Integrating LCI Data and Energy System Modelling

Kathrin Volkart and Christopher Mutel
Laboratory for Energy Systems Analysis, Paul Scherrer Institut, Switzerland

Electricity in ecoinvent v3

The new version of the LCI database ecoinvent v3 includes >1000 datasets. Thereof, >100 datasets are electricity-related. So ecoinvent v3 has a strong focus on electricity.

The reason for this focus is that the contribution of electricity to the environmental impacts of a product can be substantial:

- Preliminary results
- Environmental impacts of a product can be substantial

Among the mentioned electricity-related datasets, there are so-called electricity markets. The modelling of the electricity market is based on the two fundamentally different system models of ecoinvent v3:

- For the attributional and cut-off version of ecoinvent v3, market shares of suppliers are equal to their past (currently 2008/09) production volumes.
- For the consequential version of the database, all technologies that are classified as being erodible (i.e. competitive) supply to markets in proportion to their past production volumes. So the current modelling of electricity market mixes in ecoinvent v3 is upsampling for prospective and consequential LCA studies. For such studies, we propose the interaction with so-called energy system models.

Interaction of ecoinvent v3 Data and Energy System Models

Energy system models (ESM) consider the entire energy system from the resources to the demand. They include technical (e.g. efficiency, availability) and economic characteristics (e.g. investment cost, O&M cost).

Based on this techno-economic framework, scenarios for the future energy system can be developed, and scenario-dependent electricity mixes can be quantified using cost optimisation algorithms.

With the respective ESM, the electricity mixes of various scenarios can be defined for the region of the LCA study. The mixes can then be compared with and possibly replace the ecoinvent v3 electricity mixes. They can additionally be used for sensitivity analysis. So ESM can produce future and consequential electricity mixes required for prospective and consequential LCA studies.

Taking the aforementioned interaction of LCI databases and ESM one step further leads to the integration of the two. Integration means that the ESM is complemented with information that is available from the ecoinvent v3 LCI database.

Modelling Challenges

- Finding equivalent processes in the two models, i.e. allocation of one ecoinvent v3 to each ESM process
- Harmonization of ecoinvent v3 and ESM data by adjusting information on:
  - energy carrier flows
  - units
  - efficiencies
- Regionalization, i.e. choice of the ecoinvent v3 region(s) used to model the corresponding region in the ESM
- Modelling of future technologies that are not represented in ecoinvent v3
- Modelling of the energy own-use of the energy sector

Results from the Integration

Life-cycle emissions of the whole energy system calculated using an integrated model that is based on the integration of a multi-regional global ESM and ecoinvent v3

Conclusions

Considering the importance of the electricity mixes for overall LCA results, this topic has to be thoroughly addressed.

The electricity markets derived from ecoinvent v3 may neither be realistic nor consistent. This specifically concerns the modelling of future and marginal electricity mixes for prospective and consequential LCA studies.

Therefore, we propose an integrated approach, which is based on ESM. It provides consistent consideration of the (economic) competitiveness and vintage of production technologies for the marginal mixes and results in electricity mixes for various (future) scenarios.

Environmental LCA and ESM can complement each other. Close interaction of LCA with energy system modelling of the respective region(s) of analysis is therefore recommended in order to gain realistic future and consequential electricity mixes.

The full integration of ecoinvent v3 and ESM leads to additional results and benefits going beyond solving the problem of modelling electricity markets.