AusLCI

The Australian Life Cycle Inventory Database Initiative

Requirements

for the development of AusLCI Data sets

AusLCI committee

Version 3.0

6 March2014

ALCAS

AUSTRALIAN LIFE CYCLE ASSESSMENT SOCIETY

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1.9	10th January 2012	Tim Grant	Major rearrangement of guidelines and addition of documentation requirements and evidence for reviewers. Allot of discussion text removed
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3.0	6 March 2014	Committee	Accepted amendments arising from bio-based materials project

Preamble

These requirements have been developed over a five year period to provide the requirements for data sets for the Australian Life Cycle Inventory Database Initiative (AusLCI). This document has been developed by the AusLCI database committee. The requirements outline what is compulsory and what is suggested for development of AusLCI data. It also provide suggestions as to how these requirements should be verified in the compliance review.

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1 Introduction

1.1 AusLCI Project

This document is the first in a suite of documents providing advice to organisations preparing to submit data to the Australian Life Cycle Inventory Database Initiative (AusLCI). These documents describe the methodology to be used, the data structures and the reviews required to ensure the quality and transparency of the AusLCI datasets in three parts:

1. Requirements for development of AusLCI Data sets
2. Compliance Review Procedure for Validating and Approving Data Sets for AusLCI
3. Guidelines for Technical Review of AusLCI datasets.

This document provides the requirements and guidance for development of life-cycle inventory (LCI) data for AusLCI.

The primary objective of AusLCI is to develop publicly available LCI data modules for commonly used, generic materials, products and processes. Availability of generic data is important to support public, private and non-profit sector efforts to undertake life-cycle assessments (LCAs) and develop LCA-based decision support systems and tools such as ecolabels, environmental impact calculators and simplified design tools. This guideline focuses on LCI methodology and not the management of data or databases.

AusLCI intends to make data available for a variety of user groups in a manner that will ensure as informative and time- and cost-efficient use as possible. To achieve this, data will be documented in accordance with the ISO/TS 14048 (International Standards Organisation 2001) documentation format, and presented on a fully disaggregated unit-process basis.

1.2 AusLCI Data Collection & Publication Process

1. It is expected that organisations and companies (Data owners) will have engaged a suitably qualified practitioner to collect and assemble their life cycle inventory data (see *List of Practitioners* http://www.alcas.asn.au/resources/practitioners).
2. It is expected that organisations and companies will also engage a suitably qualified practitioner to undertake an independent technical review of data Note: this cannot be the same company that undertakes the initial LCI data collection.

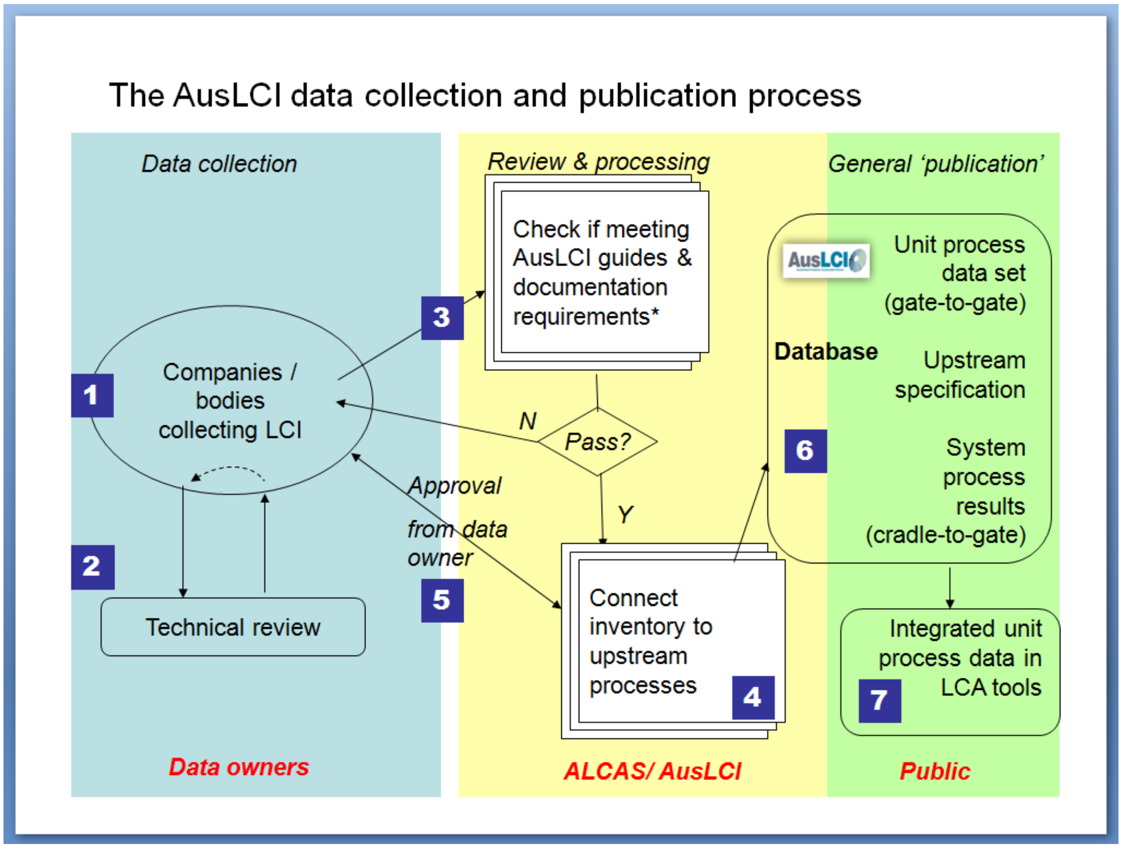


Figure 1: Summary Process/Flowchart for AusLCI Data Publication

3. Data can then be submitted to ALCAS AusLCI Database Committee for consideration for inclusion in the AusLCI Database (see requirements for submission on previous page). Information provided will then be checked against the ALCAS document *"Requirements for the Development of AusLCI Data sets".* If the information provided does not meet the requirements the data supplier will be advised of the identified concerns.

4. If the data does meet the requirements, the ALCAS AusLCI Database Committee will then work with the supplier to connect their data to any relevant Australian upstream processes required (and where relevant to determine average industry data for that sector).

5. The ALCAS AusLCI Database Committee will then formally seek approval from the Data owner for publishing.

6. The data will then be published in the AusLCI national database.

7. It is expected that software suppliers will integrate AusLCI data into their tools providing integrated unit process view of the data.

1.3 Goal and Scope Definition for inventory development

The basic goal of the Australian National LCI Database project is to establish and maintain LCI modules that can be readily accessed, combined, and augmented to develop more complex LCIs and LCAs.

The type of materials, products and processes that are to be included in AusLCI will be:

1. Those of interest to the sponsors, participants and users of AusLCI, and
2. Those background processes that are needed and are environmentally significant in the supply chain of the materials and processes of interest.

Typically these "background" processes include energy, transport, waste treatment, basic materials, chemicals and manufacturing operations. The ultimate aim of the project is for all significant background processes to be built up from submitted and verified Australian data so that subsequently only data from AusLCI are used in the inventories.

Users of the database are likely to include the following groups:

1. Manufacturers, researchers, policy analysts and others undertaking LCAs[1] of specific products or processes,
2. Developers and users of LCA practitioner tools,
3. Developers of life cycle based tools for non LCA experts, and

   Organisations or individuals engaged in product assessment and labelling

The AusLCI database will provide a resource base for LCAs, rather than presenting completed cradle-to-grave LCA results or comparisons of individual product life cycles.

As such the data collection and modelling will aim for:

- Consistency - data are collected on the same basis and to the same level of detail
- Completeness - all relevant inventory flows are included..
- Flexibility - data will have sufficient detail to allow specific user groups to adapt and utilize the data in the most appropriate manner for their decision making needs.
- Transparency - data will be shown at a unit process level to allow users to understand where impacts are coming from and to ensure consistent use of upstream processes throughout data sets.

Transparency requires open access to all pertinent "data about the data" or meta-data. Central transparency objectives of the Australian LCI database project are to develop and

[1] The term LCA is used in the broadest sense, and includes full LCAs, streamlined LCAs, carbon footprints, eco-footprints, life cycle management and life cycle thinking.

publish LCI data in a form that provides enough information about the nature and sources of the data so that users and third parties can do the following for each data item:

- Know the source(s) and age of the data,
- Know how well the data represents an industry or process,
- Understand how the underlying calculations were made,
- Evaluate the appropriateness of the data for the user's intended application,
- Validate the results through testing and cross-checking of data and modelling, and ultimately
- Make an informed determination concerning the extent to which they can rely on the data and conclusions drawn from it in relation to their goal and scope.
-

1.4 Attributional and Consequential modelling

The data developed in a generic inventory are modelled based on an "attributional" approach, which seeks to establish the burdens associated with the production and use of a product, or with a specific service or process, at a point in time (typically in the recent past). This is in contrast to a "consequential" approach, which seeks to identify the environmental consequences of a decision or a proposed change in a system under study. However, through the development of disaggregated and transparent models, the data will support consequential modelling. A separate consequential version of the AusLCI database may be produced at some time in the future.

1.5 Structure of the AusLCI database

The AusLCI database is effectively one fully connected unit process database made of three types of data inputs:

1. Submitted and verified AusLCI unit processes – This is referred to as AusLCI data.
2. A shadow database of unit process data taken from public Australian and overseas sources, which will be used to fill gaps in the current AusLCI database. Overseas data will be adapted to emulate Australian production. Specific changes in overseas unit processes will be based on known Australian data points (e.g. the fuel mix used in a process) and through the linking of AusLCI data as inputs to the shadow database (e.g. Australian electricity production replacing overseas electricity production).
3. External data sources which are used either because they represent the most appropriate supply (overseas product supply) or because they are considered the best approximation for Australian supply, yet they cannot – for aggregation or other reasons - be integrated in the shadow database.
4.

1.6 Publication of the AusLCI database

Only the first group of data will be published under the AusLCI banner:

- as standalone unit process data,
- as system process (aggregated) results through calculation of elementary flows along the supply chain using data from the second and third categories.

Because the shadow database potentially contains licensed data sets it cannot be published as such. However, a complete specification on how it is to be constructed (every alteration to the original datasets will be documented) will be published. This will allow licensed users to be able to reconstruct the shadow database. External unmodified datasets will simply be referenced so that they can be linked to again by licensed users.

For users without access to these licensed databases, fully calculated, cradle to gate system process LCIs will be published providing the complete elementary flow LCI results, but without the full disaggregation of the underlying unit process structure.

This structure maintains usefulness for both professional and casual users while respecting data licensing rights.

The management of the AusLCI database and the shadow database will be the responsibility of the AusLCI database committee or the data manager.

1.7 Submitting data to AusLCI

Organisations wishing to submit data to the AusLCI database committee require the following documents:

- Unit process data in one of the compliant formats (EcoSpold1 or 2, ILCD),
- The AusLCI submission template,
- Critical review reports or other evidence of critical review of the data sets,
- Any supporting reports which accompany the data; however the aim is to have the unit-process dataset self-sufficient in terms of documentation.

2 Requirements

2.1 What needs to be included when submitting an AusLCI data set?

2.1.1 Defined Reference flow & Functional unit (check heading)

For LCI being developed the reference flow used in each process shall be defined and needs to be appropriate to represent functionality of that product or service. The quantity used for the reference flow should present the property used in the industry (e.g. water measures in volume generally and not mass). The scale of the unit can be chosen by the data developer (per kg, or per tonne etc.). Refer to coproduction requirements in section 2.3.8 for special requirements for documenting multi-function processes. For the naming convention of product flows see section 2.3.1.

All of the other inputs and outputs included in the unit process are scaled to the reference flow output.

Documentation Requirement	Requirement
Reference unit name	Required
Unit for functional unit	Required
Quantity of product or process	Required
Comment	Optional

Evidence for reviewer
The functional unit name, and the unit used need to represent unambiguously the quantity and properties of the product or service produced.

2.1.2 Description of the system boundaries

The system boundary for each unit process shall be described in terms that detail the processes within the boundary of that process. This should describe where the boundary begins and where the boundary ends in terms of the process flows. Only the processes included in that unit process should be described, not the full connected supply chain more akin to a description in an LCA. Excluded processes can also be noted for clarity, for example for a service process such a metal coating, it should be noted that it excluded the metal which is being plated from the process.

Documentation Requirement	Requirement
Description on included processes start	Required
Description on included processes end	Required
Description on excluded processes	Optional
Graphical representation of process and system boundary	Required

Evidence for reviewer	Requirement
Fields completed in unit process documentation	Required
Graphical representation of unit process boundary included with AusLCI submission template.	Required

2.1.3 *Inputs and outputs related to the production of the functional unit.*

Specific requirements for product and elementary flows are detailed in the next sections.

All available data for the inputs and outputs of a unit process should be included selecting data that is as relevant and accurate as possible. Reference to other LCI data sets should be used to identify potential inputs and outputs.

As no cut off will be applied, the following procedure for modelling minor process flows shall be followed:

1. All available data for the inputs and outputs of a unit process should be compiled and modelled through to a final indicator results[2]. The indicators should include those most relevant to the product system but as a minimum would include greenhouse gas emissions.
2. Sensitivity analysis should then be used to test the sensitivity of the final impact assessment to the estimated data points – by doubling and halving each data item.
3. Provided the final environmental significance for the product system being modelled varies by less than 5%, then approximate values can be used – where the variation is greater than 5% then further investigation of this parameter shall be undertaken.
4. All capital and essential service inputs to a unit process should be included however as these will often be proven to be not significant under the sensitivity test approximate data is sufficient.
5. Environmental significance is defined as the important impact areas for the product category under consideration. LCI practitioners should specify which impacts they have used as the significant impact areas for these tests and it is up to the peer reviewer to determine if the impacts proposed are sufficient for the tests.

Evidence for reviewer	Requirement
Check if the cut off question in the submission template is answered.	Required

[2] Note that data submittters who are not modelling their data through to final impact assessment this process can be undertaken by ALCAS for a fee. (see schedule of fees in Appendix 5)

2.2 Requirements for modelling inputs and outputs

2.2.1 Units

All data should be presented in metric (SI) units with the only allowed exception being litres, tonnes and kilowatt-hours. Where conversions are required from imperial or non SI units, the conversion factors provided in APPENDIX A must be used and the conversion must be identified in the data documentation. When economic data is modelled Australian dollars should be used. If conversion from other currencies to Australian dollars is required, the conversion factor (exchange rate) should be clearly documented. Should state what year the dollar values are based on.

Compliance is evident by the units used in the inventory.

Evidence for reviewer	Requirement
Check for non-complying units	Required

2.2.2 Data sources

There are numerous types of data that can be acquired for conducting LCI studies, and it is important to distinguish between primary and secondary data. Primary data are those obtained from the specific facilities that are the subject of the inventory. Secondary data are those included in the product system of the life-cycle inventory that have been obtained from published sources. Examples of secondary data sources include published literature, other LCI/LCA studies, emissions permits and general government statistics (e.g., mineral industry surveys, Australian Bureau of Statistics (ABS), U.S. Bureau of Labor Statistics (BSL), U.S. Energy Information Administration (EIA) data, etc.).

The source of all data should be identified with either a document, publication, personal source or a description of the data sampling technique. The most representative and reliable data should always be used, with the proviso that critical reviewers should be able to verify that the data is current and that it reasonably represents relevant aspects of the unit process under study.

Documentation Requirement	Requirement
Published source or description of data sampling approach (at the flow level). If flow is estimated or calculated this should be noted.	Required
Bibliography of reference publications (at the unit process level)	Required

Evidence for reviewer	Requirement
Check that data sources are stated and referenced correctly	Required

2.3 Requirements for modelling technical flows (upstream process inputs)

2.3.1 *Naming of product flows*

The naming of products and processes is done with the most relevant information up front and qualifying information listed after this. Commas should be used to distinguish information fragments. Brackets, hyphens, underscores and semicolons should all be avoided. This could look as follows:

Product, technology qualifier, supply chain qualifier, region qualifier, country code.

The following product characteristics:

Product	**Technology qualifier**	**Supply chain qualifier**	**Region qualifier**	**Country code.1**
Black Coal	Crushed	at mine	NSW	AU
Hardwood	Sawn	at mill		AU
Urea	Bulk	at regional store	NE NSW	AU

1 Based on ISO 3166 country codes. For regional codes the ecoinvent classification should be followed which include GLO for global processes, and has codes for continents Asia and Europe, the UN regions and subregions. GIS co-ordinates included in unit processes will provide more specific information on location of production.

Result in the following names:

- Black coal, crushed, at mine, NSW, AU
- Hardwood, sawn, at mill, AU
- Urea, bulk, at regional store, NE NSW, AU

Evidence for reviewer	**Requirement**
Unit Process naming conforms to naming rules	Required

2.3.2 *Upstream production processes*

Data suppliers should provide sufficient information on inputs from the technosphere (material, energy and service inputs) and their origin to allow the appropriate connection to upstream LCA data. This data may include company of origin, or region of origin. Where data suppliers are aware of appropriate, published LCI data representing their inputs, these should be listed in the linking specification which is part of the AusLCI data submission template.

The process of linking unit processes to upstream supply data is the responsibility of the AusLCI database committee with advice of the data owner. (For more details on this see APPENDIX E.)

Evidence for reviewer	Requirement
Check that input processes not in AusLCI are specified with country of origin	Required
Check that input processes not in AusLCI are specified with transport mode	Optional

2.3.3 Unit-Process aggregation level

Descriptions of processes can be obtained and aggregated at different levels of complexity and extent. ISO 14040 (International Organization for Standardization 2006) defines a unit process as the "smallest portion of a product system for which data are collected when performing a life-cycle assessment."

Thus, for a plastic moulded product, data could be collected (inventory flows, product flows, and inputs from other processes) for injection moulding process, clean and trimming process, painting processes, then injection moulding, clean and trim and painting are all unit processes. If the same sorts of data are collected at the level of the entire factory encompassing all three of these steps, then the unit process in may be plastic product manufacture.

A model of an entire supply chain will generally contain unit processes at various physical scales. Provided the system boundary remains intact and all flows across the boundary are correctly accounted, then a wide variety of scales of processes can be consistently and appropriately measured. For this project, the goal is to obtain data for unit-process modules that represent subsets of an industry so that users of the data can understand and combine various components of a product system and so that critical reviewers can conduct technical analyses. Higher levels of aggregation of data (e.g., defining a unit process to include more activities) will result in a loss of information, reduce the level of transparency and inhibit critical review. In addition, some components of a product system, such as limestone quarrying, are used in many applications. Defining that type of activity as a separate unit process will eliminate the need to conduct multiple assessments of the same data. It will also prove useful to users constructing many different LCI models.

2.3.4 Requirements for disaggregation for data suppliers

In line with ISO 14044 (International Organization for Standardization 2006) 4.3.4.2 section a 1) unit processes should be disaggregated to such a level to avoid the need for allocation of jointly produced products. Furthermore aggregation of unit processes should be avoided and where possible data should be disaggregated sufficiently to enable the use of common sub processes by other product systems.

Evidence for reviewer	Requirement
Check if any joint production processes are aggregated together as a single process.	Required

2.3.5 Aggregation for protecting confidentiality

Proprietary information provided on a confidential basis by individual companies or plants will be protected where this is required by the company.

This need will automatically be met in most cases by the normal process of combining company-specific unit-process data across an industry, and reporting aggregate data for each unit process ("horizontal aggregation").

Notwithstanding the requirements in 2.3.4, In some instances, for example if the sample of reporting companies is small, it may be necessary to aggregate data for two or more unit processes which occur in series before publishing the results in the database ("vertical aggregation"). In extreme cases (e.g., when there is only one manufacturer of a product and that manufacturer needs to protect commercially sensitive information under a confidentiality agreement), it may be necessary to aggregate data for one product with that for a similar product from a different country.

Because of the losses of information, transparency, and utility, vertical aggregation should only be used when it is unavoidable to avoid disclosure of competition-sensitive information. When aggregation is necessary to protect any proprietary manufacturer's information, aggregation procedures must be clearly explained. Data suppliers should state what processes are included in the vertical aggregation.

Full vertical aggregation of a data sets (cradle to gate) is not acceptable in the AusLCI.

Evidence for reviewer	**Requirement**
Make sure there are no fully aggregated unit processes and that vertical integration is minimized and justified.	Required

2.3.6 Supply and Production mixes

The intent is to develop industry average data for the range of technologies currently in use for specific unit processes. If more than one technology is used in an industry, data should be collected for the full technology range and reported separately with the market proportion served by that technology. If it proves impossible to produce anonymous data by averaging from plants using similar technology or if there are confidentiality agreements in force to prevent disclosure then results can be aggregated to produce weighted averages, with the relative contribution to the market.

LCI data from products and materials produced by different technology types should be separately reported. Where distinctly different technology pathways are used to produce the same materials/products/commodities, then these need to be kept distinct and not aggregated – the average values would not be representative of any of the technologies. Examples include:

- Electricity from different pathways (e.g. brown coal, black coal, gas, renewables),
- Steelmaking: electric arc furnace, basic oxygen furnace, HiSmelt,
- Blast furnace or electro-refined metals,
- Wet or dry cement clinker production process.

To avoid the random use of different technologies, Australian average production should also be supplied. There may also be a rationale for regional production models for commodities that are predominantly traded within local regions, such as:

- Electricity.,

- Wood panels and timber products,
- Cement, aggregates and sand,
- Waste management services.

For some low impact materials, transport is the dominant impact in their value chain and transport distances and modes may crucially affect the LCI results with sometimes counter-intuitive outcomes. For example, aggregates shipped long distances by sea from coastal quarries may have lower net impacts than apparently more local sources traveling by road haul. Therefore it is crucial that transport scenarios are representative for typical operations and that likely ranges are provided as additional information.

LCI developers should decide the most appropriate mix of producers to include in averages (Australian supply, Australian production or individual technology or company production).

2.3.6.1 Requirement for data producers

Data suppliers must be clear whether an inventory is for 'average supply' (includes imports) or 'average production', or some other mix of producers, and this should be stated in the process name.

Evidence for reviewer	Requirement
Is it obvious from the process name what product mix the output is?	Required

2.3.7 Product disaggregation

Elements of a product group are considered different if their dominant environmental performance characteristics differ by 20% or more. In such cases product groups should be disaggregated. Product group elements which differ less than 20% may be aggregated into a single product group. For example paint products which have a range of colour options, each with different pigment, may be aggregated together as one product if the above rule is met.

Evidence for reviewer	Requirement
Does the product represent a group of products/technologies, and if so has evidence been provided as to the similarity between the product variants included.	Required

2.3.8 Treatment of Co-Production processes

Where a single process produces multiple economic outputs (co-production) the following procedure should apply in order from 1-4:

1 **Avoid allocation by subdividing systems** - In accordance with the ISO 14040 standards: "Wherever possible, allocation should be avoided by dividing the unit process to be allocated into two or more sub-processes and collecting the input and output data related to these sub-processes. If this is not possible then:

2 **Publish inventories prior to allocation** – The co-production inventories should always be published in an un-allocated form and provide such information which would allow practitioners to use or test alternative allocation approaches. Having done this data should be provided to allowthe inventory to be allocated based on the following:

3 Use underlying physical relationships between input and outputs - In accordance with the ISO 14040 standards: "Where allocation cannot be avoided, the inputs and outputs of the system should be partitioned between its different products or functions in a way that reflects the underlying physical relationships between them; i.e. they should reflect the way in which the inputs and outputs are changed by quantitative changes in the products or functions delivered by the system." Where it's not possible to establish such underlying physical relationships then:

4 Apply economic allocation to co-products - For multi-output processes allocation of co-products based on economic relationships can be used. Such decisions are required in most life cycles, for elements such as fuels and materials production. Economic allocation requires price information for commodities. Short term fluctuation in prices could have an impact on the LCA results and therefore this should be avoided by looking at a long term price trend (for example 5 years).

Data submitters should provide and explanation of the choice of allocation approach in line with the hierarchy provided above. The necessary information shall be supplied to allow the allocation to be applied in the AusLCI database. The coproducing unit process should be provided in an unallocated.

Note that for a consequential version of the AusLCI database system expansion would be used at step 4 above.

Evidence for reviewer	Requirement
Inventories are provided prior to allocation.	Required
An explanation of the choice of allocation approach is provided.	Required
Information for applying co-product allocation is provided and in line with the advice above.	Required

2.3.9 Treatment of Recycling[3] and energy recovery processes

Allocation of recycling processes is only an issue when the recycling processes cross the product system boundary. Production waste recycled within production facilities (internal recycling loops) need not be allocated as they are inside the system boundary of the product system to which they belong.

Unit processes representing the production of recycled materials or recovered energy shall be modelled from the end-of-waste stage of the prior life cycle up to point where the recycled material can substitute for primary materials. If the scrap material has zero, or positive

[3] Note recycling also includes reuse of materials and products.

economic value at the point of waste generation, then the transport and processing of scrap would belong to the recycled commodity. If the waste has a negative economic value (i.e. the producer has to pay to have it collected) then part or all of the collection, and processing will belong to the prior product system.

For product systems which include recycling and/or recycled material in the AusLCI database (eg tractors used in Agriculture), allocation should be based on allocation rules described in EN15804:2012. Specifically, a credit for avoided material production will be applied based on net output of recycled material across the product system, in line with Module D in EN15804.

The system boundary of a product system generating material for disposal should be modelled up to the “end of waste” state for all the waste generated in line with Appendix B1 of EN15804.

The impacts and benefits beyond the end of waste stage are only modelled for the net material recycled or reused, up to the point of substitutability with the avoided future use of primary materials or fuels. A credit is provided to the product system for the net material or energy avoided as a result of the recycling, reuse or energy recovery. Where the material or energy substitution is not of equivalent value, a value correction shall be applied.[4] The value correction can be based on the performance characteristic or the relative economic value of the secondary material made from scrap leaving the product system compared to the virgin material being substituted.

When there is a net consumption of scrap within a product system, the inverse procedure should be followed.

EN15804 considers reporting under module D as optional however inclusion of module D is compulsory within AusLCI product systems so that the full life cycle impacts are included.

Examples of how to apply this allocation are provided in Appendix D.

Evidence for reviewer	**Requirement**
Is the information for recycling allocation provided and in line with the advice above	Required

2.3.10 Requirements for using common and energy and transport modules

Energy modules

[4] For example: If secondary aluminium cannot perform the same functions as primary aluminium, a correction is warranted.

The database will include separate data modules for common electricity generation, energy combustion, energy pre-combustion and transportation processes applicable to virtually all LCAs. It is therefore important that all other unit-process modules avoid double counting as follows:

1. Record electricity use in kilowatt-hours and voltage (if available) at the point of use (e.g. with no adjustments for line losses), rather than in estimated amounts of primary energy used to generate electricity,
2. Record energy use by fuel and equipment type (e.g. natural gas turbine), but not combustion emissions or pre-combustion effects unless there is (measured) data available that is specific to that unit process, in which case it should be clearly described, and

The common energy modules include the following fuel production, distribution and supporting infrastructure as well as the emissions from combustion of the fuel used under standard conditions. Modules will include:

- Electricity by different fuel and by region
- Process heat by different fuel type and by different technology (furnace type)
- Mechanical energy use by different fuel type and technology.

Users of the database modules will have to be advised that the electricity grids used in an LCI should match the LCI's functional unit and boundaries:

- where unit process data are available on a regional basis, state based grids should be used, where multiple sites are known each supply should be listed. Where confidentiality does not allow this the regional grid can be used.
- where unit process data cannot be related to specific regions, the national grid should be used, and
- in situations where electricity is an especially important issue and plant locations are dictated by sources of electricity (e.g. electro-process industries), specific industry data should be used.

Both national and state electricity grids will be included in the electricity, fuels, and energy database

Transportation modules

Transport modules will be provided for known fuel use in transport (where total fuel use for a fleet is measured and available for use in the LCA), known transport distances and modes (where the type of vehicle and total kilometres travelled are known, but fuel use per kilometre need to be inferred) and for known origin and destination (total distance travelled, fuel use and allocation with other transported items are inferred based - transport task).

- Transport modes will include
- Articulated trucks,
- Rigid trucks
- Light commercial vehicles,
- Passenger vehicles
- Rail freight,

- Ocean freighters,
- Ocean bulk carriers, and
- Air freight and air passenger transport.

Any downstream transport which is included, such as delivery to site or to regional store, should be stated so it can be adjusted if necessary by the user. Also, in the process name a qualifier to describe the location of goods should be used as follows:

- at farm, at plant - when the goods have not been transported from the production site.
- at site, at regional store – when the good have been transported to the customer or an intermediate distribution point.

When using transport task inventories it's possible to adjust the backhaul ratio, location of the transport (urban and non-urban areas), and the load efficiency of the vehicle – the ratio of the actual load to the maximum load on the vehicle. If these are not known average values supplied in the transport task inventories should be used.

Evidence for reviewer	Requirement
Are standard electricity, heat and transport modules used. If not are the exceptions justified – i.e. (local data is available, electricity use is not from standard grid)	Required

2.4 Requirements for Elementary Flows (inputs from and outputs to nature)

2.4.1 Elementary flows to be included

The number and types of elementary flows collected is driven in part by the impact assessment models that will be used to further interpret the data. Although no agreed impact methods are currently available for Australia, it is expected that these will become available within the next few years. This document will be updated to reflect any changes needed as impact assessment methods are developed for Australia. In the meantime, the following impact categories are included in the scope of AusLCI:

- Resource Depletion:
    - Fossil fuel depletion,
    - Minerals depletion,
- Water use:
    - Water consumption and source (town water, groundwater, surface water, rainwater, seawater),
    - Waste water production and destination; whenever possible waste water treatment should be modelled, resulting in elementary flows as final emissions to natural waters,
- Climate change (also called Global warming or Greenhouse effect),
- Ozone layer depletion,

- Acidification,
- Eutrophication,
- Photochemical oxidant formation (Photochemical smog),
- Human toxicity (air, water and soil pollution),
- Eco-toxicity (air, water and soil pollution), and
- Land occupation and land transformation (based on Australian Land Use and Management Classification version 6 – see APPENDIX B).

The previous impact assessment categories require at least – but are not limited to - the following inventory data:

- Fuel and energy sources,
- Material flows,
- Water flows,
- Emissions to air, water and soil, including data that is required to be reported to regulators (e.g., EPA criteria air pollutants and National Pollutant Inventory data), and
- Land occupation and transformation data.

Solid waste treatment should also be modelled where possible, resulting in elementary flows as final emissions to the environmental compartments. If this information is not available, as much detail about the waste flow and destination should be provided.

2.4.2 Elementary flows and technical flows

The boundary between the techno sphere and the environment should be set in accordance with the ISO 14040:2006 definition of elementary flow, which in general means that agricultural systems, landfill sites and forestry operations are considered as part of the techno sphere.

Elementary flows that are known to occur within unit processes should be present in the inventory. If the data are highly uncertain, then an uncertainty range should be included for these data.

Evidence for reviewer	Requirement
Allwaste flows, water flows and other product flows are entered as inputs from or outputs to the techno-sphere and not as elementary flows.	Required

2.4.3 Naming convention for elementary flows

Elementary flows are inputs and outputs released into or taken directly from the environment. The nomenclature for elementary flows is captured in a growing list published on the AusLCI website and in the user template. New flows required by data submitters should be supplies with the data submission including CAS number if the flow is a chemical substance.

2.4.4 *Receiving environment specifications*

It is envisaged that impact assessment models will increasingly take account of the nature of the receiving environment that a pollutant is being released to. Already toxicity models provide different characterization factors for the emissions to agricultural and industrial soil, and for water pollutants released into fresh water and sea water. It is therefore recommended that receiving environment specifications, as described in ISO/TS 14048:2002 should be provided where they are known using the following convention:

Receiving environment	Receiving environment specifications	Definition	Assigned in general to
air	low population density	non-urban air or from high stacks	Resource extraction, forestry, agriculture, hydro energy, wind power, coal and nuclear power plants, municipal landfills, wastewater treatment, long-distance transports, shipping
	low population density, long-term	Emissions which take place in the future, 100 years or more after the start of the process.	Emissions from Uranium mill tailings.
	lower stratosphere + upper troposphere	Emissions from air planes	Air transport cruises.
	Urban air close to ground	Emission below 150 metres in areas with a population density above 400 persons per km^2	Industry, oil and gas power plants, manufacturing, households, municipal waste incineration, local traffic, construction processes.
	unspecified		Only used if no specific information available.
resource	in air	Resources in air, e.g. Argon, carbon dioxide	Used for carbon uptake in biomass and gases produced by air separation.
	biotic	Biogenic Resource, e.g. wood	
	in ground	Resource in soil e.g. ores, but also for landfill volume	
	land	Land occupation and transformation	
	in water	Resource in water, e.g. magnesium, water	
soil	agricultural	Emission to soil used for the production of food and fodder	Agriculture
	forestry	Emission to soil used for plant production (forest, renewable raw materials) which do not enter the human food chain.	Forestry
	industrial	Emission to soil used for	Industry, land farming of wastes,

Receiving environment	Receiving environment specifications	Definition	Assigned in general to
		industry, manufacturing, waste management and infrastructure.	built-up land.
	unspecified		Only used if no specific information available.
water	ground-	Ground water which will get in contact with the biosphere after some time.	
	Ground -, long-term	Emissions which take place in the future, 100 years or more after the start of the process.	Long-term emissions from landfills
	Surface water	Lakes with sweet water	
	ocean	Ocean, sea and salty lakes.	Offshore works, overseas ship transports.
	river	River and lake	Discharge of effluents from wastewater treatment facilities.
	river, long-term	Emissions which take place in the future, 100 years or more after the start of the process.	Discharge of effluents from wastewater treatment facilities.
	fossil-	Salty ground water that does not get into contact with the biosphere.	Re-injection of formation water from oil- and gas extraction;
	unspecified		Only used if no specific information available.

Source: Ecoinvent data quality guidelines (Weidema, Bauer et al. 2012) except fossil water compartment which has been added. Note this list may grow as international developments in impact methods continue.

Other specific data reporting guidelines will follow international developments including:

- Particulates,
- VOCs,
- Land Use,
- Carbon Flows, and
- Water Flows

Evidence for reviewer	Requirement
Sub-compartments are completed for processes where location can reasonably be interpreted	Required

2.4.5 *Requirements for particulate emission specification*

For particulate emissions the size distribution of particles should be included as shown in the table below.

Name	Formula	Remarks
Particulates, < 2.5 um	PM2.5	particulates with a diameter of less than 2.5 µm
Particulates, > 2.5 um and < 10 um	PM10 - PM2.5	particulates with a diameter of more than 2.5 µm and less than 10 µm
Particulates, > 10 um	TPM - PM10	particulates with a diameter of more than 10 µm

Source: ecoinvent methodology report.

Evidence for reviewer	Requirement
Are particulate emissions broken up into three size fractions?	Optional

2.4.6 *Requirements for Volatile Organic Compounds (VOC)*

Organic compounds should not be aggregated and should be listed as speciated emissions.

It is permissible to provide poly aromatic hydrocarbons as Benzo(a)Pyrene equivalents and Dioxins and furans as TCDD-equivalents.

Evidence for reviewer	Requirement
Speciation of organic compound where available	Required
Is benzo-a-pyrene recorded separately?	Optional
Are dioxins and furans recorded in TCCD-equivalents?	Optional

2.4.7 *Requirements for Land Use*

Land use is considered an important impact area for Australia. Following the ecoinvent approach to land use, two separate entries for land use will be recorded – land occupation and land transformation. The aim here is to provide maximum information to the impact assessment approach without making the land use assessment so specific that it would be unmanageable from an inventory and assessment approach. For land occupation the type of occupation, the area as well as the duration required for the production of a certain amount of products and services are important. That is why land occupation is recorded in square meters times time (m^2a). Clearly defined and relatively short changes in the land use type are recorded as land occupation (e.g. the construction of underground natural gas pipelines, which converts agricultural land to an excavation site). For these construction processes as well as for active restoration activities after decommissioning, the land use category "land occupation, construction site" is applied. For land use which has a more long term effect on the land quality a land transformation is recorded in a two-step process:

1. land transformation, from land use type X (before the activity), and

2. land transformation, to land use type Y (after the activity).

For particular processes the land use type before starting the activity may well be known. However, it is difficult to assess in detail all the historic land use types that have been converted by the processes recorded within the inventory data. If not known, the land use type "transformation, from un-known" is applied. National or regional statistics about land transformation over time may then be used in the impact assessment to attribute a specific land use type to this land use type "unknown".

Specific emissions from land transformation, such as carbon dioxide emissions, should be entered separately within the inventory.

Example: The land use specification for an open cut mining operation could be as follows:

Stage of process	**Land use record**	**Comments**
During construction	Land transformation, from arable Land transformation, to mineral extraction site	Assuming mine was taken from farming land
During use	Land occupation, mineral extraction site	
At rehabilitation	Land transformation, from mineral extraction site Land transformation, to forest, intensive, short-cycle	Assuming the land is revegetated to pine plantations

A list of land use categories is supplied in APPENDIX B, taken from Data Quality Guideline for the Ecoinvent Database version 3.(Weidema, Bauer et al. 2012)

Documentation Requirement	**Requirement**
Category of land use	Required
Unit in area time.	Required
Flow	Required

Documentation Requirement	**Requirement**
Category of land use, prior to use	Required
Category of land use, after use	Required
Unit in area	Required
Flow	Required

Evidence for reviewer	Requirement
Is land occupation documented where land use exists?	Required
Are land transformations listed correctly	Required

2.4.8 Requirements for recording carbon flows and greenhouse gas contributions

The carbon dioxide emissions generated by a system under study must take account of the following relevant aspects of the carbon cycle:

- Sequestration of carbon in carbon stock change in biomass, litter and soil,
- Distinction of emissions from combustion of fossil fuels and non-fossil fuels such as biomass,
- Process emissions (e.g. carbonation in a cement kiln), and
- Sequestration and emissions from landfills or other end-of-life processes.

Carbon dioxide emissions arising from fossil fuel combustion should be identified as "carbon dioxide, fossil" and for non-fossil fuels carbon dioxide emissions should be identified as "carbon dioxide, biogenic". Biogenic CO2 emissions are the result of combusting fuels that have only recently absorbed the carbon from the atmosphere during their cropping cycles. For soil carbon changes due to land use change, "Carbon dioxide, land transformation" should be used. GHG emissions from direct land use change shall be estimated using IPCC Tier 1 methodology and values. For carbon dioxide emissions where the source of the emissions is not known, "carbon dioxide, unspecified" is the appropriate listing. These distinctions are provided to allow users of the data modules to determine whether to include or exclude certain emissions in greenhouse gas emission calculations. This provides maximum flexibility so the user can comply with IPCC guidelines and (inter)national carbon accounting standards, as well as providing additional information in the overall balancing of the carbon cycle. Unit process data should account for sequestration of carbon as a negative component of the carbon dioxide inventory, which for some products or intermediaries may result in a negative net flux of carbon dioxide to the atmosphere. However if the carbon dioxide is sequestered from the atmosphere it should be labelled “carbon dioxide, biogenic” For example a pine forest would have an input of carbon dioxide, biogenic in the inputs from nature. Where there is multi-output processes containing biogenic carbon inputs, The apportioning of biogenic CO_2 sequestration should be based on carbon mass distribution in each of the co-products. This will allow carbon balances to be completed across the life cycle of product systems.

In the case of end-of-life unit process modules, greenhouse gas releases (or expected greenhouse gas releases), including releases in the form of methane, should be accounted for within the appropriate inventory with documentation of the rationale and calculations underlying the estimates of the expected releases.

“Carbon dioxide equivalents” is not allowed as an elementary flow. Greenhouse gases should be disaggregated in the inventory. Estimation techniques for disaggregation of carbon dioxide equivalents (CO_2e) into its contributing gases (where the contributing gases are not available) is left to the discretion of the practitioner.

Documentation Requirement	
Carbon dioxide - source	**Requirement**
Source of carbon – fossil, biogenic, land transformation, unspecified	Required
Carbon monoxide	Required
Methane	Required

Evidence for reviewer	Requirement
The source of carbon dioxide, carbon monoxide, and methane noted	Required
Are biogenic carbon flows included	Required

2.4.9 Requirement for recording water flows

Inventories should include a water balance of all incoming and outgoing water sources. This includes elementary flows and technical water flows, condensation and evaporation. Where information is available extractions from the environment should include catchment name and country data. In the future GIS references are likely to be included, but the final form of this is not ready for implementation at the time of this publication.

Change in water yield due to land use changes, so called "green water", should be dealt with via land use documentation. If such a flow is recorded in the inventory, it should be clearly labelled as catchment yield variation and not listed as unspecified water use. Unit processes which contain water extraction and land use should include GIS specification of the location of the unit process so that site specific impact assessment can be undertaken in the future.

Suggested flow names for water flows (both technical and elementary flows) are shown in Table 3 below.

Flow name	Unit
Inputs from nature	
water, groundwater, non-fossil	m^3
water, groundwater, fossil	m^3
water, groundwater, unspecified	m^3
water, surface, river	m^3
water, surface, lake	m^3
water, surface, rainwater	m^3
water, surface, unspecified	m^3

water, unspecified	m^3
Inputs from technosphere	
Water, reticulated	m^3
Water, recycled, wastewater	m^3
Water, recycled, stormwater	m^3
Water, recycled, process water	m^3
Outputs to nature	
water, release to river	m^3
water, release to groundwater, non-fossil	m^3
water, release to lake	m^3
water, release to estuary	m^3
water, release to ocean	m^3
water, evaporated	m^3
Outputs to technosphere	
Water, to sewerage treatment	m^3
Water, to recycled water treatment	m^3
Water, to reuse	m^3

Documentation Requirement	**Requirement**
Inclusion of where water is derived from or released to.	Required

Evidence for reviewer	**Requirement**
The closing error of the water balance, or explanation for lack of water balance in the inventory.	Required
Are all elementary water flows defined in terms of origin or destination	Required

2.4.10 Time frame for emissions

For waste deposition processes emissions must be considered for at least the first 100 years. Emissions that occur after one hundred years or more should be labelled as long-term using the sub-compartment specification.

Where emissions from process occur over a greater than 10 year period then a description of the timeframe of the emissions should be included in the comment field of the inventory flow. The description may include a decay function for modelling emission release from a decay process. This data may be used in the sensitivity analysis of time aspects within LCA and may assist in incorporating time into life-cycle inventory data at some future point.

Documentation Requirement	Requirement
Where emissions are modelled which are occurring after 100 years or more, they should be labelled as long-term in the sub-compartment specification.	Optional

Evidence for reviewer	Requirement
If landfill or other long-term emissions are present; are they labelled correctly in the sub-compartment field.	Optional

2.5 Other Documentation Requirements

Following ISO/TS 14048:2002 the documentation is broken up into four aspects as shown below in Figure 2:

- administrative information,
- modelling and validation,
- process description, and
- the inputs and outputs of processes.

Documentation of the inputs and outputs of processes has been described by and large in the earlier sections of these requirements. This section describes the other three aspects.

At the unit process level, administrative information and modelling and validation may be generic for a group of data sets – being about the who put the data set together and what the modelling assumptions and validation processes where. The process description will be unique for each individual data set.

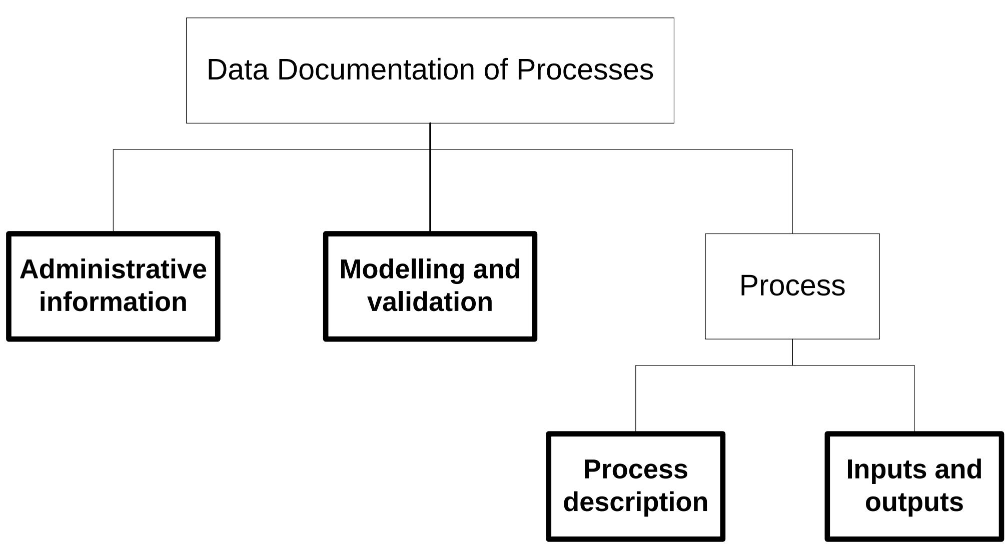


Figure 2 Data documentation of processes (Adapted from ISO/TS 14048:2002)

2.5.1 *Administrative information*

Administrative information includes the name of the person and organisation who developed the LCI unit process data (data generator), and the person and organisation that submitted the data to AusLCI (data entry). Any publication details, completion date and any version number used by the data generator need to be clearly stated.

Documentation Requirement	Requirement
Name of data generator	Required
Name of data entry	Required
Data is published?	Optional
Publication details	Optional
Date completed (for submission to AusLCI)	Required
Version number	Optional

Evidence for reviewer	Requirement
Compulsory fields are completed.	Required

Other fields will be added in this section by AusLCI, giving all datasets a unique unit process identifier in the AusLCI database and an AusLCI version number and publication date.

2.5.2 *Modelling and validation*

The modelling and validation documentation includes a check list for mass and energy balances, efficiency checks and comparisons with analogous processes.

Documentation Requirement	Requirement
Mass balance	Required*
Water balance	Required*
Energy balance	Optional
Stoichiometric balance	Optional
Credible efficiencies	Optional
Comparison with analogous processes	Required

* Mass and water balances are not required for process generating biomass –either food, fibre or forestry as the complexity of balancing growing systems is not warranted given the difficulty of tracking the range of inputs from nature and the relationship of these to mass and water uptake.

2.5.3 Process description

Process names - A process name (a description of the activity) may be different to the product name, which refers to what is produced by the process. For example, the process refinery operation will produce the products petrol, diesel, etc. The process with the name "saw milling, hardwood" may produce "sawn hardwood" and so on.

Process description – A general description of the process.

Geography - short name - A two letter code for countries or three letter code for other groupings. A comment is also possible to describe the geography in more detail including GIS specification.

Valid Time Frame - This field describes the time period during which the unit process is valid, and consists of a beginning date, ending date and a comment if needed.

Technology Level Description - The technology level of a unit process should be recorded where it can be determined. For current supply mixes, current technology should be used. Other options for technology level are worst case technology, out-dated technology, average technology, best available technology and future technology.

Documentation Requirement	**Requirement**
Process name	Required
Process description	Required
Geography – short name	Required
Geography description	Optional
Valid time period start	Optional
Valid time period end	Optional
Technology level description	Optional

Evidence for reviewer	**Requirement**
Process description fields have been completed for at least the compulsory elements	Required

3 Review of data

3.1 Technical checks

All datasets submitted for AusLCI publication must first have been subjected to a "Technical Review" conducted by an appropriate independent expert of the dataset provider or owner.

The selection of Technical Reviewer is entirely the responsibility of the dataset provider/owner. ALCAS guidance on the selection of Technical Reviewers is provided in the technical review guidance document.

The following checks and balances should be undertaken on the dataset:

Mass balance – is the mass balance documented, complete and credible for the scope and boundaries of the dataset, both in total – balancing inputs to outputs - but also for chemical species and transformations (stoichiometric balance)?

Energy balance - is the energy balance documented, complete and credible for the scope and boundaries of the dataset, both in total – balancing inputs to outputs - but also for any thermodynamic transformations (energy/work/entropy)? An energy balance is only required for energy processes i.e – a process which supplies energy as one of its products.

Credible efficiencies – for chemical processes (especially organic processes), are the reaction yields credible from the processes? Are the kinetic rates for the process feasible for the reaction conditions?

Analogous process comparison – by comparison with similar analogous processes from other documented studies, do the results appear credible, adjusting for appropriate thermodynamic factors, energy sources, feedstock properties, etc.?

Documentation Requirement	**Requirement**
Mass balance	Required*
Energy balance	Required for energy processes
Credible efficiencies	Required
Analogous process comparison	Required

* Not required for processes generating biomass.

Evidence for reviewer	**Requirement**
Mention of technical checks undertaken in technical review	Required
Result of technical checks included in dataset	Optional

3.2 Critical Review

Review of data for AusLCI has been proposed in two steps:

- Review of the data from a technical standpoint – are the data a fair representation of the process,
- Review of the data for consistency with AusLCI guidelines.

Data sets should therefore be documented sufficiently to allow this review to be undertaken with all calculations, data sources and assumptions in the unit process data being available to the critical review panel and preferably to all data users on publication of the data. Where data cannot be published for confidentiality reasons, it should be made available only to the critical reviewers.

Documentation Requirement	Requirement
Name and organisational details of technical reviewer	Required
Report from technical review	Required

Evidence for reviewer	Requirement
Technical reviewer name and contact details listed in data set	Required
Technical review statement present	Required
Technical review report present	Optional

4 References

ABARE (2010). Australian Land Use and Management Classification Version 7 Canberra, © Australian Government

International Organization for Standardization (2006). International Standard, ISO/DIS14040, Environmental Management Standard- Life Cycle Assessment, Principles and Framework. Switzerland.

International Organization for Standardization (2006). International Standard, ISO/DIS14044, Environmental Management Standard- Life Cycle Assessment, Requirements and Guidelines. Switzerland.

International Standards Organisation (2001). ISO 14048 - Environmental Management Technical Specification- Life Cycle Assessment - Data Documentation. Sydney., Australian Standards - Published as TS 14048: 2001.

Weidema, B. P., C. Bauer, et al. (2012). Overview and methodology. Data quality guideline for the ecoinvent database version 3. Ecoinvent Report 1(v3). St. Gallen, The ecoinvent Centre.

List of Acronyms

ABS – Australian Bureau of statistics

BPIC – Building product Innovation Council

BSL - U.S. Bureau of Labor Statistics

EIA – Energy Information Administration

EPA – Environmental Protection Authority

ILCD - International Reference Life Cycle Data System

ISO – International Organization for Standardization

LCI – Life Cycle Inventory

LCA - Life Cycle Assessment

LCIA - Life Cycle Impact Assessment

m^2a – square meter * annum

<u>Regions</u>

AU – Australia

NSW – New South Wales

NE NSW – Northeast New South Wales

NG – Nigeria

UCTE - Union for the Co-ordination of Transmission of Electricity (in Continental Europe)

<u>Chemical substances</u>

CO – Carbon Oxide

CO_2 – Carbon Dioxide

NO_x – Nitrogen Oxides

VOC – Volatile Organic Compounds

APPENDIX A. **Conversion Factors**

Volume and Mass

VOLUME	cubic inch	milli litres	litres	US fl. oz.	US gallons*	US barrels	cubic feet
cubic inch	1	16.387	0.0164	0.554	$4.329x10^{-3}$	$1.374x10^{-4}$	$5.787x10^{-4}$
milli litres	0.0610	1	0.001	0.03381	$2.642x10^{-4}$	$8.387x10^{-6}$	$3.532x10^{-5}$
litres	61.024	1000	1	33.815	0.264	$8.387x10^{-3}$	0.0353
US fl. oz.	1.805	29.573	0.0296	1	$7.812x10^{-3}$	$2.48x10^{-4}$	$1.044x10^{-3}$
US gallons*	231	3785	3.785	128	1	0.0317	0.134
US barrels	7276.5	$1.192x10^{5}$	119.237	4032.0	31.5	1	4.21
cubic feet	1728	$2.832x10^{4}$	28.316	957.568	7.481	0.2374	1

MASS	grams	kilograms	Ounces	pounds	grains	tons	milligrams
grams	1	0.001	$3.527x10^{-2}$	$2.205x10^{-3}$	15.432	$1.102x10^{-6}$	1000
kilograms	1000	1	35.274	2.205	15432	$1.102x10^{-3}$	$1x10^{6}$
ounces	28.350	0.28	1	0.0625	437.5	$3.125x10^{-5}$	$2.835x10^{4}$
pounds	453.59	0.453	16.0	1	7000	$5.0x10^{-4}$	$4.536x10^{5}$
grains	0.065	$6.480x10^{-5}$	$2.286x10^{-3}$	$1.429x10^{-4}$	1	$7.142x10^{-8}$	64.799
tons	$9.072x10^{5}$	907.19	$3.200x10^{4}$	2000	$1.4x10^{7}$	1	$9.072x10^{8}$
milligrams	0.001	$1x10^{-4}$	$3.527x10^{-5}$	$2.205x10^{-6}$	0.0154	$1.102x10^{-9}$	1

***NOTE:** Australian gallon = 0.80 Imperial gallons (Source: Australian National Technical Information Services)

Other units

To convert from	to	multiply by
Grams / cu ft	Milligrams / litre	35.315
Pounds / 1000 cu ft	Milligrams / litre	16.018
Barrels Imp (petroleum)	litres	158.98
Btu's	joules	1054
Cubic yards	litres	764.534
Feet	meters	0.305
Gallons (British)	litres	4.546
Gallons (U. S.)	litres	3.785
Inches (in)	meters	0.025
Kilowatt - hours (kWh)	Mega joules	3.6
Miles (statute)	kilometres	1.609
Ounces (avdp)	kilograms	0.028
Pounds	kilograms	0.454
Square feet	square meters	0.093
Tons (short)	kilograms	907.185
Watts	joules / sec	1
Yards	meters	0.914
Pounds	metric ton	0.0004
Acres	hectares	0.405
Square miles	hectares	259
Cubic feet (ft^3)	cubic meters (m^3)	0.028
Cubic inches (in^3)	cubic centimetres (cm^3)	16.393
Watt - sec	joule	1
Calories (cal)	joules	4.105
Gram - calorie	joules	4.184
Watt - years	joules	3.15×10^7

Sources: 1. Starr, C. *Energy & Power*. Scientific American , 1971; 2. Handbook of Industrial Energy Analysis.

APPENDIX B. **Land use categories**

Table 1 land use classes used in AusAgLCI

Land use class	Description
Unspecified	
Unspecified, natural (non-use)	
Forest, unspecified	Areas with tree cover >15%.
Forest, primary (non-use)	Forests (tree cover >15%), minimally disturbed by humans, where flora and fauna species abundance is near pristine.
Forest, secondary (non-use)	Areas originally covered with forest or woodlands (tree cover >15%), where vegetation has been removed, forest is re-growing and is no longer in use.
Forest, extensive	Forests (tree cover >15%), with extractive use and associated disturbance like hunting, and selective logging, where timber extraction is followed by re-growth including at least three naturally occurring tree species, with average stand age >30 years and deadwood > 10 cm diameter exceeds 5 times the annual harvest volume.
Forest, intensive	Forests (tree cover >15%), with extractive use, with either even-aged stands or clear-cut patches exceeding 250 m length, or less than three naturally occurring species at planting/seeding, or average stand age <30 years, or deadwood less than 5 times the annual harvest volume.
Wetland, coastal (non-use)	Areas tidally, seasonally or permanently waterlogged with brackish or saline water. Includes costal marshland and mangrove. Excludes coastal land with infrastructure or agriculture.
Wetland, inland (non-use)	Areas partially, seasonally or permanently waterlogged. The water may be stagnant or circulating. Includes inland marshland, swamp forests and peat bogs.
Shrub land, sclerophyllous	Shrub-dominated vegetation. May be used or non-used. Includes also abandoned agricultural areas, not yet under forest cover
Grassland, natural (non-use)	Grassland vegetation with scattered shrubs or trees (e.g., steppe, tundra, savanna).
Grassland, natural, for livestock grazing	Grasslands where wildlife is replaced by grazing livestock.
Arable land, unspecified use	Land suitable for crop production, in unspecified use
Pasture, man made	Arable land used for forage production or livestock grazing.
Pasture, man made, extensive	+ no artificial fertiliser applied, mechanically harvested less than 3 times per year or equivalent livestock grazing

LAND USE CLASS	DESCRIPTION
Pasture, man made, intensive	+ artificial fertiliser applied, or mechanically harvested 3 times or more per year or equivalent livestock grazing
Annual crop	Cultivated areas with crops that occupy the land < 1 year, e.g. cereals, fodder crops, root crops, or vegetables. Includes aromatic, medicinal and culinary plant production and flower and tree nurseries.
Annual crop, non-irrigated	Annual crop production based on natural precipitation (rainfed agriculture).
Annual crop, non-irrigated, extensive	+ Use of fertiliser and pesticides is significantly less than economically optimal.
Annual crop, non-irrigated, intensive	+ Fertiliser and pesticides at or near the economically optimal level.
Annual crop, irrigated	Annual crops irrigated permanently or periodically. Most of these crops could not be cultivated without an artificial water supply. Does not include sporadically irrigated land.
Annual crop, irrigated, extensive	+ Use of fertilizer and pesticides is significantly less than economically optimal.
Annual crop, irrigated, intensive	+ Fertiliser and pesticides at or near the economically optimal level.
Annual crop, flooded crop	Areas for rice cultivation. Flat surfaces with irrigation channels. Surfaces regularly flooded.
Annual crop, greenhouse	Crop production under plastic or glass.
Field margin/hedgerow	Land between fields with natural vegetation.
Heterogeneous, agricultural	Agricultural production intercropped with (native) trees.
Permanent crop	Perennial crops not under a rotation system which provide repeated harvests and occupy the land for >1 year before it is ploughed and replanted; mainly plantations of woody crops.
Permanent crop, non-irrigated	Perennial crops production based on natural precipitation (rainfed agriculture).
Permanent crop, non-irrigated, extensive	+ Use of fertilizer and pesticides is less than economically optimal.
Permanent crop, non-irrigated, intensive	+ Fertiliser and pesticides at economically optimal level.
Permanent crop, irrigated	Perennial crops irrigated permanently or periodically. Most of these crops could not be cultivated without an artificial water supply. Does not include sporadically irrigated land.
Permanent crop, irrigated, extensive	+ Use of fertilizer and pesticides is significantly less than economically optimal.
Permanent crop, irrigated, intensive-	+ Fertiliser and pesticides at or near the economically optimal level.

LAND USE CLASS	DESCRIPTION
Cropland fallow (non-use)	Cropland, temporarily not in use (<2 years).
Urban/industrial fallow (non-use)	Areas with remains of industrial buildings; deposits of rubble, gravel, sand and industrial waste. Can be vegetated.
Urban, continuously built	Buildings cover most of the area. Roads and artificially surfaced area cover almost all the ground. Non-linear areas of vegetation and bare soil are exceptional. At least 80% of the total area is sealed.
Urban, discontinuously built	Most of the area is covered by structures. Buildings, roads and artificially surfaced areas, associated with areas with vegetation and bare soil, which occupy discontinuous but signifi- cant surfaces. Less than 80% of the total area is sealed.
Urban, green area	Areas with vegetation within urban fabric. Includes parks with vegetation.
Industrial area	Artificially surfaced areas (with concrete, asphalt, or stabilized, e.g., beaten earth) devoid of vegetation on most of the area in question, which also contains buildings and/or areas with vegetation.
Mineral extraction site	Areas with open-pit extraction of industrial minerals (sandpits, quarries) or other minerals (opencast mines). Includes flooded gravel quarries, except for riverbed extraction. Landfill or mine dump sites, industrial or public.
Dump site	Landfill or mine dump sites, industrial or public.
Construction site	Areas under construction development, soil or bedrock excavations, earthworks.
Traffic area, road network	Motorways, including associated installations (stations).
Traffic area, rail network	Railways, including associated installations (stations, platforms).
Traffic area, rail/road embankment	Vegetated land along motorways and railways.
Bare area (non-use)	Areas permanently without vegetation (e.g., deserts, high alpine areas).
Snow and ice (non-use)	Areas permanently covered with snow or ice considered as undisturbed areas.
Inland waterbody, unspecified	Freshwater bodies.
River, natural (non-use)	Natural watercourses.
Lake, natural (non-use)	Natural stretches of water.
River, artificial	Artificial watercourses serving as water drainage channels. Includes canals.
Lake, artificial	Reservoir in a valley because of damming up river.
Seabed, unspecified	Area permanently under seawater.
Seabed, natural (non-use)	Natural seabed.
Seabed, bottom fishing	Seabed disturbed by bottom trawling or fishing dredge

LAND USE CLASS	DESCRIPTION
Seabed, sediment displacement	Seabed disturbed by dumping or shellfish- or sediment-dredging
Seabed, infrastructure	Seabed disturbed by infrastructure like harbours or platforms
Seabed, drilling and mining	Seabed disturbed by drilling and mining, including cuttings and tailings disposal

APPENDIX C. **Uncertainty estimation approach from ecoinvent**

Quite often the uncertainty for the amount of a specific input or output cannot be derived from the available information, since there is only one source of information providing only a mean value, without any information about the uncertainty of this value. A simplified standard procedure has been developed to quantify the uncertainty for these (quite numerous) cases.

The simplified approach includes a qualitative assessment of data quality indicators based on a pedigree matrix.

Basic uncertainty factors are used for the kind of input and output considered. It is assumed that for instance CO_2 emissions show in general a much lower uncertainty as compared to CO emissions. While the former can be calculated from fuel input, the latter is much more dependent on boiler characteristics, engine maintenance, load factors etc. For a number of common inputs and outputs basic uncertainty factors have been developed based on expert judgments (shown in Table D.1).

Table D.1 3. Default basic uncertainty (variance σ_b^2 of the logtransformed data, i.e. the underlying normal distribution) applied to intermediate and elementary exchanges when no sampled data are available; c: combustion emissions; p: process emissions; a: agricultural emissions (Source: Weidema et al 2012)

input / output group	c	p	a
demand of:			
thermal energy, electricity, semi-finished products, working material, waste treatment services	0.0006	0.0006	0.0006
transport services (tkm)	0.12	0.12	0.12
Infrastructure	0.3	0.3	0.3
resources:			
Primary energy carriers, metals, salts	0.0006	0.0006	0.0006
Land use, occupation	0.04	0.04	0.002
Land use, transformation	0.12	0.12	0.008
pollutants emitted to water:			
BOD, COD, DOC, TOC, inorganic compounds (NH_4, PO_4, NO_3, Cl, Na etc.)		0.04	
Individual hydrocarbons, PAH		0.3	
Heavy metals		0.65	0.09
Pesticides			0.04
NO_3, PO_4			0.04
pollutants emitted to soil:			
Oil, hydrocarbon total		0.04	
Heavy metals		0.04	0.04
Pesticides			0.033

input / output group	c	p	a
pollutants emitted to air:			
CO_2	0.0006	0.0006	
SO_2	0.0006		
NMVOC total	0.04		
NO_X, N_2O	0.04		0.03
CH_4, NH_3	0.04		0.008
Individual hydrocarbons	0.04	0.12	
PM>10	0.04	0.04	
PM10	0.12	0.12	
PM2.5	0.3	0.3	
Polycyclic aromatic hydrocarbons (PAH)	0.3		
CO, heavy metals	0.65		
Inorganic emissions, others		0.04	
Radionuclides (e.g., Radon-222)		0.3	

Data sources are then assessed according to the five characteristics "reliability", "completeness", "temporal correlation", "geographic correlation" and "further technological correlation" (see Table D.2). Each characteristic is divided into five quality levels with a score between 1 and 5. Accordingly, a set of five indicator scores is attributed to each individual input and output flow (except reference product) reported in a data source. An uncertainty factor (expressed as a contribution to the square of the geometric standard deviation) is attributed to each of the score of the five characteristics. These uncertainty factors are also based on expert judgments and are shown in Table D3.

The square of the geometric standard deviation (95% interval – SDg95) is then calculated with the following formula:

$$\sigma^2(X+Y)=\sigma^2(X)+\sigma^2(Y)+2\operatorname{cov}(X,Y)$$

$$\sigma^2=\sum_{n=1}^{6}\sigma_n^2$$

With:

U_1 basic uncertainty factor

U_2 uncertainty factor of reliability

U_3 uncertainty factor of completeness

U_4 uncertainty factor of temporal correlation

U_5 uncertainty factor of geographical correlation

U_6 uncertainty factor of technological correlation

Table D.2 Pedigree matrix used to assess the quality of data sources, derived from (Weidema1998)

Indicator score	1	2	3	4	5 (default)
Reliability	Verified[3] data based on measurements[4]	Verified data partly based on assumptions *or* non-verified data based on measurements	Non-verified data partly based on qualified estimates	Qualified estimate (e.g. by industrial expert)	Non-qualified estimate
Completeness	Representative data from all sites relevant for the market considered, over an adequate period to even out normal fluctuations	Representative data from >50% of the sites relevant for the market considered, over an adequate period to even out normal fluctuations	Representative data from only some sites (<<50%) relevant for the market considered *or* >50% of sites but from shorter periods	Representative data from only one site relevant for the market considered *or* some sites but from shorter periods	Representativeness unknown or data from a small number of sites ***and*** from shorter periods
Temporal correlation	Less than 3 years of difference to the time period of the dataset	Less than 6 years of difference to the time period of the dataset	Less than 10 years of difference to the time period of the dataset	Less than 15 years of difference to the time period of the dataset	Age of data unknown or more than 15 years of difference to the time period of the dataset
Geographical correlation	Data from area under study	Average data from larger area in which the area under study is included	Data from area with similar production conditions	Data from area with slightly similar production conditions	Data from unknown *or* distinctly different area (North America instead of Middle East, OECD-Europe instead of Russia)
Further technological correlation	Data from enterprises, processes and materials under study	Data from processes and materials under study (i.e. identical technology) but from different enterprises	Data from processes and materials under study but from different technology	Data on related processes or materials	Data on related processes on laboratory scale *or* from different technology

Table D.3 Default uncertainty factors (contributing to the square of the geometric standard deviation) applied together with the pedigree matrix (Source: Swiss Centre for Life Cycle Inventories, 2010)

Indicator score	1	2	3	4	5
Reliability	1.00	1.05	1.10	1.20	1.50
Completeness	1.00	1.02	1.05	1.10	1.20
Temporal correlation	1.00	1.03	1.10	1.20	1.50
Geographical correlation	1.00	1.01	1.02	1.05	1.10
Further technological correlation	1.00	1.05	1.20	1.50	2.00

Limitations of the uncertainty assessment

The approach for the assessment of uncertainties does not take into account the following factors which determine also the overall uncertainty for the life cycle inventory of a unit process:

- Missing information in the inventory table.
- Inappropriate modelling for the necessary inputs and outputs, e.g. demand for a similar but not exactly right product or service (e.g. consumption of 1kWh "electricity, medium voltage, NG (Nigeria)" approximated with 1kWh "electricity, medium voltage, UCTE").
- Mistakes imposed by human errors, i.e. human errors included in the information source used or errors made by the analyst during modelling.

APPENDIX D. Examples and further explanation of recycling allocation.

Figure 3 shows an example of the processes included in the production of a secondary material where the scrap has either zero or positive value at the point of generation.

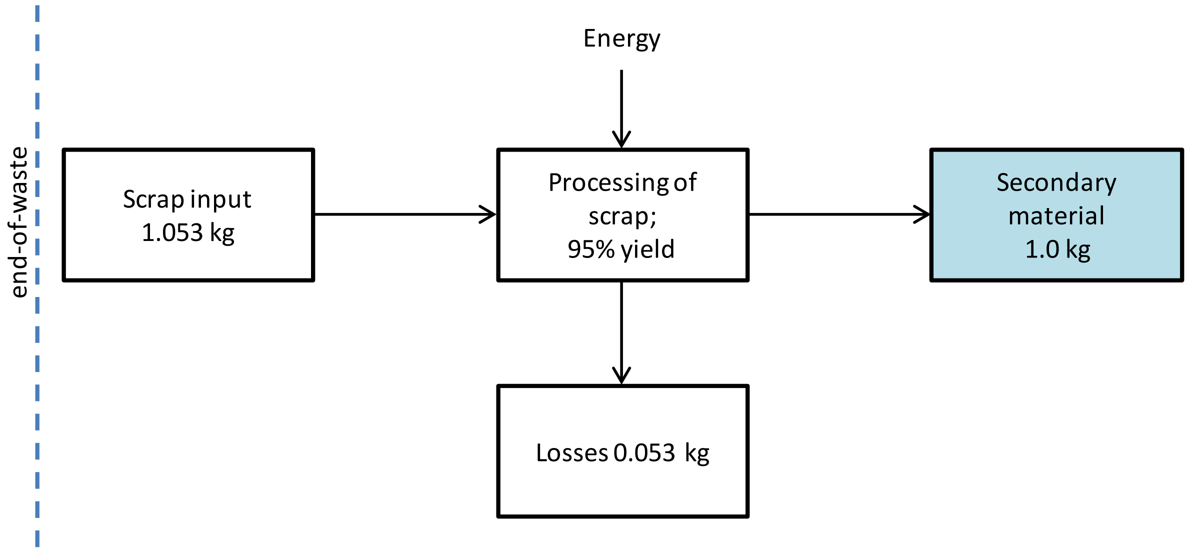
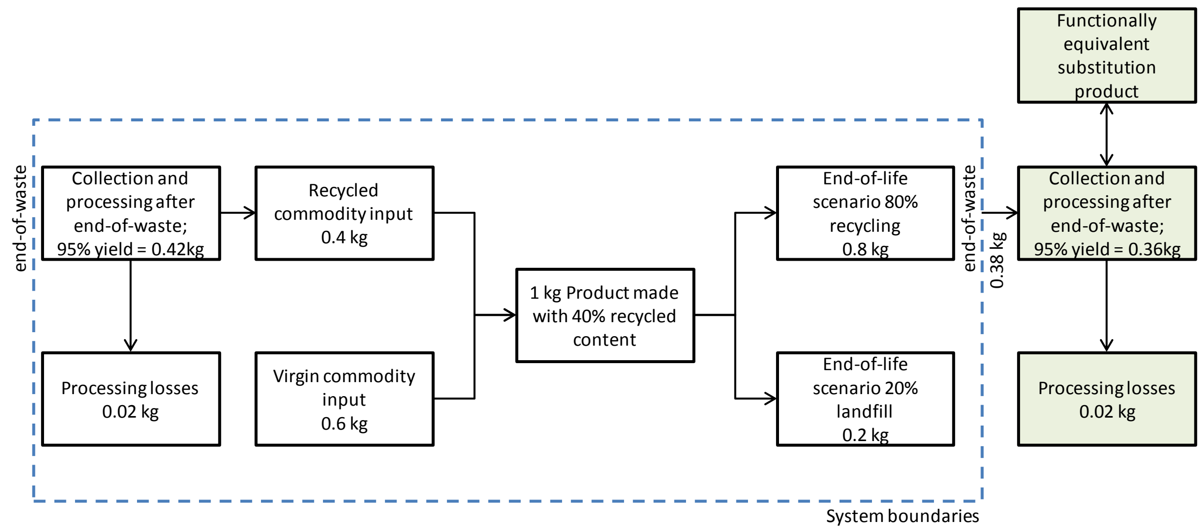


Figure 3 Example of processes to be included when entering a secondary material into AusLCI

Figure 4 shows an example of a product where collection and transport of scrap occurs at the beginning of the life cycle (after the material reaches end-of-waste status). The example shows a net outflow of recycled material, i.e. more scrap material is recovered at the end-of-life than was used to produce the product.

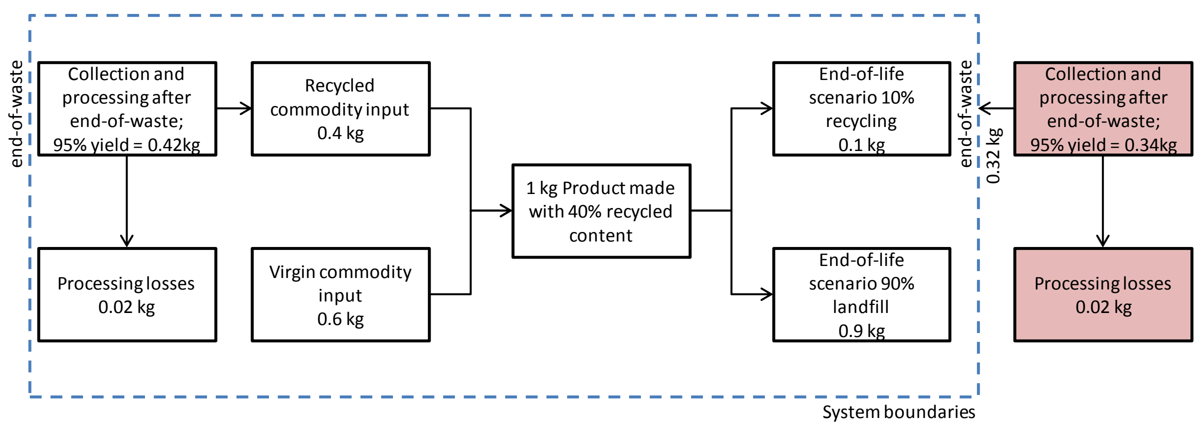


Recycled input	Recycled output	Net impacts
0.42 kg	0.8 kg	0.38 kg net output

Potential benefits reported in Module D

Figure 4 Example of recycling allocation principles; product system with net output of scrap

Figure 5 shows a net inflow of recycled material, i.e. less scrap material is recovered at the end-of-life than was used to produce the product. Less recycling at end of life can thus lead to a debit, in which case the net impact is reported in module D as per EN15804.



Recycled input	Recycled output	Net impacts
0.42 kg	0.1 kg	0.32 kg net input

Potential impacts reported in Module D

Figure 5 Example of recycling allocation principles; product system with net input of scrap

Figure 6 shows a net outflow recycled material with and lower value than the input scrap used. The collection and processing at end of life is based on the net output. The avoided product is calculated from the net scrap recycled multiplied by the efficiency loss multiplied by the value correction factor.

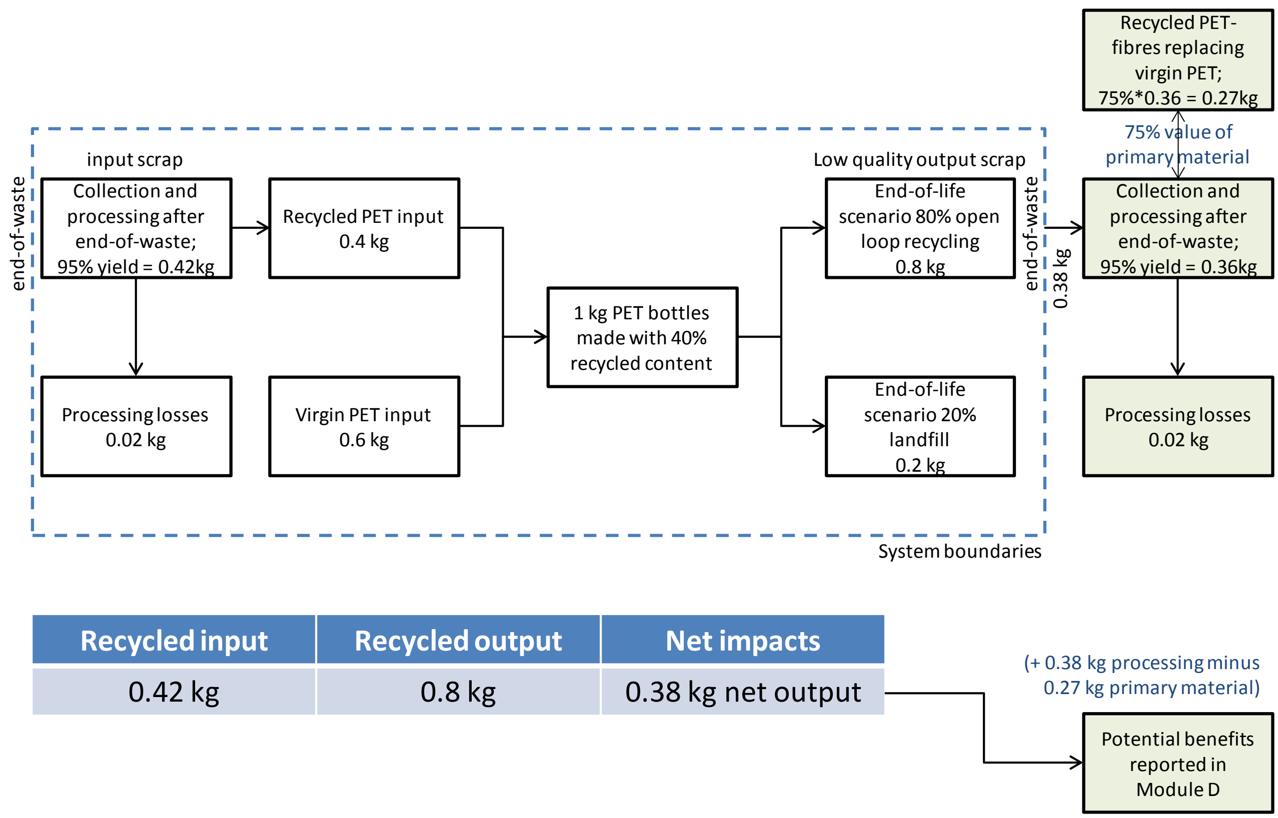


Figure 6 Example of recycling allocation principles; product system with net output of scrap but of a lower quality of the input.

Figure 7 shows a net inflow recycled material with and lower value than the input scrap used. , i.e. less scrap material is recovered at the end-of-life than was used to produce the product. Less recycling at end of life can thus lead to a debit, in which case the net impact is reported in module D as per EN15804.

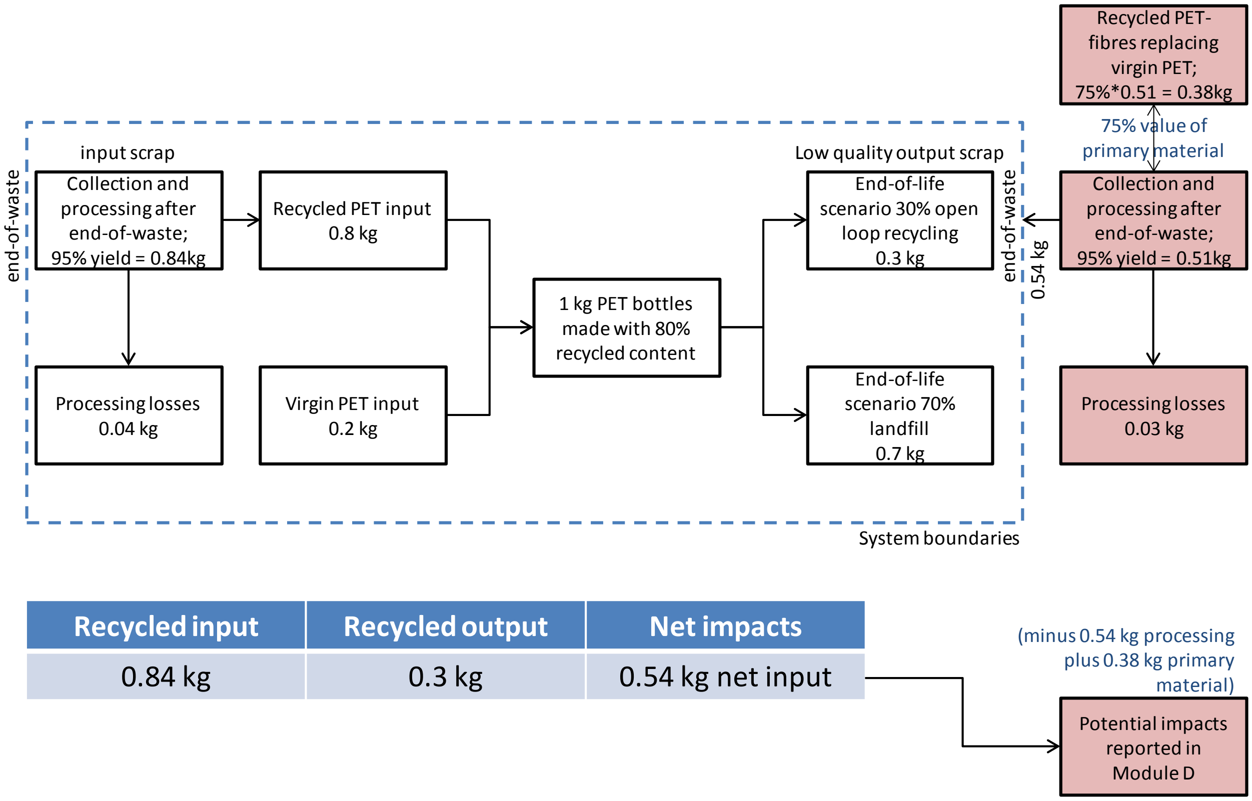


Figure 7 Example of recycling allocation principles; product system with net output of scrap but of a lower quality of the input.

APPENDIX E. **AusLCI database management**

The AusLCI database will be managed by the AusLCI database committee. Management of the database consists of the following tasks:

- Approval of data sets for inclusion in AusLCI
- Approval of data compliance reviewers who can review AusLCI data sets
- The connection of data sets to upstream and downstream processes
- The ultimate definition of technical and elementary nomenclatures
- The publishing of AusLCI datasets to the web.

Connection of data to upstream processes

If data are available for upstream processes, materials, products or services imported from overseas, and the import region is known and data of suitable quality are available, that is if they are of similar or acceptable quality to AusLCI and can be made to comply with the requirements of AusLCI, then these will be used with appropriate citations.

In cases where region-appropriate LCI data for non-domestic processes are unavailable from both primary and secondary sources, the supply chain will be modelled using the most appropriate data set from Australia or overseas based on:

- The technology match
- The quality of the data set
- The transparency and disaggregation of the dataset enabling adaptation to the relevant region.

These data will then be adapted where possible to make the data mimic the region of origin. Adaptation could consist of, for example, adjusting transportation distances and modes, electricity generation fuel mixes or calorific value and emission profile of solid fuel resources. Where such adaptations are undertaken it should be made clear that the inventories are based on Australian production data and are not actual inventories for imported products.

Where the country or region of the import is known, then the adaptation should be made to that region using the best matching LCI data. At a minimum, the electricity grid mix should be corrected based on Public databases or taken from the International Energy Agency Data and importation impacts should be included.

Where the region is not known, but the commodity's dominant region(s) of production in the world is known, then this region(s) should be used for adjusting the data set.

Where the region of origin is not known and the product is produced globally, then a global adaption should be undertaken using average global energy data and technology description.

The transformation of the data set should be documented and the name of the data set should reflect the region it is representing and that it is adapted data. The pedigree matrix which is used for uncertainty estimation should have its geography score adjusted to reflect the uncertainty in the geographical match.

Where local production exceeds 75% of supply the modelling of overseas production is not required, however it should be noted in the inventory what percentage of the Australian market is covered by the inventory being modelled.

Transportation, including resource depletion and associated waste and emissions, will be included for imports based on the actual location of production, hauling distances, and typical modes of transportation. Inventories for domestic production should be modelled separately from imported product inventories.

APPENDIX F. **Draft schedule of Indicative AusLCI fees**

The complexity of a data set will vary so the time need for each process will need to be adjusted. This will be based on the discretion of the reviewer.

Item	Fee	Explanation
AusLCI compliance review	$150 per data set, Minimum $250 payment.	Based on two hours for a dataset. Discounts can be negotiated for multiple data sets, especially where they have common content.
Format conversion from BPIC or other format.	$225 per dataset	Based on 3 hours per data set
Cradle to gate calculation and contribution analysis	300 per data set	Based on four hours. Discounts can be negotiated for multiple data sets, especially where they have common content.

International Organization for Standardization (2006). International Standard, ISO/DIS14040, Environmental Management Standard- Life Cycle Assessment, Principles and Framework. Switzerland.

International Organization for Standardization (2006). International Standard, ISO/DIS14044, Environmental Management Standard- Life Cycle Assessment, Requirements and Guidelines. Switzerland.

International Standards Organisation (2001). ISO 14048 - Environmental Management Technical Specification- Life Cycle Assessment - Data Documentation. Sydney., Australian Standards - Published as TS 14048: 2001.

Weidema, B. P., C. Bauer, et al. (2012). Overview and methodology. Data quality guideline for the ecoinvent database version 3. Ecoinvent Report 1(v3). St. Gallen, The ecoinvent Centre.