Life cycle greenhouse gas emissions of future power systems in the context of 2 °C

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“Amazingly low carbon footprints” (media coverage)

Life cycle assessment (LCA)

LCA attributes emissions to products

1) Considering emissions over the life cycle
   – Production, use, end-of-life

2) Considering emissions in production networks
   – Resource extraction, manufacturing, etc.

Figure: Adapted from Hellweg & Mila i Canals (2014)
LCA in a 2 °C context

- NTNU and partners have built a future-oriented LCA model, THEMIS
  - Incorporating future technological progress

- In the current work, coefficients derived from THEMIS were implemented into the energy scenario model REMIND
  - Operated by Potsdam Institute for Climate Impact Research
  - By default, REMIND does not systematically account for indirect, or life cycle, emissions
Introducing LCA in energy scenario modelling

• Step 1: Derive energy coefficients from LCA and organize the coefficients in a carefully chosen way

• Step 2: Implement the coefficients from Step 1 in the energy scenario model REMIND

• Step 3: Analyse life cycle emissions of global electricity supply in the context of 2 °C

• We capture technological progress and regional variation
  – In the energy technologies themselves
  – In the technologies used to supply energy and materials

• We achieve harmonization of parameter data
Example of LCA energy coefficients derived for use in scenario modelling (i.e., Step 1)

Distinguish:
- Construction (C) and operation (O)
- Energy carrier (stacked column categories)
- Industry (background colour)
- Region (not shown in figure)
- Year (not shown in figure)

Source: Arvesen et al. (2018)
Life cycle greenhouse gas emissions in 2050 in REMIND

In a 2 °C world in 2050 (these are global averages):

- Nuclear, wind and solar PV: 4-6 g CO₂e kWh⁻¹
- Hydro and bioenergy: ~100 g CO₂e kWh⁻¹ (very uncertain)
- Coal and gas with CO₂ capture: ~100 g CO₂e kWh⁻¹

Figure: Pehl et al. (2017)
In a 2 °C world in 2050 (these are global averages):

- Nuclear, wind and solar PV: 4-6 g CO$_2$ e kWh$^{-1}$
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Figure: Pehl et al. (2017)
Total global 2050 life cycle emissions in REMIND

- Indirect emissions are small
  - Compared to 2050 Baseline direct emissions
  - And compared to current real-world direct emissions

- At the same time: Indirect emissions are important in relative terms in the climate policy scenario in 2050

- REMIND already accounts for the most important indirect sources of emissions

- Life cycle emissions can influence optimal technology choice, but not by much in this case:
  - In response to indirect emissions added by LCA, REMIND changes (only) 4% of technology selections

Source: Pehl et al. (2017)
Final remarks

• Indirect emissions can influence optimal selections of technologies
  – We investigate this influence for the power sector, and find that it is fairly small
  – It is potentially more significant for other sectors, for example transport

• What LCA may contribute to energy scenario modelling:
  – Consistent treatment of indirect emissions of technologies
  – Identification of environmental win-win relationships or trade-offs looking at other impact categories than climate change (in other papers, under review)
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The research


• The LCA coefficients and an R script for using the coefficients in scenario analysis are available at: http://www.fp7-advance.eu/content/environmental-impacts-module

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Extra
Source: Arvesen et al. (2018)
CO2 intensities in REMIND

Source: Pehl et al. (2017) (supplementary)