

REVIEW TEMPLATE

LCI Review report (reviewed against "ILCD Data Network - entry-level requirements" and PEF data quality requirements)

Table 1: General review reporting items

REVIEW REPORTING**General information**

Data set name	Cobalt, refined (metal)
Data set UUID and version number	071d5149-b91b-4f4d-b245-ad620f51e795
Data set locator (e.g. Permanent URI, URL, contact point, or database name and version, etc.)	
Report (e.g. report name, report version, report date)	
Data set owner	Cobalt Development Institute - CDI
Review commissioner(s)	Cobalt Development Institute - CDI
Reviewer name(s) and affiliation(s), contact	Alessandra Zamagni, Ecoinnovazione srl spin-off ENEA a.zamagni@ecoinnovazione.it mob. 0039 3387531665
Review type applied	Independent external review
Date of review completion (DD/MM/YYYY)	04/08/2016
Reviewed against / Compliance system name	ILCD Data Network - Entry-level requirements PEF - Secondary data requirements

Reviewer assessment:

Aspect	Yes	No	Comments
Quality compliance (aspects of ISO 14040 & 14044 and PEF) fulfilled	X		The data used are consistent, appropriate and reasonable in view of the goal and scope of the study. A cut-off has been applied to lubricating oil, waste oil recycling, final neutralization and management of waste effluents, capital goods and infrastructure, packaging and workforce burden. This is within the 5 %. The representativeness of the dataset (time-related, geographical, technology) is well documented; the precision is not evaluated at statistical level but according to the information provided, it is considered good (between 10% and 20%); land use and water depletion are not covered consistently in the dataset; Carbon storage and delayed emissions are not part of the scope of the datasets; off-setting is

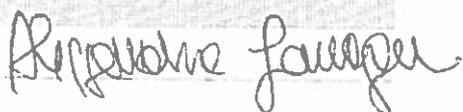
		not included; Land use and land use change is not included within the scope of the dataset, and related data have not been included; capital goods are not included in the foreground processes; Fossil and biogenic carbon emissions and removals are modelled consistently with the ILCD of elementary flows; the biogenic emissions are modelled separately; the same characterization factor for methane biogenic and fossil has been adopted. The DQR score according to PEF criteria is 2.5, with an overall quality "good".
Method compliance (as in ISO 14040 & 14044) fulfilled and documented in data set	X	The dataset complies with the requirements of the ISO standard 14040 and 14044. Goal and scope, functional unit and system boundaries are well defined, described and suitable for the intended use. Cut-off rules and allocation procedures are justified and explained; the applied LCI methods are in line with the goal and scope of the dataset, its intended applications and decision support context. The method has been consistently applied along the whole dataset. Regarding ISO 14040 and 14044, the data set is part of a critically reviewed LCA of refined cobalt. As far as PEF is concerned, the methods used are scientifically and technically valid, based on scientific and technical judgment of the reviewer.
Nomenclature compliance fulfilled	X	
Documentation compliance fulfilled	X	
Review compliance (Independent external review OR independent internal review + review report) fulfilled	X	Independent external review
Overall compliance with ISO 14040 & 14044 and PEF	X	
Overall compliance with "Compliance system"	X	ILCD entry level and PEF requirements fulfilled
Date, location, reviewer signature	Padova, August 14 th , 2016	

Table 2: Specific/detailed review reporting items for LCI data sets. Quality compliance (ISO 14040 & 14044). Please note that for the aggregated LCI result data sets, this includes key process in the background system.

ITEMs	Comments
Time-related coverage/representativeness: "age of data and the minimum length of time over which data should be collected" "qualitative assessment of the degree to which the data set reflects the true population of interest"	The reference year of the dataset is clearly documented (2012), as well as its validity (2020). For the foreground processes, the data have been collected for the 2012 or the nearest 12 month period for which data were available, and they are considered stable, i.e. no major disruptions to operations or technology change happened during the data collection period. Regarding the background, data were taken from ecoinvent v 3.1, representing as much as possible the 2012 situation. However, also older data were used, when there were no better data available.

<p>Geographical coverage/representativeness:</p> <p>“geographical area from which data for unit processes should be collected to satisfy the goal of the study”</p> <p>“qualitative assessment of the degree to which the data set reflects the true population of interest”</p>	<p>Good</p> <p>The dataset has a global geographic scope, covering ores mined in Democratic Republic of Congo, Canada, Cuba, and New Caledonia. Regarding the cobalt refining, the dataset covers Belgium, Canada, Finland, Japan, Norway, the Philippines and Zambia. The production of cobalt from Russia and China is not included.</p> <p>The used electricity grid mixes are country-specific or, in the case of Canada, region-specific. Upstream data are based either on global averages or European average information.</p>
<p>Technology coverage/representativeness:</p> <p>“specific technology or technology mix”</p> <p>“qualitative assessment of the degree to which the data set reflects the true population of interest”</p>	<p>Fair.</p> <p>The dataset covers the main production routes, i.e. from both nickel and copper mining, from which more than the 90% of the cobalt is produced. The production route from primary cobalt extraction is not included. Regarding the mining, both underground and surface mining are included, while for the processing, both oxidic and sulphidic nickel and oxidic copper ores through pyrometallurgical and hydrometallurgical techniques are included.</p>
<p>Precision:</p> <p>“measure of the variability of the data values for each data expressed (e.g. variance)”</p>	<p>Good.</p> <p>The sample of the dataset covers different technologies, producers and regions, totaling 30% of the world cobalt production. The dataset represents industry average data, calculated as mass-weighted averaging, starting from individual data by company and by facility. Normal operations are covered, together with associated maintenance. No major disruptions to the operations or technology occurred during data collection.</p> <p>This criterion has been assessed not in a statistical sense but adopting an expert judgement approach.</p>
<p>Completeness:</p> <p>“percentage of flow that is measured or estimated”; assessed on level of process</p>	<p>Good.</p> <p>The completeness of the dataset is good, as primary data were collected, and only minor flows and waste treatment processes were not reported. For the secondary datasets fromecoinvent, these are based both on measured and estimated flows, depending on the processes at hand.</p> <p>Cut-off has been applied to lubricating oil, waste oil recycling, final neutralization and management of waste effluents, capital goods and infrastructure, packaging and workforce burden. According to expert judgement, their contribution can be considered negligible, and thus within the allowed 5%.</p>
<p>Consistency:</p> <p>“qualitative assessment of whether the study methodology is applied uniformly to the various components of the analysis”</p>	<p>Good.</p> <p>The methodology is applied consistently along the process of generating the dataset. All the background datasets are from the same database (ecoinvent), and primary data of the same level of detail were collected, cross-checked with literature and verified with data providers.</p>
<p>Sources of the data;</p> <p>Appropriateness of use primary/secondary data source</p>	<p>Very good.</p> <p>The dataset represents industry average data, where primary data are from companies operating in the mining, beneficiation, primary extraction and refining of cobalt. , accounting for 30% of the world refined cobalt production. Secondary data were used for the production of ancillary materials, energy production and residual waste management.</p>

Uncertainty of the information (e.g. data, models and assumptions).	Very good The dataset is based on primary data from all the participating producers, and extensive data checks were conducted to clarify the processes, the data, correct any inconsistencies and fill data gaps. Data were requested at sub-process level and most companies provided this, although not all (some provided aggregated data by at overall process level). Generally the data represent operation during 2012, except for the one mining company where the 2012 data did not represent normal operation. Good
Others	

Table 3: Specific/detailed review reporting items for LCI data set. Nomenclature and Documentation.

ITEMs	Yes	No	Comments
Nomenclature			
Correctness and consistency of applied nomenclature (Preferred use of ILCD flows etc.; Correct nomenclature of other flows; Exclusion of not permissible waste flows, sum indicator elementary flows etc.)	X		The ILCD reference elementary flows, flow property and unit group have been used, and the ILCD nomenclature and terminology. Regarding the background datasets from ecoinvent, the nomenclature has been converted according to ILCD rules when the dataset has been implemented in GaBi, and therefore the dataset is compliant.
Documentation			
Appropriateness of documentation (see Document "Documentation of LCA data sets")	X		The documentation is appropriate and according to the requirements.
Appropriateness / correctness of documentation form (ILCD Format)	X		The ILCD format has been used to document the datasets. The dataset documentation is organized according to the ILCD format.

Table 4: Specific/detailed review reporting items for PEF data set. Methodological requirements.

ITEMs	Yes	No	Comments
Cut-off			
Cut-off rule of 95%, based on material or energy flow or the level of environmental significance, is documented.	X		Cut-off has been applied to lubricating oil, waste oil recycling, final neutralization and management of waste effluents, capital goods and infrastructure, packaging and workforce burden. According to expert judgement, their contribution can be considered negligible, and thus within the allowed 5%.
Handling multi-functional processes			
The multi-functionality decision hierarchy	X		For the foreground processes, mass allocation in the mining was applied, and the economic

for resolving all multi-functionality problems is applied: (1) subdivision or system expansion; (2) allocation based on a relevant underlying physical relationship; (3) allocation based on some other relationship.		allocation in the primary and refining stages, using average market prices across a 10-year period. For non-metallic co-products, system expansion was applied. For the background datasets, the handling of multi-functionality inecoinvent is compliant with the PEF hierarchy, as declared in Masoni et al. (2014).
Direct land use change		
GHG emissions from direct LUC are documented and allocated to goods/service for 20 years after the LUC occurs, with IPCC default values.	X	Land use and land use change is not included within the scope of the dataset, and related data have not been included.
Carbon storage and delayed emissions		
Credits associated with temporary (carbon) storage or delayed emissions are documented not to be considered.	X	Carbon storage and delayed emissions are not part of the scope of the datasets and their non-inclusion is documented.
Emissions off-setting		
Emissions off-setting is not included.	X	Off-setting emissions are not included.
Capital goods (incl infrastructure) and their end of life		
Capital goods are included, unless documented to be excluded based on the 95% cut-off rule.	X	Capital goods are not included in the foreground processes, while they are accounted for in the secondary datasets. However, the exclusion is considered to be within the allowed 5% cut-off rule.
System boundaries		
System boundaries include all processes linked to the product supply chain	X	System boundaries are consistently defined, and are from cradle-to-gate, covering the following stages: mining and overburden management, ore beneficiation/concentration, primary extraction, refining, transport of materials, production and transport of ancillary materials, water extraction and production, power production, tailing management and waste water treatment, management of production of waste. The background datasets have system boundaries that are defined in compliance with PEF requirements (Masoni et al., 2014).
Fossil and biogenic carbon emissions and removals		
The PEF requirements to carbon emissions and removals modelling are followed.	X	Fossil and biogenic carbon emissions and removals are modelled consistently with the ILCD of elementary flows; the biogenic emissions are modelled separately; the same characterization factor for methane biogenic and fossil has been adopted

Table 5: Specific/detailed review reporting items for PEF data set. Data quality requirements and scores.

ITEMs	Comments	Score
Data quality	DQR declared by the dataset provider	2.3
Dataset quality calculated based on the PEF six quality criteria:		
- Time-related representativeness	The reference year of the dataset is clearly documented (2012), as well as its validity (2020). For the foreground processes, the data have been collected for the 2012 or the nearest 12 month period for which data were available, and they are considered stable, i.e. no major disruptions to operations or technology change happened during the data collection period. Regarding the background, data were taken fromecoinvent v 3.1, representing as much as possible the 2012 situation. However, also older data were used, when there were no better data available.	2
- Geographical representativeness	The dataset has a global geographic scope, covering ores mined in Democratic Republic of Congo, Canada, Cuba, and New Caledonia. Regarding the cobalt refining, the dataset covers Belgium, Canada, Finland, Japan, Norway, the Philippines and Zambia. The production of cobalt from Russia and China is not included. The used electricity grid mixes are country-specific or, in the case of Canada, region-specific. Upstream data are based either on global averages or European average information.	3
- Technology representativeness	The dataset covers the main production routes, i.e. from both nickel and copper mining, from which more than the 90% of the cobalt is produced. The production route from primary cobalt extraction is not included. Regarding the mining, both underground and surface mining are included, while for the processing, both oxidic and sulphidic nickel and oxidic copper ores through pyrometallurgical and hydrometallurgical techniques are included.	2
- Completeness	Land use and water depletion are not consistently covered, during to uncertainty related to data collection and to the maturity of the environmental impact category. They are thus not within the scope of the dataset.	3
- Precision/uncertainty	The dataset is based on primary data from all the participating producers, and extensive data checks were conducted to clarify the processes, the data, correct any inconsistencies and fill data gaps. Data were requested at sub-process level and most companies provided this, although not all. Generally the data represent operation during 2012, except for the one mining company where the 2012 data did not represent normal operation. The sample of the dataset covers different technologies, producers and regions, totaling 30% of the world cobalt production. The dataset represents industry average data, calculated as mass-weighted averaging, starting from individual data by company and by facility. Normal operations are covered, together with associated maintenance. No major disruptions to the operations or technology occurred during data collection.	2

- End of Life (EoL)	Scrap use in the dataset falls below cut-off criteria. All secondary data for background processes are from ecoinvent v 3.1 as implemented in the GaBi LCA software, in which the EoL formula can be applied, but it is not applied yet.	3
DQR of the dataset evaluated by the reviewer		2.5