PAUL SCHERRER INSTITUT

PSI

ecoinvent Centre

Swiss Centre for Life Cycle Inventories

Wir schaffen Wissen – heute für morgen

Electricity markets in version 3 of the ecoinvent database: modeling and results

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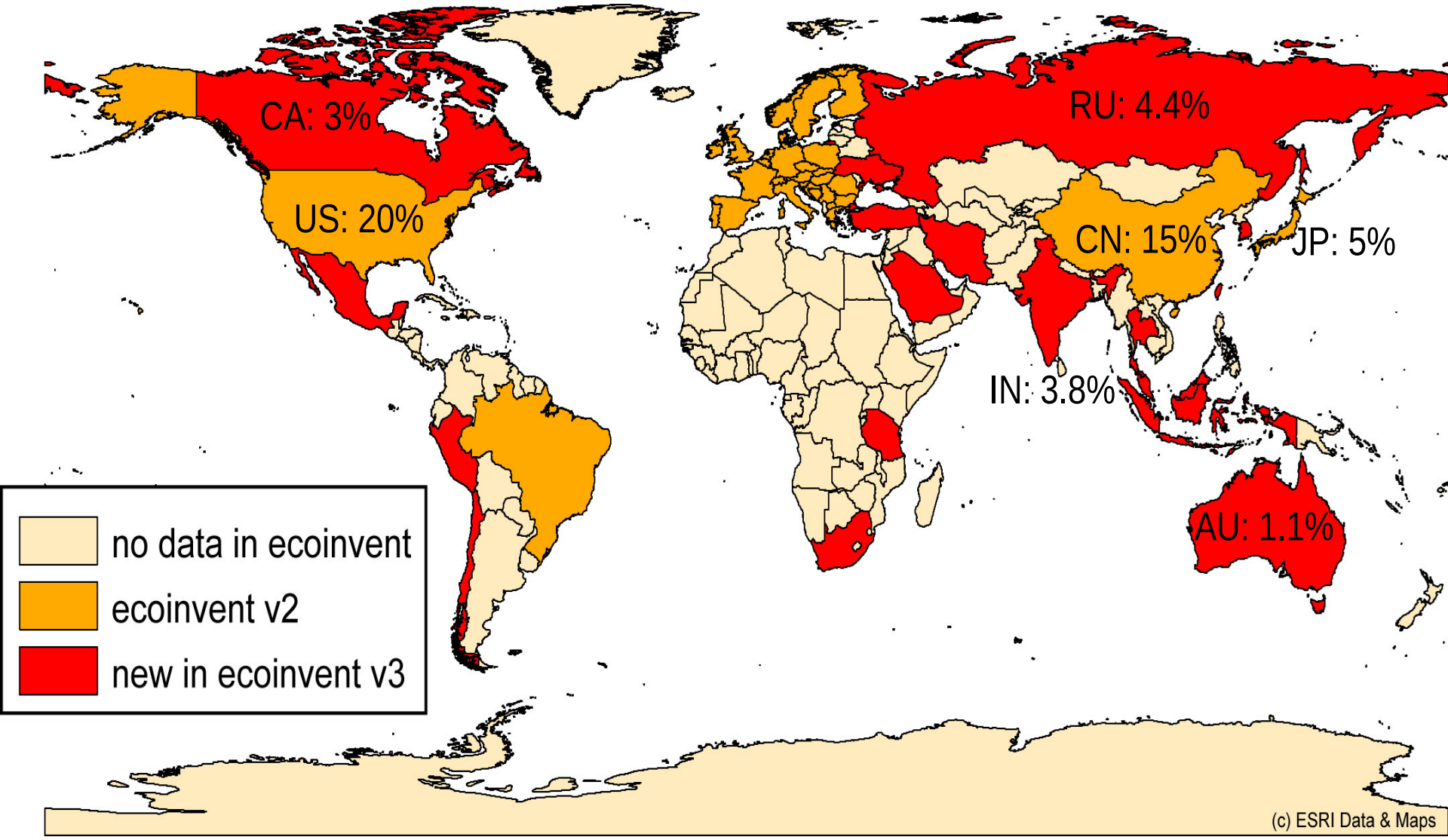
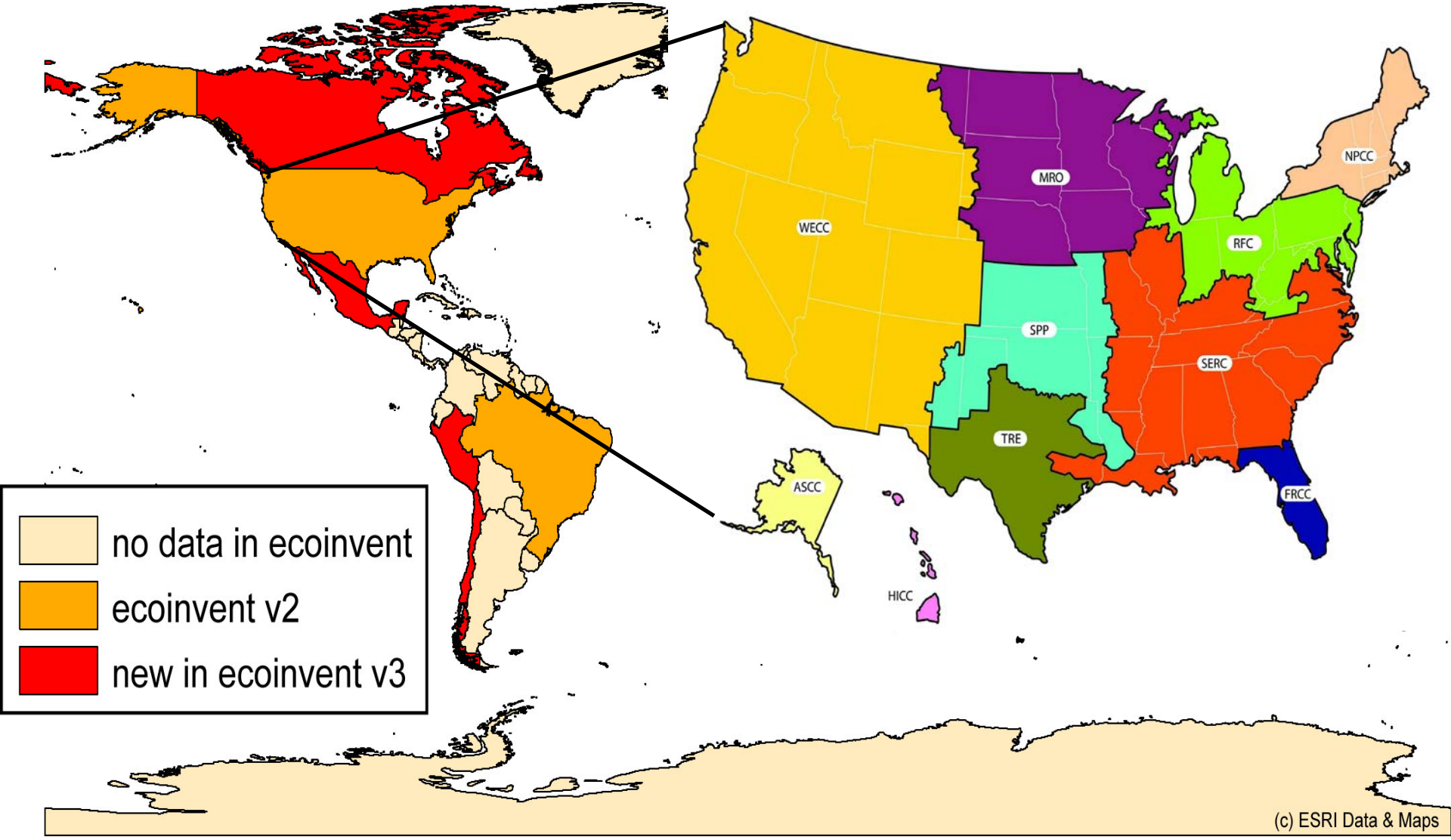
Electricity in ecoinvent v3: coverage

50 countries – all countries generating >1% of global production included



Electricity in ecoinvent v3: coverage

Partitioning of countries → 71 geographies with specific electricity markets



Electricity in ecoinvent v3: markets

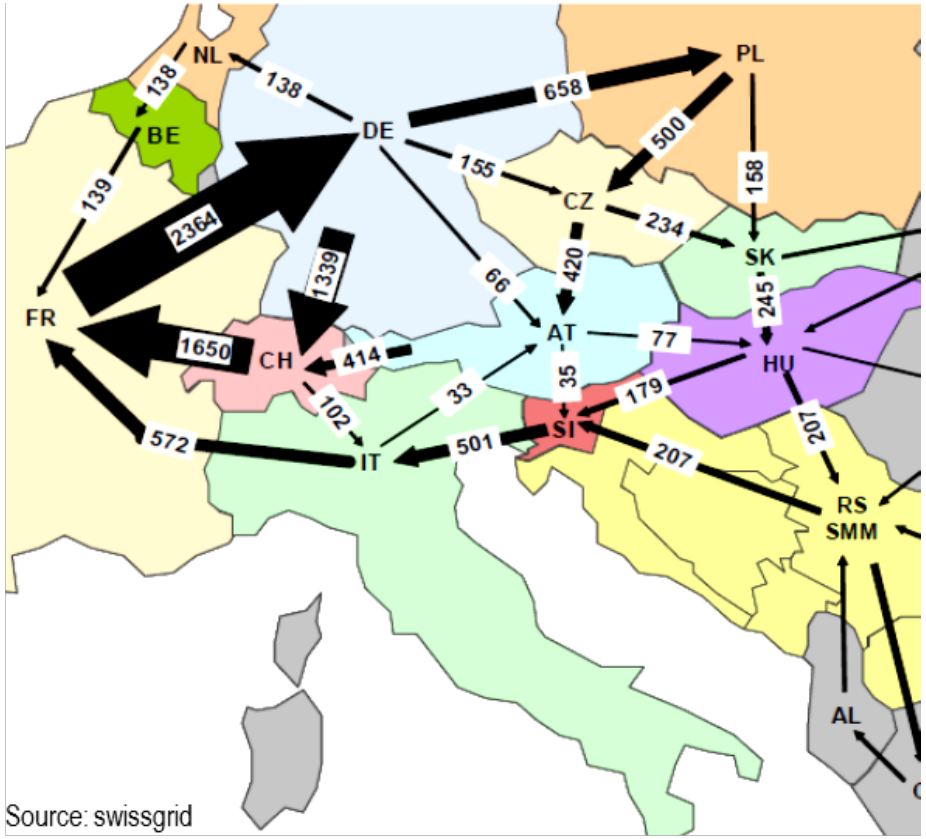
Electricity supply mix =

electricity market =

Domestic production mix

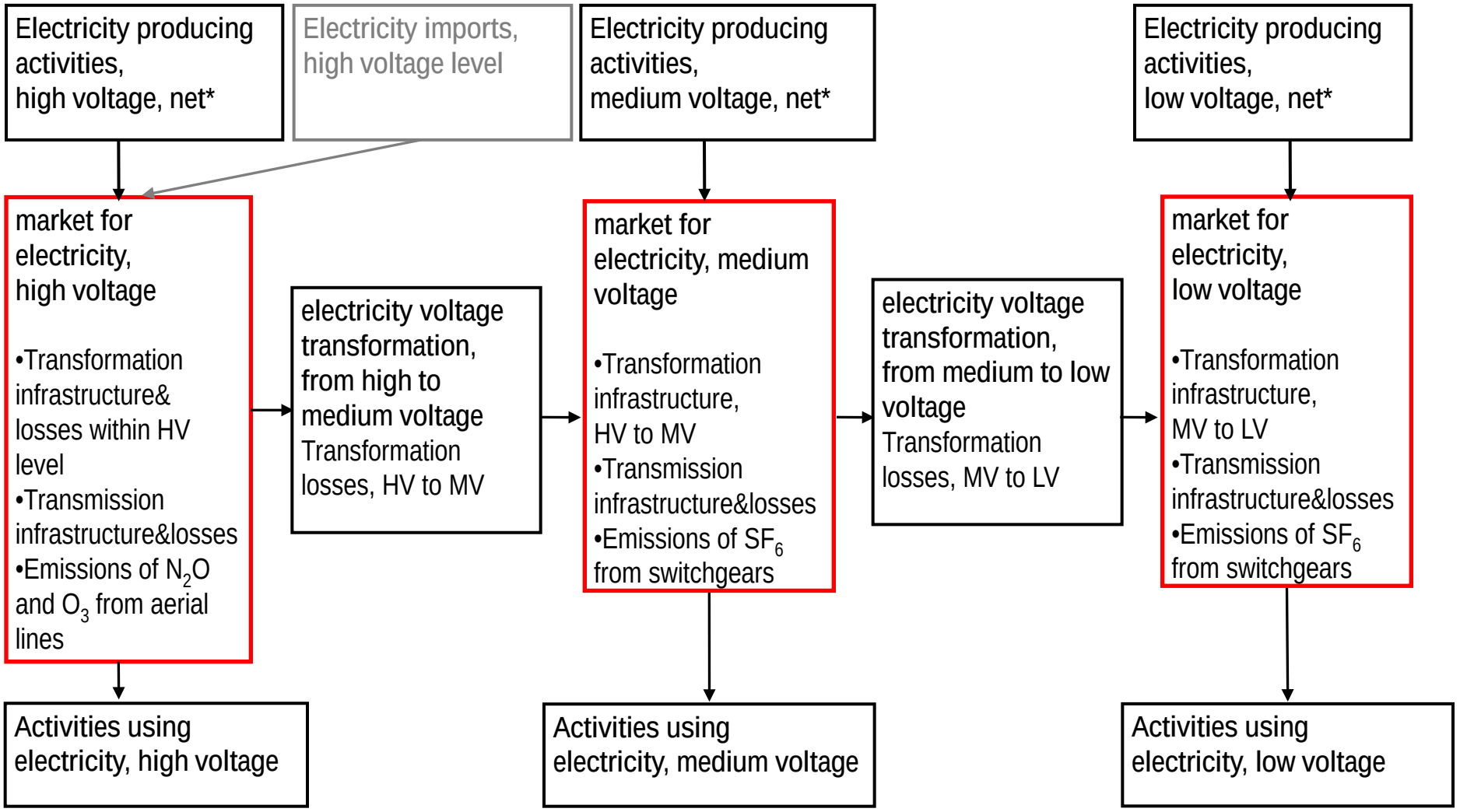
+ imports from neighbour markets

– transformation & transmission losses



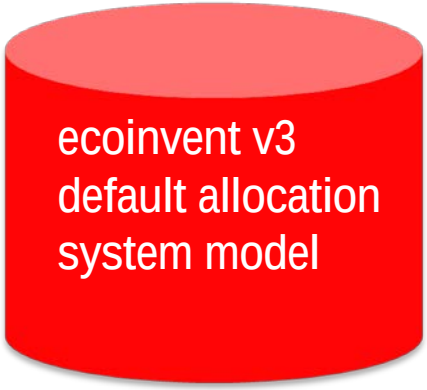
- Markets for high (HV), medium (MV) and low (LV) voltage
- Specified using the annual production volumes (2008 / 2009) of generation technologies

Electricity in ecoinvent v3: markets



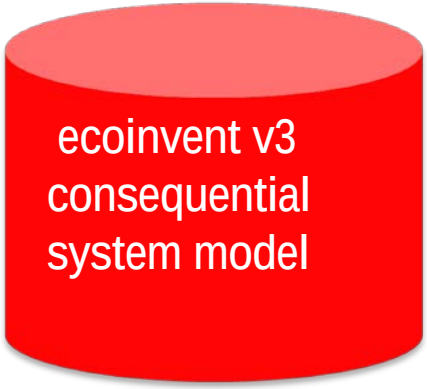
* Net = Gross production minus own consumption of the power stations auxiliary services (Losses)
HV, MV, LV = High/Medium/Low Voltage

New in ecoinvent v3: system models for DS linking



Attributional model:

All activities supply the markets (average suppliers)



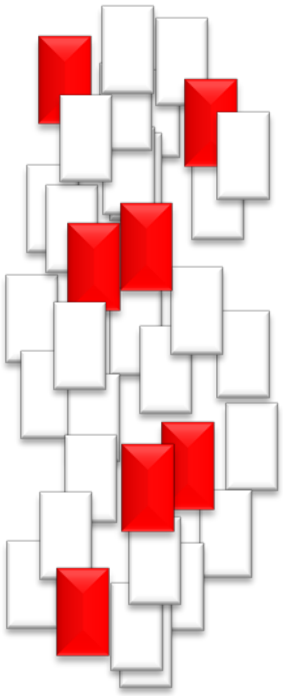
Consequential model (long-term):

Only unconstrained (marginal) suppliers on the markets

New in ecoinvent v3: system models for DS linking

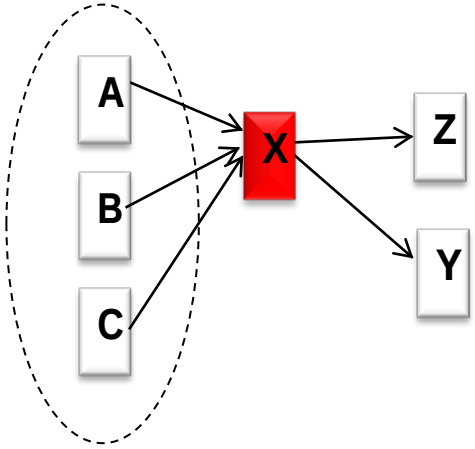
Unlinked database

- Transforming activity
- Market activity

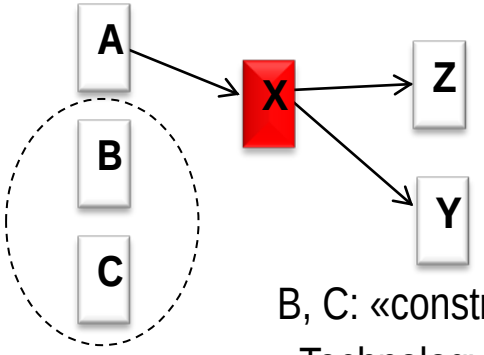


default allocation system model: no constraints

Calculated database

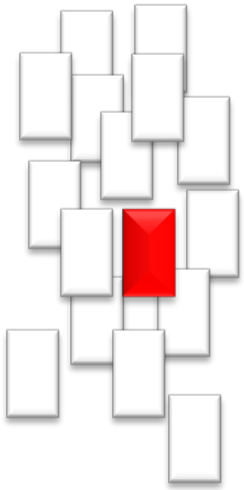


Consequential system model (substitution, long-term)

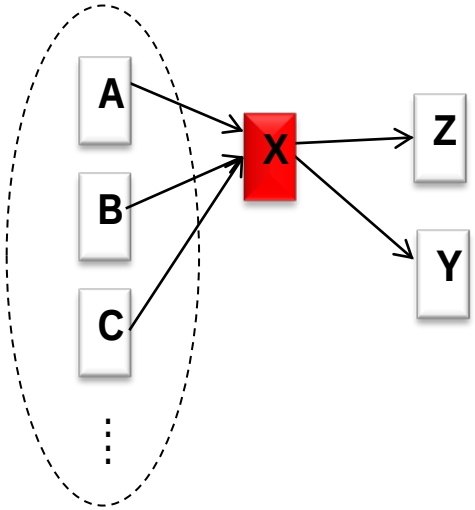


B, C: «constrained producers»
- Technology level constraints
- By-product constraints

Example: HV market in Germany

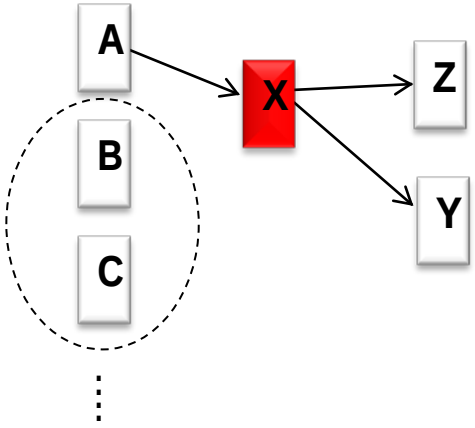


default allocation system model: no constraints



A: wind power
B: nuclear
C: natural gas CHP
...

Consequential system model (substitution, long-term)



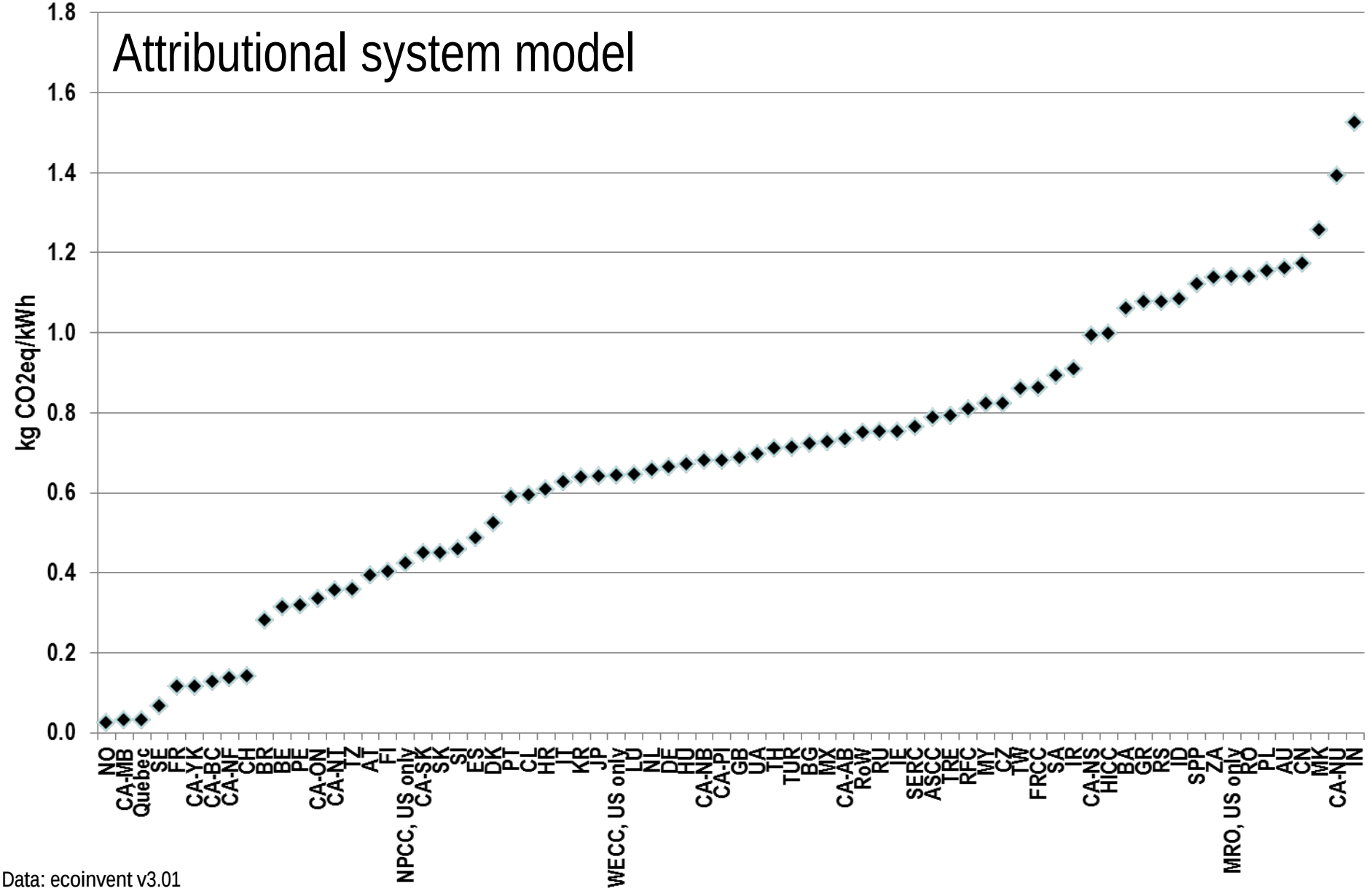
Attributional vs. Consequential electricity markets

Technologies supplying electricity markets in the different system models (v3.01)

- ✓ Yes
- X No
- O Depends on the geography (country)

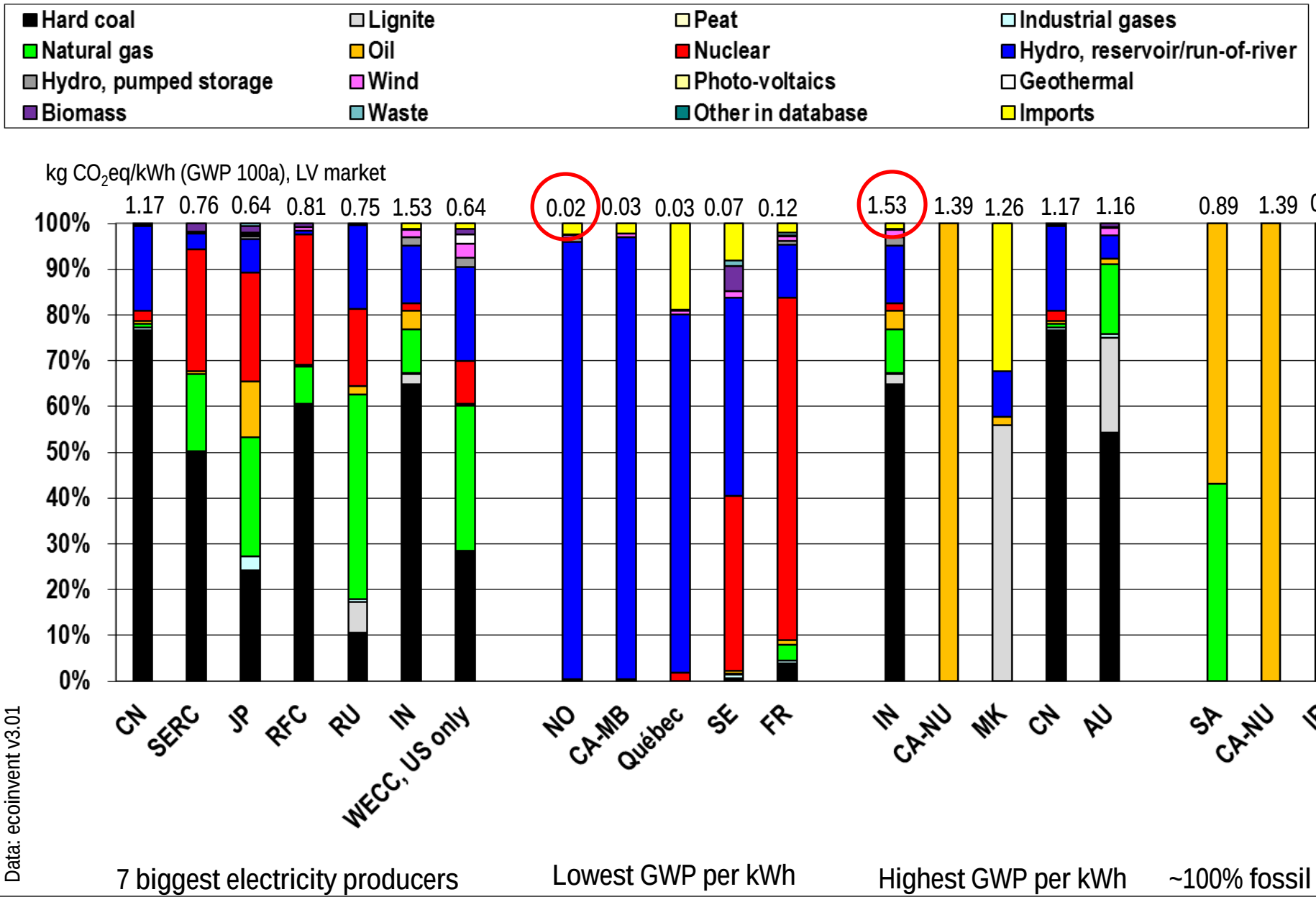
		Attributional	Consequential
Coal	Hard coal	✓	✓
	Lignite	✓	✓
	Peat	✓	X
Natural gas	Conventional w/o CHP	✓	X
	Combined cycle (CC) w/o CHP	✓	✓
	Conventional & CC with CHP	✓	X
Oil		✓	O
Nuclear	BWR & PWR	✓	O
Hydro	Reservoir & run-of-river, pumped storage	✓	✓
Other renewables	Wind: on- & offshore	✓	✓
	Solar PV (on LV level)	✓	✓
	Geothermal	✓	✓
	Wood CHP	✓	X
Treatment activities	MSW, biogas, industrial gases	✓	X
Imports	From neighbour markets	✓	X

LCIA results: GWP, electricity markets, LV



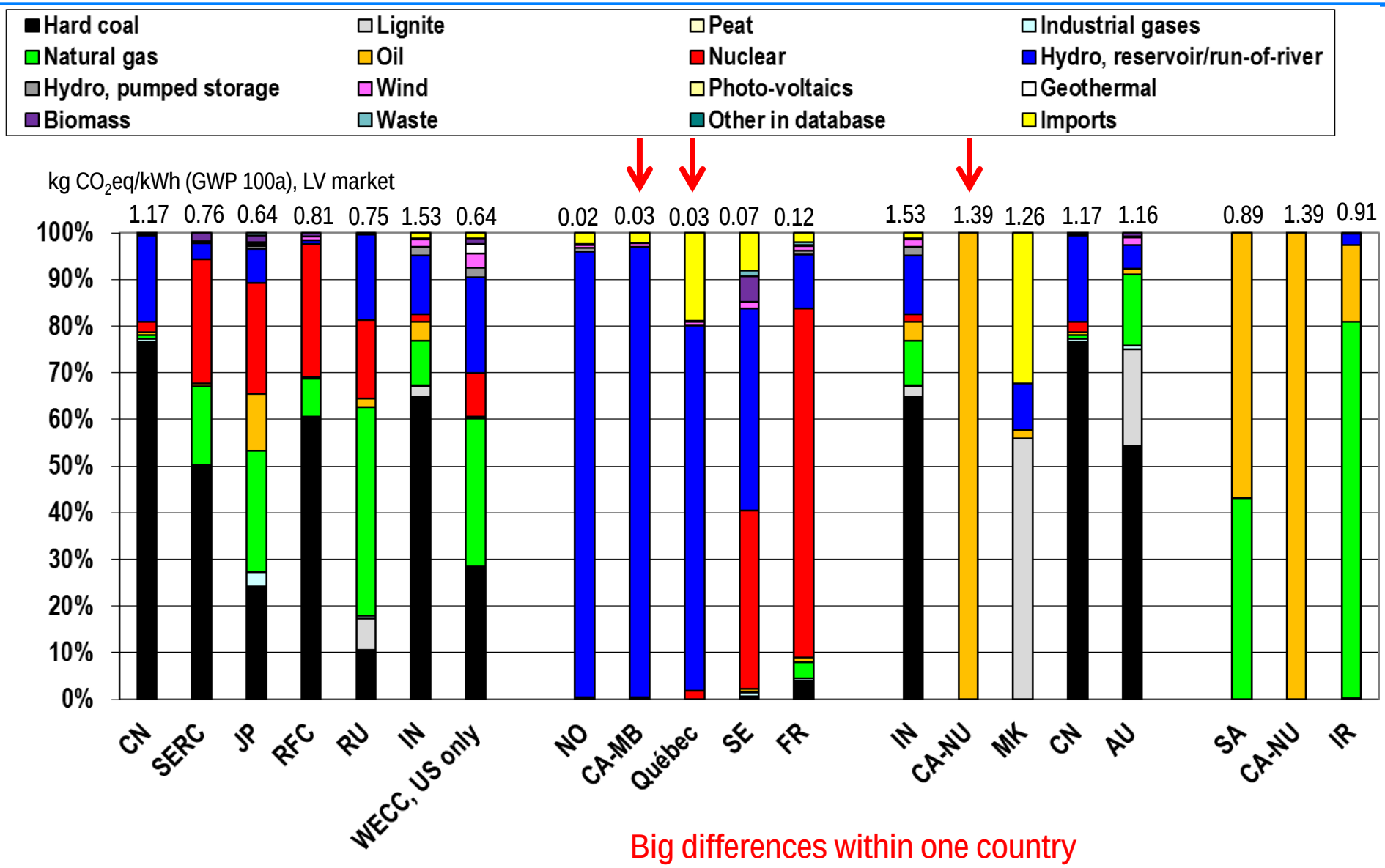
Data: ecoinvent v3.01

Electricity market compositions, attributional



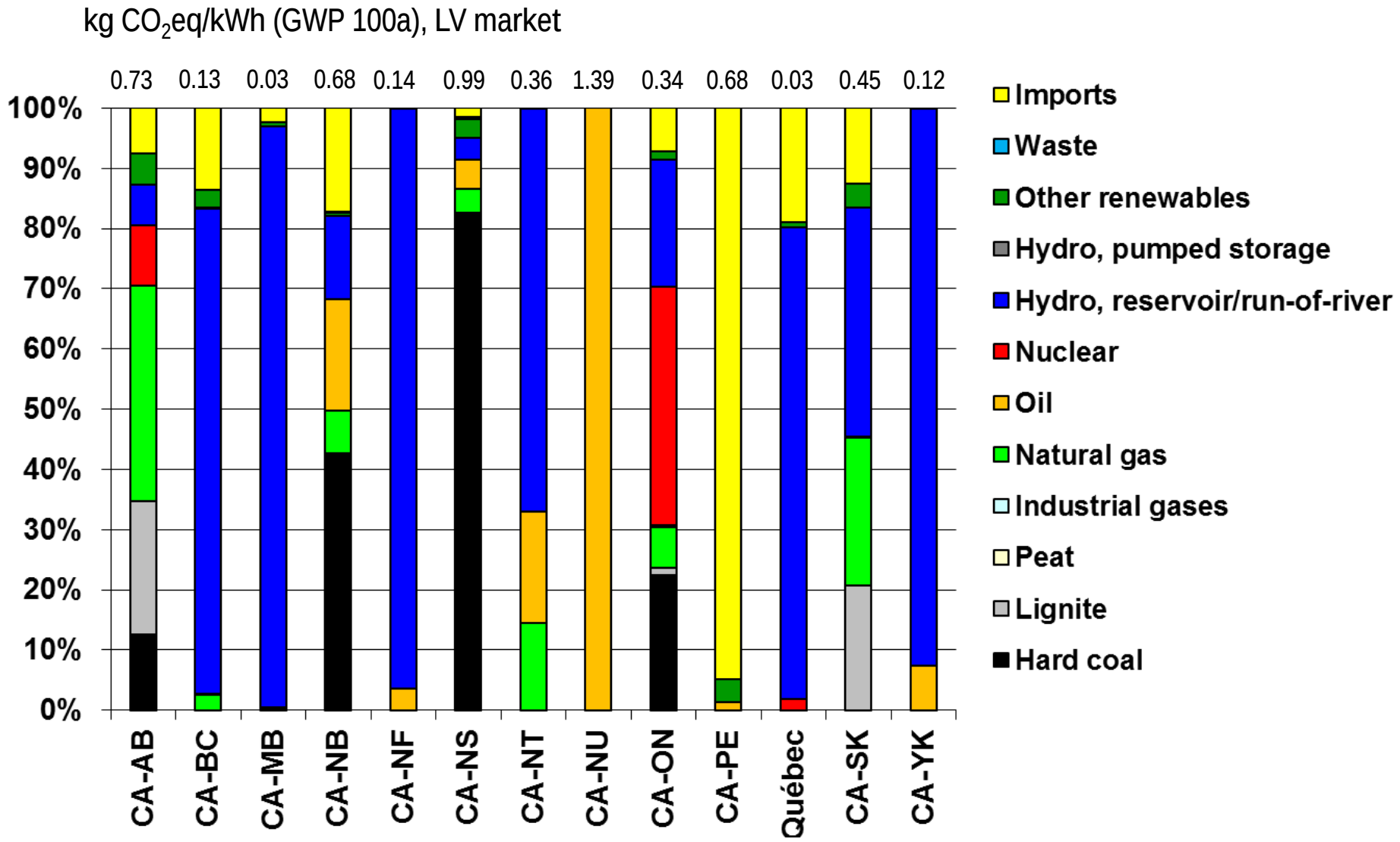
Data: ecoinvent v3.01

Electricity market compositions, attributional



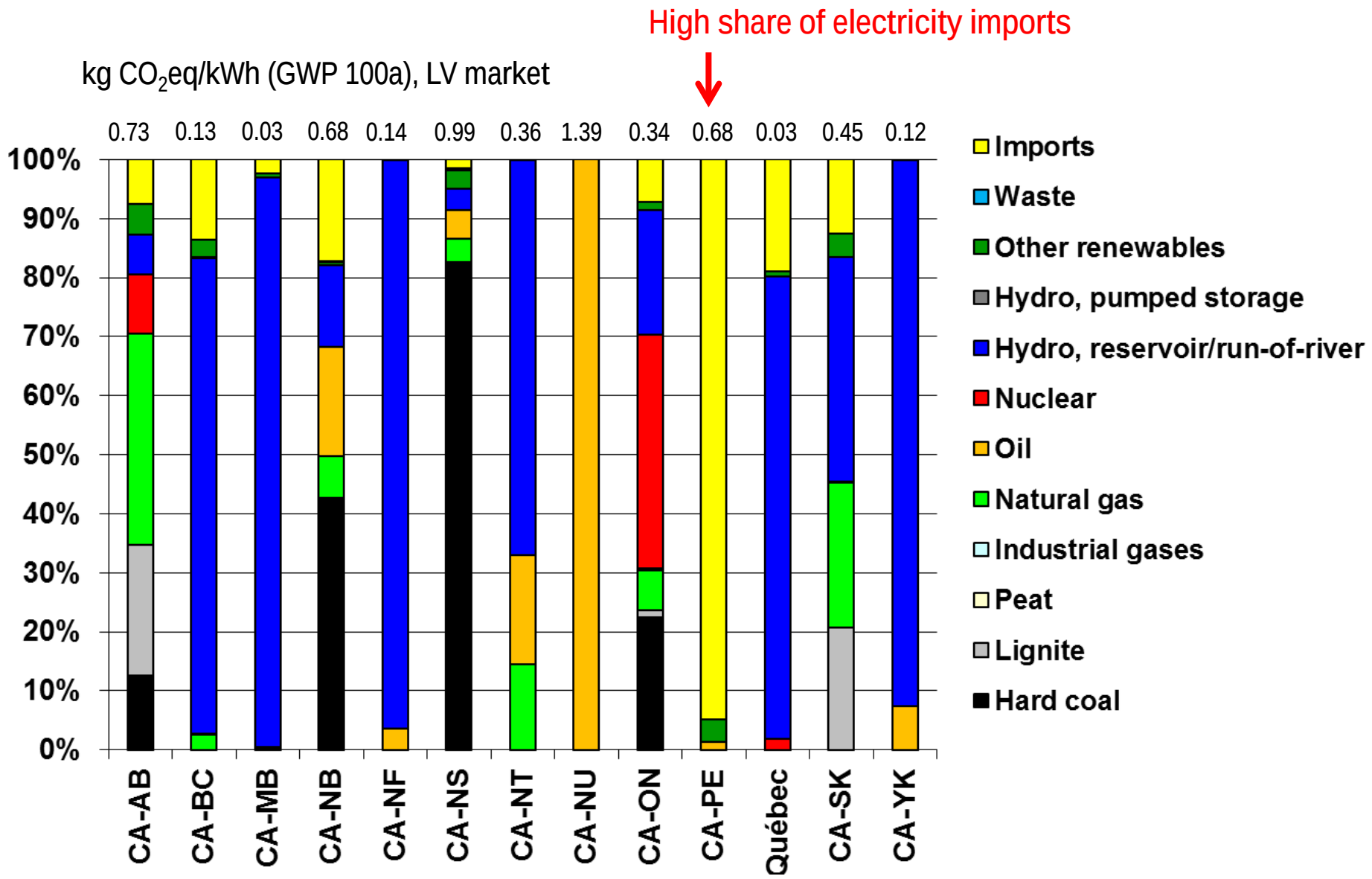
Data: ecoinvent v3.01

Canadian electricity markets, attributional



Data: ecoinvent v3.01

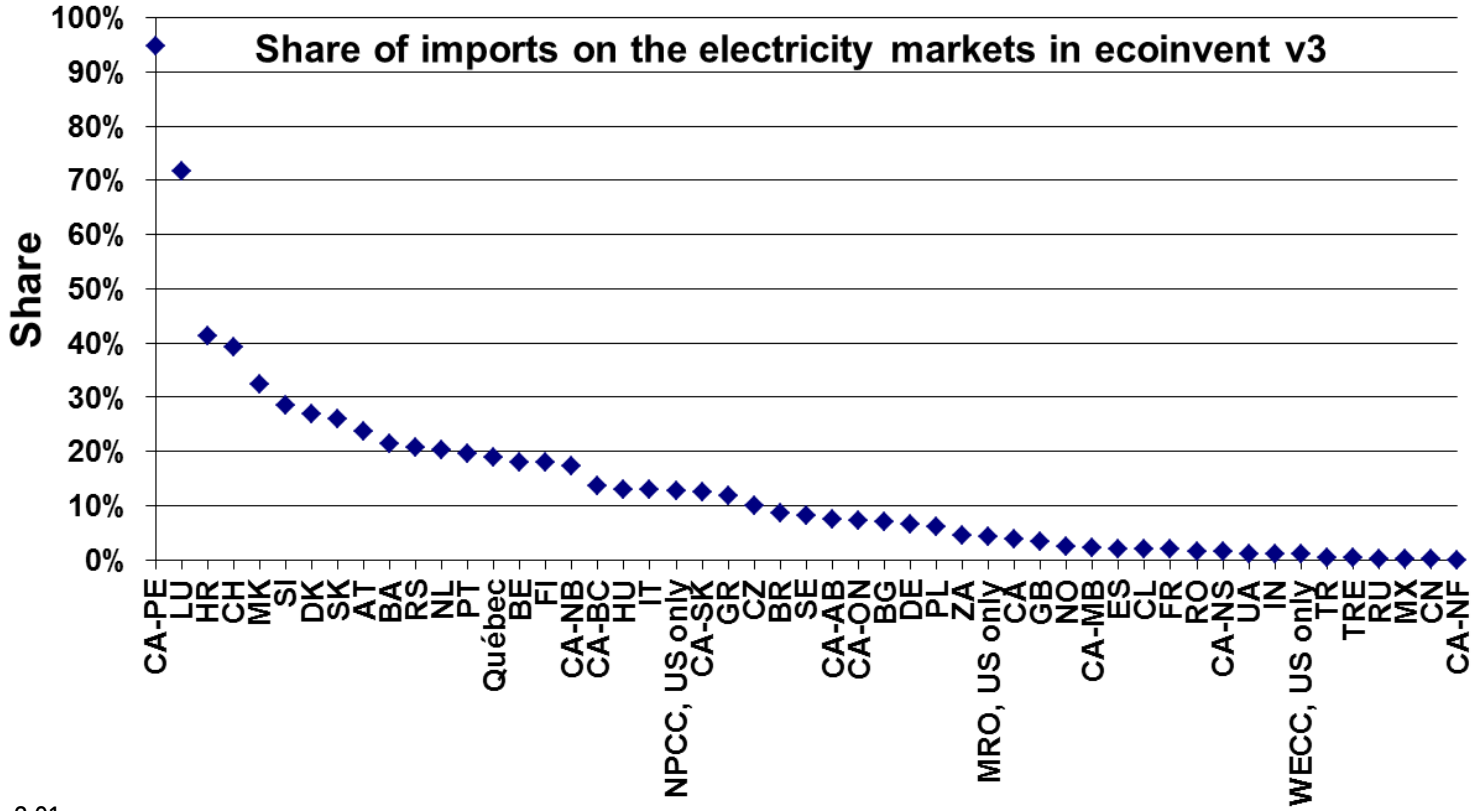
Canadian electricity markets, attributional



Data: ecoinvent v3.01

Electricity imports on attributional HV markets

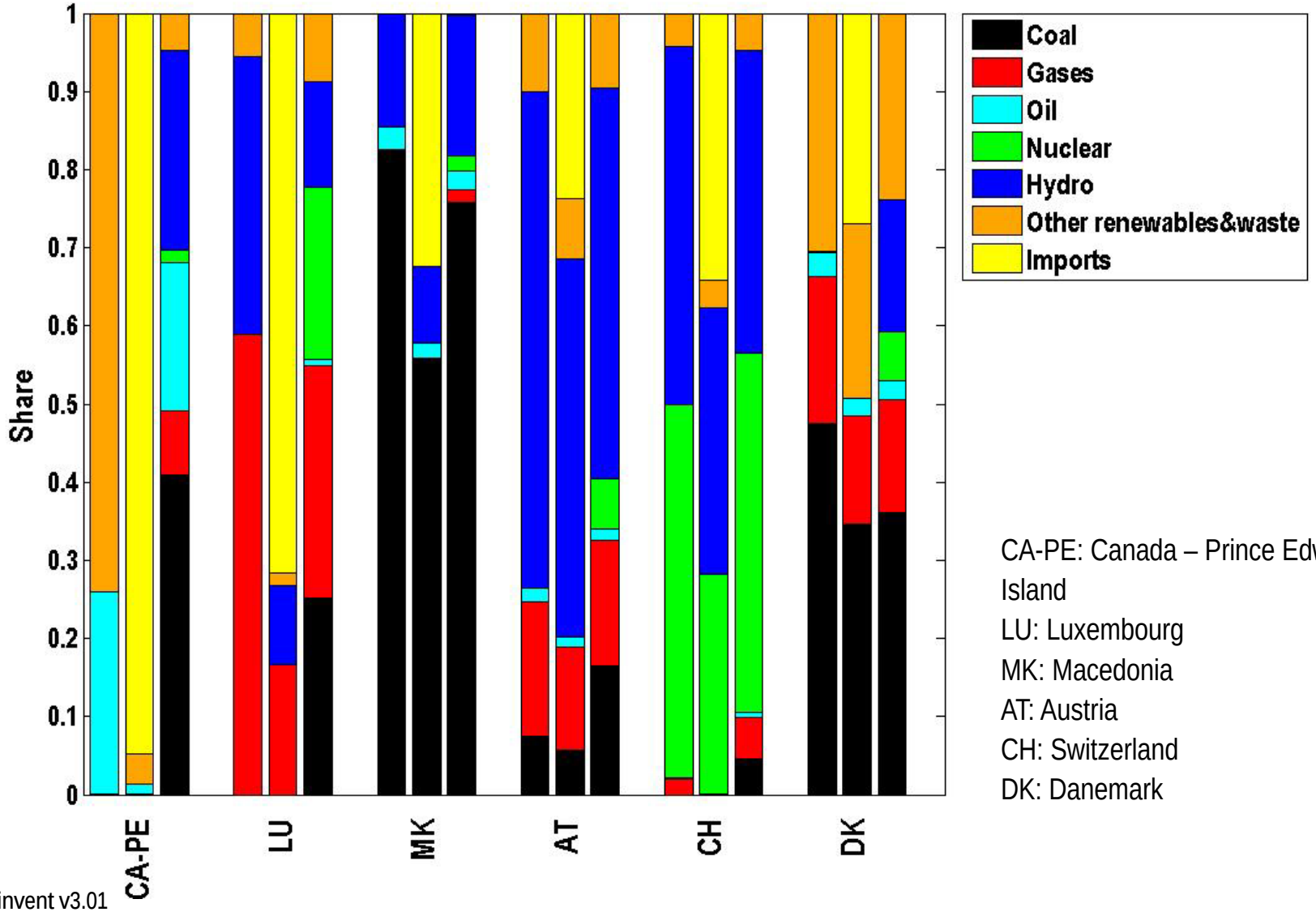
- Market for electricity = Supply mix = Production mix + Imports – T&T losses
- 21 markets without electricity imports
- 28 markets with less than 10% imports
- Most imports in Europe: 18 countries import more than 10% of their electricity (10-71%)
- Imports within the United States have not been modeled yet



Data: ecoinvent v3.01

Production mix – imports – supply mix (attributional)

Production mix (left) / Production mix + imports (middle) / Supply mix (right)



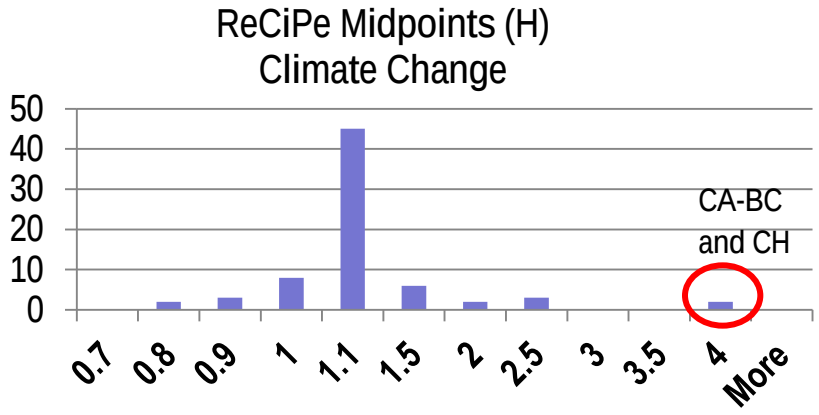
CA-PE: Canada – Prince Edward Island
LU: Luxembourg
MK: Macedonia
AT: Austria
CH: Switzerland
DK: Danemark

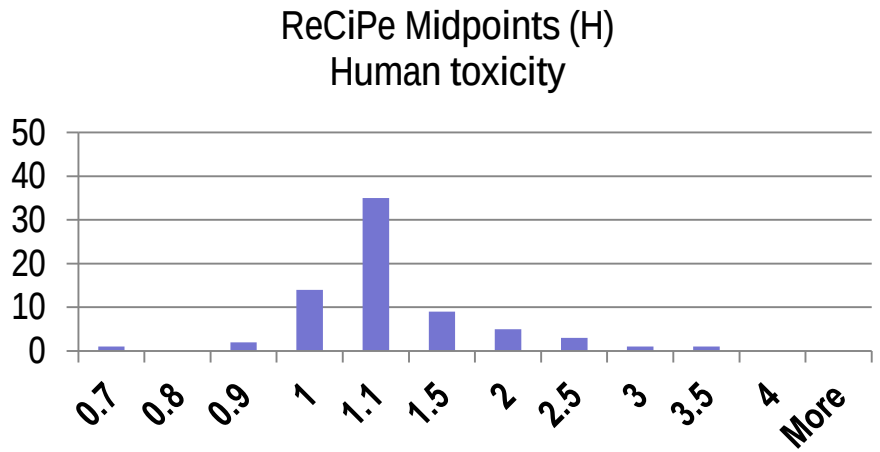
Data: ecoinvent v3.01

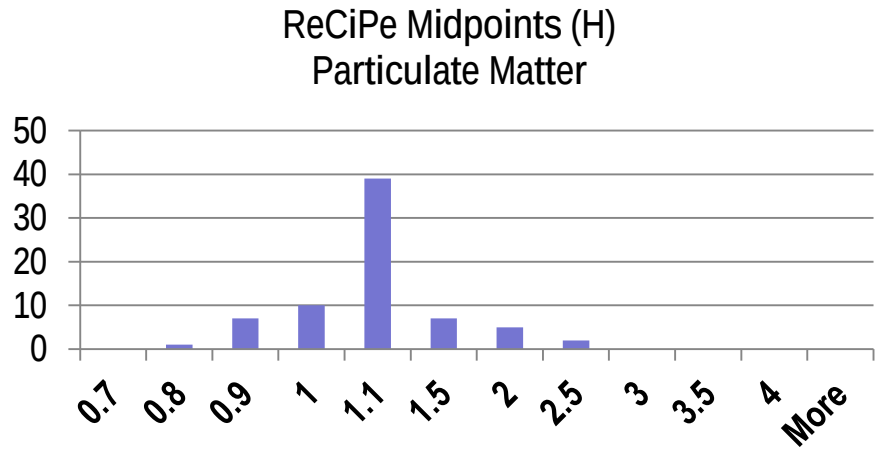
Impact of imports on LCIA results

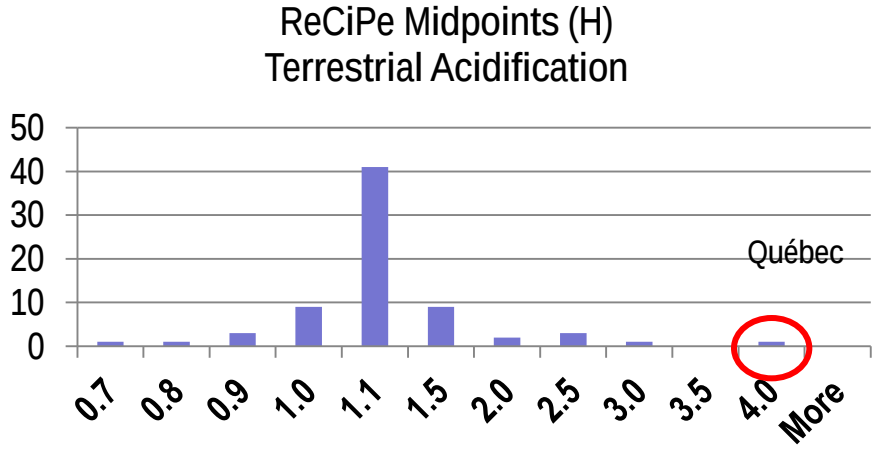
Histograms of LCIA results: electricity supply mix vs production mix for all 71 geographies (attributional)

y-axis: Number of geographies // x-axis: Relation impact of supply mix/impact of production mix







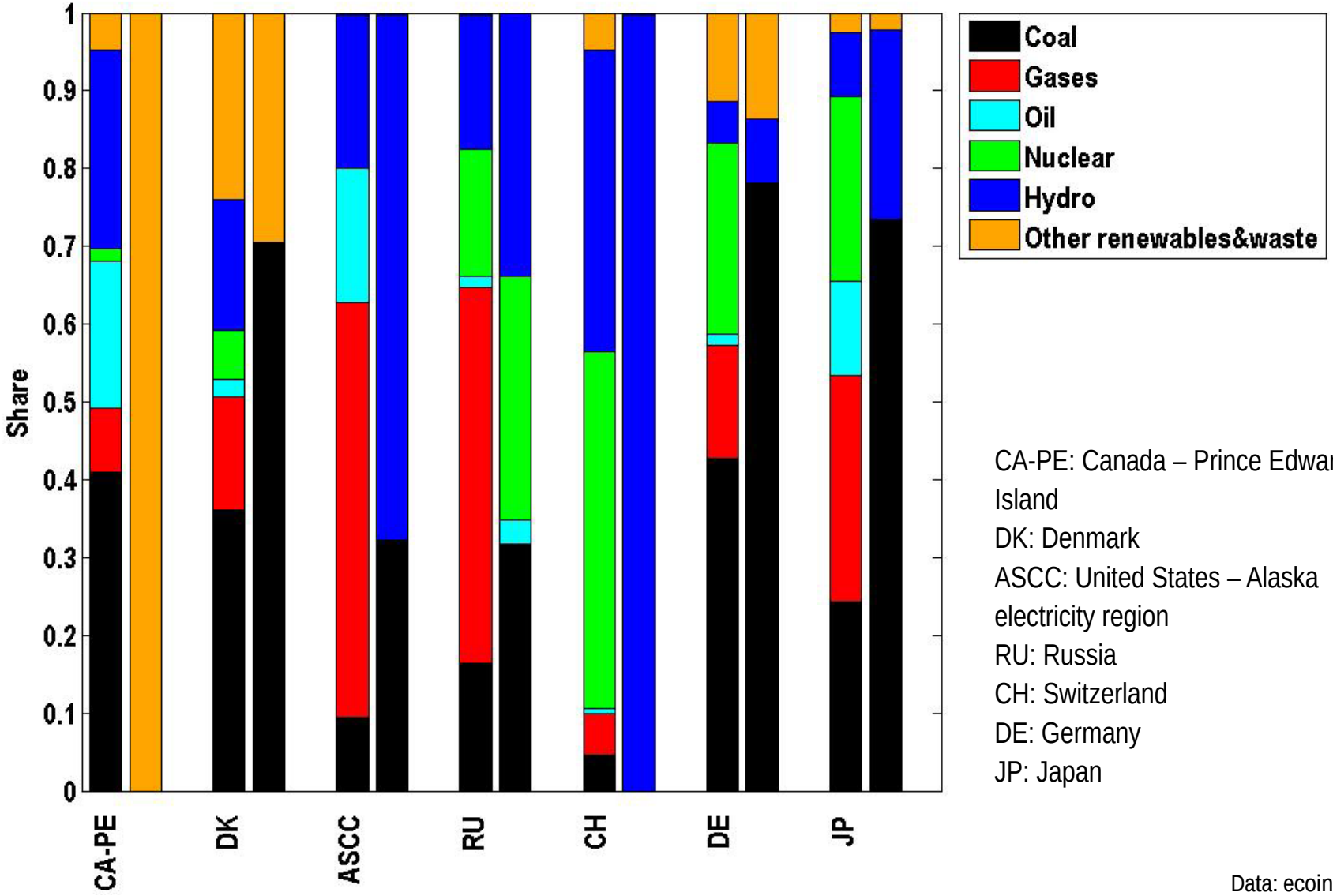


Data: ecoinvent v3.01

* only higher part of a bin written on the x-axis, e.g. 1.1 means actually "1.0 – 1.1"

Attributional vs. Consequential HV markets

Left: attributional (avg. supply) Right: consequential (unconstrained supply)



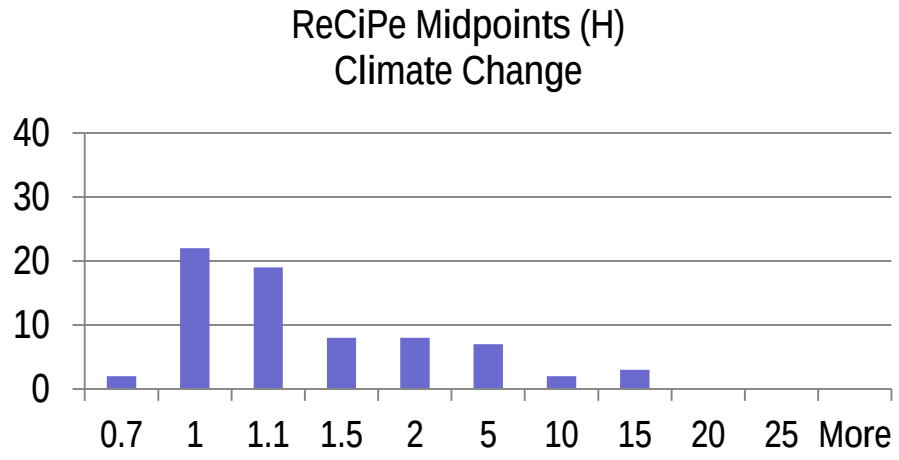
CA-PE: Canada – Prince Edward Island
DK: Denmark
ASCC: United States – Alaska electricity region
RU: Russia
CH: Switzerland
DE: Germany
JP: Japan

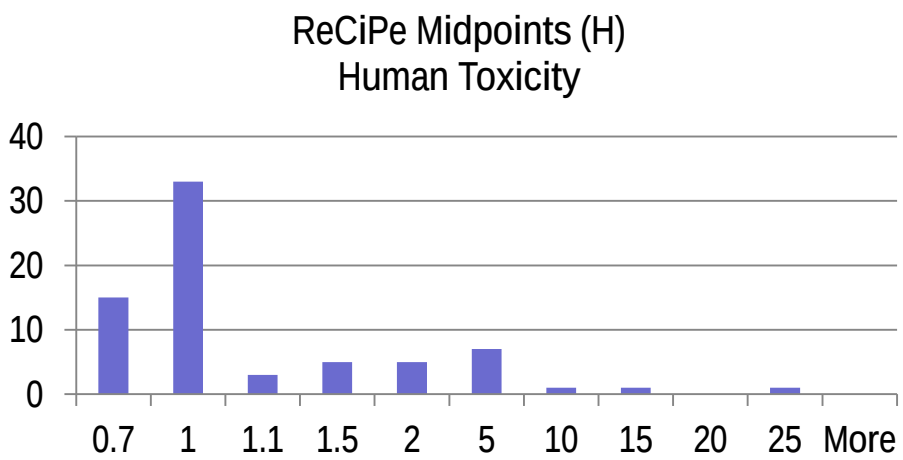
Data: ecoinvent v3.01

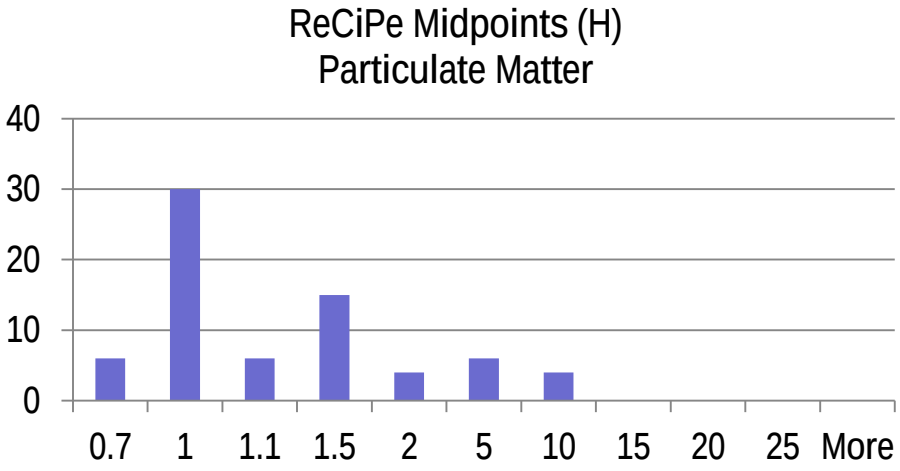
Attributional vs. Consequential HV markets

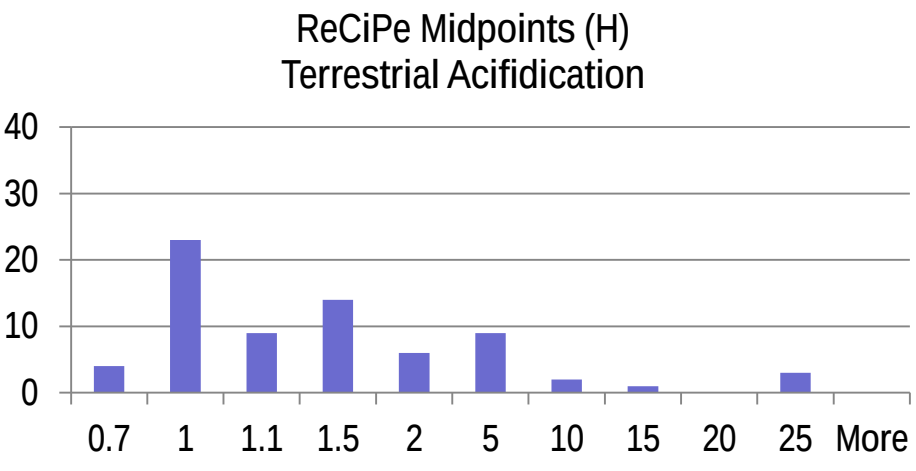
Histograms of LCIA results: attributional vs. consequential electricity supply mix for all 71 geographies

y-axis: Number of geographies // x-axis: Relation impact of attributional mix/impact of consequential mix









Data: ecoinvent v3.01

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Conclusions – electricity markets in v3

- Broad **geographical coverage** of region-specific electricity supply with high variability in LCIA results
  - → Important step towards internalisation of ecoinvent
  - → Allows for more precise LCA of global production chains

- National borders are not necessarily representative for electricity markets
  - → Large countries such as China, Russia, India or Australia should also be split into smaller electricity markets

- **Imports** can substantially alter environmental burdens of electricity supply

- **Attributional & consequential** system models result in very different electricity markets
  - → Consequential modeling needs to be improved

Thanks to ecoinvent staff & CIRAIG for collaboration

Thanks for your attention!