



openLCA case study
of a beer bottle: Aluminium can vs PET bottle

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1 Tutorial Goal

This tutorial aims at explaining a typical Life Cycle Assessment example, while using and discovering openLCA software. Please consider that this is not a real LCA. Though personal research, these figures are given as example and are not meant to be accurate.

This example is based on the “U.S. Life Cycle Inventory Database”, which is free to use. Moreover, it combines the latest ecoinvent assessment methods which allow impact assessment of models to be displayed and compared.

Using a step-by-step method, this tutorial gives you an understanding of working with openLCA. If you feel that some steps are missing (instructions are not clear enough), please first refer to the basic help documentation (www.openlca.org/documentation). Otherwise consider using the forum to ask your question: www.openlca.org/forum

2 Description of the functional unit

The goal of this case study is to compare two options of a typical 500ml beer bottle. The packaging could be made of aluminium or of PET (PolyEthylene Terephthalate). Both options do not look the same, but have the same function: contain and protect the precious beverage.

When designing a life cycle analysis you always start by defining your functional unit. In this tutorial we like to analyse different material design of a beer container, so the functional unit could be called **500ml beer bottle**. The first option will be called ‘PET bottle’ and the other one ‘ALU can’. 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. Also, the bottle is considered to be produced, consumed and disposed of nowadays in the USA.

Creating a Life Cycle Analysis, one should always be sure of its capabilities. In the following case study, there are a lot of approximations; exact weight of can and bottle, origin of aluminium, current recycling rate, transport and energy needed and some other processes can only be guessed or estimated. Nevertheless we are sure to be able to give a good clue about potential environmental impacts. At last, 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.

3 Build and compare systems

3.1 Information on the database

At first, one needs to get a life cycle inventory database. This case study will be based on the database created by the NREL laboratory (www.nrel.gov/lci). To ensure a smooth example, we already downloaded this database, classified flows and processes, changed and added some processes (and flows). Moreover, we inserted ecoinvent methods and created a mapping between NREL flows and ecoinvent impacts. These improvements allow producing a complete LCA for free.

Attention: Please consider that the improved database also contains some approximations (NREL andecoinvent flows may not be always exactly the same) and gaps (some NREL flows cannot be compared and thus have no environmental impacts). This database must be rather used only in this case study or very cautiously for other intended purpose (it is at your own risk and we cannot be held responsible for it).

3.2 Install the database

To install the database, follow these steps:

- Download the database CaseStudy_PETvsALU_empty.olca from the openLCA-website.
- To add it to your database, right click on your MySQL connection (e.g. 'MySQL at localhost:3306') and select 'Import database'.
- Select the downloaded olca-database, rename and import it.
- You can start with the case study, now.

3.3 Build the 'PET bottle' model

To ease your discovery of openLCA, some flows and processes have already been created. Nevertheless, to practice and improve your understanding, there are a few things you need to do.

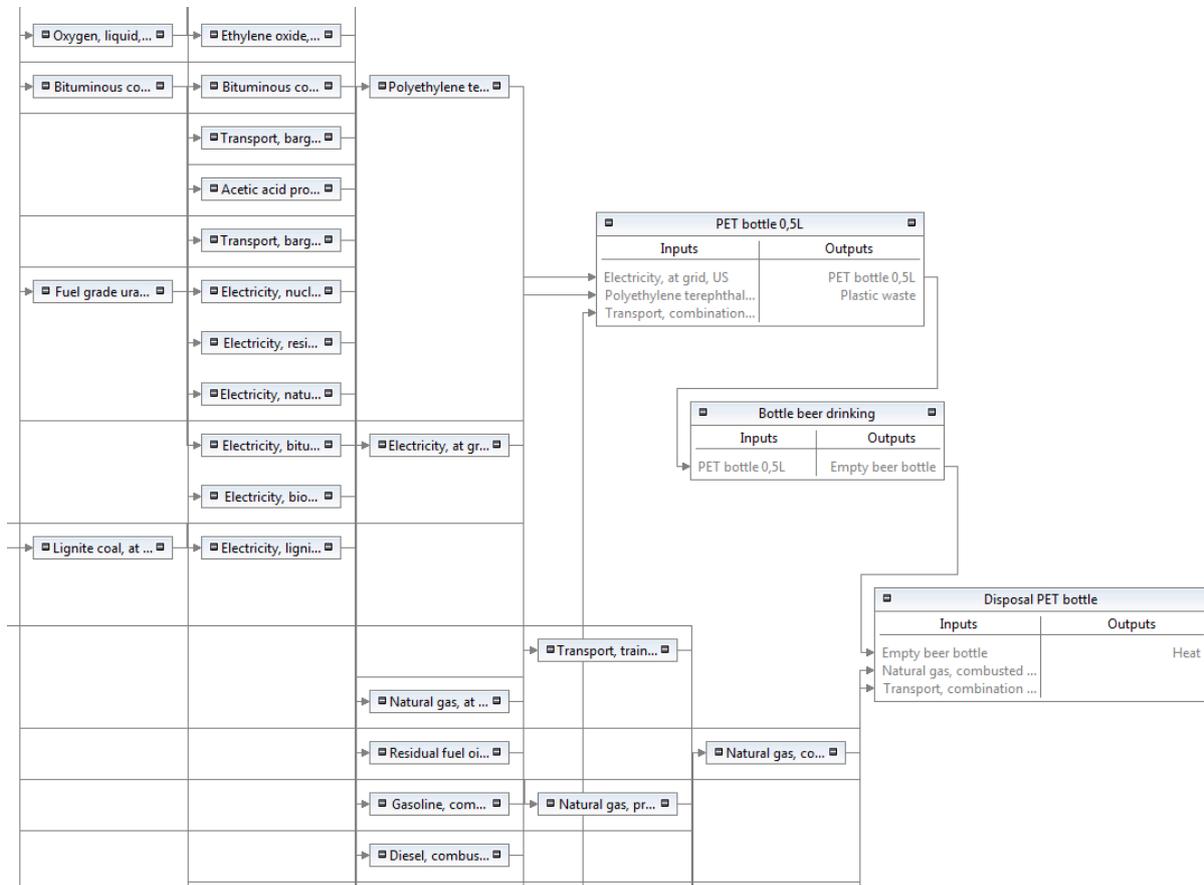
- Go to **Flows** and right click on "Case study – beer bottle" to create a new flow:
 - Name: Heat
 - Description: Case study - beer bottle
 - Flow type: Product
 - Reference flow property : Net calorific value
- Go to **Processes** and right click on 'Case study – beer bottle' to create a new process:
 - Name: Disposal PET bottle
 - Description: Case study – beer bottle
 - Quantitative reference: Heat
 - Add inputs as described below
 - Save and close

Flow	Category	Flow type	Amount	Unit
Empty beer bottle	Case study – beer bottle	Product	1	Item
Natural gas, combusted in industrial boiler (US)	Product and waste flows	Product	m ³	0.0034
Transport, combination truck, diesel powered (US)	Product and waste flows	Product	kg·km	430*0.026

- Before adding a new Product system, right click on **Product systems** and create a new child category called 'Case study – beer bottle'. Then right click on it to create a new product system:
 - Name: PET bottle
 - Description: Case study – beer bottle
 - Reference process: Disposal PET bottle

- To connect the upstream chain, ensure 'Add connected processes' and 'Connect with system processes if possible' are checked
- Click the Finish-button

■ Connections should look like this:



■ To assess the impact of this system:

- Click on the button (on the openLCA main navigation),
- select the LCIA-method 'CML2001',
- and click calculate.
- Now, you can have a look at the full impact assessment data of this model.

Even if our functional unit is the PET bottle, it is useful to consider the disposal as the reference process, so it can be considered part of the whole process. Another way to deal with waste management is to consider the waste as an input of the reference process. This is further described in the case study: [Remodelling of a park](#)

3.4 Build the 'ALU can' model

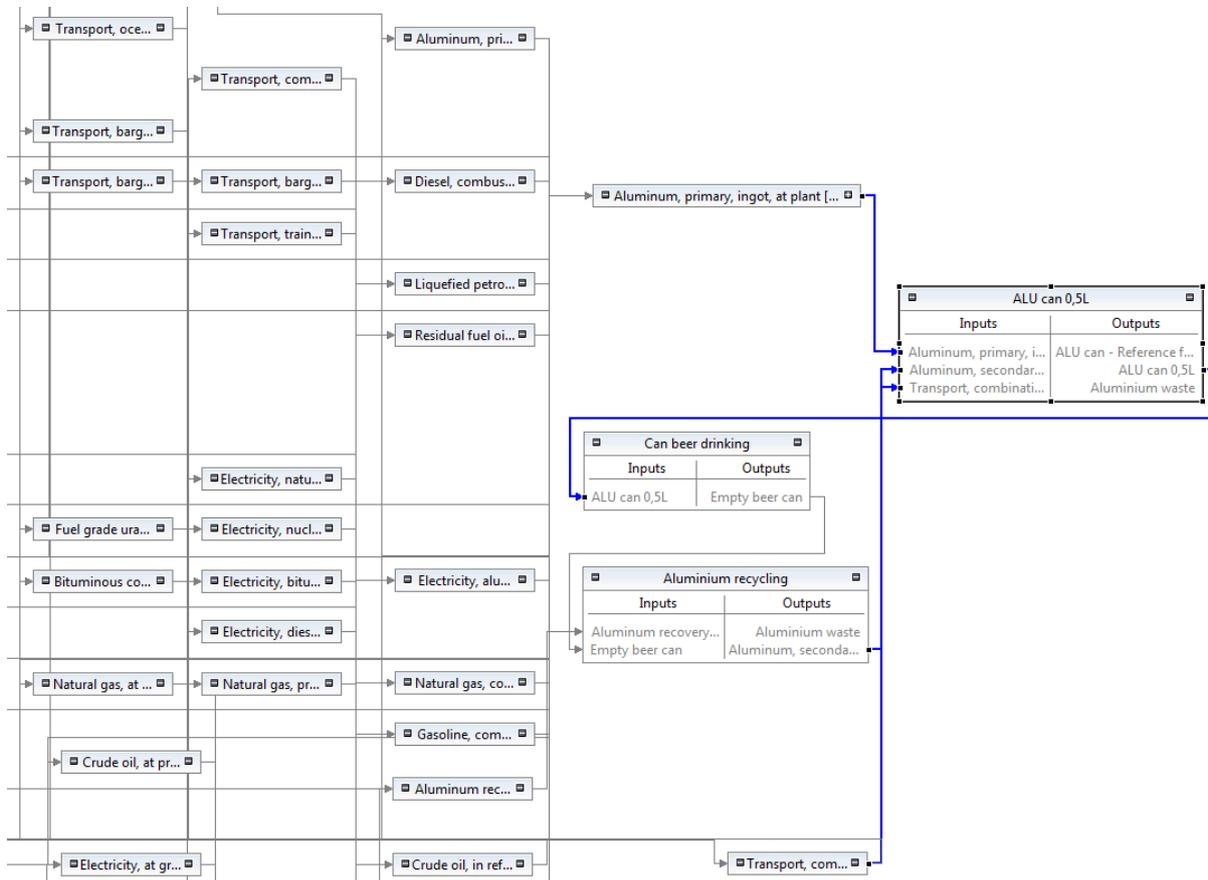
This time, you don't need to create processes or flows because this has already been done. Anyway, you should first have a look at the processes included in "Case study – beer bottle". Find out the quantities and how they are supposed to be connected.

■ Go to **Product systems**, right click on 'Case study – beer bottle' to create a new product system:

- Name: ALU can
- Description: Case study – beer bottle

- Reference process: ALU can 0,5L
- Ensure “Add connected processes” and “Connect with system processes if possible” are checked
- Click the Finish-button

■ This should look like this:



■ To assess the impact of this system:

- Click on the  button (on the openLCA main navigation),
- select the LCIA-method ‘CML2001’,
- and click calculate.
- Now, you can have a look at the full impact assessment data of this model.

3.5 Important explanations on flow management

A product system must be considered with boundaries. Inside these, any process and connection can exist. The only interactions with the environment are the element flows and the functional unit (also called here the reference exchange). This product flow leaves the system and all calculations (leading to the LCI) are based on this flow. This means, it cannot be at the same time linked to other processes and/or used in internal loops. This would lead to false results. The trick is thus to have one flow as reference (here: ‘ALU can - Reference flow’), and one used for internal connections (here: ‘ALU can 500ml’). Moreover, both flows must be allocated with the same factor (here: 0.5 and 0.5).

Waste flows are neither element flows nor product flows. But when it comes to computing the LCI, openLCA considers waste flows like product flows. In our case, ‘Aluminium waste’ may be charged with a part of the impacts (because it looks like a multi-output process) and a special allocation must

be achieved to avoid that. The best is to set a null factor to the waste. Regarding the 'ALU can 500ml' process, allocation factors are:

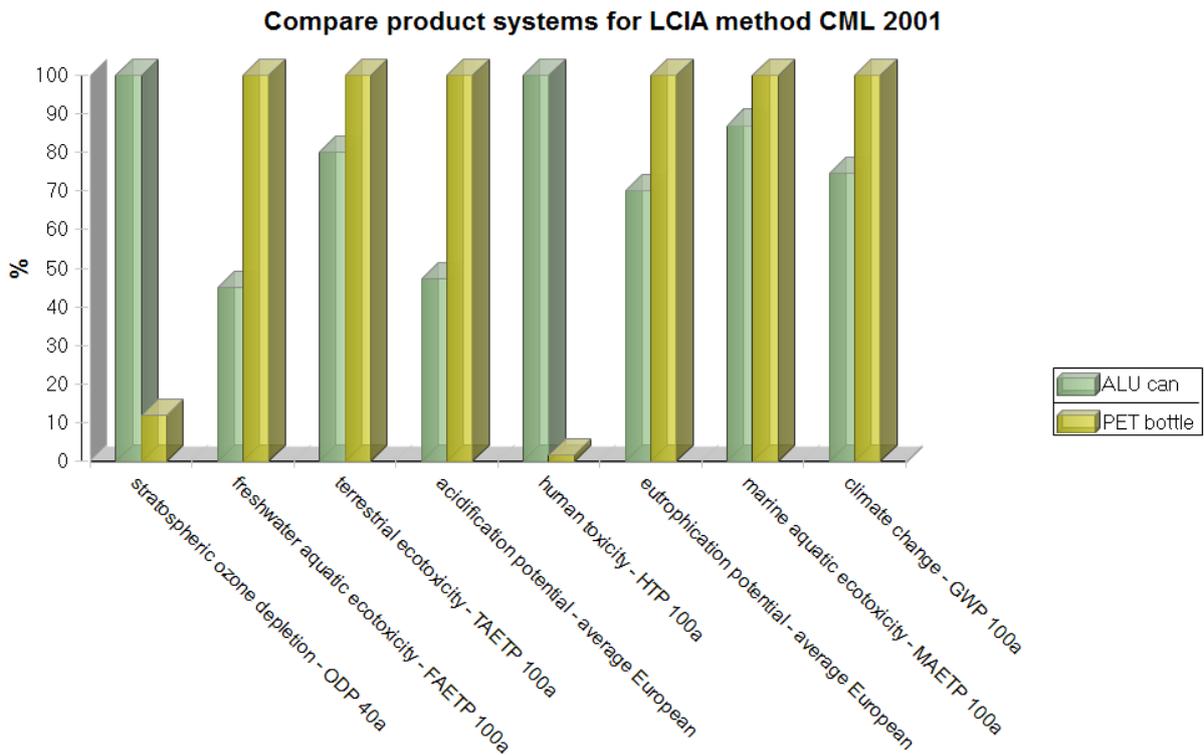
- ALU can – reference flow : 0.5
- ALU can 500ml : 0.5
- Aluminium waste : 0

In any case, when a process has a multi output, allocation factors must be set up. Otherwise, openLCA will compute the model with wrong settings. It is essential to define correct factors regarding instructions above.

3.6 Compare results

To compare the results of the two product systems, PET bottle and ALU can, you need to create a new Project in openLCA:

- Right click on **Projects** and create a new child category called 'Case study – beer bottle'. Right click on it to create a new project:
 - Name: Beer bottle: PET vs ALU
 - Add the 2 product systems
- In the comparison tab, select the 'CML 2001' LCIA method, and draw a chart with the following main categories:
 - Acidification potential – average European
 - climate change – GWP 100a
 - eutrophication potential – average European
 - freshwater aquatic ecotoxicity – FAETP 100a
 - human toxicity – HTP 100a
 - marine aquatic ecotoxicity – MAETP 100a
 - stratospheric ozone depletion – ODP 40a
 - terrestrial ecotoxicity – TAETP 100a
- The result should be like this:



In six categories out of eight, the PET bottle has higher impacts. An overall conclusion cannot be drawn without deeper analysis.

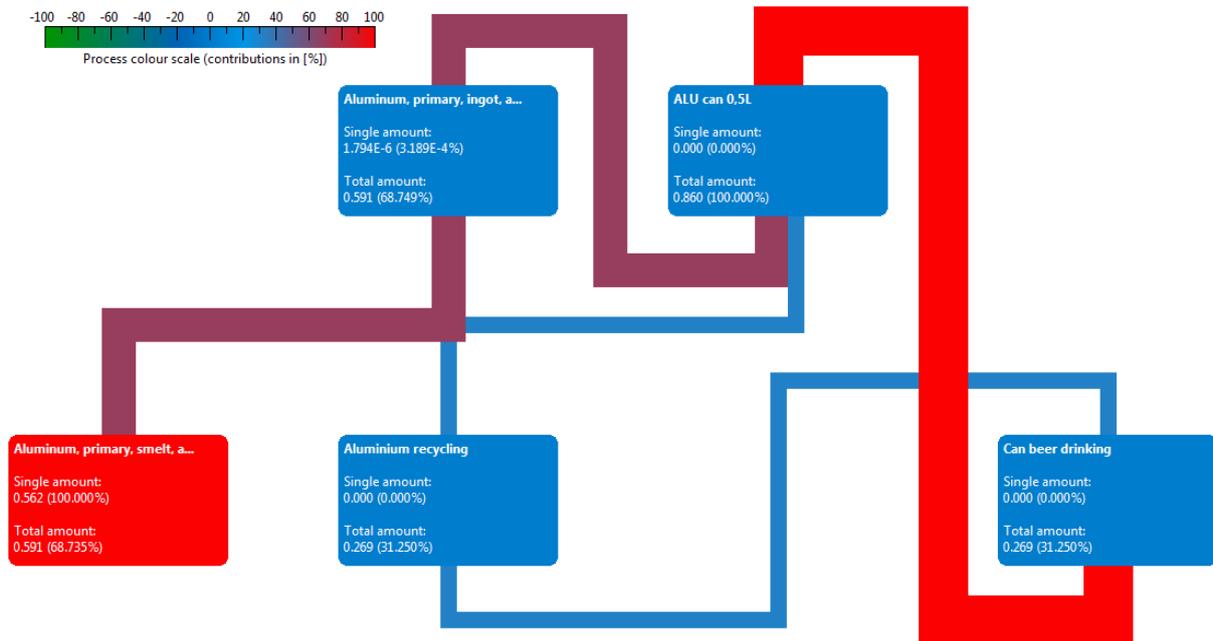
Another way to compare data is to export both impact assessments to Excel. To do so, once you have calculated the impact assessment, a new icon  in the menu shows: 'Export to MS-Excel file'. Click on it and save both files. You can now manage the raw data as you want and produce new charts and further calculations.

4 Analysis of the aluminium model

4.1 Sankey diagram

A Sankey diagram can help to find the source of an impact. Regarding the previous comparison, it is interesting to analyse the aluminium model to find out why 'stratospheric ozone depletion' and 'human toxicity' are so high. The following Sankey diagram shows that the high impact on the human toxicity comes entirely (or almost as there is a 5% cut off) from the aluminium production. To create the same diagram, please refer to [Sankey Diagram](#).

Product system: ALU can
 Impact category: human toxicity - HTP 100a
 Cut-off: 5.000%



4.2 Recycling scenarios

Creating scenarios helps checking the influence of parameters and their impact on the final result. In our study, we can point out two hot spots:

- Part of aluminium needed for a can that comes from recycled aluminium (Parameter: recycledalu in the 'ALU can 500ml' process)
- Recycling rate of an aluminium can (Parameter: alurecyrate in the 'Aluminium recycling' process)

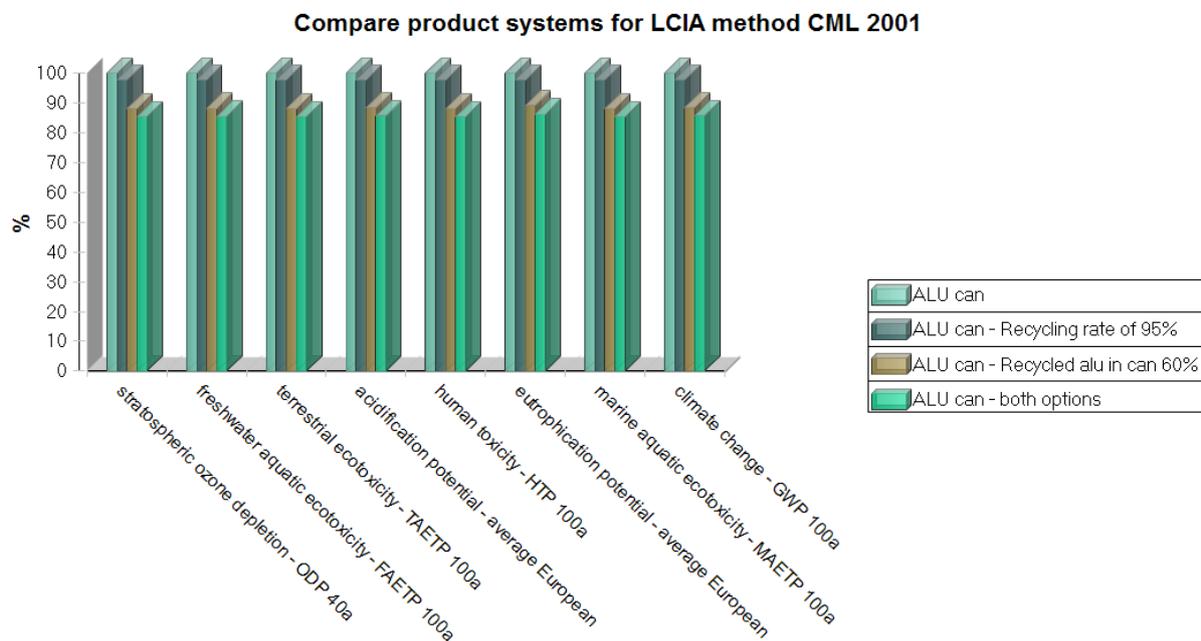
These two processes have been built with the two mentioned parameters inside; ensure you find and understand them.

The best way to create a scenario is the use of product system's parameters. Without changing any data in processes, they simply overwrite process' parameters and allow new values for calculations.

- Create a new product system to change the Parameter **recycledalu**:
 - Copy-paste the 'ALU Can' product system and rename it to 'ALU can - Recycled alu in can 60%';
 - In tab 'Parameters', add recycledalu with value 0.6;
 - Assess the impact of this system and save it.
- Create a new product system to change **alurecyrate**:
 - Copy-paste 'ALU Can' and rename it to "ALU can - Recycling rate of 95%";
 - In tab 'Parameters', add alurecyrate with value 0.95;
 - Assess the impact of this system and save it.
- Create a new product system to change both parameters
 - Copy-paste 'ALU Can' and rename it to 'ALU can – both options';

- In tab 'Parameters', add recycledalu with value 0.6 and alurecyrate with value 0.95;
- Assess the impact of this system and save it.

- Create a new project 'Recycling options for an aluminium can', with the four scenarios:



The chart allows a few conclusions:

- Increasing the recycling efficiency from 90% to 95% improves slightly the impact in each category.
- Changing the recycled part of aluminium from 50% to 60% has a greater positive effect.
- Considering both improvements yields to a 15% reductions of the environmental impact.

5 Conclusions

This case study has only an educational purpose. Thus, results shouldn't be considered as part of a complete Life Cycle Assessment.

Nevertheless, it gives a good clue about how to model and compare different product designs. This case study shows also how recycling scenarios can be modeled and used to find the recycling way with the least environmental impacts. Especially in case of allocation, multi-output processes, waste management and closed loops, there are few model rules which need to be considered.

6 References

To improve this case study and go further into details, you can have a look at the following websites and documents:

- Life Cycle Assessment of aluminium products: <http://www.alueurope.eu/sustainability/life-cycle-assessment/>
- "LCA and recycling policy - a case study in plastic": <http://www.lcacenter.org/LCA9/presentations/208.pdf>

- "Aluminum Association challenges PETRA's LCA study": <http://www.life-cycle.org/?p=805>
- "Life Cycle Inventory of 100% postconsumer HDPE and PET recycled resin from postconsumer containers and packaging":
http://www.napcor.com/pdf/FinalReport_LCI_Postconsumer_PETandHDPE.pdf