PAUL SCHERRER INSTITUT

PSI

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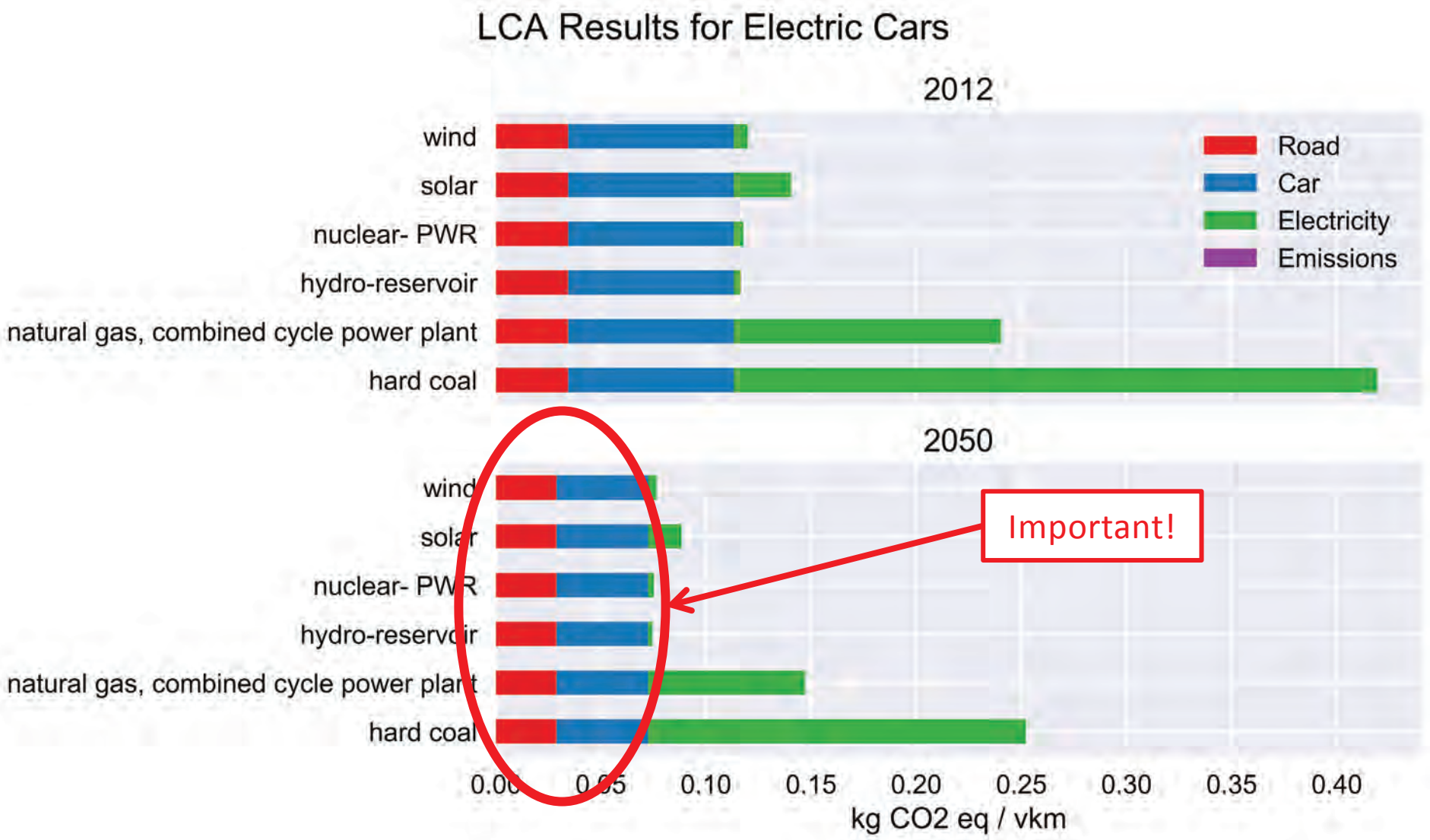
***Paul Scherrer Institute**

LCI of future mobility technologies

LCA Discussion Forum 30. August 2017

Current state of the art for prospective LCA



Electric car LCI: Bauer et al. 2015: DOI: 10.1016/j.apenergy.2015.01.019

Goal

Produce a version of «Future ecoinvent» for prospective LCA:

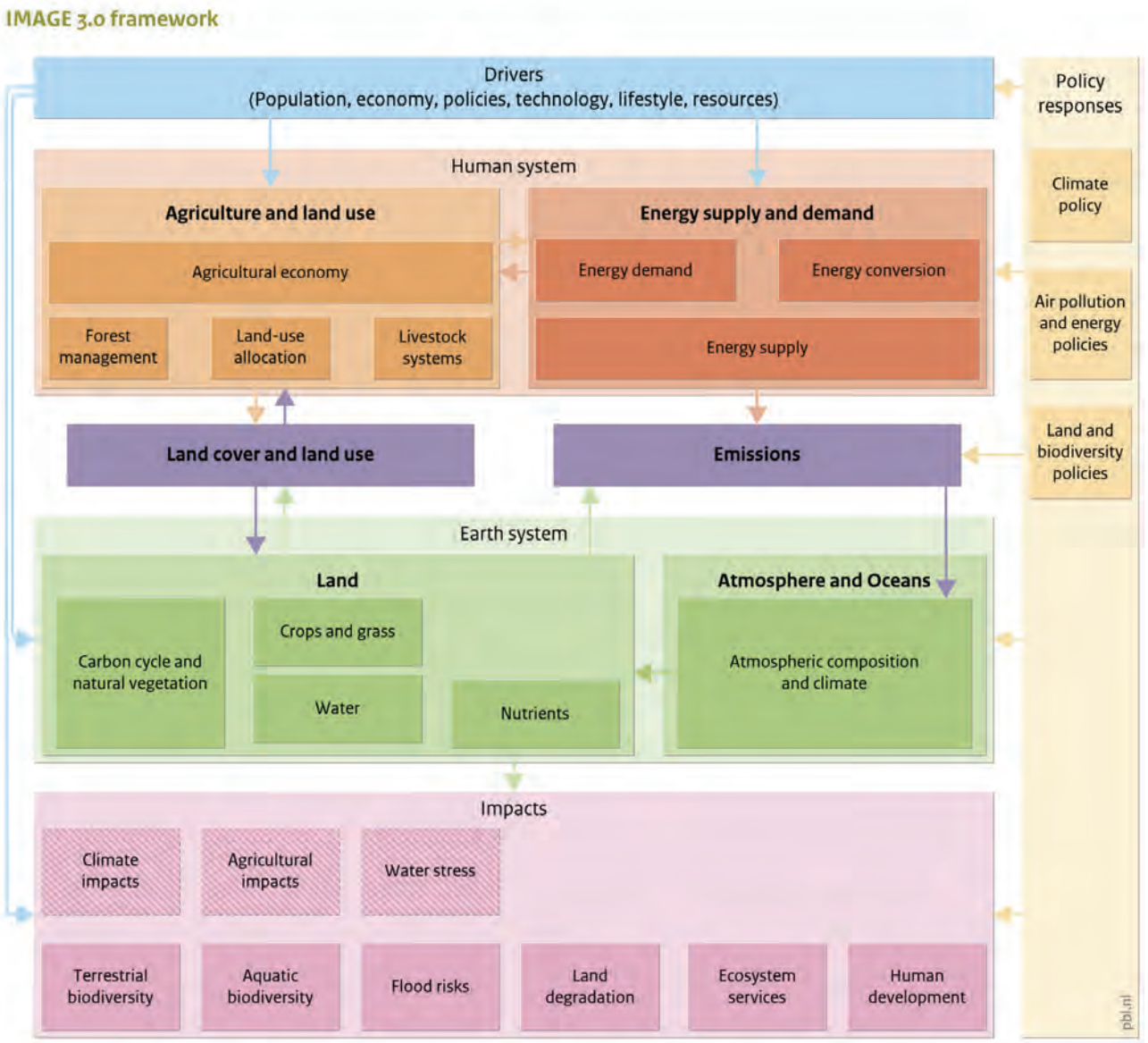
1. Need to know what the future will look like

2. Need to map these changes to ecoinvent activities and exchanges

3. Need to make the changes
   - Process needs to be fast and repeatable

Input data: IMAGE model

Integrated
Model to
Assess the
Global
Environment



themasites.pbl.nl/models/image

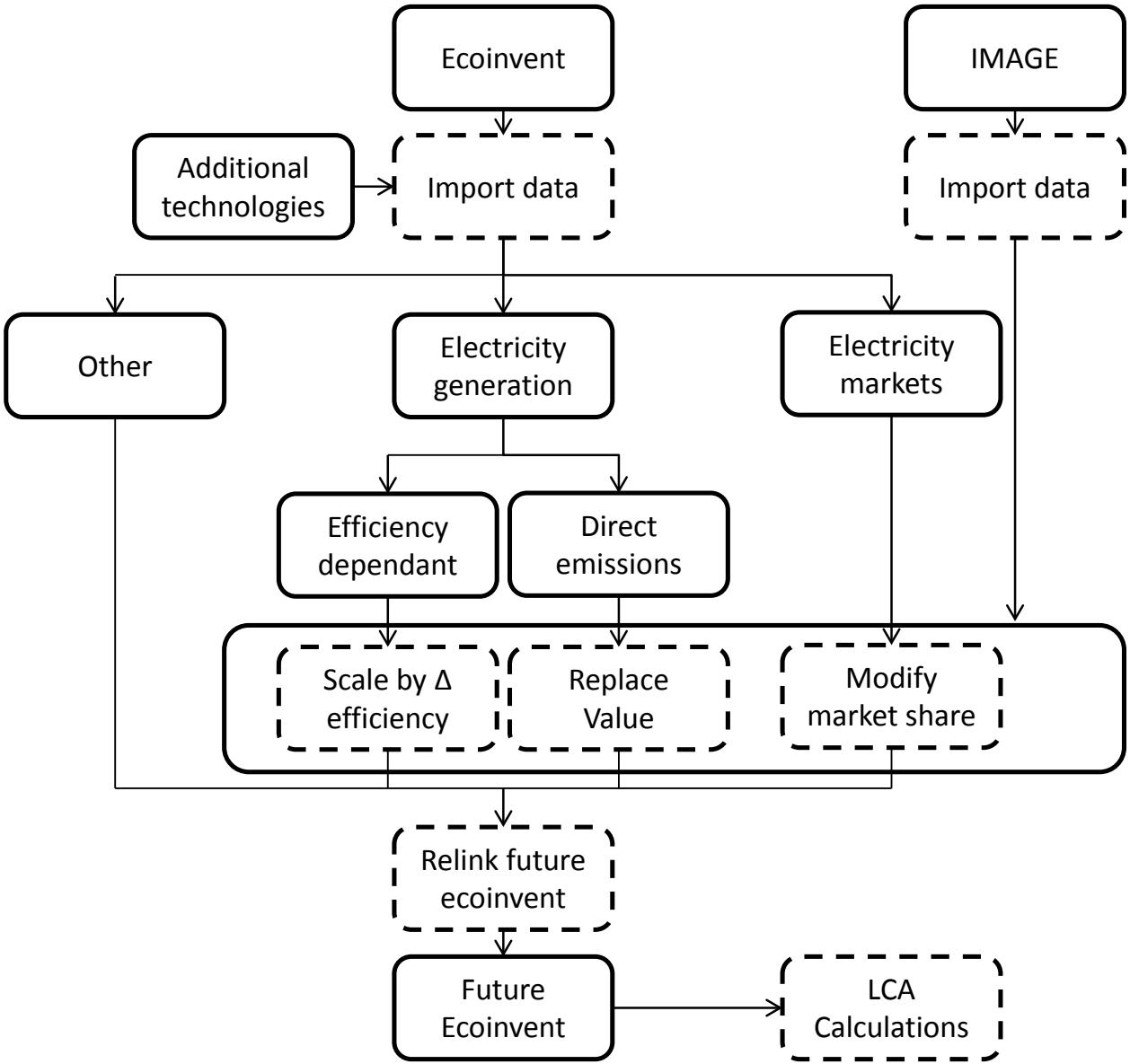
IMAGE – results available

- 1970 to 2100
- 26 Regions
- Energy and Agriculture
- 27 Electricity technologies
- 9 Sectors
- 5 Fuel types
  - Coal, Heavy liquid, Light liquid, Natural gas, Biomass
- Direct Emissions
  - CO_2, CH_4, CO, N_2O, NO_x, SO_2, VOC, Black carbon

2 types of changes to Electricity

- Type I: Changes in electricity generation **technology**
  - Coal, gas, biomass, nuclear
    - Efficiency
    - Emissions
- Type II: Changes in electricity generation **mix**
  - Share of technologies
- Preliminary goal: Create 3 new versions of ecoinvent:
  - 2012
  - 2050 BAU
  - 2050 450 ppm

Methodology



Updating coal fired electricity plants

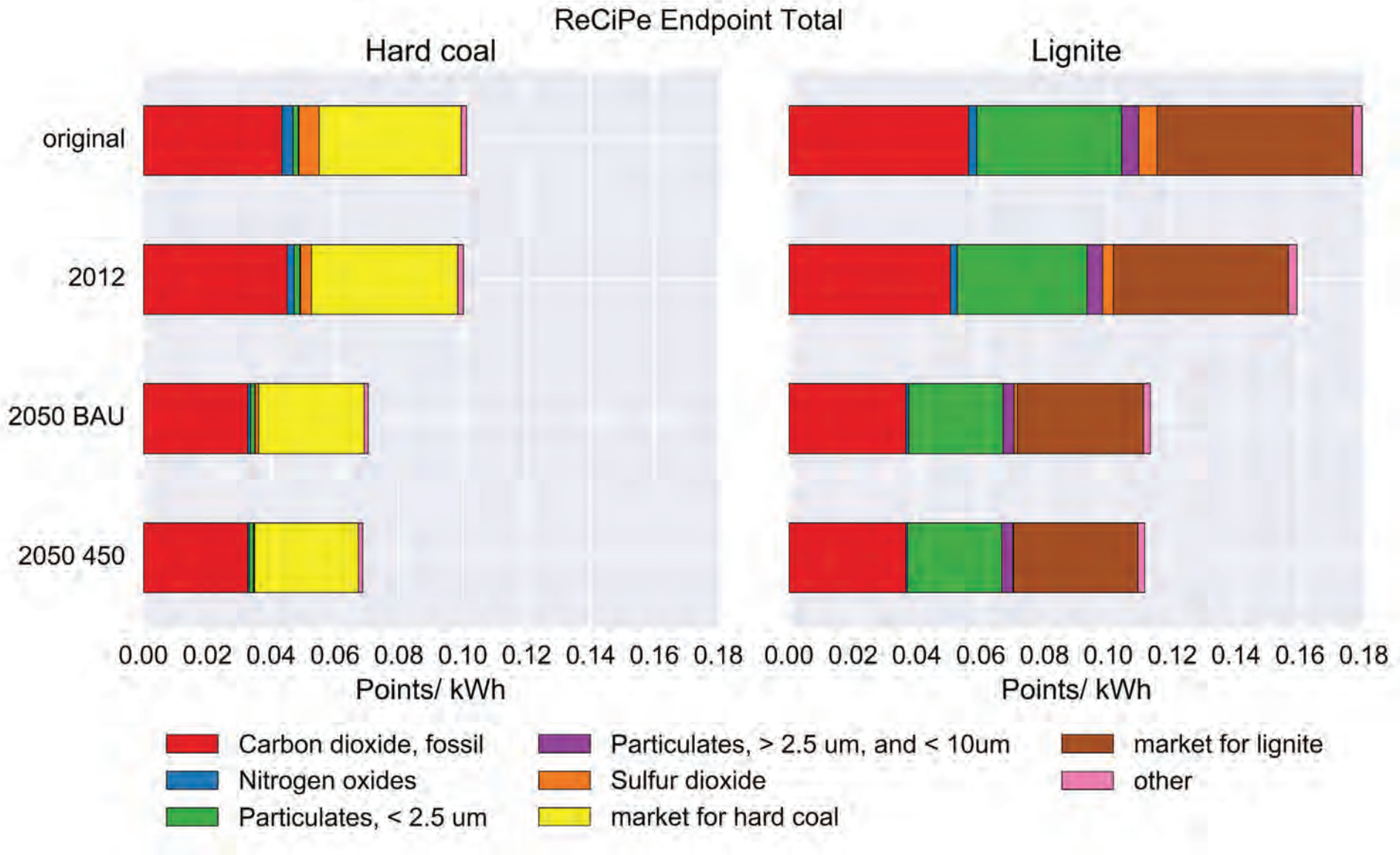
Technosphere

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

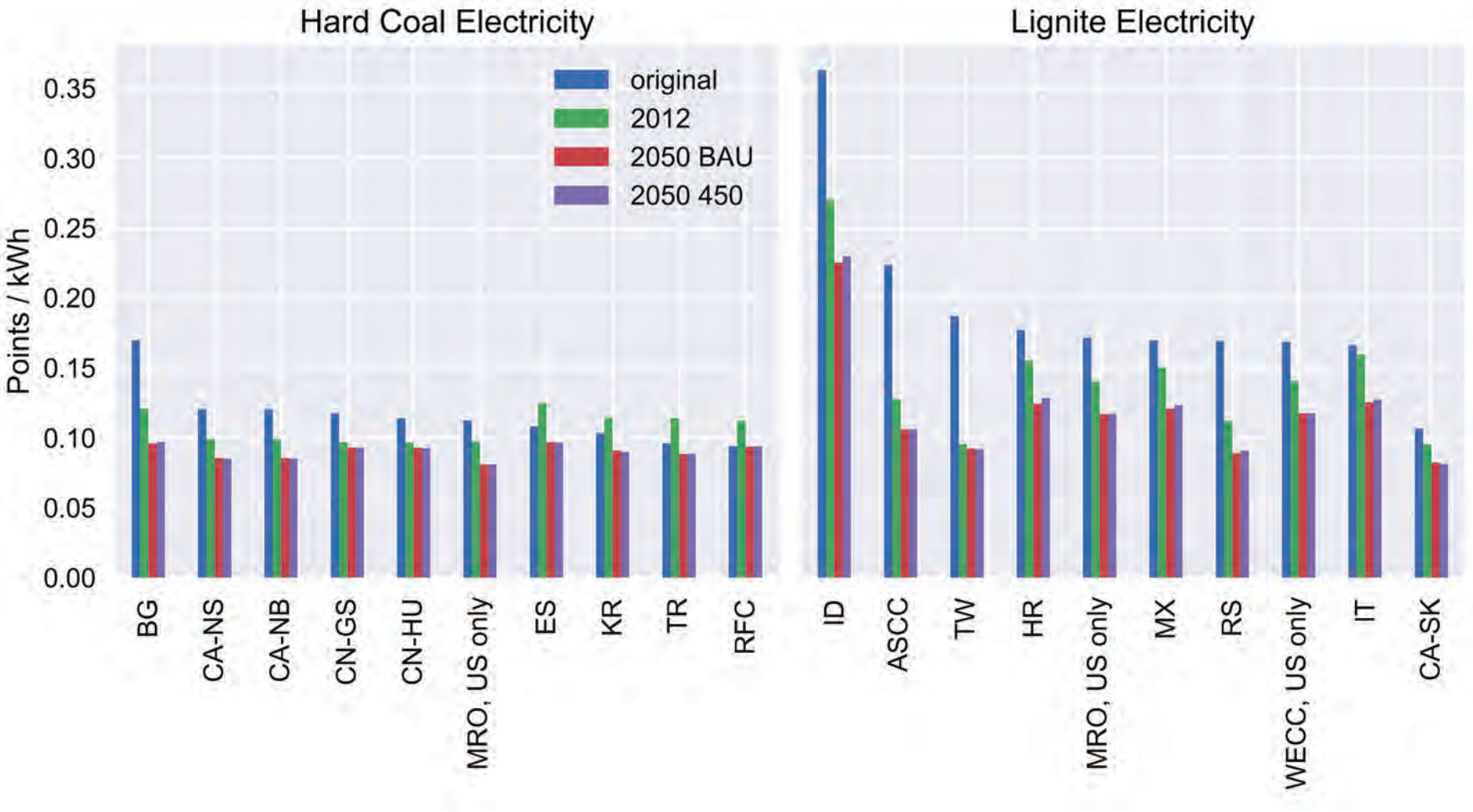
Biosphere

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

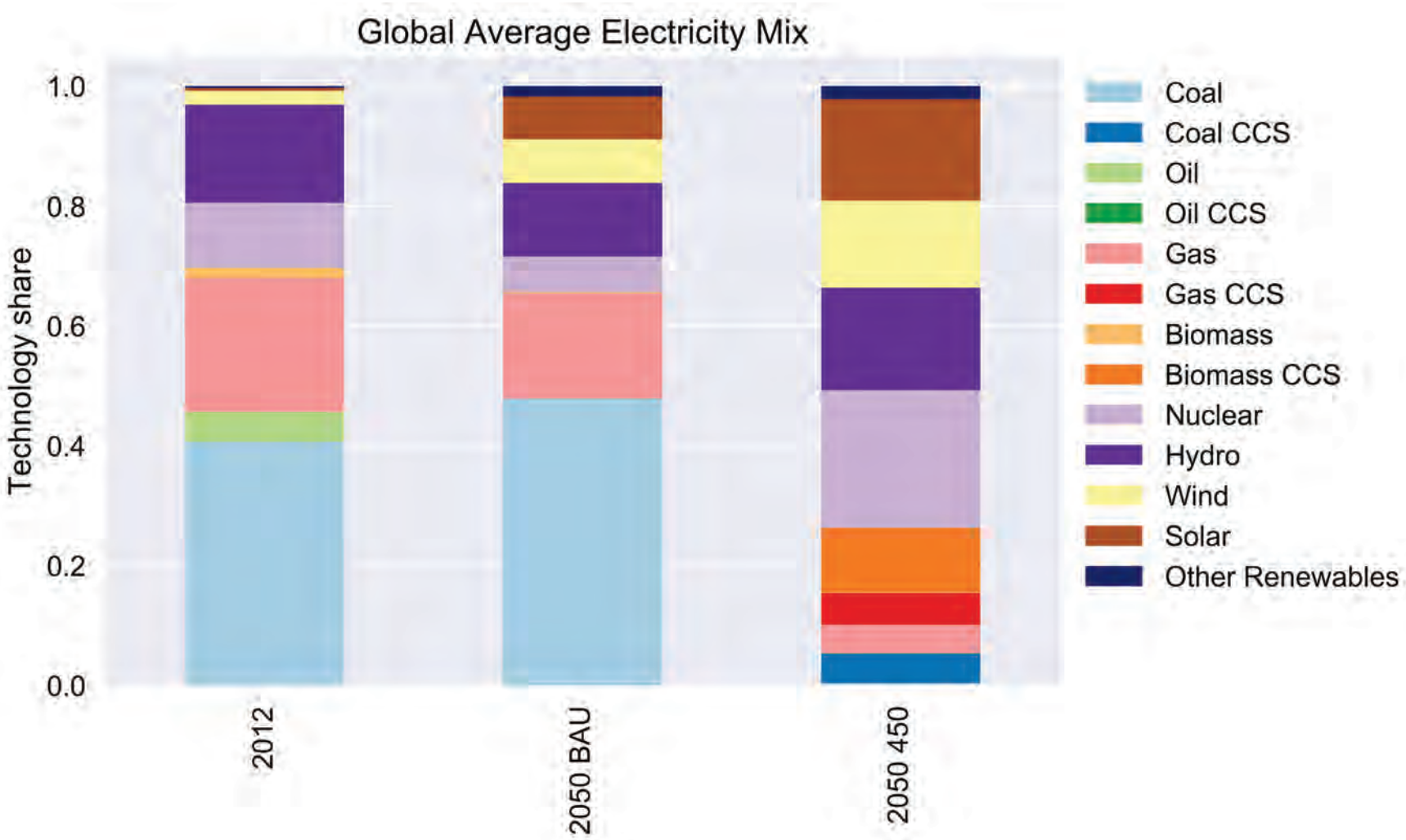
LCA Results: Coal fired electricity plants



LCA Results: Coal fired electricity plants



Updating Electricity Markets



Matching ecoinvent datasets to IMAGE markets

'Wind onshore': ['electricity production, wind, <1MW turbine, onshore',
'electricity production, wind, 1-3MW turbine, onshore',
'electricity production, wind, >3MW turbine, onshore'],

'Wind offshore': ['electricity production, wind, 1-3MW turbine, offshore'],

'Hydro': ['electricity production, hydro, reservoir, alpine region',
'electricity production, hydro, reservoir, non-alpine region',
'electricity production, hydro, reservoir, tropical region',
'electricity production, hydro, run-of-river'],

'Oil ST': ['electricity production, oil'],
'Oil CHP': ['heat and power co-generation, oil'],
'Oil CC': ['electricity production, oil'], ← Proxy

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

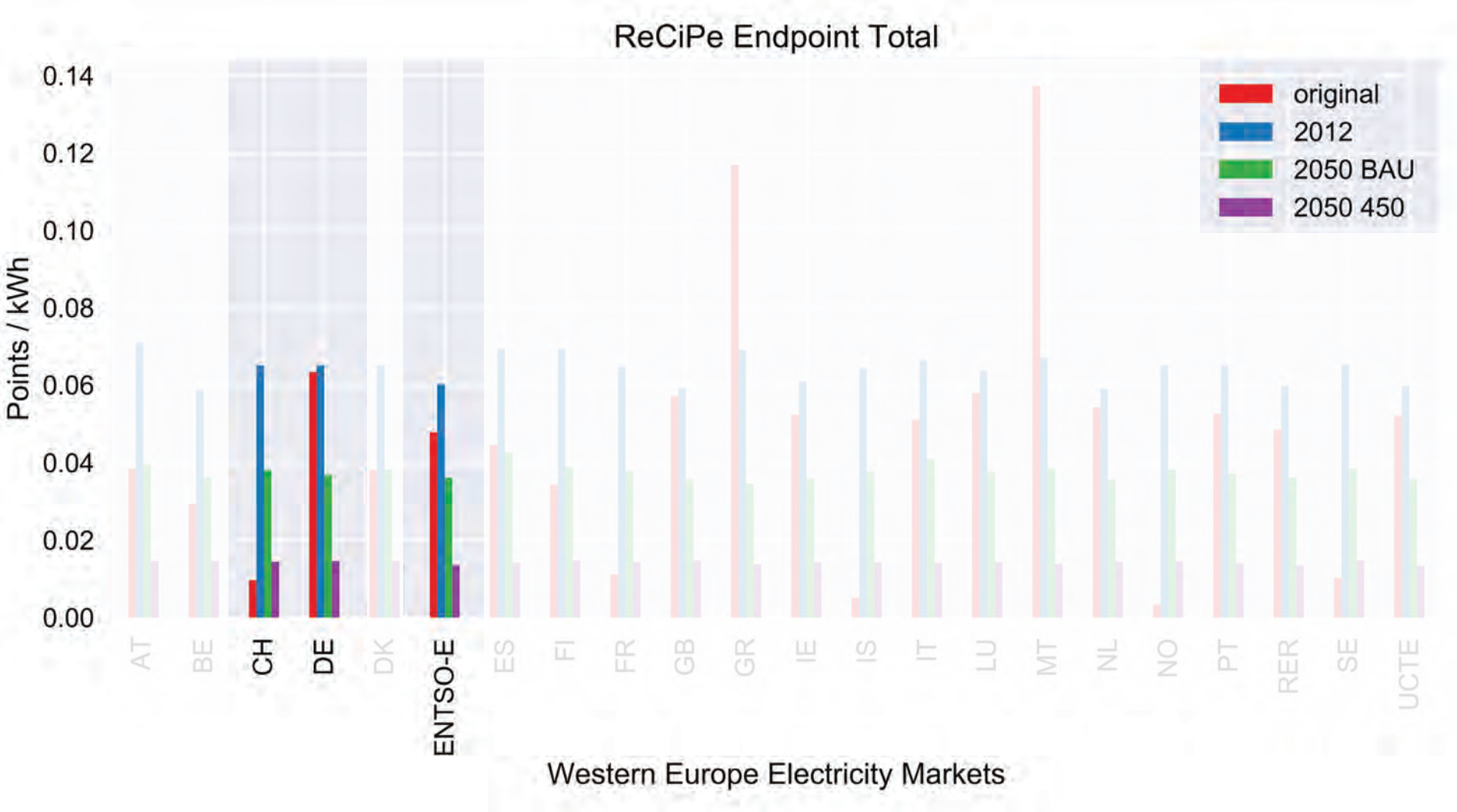
- More than 1 ecoinvent dataset matches image technology
  - Example: coal = hard coal and lignite
  - assume equal share of all technologies available in the market

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

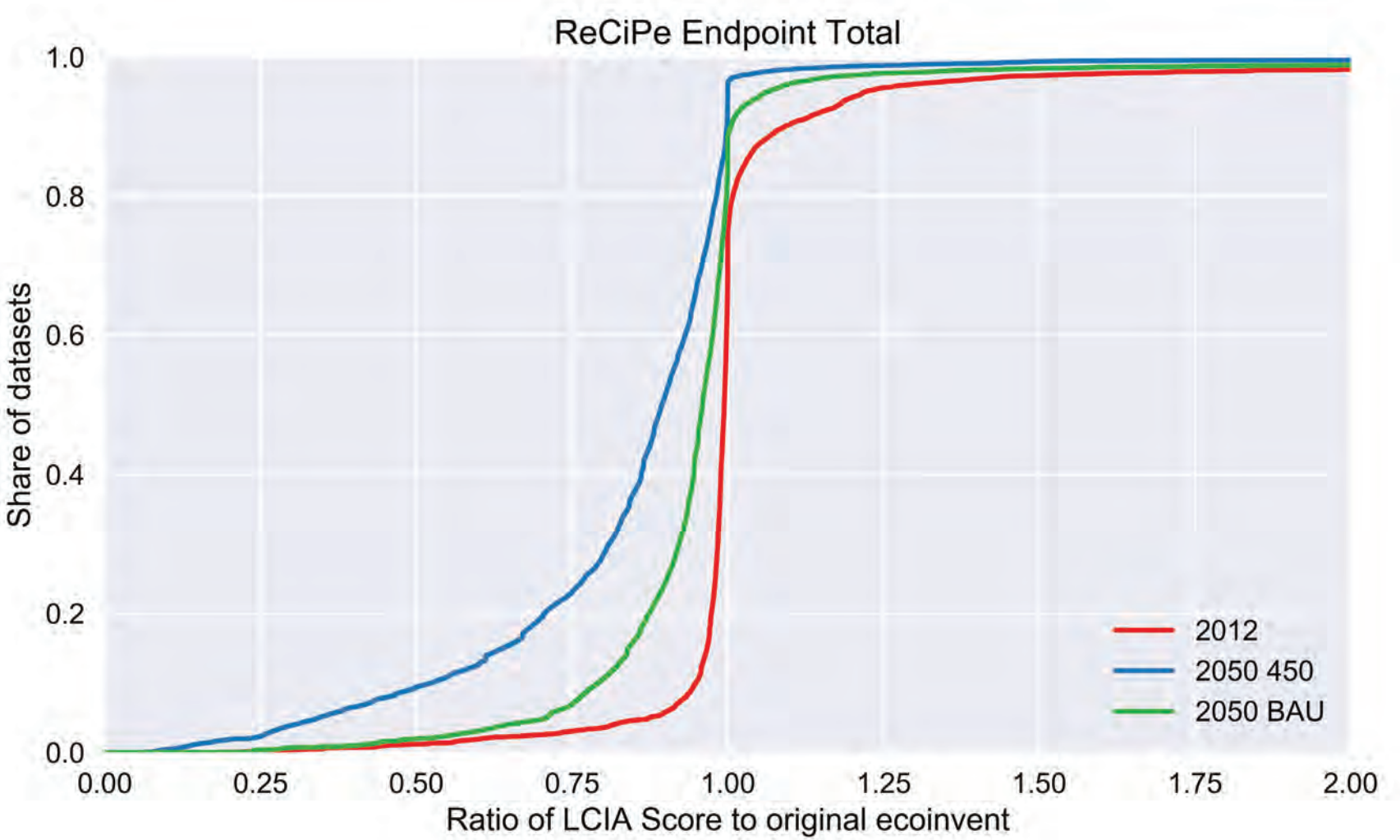
- Had to simplify low and medium voltage levels
  - Assume all technology contribute to high voltage

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

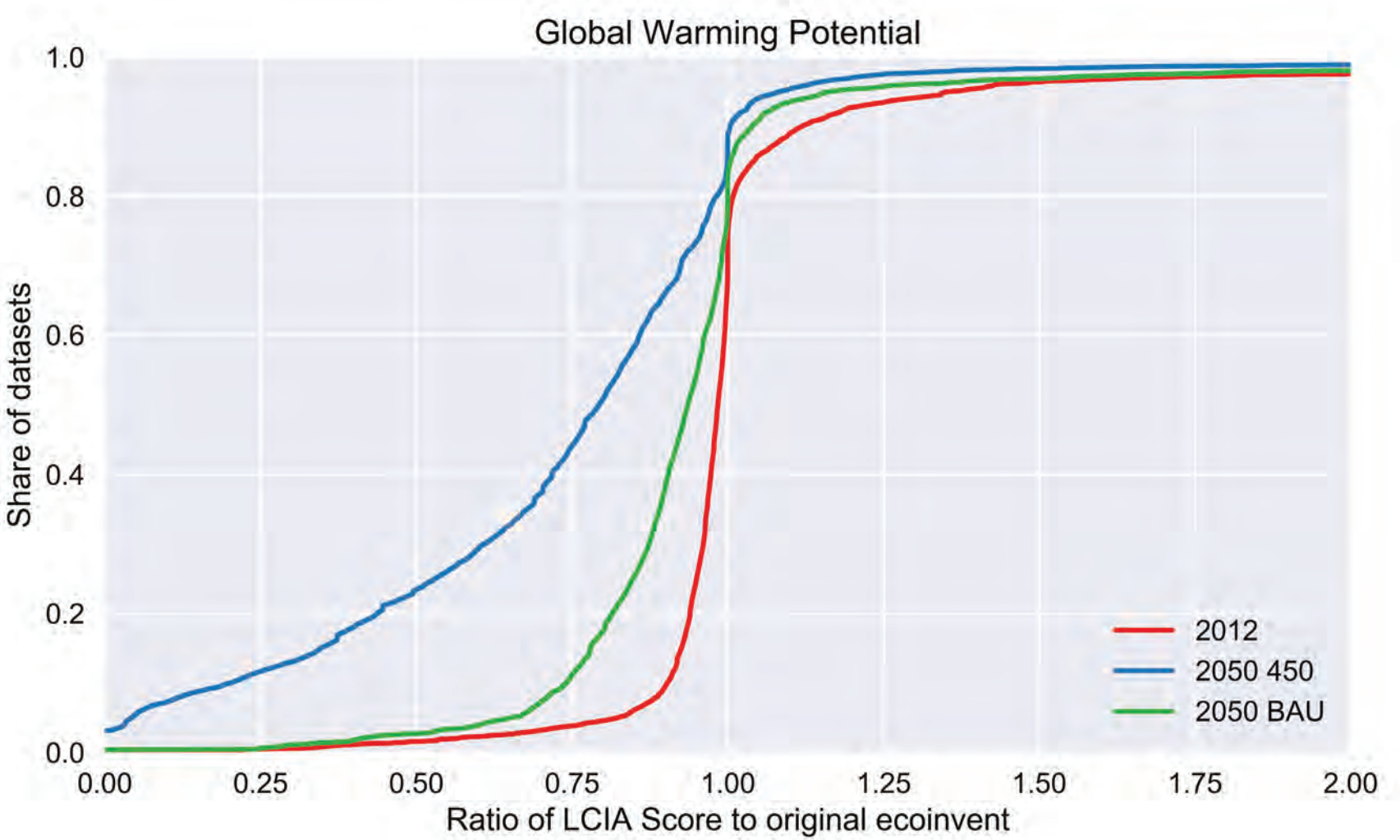
Electricity Market LCA results



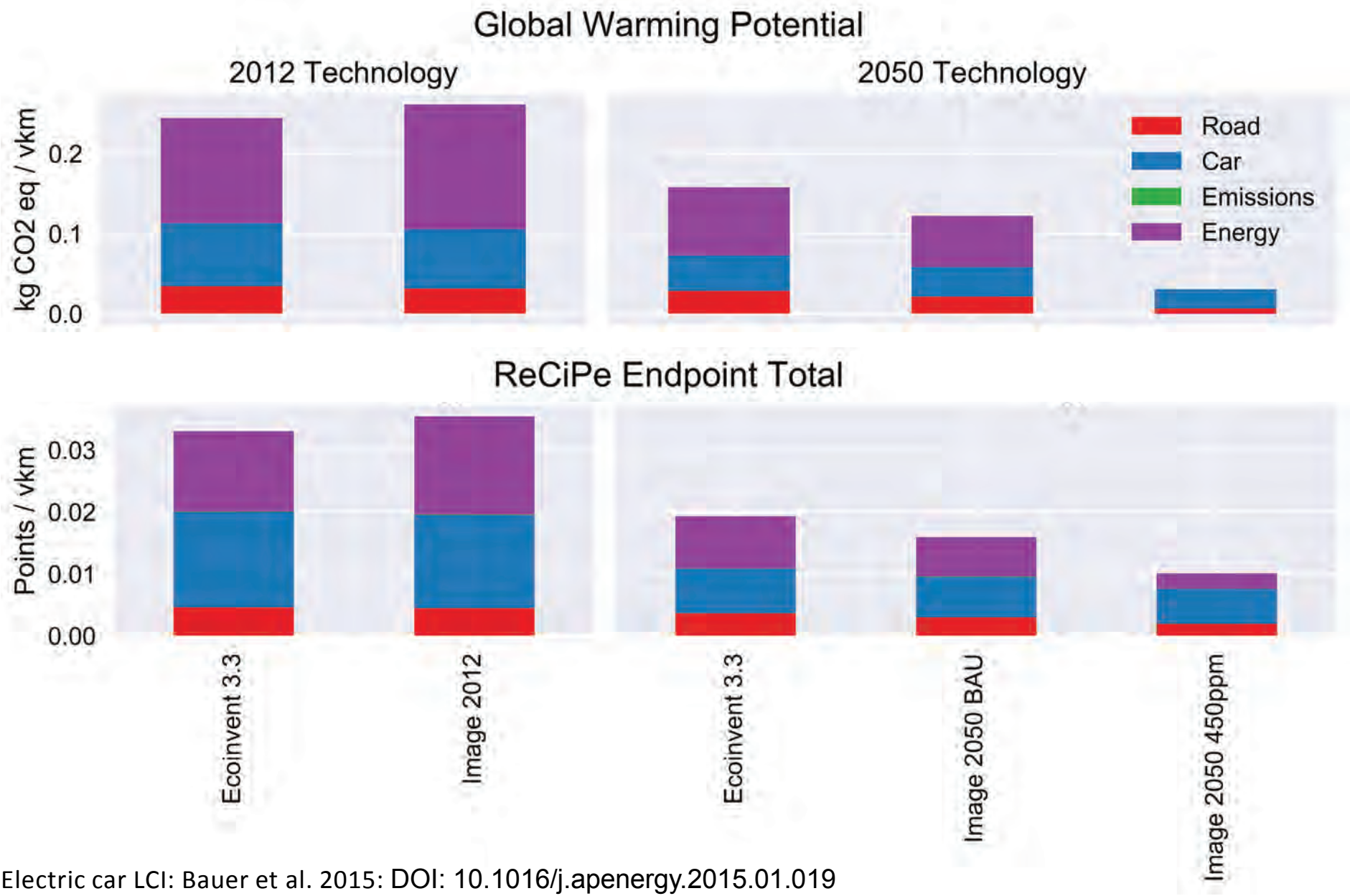
Overall Results



Overall Results



Results for European mid-sized electric car



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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
- Other sectors could be much more difficult as future datasets not available – example, freight transport with fuel cell vehicles

Strengths

- Software is quite fast
  - We can compare many scenarios with little effort
- Changes are transparent
- Easy to integrate results into normal work in Brightway2
  - create 3 scenarios and keep them ‘on hand’ for prospective LCA
- Modifying electricity sector has significant impact on results
  - Extend methodology to other sectors?

Wir schaffen Wissen – heute für morgen

Thank you for listening!

Special thanks to:

- **Angelica Mendoza Beltran**
- **Detlaf van Vuuren**

- **Prof. Wokaun**

- **SCCER Mobility**