EN15804 add-on

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the EN15804 add-on for ecoinvent by GreenDelta

openLCA

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GreenDelta

Content

1 The EN15804 add-on – the database for EPDs in the construction sector

EN15804 is a European Norm about Environmental Product Declarations (EPDs) for construction, the long name being “Sustainability of construction works -Environmental product declarations - Core rules for the product category of construction products”. The norm specifies core aspects for EPDs, including product category rules, the content of an EPD, and also indicators to be contained in an EPD.

EPDs are basically Life Cycle Assessments (LCAs) that follow specific rules, as described in general in ISO 14025 and (for construction products) EN15804, and of course more specifically in product category rules, PCRs, for different product groups. These rules make EPDs align their goal and scope, which makes EPD results easier to compare, and more consistent across different products and studies.

Since EPDs are in the end LCA models, however, they can of course use generic LCA background databases. Evidently, these databases need to be in line with the rules of the EPD. For EPDs according to EN 15804, the database must focus on the product life cycle and not consider more than one life cycle, thus ignoring impacts caused by production of recyclates in a first life cycle, and, further, ignoring benefits achieved from recyclates produced in the considered life cycle. Second, the database needs to support the indicators specified in EN15804.

The first requirement, a database that is focussed on the product life cycle, is met by the ecoinvent cut-off system model. For the second requirement, some of the required indicators are not commonly calculated and thus supported by LCA databases and also not by the ecoinvent cut-off model[1]. This “EN15804 add-on for ecoinvent by GreenDelta”, in short “EN15804 add-on” is created to provide this support.

2 Indicators required by EN15804

According to EN15804 A2, indicators listed in **Table 1** must be contained in an EPD, in total and for each of the declared life cycle stages (modules) separately[2].

[1] https://ecoinvent.org/the-ecoinvent-database/system-models/#!/allocation-cut-off

[2] “These core environmental impact indicators shall be included in each module declared in the EPD.“ EN15804, 7.2.3.1; “[...] indicators describing resource use which shall be included in each module declared in the EPD.“ EN15804, 7.2.4.2; “[...] indicators describing waste categories [...]. They shall be included in each module declared in the EPD.“ EN15804, 7.2.4.3;

Table 1: Mandatory indicators following EN15804 A2

	Mandatory indicators#	Units
	Core environmental impact indicators (EN15804, 7.2.3.1)	
	EI acidification	mol H+ eq.
	EI climate change, GWP biogenic	kg CO2 eq.
	EI climate change, GWP fossil	kg CO2 eq.
	EI climate change, GWP land transformation	kg CO2 eq.
	EI climate change, GWP total	kg CO2 eq.
	EI depletion of abiotic resources - ADPE elements	kg Sb eq.
	EI depletion of abiotic resources - ADPF fossil fuels	MJ, net calorific value
	EI eutrophication, freshwater	kg PO4 eq.
	EI eutrophication, marine	kg N eq.
	EI eutrophication, terrestrial	mol N eq.
	EI ozone depletion	kg CFC 11 eq.
	EI photochemical ozone formation	kg NMVOC eq.
	EI water use, AWARE	m3 world eq. deprived
	Output flows (EN15804, 7.2.3.1)	
	output flows - components for reuse	kg
	output flows - exported energy	kg
	output flows - materials for energy recovery	kg
	output flows - materials for recycling	MJ per energy carrier
	Resources (EN15804, 7.2.4.2)	
	resources - energy, non-renewable - PENRT	MJ, net calorific value
	resources – energy, non-renewable, use as raw materials - PENRM	MJ, net calorific value
	resources - energy, non-renewable, use as energy - PENRE	MJ, net calorific value
	resources - energy, renewable - PERT	MJ, net calorific value
	resources - energy, renewable - PERM, use as raw material	MJ, net calorific value
	resources - energy, renewable - PERE, use as energy	MJ, net calorific value
	resources - net use of fresh water - FW	m^3
	resources - use of secondary materials - SM	kg
	resources -use of non-renewable secondary fuels - NRSF	MJ, net calorific value
	resources -use of renewable secondary fuels - RSF	MJ, net calorific value
	Waste (EN15804, 7.2.4.4)	
	waste - hazardous, disposed - HW	kg
	waste - non-hazardous, disposed -NHW	kg
	waste - radioactive, disposed - RW	kg

name of the indicator corresponds to the name in openLCA which is sometimes shortened compared to the name used in EN15804 – for example, for
‘resources - energy, non-renewable, use as energy – PENRE’
the official name is
‘Use of renewable primary energy excluding renewable primary energy resources used as raw materials’

The core "environmental" indicators are common LCIA indicators which are used also in LCAs, and are easily supported by modern LCA databases, such as ecoinvent. EN 15804 proposes additional environmental indicators that are not mandatory, see **Table 2**. These follow the usual LCA calculation as well, and are also supported by the ecoinvent database.

Table 2: Optional ("additional") indicators following EN15804 A2

	Optional indicators	Units
	Environmental impact indicators (EN15804, 7.2.3.1)	
	Particulate Matter emissions	Disease incidence
	Ionizing radiation, human health	kBq U235 eq.
	Eco-toxicity (freshwater)	CTUe
	Human toxicity, cancer effects	CTUh
	Human toxicity, non-cancer effects	CTUh
	Land use related impacts/ Soil quality	dimensionless

The output flow, resource, and waste indicators are different from the "normal" LCA calculation, and thus need a modified LCA database and/or LCA tool. So let's focus on these indicators.

3 Principles of the EN15804 indicators, a motivation for a database add-on

But before we do this, it is good to have a look at all the indicators foreseen in EN 15804, and explain why a database add-on is needed for ecoinvent, i.e. why the "normal" ecoinvent cut-off system model database is not sufficient. We will do so by using a generic life cycle model for illustration.

At the core, there is the life cycle of the investigated product, shown in Figure 1 as some connected processes, the connected boxes in the dotted larger box. As common in LCA product systems, these processes are connected by exchanging products and waste. Elementary flows as resources are input in various processes in this life cycle, emissions are output of various processes in this life cycle. These resources and emissions contribute to the various environmental impact indicators suggested by EN15804. So far, this is "common ground" with LCA, see e.g.[3]: resources and emissions are elementary flows which are representing direct input from nature or direct output to nature (iron ore in ground, CO2 emissions to air), these are input / output in various processes, as result of the calculation, the elementary flows "survive" in the inventory result. Elementary flows that contribute to LCIA categories are multiplied with a respective characterisation factor and the resulting products are aggregated per category.

[3] Hildenbrand, J.; Arvidsson, R.: The Link Between Life Cycle Inventory Analysis and Life Cycle Impact Assessment, Chapter 9 in Ciroth, A., Arvidsson R. (ed): Life Cycle Inventory Analysis, Methods and Data. Springer, ISBN: 978-3-030-62270-1, 2001

Different from LCA are

- the resource indicators,
- the output indicators,
- and waste.

They are different because these indicators are not building on elementary flows, but on product and waste flows. In the LCA calculation, product and waste flows are scaled so that they disappear in the result. These indicators thus cannot be obtained from the usual LC inventory result.

Resources and output flows are, moreover, reflecting connections to a previous (resources) or a next (output flows) life cycle. In the ecoinvent cut-off system model, these connections are on purpose removed, and they are removed so that these flows, too, do not show up in the calculation result, despite their connections being cut-off.

All this calls for a modification or extension of the ecoinvent database, to be able to calculate all indicators foreseen by EN15804 in a generic background database.

Note that for the foreground model, it is responsibility of the user to model and support these indicators appropriately, as the generic database can only cover the background model.

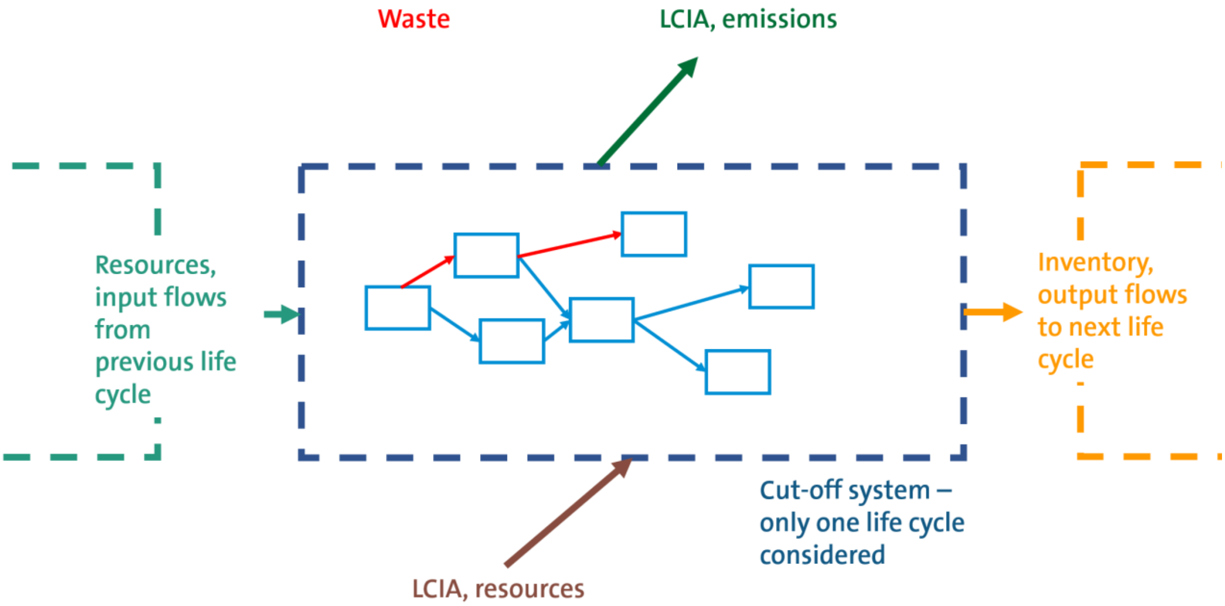


Figure 1: a generic life cycle model to explain the different EN15804 indicator types

4 Comments on the implementation of selected indicators in the extension

The implementation of the EN15804 add-on builds on the previous implementation of an EPD database based on ecoinvent, performed by Chris Foster from Eugeos, the “EuGeos 15804-IA”[4]. The new extension database uses now ecoinvent 3.8, starting from the cut-off model, and the modification of the database was performed using scripts rather than changing processes manually. Also some parts of the logic of the implementation have been changed.

ecoinvent itself has also released a system model for EN15804[5]. This is different from our implementation and has not been considered, with exception of an initial quick investigation; we believe the implementation is not reflecting EN15804 correctly and thus started with our own implementation.

This implementation makes use of openLCA features that are not necessarily available in other LCA software: in openLCA, a product flow can exist and be considered in a life cycle calculation even though it is not produced by a process; this is not possible in e.g. SimaPro (and maybe reason for ecoinvent to create the recycled content cut-off processes that make the inventory result less clear than necessary; they basically obfuscate that the calculated system has truncated supply chains). Second, product flows can be considered in LCIA methods in openLCA.

4.1 Output flows

Output flows are ‘components for reuse’, ‘exported energy’, ‘materials for energy recovery’, and ‘materials for recycling’. In the ecoinvent cut-off model, they can be identified as follows:

Processes with output flows have negative inputs of product flows that are provided by specific “Recycled Content Cut-off” processes. For example, the UUID ‘020af9b5-7668-3333-9286-75f7ba5291a1’ is a recycled content process for aluminium scrap (Figure 2)[6]. The process has only one flow, aluminium scrap, in output.

[4] With permission – thank you Chris! The EuGeos database is still available on openLCA Nexus, https://nexus.openlca.org/database/EuGeos'%2015804-IA

[5] https://ecoinvent.org/the-ecoinvent-database/system-models/#!/EN15804

[6] UUIDs refer to the ecoinvent implementation of the cut-off system model in openLCA

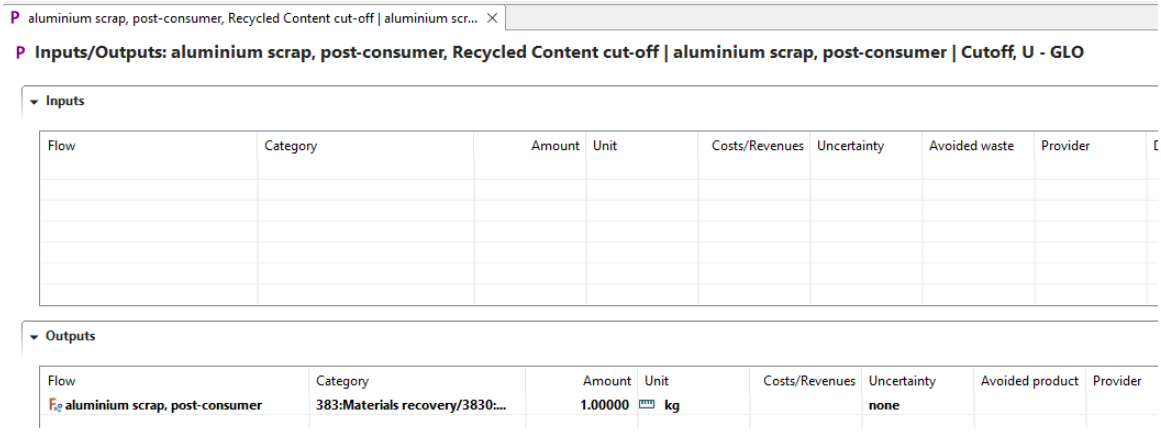


Figure 2: example for a recycled content cut-off process in ecoinvent 3.8 cut-off (original, not EN15804 extension); screenshot from openLCA

This aluminium scrap is quite often input in processes (Figure 3). Often, though, the input is negative, for example in 'd7da3ace-d103-3f6a-a1a2-ec3577a744c0', building construction, luxury hotel | building, luxury hotel | Cutoff, U (Figure 4). For the example process, this flow is provided by the recycled content cut-off process, which (see Figure 2) does not add any impacts or further life cycle chain but basically truncates the supply chain. As the input flow in the example hotel process is negative, it is basically an output of the hotel process, and it is not waste but a product for further treatment. ecoinvent calls this a recyclate, as flow type in-between waste and product. Basically, this negative input modeling hides that the process is a multi-functional process (and thus neither allocation nor system expansion is applied).

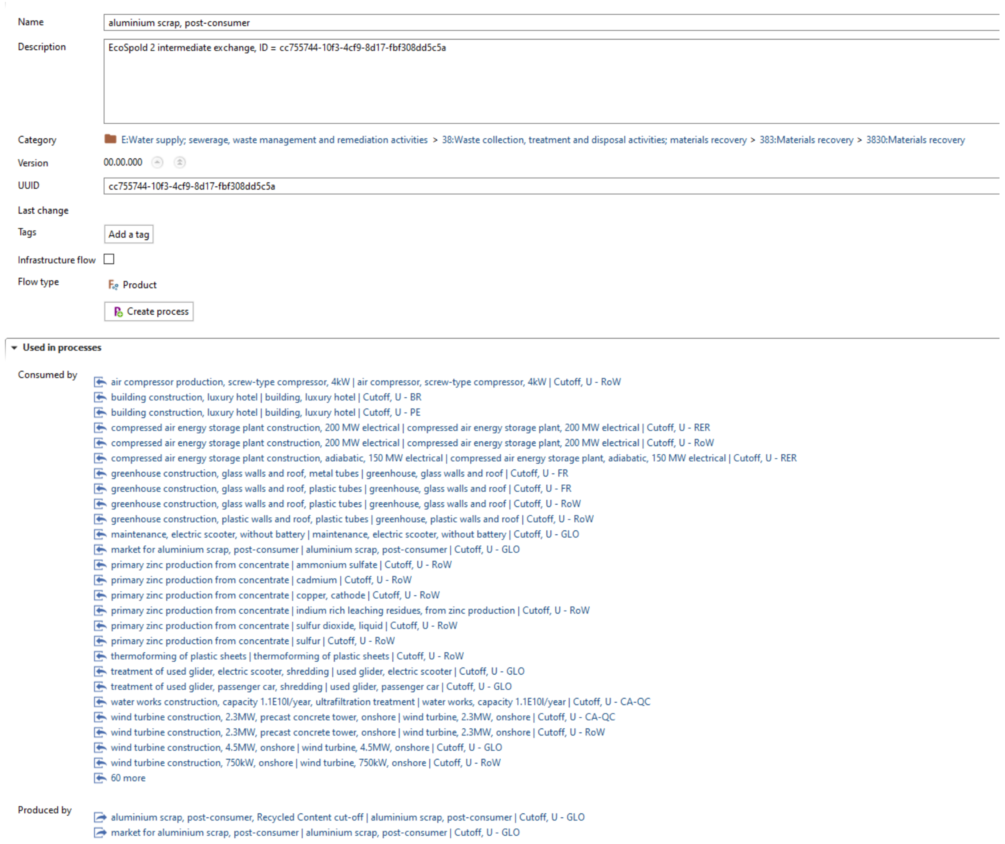


Figure 3: use of the output flow aluminium scrap post-consumer in ecoinvent 3.8 cut-off (original, not EN15804 extension); screenshot from openLCA

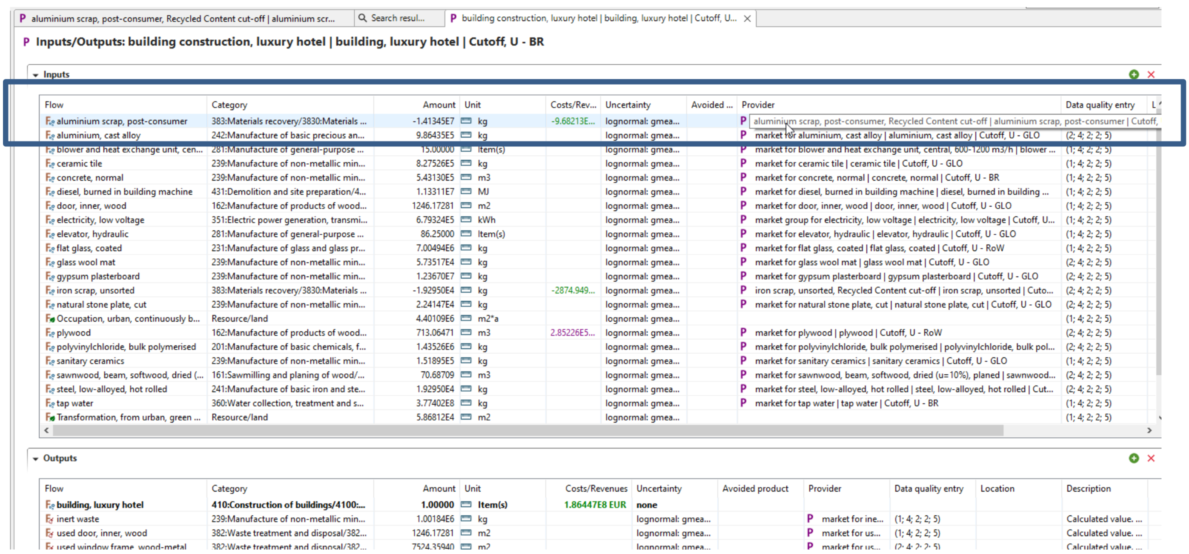


Figure 4: Example process with input of the "output flow" aluminium scrap post-consumer in ecoinvent 3.8 cut-off (original, not EN15804 extension); screenshot from openLCA

In order to make this output flow appear in the calculation result, in openLCA, we created a new product flow for aluminium scrap, 'aluminium scrap post-consumer, for recycling', and replaced the old flow with this flow. This flow does not have a provider then in the process (Figure 5).

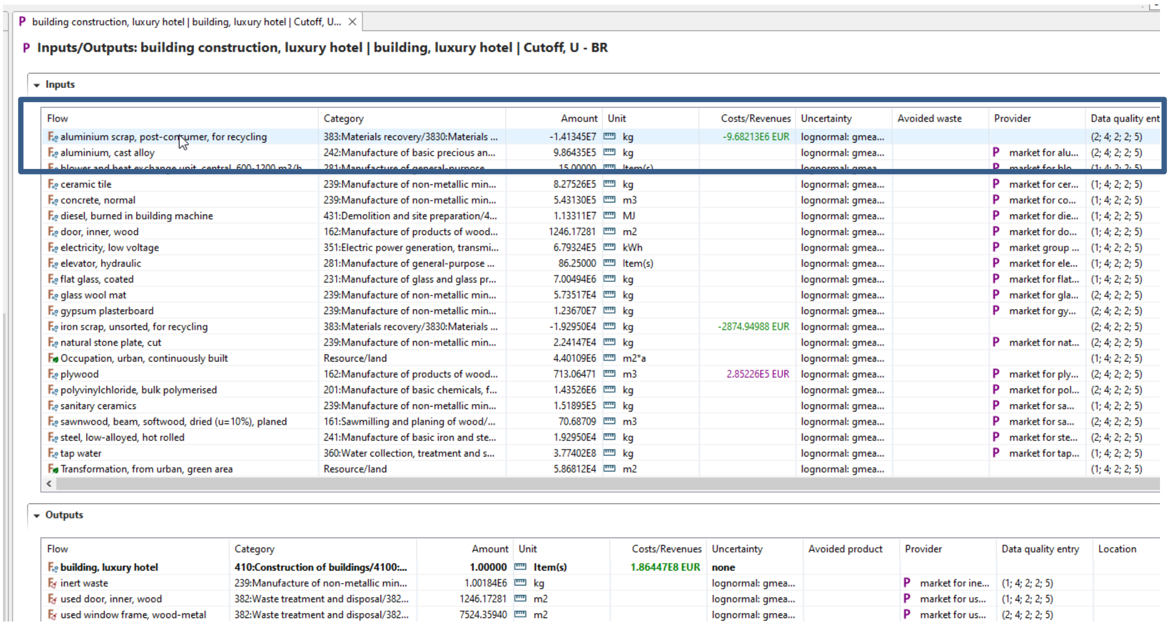


Figure 5: Example process with input of the "output flow" aluminium scrap post-consumer, for recycling in ecoinvent 3.8 cut-off (EN15804 extension); screenshot from openLCA

The effect of this change is that in the inventory calculation result, the new flow appears (Figure 6, here together with other similar output flows of course). This is possible as this flow was added to the process (Figure 5) without a provider.

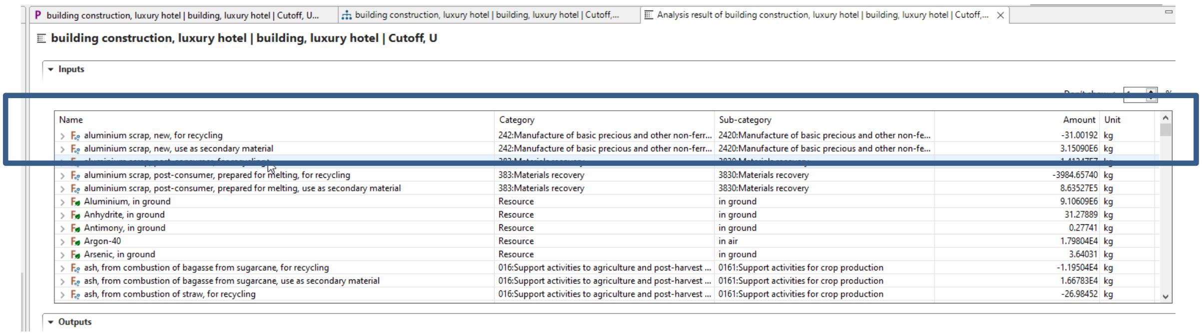


Figure 6: Inventory calculation result showing also the "output flow" aluminium scrap post-consumer, for recycling, in ecoinvent 3.8 cut-off (EN15804 extension); screenshot from openLCA

What now remains is to add this flow to the respective LCIA method (Figure 7-Figure 9). To take into account the negative amount of all output flows in the processes, the characterization factor is negative as well.

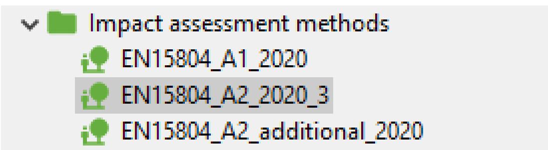
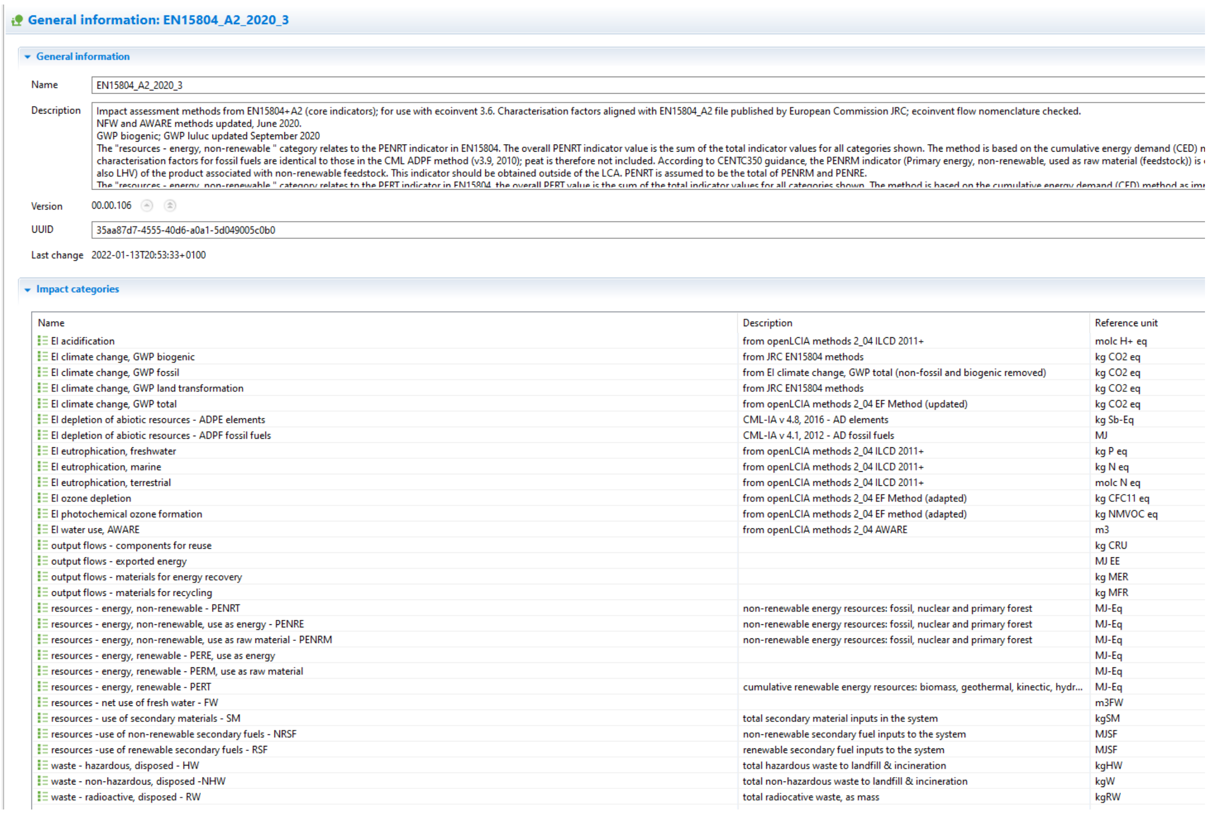


Figure 7: EN15804 methods in openLCA, "_A1" for EN15804 A1, "_A2" for EN15804 A2


General information: EN15804_A2_2020_3

General information

Name: EN15804_A2_2020_3

Description: Impact assessment methods from EN15804+A2 (core indicators); for use with ecoinvent 3.6. Characterisation factors aligned with EN15804_A2 file published by European Commission JRC; ecoinvent flow nomenclature checked.
NFW and AWARE methods updated, June 2020.
GWP biogenic; GWP luluc updated September 2020
The "resources - energy, non-renewable " category relates to the PENRT indicator in EN15804. The overall PENRT indicator value is the sum of the total indicator values for all categories shown. The method is based on the cumulative energy demand (CED) n
characterisation factors for fossil fuels are identical to those in the CML ADPF method (v3.9, 2010); peat is therefore not included. According to CENTC350 guidance, the PENRM indicator (Primary energy, non-renewable, used as raw material (feedstock)) is
also LHV) of the product associated with non-renewable feedstock. This indicator should be obtained outside of the LCA. PENRT is assumed to be the total of PENRM and PENRE.

Version: 00.00.106

UUID: 35aa87d7-4555-40d6-a0a1-5d049005c0b0

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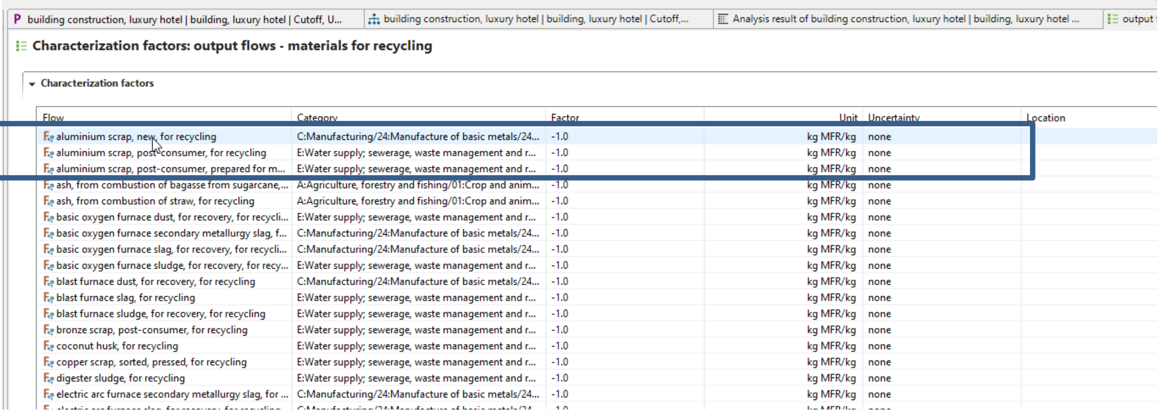
Impact categories

Name	Description	Reference unit
EI acidification	from openLCIA methods 2_04 ILCD 2011+	molc H+ eq
EI climate change, GWP biogenic	from JRC EN15804 methods	kg CO2 eq
EI climate change, GWP fossil	from EI climate change, GWP total (non-fossil and biogenic removed)	kg CO2 eq
EI climate change, GWP land transformation	from JRC EN15804 methods	kg CO2 eq
EI climate change, GWP total	from openLCIA methods 2_04 EF Method (updated)	kg CO2 eq
EI depletion of abiotic resources - ADPE elements	CML-IA v 4.8, 2016 - AD elements	kg Sb-Eq
EI depletion of abiotic resources - ADPF fossil fuels	CML-IA v 4.1, 2012 - AD fossil fuels	MJ
EI eutrophication, freshwater	from openLCIA methods 2_04 ILCD 2011+	kg P eq
EI eutrophication, marine	from openLCIA methods 2_04 ILCD 2011+	kg N eq
EI eutrophication, terrestrial	from openLCIA methods 2_04 ILCD 2011+	molc N eq
EI ozone depletion	from openLCIA methods 2_04 EF Method (adapted)	kg CFC11 eq
EI photochemical ozone formation	from openLCIA methods 2_04 EF method (adapted)	kg NMVOC eq
EI water use, AWARE	from openLCIA methods 2_04 AWARE	m3
output flows - components for reuse		kg CRU
output flows - exported energy		MJ EE
output flows - materials for energy recovery		kg MER
output flows - materials for recycling		kg MFR
resources - energy, non-renewable - PENRT	non-renewable energy resources: fossil, nuclear and primary forest	MJ-Eq
resources - energy, non-renewable, use as energy - PENRE	non-renewable energy resources: fossil, nuclear and primary forest	MJ-Eq
resources - energy, non-renewable, use as raw material - PENRM	non-renewable energy resources: fossil, nuclear and primary forest	MJ-Eq
resources - energy, renewable - PERE, use as energy		MJ-Eq
resources - energy, renewable - PERM, use as raw material		MJ-Eq
resources - energy, renewable - PERT	cumulative renewable energy resources: biomass, geothermal, kinectic, hydr...	MJ-Eq
resources - net use of fresh water - FW		m3FW
resources - use of secondary materials - SM	total secondary material inputs in the system	kgSM
resources -use of non-renewable secondary fuels - NRSF	non-renewable secondary fuel inputs to the system	MJSF
resources -use of renewable secondary fuels - RSF	renewable secondary fuel inputs to the system	MJSF
waste - hazardous, disposed - HW	total hazardous waste to landfill & incineration	kgHW
waste - non-hazardous, disposed -NHW	total non-hazardous waste to landfill & incineration	kgW
waste - radioactive, disposed - RW	total radioactive waste, as mass	kgRW

Figure 8: EN15804 A2 method in openLCA, with impact categories


building construction, luxury hotel | building, luxury hotel | Cutoff, U... | building construction, luxury hotel | building, luxury hotel | Cutoff,... | Analysis result of building construction, luxury hotel | building, luxury hotel ... | output

Characterization factors: output flows - materials for recycling

Characterization factors

Flow	Category	Factor	Unit	Uncertainty	Location
aluminium scrap, new, for recycling	C:Manufacturing/24:Manufacture of basic metals/24...	-1.0	kg MFR/kg	none	
aluminium scrap, post-consumer, for recycling	E:Water supply; sewerage, waste management and r...	-1.0	kg MFR/kg	none	
aluminium scrap, post-consumer, prepared for m...	E:Water supply; sewerage, waste management and r...	-1.0	kg MFR/kg	none	
ash, from combustion of bagasse from sugarcane,...	A:Agriculture, forestry and fishing/01:Crop and anim...	-1.0	kg MFR/kg	none	
ash, from combustion of straw, for recycling	A:Agriculture, forestry and fishing/01:Crop and anim...	-1.0	kg MFR/kg	none	
basic oxygen furnace dust, for recovery, for recycli...	E:Water supply; sewerage, waste management and r...	-1.0	kg MFR/kg	none	
basic oxygen furnace secondary metallurgy slag, f...	C:Manufacturing/24:Manufacture of basic metals/24...	-1.0	kg MFR/kg	none	
basic oxygen furnace slag, for recovery, for recycli...	C:Manufacturing/24:Manufacture of basic metals/24...	-1.0	kg MFR/kg	none	
basic oxygen furnace sludge, for recovery, for recy...	E:Water supply; sewerage, waste management and r...	-1.0	kg MFR/kg	none	
blast furnace dust, for recovery, for recycling	C:Manufacturing/24:Manufacture of basic metals/24...	-1.0	kg MFR/kg	none	
blast furnace slag, for recycling	E:Water supply; sewerage, waste management and r...	-1.0	kg MFR/kg	none	
blast furnace sludge, for recovery, for recycling	E:Water supply; sewerage, waste management and r...	-1.0	kg MFR/kg	none	
bronze scrap, post-consumer, for recycling	E:Water supply; sewerage, waste management and r...	-1.0	kg MFR/kg	none	
coconut husk, for recycling	E:Water supply; sewerage, waste management and r...	-1.0	kg MFR/kg	none	
copper scrap, sorted, pressed, for recycling	E:Water supply; sewerage, waste management and r...	-1.0	kg MFR/kg	none	
digester sludge, for recycling	E:Water supply; sewerage, waste management and r...	-1.0	kg MFR/kg	none	
electric arc furnace secondary metallurgy slag, for ...	C:Manufacturing/24:Manufacture of basic metals/24...	-1.0	kg MFR/kg	none	

Figure 9: Impact category material for recycling, showing also the "output flow" aluminium scrap post-consumer, for recycling, in ecoinvent 3.8 cut-off (EN15804 extension); screenshot from openLCA

The modeling principle showed here for material for recycling, using aluminium scrap as an example, was used for all output flows, thus also 'for components for reuse', 'exported energy', and 'materials for energy recovery'. Flows were assigned to these types of output flows, and the newly created flows received a different extension, matching to the output flow. For exported energy, however, there was no case found in the ecoinvent cut-off database (Figure 10, Figure 11).

Note that 'heat, for reuse in municipal waste incineration only' and 'electricity, for reuse in municipal waste incineration only' occur only as output from a dummy "cut-off" process, and are input into several incineration processes, probably to account for different heating values of the incinerated goods. These two flows are therefore considered in the energy input section.

Characterization factors: output flows - components for reuse

Characterization factors

Flow	Category	Factor
component for re-use	resource + waste indicators	1.0
used toner module, laser printer, black/white, for reuse	C:Manufacturing/28:Manufacture of machinery and equip...	-1.0
used toner module, laser printer, colour, for reuse	E:Water supply; sewerage, waste management and remedi...	-1.0

Figure 10: Impact category components for reuse, with only two flows, used toner module, in ecoinvent 3.8 cut-off (EN15804 extension); screenshot from openLCA

Characterization factors: output flows - materials for energy recovery

Characterization factors

Flow	Category	Factor
blast furnace gas, for energy recovery	D:Electricity, gas, steam and air conditioning supply/35:Ele...	-1.0
material for energy recovery	resource + waste indicators	1.0

Figure 11: Impact category material for energy recovery, with only one flow, blast furnace gas, in ecoinvent 3.8 cut-off (EN15804 extension); screenshot from openLCA

4.2 Resources

Resource indicators are energy, non-renewable; energy, renewable; net use of fresh water; use of secondary materials; use of non-renewable secondary fuel; and use of renewable secondary fuels.

4.2.1 Primary energy

The primary energy indicators are merely meant to sum up the energy content of any product used in the life cycle, resembling the cumulative energy demand approach[7]. These indicators (‘Resources - energy, non-renewable – PENRT’ and ‘Resources - energy, renewable – PERT’) can be captured by simply adding the respective LCA elementary flows to the impact category, as Figure 12 shows for non-renewable primary energy. The ‘Resources - energy, non-renewable – PENRT’ corresponds to the parameter ‘Total use of non-renewable primary energy resources

[7] E.g. Frischknecht, R., Wyss, F., Büsser Knöpfel, S. *et al.* Cumulative energy demand in LCA: the energy harvested approach. *Int J Life Cycle Assess* **20**, 957–969 (2015). https://doi.org/10.1007/s11367-015-0897-4

(primary energy and primary energy resources used as raw materials)' of the EN15804 norm, while the 'Resources - energy, renewable – PERT' corresponds to the parameter 'Total use of renewable primary energy resources (primary energy and primary energy resources used as raw materials)'.

Characterization factors: resources - energy, non-renewable - PENRT

Characterization factors

Flow	Category	Factor	Unit
Coal, brown, in ground	Elementary flows/Resource/in ground	13.96	MJ-Eq/kg
Coal, hard, unspecified, in ground	Elementary flows/Resource/in ground	27.91	MJ-Eq/kg
Energy, gross calorific value, in biomass, primary forest	Elementary flows/Resource/biotic	1.0	MJ-Eq/MJ
Gas, mine, off-gas, process, coal mining	Elementary flows/Resource/in ground	38.84	MJ-Eq/m3
Gas, natural, in ground	Elementary flows/Resource/in ground	38.84	MJ-Eq/m3
Oil, crude, in ground	Elementary flows/Resource/in ground	41.87	MJ-Eq/kg
Uranium, in ground	Elementary flows/Resource/in ground	560000.0	MJ-Eq/kg

Figure 12: Impact category primary energy non-renewable total in ecoinvent 3.8 cut-off (EN15804 extension); screenshot from openLCA

To distinguish the energy and feedstock use of the primary energy (indicators xyRE, for energy , and xyRM, for material / feedstock, respectively) the processes where these energy flows are input were investigated, and flows "..use as material" and "..use as energy" were created and used then instead of the generic original flow.

For example, for the original flow 'Energy, gross calorific value, in biomass' a new flow 'Energy, gross calorific value, in biomass, used as raw material' was created, and added to PERM. The original flow Energy, gross calorific value, in biomass was added to PERE. In processes for food production and construction wood etc. the existing energy in biomass flow was replaced by the '..used as material flow' flow (Figure 13). For system processes, this logic was also used, assuming that most of the energy is needed by the final process which gives name to the system process, but this was not entirely solvable evidently.

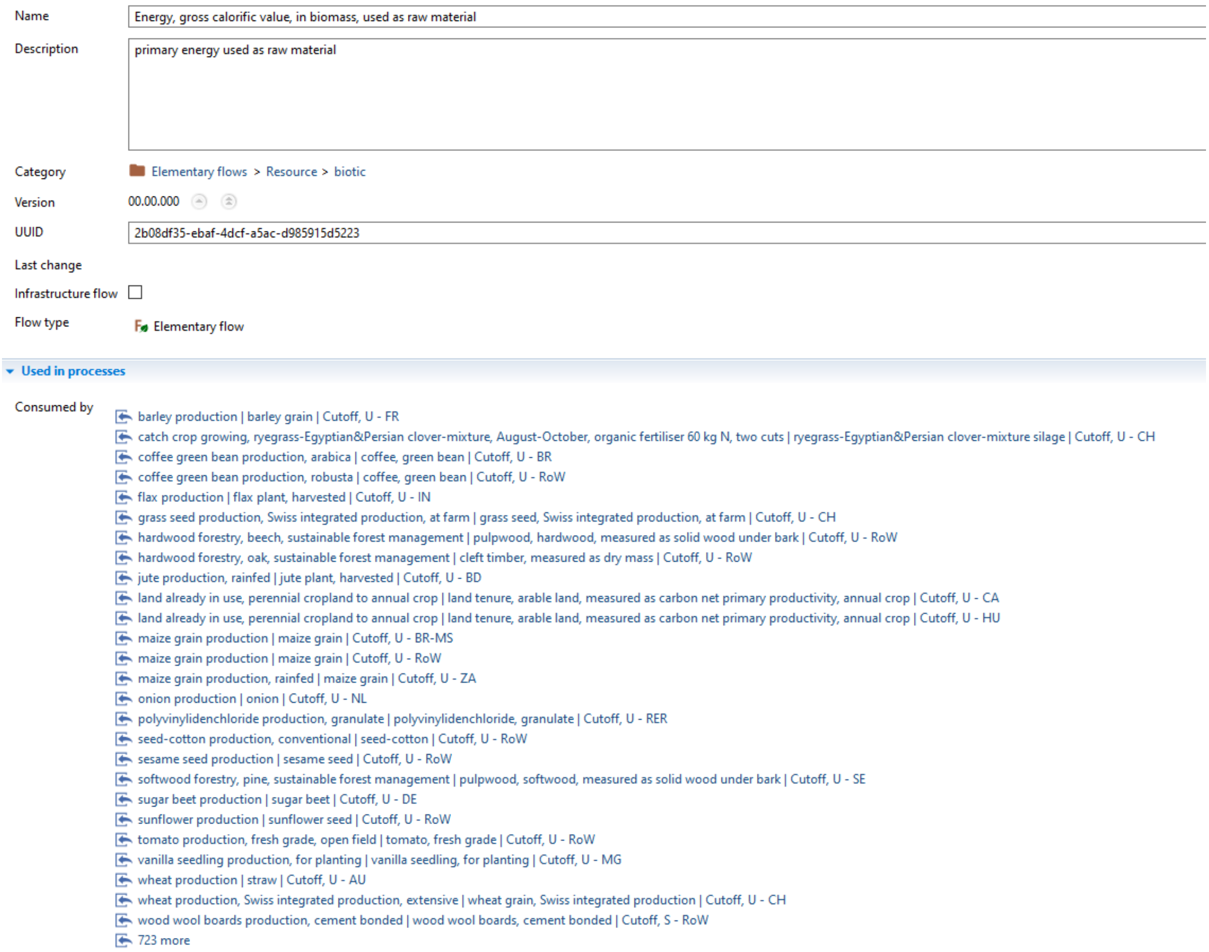


Figure 13: Uses of the flow 'Energy, gross calorific value, in biomass, used as raw material' as input into processes of the EN15804 add-on, screenshot from openLCA

4.2.2 Net fresh water

Net use of fresh water can again be directly captured via an LCA calculation, by adding input and output elementary water flows to the category; output water obtains a negative sign to achieve the overall net result (Figure 14).

Characterization factors: resources - net use of fresh water - FW

Characterization factors

Flow	Category	Factor	Unit
Waste water/m3	Elementary flows/Emission to water/river	-1.0	m3FW/m3
Waste water/m3	Elementary flows/Emission to water/unspecified	-1.0	m3FW/m3
Water	Elementary flows/Emission to water/river	-0.001	m3FW/kg
Water	Elementary flows/Emission to water/surface water	-1.0	m3FW/m3
Water	Elementary flows/Emission to water/surface water	-0.001	m3FW/kg
Water	Elementary flows/Emission to water/unspecified	-1.0	m3FW/m3
Water	Elementary flows/Emission to water/unspecified	-0.001	m3FW/kg
Water	Elementary flows/Resource/in water	0.001	m3FW/kg
Water (fresh water)	Elementary flows/Emission to water/surface water	-0.001	m3FW/kg
Water (fresh water)	Elementary flows/Resource/in water	0.001	m3FW/kg
Water (groundwater from technosphere, waste water)	Elementary flows/Emission to water/fresh water	-0.001	m3FW/kg
Water (river water from technosphere cooling water)	Elementary flows/Emission to water/fresh water	-0.001	m3FW/kg
Water (river water from technosphere turbined)	Elementary flows/Emission to water/fresh water	-0.001	m3FW/kg
Water (river water from technosphere, waste water)	Elementary flows/Emission to water/fresh water	-0.001	m3FW/kg
Water Cooling fresh	Elementary flows/Resource/in water	0.001	m3FW/kg
Water vapour	Elementary flows/Emission to water/unspecified	-0.001	m3FW/kg
Water, AD	Elementary flows/Emission to water/unspecified	-1.0	m3FW/m3
Water, AE	Elementary flows/Emission to water/unspecified	-1.0	m3FW/m3
Water, AF	Elementary flows/Emission to water/unspecified	-1.0	m3FW/m3
Water, AG	Elementary flows/Emission to water/unspecified	-1.0	m3FW/m3
Water, AI	Elementary flows/Emission to water/unspecified	-1.0	m3FW/m3
Water, AL	Elementary flows/Emission to water/unspecified	-1.0	m3FW/m3
Water, AM	Elementary flows/Emission to water/unspecified	-1.0	m3FW/m3
Water, AO	Elementary flows/Emission to water/unspecified	-1.0	m3FW/m3
Water, AR	Elementary flows/Emission to water/river	-1.0	m3FW/m3
Water, AR	Elementary flows/Emission to water/unspecified	-1.0	m3FW/m3
Water, AS	Elementary flows/Emission to water/unspecified	-1.0	m3FW/m3

Figure 14: Impact category net use of fresh water in ecoinvent 3.8 cut-off (EN15804 extension); screenshot from openLCA

4.2.3 Secondary materials and fuels

The secondary materials and fuels could also be called 'input flows'; these indicators follow the same logic as output flows, the only difference being that they are input into processes. They appear in processes on the input side (just like the output flows, see above), but the amount is positive.

Taking again aluminium scrap, post-consumer, this flow is in ecoinvent (3.8 cut-off) e.g. input in a market process (Figure 15), provided by the Recycled Content cut-off process (see Figure 2), with a positive amount of 1.

Inputs/Outputs: market for aluminium scrap, post-consumer | aluminium scrap, post-consumer | Cutoff, U

Inputs

Flow	Category	Amount	Unit	Costs/...	Uncertainty	Avoided ...	Provider	Data quality entry	Description
aluminium scrap, post-consumer	383:Materials recovery/3830:Materials recovery	1.00000	kg		none		aluminium scrap, post-consumer, Recycled Content cut-off | aluminium scrap, post-consumer | Cutoff, U - GLO		
transport, freight train	491:Transport via railways/4912:Freight rail transp...	0.11200	t*km		lognormal: gmean=0.11...		market group for tra...	(1; 1; 5; 5; 4)	Transport distance b...
transport, freight, inland waterways, barge	502:Inland water transport/5022:Inland freight wa...	0.01990	t*km		lognormal: gmean=0.01...		market group for tra...	(1; 1; 5; 5; 4)	Transport distance b...
transport, freight, lorry, unspecified	492:Other land transport/4923:Freight transport b...	0.19320	t*km		lognormal: gmean=0.19...		market group for tra...	(1; 1; 5; 5; 4)	Transport distance b...
transport, freight, sea, container ship	501:Sea and coastal water transport/5012:Sea and ...	0.21150	t*km		lognormal: gmean=0.21...		market for transport,...	(1; 1; 5; 5; 4)	The total marine tra...

Outputs

Flow	Category	Amount	Unit	Costs/Reve...	Uncertainty	Avoided product	Provider	Data quality entry	Description
aluminium scrap, post-consumer	**383:Materials recovery/3830:Materials recovery**	**1.00000**	**kg**	0.68500 E...	**none**				

Figure 15: Example process with input of the "resource flow" aluminium scrap post-consumer in ecoinvent 3.8 cut-off (original, not EN15804 extension); screenshot from openLCA

In the add-on version, this market process has a different input, "aluminium scrap, post-consumer, use as secondary material", without provider (Figure 16).

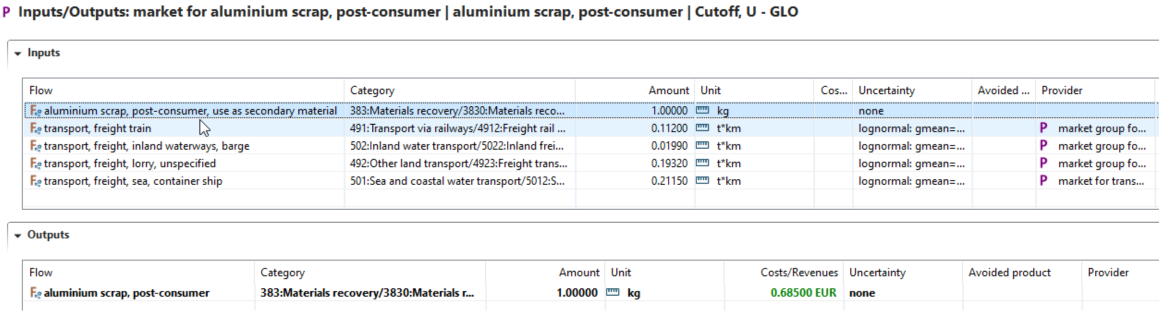


Figure 16: Example process with input of the "resource flow" aluminium scrap post-consumer, use as secondary material, in ecoinvent 3.8 cut-off (EN15804 extension); screenshot from openLCA

This new flow is also added to the LCIA category (Figure 17), and will then contribute to the EPD calculation result.

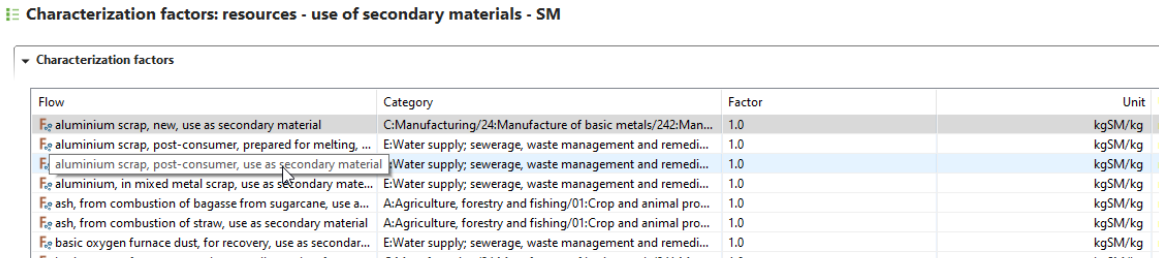


Figure 17: Impact category use of secondary material, showing also the "resource flow" aluminium scrap post-consumer, use as secondary material, in ecoinvent 3.8 cut-off (EN15804 extension); screenshot from openLCA

For the other secondary resources flows, the approach was identical; for renewable secondary fuel, there was no case found in the database; for non-renewable secondary fuel, there is only "blast furnace gas" to consider.

4.3 Waste

Waste is again a different case; according to EN15804, only waste in its final waste state must be addressed, to prevent double counting if a waste stream goes through different consecutive treatment steps.

For the ecoinvent database (and also elsewhere) this means that final landfill / disposal, and incineration are to be considered only.

Waste input in these respective processes was then collected and characterized, to reflect that the EN15804 indicators require a distinction into non-hazardous waste, hazardous waste, and radioactive waste.

This distinction was for one done by the flow and process names ("bilge oil" as input into hazardous waste incineration is hazardous waste; "waste polystyrene", input into municipal waste incineration, is non-hazardous waste), and also considering the ecoinvent classification of flows and processes ('Treatment and disposal of non-hazardous waste is typically non-hazardous waste'), Figure 18.

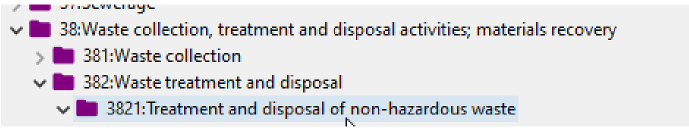
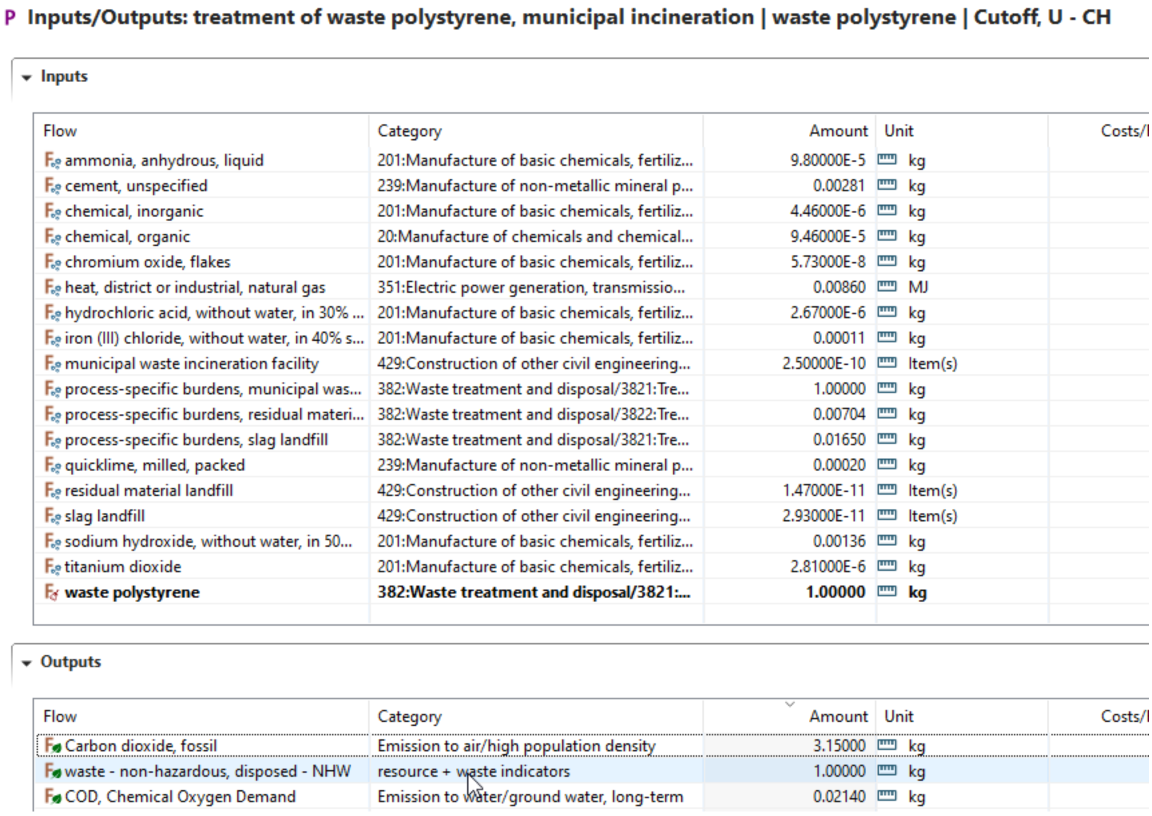


Figure 18: ecoinvent category for processes "treatment and disposal of non-hazardous waste"

In the classification, radioactive waste overwrites hazardous waste; radioactive waste is not in addition classified as hazardous waste, to avoid double counting.

Since waste flows are handled in the same life cycle, in difference to resources and output flows, they disappear in the calculation and are not accessible in the calculation result. To prevent this, in each case, a new elementary flow was created and added to the respective processes. These "waste elementary flows" were also added to the LCIA method.

For example, the waste polystyrene incineration obtained an additional elementary flow 'waste - non-hazardous, disposed' (Figure 19).



P Inputs/Outputs: treatment of waste polystyrene, municipal incineration | waste polystyrene | Cutoff, U - CH

Inputs

Flow	Category	Amount	Unit	Costs/I
ammonia, anhydrous, liquid	201:Manufacture of basic chemicals, fertiliz...	9.80000E-5	kg	
cement, unspecified	239:Manufacture of non-metallic mineral p...	0.00281	kg	
chemical, inorganic	201:Manufacture of basic chemicals, fertiliz...	4.46000E-6	kg	
chemical, organic	20:Manufacture of chemicals and chemical...	9.46000E-5	kg	
chromium oxide, flakes	201:Manufacture of basic chemicals, fertiliz...	5.73000E-8	kg	
heat, district or industrial, natural gas	351:Electric power generation, transmissio...	0.00860	MJ	
hydrochloric acid, without water, in 30% ...	201:Manufacture of basic chemicals, fertiliz...	2.67000E-6	kg	
iron (III) chloride, without water, in 40% s...	201:Manufacture of basic chemicals, fertiliz...	0.00011	kg	
municipal waste incineration facility	429:Construction of other civil engineering...	2.50000E-10	Item(s)	
process-specific burdens, municipal was...	382:Waste treatment and disposal/3821:Tre...	1.00000	kg	
process-specific burdens, residual materi...	382:Waste treatment and disposal/3822:Tre...	0.00704	kg	
process-specific burdens, slag landfill	382:Waste treatment and disposal/3821:Tre...	0.01650	kg	
quicklime, milled, packed	239:Manufacture of non-metallic mineral p...	0.00020	kg	
residual material landfill	429:Construction of other civil engineering...	1.47000E-11	Item(s)	
slag landfill	429:Construction of other civil engineering...	2.93000E-11	Item(s)	
sodium hydroxide, without water, in 50...	201:Manufacture of basic chemicals, fertiliz...	0.00136	kg	
titanium dioxide	201:Manufacture of basic chemicals, fertiliz...	2.81000E-6	kg	
waste polystyrene	**382:Waste treatment and disposal/3821:...**	**1.00000**	**kg**	

Outputs

Flow	Category	Amount	Unit	Costs/I
Carbon dioxide, fossil	Emission to air/high population density	3.15000	kg	
waste - non-hazardous, disposed - NHW	resource + waste indicators	1.00000	kg	
COD, Chemical Oxygen Demand	Emission to water/ground water, long-term	0.02140	kg	

Figure 19: waste elementary flow 'waste non-hazardous, disposed - NHW' as addition to a municipal solid waste incineration

5 Comparison against other databases

It is interesting to compare the results obtained in the EN15804 add-on to other databases, especially to the previous Eugeos database. For the comparison, the entire database in openLCA was calculated via a script, thus results for all processes in the database were obtained.

5.1 EuGeos 15804-IA

In its most recent version, the EuGeos database is based on ecoinvent 3.7.1, thus the previous version of ecoinvent, while the EN15804 add-on builds on ecoinvent 3.8. This alone introduces some differences evidently.

We will look into these differences using xy plots that show total life cycle results in one database, per indicator and per process dataset in one of the databases, over total life cycle result per indicator in the other database. If both databases provide the same result per indicator and system process dataset, plotted dots should lie on one linear line, which you sometimes called 'bisector' in English.

This can be seen for indicators such as GWP total, where the switch between these databases does not introduce major differences (Figure 20). The extreme scale is due to results for airport and seaports.

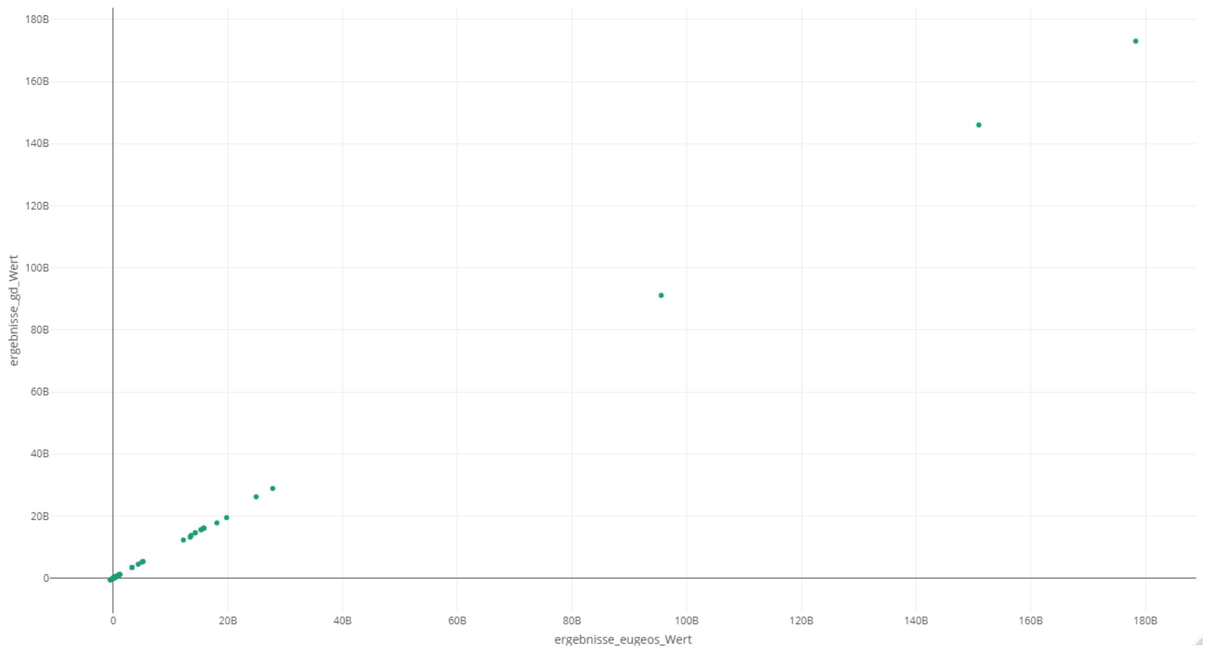


Figure 20: EN15804 add-on database values over Eugeos values, per process, for the indicator GWP total

For other indicators, some differences between the two databases are visible. Figure 21 and, Figure 22 show results for abiotic depletion potential, fuel.

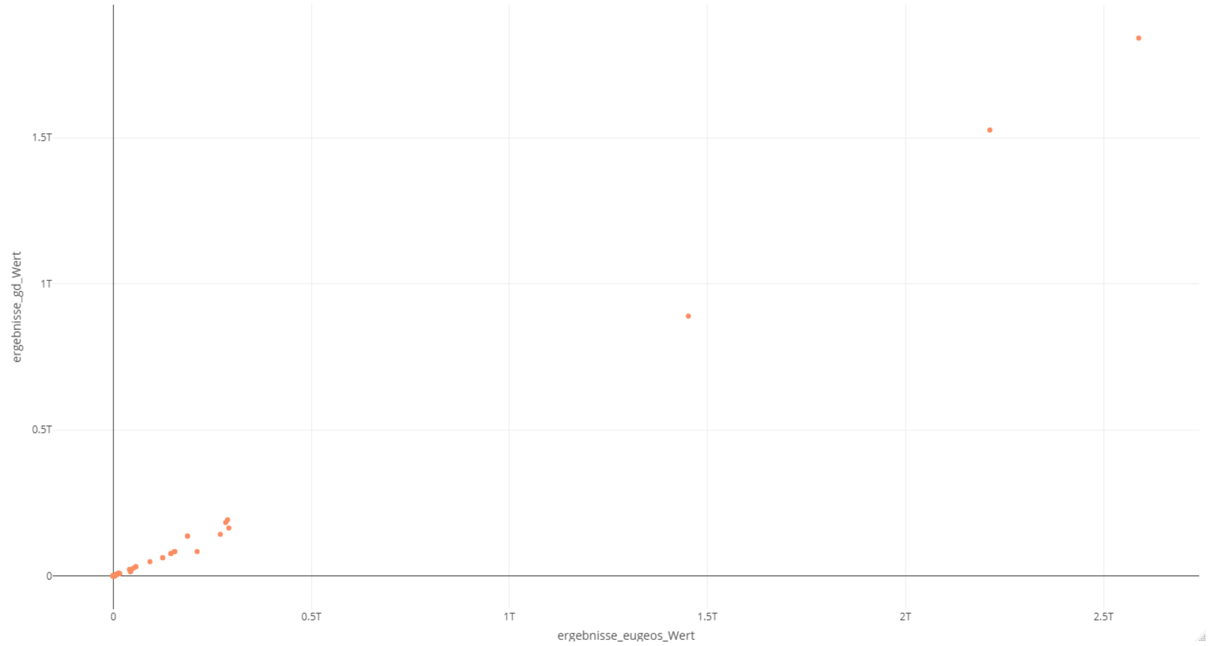


Figure 21: EN15804 add-on database values over Eugeos values, per process, for the indicator abiotic depletion potential, fuel

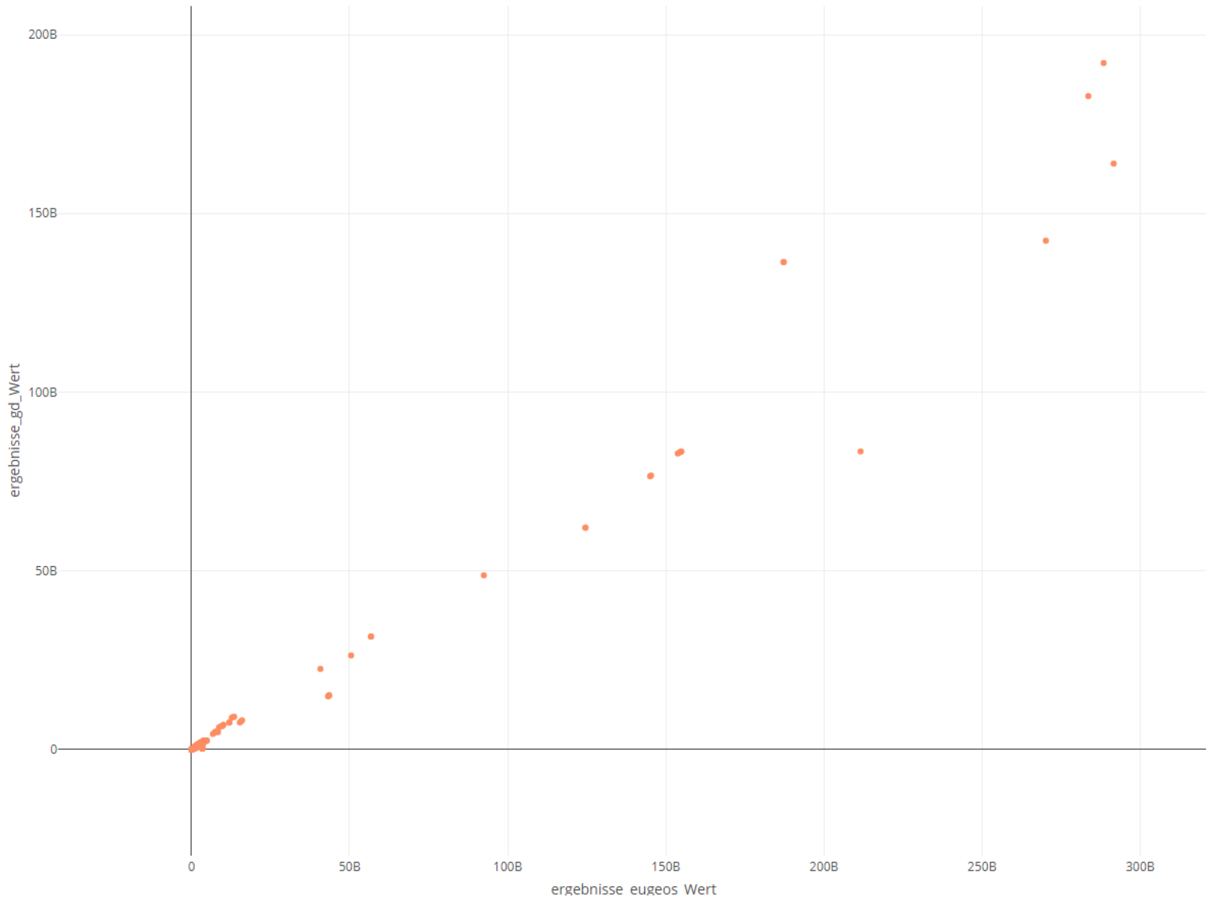
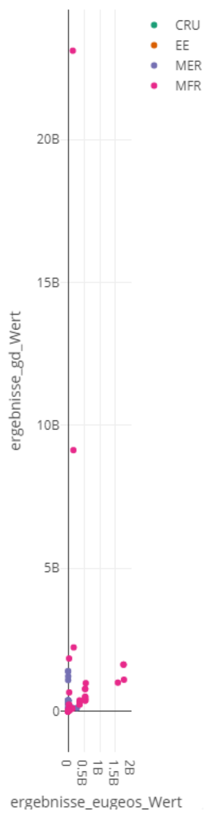


Figure 22: EN15804 add-on database values over Eugeos values, per process, for the indicator abiotic depletion potential, fuel, only smaller values

For the EPD-specific indicators, the situation is more different; now, with the EN15804 add-on, flows are entered throughout the database systematically, and based on lessons learned, some parts are now modelled in another way, e.g. the negative product flows in the cut-off datasets.

This leads to quite different results. Output flows are in the EN15804 add-on much higher (Figure 23, left). Some (CRU, Components for re-use) do not exist in EuGeos and are for that reason not shown, Exported Energy, EE, does not exist in both databases and thus is also not shown.



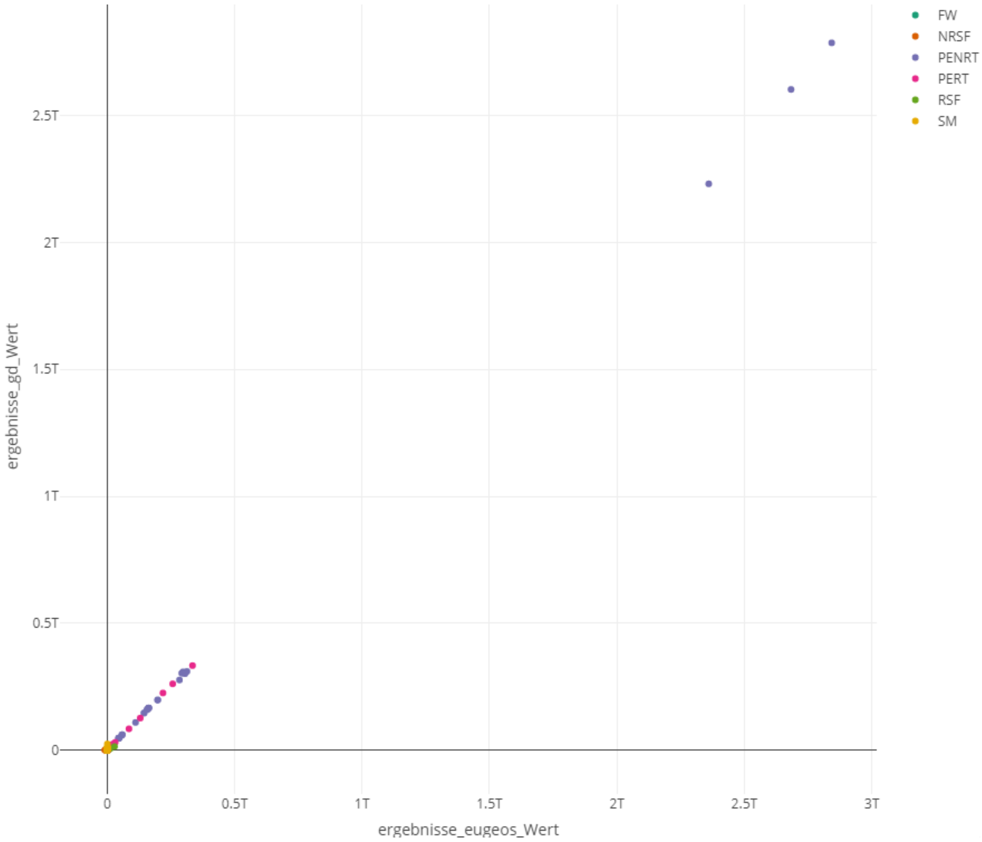


Figure 23: EN15804 add-on database values over Eugeos values, per process, left for all output flow indicators, right for all resources indicators

For the resources, results seem more aligned (Figure 23, right). However, a more detailed view shows that in the EN15804 add-on, secondary material (SM) is often about ten times higher (Figure 24, left), and non-renewable secondary fuel is even sometimes negative in Eugeos (Figure 24, right). This is most likely linked to the different modeling, which now treats negative input products differently (see the previous chapters).

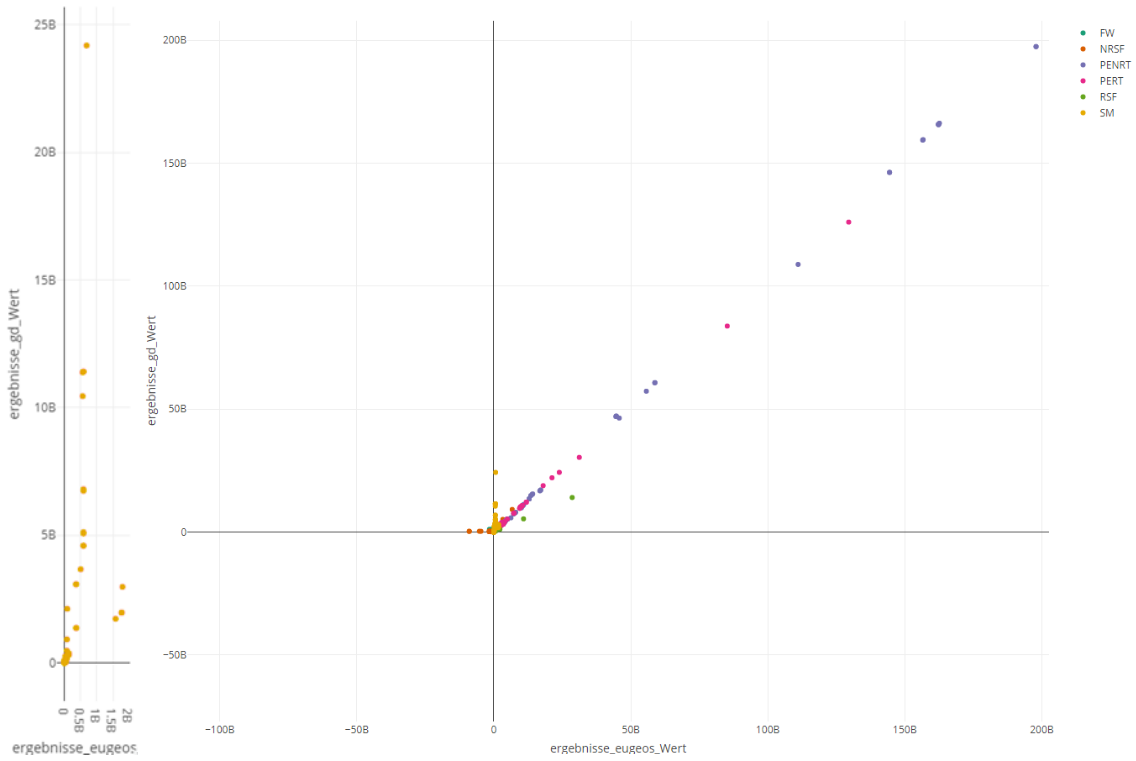


Figure 24: EN15804 add-on database values over Eugeos values, per process, left for the indicator SM, right for all resources, more detailed view

For waste, results are also quite different (Figure 25). They are rather caused by a different classification of a given waste flow. EN15804 add-on has higher hazardous waste flows and Eugeos has higher non-hazardous waste flows. This is due to the classification of waste flows as hazardous that are listed in the ecoinvent category treatment of hazarous waste (see above).

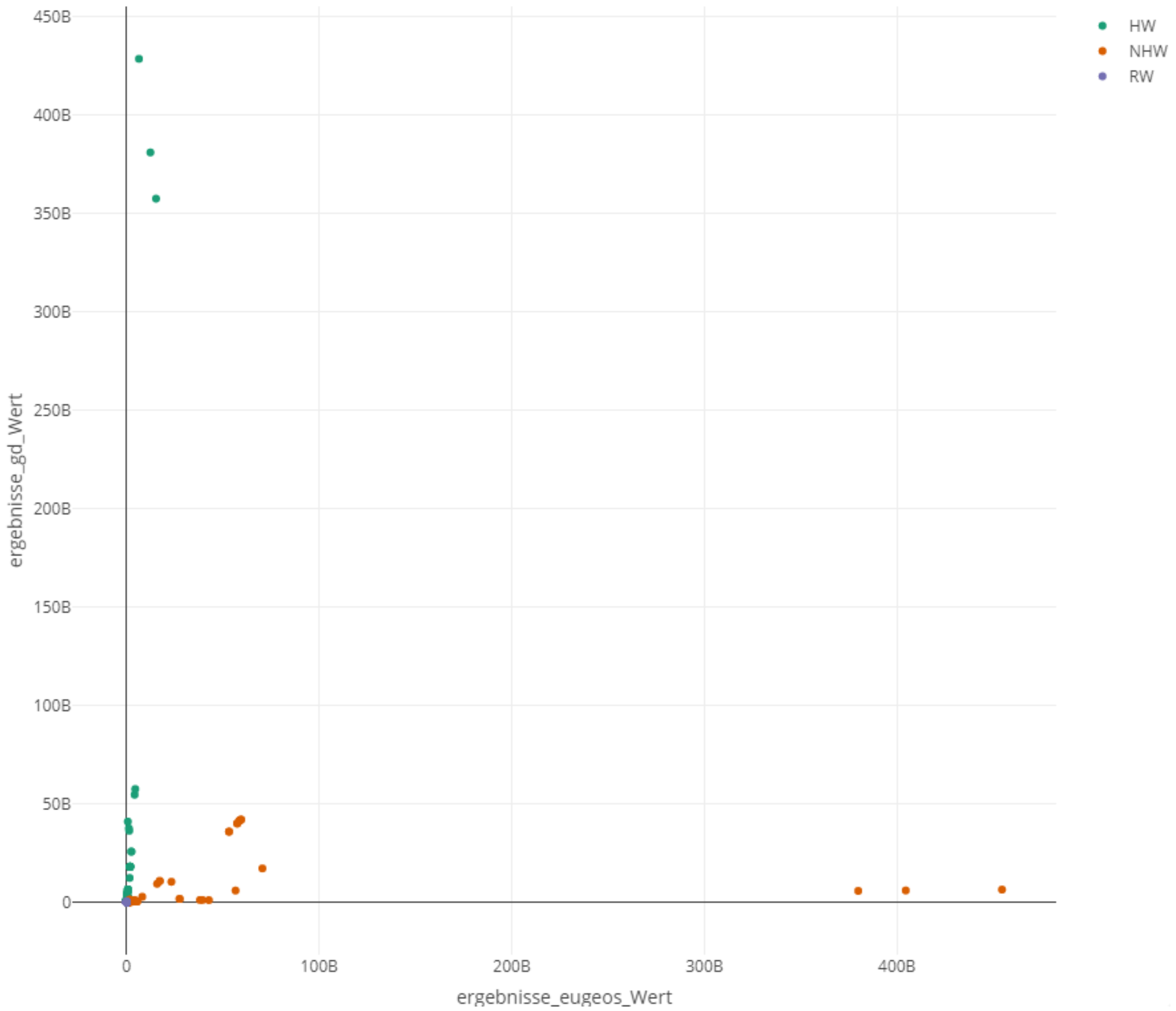


Figure 25: EN15804 add-on database values over Eugeos values, per process, for the waste indicators

A more detailed view shows also that Eugeos has much less radioactive waste (RW, in the figure; Figure 26).

Figure 26: EN15804 add-on database values over Eugeos values, per process, left for the waste indicators, detailed view

5.2 GaBi database, Sphera datasets

GaBi is so far probably the most widely used LCA database for EN15804; Sphera provides background datasets for the Ökobaudat database. It is somewhat surprising as for many of the non-LCIA, EPD-related indicators, there are no results provided. This can be seen also when looking at published, verified EPDs from public databases of EPD program operators.

Just one arbitrary example, Structural Steel: Sections and Plates, from bauforum stahl e.V., published as EPD via IBU[8]:

> "This environmental product declaration covers steel products rolled out to structural sections, merchant bars and heavy plates, intended for bolted, welded or otherwise connected constructions of buildings, bridges and other structures."

[8] https://ibudata.lca-data.com/datasetdetail/process.xhtml?uuid=5cb2c568-76fe-4803-8b46-0084e79800c8&version=00.14.000&stock=PUBLIC&lang=en

In the result view, it is shown that indicator results are 0 for Material for Energy Recycling (MER) for example. You would expect blast furnace gas as output from a steel product, and thus a contribution to MER.

Table 3 energy output flow results for EPD 'Structural Steel: Sections and Plates', copied from ibu.data[8]

Indicator	Direction	Unit	Production A1-A3	Waste processing C3	Recycling Potential D
Materials for energy recovery (MER)	Output	kg	0	0	0
Exported electrical energy (EEE)	Output	MJ	0	0	0
Exported thermal energy (EET)	Output	MJ	0	0	0

For the EPD, the GaBi databases were used (Figure 27).

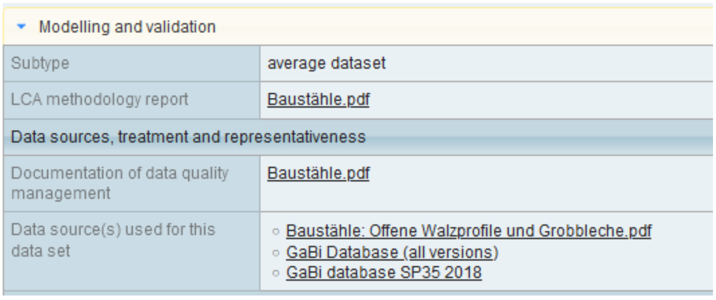


Figure 27: Background databases used for the EPD on Structural Steel, screenshot from EPD at ibu.data[8]

Similar results are shown for background datasets meant to be used for EPDs, created on behalf of the BBSR in Germany, integrated into the 'Ökobaudat' database. For example, 'Steel window fitting; 2,63 kg/piece'[9] consists, according to the dataset documentation, of aluminium and steel parts, among other things (Figure 28). This is credible. The dataset is fully aggregated, thus the modeling is not accessible to the public however.

Also for this dataset, results for many of the EPD-specific indicators are 0, according to the dataset (Table 4). This includes Material for Energy Recovery. For an entire life cycle, these values do not seem realistic.

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9 https://oekobaudat.de/OEKOBAU.DAT/datasetdetail/process.xhtml?uuid=ea4ff1e8-4ee8-4ecf-8951-a79b5b60dd2a&version=20.19.120&stock=OBD_2021_II&lang=en

Table 4 some of the EPD-specific indicators for the Ökobaudat-dataset 'Steel window fitting; 2,63 kg/piece', copied from oekobaudat.de[9]

Indicator	Direction	Unit	Production	De-construction	Transport	Recycling Potential
			A1-A3	C1	C2	D
Primary energy resources used as raw materials (PERM)	Input	MJ	0	0	0	0
Non-renewable primary energy resources used as raw materials (PENRM)	Input	MJ	0	0	0	0
Input of secondary material (SM)	Input	kg	0	0	0	0
Use of renewable secondary fuels (RSF)	Input	MJ	0	0	0	0
Use of non renewable secondary fuels (NRSF)	Input	MJ	0	0	0	0
Components for re-use (CRU)	Output	kg	0	0	0	0
Material for Energy Recovery (MER)	Output	kg	0	0	0	0
Exported electrical energy (EEE)	Output	MJ	0	0	0	0
Exported thermal energy (EET)	Output	MJ	0	0	0	0

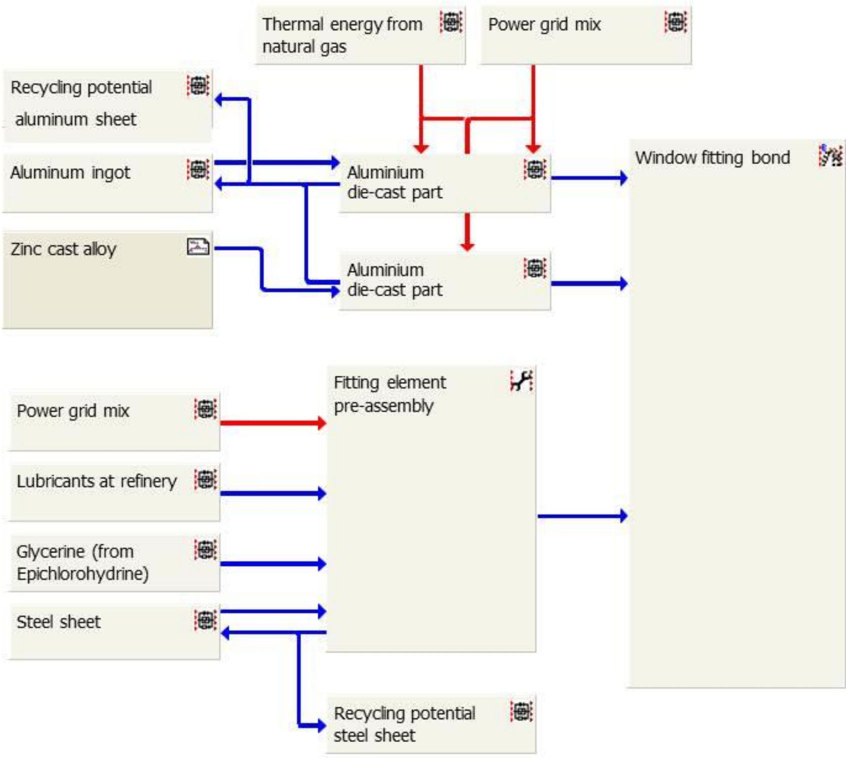

Figure 28: Dataset 'Steel window fitting; 2,63 kg/piece ', dataset flow diagram[9]

For these aggregated datasets, it is of course not possible to investigate specific processes in the supply chain which should provide contributions to the EPD-specific indicators.

5.3 ecoinvent EN15804 system model

The ecoinvent EN15804 system model was not fully available for the analysis and will be compared later. Some parts are done differently here, it seems, for example the dealing with negative input product flows which are provided by dummy processes and thus lead to a reduction and net calculation of EPD indicators potentially.

6 Summary

The implementation of the EN15804 in ecoinvent involves a couple of different approaches to "squeeze" the EN15804 inventory indicators (energy, output flows, waste, etc.), but we think we found a solution for each case.

Evidently, ecoinvent was not designed with this EN15804 addition in mind, even though the thinking of EN15804 fits well to the ecoinvent cut-off system model. At some few points, asymmetries become visible, which could maybe be overcome in a revision of the database (or any other database, evidently). Especially the lack of exported energy comes to mind, while imported energy is reflected in the database. Overall, though, we believe the EN15804 requirements are quite well reflected in the EN15804 add-on.

This is also thanks to the openLCA software, which allows some flexibility in modelling and thus avoids use of dummy processes and other more complicated workarounds.

The lack of support for these inventory indicators in other, broadly used databases for EPDs is somewhat surprising. Here, in the EN15804 add on for ecoinvent by GreenDelta, each individual process can be transparently checked in how exactly the EN15804 standard is implemented and supported. Maybe, therefore, this contribution can help to promote a discussion about these other databases as well, and thus contribute to an overall improved data quality for EPDs.

7 Support

The EN15804 add-on is developed by GreenDelta GmbH, https://www.greendelta.com/, developers of openLCA, creators of the Nexus data space (https://nexus.openlca.org/), EPD verifiers for IBU, kiwa, and environdec.

Support is available as trainings, direct support, and on demand:
https://nexus.openlca.org/services.

For direct contact, please refer to https://www.greendelta.com/about-us/contact-us/

Many thanks!