POTSDAM INSTITUTE FOR CLIMATE IMPACT RESEARCH

Combining Integrated Assessment Modeling with Life-Cycle Assessment

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Based on work with: Anders Arvesen, Thomas Gibon, Edgar Hertwich, Anders H. Stromman, Ioanna Mouratiadou, Benjamin Bodirsky, Robert Pietzcker, Alexander Popp, Harmen-Sytze de Boer, Oliver Fricko, Silvana Mima, Ilker Guyer

Leibniz Gemeinschaft

Integrating IAM and LCA approaches

Plan for the course:

- 15 min overview of the method and its purpose
- 20 min walk through code
- 10 min questions and discussion

R notebook available at
http://tiny.cc/LCAtoolbox

Full toolbox with code and input data:
http://fp7-advance.eu/content/environmental-impacts-module

Integrating IAM and LCA approaches

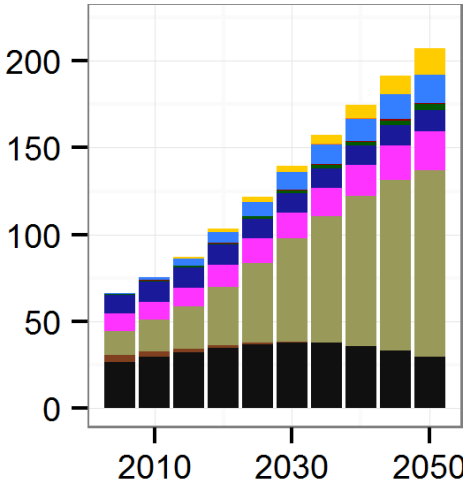
- **Integrated Assessment Modeling** considers the dynamics of the long-term transformation, but so far focused on climate change mitigation
- **Life cycle assessments** considers broad set of impacts and the full process chain, but mostly focuses on individual technologies and apply static assumptions, thus not considering the long-term system evolution

Integration of the two approaches allows addressing **key research questions:**

- *What are environmental co-benefits and adverse side-effects of the low-carbon transformation?*
- *How do alternative decarbonization pathways perform in terms of their environmental impacts?*
- *What are life-cycle indirect energy demands and greenhouse gase emisssions of different technologies?*

The approach in a nutshell

IAM scenario data



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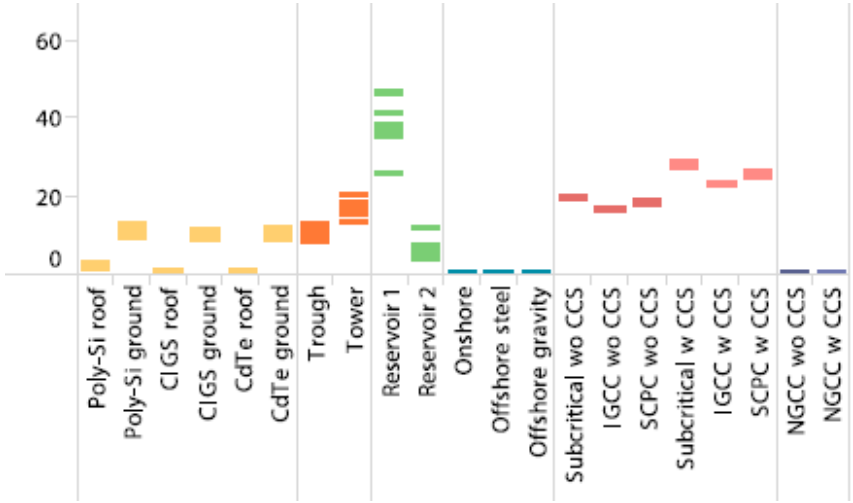
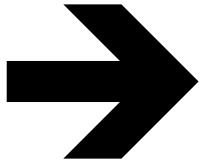
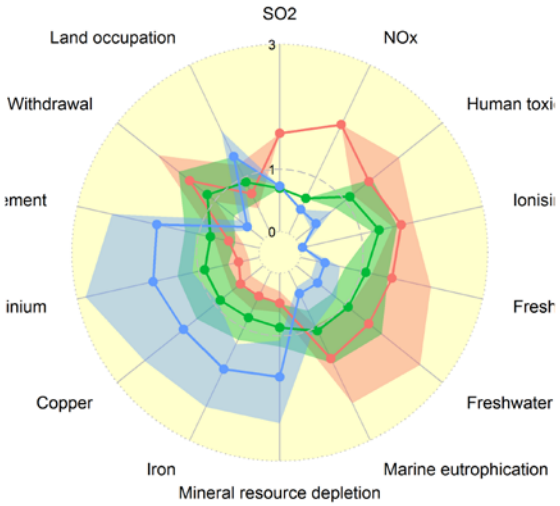
Prospective LCA data







Multi-dimensional environmental impact assessment

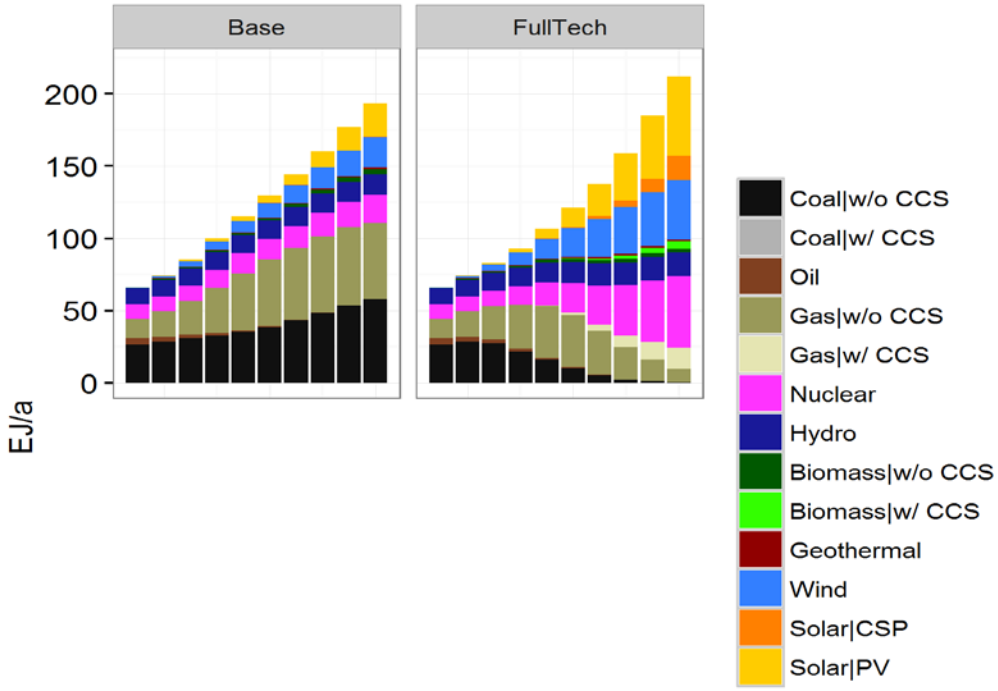
IAM scenarios considered

Climate policy implementation

- Policy scenarios with constraint on cumulative 2011-2050 power sector emissions of 240 $GtCO_2$
- Comparable policy ambition in other sectors

Three different technology scenarios:

- **FullTech**
- **Conventional** (Wind and solar limited to 10%)
- **Renewable** (nuclear phase-out, no CCS for power stations)



Prospective LCA methodology

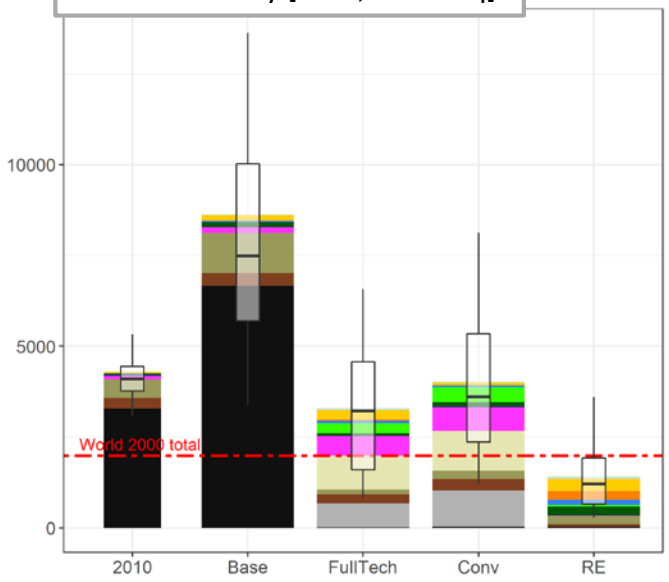
- Aspects of future **technological change** addressed within the LCA
  - Changing performance of individual electricity generation technologies
  - Projected improvements in selected industrial processes
- **Coherent life cycle inventories** for power generation technologies, combined with impact assessment based on ReCiPe methodology
- Separate **construction and operation** phases, to accurately account for timing of capacity expansions and operation

References

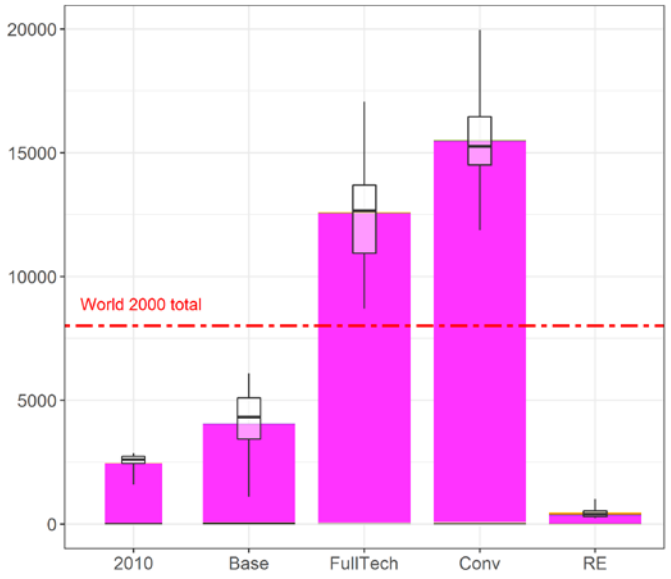
- **Gibon, T.**, Wood, R., Arvesen, A., Bergesen, J.D., Suh, S., Hertwich, E.G., 2015. A methodology for integrated, multiregional life cycle assessment scenarios under large-scale technological change. Environmental Science & Technology.
- **Hertwich, E.G.,** Gibon, T., Bouman, E.A., Arvesen, A., Suh, S., Heath, G.A., Bergesen, J.D., Ramirez, A., Vega, M.I., Shi, L., 2015. Integrated life-cycle assessment of electricity-supply scenarios confirms global environmental benefit of low-carbon technologies. PNAS 112(20)

Impacts to human health

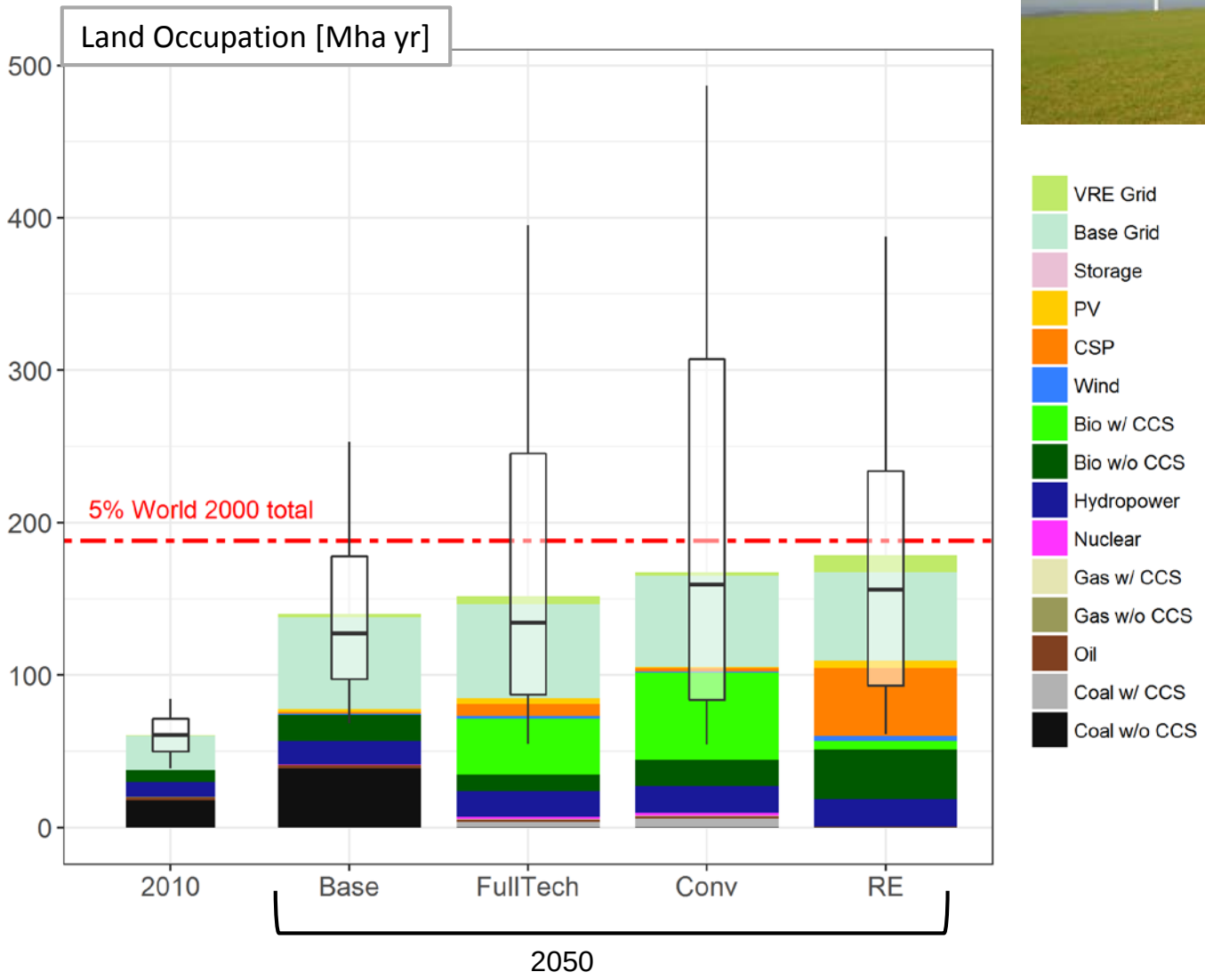
Human Toxicity [Mt 1,4-DCB eq]



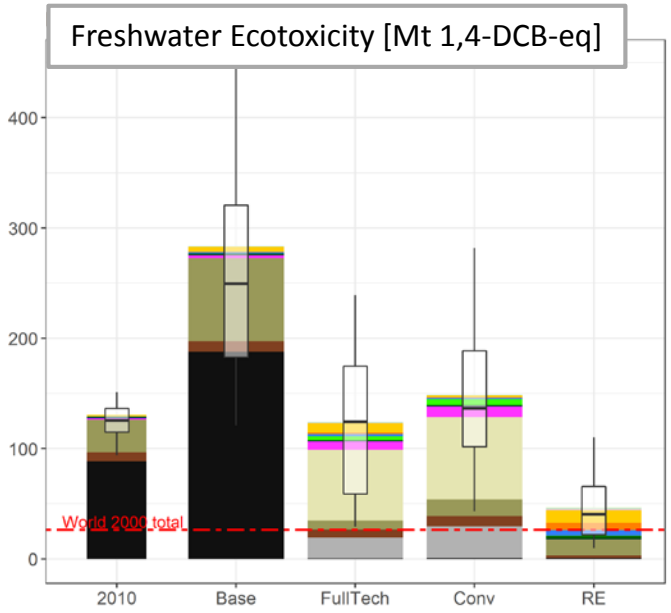
Ionizing Radiation [Mt U235- eq]

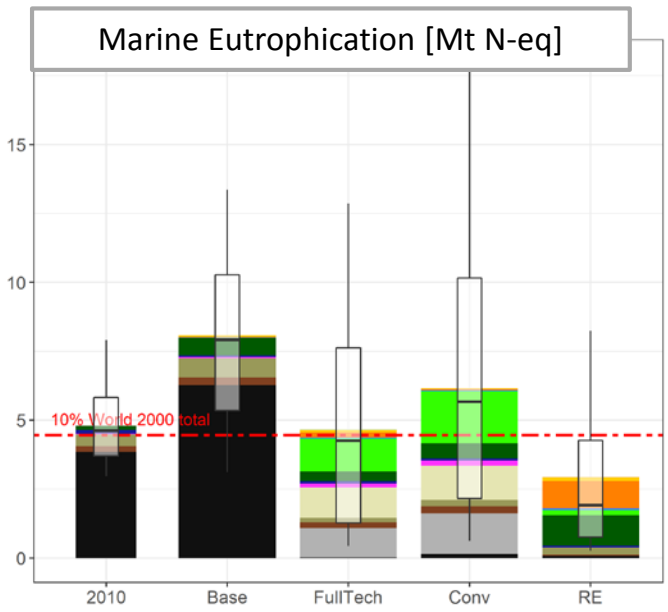


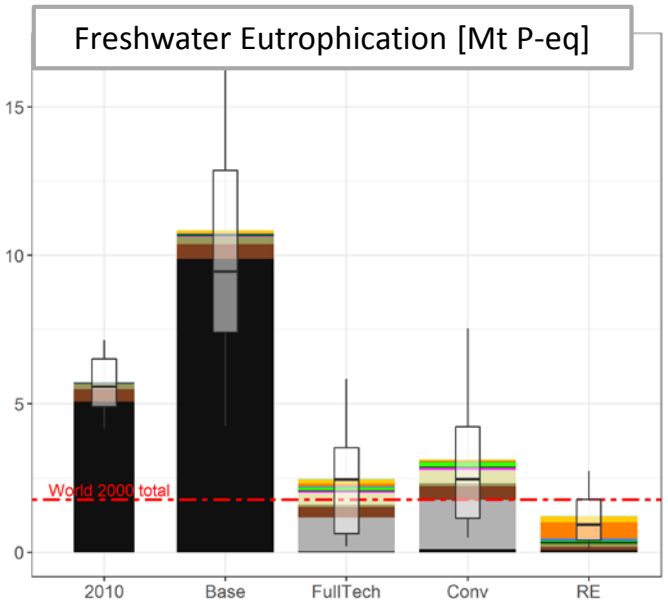
Land occupation



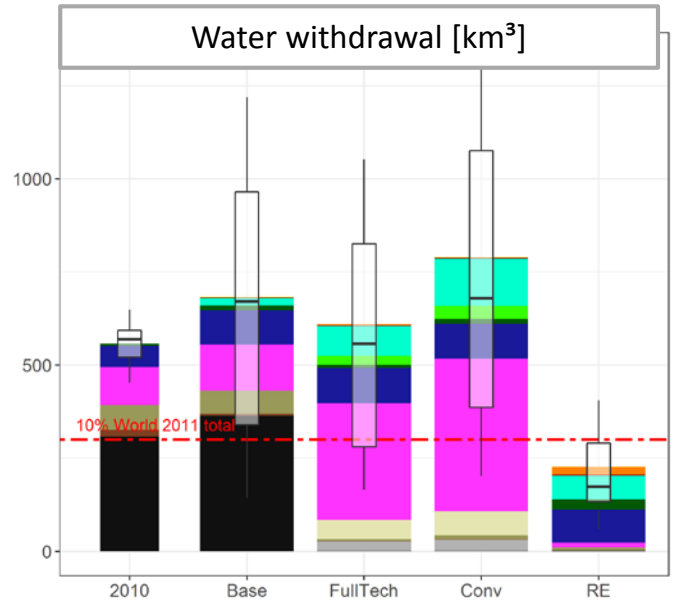
Impacts to ecosystems

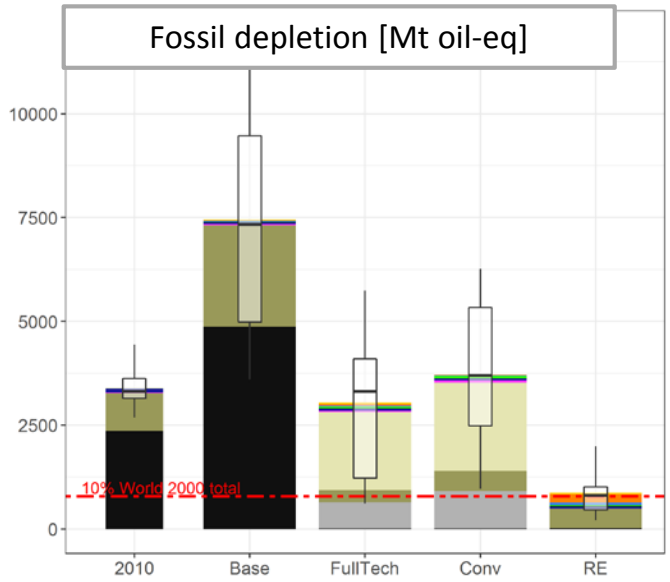


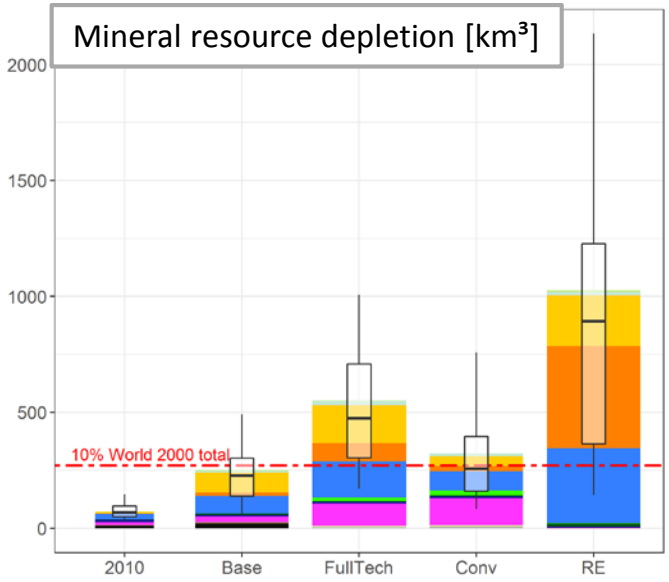




Resource depletion



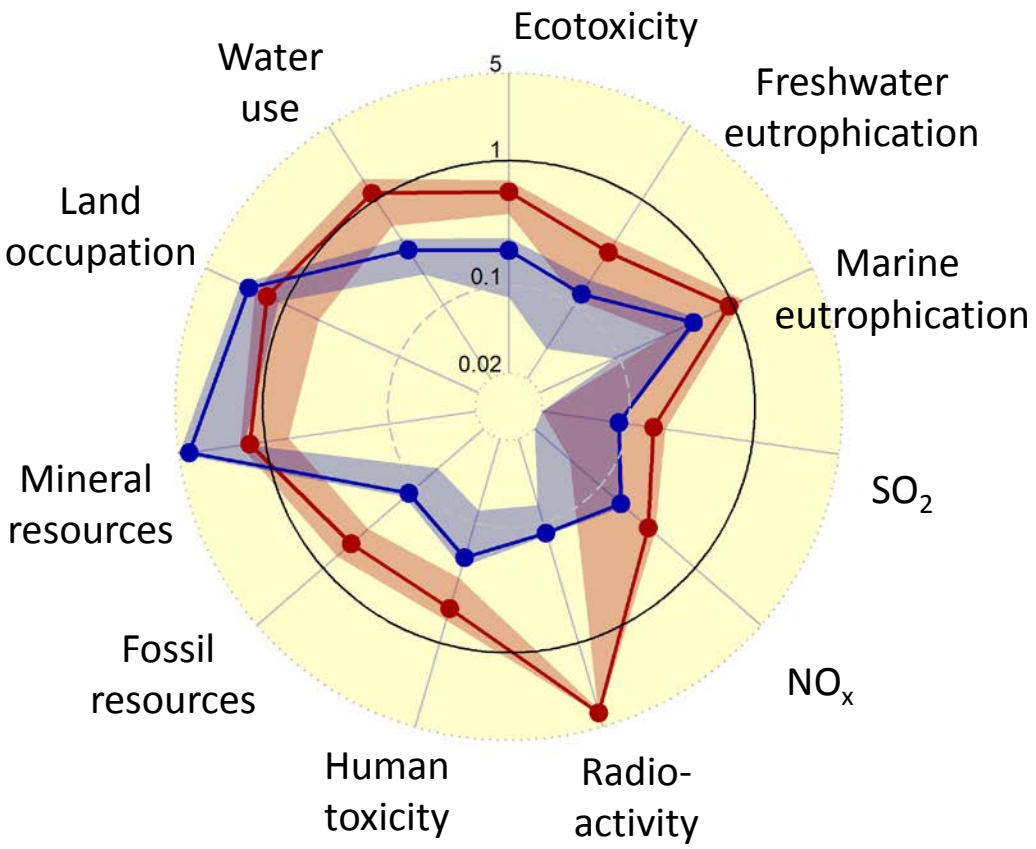




Combined assessment

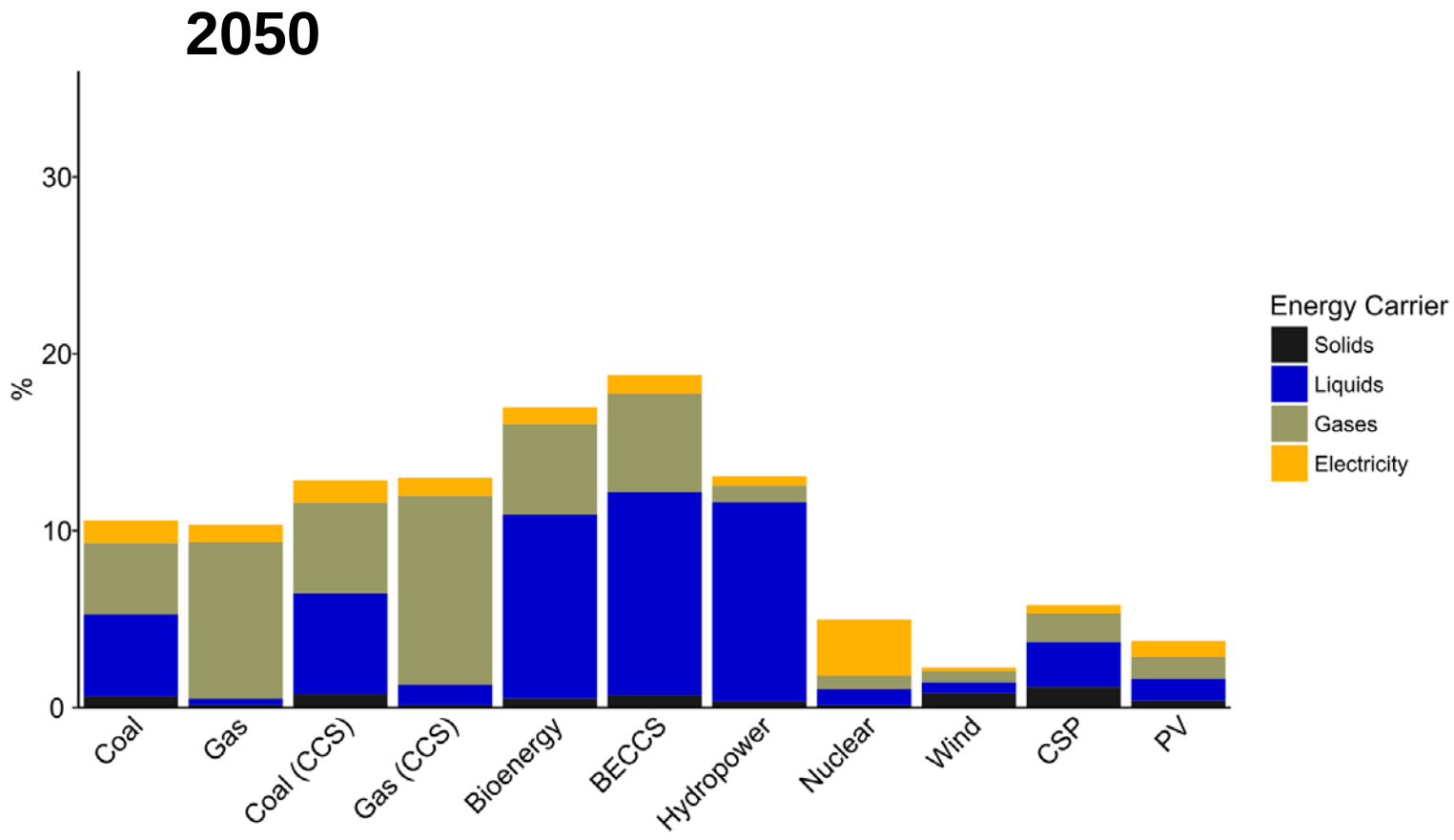
Wind/solar-based
vs
CCS / Nuclear-based
decarbonization

Impacts for 2050 relative to no-policy baseline



- Substantial co-benefits of decarbonization for reducing pollution
- However, increased requirements for land and raw material requirements
- Distinctly different environmental profiles
  - Nuclear and CCS-based strategies more water-intensive, have fewer environmental co-benefits
  - RE-based decarbonization increases the requirements for raw materials, but also greater co-benefits

Embodied upstream energy requirements



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Web resources

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Thank you!

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Land occupation