LCM Conference Series

Workshop on the integration of energy scenarios into LCA

Side event LCM 2017 - Wednesday 6th of September 2017

PAUL SCHERRER INSTITUT PSI | Wallonie - Bruxelles International.be | UNIVERSITÉ DE SHERBROOKE | LUXEMBOURG INSTITUTE OF SCIENCE AND TECHNOLOGY LIST | NTNU Norwegian University of Science and Technology

Introduction : three important layers in prospective LCA

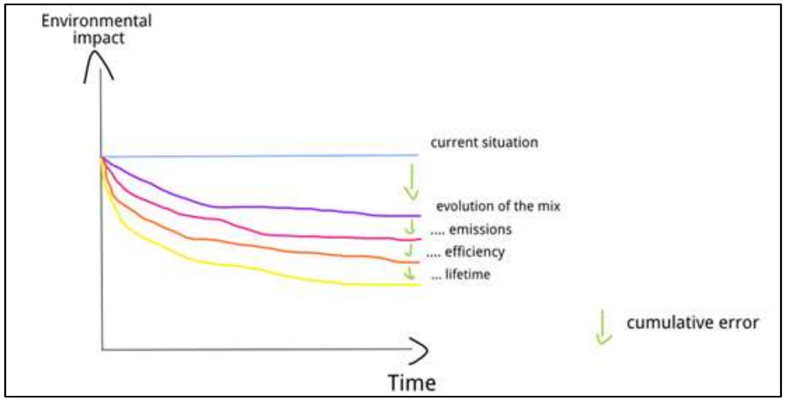
• Single technology, technosphere only	• Change of the technologies: energy and/or material efficiency, direct emissions, lifetime, recycling rate at the end of life, etc.
• Regional or global, technosphere only	• Change of composition of market mixes: electricity generation, transportation, and other 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 degradations (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).

Use energy scenarios in prospective LCA

- Energy scenarios can be integrated into LCA to model energy systems that are more representative of future situations:

  - Information about energy mixes (layer2)

  - Change about single technologies from technological info available in the model (layer 1)



- Energy is a hotspot in many LCAs, this is transferrable to other sectors (e.g. transportation, agriculture, etc.) and vice versa.

Objectives of the workshop

- To determine what has already been done in terms of reusable modules to integrate energy scenarios into LCA, what are the overlaps and complementarities between the existing projects

- To identify the current issues and challenges

- To exchange ideas to solve these and to establish a roadmap with short-term/medium-term/long-term goals to create an open framework for the integration of energy scenarios into LCA. Share the work to take this further.

Structure of the workshop

- Short presentations about recent works on the topic (30 minutes)
- Discussions + address the objectives (1 hour)

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Update marginal electricity mixes in ecoinvent 3.4

Laurent Vandepaer - Wednesday 6th of September 2017

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Update of the marginal electricity supply mixes in ecoinvent 3.4

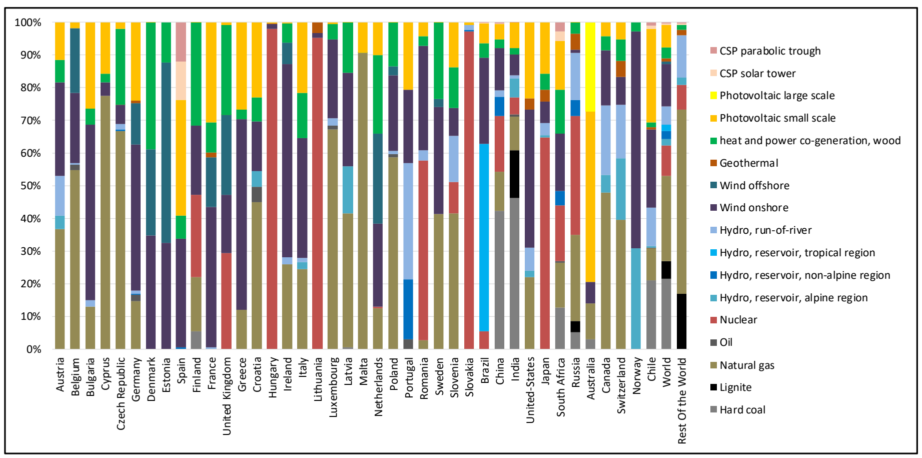
Marginal electricity supply mixes provided in previous versions of the ecoinvent database were based on historical data.

Objectives:

- Provide marginal mixes based on energy scenarios to take into account future market trends and constraints (i.e. which technologies are growing the most)
- *Perform several sensitivity analyses to understand the influence of the key parameters and methodological choices on the mix composition.*

Update of the marginal electricity supply mixes in ecoinvent 3.4

- Compilation of public energy scenarios from 40 different countries to calculate the marginal electricity supply mixes.
- Covering ~76.5 % of the global electricity production in 2015.



Challenges

- Diversity in the origin of the scenarios and their underlying assumptions: use of « current policy » as a comon storyline.

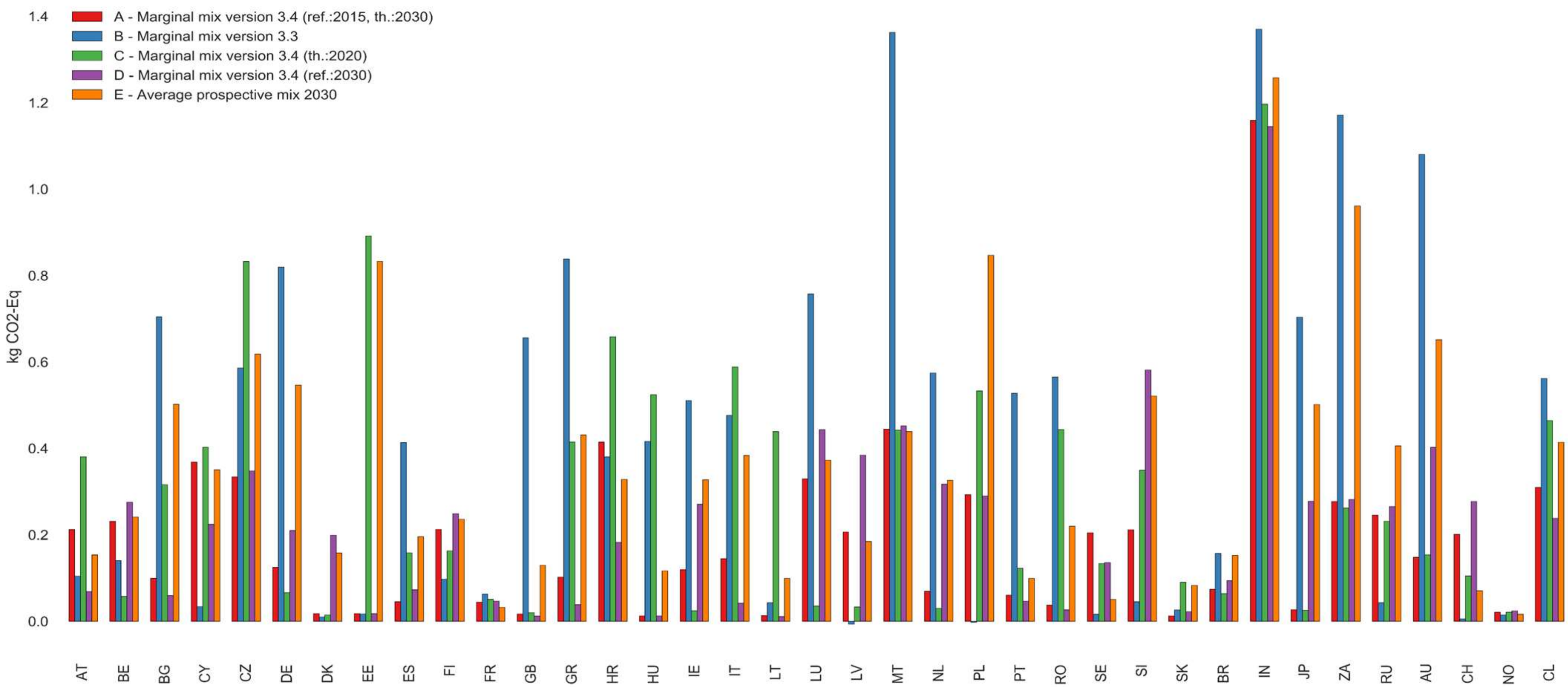
- High-level of aggregation in terms of technology in comparison to the technological detail in ecoinvent :
  - Disagregation based on current data to split coal and hydro technologies.
  - Disagregation based on scenarios for wind to split into onshore and offshore.
  - Expert judgement to realize a one to one mapping of the technologies.

What is reusable ?

- Mapping table to connect mainstream scenarios to ecoinvent technologies: IEA, European Commission, Energy Information Administration, etc.
- Prospective average mixes from these scenarios for 2020, 2030, 2040 and 2050.
- BW2 tools (from Wurst Package developed by Brian Cox and Chris Mutel) to transfer electricity mixes from an excel table to generate several version of Ecoinvent (more details https://wurst.readthedocs.io/marginals.html).

Results

Comparison the global warming potential (IPCC 2013, GWP 100a) of the marginal mixes calculated through the various approaches for a set of country.



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Feedback on the integration of IEA scenarios in hybrid LCA

Thomas Gibon - Wednesday 6th of September 2017

+ NTNU Norwegian University of Science and Technology

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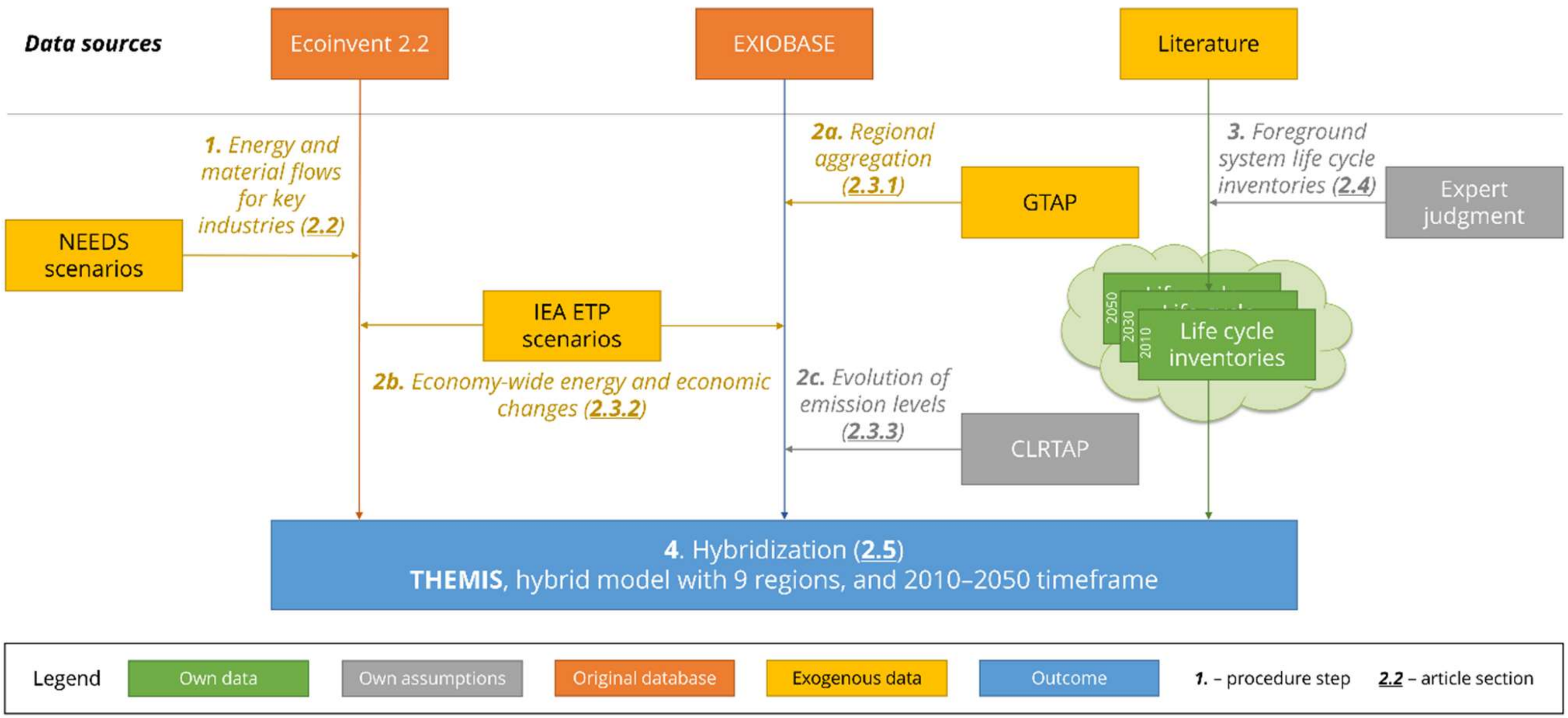
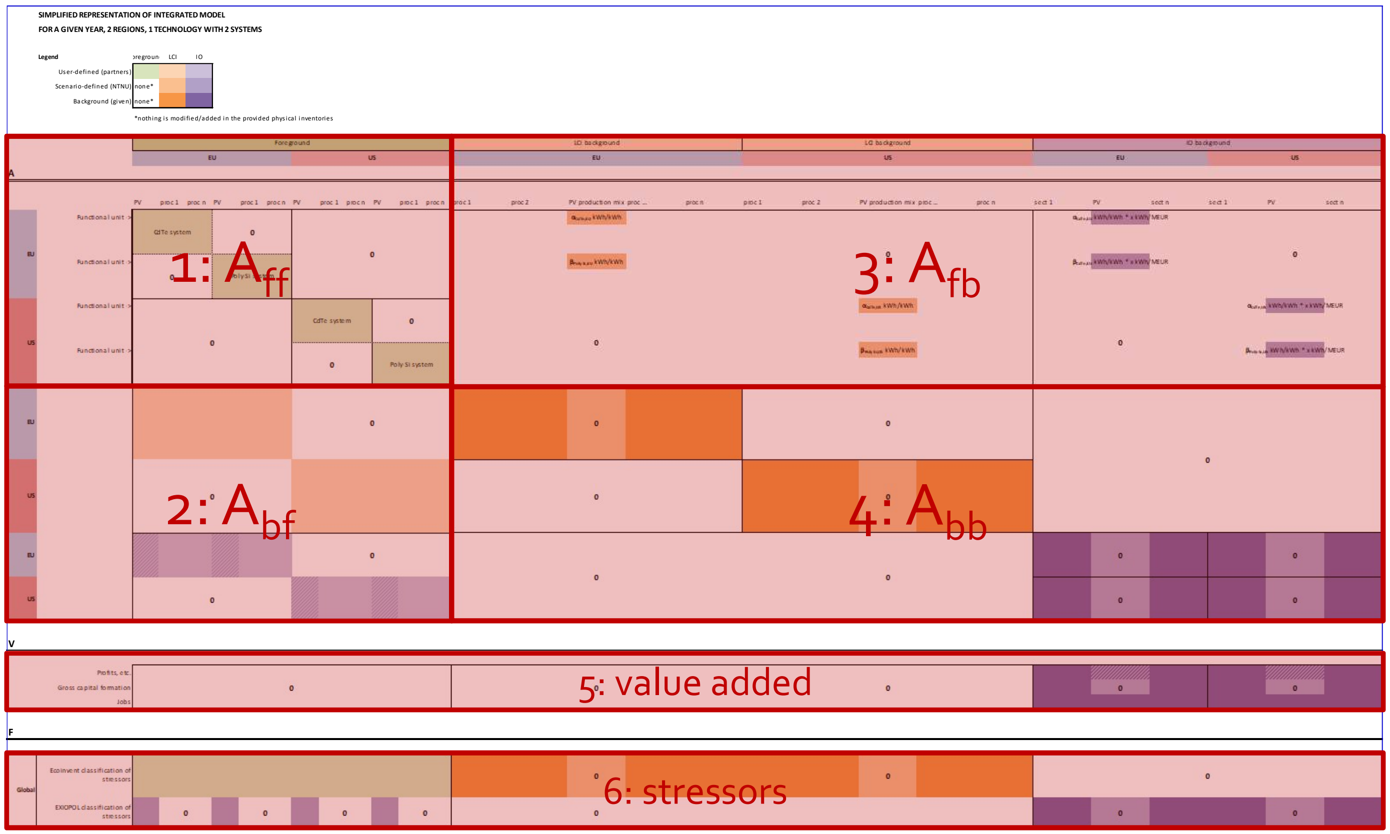
The idea

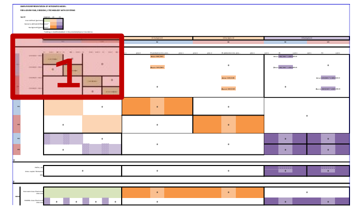


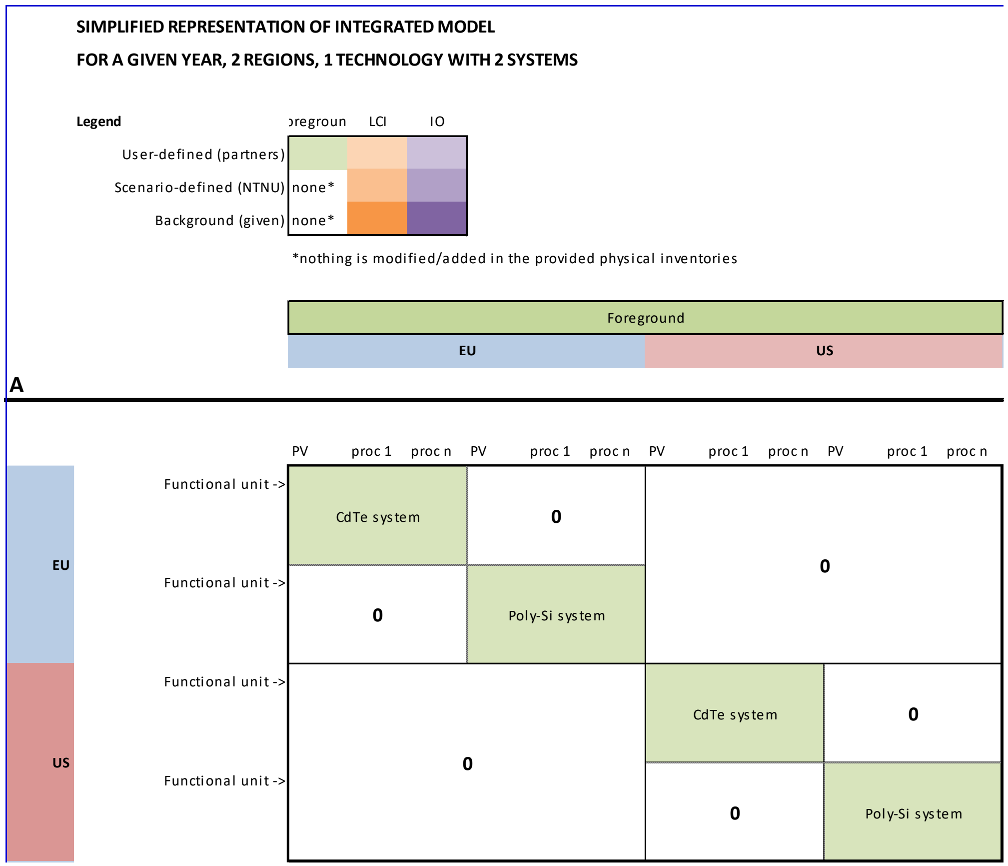
Data sources
Ecoinvent 2.2
EXIOBASE
Literature
1. Energy and material flows for key industries (2.2)
2a. Regional aggregation (2.3.1)
3. Foreground system life cycle inventories (2.4)
GTAP
Expert judgment
NEEDS scenarios
IEA ETP scenarios
2050
2030
2010
Life cycle inventories
2b. Economy-wide energy and economic changes (2.3.2)
2c. Evolution of emission levels (2.3.3)
CLRTAP
4. Hybridization (2.5)
THEMIS, hybrid model with 9 regions, and 2010–2050 timeframe
Legend
Own data
Own assumptions
Original database
Exogenous data
Outcome
1. – procedure step
2.2 – article section

The implementation



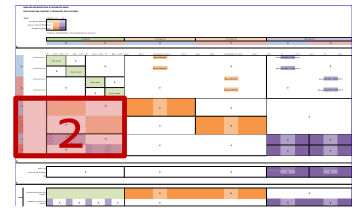
Quadrant 1: A_{ff}

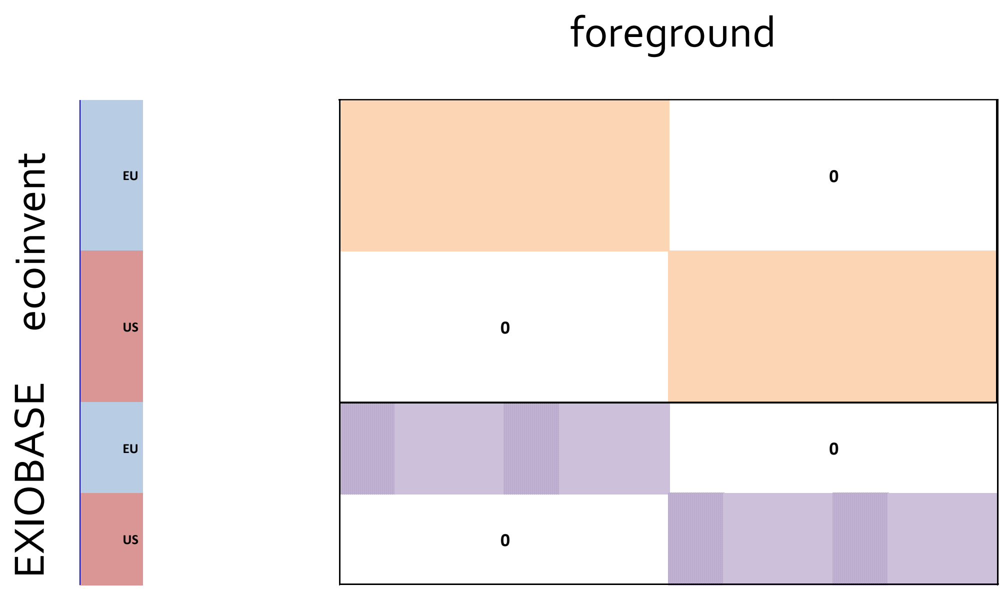




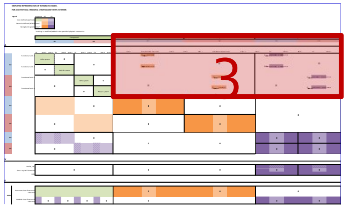
- 15 technologies are made of a set of 37 systems, representing the market
- For all 9 regions
- Diagonal quadrants contain physical information on foreground processes
- Systems do not interact with each other at that point (off-diagonal quadrants are zero matrices)

Quadrant 2: A_{bf}

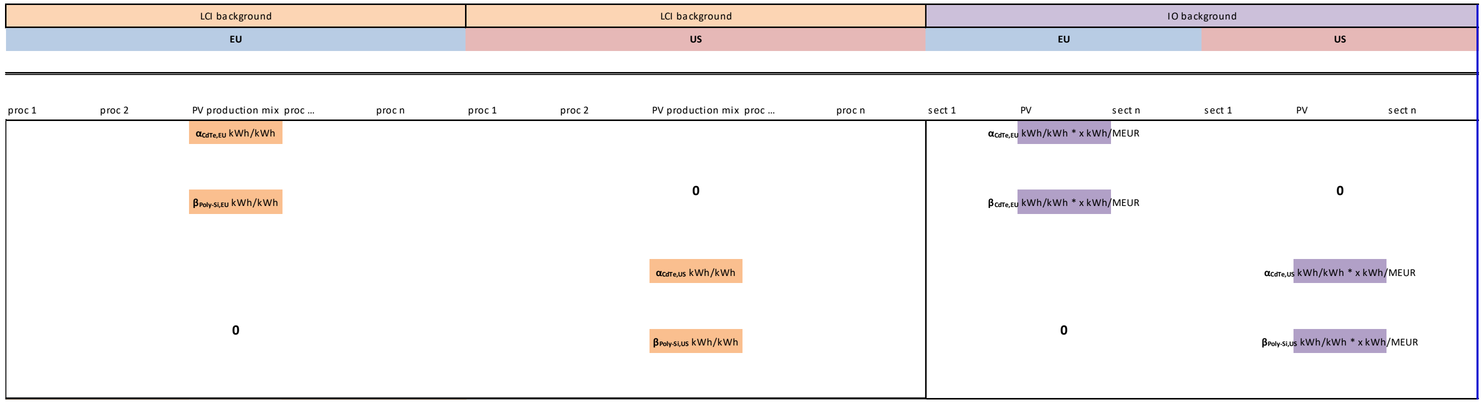




- Linkage between databases and own systems
- For all 9 regions
- Diagonal quadrants contain physical information on foreground processes
- Systems do not interact with each other at that point (off-diagonal quadrants are zero matrices)
- …BUT some inventories are modified a posteriori to be connected with more regions

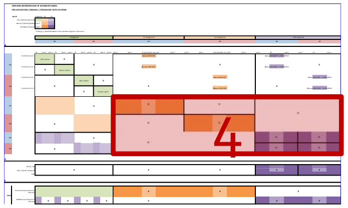


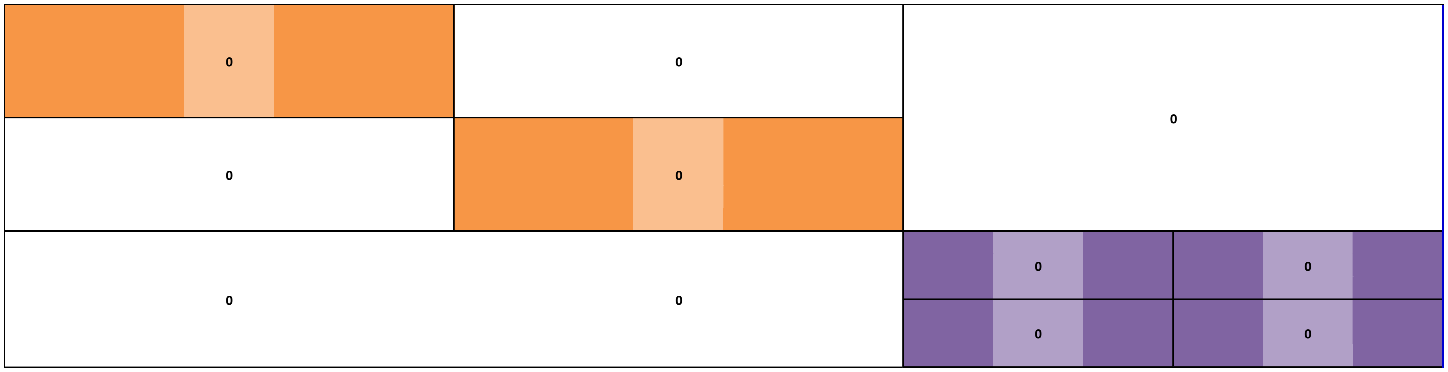
Quadrant 3: A_{fb}



- Feedback loop integrating the systems back to the databases
- For all 9 regions
- Sparse matrices linking systems' functional units with processes/sectors of the background
- Price and market share adjustments

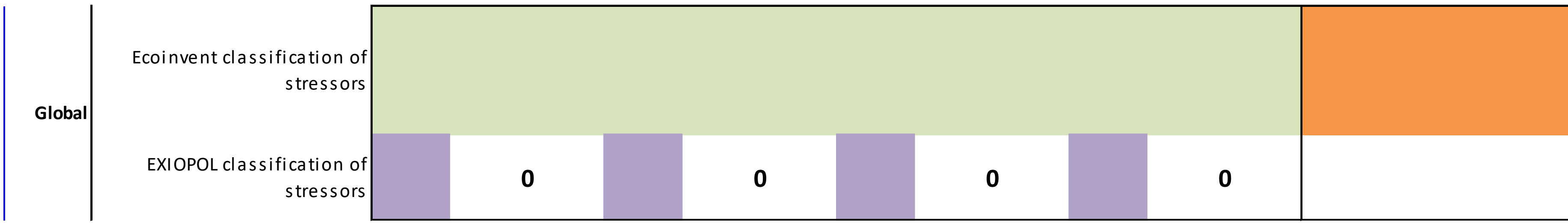
Quadrant 4: A_{bb}





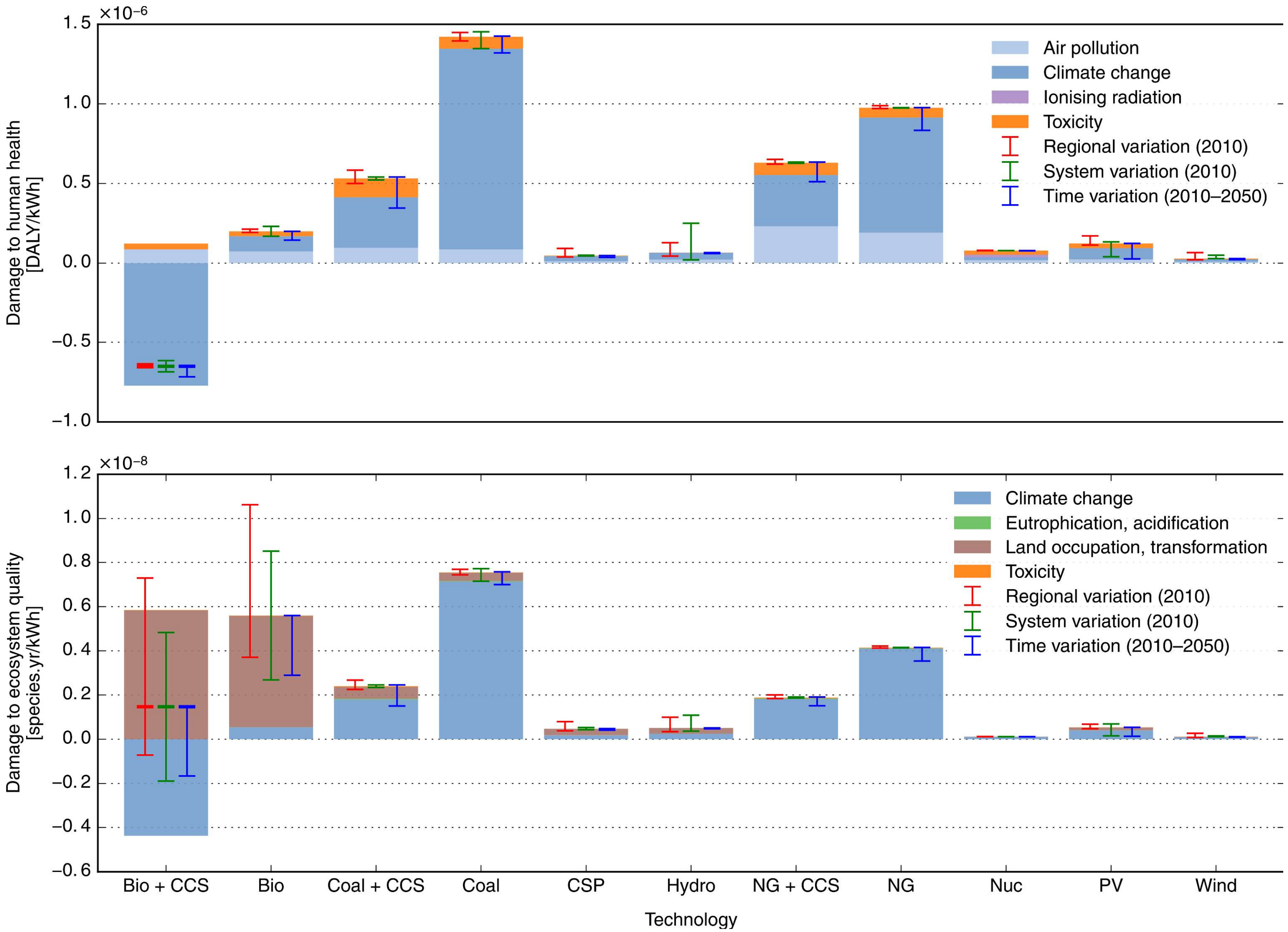
- Regionalised ecoinvent databases (orange) and MRIO (purple)
- For all 9 regions
- Electricity mix is adapted in “each ecoinvent”
- Processes/sectors represented by a foreground system have their inputs zeroed out
- Other adjustments for 2030 and 2050

«Quadrant» 6: stressors



- Processes/sectors represented by a foreground system have their stressors zeroed out
- For all 9 regions
- Other adjustments for 2030 and 2050
  - Decrease of emissions
  - Higher industry efficiency

Results



×10⁻⁶
1.5
1.0
0.5
0.0
−0.5
−1.0
Damage to human health
[DALY/kWh]
Air pollution
Climate change
Ionising radiation
Toxicity
Regional variation (2010)
System variation (2010)
Time variation (2010–2050)
×10⁻⁸
1.2
1.0
0.8
0.6
0.4
0.2
0.0
−0.2
−0.4
−0.6
Damage to ecosystem quality
[species.yr/kWh]
Climate change
Eutrophication, acidification
Land occupation, transformation
Toxicity
Regional variation (2010)
System variation (2010)
Time variation (2010–2050)
Bio + CCS
Bio
Coal + CCS
Coal
CSP
Hydro
NG + CCS
NG
Nuc
PV
Wind
Technology

Challenges

- **Data missing**: technologies non commercially available are not in current LCI databases (*e.g. carbon dioxide capture and storage*),
- **Matching** is made **by hand** and arbitrarily for the regional level of a technology (*e.g. assuming coal power in India can be represented by coal power in Poland*),
- **Disaggregation**: within the increasing market share of an emerging technology, no data on exact technical systems involved (*e.g. shares of poly-Si, CdTe, CIGS, etc. have been "guestimated"*)
- **Uncertainty** is not addressed at all (*only variability is*)

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Integrating TIMES in LCA, feedback and challenges

Miguel Fernandez Astudillo - Wednesday 6th of September 2017

UNIVERSITÉ DE SHERBROOKE

Chair in Energy Sector Management
HEC MONTRĒAL

Existing literature

- Volkart et al 2017 *
- Levasseur et al 2017 *
- García-Gusano et al 2016a + *
- Garcia-Gusano et al 2016b +
- Tokimatsu et al. 2016 +*
- Hertwich et al. 2015 +*
- Menten et al. 2015
- Choi et al. 2012 + *
- Pietrapetrosa et al. 2009 *

New projects

- Reem
- Reflex
- Store&go

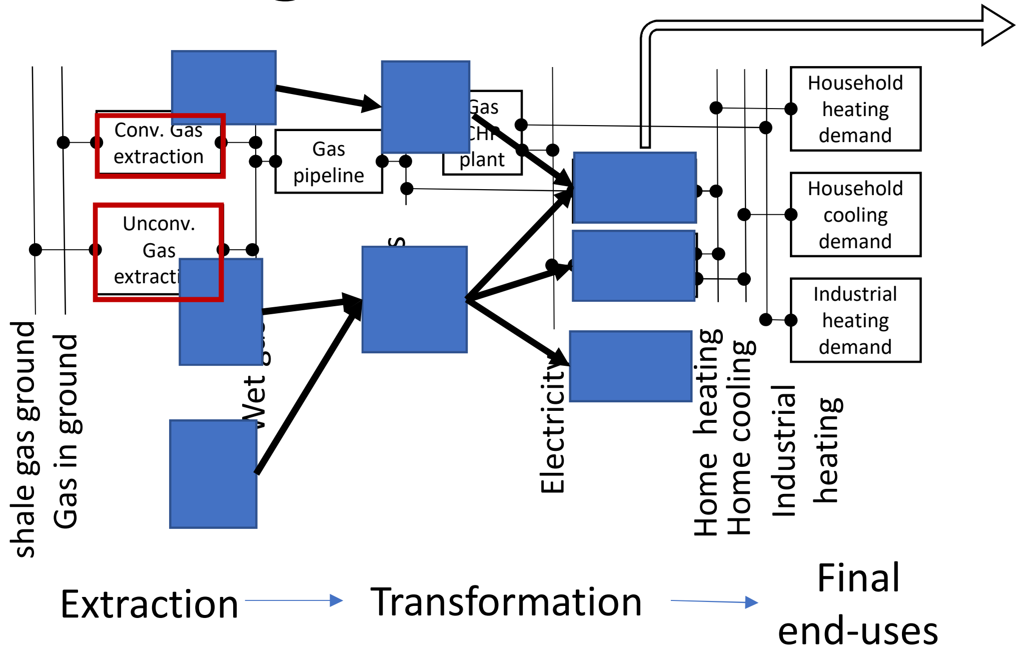
Not new but picking up

With exceptions, most of the studies are attributional * and covering only the electricity sector +.

Considerable differences in the level of integration between TIMES and LCA in each model.

"Deep" integration (i.e. 1 LCI activity per TIMES process) has only been achieved for "small" models (up to 192 tech).

Linking ESM and LCI



Natural gas → **Gas furnace Detached houses** → Detach. house heat

Heating value

Efficiency
Emission factors

Demand

NATEM process ⇔ Ecoinvent process

$$Output_{CLCA} = Output_{conterfactual} - Output_{baseline}$$

Complete but not accurate!
(Changes in the background)

Some challenges for deep integration

- **Too many processes** -> one to one *mapping* may be unfeasible.
- **Double counting** (e.g. cement industry not linked to infr. Development)
- **Different temporal scope** -> parameters defining processes require updating
- **Dynamic vs static parameters** -> in TIMES parameters can change over time
- **Multifunctional processes**

What is reusable:

- Strategies to simplify the integration (and the implementation!).
- Better documented replicable procedures with common language
- Lists of equivalences (proxy LCI – TIMES process)
- LCI derived from integration efforts (e.g. NEEDS)

PS: TIMES has its own limitations that may require further linking with other models (e.g. time resolution)

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Integration of energy scenarios in Swiss mobility assessment

Didier Beloin-Saint-Pierre - Wednesday 6th of September 2017

Empa
Materials Science and Technology

Case study

Scope and assumptions of the current LCA model

Electricity production in Switzerland by source as shown in legend of figures

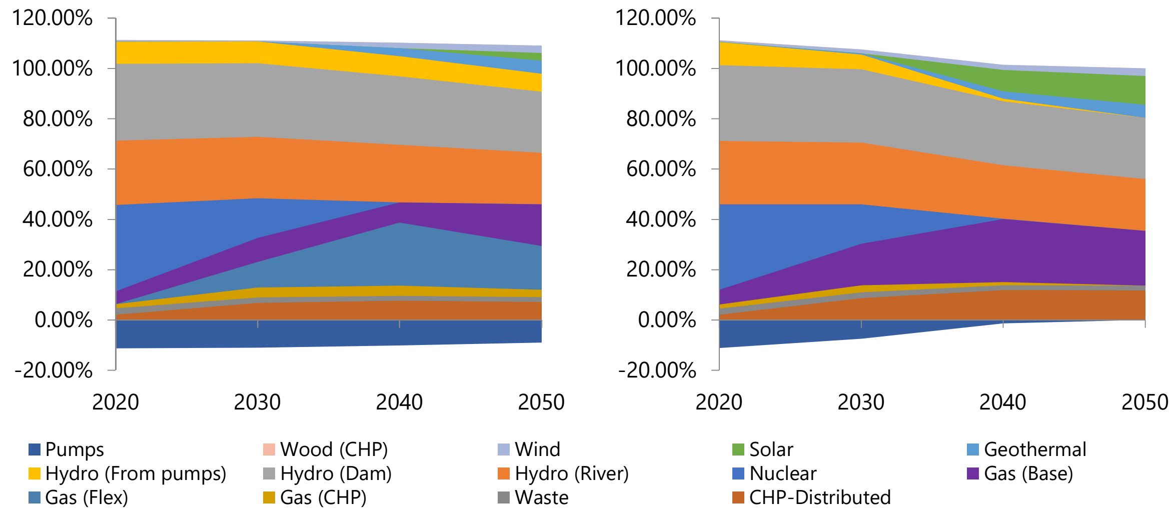
Database: ecoinvent 3.3 cut-off

Future scenarios based on Swiss TIMES model [1]

BAU: Business-as-usual – Current policies & no net import of electricity

LC60: Low carbon 60 – Meets requirements of new Swiss energy policy

LCIA method: GWP from IPCC 2013, time horizon = 100 years



Steps for considering the prospective data from TIMES in LCA model

1. Choosing the relevant TIME models and scenarios
2. Mapping the TIMES data
3. Mapping the ecoinvent v3.3 cut-off dataset
4. Creating datasets/scenarios for 2020, 2030, 2040 and 2050
5. Running LCA calculations

[1] 1. Kannan R, Hirschberg S (2016): Interplay between electricity and transport sectors – Integrating the Swiss car fleet and electricity system. Transportation Research Part A: Policy and Practice 94, 514–531

Challenges

- Comprehensive list of usable prospective modelling methods is missing

  Linking the model to the question

  Which assumptions should be mentioned?

- What is the consequential mix for the future in relation to the assessed process

  Listing the hypotheses for future marginal mixes

  Should we always link to a marginal mix during a lifecycle

- Getting the data

  Is there enough in open access databases/models?

- No standard for mapping scenario outputs to inputs of LCA models

  General strategy or updatable mapping files

  Aggregation / Disaggregation / Missing information

Challenges

- Considering the evolution of mixes/technologies in the models

  Dynamic LCA and temporally differentiated LCI

  Which parameters to modify in technology proxies for the future

  Limit to our assessment: paradigm shifts

- Defining temporal uncertainty and variability for the future

  Modification to pedigree matrix based on statistics per technology

- Choosing the LCIA methods

  Are methods still valid for the future (temporal horizons - period of validity – update rates)

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Integrating IMAGE results in LCA with the WURST Python package

Brian Cox - Wednesday 6th of September 2017

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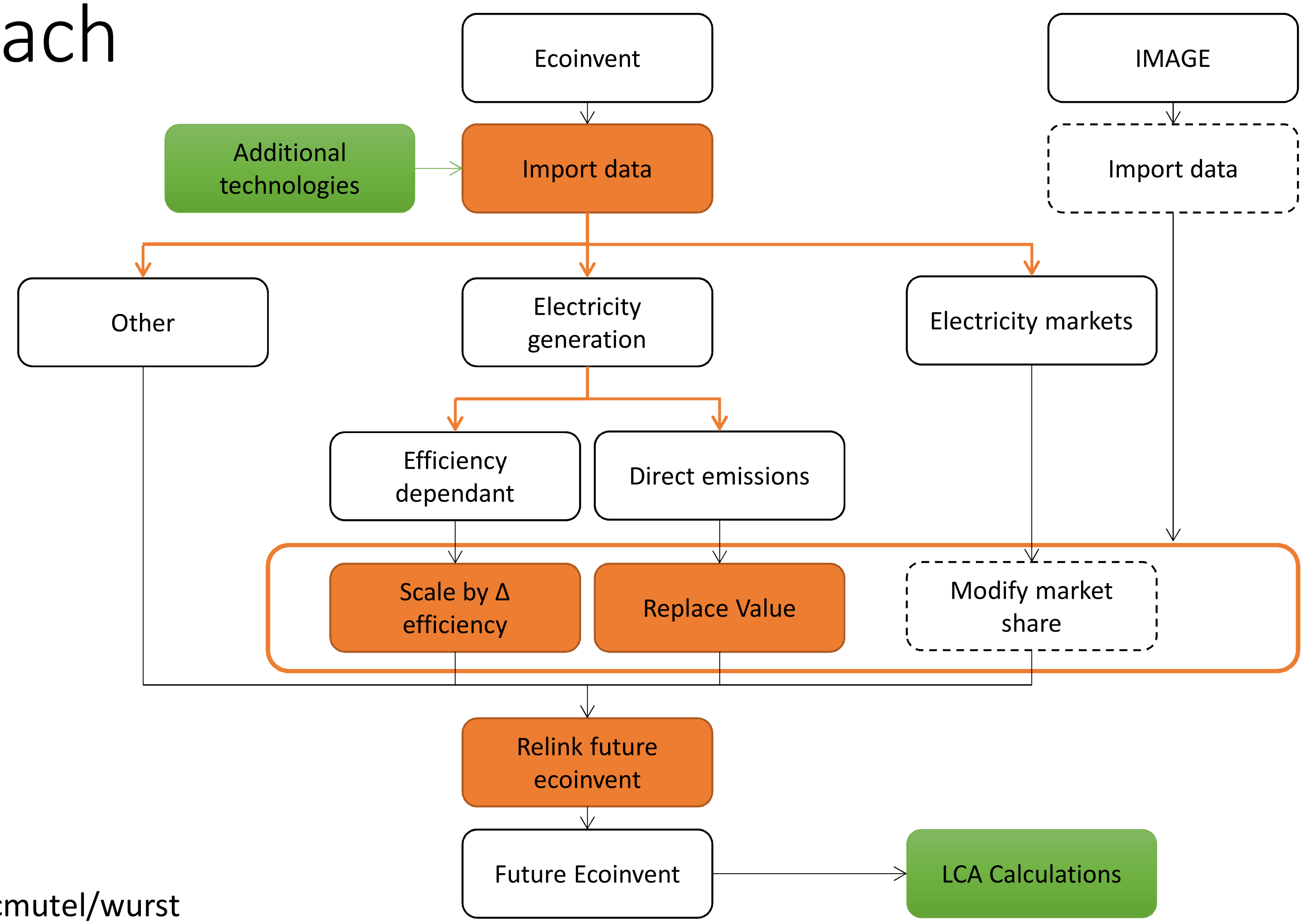
Approach



Wurst

Brightway

https://github.com/cmutel/wurst

Updating coal fired electricity plants

Technosphere

market for NOx retained by selective catalytic reduction

market for SOx retained in hard coal flue gas desulfurisation

market for SOx retained in lignite flue gas desulfurisation

market for chlorine gaseous
market for hard coal
market for hard coal ash
market for hard coal power plant
market for light fuel oil
market for lignite
market for lignite ash
market for lignite power plant
market for petroleum coke
market for residue from cooling tower
market for transport freight sea transoceanic
market for water completely softened from decarbonised water at user
market for water decarbonised at user
market group for light fuel oil

Biosphere

Acenaphthene
Acrolein
Actinides radioactive
Aldehydes unspecified
Antimony
Arsenic
Barium
Benzene
Benzene ethyl-
Benzo(a)pyrene
Beryllium
Boron
Bromine
Butane
Cadmium
Carbon dioxide fossil
Carbon disulfide
Carbon Monoxide
Chloroform
Chromium
Chromium VI
Cobalt
Copper
Cumene
Cyanide
Dioxins
Ethane
Ethane 12-dichloro-

Ethene tetrachloro-
Formaldehyde
Furan
Hexane
Hydrocarbons aliphatic alkanes cyclic
Hydrocarbons aliphatic alkanes
Hydrocarbons aliphatic unsaturated
Hydrocarbons chlorinated
Hydrogen chloride
Hydrogen fluoride
Iodine
Lead
Lead-210
Magnesium
Manganese
Mercury
Methane
Methane dichloro- HCC-30
Methane monochloro- R-40
Molybdenum
NMVOC
Nickel
Nitrogen oxides
PAH
Particulates < 2.5 um
Particulates > 10 um
Particulates > 2.5 um and < 10um
Pentane

Phenol
Polonium-210
Potassium-40
Propane
Propene
Protactinium-234
Radium-226
Radium-228
Radon-220
Radon-222
Sulfur dioxide
Selenium
Strontium
Styrene
Sulfate
Thorium-228
Thorium-230
Thorium-232
Thorium-234
Toluene
Uranium-234
Uranium-238
Vanadium
Water
Water
Xylene
Zinc

Updating Electricity Markets - Difficulties

- Not all Image technologies in ecoinvent
  - CSP will be in ecoinvent 3.4
  - CCS technologies from CARMA project
  - Take proxies for «unimportant» technologies

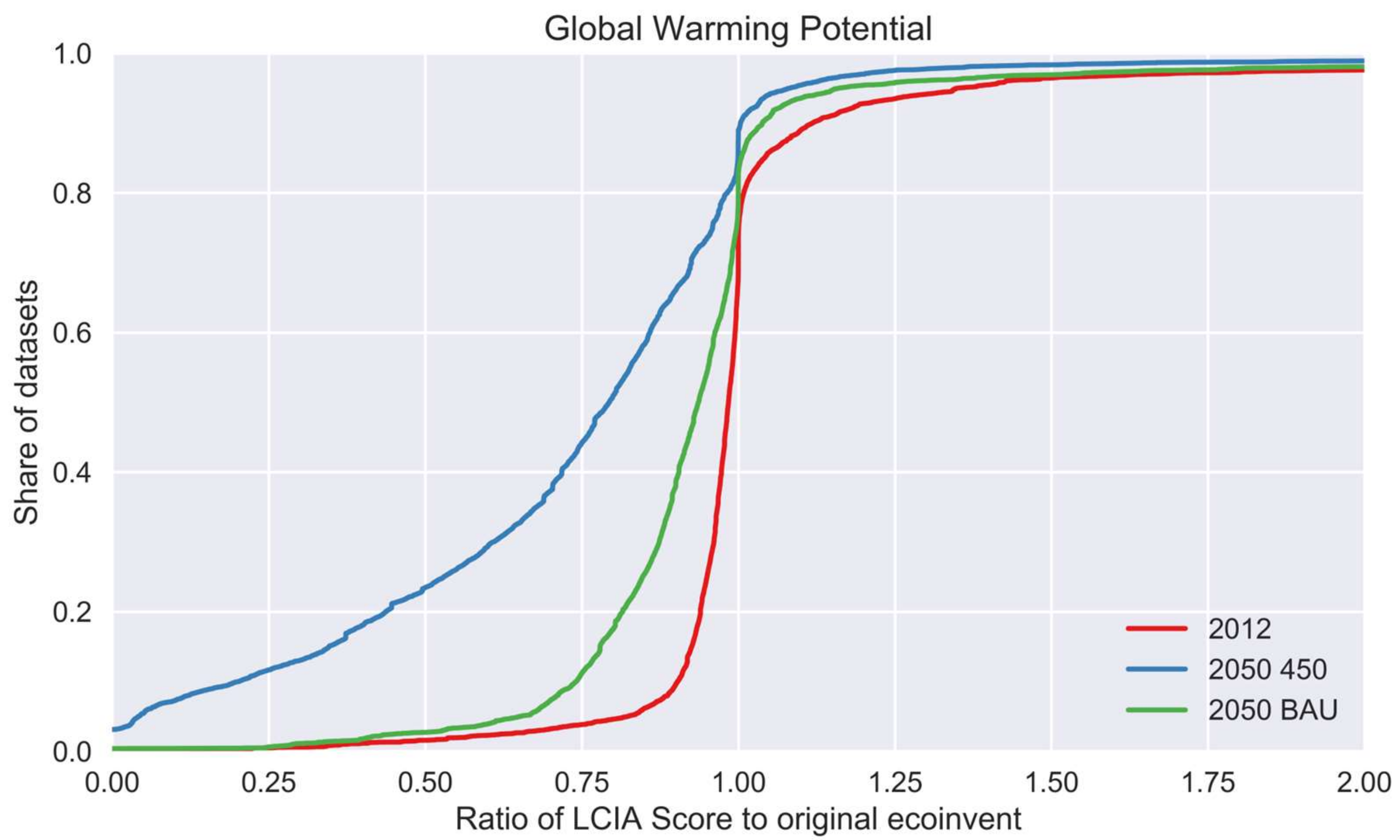
- More than 1 ecoinvent dataset matches image technology
  - Example: coal = hard coal and lignite
  - assume equal share of all technologies available in the market

- No ecoinvent dataset in that region!
  - Go up one regional level

- Had to simplify low and medium voltage levels
  - Assume all technology contribute to high voltage

CCS & IGCC Datasets: Volkart et al. 2013: DOI: 10.1016/j.ijggc.2013.03.003

Overall Results



Conclusions

Weaknesses:
- Don't consider improvement of renewables
- Some proxies used to complete electricity markets
- Some regional data issues – ie Switzerland versus Western Europe
- Only electricity sector modified

Strengths:
- Software is quite fast
- Changes are transparent
- Easy to integrate results into Brightway2

Future work:
- Compare many scenarios from other data sources
- Other sectors?