



**Wir schaffen Wissen – heute für morgen**

## **Electricity technologies in version 3 of the ecoinvent database: modeling and results**

Karin Treyer, Christian Bauer

Laboratory for Energy Systems Analysis  
Paul Scherrer Institute

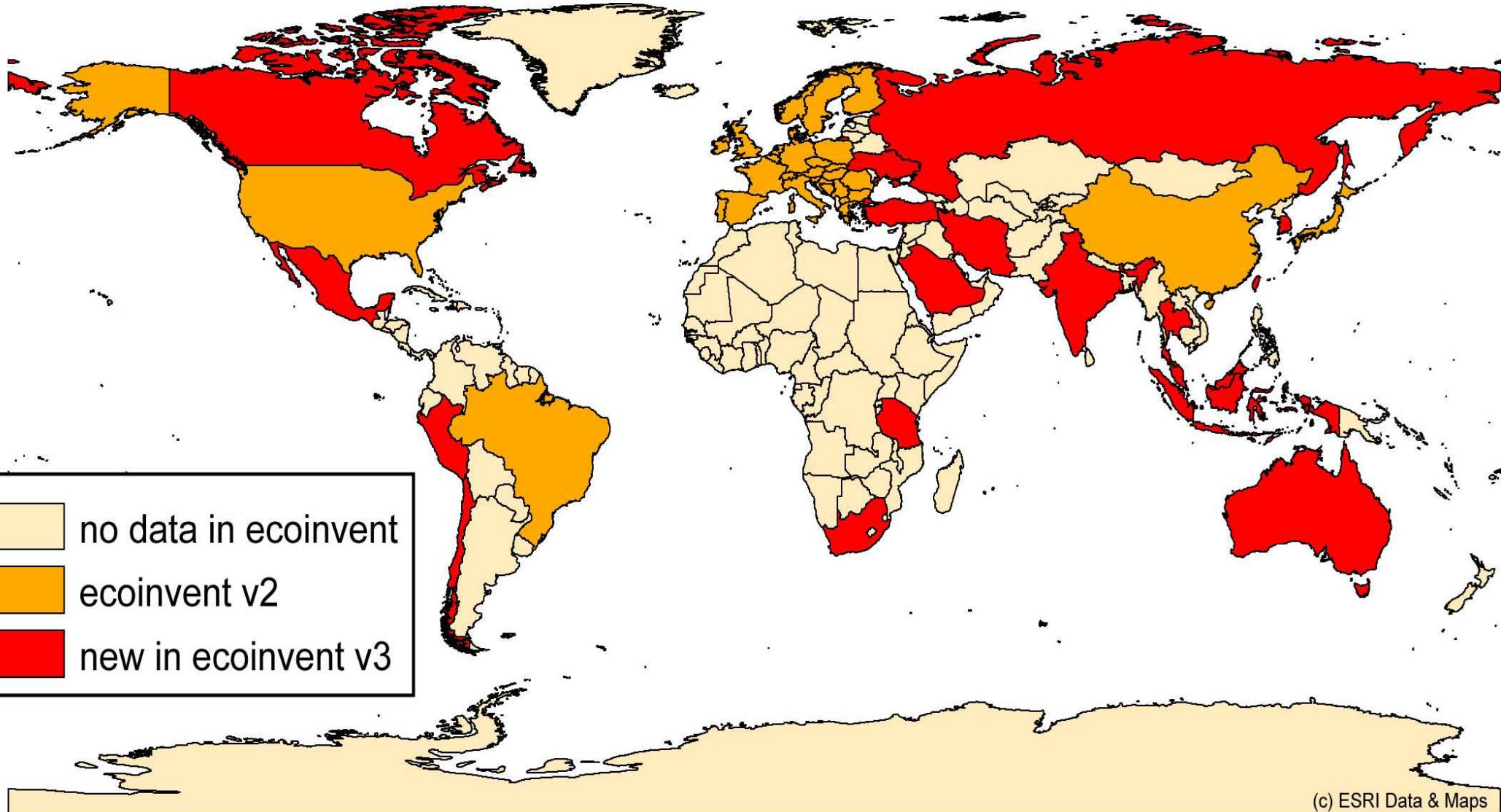
## Electricity generation: country specific technology datasets for 50 countries



# Coverage

v2: 32 countries – ca. 65% of 2004 worldwide electricity production

v3: 50 countries – ca. 83% of 2008 worldwide electricity production



(c) ESRI Data & Maps

# Technologies

Fossil fuels	Coal	Hard coal	Renewables	Hydropower	Reservoir power plants: alpine/non-alpine/tropical region
		Lignite			Run-of-river power plants
		Peat			Pumped storage power plants
	Industrial gases	Blast furnace gases		Geothermal	<b>Hot-Dry-Rock (EGS)</b>
		Coke (coal) gases		Solar	Photovoltaic: Building integrated and <b>open ground</b>
	Oil				<i>Solar thermal (no data)</i>
	Natural gas	Conventional gas power plant, without/ <b>with CHP</b>		<i>Wave and tidal energy</i>	<i>(no data)</i>
		Combined cycle gas power plant, without/ <b>with CHP</b>		Wind	Onshore, capacity class <1MW / <b>1-3MW / &gt;3MW</b>
Nuclear		Pressurised water reactor (PWR)			Offshore, capacity class 1-3MW
		Boiling water reactor (BWR)		Wood	Wood chips, with/without extensive emission control
In <b>red</b> : Newly implemented technologies				Biogas	Biogas from biowaste, sewage sludge and landfill gases
			<b>Waste</b>	Waste incineration	Municipal and industrial waste

- **No ecoinvent reports** published anymore, as all necessary information are included directly in the datasets.
- **Annual production volumes** determining the shares of technologies supplying the electricity markets
- **Tags** for grouping datasets, e.g. «coal power», «nuclear power»
- **Technology level** defining the marginal mix for consequential modeling
- Use of **mathematical relations**
- Use of **parameters**, mainly:
  - net efficiencies of thermal power plants
  - yield of solar modules & wind turbines

# LCI – ecoEditor software

ecoEditor for ecoinvent version 3

File Edit View Extras Help

Activity Description Modelling and Administrative Exchanges Exchange Properties Parameters Tasks

Add Remove Column Layouts: Amount Only Compact Extended Customize Current Column Layout... Reset Column Layout

Exchange		electricity production, hydro, reservoir, alpine region, GLO 2008												
Type	Name	Unit	Amount	Variable Name	Mathematical Relation	Comment	Uncertainty	Source	Annual Production Volume	Production Volume Variable Name	Production Volume Mathematical Relation	Production Volume Comment	Production Volume Source	Production Uncert
0 - Reference	electricity, high voltage	kWh	1					< None...	$f(x) 4.05E+11$	apv_electricity	net_electricity_2008* shar...	Calculated	< None >	
2 - ByProduct	waste mineral oil	kg	$f(x) 7.56E-06$	waste_oil	lubricating...	Estim	Lognorma...	< None...	$f(x) 3.0618E+06$		apv_electricity* waste_oil	Calculated	< None >	
4 - ToEnviro...	Dinitrogen monoxide	kg	7.7E-08					Lognorma...	1996, D...					
4 - ToEnviro...	Methane, non-fossil	kg	$f(x) 1.4E-05$		40 / (20000...	Estim	Lognorma...	< None...						
4 - FromEnv...	Transformation, to industrial area	m <sup>2</sup>	$f(x) 2.3E-07$	transfor...	transformati...	Estim	Lognorma...	< None...						
4 - FromEnv...	Transformation, from unspecified	m <sup>2</sup>	2.3E-05	transfor...		Estim	Lognorma...	< None...						
4 - FromEnv...	Occupation, lake, artificial	m <sup>2</sup> *y...	$f(x) 0.00345$		transformati...	calcul	Lognorma...	< None...						
4 - FromEnv...	Water, turbine use, unspecified natural...	m <sup>3</sup>	0.81			Litera	Lognorma...	< None...						
4 - FromEnv...	Volume occupied, reservoir	m <sup>3</sup> *y...	0.15			Estim	Lognorma...	1991, B...						
4 - FromEnv...	Transformation, to lake, artificial	m <sup>2</sup>	$f(x) 2.277E-05$		transformati...	Estim	Lognorma...	< None...						
5 - FromTec...	lubricating oil	kg	$f(x) 7.56E-06$	lubricatin...	$0.000009^0.0...$	Estim	Lognorma...	Vöglin...						
5 - FromTec...	hydropower plant, reservoir, alpine region	unit	3.9E-13											

# LCI – ecoEditor software

ecoEditor for ecoinvent version 3

File Edit View Extras Help

Activity Description Modelling and Administrative Exchanges Exchange Properties Parameters Tasks

+ Add - Remove Column Layouts: Amount Only Compact Extended Customize Current Column Layout... Reset Column Layout

Exchange		electricity production, hydro, reservoir, alpine region, GLO 2008												
Type	Name	Unit	Amount	Variable Name	Mathematical Relation	Comment	Uncertainty	Source	Annual Production Volume	Production Volume Variable Name	Production Volume Mathematical Relation	Production Volume Comment	Production Volume Source	Production Uncert
0 - Reference	electricity, high voltage	kWh	1					< None...	$f(x) 4.05E+11$	apv_electricity	net_electricity_2008* shar...	Calculated	< None >	
2 - ByProduct	waste mineral oil	kg	$f(x) 7.56E-06$	waste_oil	lubricating...	Estim	Lognorma...	< None...	$f(x) 3.0618E+06$		apv_electricity* waste_oil	Calculated	< None >	
4 - ToEnviro...	Dinitrogen monoxide	kg	7.7E-08					1996, D...						
4 - ToEnviro...														
4 - FromEnv...														
4 - FromEnv...														
4 - FromEnv...														
4 - FromEnv...														
5 - FromTec...														
5 - FromTec...														

ecoEditor for ecoinvent version 3

File Edit View Extras Help

Activity Description Modelling and Administrative Exchanges Exchange Properties Parameters Tasks

+ Add - Remove Column Layouts: Amount Only Compact Extended Customize Current Column Layout... Reset Column Layout

Parameter		electricity production, lignite, GLO 2008					
Name	Unit	Amount	Variable Name	Mathematical Relation	Uncertainty	Comment	
efficiency	dimensionless	0.309	efficiency		Lognormal (...)	Literature	
factor: input of MJ for the production of 1...	MJ/kWh	$f(x) 11.65$	factor_MJ_kWh	$1*3.6/efficiency$	Lognormal (...)	Calculate	
gross electricity production in 2008	kWh	$8.5957E+11$	gross_electricity...		Lognormal (...)	Literature	
losses from gross electricity production	dimensionless	0.07	gross_net_elect...		Lognormal (...)	Literature	

Wherever possible, technology-specific data was assembled:

- Electrical efficiency
- Wind load hours, solar yields
- Emissions of SO<sub>2</sub>, NO<sub>x</sub>, particulate matter
- Technology level

## Data sources

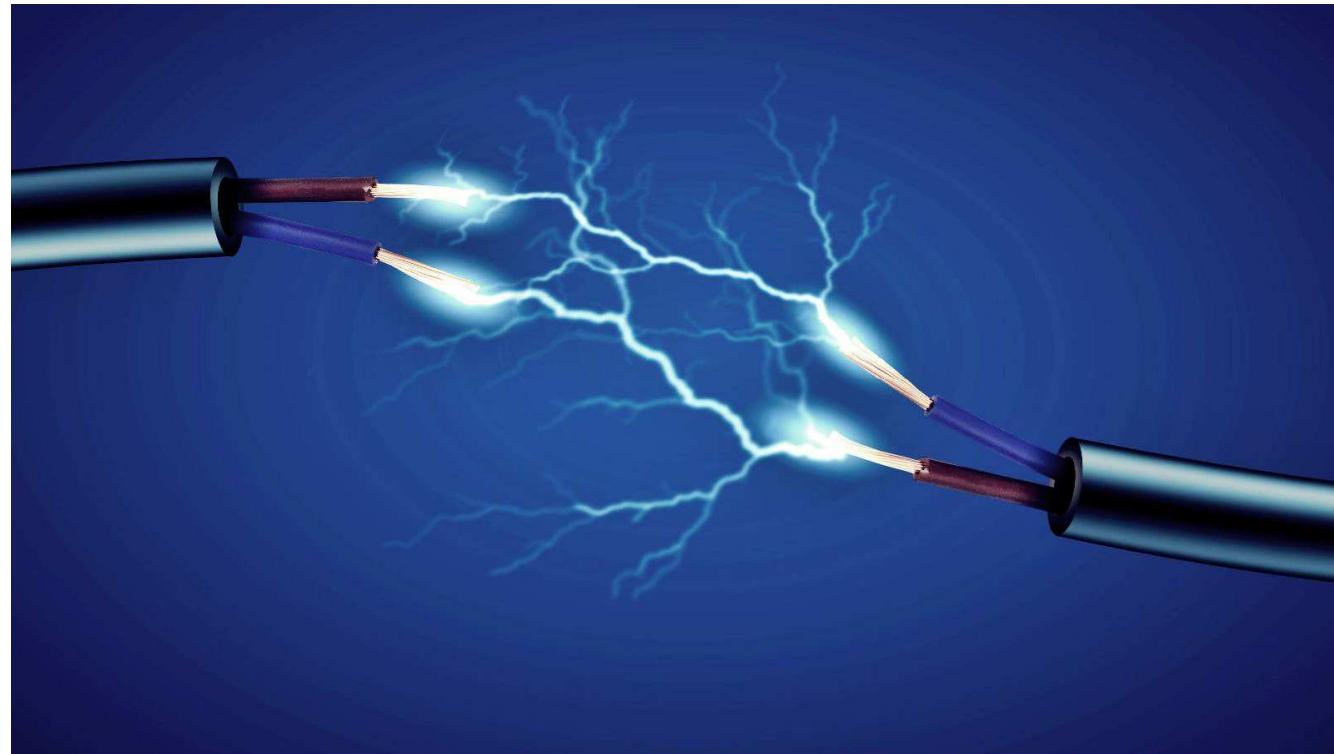
- **Hard coal & lignite:** IEA statistics; national pollutant inventories; personal information; IEA clean coal center power plants database\*
- **Natural gas:** IEA statistics; expert judgement
- **Oil:** IEA statistics
- **Nuclear:** WNA reactor database\*
- **Wind power:** manufacturer's information; wind turbine database\*
- **Photovoltaics:** ESU-services - manufacturer's information; IEA PVPS
- **Geothermal:** data from EGS plant in Basel
- **Hydro, wood, biogas and waste:** ecoinvent v2.2
  - \* contains data for all single plants operating

# Dataset types

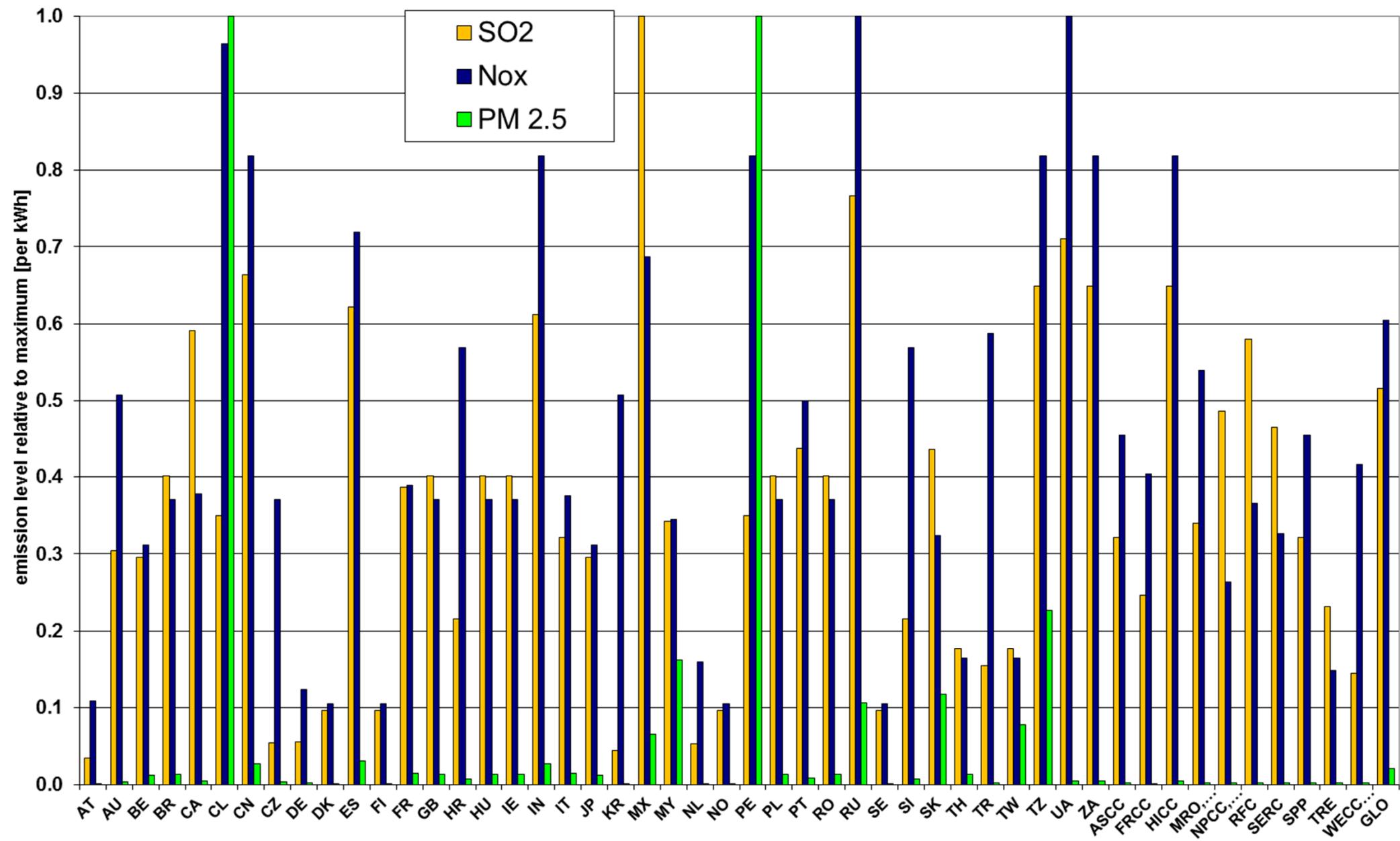
## Modeling of electricity production – «Ordinary Transforming Activities»

- **Electricity generating activities:** Reference product 1kWh net electricity
- **Heat and power co-generation activities:**
  - Electricity as a by-product
  - Allocation: Price, true value (exergy-based)
- **Treatment activities:**
  - Electricity as a by-product
  - Electricity receives a part of the activities producing the material for treatment (economic allocation)

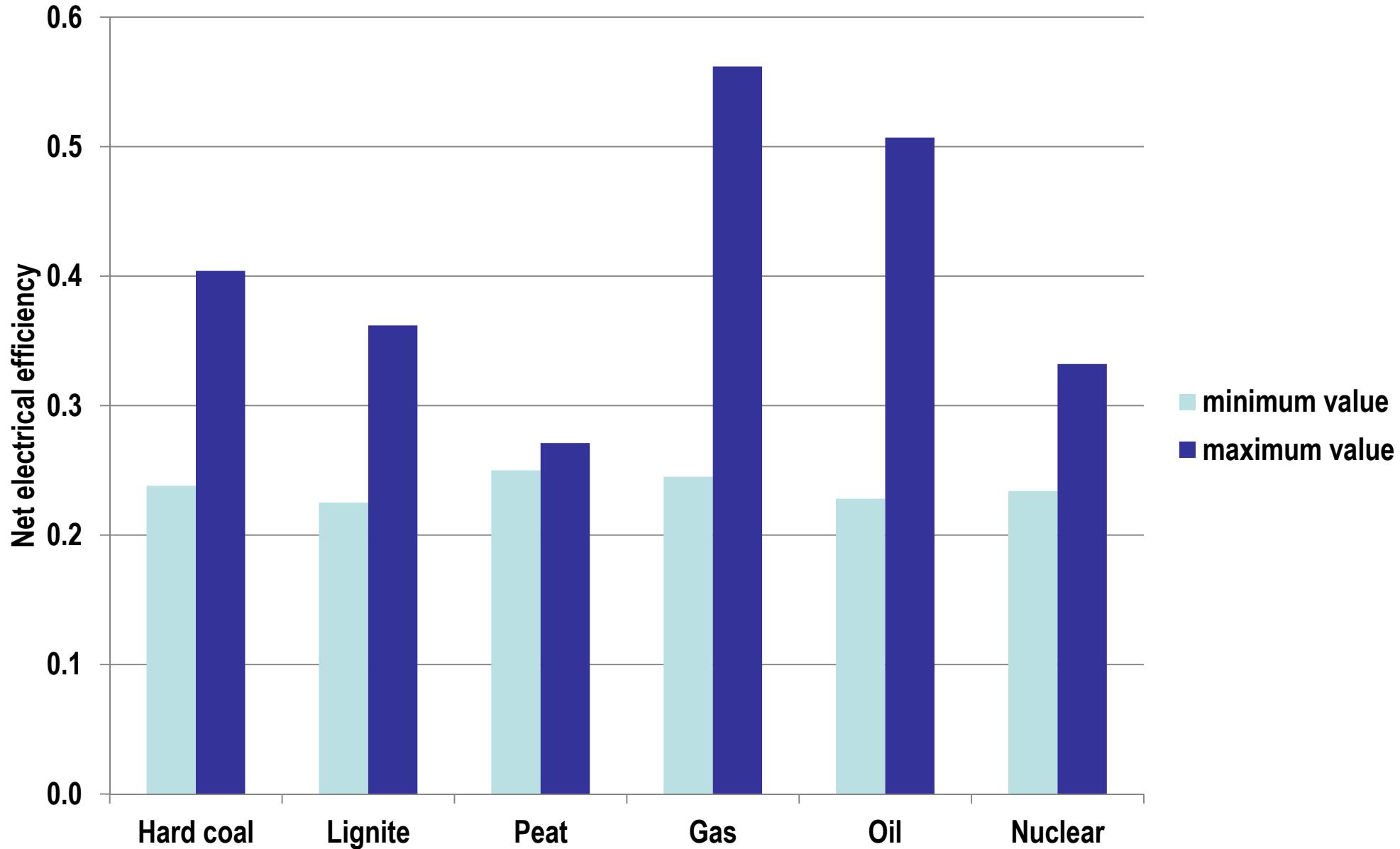
# Selected results from the Life Cycle Inventory and the Life Cycle Impact Assessment



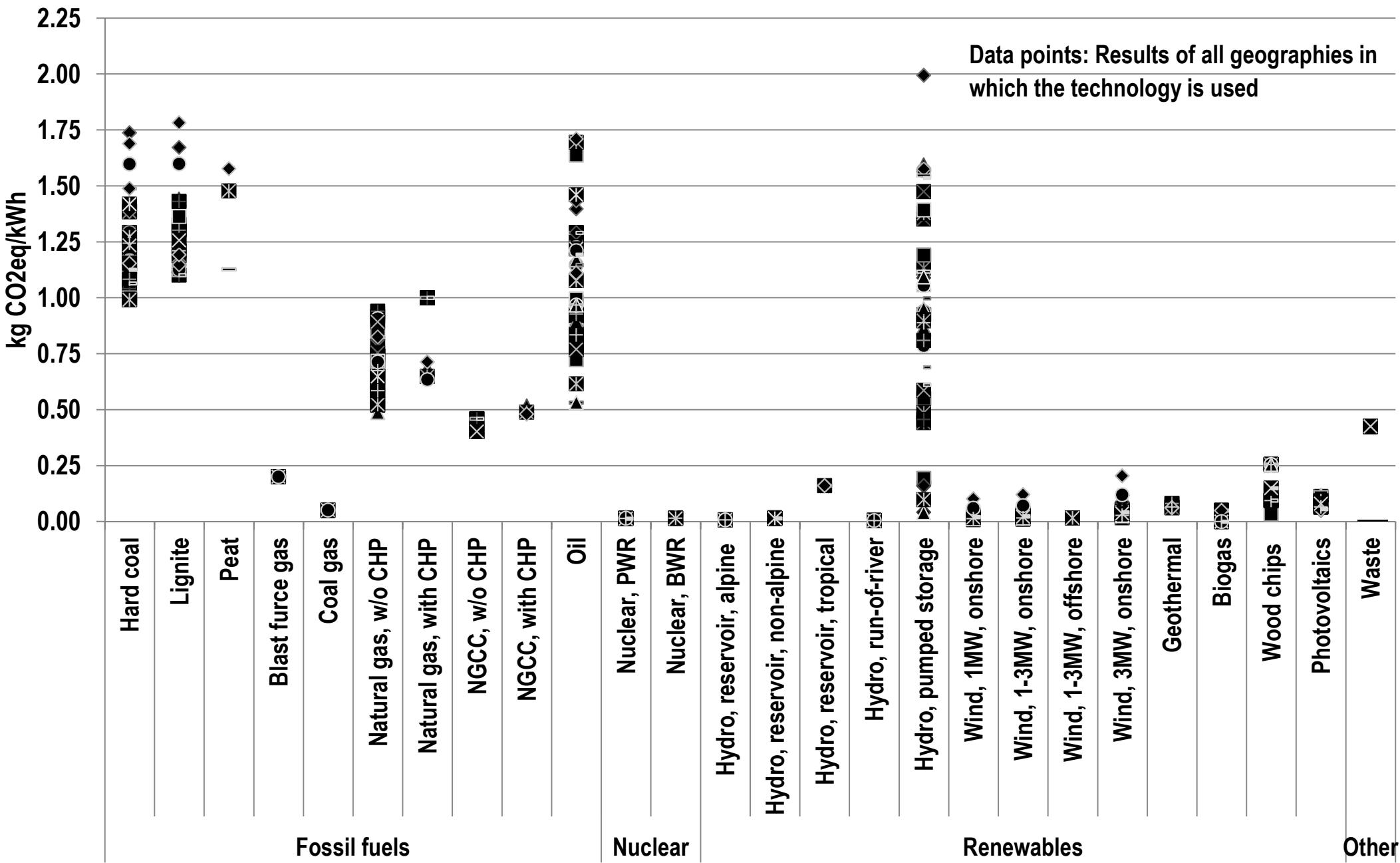
# LCI – Direct emissions from hard coal burning

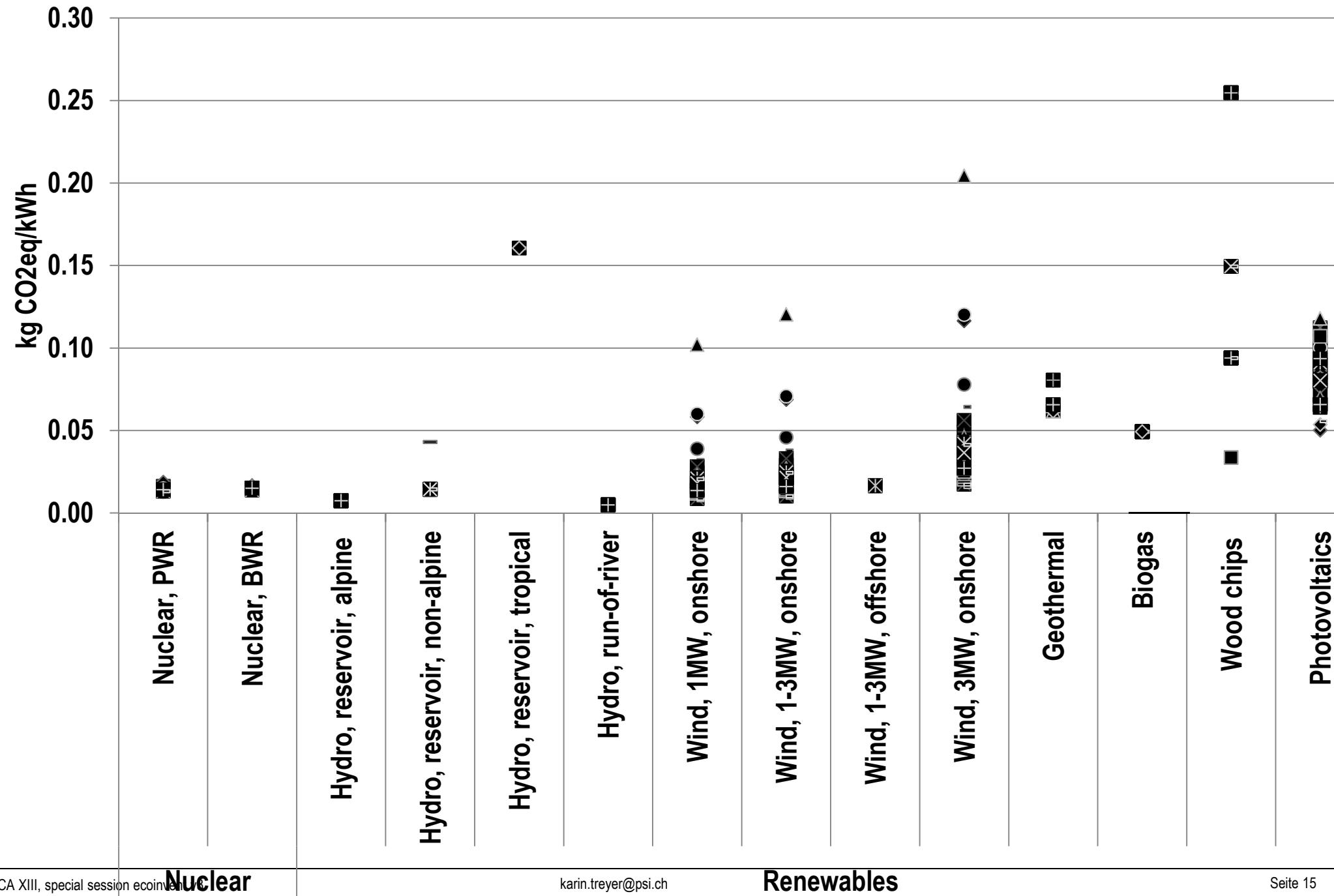


# LCI – Net electrical efficiencies in the 71 geographies

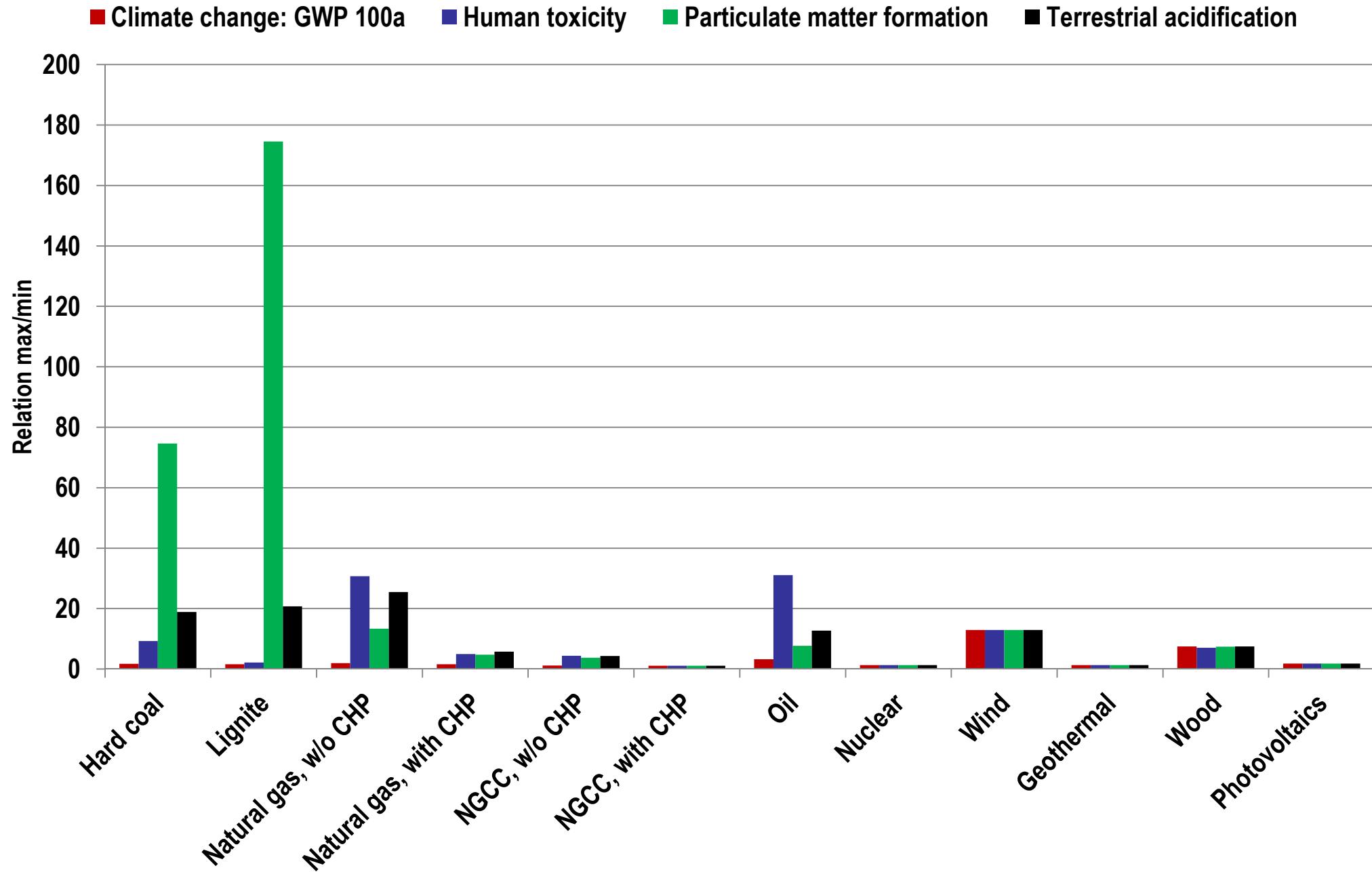


# LCIA results: IPCC 2007, GWP 100a for all technologies





# LCIA results: Relation max/min for selected ReCiPe Midpoints (H)



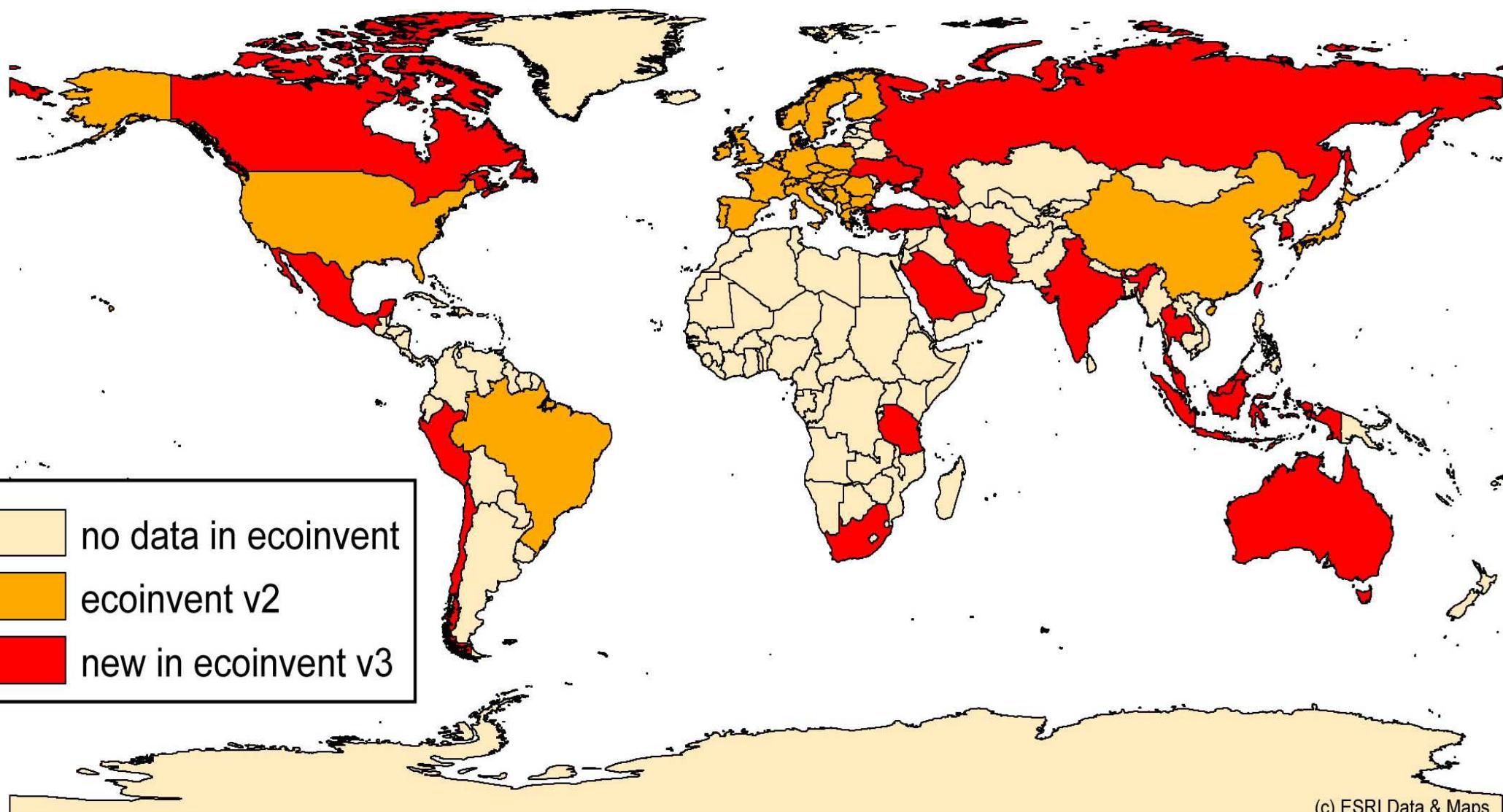
# Conclusions – electricity datasets in v3

- High geographical variability of LCIA results – **regionalisation** is crucial
- ecoEditor enhances **transparency** and the possibility of local data providers to provide more accurate data
- New allocation method and gaps in the database can result in questionable LCIA results

# Outlook for the electricity datasets in v3

- **Updates** are needed for refining the electricity datasets in v3:
  - Update of datasets already existing in v2
  - Fuel chain update, including considering country-specific trade information
- **Extension** of the electricity datasets in terms of
  - technologies, e.g. wave power, solar thermal
  - specific power plant types used in specific geographies
  - inclusion of more geographies/regionalisation

Thanks to ecoinvent staff for support  
Thanks for your attention!



(c) ESRI Data &amp; Maps

## Transfer of datasets from v2 to v3 / new datasets in v3

- **Existing 32 countries in v2:**
  - Electricity generating datasets were transferred automatically to v3 – no updates made
  - Proxy datasets were copied and in general not adapted
  - Newly implemented technologies: New child datasets
- **18 additional, new countries in v3:**
  - Child datasets
  - Geography-specific parameters implemented where possible, e.g. efficiencies
  - Use of the functionalities of ecospold 2