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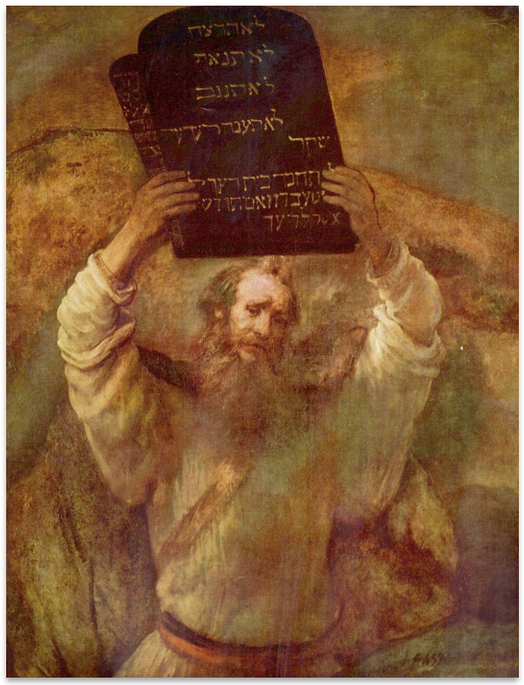
Transforming ecoinvent for fun and profit

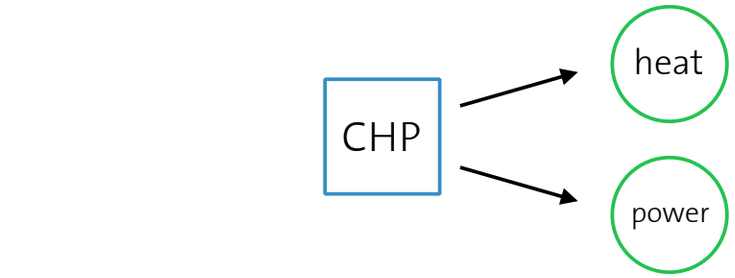
Ecoinvent 3: System Models

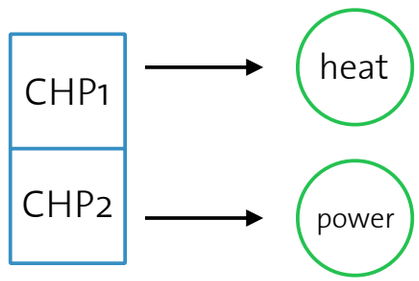


SOUP = Single output unit process

Ecoinvent 3 introduces system models. These are not new - they have always been there - but they are now explicit. A system model includes ways of taking master data sets and creating SOUPs - single output unit processes; For example, substitution, allocation etc.
Image credits: Rembrandt, https://www.flickr.com/photos/dalboz17/2916250490/

Ecoinvent 3: System Models

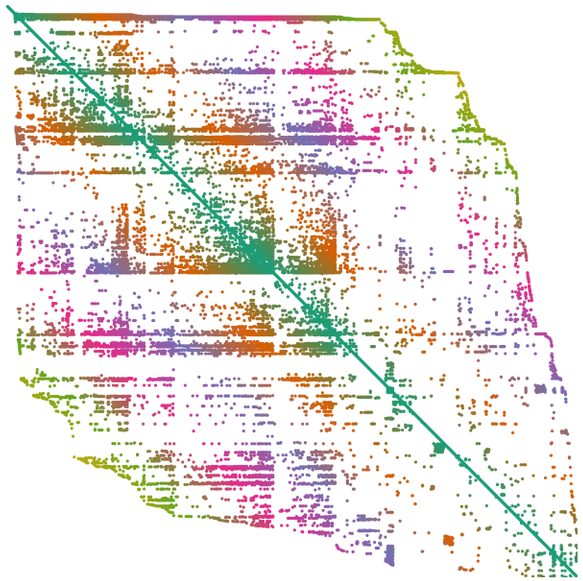


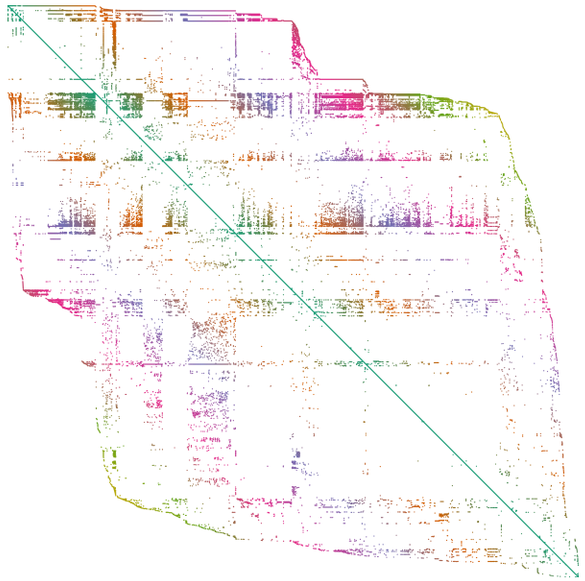


- Technology levels
- Combined/joint production
- Allocation methods
- Markets
- Spatial relationships

System models cover allocation, but also technology levels (used for determining marginal producers), different types of multi output processes, and temporal and spatial relationships.

High complexity





2.2:
~4.000 processes
~40.000 techno. exchanges
~90.000 biosphere exchanges

3.1 (cutoff):
~11.000 processes
~250.000 techno. exchanges
~270.000 biosphere exchanges

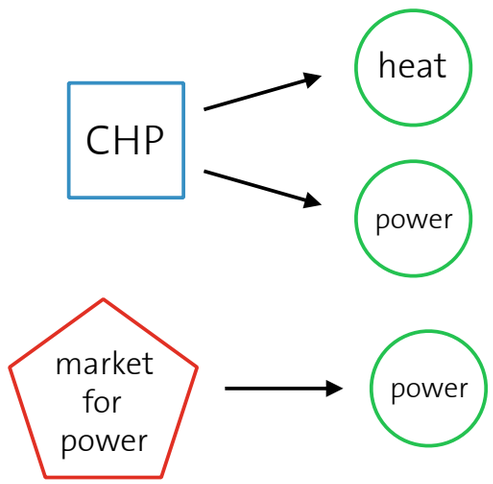
As ecoinvent grows, the level of complexity also increases. It is now basically impossible to understand the database without using computer tools.

We can manipulate ecoinvent

- Better reflect the system models in our head or in standards
- More efficiently build foreground inventories
- Better understand the database

We can use the data given in ecoinvent 3 to change and interpret the database. There are many reasons to do such manipulation, including making the database easier to understand, to fit assumptions and constraints in standards, and to more easily link or integrate ecoinvent to other databases.
Image credit: http://funnyjunk.com/funny_pictures/4331615/We+have+the+technology

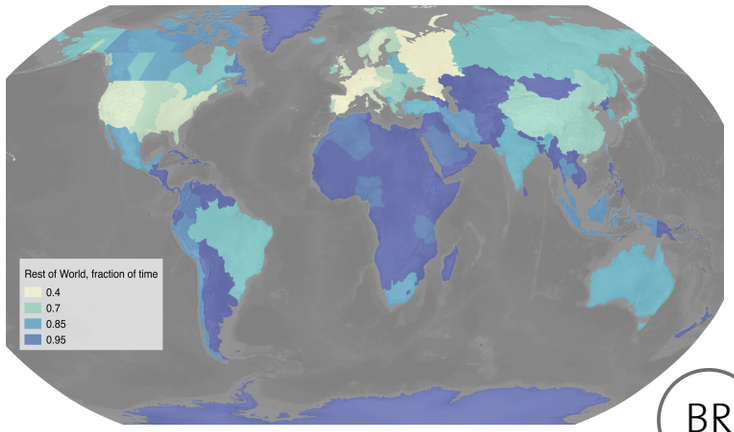
Example 1: Include substitution in cutoff system model

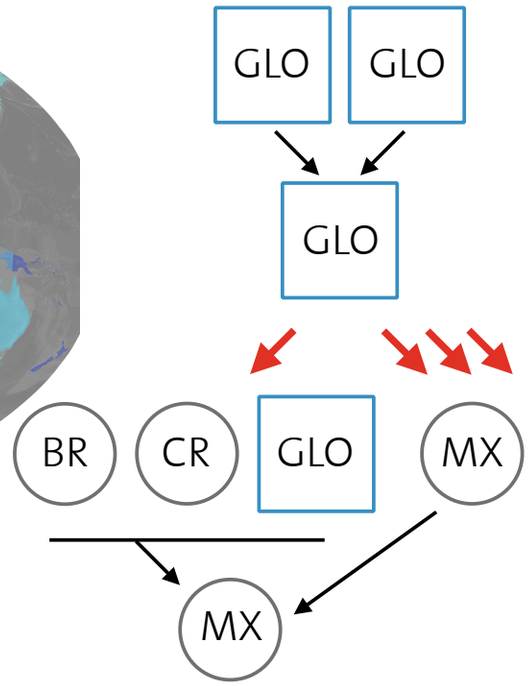


- 11.301 SOUPs
- 615 multioutput processes
- 1.489 allocated SOUPs
- 618 can be substituted

Instead of doing allocation, we can apply substitution in the cutoff system model. Not all products can be substituted, but many of them can, and substitution is normally preferred to allocation.

Example 2: Breaking up global or RoW datasets





3.1 cutoff:
- 11.301 processes
- 3.187 in “global”
- 2.683 in “rest of the world”

Poster: Constructive geometries: Making sense of the world and the "rest of the world"

Another interesting idea is to disaggregate the “global” or “rest of world” processes using input-output tables that give physical production amounts in countries or regions. We can then link to local inputs, essentially getting a more detailed global database for free.

Example 3: Common mixes

e.g. ENTSO-E electricity grid

Product	Amount	Uncertain	Unit
electricity, medium voltage	1.39e-05	True	kilowatt hour
electricity, medium voltage	4.792e-06	True	kilowatt hour
electricity, medium voltage	7.096e-05	True	kilowatt hour
electricity, medium voltage	1.435e-05	True	kilowatt hour
electricity, medium voltage	3.337e-05	True	kilowatt hour
electricity, medium voltage	0.000295	True	kilowatt hour
electricity, medium voltage	1.712e-05	True	kilowatt hour
electricity, medium voltage	7.342e-05	True	kilowatt hour
electricity, medium voltage	0.0001466	True	kilowatt hour
electricity, medium voltage	6.368e-05	True	kilowatt hour
electricity, medium voltage	0.0002542	True	kilowatt hour
electricity, medium voltage	2.773e-05	True	kilowatt hour
electricity, medium voltage	2.09e-05	True	kilowatt hour
electricity, medium voltage	4.15e-06	True	kilowatt hour
electricity, medium voltage	7.059e-06	True	kilowatt hour
electricity, medium voltage	4.518e-05	True	kilowatt hour

Technosphere matrix:

- 253.427 entries
- 40.188 unique entries

Biosphere matrix:

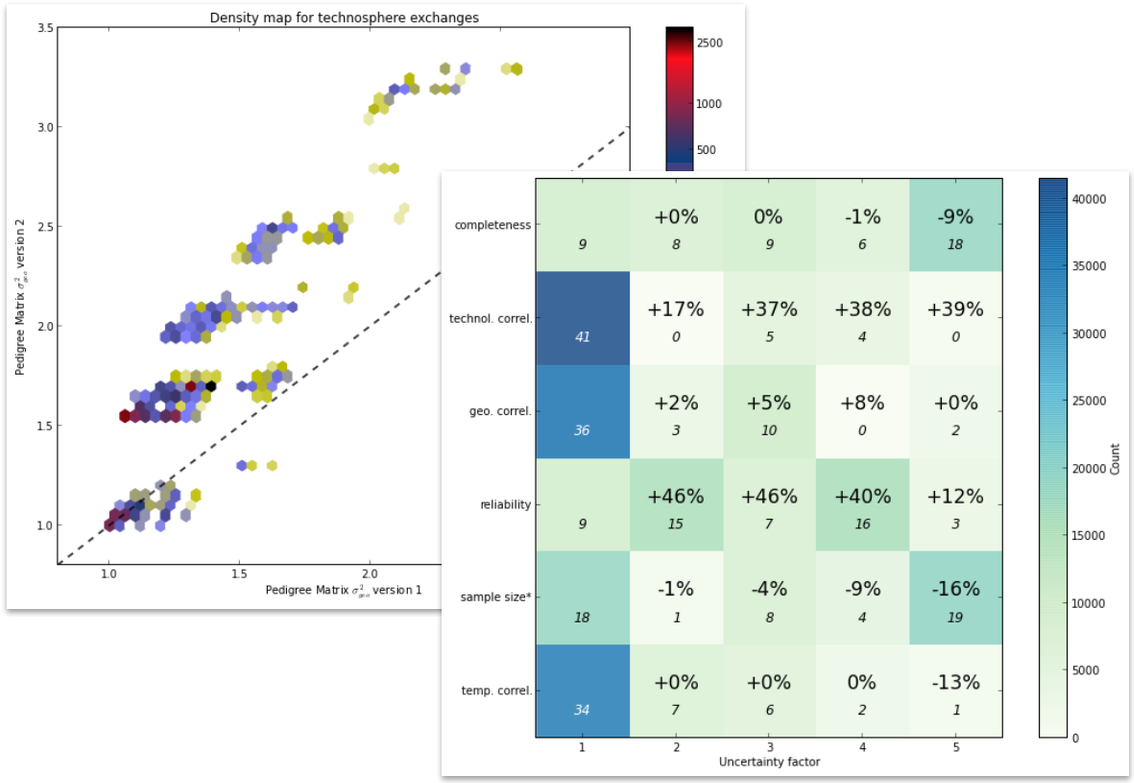
- 268.285 entries
- 165.369 unique entries

Why?

- Consistent sampling under uncertainty
- Automatic data updates
- Understand database structure

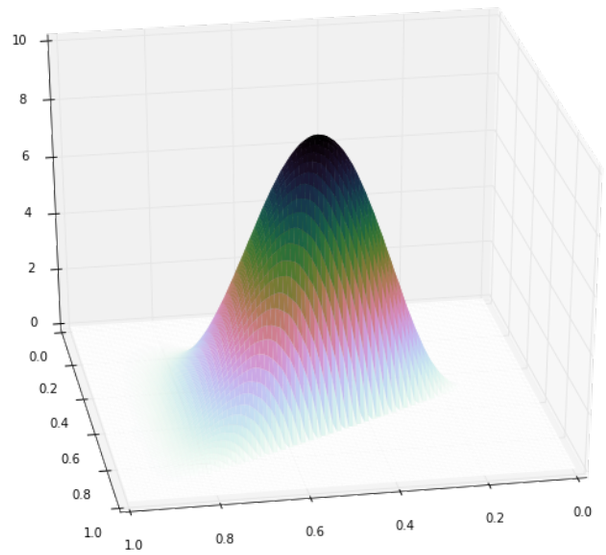
There are many mixes which occur several times in ecoinvent, e.g. what used to be the ENTSO-E electricity grid. If we gather these mixes into new, separate processes, we can sample them in a consistent way when doing uncertainty analysis, as well as increase the information criteria of the database (basically, number of unique exchange values divided by number of exchanges). We can also more easily update the mix amounts.

Example 4: Pedigree matrix versions

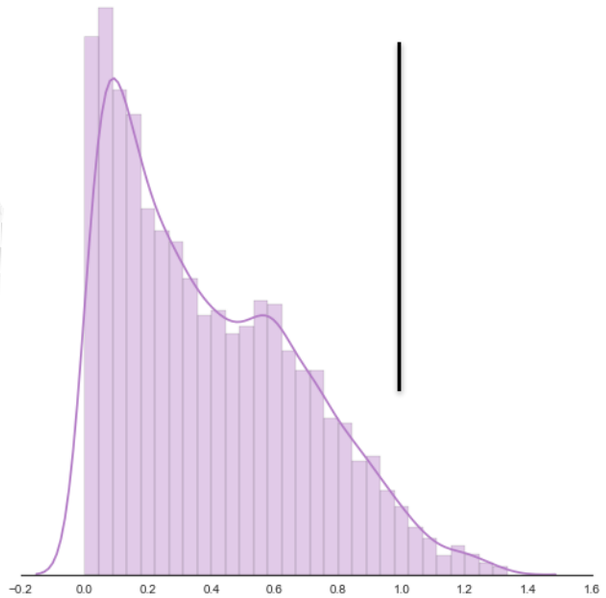


Another simple example is to apply the new data values for the pedigree matrix. See [Empirically based uncertainty factors for the pedigree matrix in ecoinvent].

Example 5: Modelling fractions



Dirichlet distribution
- Automatic summing to 1
- Only need to specify means

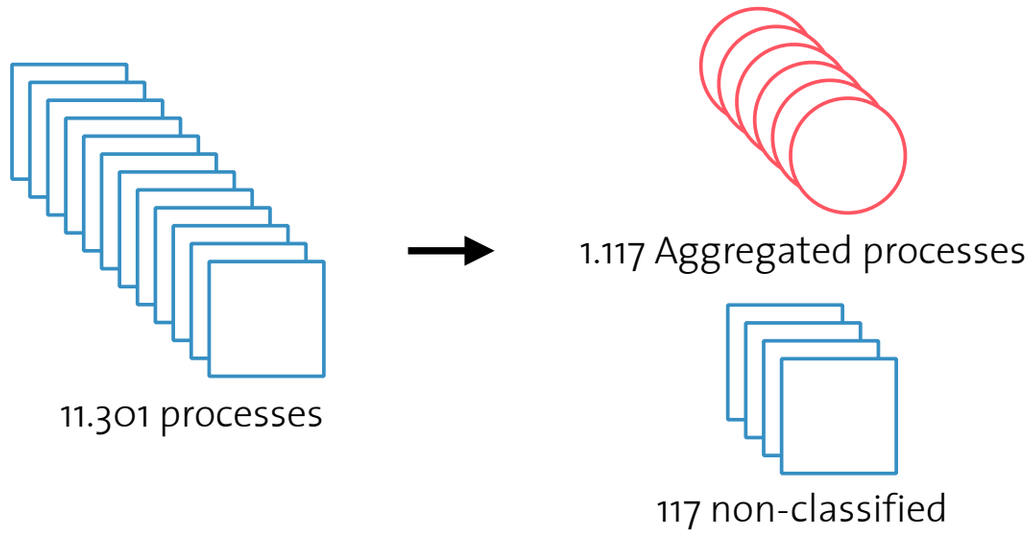


Fraction of electricity consumption supplied by wind
- Denmark, 2014, hourly resolution

The Dirichlet distribution always sums to a constant. This is helpful when looking at fractional contributors to a market mix. Currently, we can normalise to get these numbers to sum to 1 after doing the sampling, but most software doesn't do this, and we don't even know where all these mixes occur.
However, more work is needed here, as some data might break our expected bounds; moreover, the Dirichlet is influenced by the sum of the market shares (i.e. a sum of 10 is "pointier" than a sum of 1), so this is a parameter that should be fit to the data.

Example 6: Underspecification

0161:Support activities for crop production - CA-QC: **17**
1610:Sawmilling and planing of wood - RER: **47**
2610:Manufacture of electronic components and boards -CH: **16**
3510:Electric power generation, transmission and distribution - AU: **19**
5012:Sea and coastal freight water transport - GLO: **6**



Underspecification has been looked into in detail by a team from MIT: Exploring the Viability of Probabilistic Under-Specification To Streamline Life Cycle Assessment. We can use the industry classifiers in ecoinvent 3 to aggregate processes to come up with a database that a lower quantity, but also perhaps a higher quality.

Conclusions

Ecoinvent is not longer a "fixed" thing

- Different system models → no one "ecoinvent" answer
- "Enhanced" ecoinvent available from e.g. Treeze, EarthShift
- Different biosphere flows in simapro, openlca, and ecoinvent
  - Already different LCIA results for same system
- Can change common assumptions in all ecoinvent system models

Manipulation is a mixed blessing

- **Good**: Model assumptions are a key category of uncertainty
- **Bad:** Includes potential for mistakes and mischief
- Must be transparent in changes that are made
  - Opportunities for software and new workflows

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