of each subsystem that is included within the studied system*
  The documentation requirements serves as a checklist to ensure that all relevant information is acquired of each data set that included in the study. At the time of the data acquisition the knowledge of the data is generally most extensive. If that knowledge is not documented there is a risk that it will be lost, and it may be difficult or impossible to recreate the knowledge later in the project. For example, a specific interpretation of the data is often done for the actual application. This interpretation should be documented, since a different data user may interpret the data differently.

- *Data quality assessment*
  The different aspects of data quality may easily be assessed, to ensure that data quality requirements established in the goal and scope is fulfilled.

- *Validity check of data*
  The documentation allows for different types of review and validity checks to be performed on the data. This is a requirement according to ISO 14041:1998(E).

- *Avoid double counting and data gaps*
  In order to avoid double counting and data gaps a thorough knowledge is required of the content and the scope of each subsystem that is included in the study. This may be achieved if each data set that has been included is clearly defined and explicitly described.

The CPM data documentation criteria may seem too detailed and time consuming to really be efficient during the inventory part of an LCA. However, the time that is spent on documentation is repaid by the advantage of having a well-documented basis for the study during the interpretation and in the reporting and review of the study.

Another obvious advantage of carefully documenting the data is that the data may easily be reused in subsequent studies and by other users. The documentation of data will thus facilitate efficient shared use of data and databases, since all relevant information of the technical system and the data is readily available and easily interpretable.

Interpretation of the result

The interpretation of the result is facilitated since a thorough knowledge of the data is acquired. The practitioner can be well acquainted with every part of the studied system, and know exactly what data in the model that may be unreliable. Every part of the studied system can be easily checked through the documentation, to understand the reasons for the result.

This is necessary to enable a proper assessment and interpretation of the result. Consequently, the risk for erroneous conclusions to be drawn from the result will be reduced.

Reporting

The report from the project is well prepared, since both the choices made in the modelling of the flow chart and the included subsystems are consistently documented. This inherently implies a transparent report of the study. Thus, it is would be possible to automatically generate a study report, consisting of a description on how the modelling of the composite technical system was performed and a description of each of the included models of technical subsystems.

Note: The ability of the SPINE-format to store composite system means that a study performed with a SPINE database and the CPM documentation criteria could be reported in the database using e.g. a special browser. There is however at present no software tools that supports this type of reporting.

Review

Efficient review requires a structured format for reporting, where all relevant information is transparently described. Thus, if the reporting of the study and the data is done according to the CPM data documentation criteria, the time needed for review will decrease, since the information of the project is easily accessible and interpretable. This may in the long term decrease the cost to review LCA-studies. This is for example vital to allow for review of an LCA-study to be used a basis for type III ecolabelling.

General recommendations when working with documentation

The documentation of LCI-data according to the CPM documentation criteria constitutes a report describing the technical system that is studied and the choices made in the data acquisition. This should enable an assessment and analysis of the data and of all aspects of data quality by the data user, by the receiver of the result and by reviewers. For example, the documentation should enable an assessment of similarities and dissimilarities between different data sets describing similar technical systems. A difference in a specific emission for two similar technical systems may for instance originate in minor differences in the technology used.

Ideally, the documentation of data should be completed by the person or persons that are originally acquiring the data. The documentation will in such case only involve a report of the data acquisition procedure. However, in any LCA project generally several different sources of data are used. Often the data is not sufficiently documented in the original source or the documentation is difficult to interpret. Regardless of the source, however, the data should be handled adequately.

Working with secondary sources

When using data from secondary sources such as different types of written reports, the main part of the work with data involves interpretation and analysis of the material. This is generally a time consuming task, and in order to avoid duplication of efforts it is important that the work with the interpretation is documented. Otherwise the next data user may have to reinterpret the material, before it may be used.

In many cases, the material is extensively interpreted, beyond what is explicitly described in the original source, and it is important that this is documented in order for the acquired knowledge not to be lost. For example, the person performing the documentation may have been in touch with the person responsible for the original material in order to clarify some issues. The person interpreting the material may also in some cases be able to supplement the information in the original source regarding knowledge of the business in which the technical system operates.

It should also be remembered that any information regarding inconsistencies in the original material and comments by the person that has done the interpretation of the material is also valuable for a data user, and should therefore be documented. It should however be clearly stated in the documentation that this type of information regards views of the person responsible for the documentation.

Obviously, there will always be a risk when working with different types of written reports that the original source may be misinterpreted, through misunderstandings, wrongful translation of technical terms, misinterpretation of nomenclature etc. Hence, whenever possible, it is strongly recommended that the person(s) responsible for the original data acquisition should do the documentation or at least review the documentation.

Remodelling

Sometimes models of technical systems are remodelled to transform the data into a form that is suited for LCA or to better suit the immediate purpose for which it will be used. For example, data from environmental reports describing an industrial plant may be remodelled into data describing a specific product produced within the plant.

It is then vital that the practitioner thoroughly documents the work and explicitly explains the choices and assumptions that have been made in the remodelling. Both to ensure the trust of the original data supplier, that the supplied data has been handled correctly and to ensure the trust of the commissioner or other parties interested in the result.

Today, it is not uncommon in LCA that practitioners remodels data without explanations or with only implied references. The remodelling may be based on a thorough analysis and interpretation of the original material, but if that is not explicitly described it is impossible to assess the result. Consequently, if the remodelling are not explained, the data is useless.

Aggregated systems

Aggregated data on large aggregated composite systems are generally difficult to document without loss of vital information. Such systems should preferably be divided into the subsystems of which is consists, thus allowing separate documentation of each individual subsystem. The advantage of this approach is that the composite system will be fully transparent. This enhances the flexibility. Parts of an aggregated system may be updated when needed. For instance a cradle to gate system for some material can be updated regularly. The system boundaries chosen for the complete aggregate system may also not be applicable in other studies, but parts of the system may be applicable and reused in other studies.

However, if it is not feasible or possible to disaggregate the system; the technical system, the purpose of the study, the system boundaries, use of allocation methods etc. need to be carefully described in order to avoid misinterpretation of data. The person responsible for the documentation should be especially observant on issues that have a large influence on the result. For instance, if the purpose of the study was to compare different alternatives, several systems may have been excluded that were similar in the compared alternatives. This may lead to large errors if any of the compared alternatives are used to represent a “real” cradle to gate system.

Also, when describing large aggregate systems it is important to clearly state whether or not “general” systems (such as electricity production or transports), or “cradle to gate” systems (such as production systems of materials) are included in the system. Also, what is included within these types of systems should be described.

Missing information

In some cases it may be difficult to acquire all information that is required by the CPM documentation criteria. Some of the information may be missing or lost in the original material, and it is not feasible (due to e.g. economical reasons) or possible (due to e.g. the fact that the information simply is not available) to obtain the information.

The fact that the information is missing is however important information for the data user. It should therefore be explicitly stated in the documentation that it has not been possible to obtain the information, and if possible the reason to why it was not possible. Otherwise, other users may think that the information was available, but have been overlooked by the person responsible for the documentation. The data user may then make new attempts to obtain the information and fail by the same reason.

Different data sources

In LCA, generally a large variety of several different data sources are used such as:

Producing companies:

Producing companies is the major source of data used in LCI. However, at this point LCI-data acquisition within industrial plants is often isolated activities that take place only when data is required by e.g. a customer. Methodology, resources and routines for LCI-data acquisition is generally lacking, since LCI-data acquisition at sites seldom is integrated with other data management routines within e.g. an environmental management systems (EMS).

The general approach of the LCA practitioner when acquiring data from producing companies is via *personal communication* or via specifically developed *questionnaires*. An example and some aspects of the communication via questionnaires can be found in the project report from the establishment of the CPM database[6]

Another approach to acquire data from producing companies is to use the *environmental reports* from the companies. However, in general all information required for LCA is not reported in environmental reports. Thus, the information generally needs to be supplemented and the data may also need to be remodelled. Aspects of using environmental reports as a basis for LCA-data have been explored in a project within CPM[7,8].

General technical literature, process descriptions, theoretical models etc.

Data may also be acquired from different general sources, not specifically developed for LCA. Such sources generally require remodelling for the data to be suited for LCA, which in turn requires expertise in the field.

Reports from LCAs and similar projects

Data found in LCA reports describes complete models. However, data found in LCA reports are often insufficiently documented. Vital information to assess the models is often missing, For example, descriptions of system boundaries for included subsystems in LCAs are often not given. The information found in LCA reports may also be difficult to interpret due to varying formats for documentation.

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[6] Carlson R., Pålsson A-C. *Establishment of the CPM´s LCA data base* CPM report 3:1998, CPM
[7] Erixon M., Ågren S. *Miljörapport som underlag till livscykelanalys* CPM report 5:1997
[8] Erixon M., Ågren S *Utvärdering av inmatning i SPINE av information från miljörapporter* CPM internal report

Sufficient documentation

Data sufficiently documented according to the CPM documentation criteria should ideally not need further research for the data user to be able to interpret and correctly use the data. In practice the general ambition for documentation may vary depending on for what the data will be used and within which contextual environment the data will be communicated. The concept of sufficient documentation is thus very much dependant on the application and the receiver of the information.

Data that are only to be communicated within a specific context, e.g. internally within an organisation, generally requires a less detailed description, than if the same data will be communicated externally e.g. between a customer and supplier. Within an organisation the users may be assumed to share a common terminology and much information is implicit and more or less general knowledge within the company regarding technology, processes etc. Consequently, such details do not require an explanation within the organisation.

However, when the data is transferred to a different contextual environment the terminology and implicit knowledge needs to be explained, in order for the receiver of the information to be able to correctly interpret and use the information. The receiver of the information can not be expected to hold the knowledge that is internal within the company. A general recommendation is therefore that when data is to be communicated externally, a more detailed description may be needed, in order for the data to be directly useful for the receiver of data.

Also, documentation of the data constitutes an investment, and depending on how valuable the data is considered, the ambition for the documentation will most likely vary. For example, if it is known that a data set will only be used in a specific application and not communicated, a less detailed description may be sufficient. However, if the data will be reused in many applications and by several users (e.g. be included in a company internal database) a more detailed description is necessary to avoid further costs for data. And data that has been acquired has a tendency to be reused, even if it was thought at the time of the data acquisition that the data would not be used more than once!

Hence, it may be difficult to know at the time of data documentation, how the data will be communicated and for what the data will be used, other than the intended application for which it was acquired. The person responsible for the documentation should therefore always aim to provide the prospective data user with all relevant information available at the time of the documentation, thus giving the best possible starting point.

Appendix 1. The SPINE format

SPINE was developed to handle, structure and store all relevant information regarding LCA data and was originally implemented as relational database structure[9].

The central concepts in SPINE for documentation of LCI-data sets and flow charts

The central concepts for LCI-data sets and flow charts in SPINE are '*Activity*' and '*Flow*'.

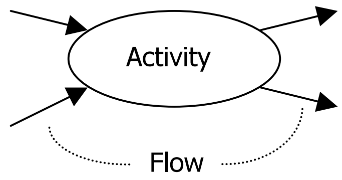

Figure 2. An activity

An 'Activity' corresponds to an LCI-data set as defined in chapter "LCI-data, a model of a technical system. An 'Activity' consists of the concepts 'ObjectOfStudy', 'Inventory', 'Flow' and 'QMetaData'. Each of these concepts is defined as follows:

ObjectOfStudy

- The description of the technical system

Inventory

- Description of choices made in the data acquisition and the objective for the choices (e.g. choice of functional unit and system boundaries etc.),
- Recommendations for the use of data
- General and administrative information

Flow

- Inflows and outflows to the system

QMetaData

- Description of the methods used to acquire the numerical data for inflows and outflows

In addition to this, there are a number of concepts that handles information used in the description of the data:

Address register:

- *JuridicalPerson*: Handles all addresses that are used in the documentation such as contact persons and addresses to industrial sites. Addresses is specified by name, mailing address, phone number, facsimile number and e-mail addresses to e.g. plants and contact persons.

Nomenclatures

Nomenclatures used for: description of the technical system

[9] Carlson R. Et al., 1995, SPINE *A Relation Database Structure for Life Cycle Assessments* IVL-report B 1227, Swedish Environmental Research Institute, Göteborg, Sweden

- *ProcessType;* Types of technical systems.
- *Sector:* Names of different sectors.

Nomenclatures used for: Inflows and outflows

- *Substance:* names of substances
- *Environment:* names of environmental types from which a flow originate when entering or end up after leaving the technical system.
- *Geography:* names of geographical locations from which a flow originate when entering or end up after leaving the technical system. This is used in the flow table
- *Unit* Units of flows.

Nomenclatures used for: Description of the methods used to acquire the numerical data

- *QMetaDataType:* names of different types of methods used to obtain the numerical data.

Appendix 2.
An example data set, with comments on the documentation

1. Description of the technical system

Name:
Heavy truck, long distance transportation

Type of technical system (Category):
Unit operation

Comment: The type *unit operation* indicates that the transport does not e.g. include production and distribution of the fuel.

Sector:
Land transport

Comment: Road transports belong to the land transport sector. The sector nomenclature allows e.g. for easy queries for technical systems and data that operates in a specific sector.

Geographical location (Site):
Name:
MailAddress: Sweden
Telephone:
Fax:
EMailAddress:

Comment: The system is intended to represent a "general" truck used for long distance transportation in Sweden.

Description of Function (Function):
Operation of diesel driven heavy trucks and trailers with maximum total gross weight 40 and 52 tonnes. The available loading capacity with regard to weight is 25 and 32 tonnes for the 40 tonne and the 52 tonne equipage respectively. The vehicles are assumed to operate in long distance traffic, i.e. trips longer than 100 km.

The type of tow car and engine used in the tow car are not specified.

Comment: Due to the fact that this system represents a generic system and that a detailed description of what technical systems that has been included in the average is missing, the description of the system is fairly schematic. Ideally, however this description would have included a description of what types of vehicles that have been included with the average.

Owner:
Name:
MailAddress: Not relevant

Telephone:
Fax:
EMailAddress:

Comment: Since this represents a generic system, the owner of the system can not be specified. However, instead of leaving the field empty, this is explicitly stated.

2. Description of choices made during the data acquisition and the objective for the choices

Objective and intended user of data

Commissioner:
Name:
MailAddress: Not specified
Telephone:
Fax:
EMailAddress:

Comment: The commissioner for the compilation of the data was not explicitly stated in the report that was used as basis of this data set.

Intended User:
LCA practitioners

General Purpose:
There is a need for standard values for energy use and exhaust emissions that may be used for transport considerations in LCA. This is especially valuable if the actual transport routes and transport operators are not known, and when it is not possible to make specific transport considerations.

Comment: The background for the work is briefly described.

Detailed Purpose:
The aim was to compile a set of standard values for energy use and exhaust emissions for different means of transportation using *available published literature*. Also, an update was needed of standard values that was complied for an earlier investigation published in: Tillman, A-M., Baumann, H., Eriksson, E., Rydberg, T. `*Livscykelanalyser för förpackningsmaterial - beräkning av miljöbelastning*` SOU 1991:77, Allmänna förlaget, Stockholm, 1991.

Comment: The fact that the ambition of the work was only to use published literature, determines the level of detail for the data that is presented.

Persons and organisations responsible for the data acquisition

Practitioner:

Name: Tillman, Anne-Marie
MailAddress: Technical Environmental Planning
Chalmers University of Technology
412 96 Göteborg
Sweden
Telephone: + 46-(0)31-772 21 22
Fax: + 46-(0)31-772 21 72
EMailAddress: amt@vsect.chalmers.se

Comment: Tillman was responsible for the compilation of the data that is presented.

Reviewer:
Name: Pålsson, Ann-Christin
MailAddress: CPM
Technical Environmental Planning
Chalmers University of Technology
412 96 Göteborg
Telephone: + 46 - (0)31-772 21 81
Fax: + 46 - (0)31-772 21 72
EMailAddress: acp@vsect.chalmers se

Comment: In this case, the review concerned the compilation of data *and* the literature sources that was used in the compilation. An attempt was made to try to follow the literature sources that were used, to see how the data was originally acquired and handled. Thus, all information that is presented in this documentation is not available in the report, but has been acquired by the reviewer. In such cases it should ideally be explicitly stated in the documentation what information in the documentation that has been acquired by the reviewer. This has however not been done for this data set. See also Notes in section 5.

Choice of functional unit

Functional Unit:
tonkm, 50 %

Explanation of Functional Unit (FUExplanation):
The energy use and exhaust emissions are calculated with reference to the transportation of 1 ton goods, 1 kilometre, for an utilisation level with regard to weight of 50%.

An utilisation level of 50 % with regard to weight was assumed to represent the average utilisation of transportation in Sweden. This is a conservative assumption.

Comment: A motivation is missing to e.g. why this functional unit has been chosen, or why an utilisation level of 50 % is a conservative assumption.

Choice of system boundaries

System boundaries towards the environmental system (Nature Boundary):
Emissions to air from combustion of the fuel are included. Only parameters regulated by law have been studied i.e. regulated exhaust gases for engines (CO, HC, NOx and particles), fuel regulated (SO_2) and tax regulated (CO_2)

Other environmental impacts from the operation of the vehicle are not included, e.g. emissions to water and soil, land use etc..

Comment: The criteria for selecting flows to the environmental system, was that only regulated flows should be considered.

System boundaries in time (TimeBoundary):
The aim was that the studied system should represent the active truck fleet in 1994. Due to the fact that new regulations on exhaust emissions are introduced, and the vehicle fleet is renewed, the system will most probably not be relevant after 1994.

Geographical system boundaries (GeographyBoundary):
The system is intended to represent the average fleet in Sweden. The system may be relevant also in other countries, provided that the composition of the fleet and the fuel quality that are used in the country is similar.

Comment: In the work, only transportation in Sweden was considered.

Other system boundaries (Other Boundaries):
For the transportation, the utilisation level with regard to weight has been assumed to 50%, which is a conservative assumption for the utilisation in long distance transportation.

The following sub-systems have been excluded:
-Production and distribution of the fuel
-Manufacture and maintenance of the vehicle and production of maintenance material e.g. motor oil
-Establishment and maintenance of an infrastructure

Comment: A motivation with regard to why the subsystems have been excluded is missing

Description of allocations (Allocations):
Not applicable

Comment: In this case, no allocations have been done. Instead of leaving this field empty, however, this has been explicitly stated.

Description of system expansions (LateralExpansion)
Not applicable

3. Inflows and outflows to the system

Direction	*FlowType*	*Substance*	*Quantity*	*Min*	*Max*	*SDev*	*Unit*	*Environment*	*Geography*
Input	Cargo	Cargo	1				ton	Technosphere	Sweden
Input	Resource	Diesel	0,9				MJ	Technosphere	Sweden
Output	Cargo	Cargo	1				ton	Technosphere	Sweden
Output	Emission	CO	0,31				g	Air	Sweden
Output	Emission	CO2	66				g	Air	Sweden
Output	Emission	HC	0,08				g	Air	Sweden
Output	Emission	NOx	0,81				g	Air	Sweden
Output	Emission	Particles	0,09				g	Air	Sweden
Output	Emission	SO2	0,085				g	Air	Sweden

Comment: All inflows and outflows are given with regard to 1 tonkm for a utilisation level of 50 % as specified in Functional Unit in section 2.
For transports the in- and outflow "cargo" must be specified.

4. Description of methods used to acquire the numerical data

For the entire data set

Time period during which data was acquired (DateConceived):
1985-01-01 – 1994-01-01

Comment: The original material that was used in the compilation and the calculations that was performed in the compilation was from between 1985 and 1994.

Type of method (DataType):
Derived, unspecified

Comment: The data was derived using data from different literature sources. The numerical basis for the data was however not specified in the sources that was used.

Description of method (Method):
The emissions were calculated from emission factors; the emission factor for each specific substance (g/MJ) was multiplied with the energy use (g/tonkm). Details on how the emission factors and energy use were obtained are described in metadata for each specific substance. Metadata for NOx, CO, CO2 and HC can be found under NOx.

The basis for the values is different literature sources. The values are presented in Tillman.

Comment: A general description is given on how the emissions have been derived. The details for the basis of the emissions are described for each specific emission.

Represents:

References (LiteratureRef):
Tillman, A-M. ‘Goods transportation in life cycle assessment. Standard values for energy consumption and emissions.‘ In: Life Cycle Assessment - Inventory Analysis Methodology: Overview, Recycling, Electricity and Transports, Swedish Waste Research Council (AFR) report nr 74, April 1995

Further notes (Notes):

For specific substances

-->Substance Name: SO2

Time period during which data was acquired (DateConceived):
1992-01-01

Type of method (DataType):
Legislated limit

Description of method (Method):
The emission factor that was used is based on the sulphur content in the diesel. The sulphur content is based on the Swedish ordinance for sulphurous fuels (SFS 1987:286) which allows a maximum of 0.2 weight-% sulphur in diesel. This is equivalent to 0.094 g SO_2/MJ.

> *Comment:* Details on how the sulphur content has been converted into a emission factor is missing, e.g. how the emission factor was calculated and what data regarding the fuel that was used in the calculation.

Represents:

References (LiteratureRef):
SFS 1987:286. "Förordning om ändring i förordningen (1976:1055) om svavelhaltigt bränsle" Svensk författningssamling 1987

Further notes (Notes):

-->Substance Name: NOx

Time period during which data was acquired (DateConceived):
1989-01-01 –1993-01-01

Type of method (DataType):
Derived, unspecified

Description of method (Method):
The emission factors that have been used to calculate the emissions of NOx, CO, CO_2, and HC are derived from Lenner.

In Lenner emissions and energy use were reported in g/tonkm and kWh/tonkm respectively (table 3, page 14) for two types of transports:

- distribution - an average value for 7-tonne and 14-tonne vehicles with an average load factor of 48%
- long distance - 50-tonne truck with trailer with an average load factor of 60%.

To obtain emission factors in g/MJ, the data presented in Lenner was recalculated. The emissions stated in g/tonkm was divided by the energy use that were stated in the report in kWh/tonkm for the transports. A mean value of the calculated emission factors (g/MJ) for the two types of transports was then used. The resulting emission factors that were used in the calculation was:
HC 0,09 g/MJ
CO 0,34 g/MJ
NOx 0,9 g/MJ
CO2 73,4 g/MJ

The figures stated by Lenner were derived from data reported by Hammarström (1). The data in Hammarström (1) were based on measurements by the ECE R49 13-mode method, conducted by the engine exhaust laboratory of the Swedish Motor-Vehicle Inspection Co. The measurements can be found in Laveskog. The 13-mode method results in energy use and emissions in g/kWh, where kWh is related to the mechanical work done by the engine. Lenner has made corrections to these figures to make them represent a real traffic situation. The corrections were assumed to follow earlier relations between 13-mode data (g/kWh) and data representing a real traffic situation (g/km) described by Hammarström (2). Energy use and emissions in g/tonkm were obtained by division with the cargo weight for the specified utilisation level (tonnes).

The following data was used in the calculations (from Lenner)

Long distance:
HC 0,06 g/tonkm
CO 0,24 g/tonkm
NOx 0,7 g/tonkm
CO2 53 g/tonkm
Diesel 0,20 kWh/tonkm

Distribution:
HC 0,25 g/tonkm
CO 0,84 g/tonkm
NOx 1,87 g/tonkm
CO2 169 g/tonkm
Diesel 0,64 kWh/tonkm

data for diesel (from Lenner)
energy content: 11,9 kWh/kg
density: 0,83 kg/dm3
CO2 at combustion: 2,61kg/dm3

Comment: The calculations that has been performed and the data and assumptions that was used in the calculations are described as detailed as they have been described in the references that was used. However, some relevant information is missing e.g. no details is given to why certain assumptions has been made; for instance why a mean value of the emission factors for the two types of transports was used.
All literature sources that were used are referenced in the documentation and listed in References below.

Represents:

References (LiteratureRef):

Lenner, M. 'Energiförbrukning och avgasemission` VTI meddelande nr 718, Statens Väg- och trafikinstitut 1993

(1) Hammarström U `Bränsle- och emissionsfaktorer för kallstart och varmkörda motorer` VTI notat T 119, 1992.

(2) Hammarström, U. "Trafik och avgasutsläpp - utblick mot 2015. Emissions- och bränslefaktorer för vägtrafik. VTI notat T 84, 1990.

Laveskog, A "Utsläpp från tunga dieselfordon. Mätningar 1980-1988" Bilavgaslaboratoriet. Rapport 3579. Naturvårdsverket. 1989

Further notes (Notes):

-->Substance Name: Diesel

Time period during which data was acquired (DateConceived):
1992

Type of method (DataType):
Unspecified

Description of method (Method):
The value are based on simulation calculations conducted by AB Volvo of the energy use for heavy trucks and trailers with maximum total weight 40 and 52 tonnes (de Val). Simulations were conducted for full load with regard to weight and empty load, assuming long distance driving technique, i.e. constant speed and few starts and stops. To obtain the energy use for an utilisation level of 50 %, a mean value of the result of the simulations at full and empty load was calculated. The loading capacity with regard to weight is 25 tonnes and 32 tonnes for the 40 and 52 tonne equipage respectively. The energy use with regard to loading capacity was similar for both 40 and 52 tonnes equipage.

The simulations were conducted for F12 and F16 Volvo models manufactured in 1987, both with international semi-trailer (40 tonnes) and with trailer (52 tonnes).

The result from the simulations for truck with semitrailer was:
Empty load: 0,26-0,28 litres/km

Full load with regard to weight: 0,37-0,39 litres/km

The result from the simulations for truck with trailer was:
Empty load: 0,29-0,31 litres/km
Full load with regard to weight: 0,47-0,49 litres/km

(The lower values are valid for F12 trucks.)

The energy content in the fuel were assumed to be 36,0 MJ/litre.

Represents:

References (LiteratureRef):
de Val, D. 'Schablonvärden för energiförbrukning vid godstransporter med lastbil.` Teknisk rapport, LM-54969, AB Volvo, Teknisk Utveckling, 1992

Further notes (Notes):
Simulation using diesel-driven Volvo trucks manufactured in 1987 was used with the aim that the values would represent an average value of the active fleets in 1992.

Note that the energy use for new trucks is lower. The values will therefore need to be updated regularly.

Comment: Some notes on aspects that should be considered for the flow is given.

-->Substance Name: Particles

Time period during which data was acquired (DateConceived):
1985-01-01

Type of method (DataType):
Unspecified

Description of method (Method):
The emission factor that was used was 0,1 g/MJ. The origin of the value is however not known. The value was presented in Tillman et.al., but no details are given to how it was acquired, except for a reference to Umweltbundesamt.

Comment: A comment of the fact that information is missing is given, when the information was not available.

Represents:

References (LiteratureRef):
Tillman A-M, Baumann, H, Eriksson, E, Rydberg, T. `Livscykelanalyser för förpackningsmaterial - beräkning av miljöbelastning`. SOU 1991:77, Allmänna förlaget, Stockholm, 1991

Umweltbundesamt, Germany, 1985

Further notes (Notes):

5. Recommendations on the use of the model and the data and other relevant information

Applicability:

The values are intended as standard values for and should not be used for detailed study of transportation. In such cases more information is needed e.g. regarding the vehicle that is used for the transportation, the utilisation level and the nature of the goods.

The utilisation level has a large influence on the energy use and emissions per tonkm. The data are only applicable for an utilisation level of 50 %, of the available loading capacity with regard to weight. This is a conservative assumption for the level of use. An utilisation level of 50 % is fairly representative for long-distance transport in Sweden when empty return trips is included. It should however be recognised that the utilisation may vary extensively between different types of goods and firms of haulage.

When considering transportation it should be considered whether the goods that is to be transported is weight or volume limited. If the data is to be used for goods that are volume limited, the volume of the goods should be recalculated into an equivalent weight. In the transportation business conversion factors are used to convert the volume of bulky goods into an equivalent weight. The conversion factor varies between different firms of haulage. However a generally accepted conversion factor is 250 kg/m3.

The energy use is based on trucks manufactured in 1987, to represent an average of the trucks that were used in 1992-93. It should be recognised that newer trucks have lower fuel consumption due to technical development. Also, the emissions from newer engines are lower.

Comment: An attempt has been made to alert the data user of relevant aspects regarding transportation that should be considered before using the data.

About Data:

The data is based on material compiled from different sources. The value for the energy use is based on Volvo, whereas the data for the different emission parameters were acquired from different literature sources. Thus, there are differences in the quality and the prerequisites of the data that were used. For example, the value for particle emission is based on material with unknown origin.

The energy use is based on simulations. It should however be noted that the energy use may vary depending on driving technique, climate, maintenance etc.

Comment: Some information is given of quality deficiencies of the data that is given. However, it would have been helpful with an analysis of the influence on the reliability of the data that is presented, due to the fact that the quality of the sources varies.

Notes:

The review of the original report (Tillman A-M.) was quite extensive. An attempt was made to try to follow the presented data to the original sources. However, in most cases this was not possible due to insufficient references and documentation of the assumptions and calculations that had been made in the material that was used. The authors of some of the material that was used were contacted for some clarifications, but they did not have the information available.

Comment: The “Reviewer” field in the SPINE structure (section 2) only allows specification of the person, but no description with regard to what the review has been concerned. Therefore, a brief description of what has been done in the review is given in the Notes field.

6. Administrative and general information on the dataset

Date Completed:
1994-04-01

Publication:
Tillman, A-M. `Goods transportation in life cycle assessment. Standard values for energy consumption and emissions.` In: Life Cycle Assessment - Inventory Analysis Methodology: Overview, Recycling, Electricity and Transports, Swedish Waste Research Council (AFR) report nr 74, April 1995

Documentation and review of the report done by: Ann-Christin Pålsson, CPM/TEP, Chalmers University of Technology
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Comment: At present there are no requirements in the structure to specify the person responsible for the documentation, if this person is not the same as the “Practitioner” i.e. have been involved with the actual data acquisition (section 2). However, since the documentation in practice reflects the interpretation of the material by the person responsible for the documentation, a specification of that person is important. This has therefore been supplied as extra information in the “Publication” field

Availability:
Public

Copyright:
AFR

Appendix 3. Quick reference

1. Description of the technical system

Name

The most prevalent name of the technical system. The name is preferably descriptive, since it should give a first identification on what technical system that is described.

Type of technical system (Category)

The type or the scope of the technical system that is studied e.g. unit operation, "gate to gate", ”cradle to gate” etc.

In the SPINE-format, this nomenclature is called *ProcessType*. A general structure for the ProcessType nomenclature has been developed within CPM for this purpose, based on the different types of technical systems that are studied in LCA.

Sector

The sector within which the technical system operates.

If the data describes a large aggregate technical system, the sector is specified by the last process in the chain, or in accordance with the general function of the system.
In the SPINE format the nomenclature is called *Sector*. A simplified nomenclature for the sector nomenclature has been developed within CPM

Geographical location (Site)

The geographical location where the system is situated, i.e. address or geographical area.

If the studied technical system is a specific process or plant, the address is given. For general or complex systems such as averages or geographically extended systems, where the activities included in the system takes place in several geographical places, a geographical region is given, e.g. the country within which the activities take place.

Addresses are specified by name, mailing address, phone number, facsimile number and e-mail address. In the SPINE format, the information is handled in the JuridicalPerson address register.

Description of system content (Function)

Detailed description of the system content and the scope of the technical system that are studied, with regard to the included process steps and activities, technology etc.. The description should ideally provide an understanding on how reported inflows are transformed into the reported outflows.

To structure a complex description; a brief abstract may be given of the main process steps that are included, followed by a more detailed description, where the included process steps are described in detail.

Owner

The owner of the technical system.

Addresses are specified by name, mailing address, phone number, facsimile number and e-mail address. In the SPINE format, the information is handled in the JuridicalPerson address register.

2. Description of choices made during the data acquisition and the objective for the choices

Objective and intended user of data

Intended User

The intended target group for the information.

General Purpose

The background to why the data acquisition or the study was initiated.

Detailed Purpose

The specific objective to why data was acquired or the study was performed.

Commissioner

The person or organisation responsible for initiating or commissioning the data acquisition or study.

The Commissioner is specified by name, mailing address, phone number, facsimile number and e-mail address. In the SPINE format this type of information is handled in the JuridicalPerson address register.

Persons responsible for the data acquisition

Practitioner

The person or persons responsible for the modelling and main part of the information that is presented, with compilation and interpretation.

The practitioner/s is specified by name, mailing address, phone number, facsimile number and e-mail address. In the SPINE format this type of information is handled in the JuridicalPerson address register.

Reviewer

The person or persons responsible for reviewing the data or the data acquisition.

The reviewer/s is specified by name, mailing address, phone number, facsimile number and e-mail address. In the SPINE format this type of information is handled in the JuridicalPerson address register.

Choice of functional unit

Functional Unit

The functional unit is the reference to which all numerical data on inflows and outflows are presented.

Explanation of the Functional Unit (FunctionalUnitExplanation):

Explanation and motivation of the choice of the functional unit.

Choice of system boundaries

System boundaries towards the environmental system (NatureBoundary)

Description of system boundaries towards the environmental system. The description is primarily done by a description of the criteria that have been used for the choice of parameters that are considered environmentally relevant, i.e. the choice of flows that originates in or ends up in the environmental system.

System boundaries in time (TimeBoundary)

System boundaries in time describe different time related aspects of the studied technical system, such as the time period during which the process or the technology can be considered valid.

Geographical system boundaries (GeographyBoundary)

The geographical extension or geographical limitations of the studied process or system.

Other system boundaries (OtherBoundary)

Description of other system boundaries, such as boundaries towards other technical systems and cut-offs.

Description of allocations (Allocations)

Description of allocations that have been performed to obtain the numerical data that are presented (when applicable).

Description of system expansions (LateralExpansion)

If a system expansion or system enlargement has been done, the motives and the details for the system expansion should be described, regarding for instance what technical subsystems that have been included in the system.

3. Inflows and outflows to the system

Direction (SubType)

The direction of the flow i.e. input or output

Type of flow (Category)

Categorisation to distinguish between different flows e.g. Resource, Emission, Product etc.

In the SPINE format the nomenclature is called FlowType. A limited nomenclature has been developed within CPM for this purpose.

Substance (SubstanceName)

Name of the substance, entering or leaving the technical system

In the SPINE format this nomenclature is called *Substance*. A suggestion for the Substance nomenclature has been developed within CPM.

When introducing new substances in the substance nomenclature, the name should be clearly defined and explained. The following rules of thumb for the naming should also be used

- British English
- Established notation
- If two notations can be considered to be equally established, use the shortest notation.

Quantity

The size of the flow, normalised to the functional unit

QuantityMin

The corresponding minimum value for the flow, normalised to the functional unit

QuantityMax

The corresponding maximum value for the flow, normalised to the functional unit

StandardDev

The corresponding standard deviation of the flow, normalised to the functional unit

Unit

The unit for the given quantity for the flow

Origin or destination of flow – environmental type or media (Impact Media)

Type of environment where the flow originated when entering the technical system (e.g. technosphere) or end up when leaving the technical system (e.g. Air water, ground).

In the SPINE format this nomenclature is called *Environment*. A general structure, with a suggested detailed structure has been developed at CPM for the Environment nomenclature.

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Origin or destination of flow – geographical (Impact Region)

Description of the geographical location where the flow originated when entering the technical system or end up when leaving the technical system

In the SPINE format this nomenclature is called *Geography*. A nomenclature has been developed within CPM for this purpose.

4. Description of methods used to acquire the numerical data

Time period during which data was acquired (DateConcieved)

The time period during which the data and the numerical basis for the data was acquired.

The following format should be used:
YYYY-MM-DD - YYYY-MM-DD
If only the year is known: YYYY-01-01
If only the year and the month is known: YYYY-MM-01

Type of Method (DataType)

The type of method that has been used to obtain the data, e.g. Derived, unspecified. In the SPINE format the nomenclature is called QMetaDataType. A general nomenclature for QMetaDataType has been developed within CPM.

Description of Method (Method)

The description of method includes a clear account of the methods that have been used and the assumptions and calculations that have been performed to obtain the numerical data that are presented. Ideally, the description should be thorough enough to enable a check of the calculations etc. that have been performed from the original source.

Represents

In some cases, data describing a similar technical system is used to represent the studied technical system. If this has been done, a description should be given of relevant aspects of the original conditions for the data, i.e. what system the data originally represents. It should also be argued for how well the assumed value may be considered to correspond to the true value.

References (LiteratureRef)

References that have been used in the data acquisition (literature or personal contacts), and that are referred to in Method or Represents.

Further notes (Notes)

Further information of the data or the flows that are not related to how the numerical data for the flows was acquired..

5. Recommendations on the use of the model and the data and other relevant information

Applicability

Description of an assumed area of application for the described technical system regarding e.g. geographical, technology or other trade specific applicability. Also, other general cautions and recommendations may be given regarding how data can be used.

AboutData

General description of numerical and other qualities, or quality deficiencies in the overall documentation and numerical basis for the data.

Notes

Other relevant information about the technical system and the data that are not appropriate in any of the other fields.

6. General and administrative information

Date Completed

The date when complete data set or the study that is presented was final reported.

The following format should be used:
YYYY-MM-DD
If only the year is known: YYYY-01-01
If only the year and the month is known: YYYY-MM-01

Publication

Literature reference to where the complete data set or the study has been published (when applicable), or contact person.

Availability

Conditions or agreements regarding how data may be distributed.
For instance, details in secrecy agreements or restrictions regarding the data should be described.

Copyright

Holder of copyright.