

## IEooc\_Methods4\_Exercise7: LCA with openLCA: Modification of processes

### Sample Solution

**Goal:** Copy processes, modify processes, change source of electricity, and conduct a comparative LCA

**Note:** For this exercise an ecoinvent licence for openLCA is needed. If no license is at hand the exercise can be modified, using the freely available life cycle databases on the openLCA Nexus.

#### Research question:

**How large is the impact of producing a ton of steel on climate change for different process routes?**

**Scope:** Compare three different production routes:

- 1) primary production
- 2) secondary production (remelting) with coal-based electricity
- 3) secondary production (remelting) with wind-based electricity

#### General hints:

+ Never modify ecoinvent processes! Your modifications will affect all subsequently calculated LCAs and comparability and reproducibility are lost.

+ You can copy an entire ecoinvent process inventory by right-clicking it and past a copy of it into your private \_MyProcesses (or so) folder. You will notice that the UUIDs of the original process and its copy are different, meaning that they are separate entities. Both the original and the copy still share the same reference product, which breaks the 1:1 correspondence of flows and processes, which is why a new reference flow for the copied process has to be created (or copied), added to the process copy, set as reference flow (Fig. E5.1), and then the old reference output flow can be deleted.

+ Copy existing ecoinvent processes to use them as basis for your modelling, create a product system for each of them, and then combine them into a project. Select “**ReCiPe Midpoint (H) w/o LT**” as impact assessment method.

#### Hints for production route 1:

+ Use the ecoinvent process “**steel production, converter, unalloyed | steel, unalloyed | cut-off, U - RoW**” (ecoinvent process group 2410) as template, and copy it.

+ Converter steel production often includes scrap use, and for modelling primary steel production, the scrap input has to be set to zero and replaced by an equivalent amount of pig iron instead.

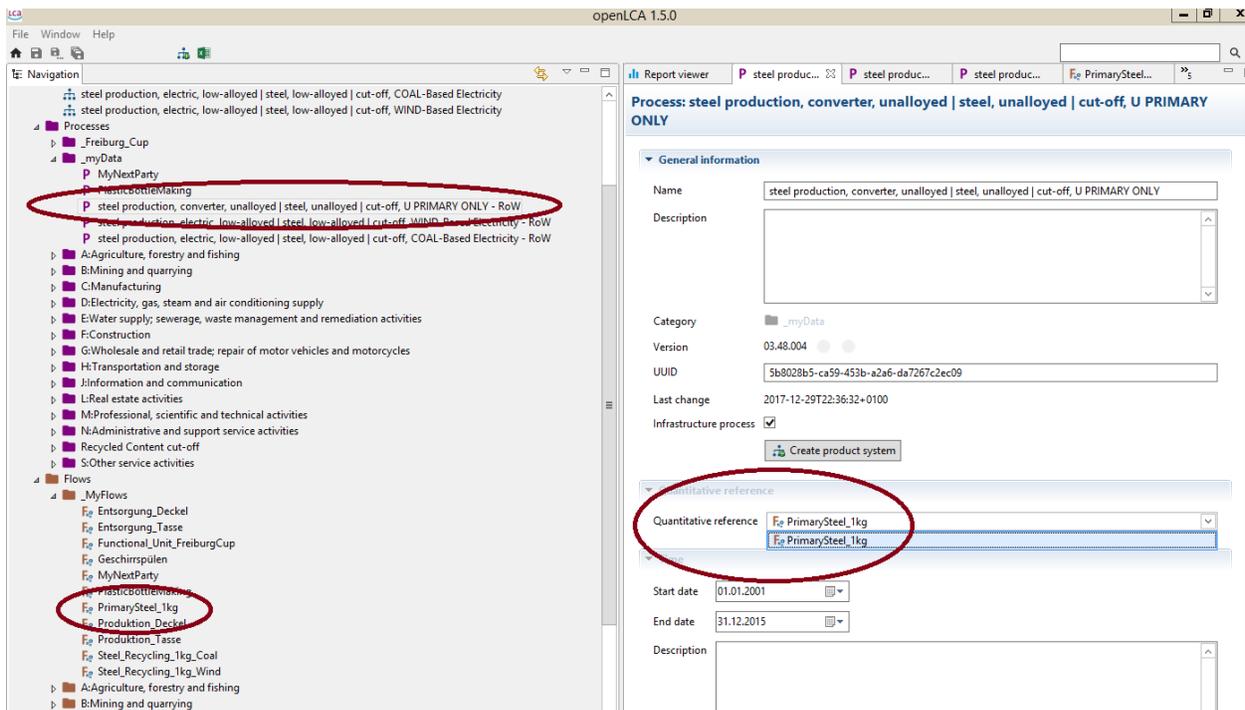
## Part II Methods

## Methods part 4 (Life cycle assessment)

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- Remove the scrap inflow (0.2125 kg) from the input table.
- Convert this scrap flow to a pig iron equivalent in terms of elemental iron. Pig iron has an iron content of 96%.
- Add the thus converted scrap input to the 0.9 kg of pig iron in the input table.

**Solution: 1.12135 kg pig iron per kg of primary steel are needed.**



**Figure E5.1:** Snapshot for a process inventory in LCA that was copied into `_myData` from ecoinvent, and which has the flow `PrimarySteel_1kg` as reference. The reference flow for this process can be chosen on the ‘General information’ tab (right side).

### Hints for production route 2:

- + Use the ecoinvent process “**steel production, electric, low-alloyed | steel, low-alloyed | cut-off, U - RoW**” (ecoinvent group 2410) as template, and copy it.
- + Take the total electricity input (two flows with together 0.57129 kWh/kg), and replace these inflows by an equivalent inflow of *coal-based* electricity. Transmission losses and grid infrastructure do not need to be considered. Take the ecoinvent flow “**electricity, high voltage | electricity production, lignite - IN**” (ecoinvent flow group 3510, for India) as reference to obtain comparative results.

Part II Methods

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Hints for production route 3:

+ Use the ecoinvent process “**steel production, electric, low-alloyed | steel, low-alloyed | cut-off, U - RoW**” (ecoinvent group 2410) as template, and copy it.

+ Take the total electricity input (two flows with together 0.57129 kWh/kg), and replace these inflows by an equivalent inflow of *wind-based* electricity. Transmission losses and grid infrastructure do not need to be considered. Take the ecoinvent flow “**electricity, high voltage | electricity production, wind, <1MW turbine, onshore - IN**” (ecoinvent group 3510, for India) as reference to obtain comparative results.

The final result is shown in Figures E5.2 and E5.3.

**LCIA Results**

This table shows the LCIA results of the project variants. Each selected LCIA category is displayed in the rows and the project variants in the columns. The unit is the unit of the LCIA category as defined in the LCIA method.

Impact category	Primary steel	Steel recycling, lignite	Steel recycling, wind	Unit
agricultural land occupation	3.13016e-2	1.44438e-2	1.40511e-2	m <sup>2</sup> *a
climate change	2.29872e+0	1.16175e+0	3.72932e-1	kg CO <sub>2</sub> -Eq
fossil depletion	5.37191e-1	2.99755e-1	1.23798e-1	kg oil-Eq
freshwater ecotoxicity	7.74583e-4	1.17449e-3	1.02580e-3	kg 1,4-DCB-Eq
freshwater eutrophication	1.01745e-4	2.21903e-4	3.57271e-5	kg P-Eq
human toxicity	2.08305e-1	1.34011e+0	1.30537e+0	kg 1,4-DCB-Eq
ionising radiation	3.09249e-2	1.31179e-2	1.24444e-2	kg U235-Eq
marine ecotoxicity	1.53813e-3	3.11506e-3	2.94171e-3	kg 1,4-DCB-Eq
marine eutrophication	2.05529e-4	1.46573e-4	5.05034e-5	kg N-Eq

Figure E5.2: Snapshot from results report for the tree production routes for steel.

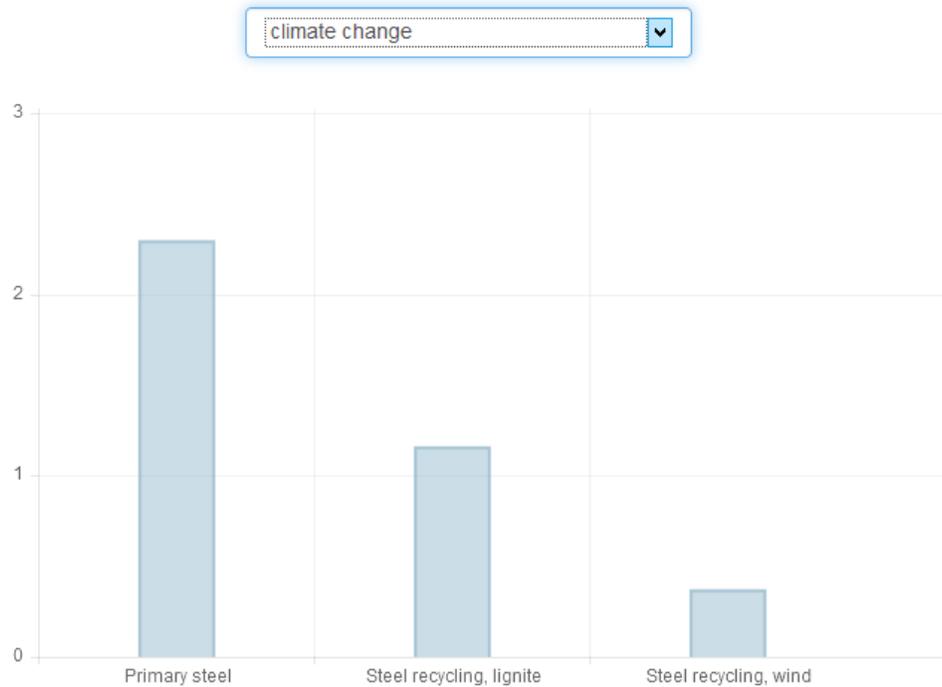
The total contribution to climate change, according to the ReCiPe Midpoint Hierarchist method without long-term effects, is ca. 2.3 kg of CO<sub>2</sub>-eq per kg of primary steel, ca. 1.2 kg of CO<sub>2</sub>-eq per kg of remelted steel using lignite-based electricity, and ca. 0.4 kg of CO<sub>2</sub>-eq per kg of remelted steel using wind-based electricity.

Even with a very carbon-intensive source of electricity, steel recycling thus saves about 50% of GHG emissions compared to primary steel, but this number can increase to up to 84% for low-carbon sources of electricity for remelting steel scrap.

A number of simplification were made that require further analysis: Electricity losses and grid infrastructure was not considered, and quality constraints to recycling were excluded from the analysis.

### Single Indicator Results

The following chart shows the single results of each project variant for the selected indicator. You can change the selection and the chart is dynamically updated.



**Figure E5.3:** Snapshot from results report for the tree production routes for steel. Climate change category.

**Tutorials for openLCA:**

<https://www.youtube.com/channel/UCGiahq1YZWK4pRXDVXuli6w>