Report: workshop on the integration of energy scenarios into LCA - side-meeting of LCM 2017, Luxembourg

Contributors to the report

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Introduction

A large variety of models exists to make projections about future technological and environmental changes. These tools can be used in life cycle assessment (LCA) as data inputs to build life cycle inventories that are more representative of future situations. Nevertheless, the realization of a practical connection between these elements can be challenging and time-consuming. With the development of new tools from the LCA field and from other data-intensive domains, there is an opportunity to stop reinventing the wheel in every project and to create a common open framework addressing this issue. The goal is to build a suite of tools allowing systematic connections, following unified protocols for data integration. These tools can then be applied to any project and provide greater transparency for data manipulation and increased traceability of data input, making prospective LCA more easily reproducible than existing attempts.

The focus of this meeting was on energy scenarios given its limited duration and the important role of energy in LCAs. However, this issue is not limited to one sector but to any sectors likely to face significant changes in the future (e.g. transportation, agriculture, mining etc) and concerns also non-energy flows (e.g., emissions, recycling shares, material efficiency, etc). This report summarizes the current issues and challenges identified during the workshop, lists the existing and reusable tools or data. The next step would be to set a tentative short-term/medium-term/long-term goal for the integration of prospective models into LCA.

Current issues and challenges for the use of prospective models in LCA

LCA requires a high level of detail which may imply to mix models with various technological/sectoral/geographical scopes. Prospective models are not designed to exchange and to connect with each other. By default, a full coupling is impossible in practice and mixing models is challenging due to differences/inconsistencies between them (e.g.: underlying assumptions, technology details and level of aggregations, in the

input data and output format, temporal scope, etc). In addition, some parts of prospective LCA models do not have dedicated projections available. In presence of these inevitable data gaps, current situations are often used as a proxy to future situations implying mismatch in terms of time.

It is not always straightforward how to match technologies from prospective models to available LCI datasets:
- Technologies unavailable at a commercial scale are usually not represented in current LCI databases but make their appearance in scenario (e.g. carbon dioxide capture and storage, a central technology in the most aggressive climate change mitigation scenarios).
- Some LCA datasets are not available for certain countries (e.g. power from natural gas in Switzerland).

Matching technologies is made by hand and arbitrarily relying on name "resemblance", between the prospective model and the technologies in the LCA database, or on "more or less" informed guesses (e.g. assuming coal power in India can be represented by coal power in Poland). Energy system modelers on one hand, as well as LCA practitioners on the other hand, usually do not have an expert knowledge of each technology analyzed, and are not always able to substantiate the matching properly.

Technological and geographical details are sometimes higher in LCA database than outputs from prospective models which requires disaggregation. This work can be highly time-consuming and adequate data are often missing. It is for example misleading to disaggregate based on current market share as they are likely to evolve over the years.

In some other cases, the detail in prospective models is higher than in the LCA database, technologies must be aggregated to match them to the technologies represented in the LCA database, hence losing scenario detail.

Prospective models usually describe multiple scenarios to cover a large set of plausible changes in the system. It is important that prospective LCA also covers various scenarios. For this reason, the connection should be as easy as possible allowing to broadcast many different scenarios in the LCI.

For increased consistency, it is important to harmonize the technological information contained in the LCA model and in the prospective models (e.g. efficiency and lifetime in energy production). One should also consider that these may vary according to the underlying scenarios and in time.

Uncertainty is not addressed at all, only variability is usually evaluated. More generally, it is challenging to assess the quality of prospective data.

Many different types of prospective models exist, and picking the most adequate for the study at hand is challenging. In many studies cost-optimization models are used but it is questionable whether they always correspond to an accurate representation of the future. This will for example depend which sector or demand area is represented by the model (i.e. households are not likely to behave as perfect cost-optimizers while industries are more likely to do so). Nevertheless, with optimization models, it is possible to relax some constraints to reach a more accurate representation of suboptimal behavior.

Another common criticism is the lack of transparency of prospective models. Moreover, no crystal-ball exist and these models are imperfect in many senses (e.g. cannot capture radical shifts).

The effects of future environmental degradations on the future technosphere (e.g. change in solar Direct Normal Irradiance and change in heat demand due to climate change, etc.) or on the future biosphere (e.g. change in crop productivity due to modified weather pattern, increased ore grade degradations) are not taken into account in existing prospective LCAs.

LCIA methods are not always valid for actions or impacts occurring into the future. For example, indicators with a time-horizon should be adapted to take this into account. This also include feedback effects, such as how GWPs change with GHG atmospheric concentration. Similarly, when weighting is used, the weight attributed to different impacts might evolve over time.

Another aspect is the integration of the LCA data into prospective models: there the issue of double counting is not clear to many people.

Possible solutions
Create a repository with LCI datasets of emerging, new and future technologies.

Common repository for metadata on matching activity and product names for various data sources: energy (IEA, WEC, MESSAGE, energy plan, TIMES flavors), copper, building materials (Niko), future emissions of energy production technologies (IMAGE), ecoinvent, EXIOBASE. This repository could contain:
- Translation/mapping table from this model to existing LCA database;
- Sources to disaggregate or aggregate the various models;
- Uncertainty values;

- Detailing important parameters and assumption in the model for harmonization.

Define a standard for mapping prospective models outputs to inputs of LCA models. This could look as a general strategy, an ontology, a protocol or several updatable mapping files explaining how to deal with aggregation, disaggregation, missing information, etc. Practical information such as default technologies or region proxies to use whenever you do not have enough detail in scenario data. This could look for example: (1) **if** the region doesn't exist **then** move up one regional level, (2) Apply LCA allocation rules from ISO14040 **if** multioutput process **else** uses allocation rules.

Common repository for examples of how people have used outside data to transform LCI databases using. Wurst (https://github.com/IndEcol/wurst) is an example but other prospective or non-prospective work have dealt with similar issues (e.g. Christopher Oberschelp with disaggregation)

Common repository for open-source tools to build LCI inventories (including uncertainty). Examples are manipulation of egrid to create electricity generators in the US, manipulation of motorcycle database to build motorcycle inventories, hydropower LCI, transportation distances, transportation emissions from HBEFA.

Other: a tool to make some cut in the inventory in order to avoid double-counting, a more parametrized version of ecoinvent.

Create a best practice document or an article about how to incorporate data from other models into LCIs. Example of practical best practice:
- The tools don't need to all be in the same language or programming paradigm but should follow some standards e.g. in Python, create reproducible environments, i.e. conda env export > env.yml.

- Traceability is paramount. For this reason, when using public data, one must verify if there are a permanent repository and DOI using a service like Zenodo (https://zenodo.org/). Otherwise, be sure to list exact version number and some unique identifier, e.g. SHA hash.

- State the limitations of the prospective models explicitly.

Data and tools available:
Mapping table to connect mainstream energy scenarios to ecoinvent technologies (e.g. IEA, European Commission reference scenario, Energy Information Administration).

Prospective average mixes from 40 countries for 2020, 2030, 2040 and 2050.

WURST (https://github.com/IndEcol/wurst) allow to modify datasets at the database level based account for the evolution of the technologies: modify energy markets, modify key parameters in energy production sources (e.g. efficiency), modify emissions, etc.
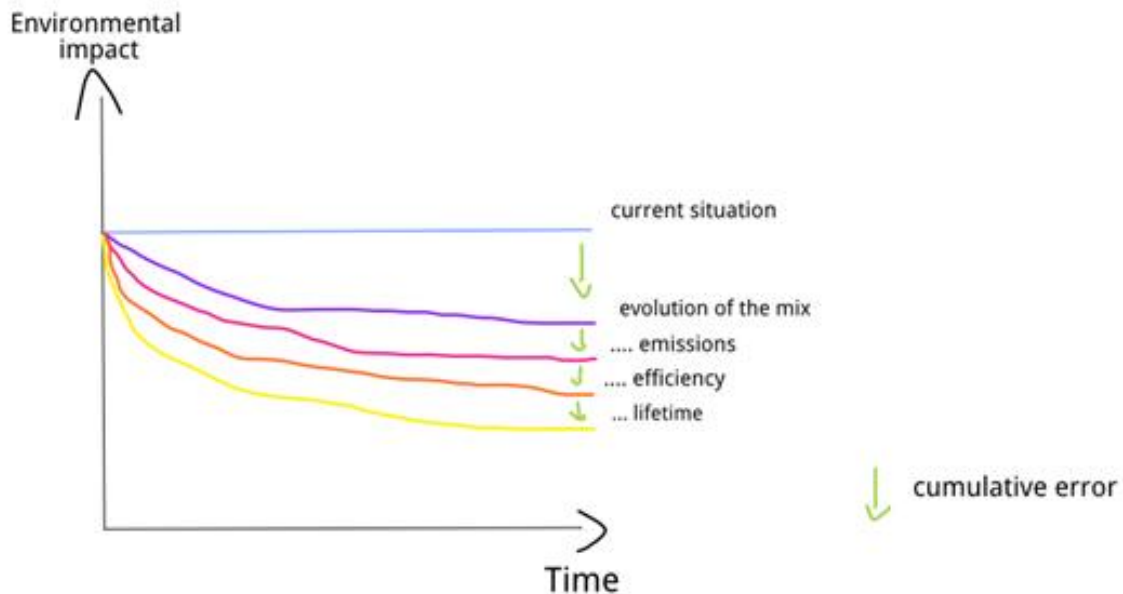
Brightway2 (https://brightwaylca.org/) can be used to integrate external models into LCA

List of existing initiatives and forum on this topic: task 72 of the International energy agency (EBC program), Reem, Reflex, Store & go.

The LCA Interest Group of SETAC North America has been working on a "Capability Roadmap" dealing with "Inventory model description and revision." The discussion has been focusing on how LCA practitioners can describe product system models and share them with one another, even across different software systems. This project is related to as it deals with changing inventory models: http://www.setac.org/resource/resmgr/advisory_groups_north_america/SNA_LCA_IG_Roadmap-Inventory.pdf

Why is using energy scenarios important in prospective LCA:

Three important layers in prospective LCA:

Scope	Nature
Single technology, technosphere only	Change of the technologies: energy and/or material efficiency, direct emissions, lifetime, recycling rate at the end of life, etc.
Regional or global, technosphere only	Change of composition of market mixes electricity generation, transportation, and other non-energy sectors.
Regional or global, technosphere and biosphere	Larger changes affecting the system as whole or part of it: negative effects from upcoming environmental degradation (e.g. ore grade degradations, negative climate change effects on infrastructure, etc.), or general industrial trends (e.g. increase in recycling rates, improved tailing treatments, increase material efficiency etc).

The meeting started with the following presentations:

Laurent Vandepaer (Université de Sherbrooke, Canada, and PSI, Switzerland):
- Introduction
- Short description of the use of multiple scenarios to update marginal mixes in ecoinvent and data that spilled-over from this project.

Thomas Gibon (LIST, Luxembourg):
- Feedback on aggregation/disaggregation, life cycle inventory modification, mapping in general, from the development of THEMIS.

Brian Cox (PSI, Switzerland):
- Short description of our use of IMAGE results to modify ecoinvent
- WURST python package

Miguel Fernandez Astudillo (Université de Sherbrooke, Canada):
- Overview of the use of TIMES models together with LCA: what have we learned so far
- Challenges of linking bottom-up tech-rich models (e.g. TIMES) with process-based LCA inventories

Didier Beloin-Saint-Pierre (Empa, Switzerland):
- Integration of energy scenarios in Swiss mobility assessment