THE UNIVERSITY OF BRITISH COLUMBIA

ENGR 544, Life Cycle Assessment and Management

School of Engineering, Faculty of Applied Science

The University of British Columbia (Okanagan)

Learning Objectives

- **Create multiple processes** and product systems in openLCA.
- **Analyse and compare** Aluminium can & PET bottle.
- **Interpret the results** of comparison.

Scope Definition

PET bottle vs ALU can:

- First, functional unit should be defined for the life cycle analysis;
  - In this case, both the PET and aluminum packaging options have the same function: contain and protect the valuable beverage. So, the **functional unit** can be defined as **500ml container**.
- To **avoid too complicated models** in this case study, the sealing and cap options will not be considered, but only **the core body of the packaging**.
- The bottle is considered to be produced, consumed and disposed in the USA.
- There are a lot of **approximations**, such as **weight of can and bottle**, **recycling rate**, **transport** and **energy** needed.

Limitations

- In this case study , we do not have exact data from a producer, and we are using **a limited database**.
- Therefore, some data cannot be found in the database and a number of approximations and assumptions have to be made.
- The exact weight of the can and bottle, the origin of aluminum, current recycling rates, transport and energy needed and some other processes can only be guessed or estimated.
- This study does not intend to take part in the debate between two industries. It has a rather exemplary character, showing the functions and capabilities of the software and sharing a typical case of eco-design.

PET bottle

Build the ‘PET bottle’ model

- ❑ We assumed the PET bottle is composed of
  - ➢ **Polyethylene Terephthalate**, and the **method of disposal** is recycling by burning natural gas to melt the PET, but we do not reuse the melted PET in this production system.

- ❑ We will create the disposal phase of the PET.
  - ➢ **Transport** the empty bottles to the recycle site, and then use the natural gas to melt the bottle, so the only output flow will interact with the environment will be the **heat**.

Create Flows

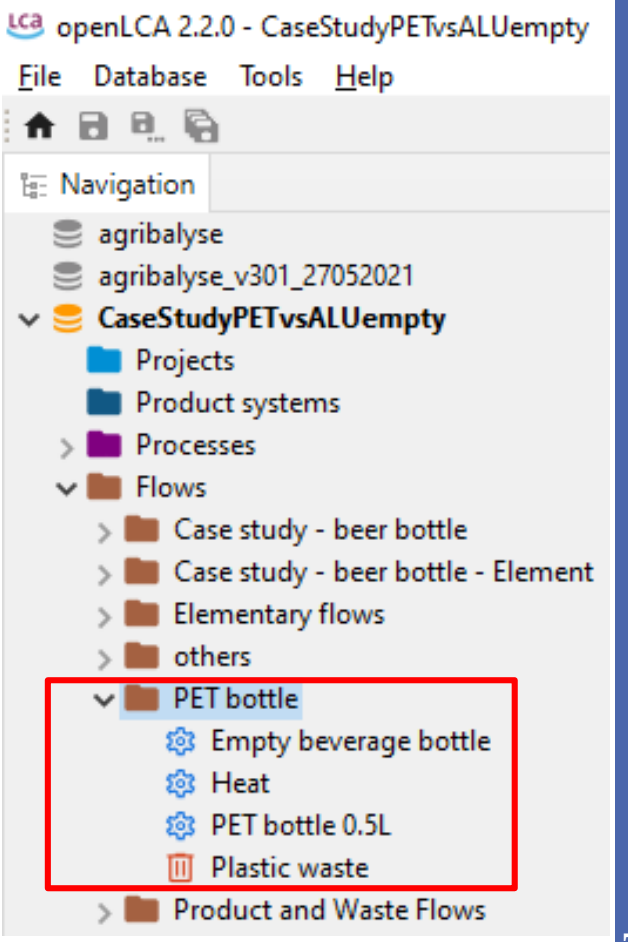
- Right click on Flows and create a new child category called ‘PET bottle’. Then, create the following flows:

- **Empty beverage bottle**
  - Flow type (product); Flow properties (**number of items**); Reference unit (**items**).

- **Heat**
  - Flow type (product); Flow properties (**net calorific value**); Reference unit (**MJ**).

- **PET bottle 0.5L**
  - Flow type (product); Flow properties (**number of items**); Reference unit (**items**).

- **Plastic waste**
  - Flow type (waste); Flow properties (**mass**); Reference unit (**kg**).



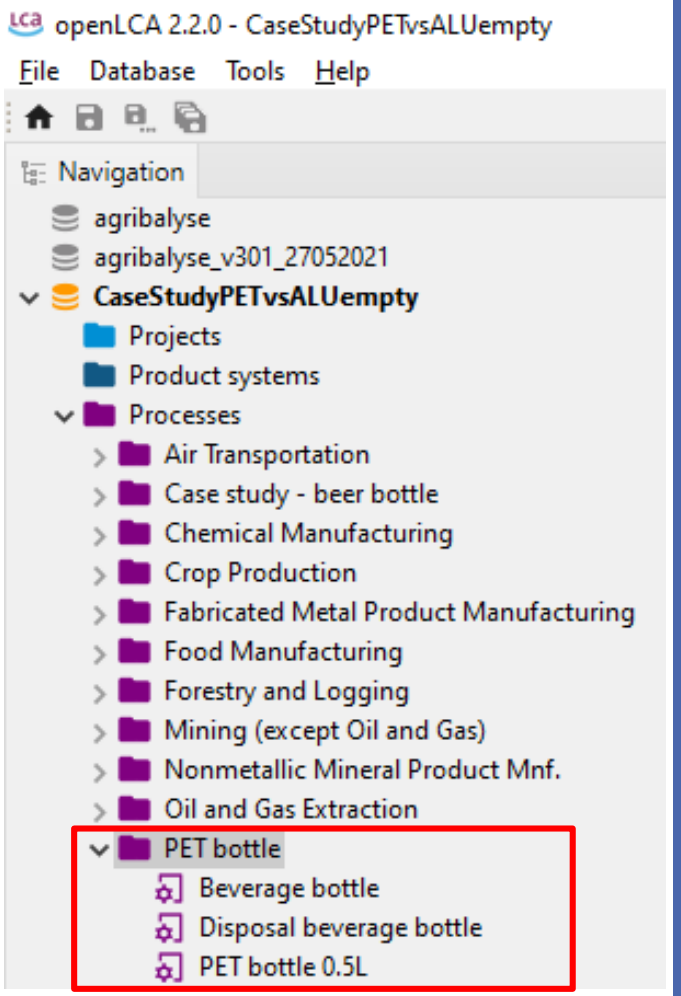
Create Processes

- Right click on Processes and create a new child category called ‘PET bottle’. Then, create the following processes:

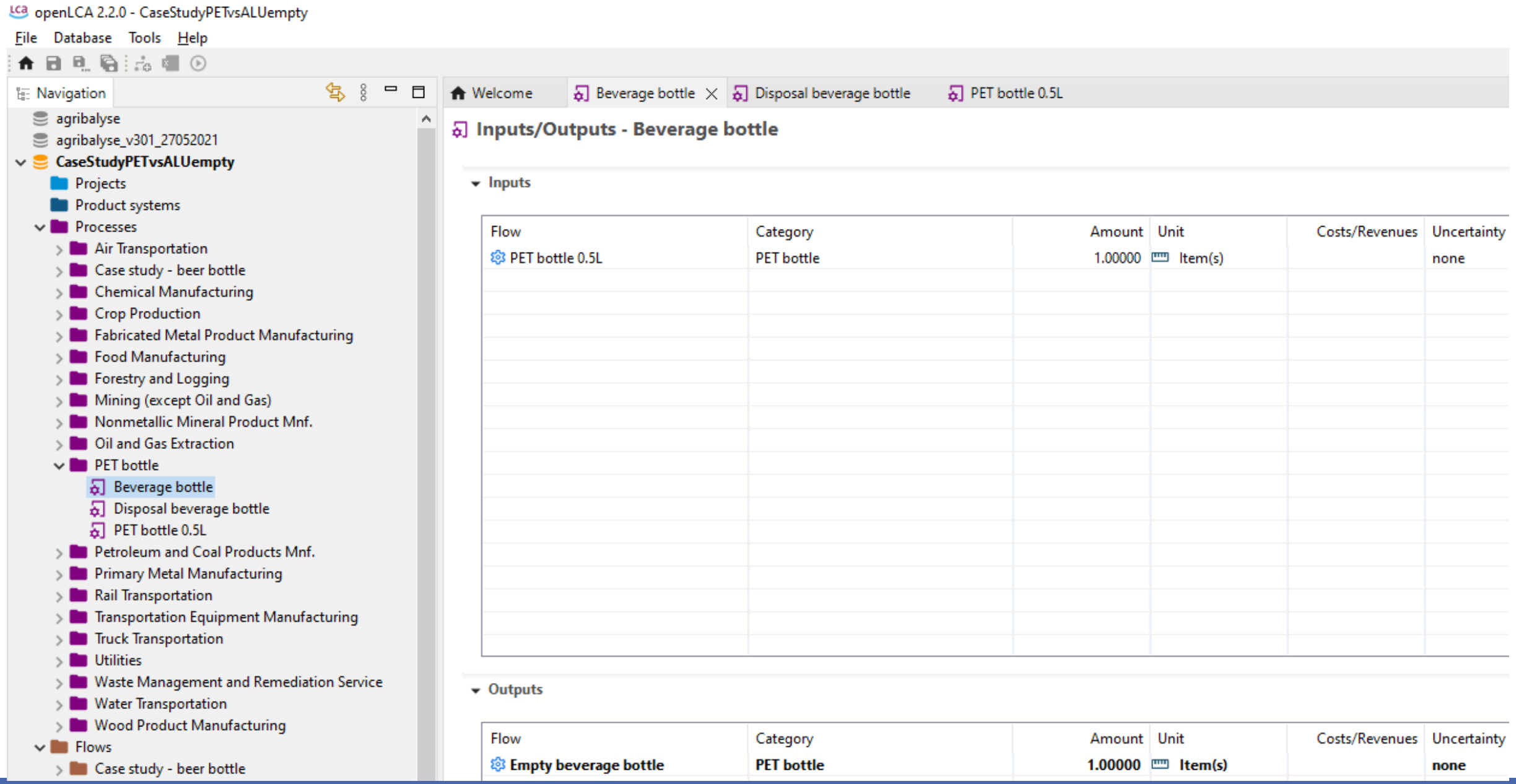
- **Beverage bottle**
  - Input flow (PET bottle 0.5L); Output Flow (Empty beverage bottle).
  - Quantitative reference (Empty beverage bottle).

- **Disposal beverage bottle**
  - Input flow (Empty beverage bottle, Natural gas combusted in industrial boiler, Transport combination truck); Output Flow (Heat).
  - Quantitative reference (Heat).

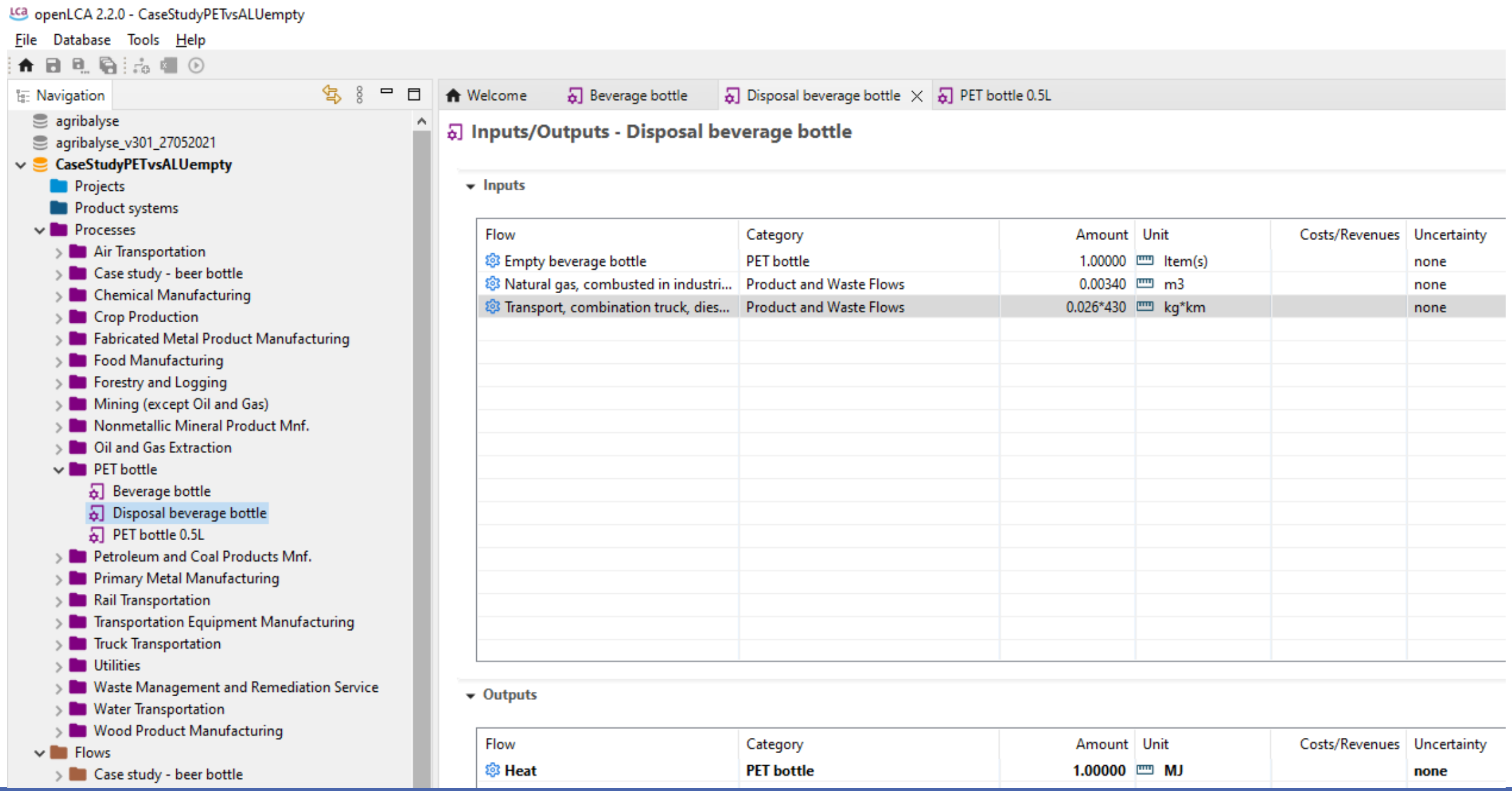
- **PET bottle 0.5L**
  - Input flow (Electricity at grid, Polyethylene terephthalate resin, Transport combination truck); Output Flow (PET bottle 0.5L, Plastic waste).
  - Quantitative reference (PET bottle 0.5L).



Beverage Bottle



Disposal Beverage Bottle



PET bottle 0.5L

openLCA 2.2.0 - CaseStudyPETvsALUempty

File Database Tools Help

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Welcome | Beverage bottle | Disposal beverage bottle | PET bottle 0.5L

Inputs/Outputs - PET bottle 0.5L

Inputs

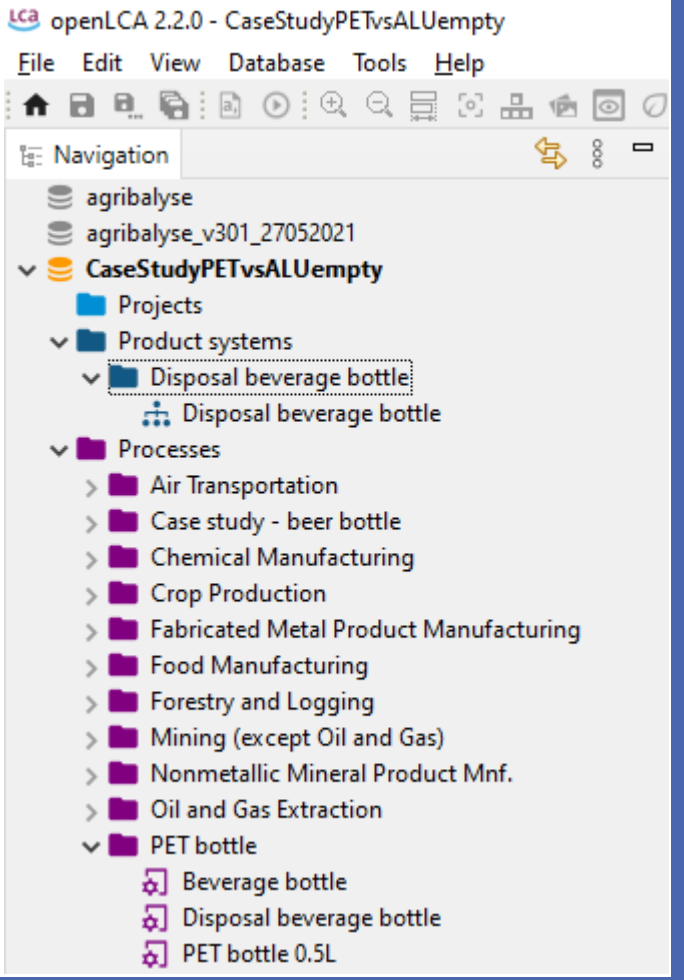
Flow	Category	Amount	Unit	Costs/Revenues	Uncertainty
Electricity, at grid, US - RNA	Product and Waste Flows	0.50000	MJ		none
Polyethylene terephthalate resin, at plant - RNA	Product and Waste Flows	27.00000	g		none
Transport, combination truck, diesel powered - RNA	Product and Waste Flows	1000*0.026	kg*km		none

Outputs

Flow	Category	Amount	Unit	Costs/Revenues	Uncertainty
PET bottle 0.5L	**PET bottle**	**1.00000**	**Item(s)**		**none**
Plastic waste	PET bottle	1.00000	g		none

Create Product Systems

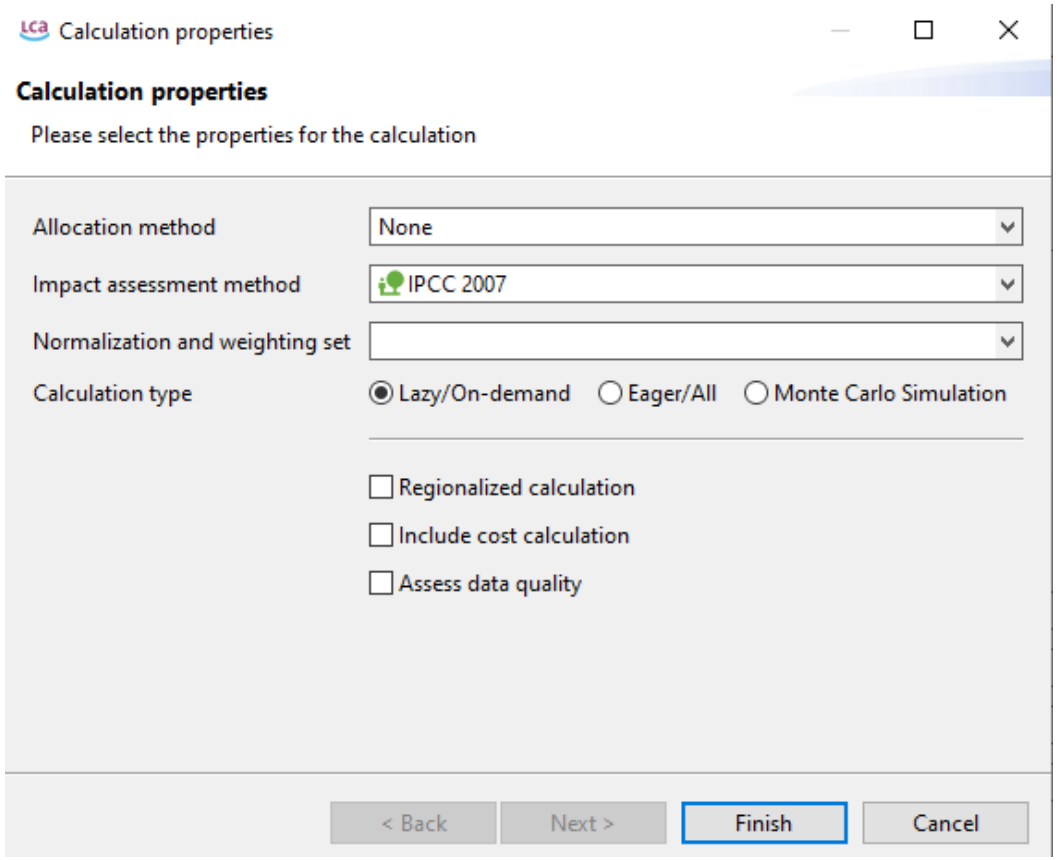
- Right click on Product systems and create a new child category called ‘Disposal beverage bottle’. Then, Open the process “Disposal beverage bottle” and click on “Create Product System ” to create a new product system:



- Disposal beverage bottle
  - Name: Disposal beverage bottle
  - Reference process: Disposal beverage bottle
  - To connect the upstream chain, ensure ‘Auto-link processes’ are checked.
  - Preferred process type: Unit process.
  - Click the 'Finish' button.

Impact Assessment

- To assess the impact of this system:
  - Click on the “ Calculate” button (in the “General Information” of the product system tab),
  - Select the LCIA-method ‘**IPCC2007**’, you can choose “Quick result”, or “Analysis” if you want to see Sankey diagram.
  - Click finish.

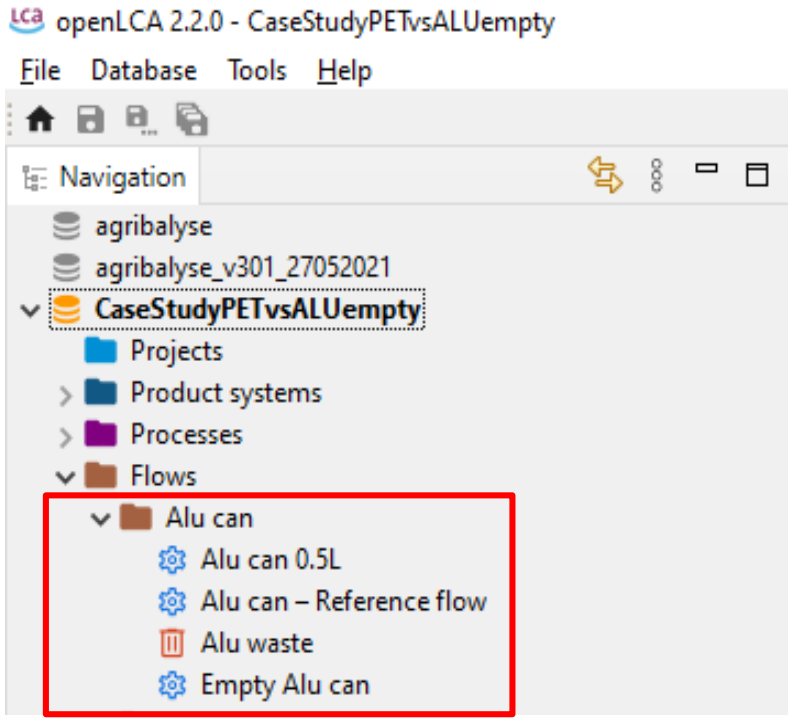


Aluminum Can

Create Flows

- Right click on Flows and create a new child category called 'Alu can'. Then, create the following flows:

- **Alu can – Reference flow**
  - Flow type (product); Flow properties (number of items); Reference unit (items).
- **Alu can 0.5L**
  - Flow type (product); Flow properties (number of items); Reference unit (items).
- **Alu waste**
  - Flow type (waste); Flow properties (**mass**); Reference unit (**kg**).
- **Empty Alu can**
  - Flow type (product); Flow properties (number of items); Reference unit (items).
- **Alu waste**
  - Flow type (waste); Flow properties (mass); Reference unit (kg).



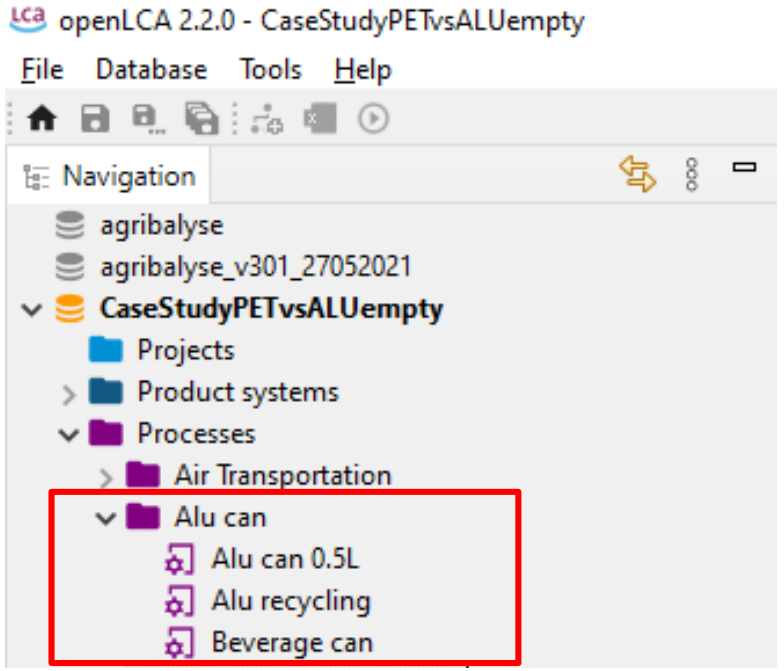
Create Processes

- Right click on Processes and create a **new child category** called '**Alu can**'. Then, create the following processes:

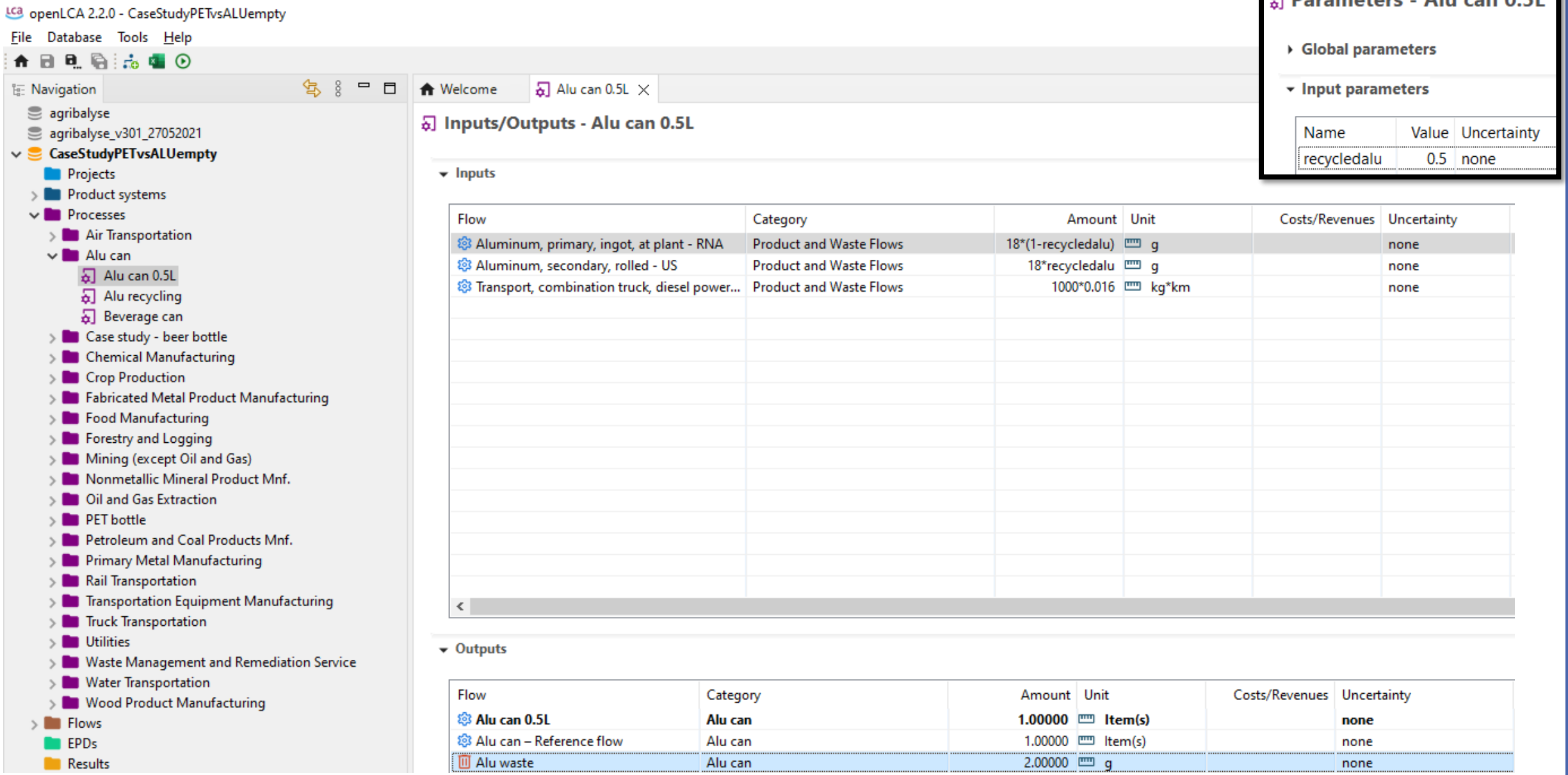
- **Alu can 0.5L**
  - Input flow (Aluminum, primary, ingot); (Aluminum, secondary, rolled); (Transport, combination truck)
  - Output Flow (Alu can - Reference flow); (Alu waste)
  - Quantitative reference (Alu can 0.5L).

- **Alu recycling**
  - Input flow (Aluminum recovery, transport); (Empty Alu can)
  - Output Flow (Alu waste).
  - Quantitative reference (Aluminum, secondary, rolled).

- **Beverage can**
  - Input flow (Alu can 0.5L).
  - Quantitative reference (Empty Alu can).



Alu Can 0.5L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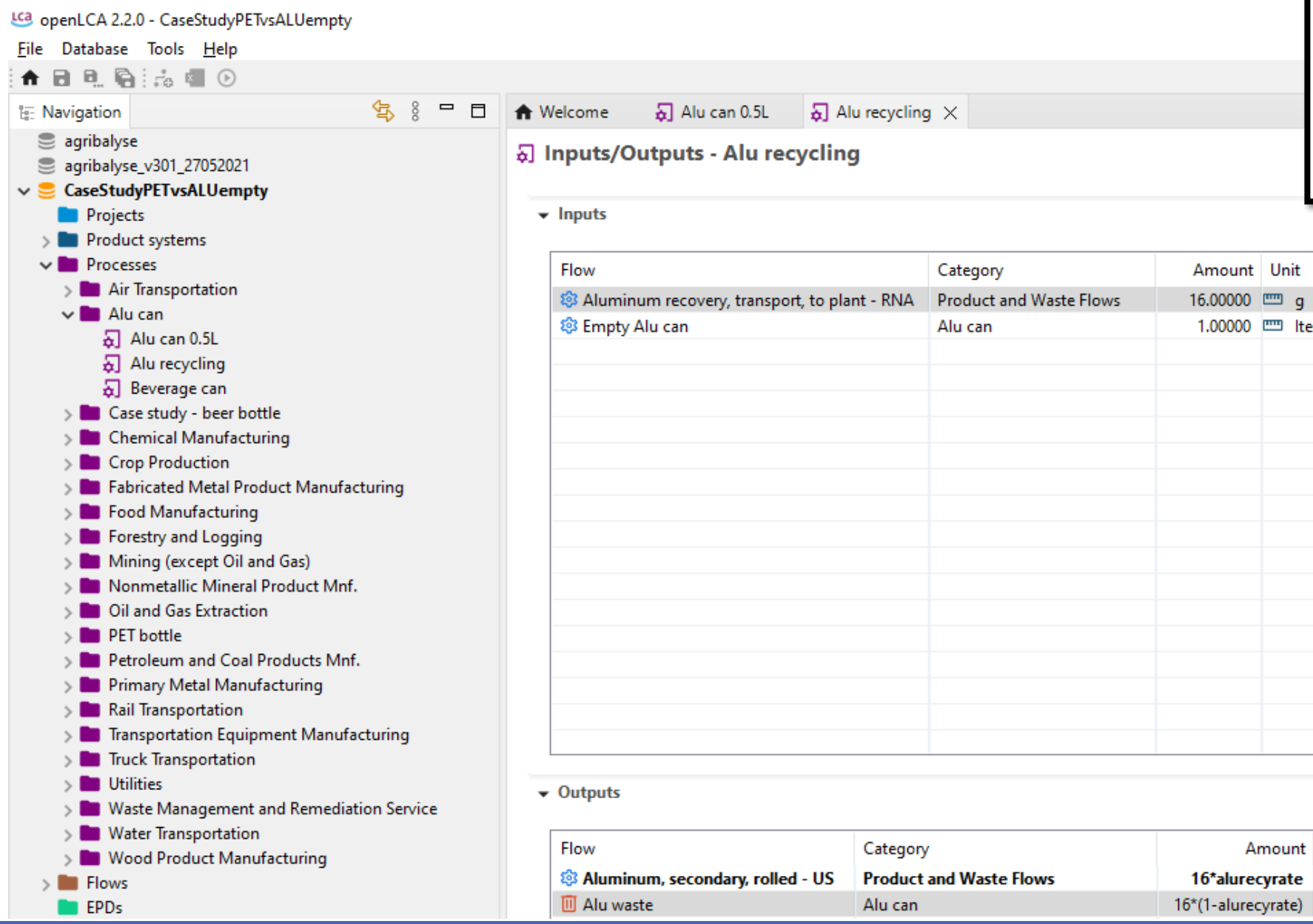
Results
Welcome
Alu can 0.5L
Inputs/Outputs - Alu can 0.5L
Inputs
Flow | Category | Amount | Unit | Costs/Revenues | Uncertainty
Aluminum, primary, ingot, at plant - RNA | Product and Waste Flows | 18*(1-recycledalu) | g | | none
Aluminum, secondary, rolled - US | Product and Waste Flows | 18*recycledalu | g | | none
Transport, combination truck, diesel power... | Product and Waste Flows | 1000*0.016 | kg*km | | none
Outputs
Flow | Category | Amount | Unit | Costs/Revenues | Uncertainty
Alu can 0.5L | Alu can | 1.00000 | Item(s) | | none
Alu can – Reference flow | Alu can | 1.00000 | Item(s) | | none
Alu waste | Alu can | 2.00000 | g | | none
Welcome
Alu can 0.5L
Parameters - Alu can 0.5L
Global parameters
Input parameters
Name | Value | Uncertainty
recycledalu | 0.5 | none

Alu Recycling



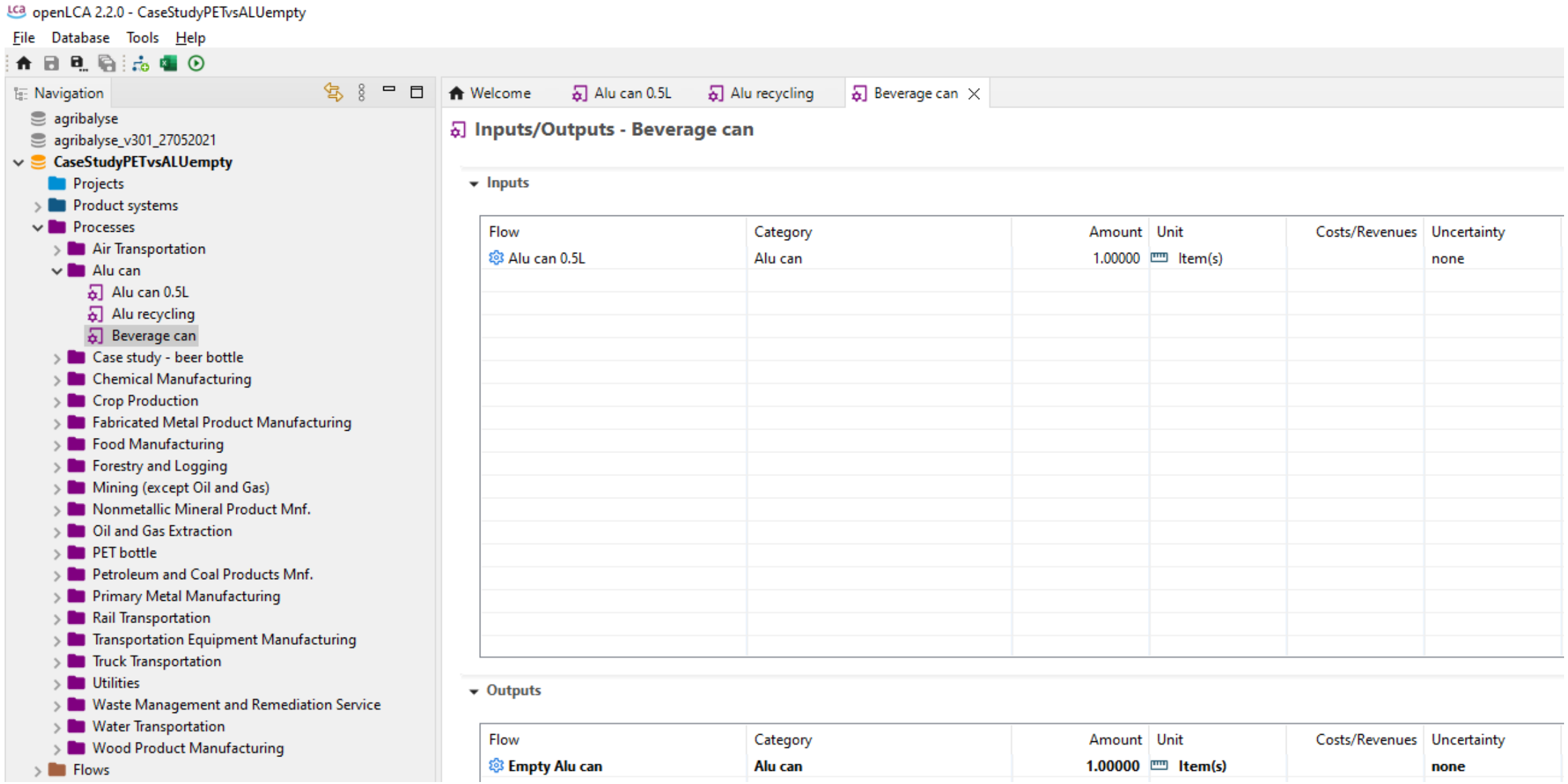
Parameters - Alu recycling

Global parameters

Input parameters

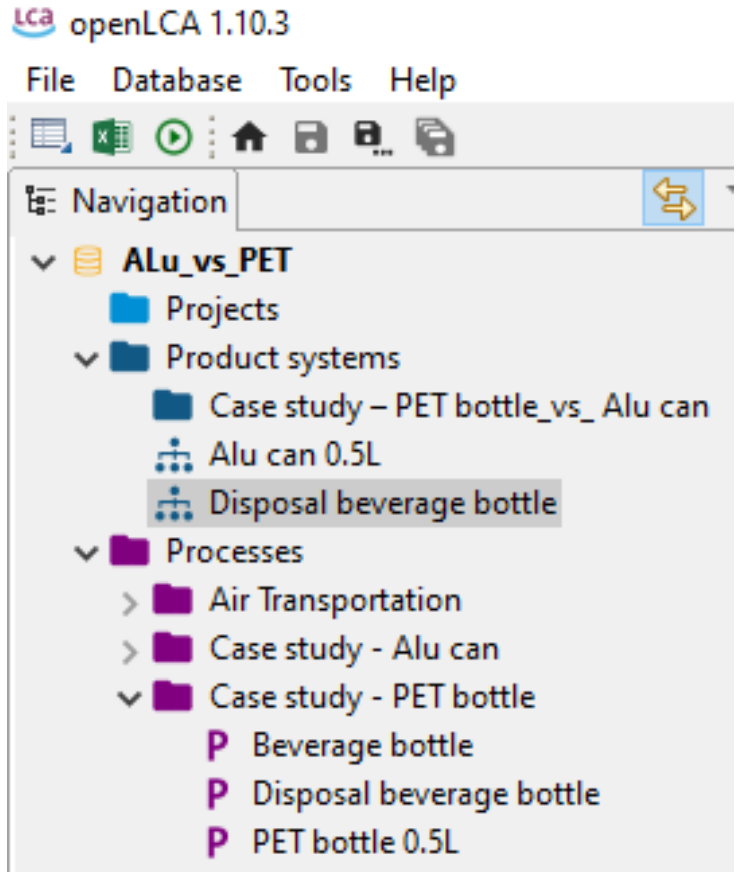
Name	Value	Uncertainty
alurecyrate	0.9	none

Beverage Can



Create Product Systems

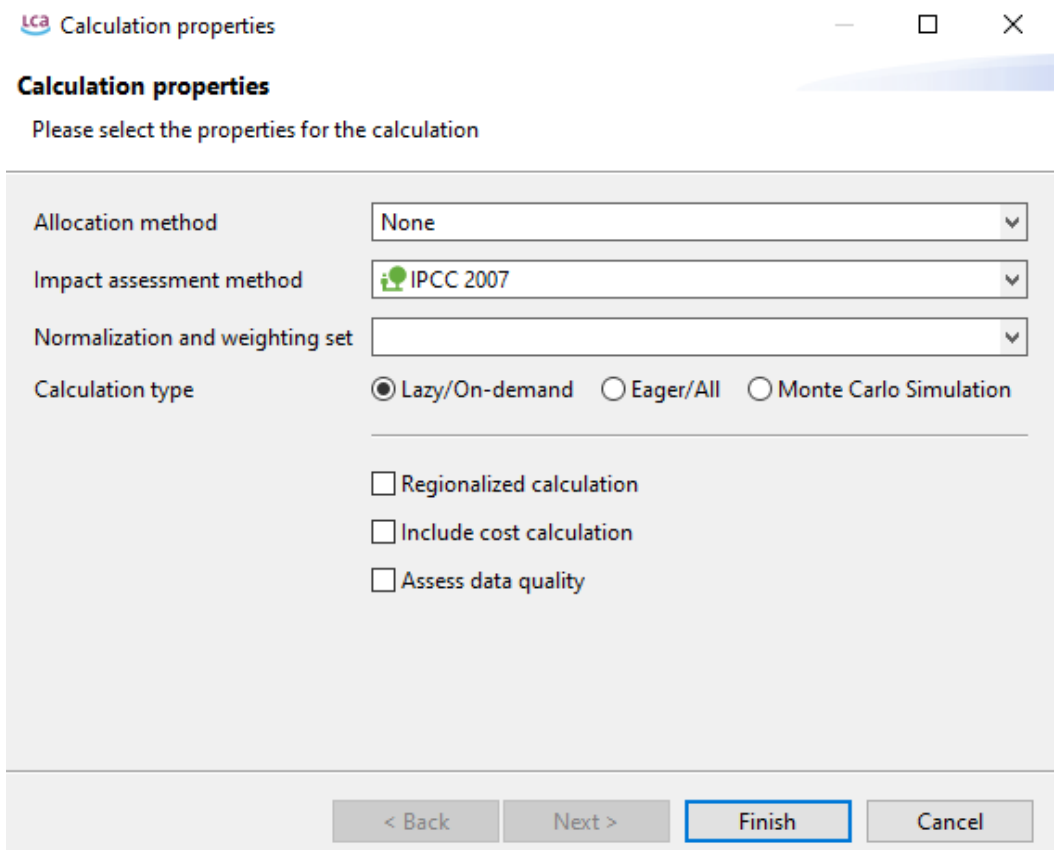
- Right click on Product systems and create a new child category called ‘Alu can 0.5L’. Then, Open the process “Alu can 0.5L” and click on “Create Product System ” to create a new product system:



- Alu can 0.5L
  - Name: Alu can 0.5L
  - Reference process: Alu can 0.5L
  - To connect the upstream chain, ensure ‘Auto-link processes’ are checked.
  - Preferred process type: Unit process.
  - Click the 'Finish' button.

Impact Assessment

- To assess the impact of this system:
  - Click on the “ Calculate” button (in the “General Information” of the product system tab),
  - Select the LCIA-method ‘IPCC2007’, you can choose “Quick result”, or “Analysis” if you want to see Sankey diagram.
  - Click finish.



Class Participation 14:

- Compare the results of impact assessment for Aluminum Can and PET bottle based on LCIA-method ‘IPCC2007’:

Source from https://www.openlca.org/wp-content/uploads/2015/11/1412_GreenDelta_LSA-Case-study_Comparison-of-PET-bottles.pdf