MESSAGE$_{ix}$ Workshop

Session I: Introduction to MESSAGE$_{ix}$ Modeling Framework

7 June 2021

Energy, Climate, and Environment (ECE) Program

International Institute for Applied Systems Analysis (IIASA), Austria

The MESSAGE$_{ix}$ workshop team, June 2021


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Agenda for the week

Day 1: Introduction to the MESSAGE$_{ix}$ Framework

- Learn about different components of MESSAGEix and their capabilities

Days 2: MESSAGE$_{ix}$ as an optimization model

- Describing the structure of the mathematical model
- hands-on model development work using a rudimentary example

Day 3: Energy modeling using MESSAGE$_{ix}$

- Walk through a simple energy model from MESSAGE$_{ix}$ Westeros tutorials
- hands-on work on how to add energy policy constraints to a MESSAGEix model

Day 4: Post-processing or "reporting" and continuous model development

Day 5: Modeling Forum (free format discussions and answering remaining questions)

Today's agenda

- Short intro to MESSAGE$_{ix}$ and its applications.
- Breakout discussion: modeling and model development.
- Detailed tour of the MESSAGE$_{ix}$ "ecosystem" of tools, including terminology.
- Answering questions related to installation (preparation for Sessions 2–4).

Ground rules

- Questions are welcome and valid.
  - ⇒ Raise your hand (using Zoom features).
  - ⇒ Ask in Zoom chat: "Everyone", or to a colleague with " (IIASA)" in their name.
  - ⇒ Follow-up via Slack channel.
- Respect for diversity of participants, their level of knowledge, and their time.
- The slides and the video will be shared after each session

MESSAGE at IIASA

IIASA and MESSAGE are at the center of global energy policy assessment

- Since 1980s MESSAGE used for assessing sustainable development and energy/climate policies at national, regional and global scales.

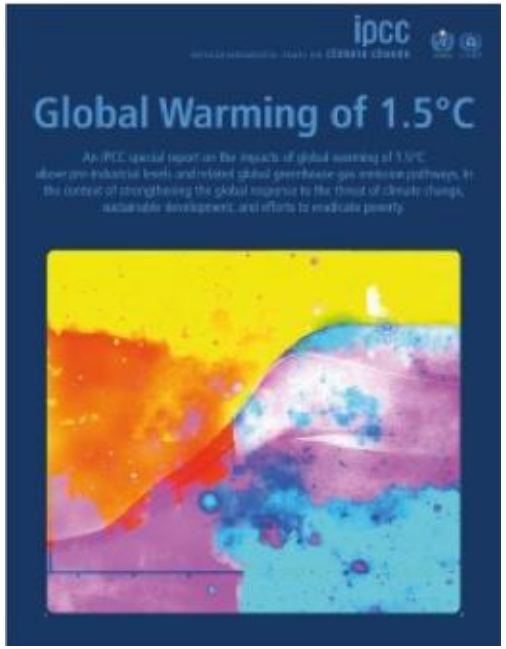
- MESSAGE is a systems engineering, long-term planning optimization model.

- MESSAGE widely in use in other organizations like IAEA and member countries.

- In 2018, transformed to an open-source modelling framework: **MESSAGEix**

  ⇒ Relying on the state-of-the-art and powerful data management infrastructure

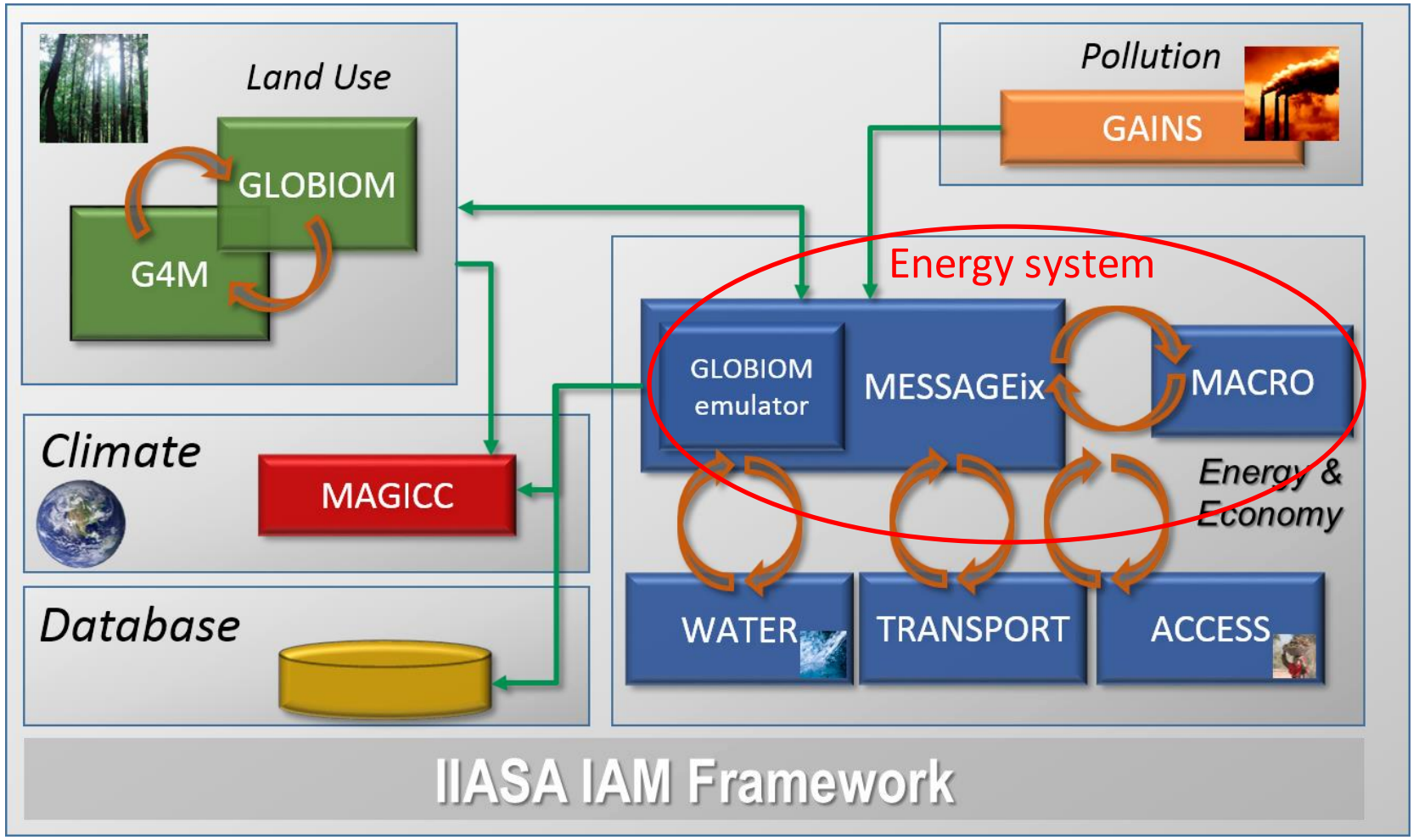
  ⇒ Building a community of developers, transparency and knowledge sharing



http://www.ipcc.ch/report/sr15/

IIASA's Integrated Assessment Model (IAM)

MESSAGE$_{ix}$ *as an energy system can be linked with other models and modules*

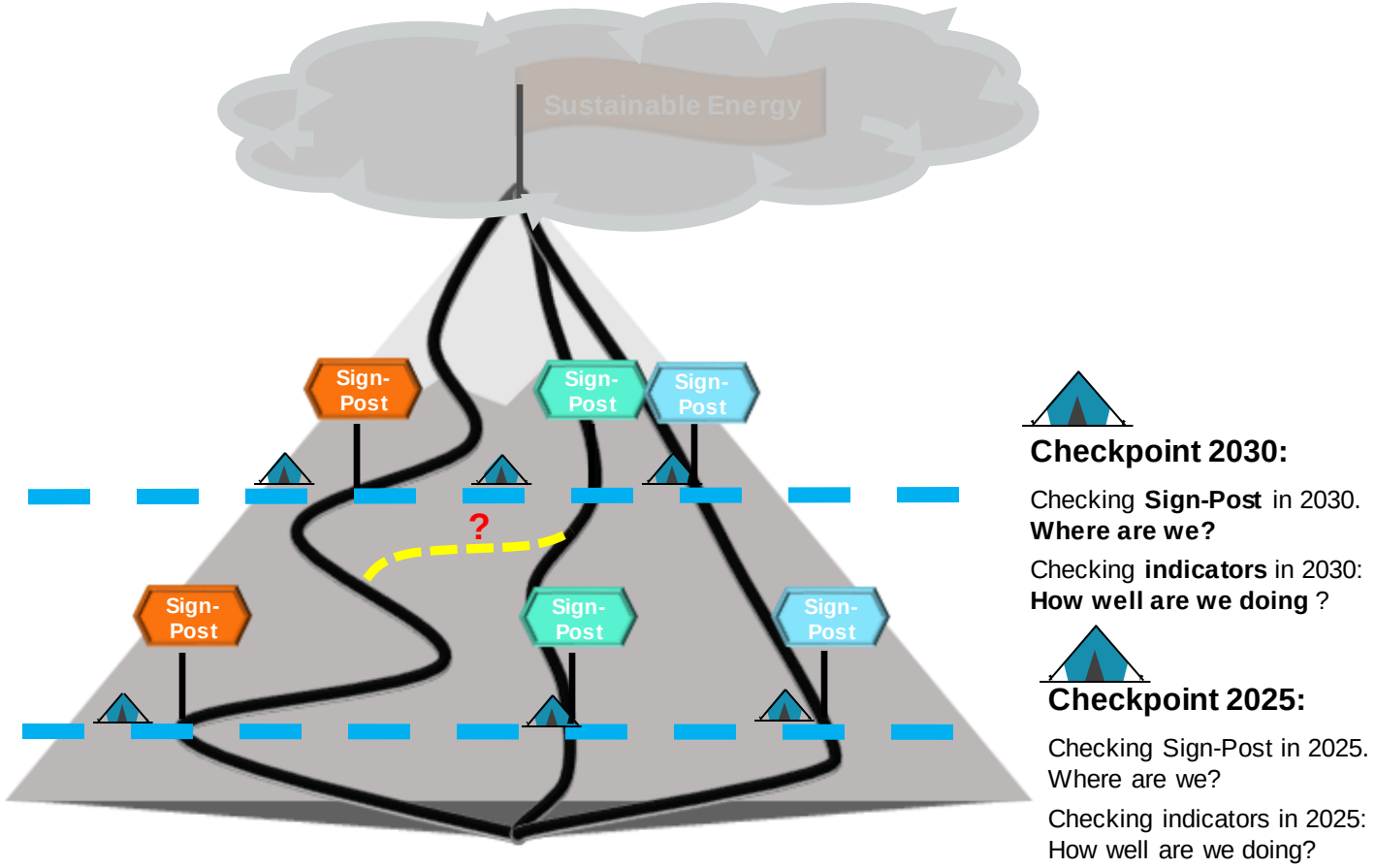


Focus of this workshop

MESSAGEix for Planning and Policy Making

Model for Energy Supply Strategies and their General Environmental Impacts

- **Energy systems** are path-dependent, capital intensive, involving many technologies, agents, and interactions between them ➔ Transition is not straightforward
- **Alternative pathways** may exist to reach the same target.
- **Implications of decisions** made today may last over several decades. Testing each pathway is not possible or it may be too costly.
- **Planning tools** can help us to estimate/understand the implications of each pathway for reaching certain development or policy goals.



Same starting point - different pathways represent different policy options

Figure: Holger Rogner (IIASA)

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MESSAGEix: A process-based, energy system model

Bottom-up representation of technologies

- A system of interlinked resources, technologies, commodities, levels, etc. to deliver certain services
- Representing different sectors of energy systems (buildings, transport, industry)
- A linear optimization model for planning over several decades (mid-term or long-term)

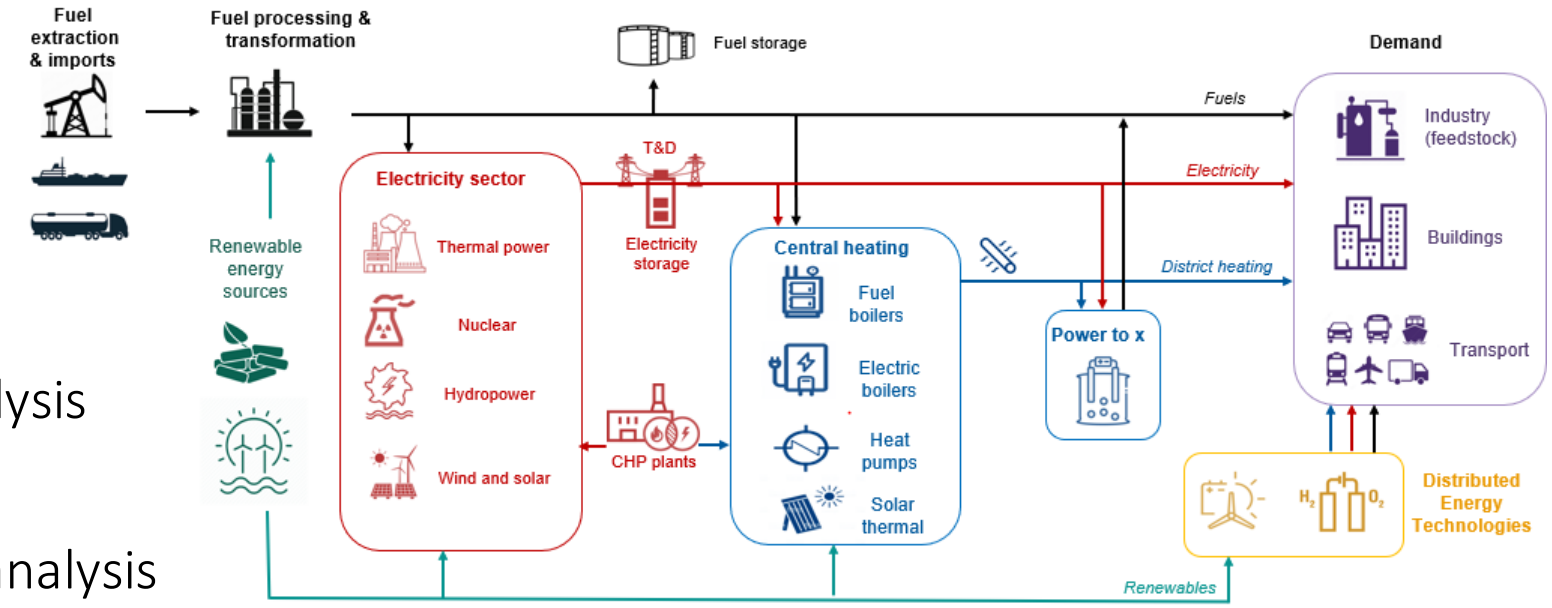


Figure: Behnam Zakeri (IIASA)

MESSAGEix not suitable for:

- Unit commitment, small-scale analysis
- Power load flow DC/AC analysis
- Snapshot operation and dispatch analysis

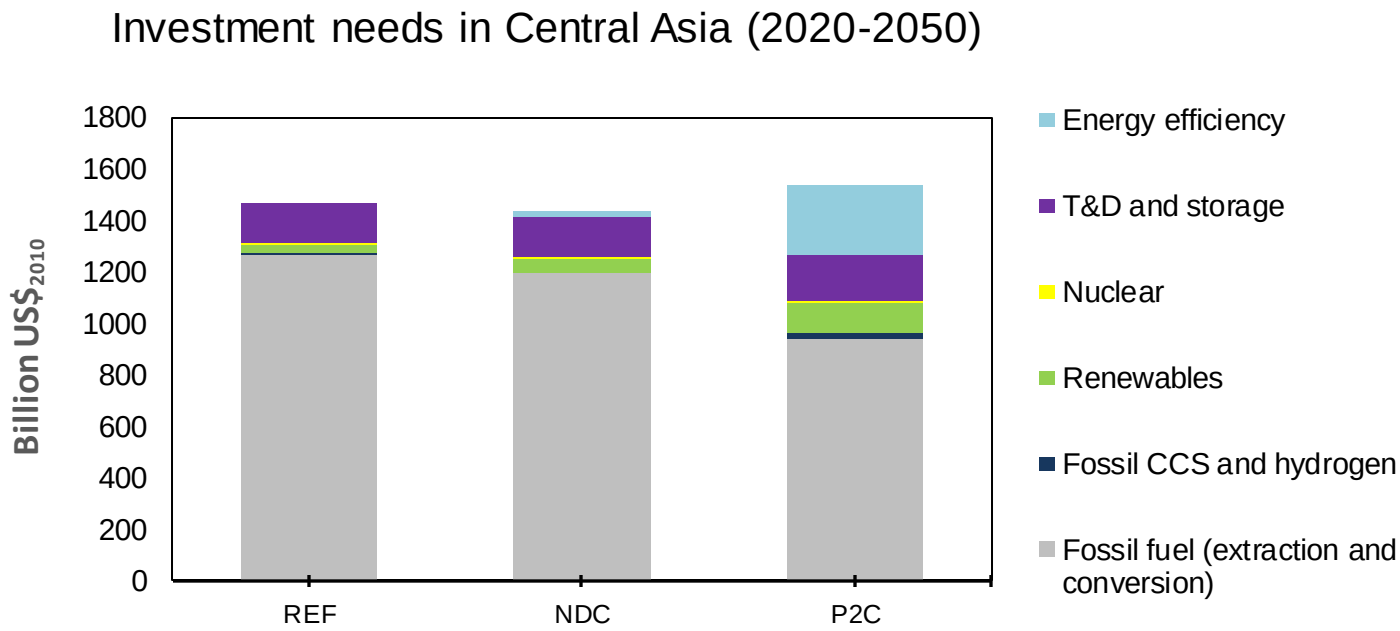
MESSAGE$_{ix}$ example projects 1: Regional energy transition

Central Asia: conflict between energy and water demand

Modelling of hydropower storage solutions and sub-annual timeslices

- Impact of gas demand in China on gas exports from the region
- Coal and gas demand in a 2-degree world
- Role of renewables in the region
- Assessment of investment needs

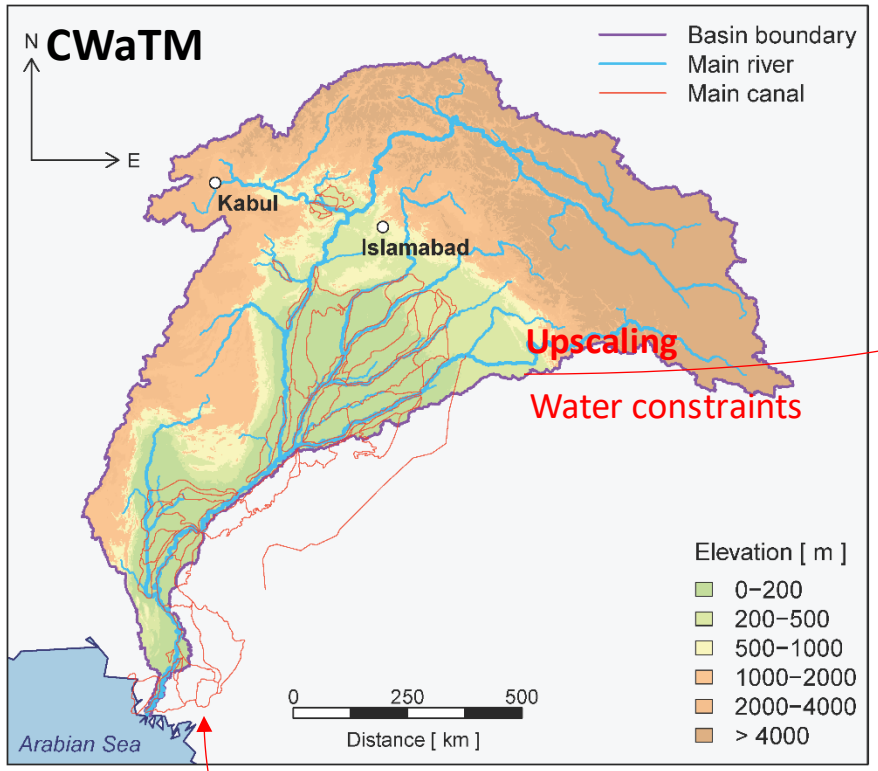
image: moneyweek.com



REF: reference scenario, NDC: nationally determined contributions, P2C: 2-degree

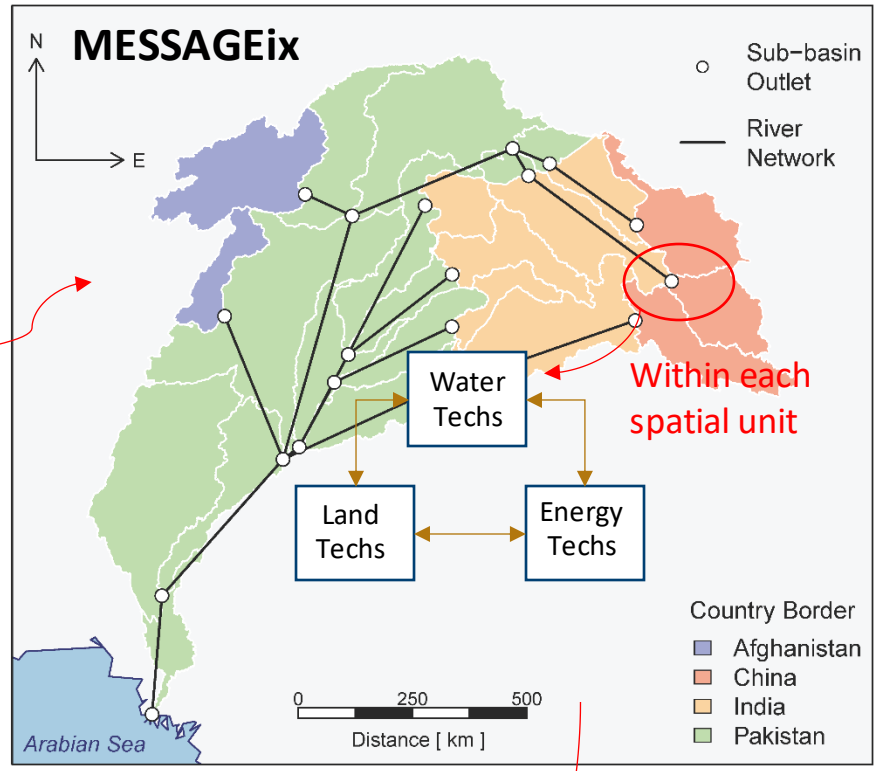
MESSAGE$_{ix}$ example projects 2: NEST model framework

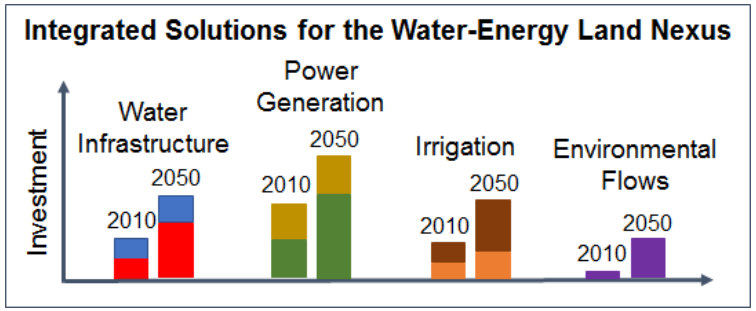
Transboundary analysis of water-energy-land use (Indus Basin)



Upscaling
Water constraints

Downscaling
Water and land-use





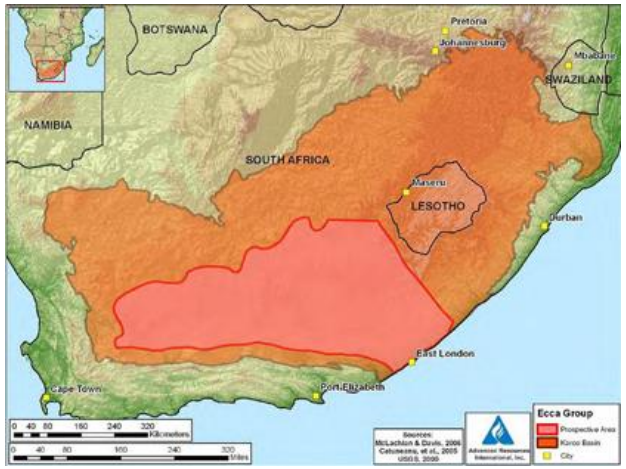
Minimize total system cost

Vinca et al. (2020)

MESSAGE$_{ix}$ example projects 3: South Africa (MESSAGE-ZA)

Shale gas in South Africa

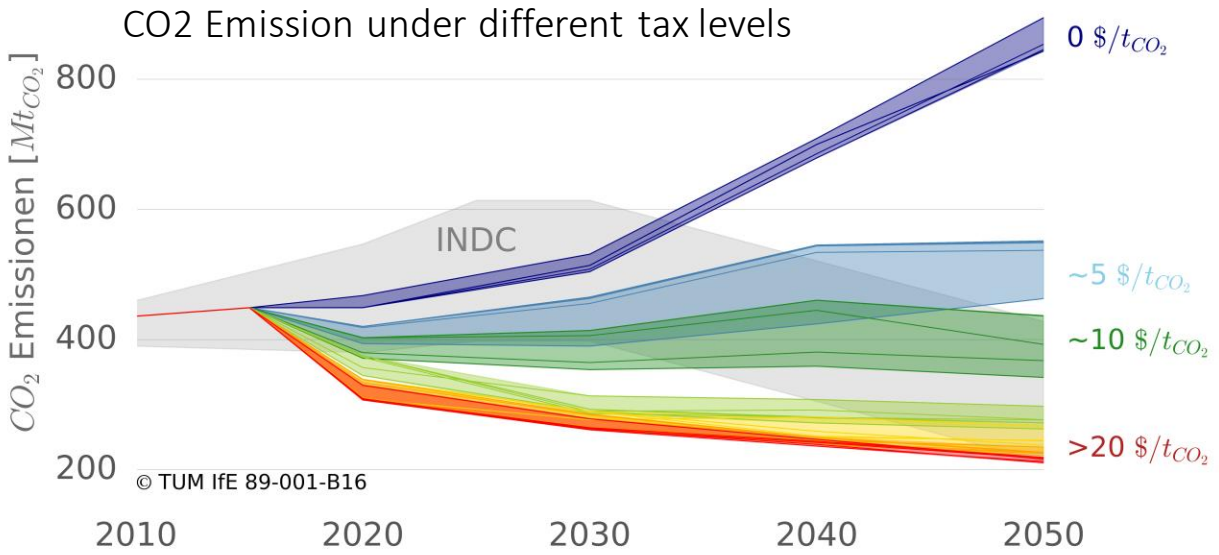
- South Africa beyond shale gas to meet NDC pledges
- Gas can function as a transition fuel from a coal to renewables
- Methane emissions from shale gas production need to be managed to avoid climate effects of gas usage
- Water scarcity might be an obstacle to shale gas use



Source: EIA - World Shale Gas Resources (April 2011)

Orthofer, C., Huppmann, D. and Krey, V., 2019. South Africa After Paris—Fracking Its Way to the NDCs?. Frontiers in Energy Research, 7, pp.art-20.

Link to the model:
https://github.com/tum-ewk/message_ix_south_africa

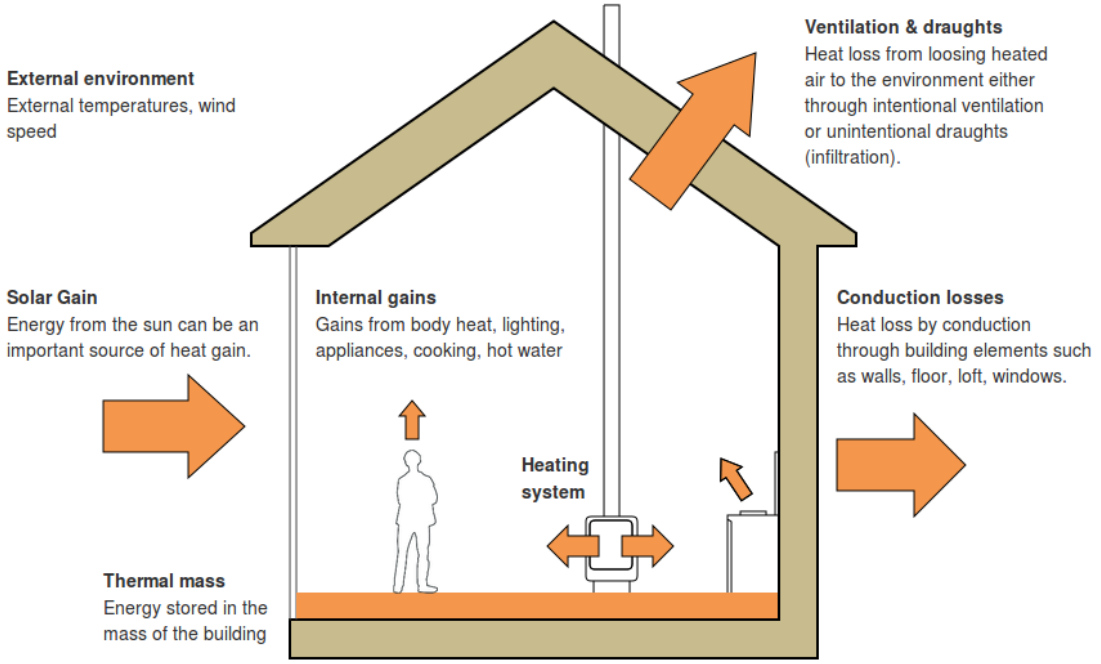


Modeling and Model Development

What's a good model like?

- We use models to represent and investigate a phenomenon in real world or hypothetically
- Examples: building model, forestry model, energy and climate models etc.

- Elements of modeling work:
  - Structural relations (equations)
  - Data
  - States of the system (scenarios and simulation)
  - etc.



openenergymonitor.org

Question

*1. What are the desirable features of an energy **modeling tool**?*

*2. What is the best practice in **model development**?*

Everyone (individually) (3 min):

- Think about your experiences in the past and your expectations from this workshop
- List **three items** that are important to you

Group work (10 min):

- You will be grouped in parallel breakout sessions
- Please turn on your video, and introduce yourself to each other
- **Discuss your views on the questions**

Question

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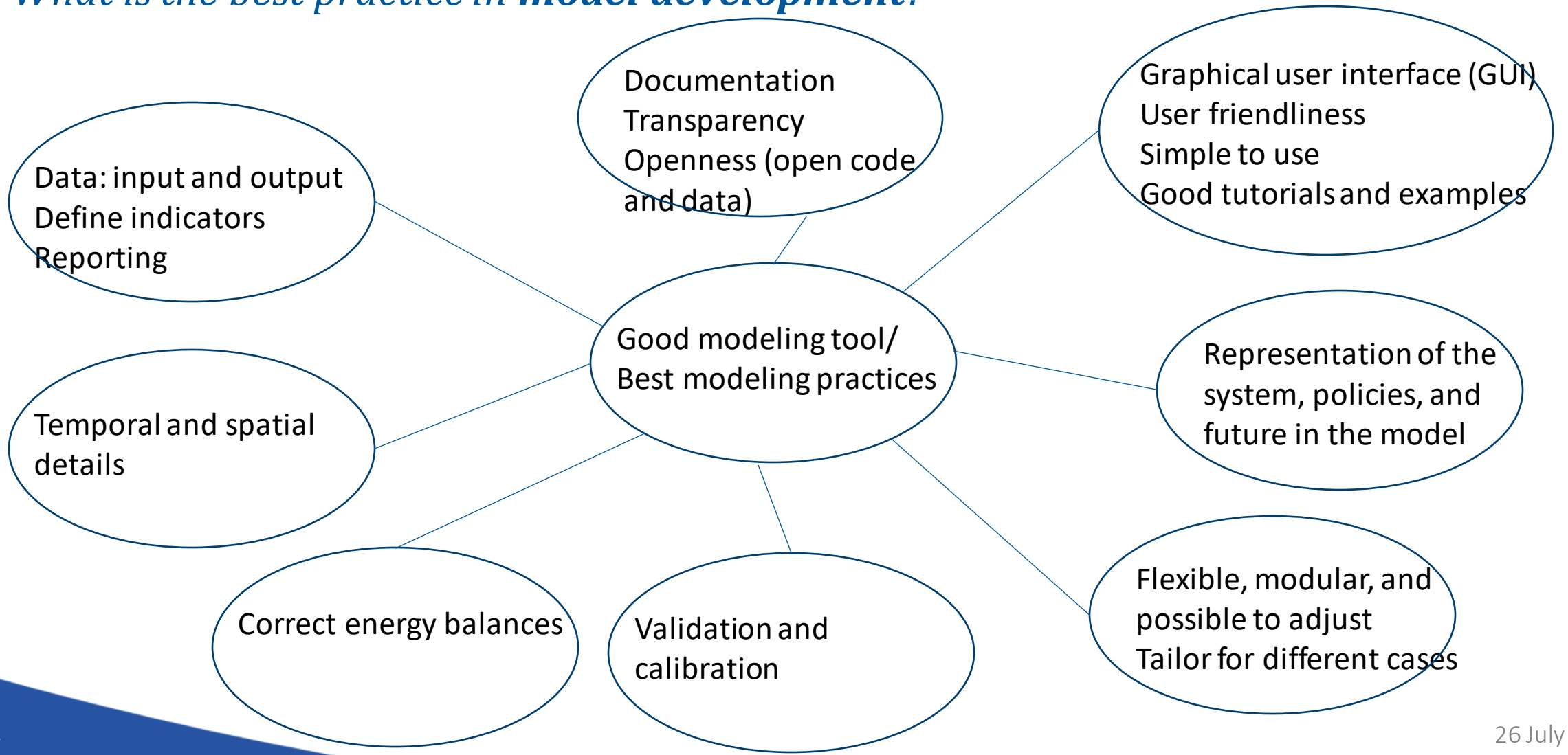

Thank you very much for your attention!