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

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Electricity generation: country specific technology datasets for 50 countries
v2: 32 countries – ca. 65% of 2004 worldwide electricity production
v3: 50 countries – ca. 83% of 2008 worldwide electricity production
## Technologies

<table>
<thead>
<tr>
<th>Fossil fuels</th>
<th>Coal</th>
<th>Hard coal</th>
<th>Renewables</th>
<th>Hydropower</th>
<th>Reservoir power plants: alpine/non-alpine/tropical region</th>
</tr>
</thead>
<tbody>
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<tr>
<td></td>
<td></td>
<td>Lignite</td>
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<td></td>
<td></td>
<td>Peat</td>
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<tr>
<td>Industrial gases</td>
<td>Blast furnace gases</td>
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<tr>
<td>Industrial gases</td>
<td>Coke (coal) gases</td>
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<tr>
<td>Oil</td>
<td></td>
<td>Conventional gas power plant, without/with CHP</td>
<td>Wave and tidal energy</td>
<td></td>
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<tr>
<td>Nuclear</td>
<td></td>
<td>Pressurised water reactor (PWR)</td>
<td></td>
<td>Offshore, capacity class 1-3MW</td>
<td></td>
</tr>
<tr>
<td>Nuclear</td>
<td></td>
<td>Boiling water reactor (BWR)</td>
<td></td>
<td>Wood chips, with/without extensive emission control</td>
<td></td>
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<tr>
<td>Waste</td>
<td></td>
<td>Biogas</td>
<td></td>
<td>Biogas from biowaste, sewage sludge and landfill gases</td>
<td></td>
</tr>
<tr>
<td>Waste</td>
<td></td>
<td>Waste incineration</td>
<td></td>
<td>Municipal and industrial waste</td>
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</tr>
</tbody>
</table>

In red: Newly implemented technologies
LCI – ecoEditor software

- **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

<table>
<thead>
<tr>
<th>Exchange</th>
<th>electricity production, hydro, reservoir, alpine region, GLO 2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>Annual Production Volume</td>
</tr>
<tr>
<td>D - Referenc. electricity, high voltage</td>
<td>&lt; None &gt;</td>
</tr>
<tr>
<td>2 - ByProd. waste mineral oil</td>
<td>7.56E-06</td>
</tr>
<tr>
<td>4 - ToEnv. Nitrogen monoxide</td>
<td>7.7E-38</td>
</tr>
<tr>
<td>4 - ToEnv. Methane, non-fossil</td>
<td>1.4E-05</td>
</tr>
<tr>
<td>4 - FromEnv. Transformation, to industrial area</td>
<td>2.3E-07</td>
</tr>
<tr>
<td>4 - FromEnv. Transformation, from unspecified</td>
<td>2.3E-05</td>
</tr>
<tr>
<td>4 - FromEnv. Occupation, lake, artificial</td>
<td>0.00345</td>
</tr>
<tr>
<td>4 - FromEnv. Water, turbine use, unspecified natural</td>
<td>0.51</td>
</tr>
<tr>
<td>4 - FromEnv. Volume occupied, reservoir</td>
<td>0.15</td>
</tr>
<tr>
<td>4 - FromEnv. Transformation, to lake, artificial</td>
<td>2.27E-05</td>
</tr>
<tr>
<td>5 - FromTec. Lubricating oil</td>
<td>7.56E-06</td>
</tr>
</tbody>
</table>
LCI – ecoEditor software
LCI - Parameters

Wherever possible, technology-specific data was assembled:

- Electrical efficiency
- Wind load hours, solar yields
- Emissions of SO$_2$, NO$_X$, 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

- SO2
- NOx
- PM 2.5

Emission level relative to maximum [per kWh]
LCI – Net electrical efficiencies in the 71 geographies

- Hard coal
- Lignite
- Peat
- Gas
- Oil
- Nuclear

Net electrical efficiency

Minimum value: 0.22
Maximum value: 0.57

- Hard coal
- Lignite
- Peat
- Gas
- Oil
- Nuclear
LCIA results: IPCC 2007, GWP 100a for all technologies

Data points: Results of all geographies in which the technology is used
LCIA results: GWP 100a for technologies – zoom on nuclear and renewables.
LCIA results: Relation max/min for selected ReCiPe Midpoints (H)

- Climate change: GWP 100a
- Human toxicity
- Particulate matter formation
- Terrestrial acidification

Graph showing the relation max/min for different energy sources and environmental impacts:
- Hard coal
- Lignite
- Natural gas, w/o CHP
- Natural gas, with CHP
- NGCC, w/o CHP
- NGCC, with CHP
- Oil
- Nuclear
- Wind
- Geothermal
- Wood
- Photovoltaics
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!
Inventories of electricity production

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