Lecture 5:
What's next?

Open-Source Energy System Modeling
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Part 1

Open-source energy system modelling – boon or bane?

Open-source lowers barriers to entry for energy-system++ modelling

The barriers to energy system modelling are almost zero.
Is that a good thing?

Required ingredients to energy system modelling

- ⇒ Cheap computing power to run large-scale assessments
- ⇒ Open-source tools for data processing, model execution, and results analysis
- ⇒ Publicly available data sets
- ⇒ Free lecture material, online courses, etc.
  E.g.: Youtube channel “Teaching Energy Modelling OSeMOSYS Teaching Kit“

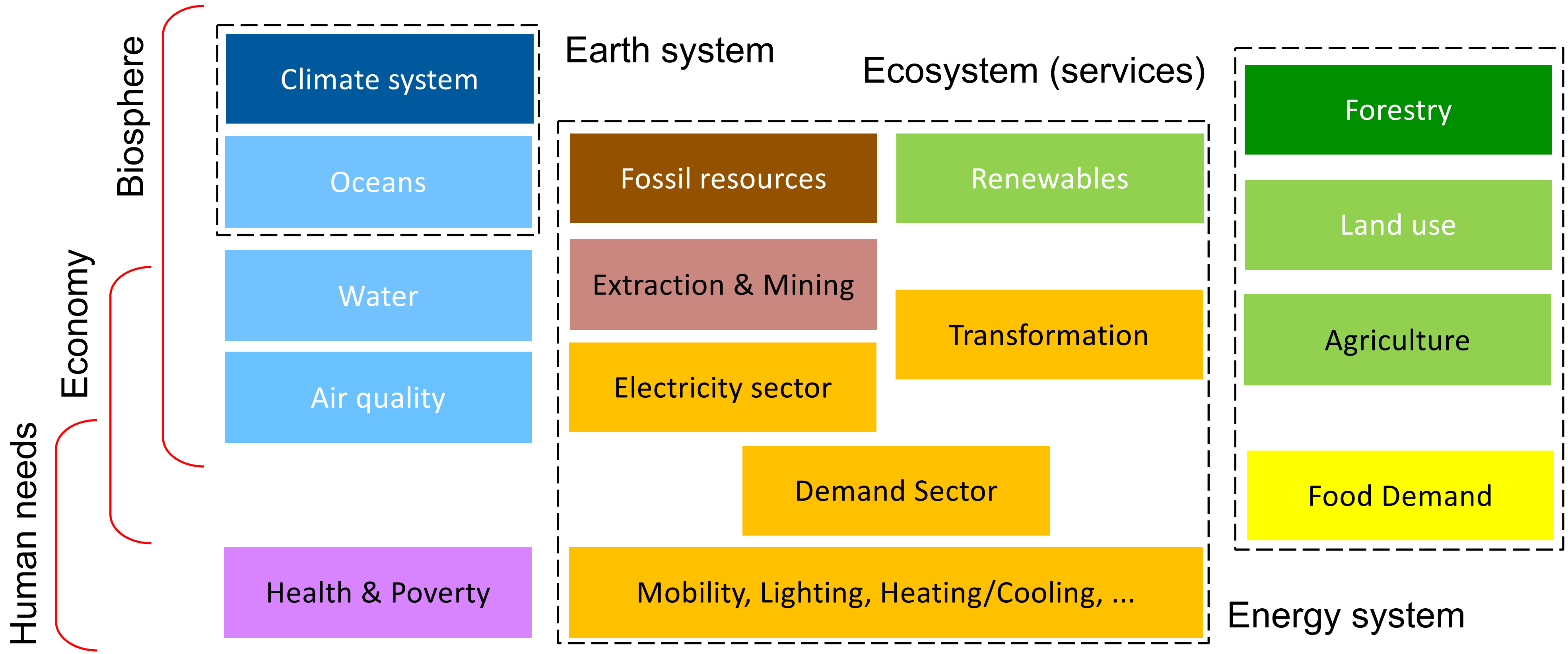
The barriers to start model development are virtually zero

- ⇒ Advantage: “democratization” of research
- ⇒ Disadvantage: risk of doing subpar research (herd behaviour, quick-and-dirty

The academic incentive structure is misaligned towards novelty rather than collaborative work

Some practical considerations for starting model development

Make a conscious choice concerning the system boundaries of your work



More practical considerations for starting model development

Choose an appropriate methodology for the research question at hand

Commonly used methodologies:

⇒ Optimization: determine the system that is optimal according to a metric

⇒ Equilibrium: determine the system as a result of interacting agents

⇒ Simulation: determine the system given some decision rules

Dealing with uncertainty:

⇒ Deterministic optimization (perfect foresight):

all future states (exogenous parameters) are known at the beginning of the model horizon

⇒ Stochastic optimization:

all future states along an "uncertainty tree" are known, including probabilities of each branch

⇒ Myopic (rolling horizon) optimization:

- decisions in period y are taken under some assumptions about the future;
- move to period $y + 1$ and repeat, with (possibly altered) assumptions about periods $[y + 2, \ldots]$

Yet more practical considerations for starting model development

There are many issues that a self-critical modeller should consider...

- Model uncertainty:

  ⇒ Is the approach appropriate? Are results dependent on the methodology?
- Parameter uncertainty:

  ⇒ How much confidence can you have on input assumptions?
- Model horizon and level of temporal/spatial disaggregation:

  ⇒ What is the intended scope of analysis? Beware of the "end-of-horizon"-effect!
- Model simplifications for numerical tractability and comprehensibility:

  ⇒ What are appropriate trade-offs between having a high level of detail vs. loosing focus?
  E.g., variable renewables require infrastructure for system stability – assumption or result?
- System boundaries and model closure:

  ⇒ Are the assumptions to "close" the model valid?
  E.g., for a national electricity model, you need to make assumptions about import/export

Methods to evaluate the robustness of results

Think hard about testing your model behaviour

Methods for validation:

- Sensitivity analysis:
  Structured variation of key input parameters to understand the impact on results
  ⇒ Relatively easy to do, but you can never do sensitivity assessment for all parameters...
- Multi-criteria analysis:
  Include multiple dimensions in the objective function, solve model with different weights
  ⇒ Requires some work, still prone to modelling artefacts
- “Modelling to generate alternatives”
  Re-solve a model to get a different solution within some additional bounds
  ⇒ Very elegant, but requires substantial effort to implement
  Further reading: Joseph F. DeCarolis. Using modeling to generate alternatives (MGA) to expand our thinking on energy futures. *Energy Economics* 33(2):145-152, 2011. doi: 10.1016/j.eneco.2010.05.002

Part 2

So you have some results...
How can you present them to maximize impact?

A few comments on netter-practice for communication of insights

The importance of framing for good science communication

Scientists (engineers in particular) tend to frown upon framing

- Economists believe in the “invisible hand” of efficient markets
  ⇒ They too often ignore the key assumption of full information in markets
- Engineers are confident that they have “the right answer” and hope that science will prevail
- Social scientists and marketing executives understand the importance of communication
  ⇒ They understand the role of appropriate words, intuitive visuals, appealing to emotions, etc.

”Framing” is not about distorting the message!
It means ensuring that message & messaging are aligned and reflect the same values!

- Possible entrypoints:
  ⇒ George Lakoff, Professor Emeritus at the University of California, Berkeley
  https://framelab.us (check out their podcast)
  ⇒ Podcast ”Petajoule” by the Austrian Energy Agency (in German)

An example for great framing: More than showing ranges of scenarios

The arrows indicate that more (ambition) means less (GHG emissions) and they illustrate how various levels of ambitions build on each other

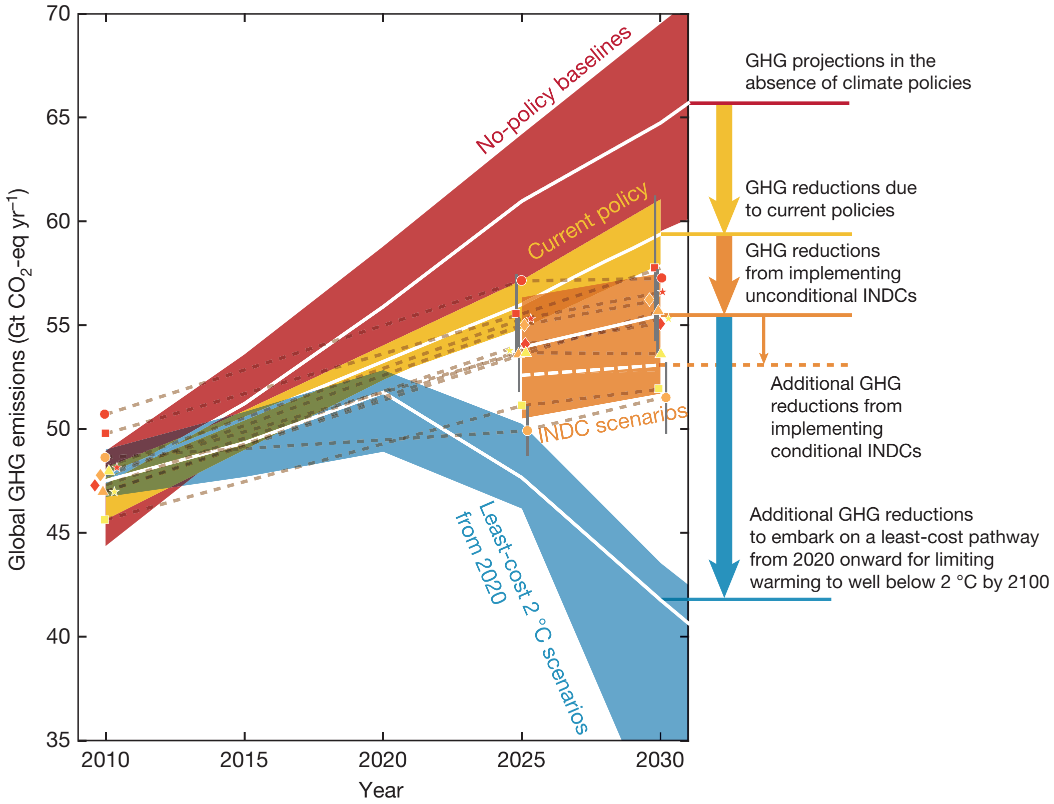


Figure 1 | Global greenhouse gas emissions as implied by INDCs compared to no-policy baseline, current-policy and 2 °C scenarios.

Joeri Rogelj et al. (2016)
Paris Agreement climate proposals need a boost to keep warming well below 2 °C.
Nature 534:631, 2016.
doi: 10.1038/nature18307

Visualizing beyond the data: include icons and other elements in figures

The key messages of this commentary are the process as much as the data, so it's ok to include an appealing visual representation to highlight this aspect

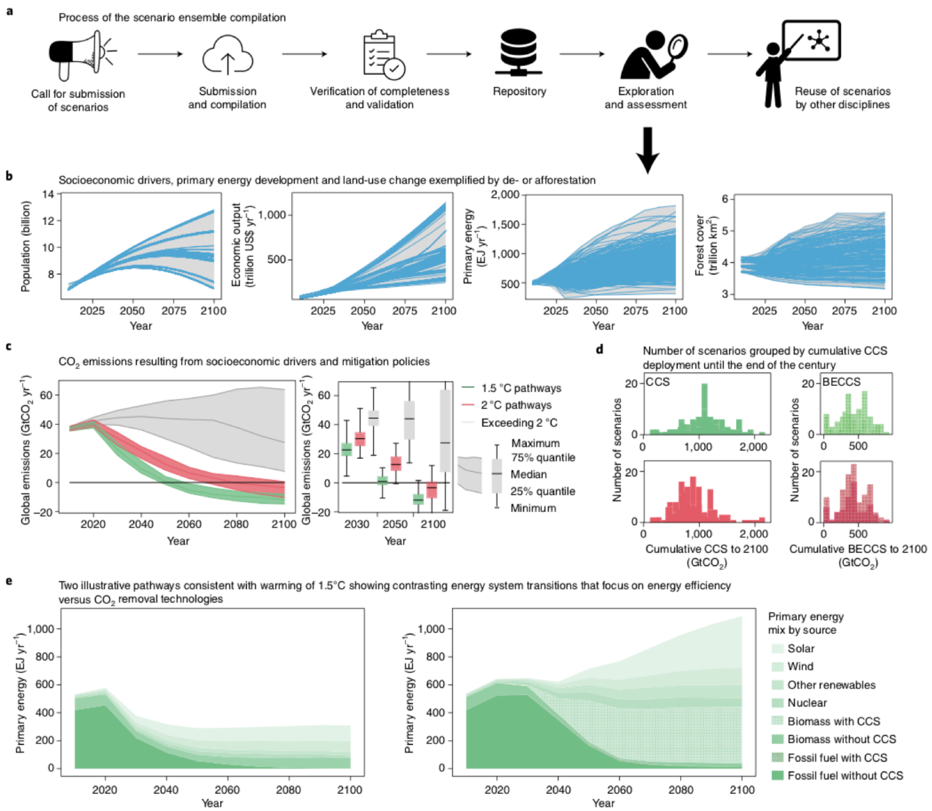


Figure 1 | Overview of process of compilation of scenario ensemble data and illustrative data visualizations.

D. Huppmann et al. (2018). A new scenario resource for integrated 1.5 °C research. *Nature Climate Change*, 8:1027-1030. doi: 10.1038/s41558-018-0317-4

A short clip on how to improve data table visualization

via Twitter from [@jessicadjewell](https://t.co/gE0qnRxBLK)
https://t.co/gE0qnRxBLK

Thank you very much for your attention!

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