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science for global insight

A brief introduction to integrated assessment modeling and the role of scenarios

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CD-LINKS Capacity Building Workshop
The Energy and Resources Institute (TERI)
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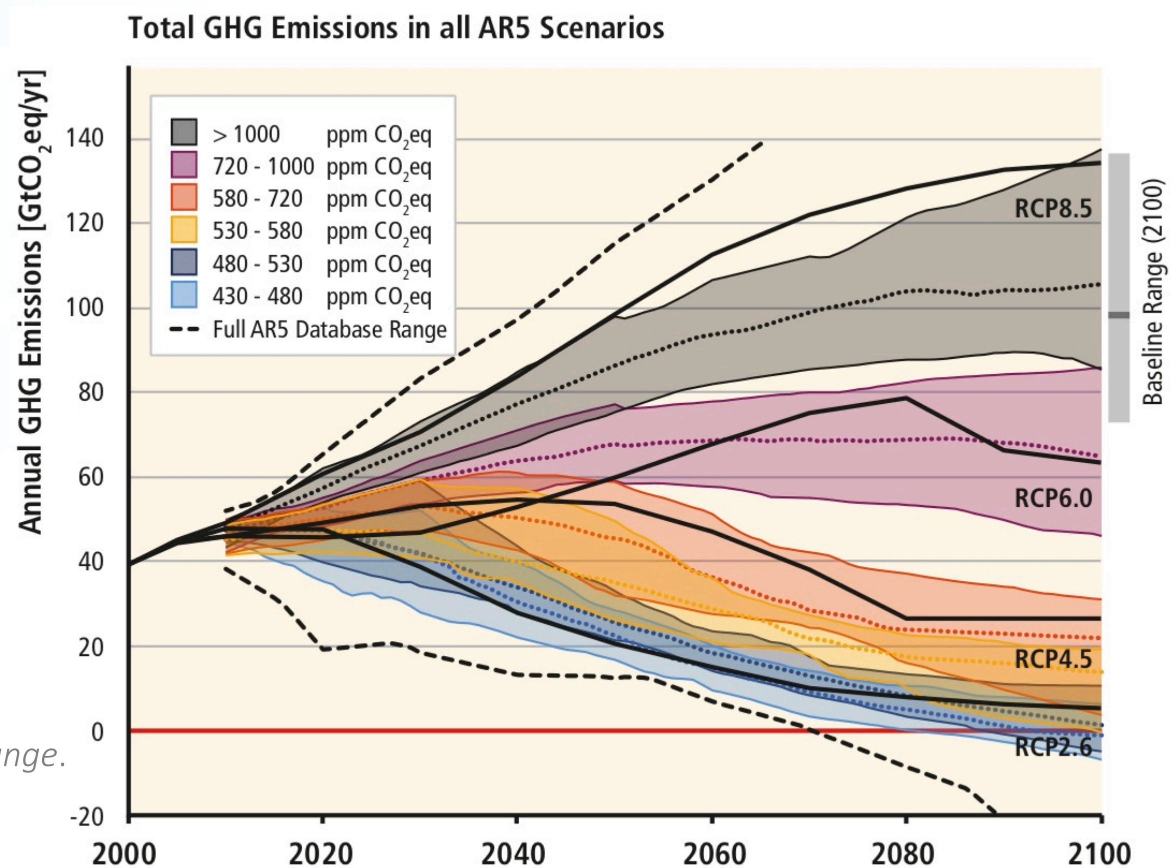
The role of scenarios in the international policy process

Scenarios from the 5th Assessment Report

Emissions pathways for total GHG emissions for the various categories defined in Table 6.2. The bands indicate the 10th to 90th percentile of the scenarios included in the database. The grey bars to the right indicate the 10th to 90th percentile for baseline scenarios.

Source: Figure 6.7a from Clarke L., K. Jiang, K. , et al., 2014: Assessing Transformation Pathways In: *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

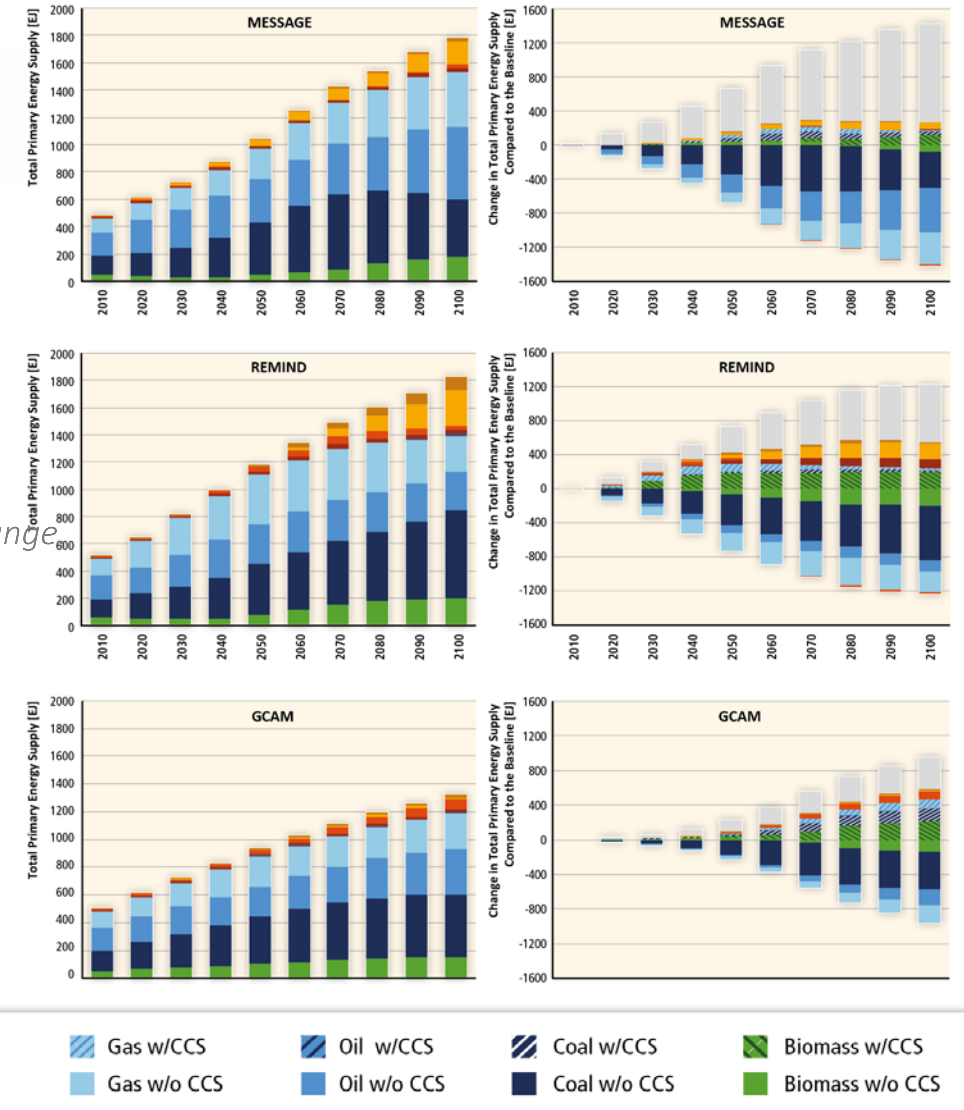


The role of scenarios in the international policy process

Scenarios from the 5th Assessment Report

Development of annual
primary energy supply (EJ) in three illustrative baseline scenarios (left-hand panel);
and the change in primary energy compared to the baseline to meet a long-term concentration target between
430 and 530 ppm CO2eq.

Source: Figure 7.10
from Bruckner T., et al., 2014: Energy Systems.
In: *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*.
Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.



The role of scenarios for national policy

Modelling & scenarios also play a big role on the national stage

- The CD-LINKS project seeks to bridge global models and a detailed implementation of national policies.

- TERI is consulting for the Indian Government by providing "long-term strategies for low-carbon development" using numerical modelling tools and contributed to the definition of the Indian *Nationally Determined Contributions (NDC)* for the 2015 Paris Agreement.

- The MESSAGE Brazil model developed by COPPE was also used as an input in the definition of the Brazilian NDCs

  ⇒ Alex Koeberle will present his work on MESSAGE Brazil and the policy relevance later in this workshop

Some definition of terms

What are models and scenarios, and why do we need them in energy policy assessment?

- One possible definition of a **model**:
  ⇒ A *stylized* representation of a system (theoretical, qualitative or quantitative) to understand or illustrate its behaviour
- One possible definition of a **scenario**:
  ⇒ An *internally consistent* description of (future) events or actions based on *well-defined assumptions* (irrespective of likelihood)
- Why do we need numerical (quantitative) models and scenarios?
  ⇒ Quantitative models force us to structure assumptions
  ⇒ They allow us to identify interactions in complex systems
  ⇒ Scenarios help us to illustrate narratives with numerical results

A brief overview of model types

Classifying existing models is as difficult as building a model

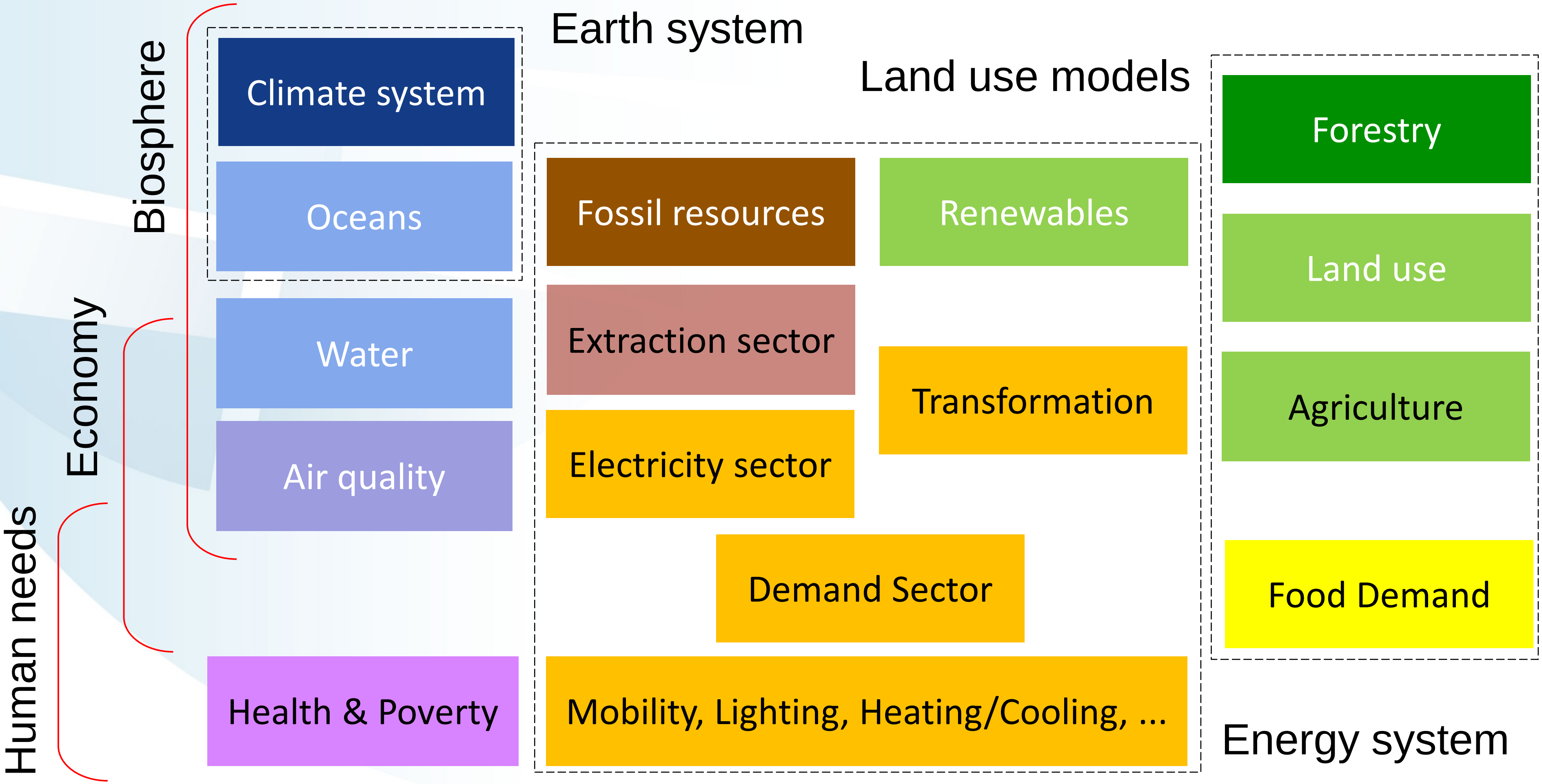
An (incomplete) overview of modelling approaches used for IAMs

- Optimization
  ⇒ Determine the least-cost solution for a system,
  e.g., satisfy given demand for energy services (TIMES, MESSAGE)
- Equilibrium approaches
  ⇒ Define the utility functions for individual actors (e.g., AIM-CGE)
- Simulation
  ⇒ Define decision rules for the evolution of the system (e.g., GCAM)
- Accounting models
  ⇒ ”Fill the blanks” given other specifications of the system (e.g., LEAP)

⇒ *But most applied IAMs use a combination of these approaches!*

The evolution of a model (I)

The key to understanding a model is to know what's not in it!
From energy system optimization to integrated assessment



The evolution of a model (II)

A model is never finished – you will always want to develop and extend it for the next research question

There are three general approaches to extend a model setup

- Coupling of two existing models

  This is not the topic of today's workshop...

- Including a (stylized) representation of a new sector
  - ⇒ make the sector internal/endogenous to the model logic
  - ⇒ Presentation by *Alex Köberle* @ COPPE & Imperial on including non-CO2 gases & linkages to agricultural phase of bioenergy crops

- Applying ex-post processing to model results
  - ⇒ easier to implement, but the sector is not become par
  - ⇒ Presentation by *Gunnar Luderer* @ PIK on life cycle assessment

The IAMC template for timeseries data (I)

A community effort towards a standardized format

The IAM consortium developed a common template
to exchange processed model results and reference data

⇒ The IAMC format strikes a balance between *structure* and *flexibility*

	A	B	C	D	E	F	G	H	I
1	**Model**	**Scenario**	**Region**	**Variable**	**Unit**	**2005**	**2010**	**2015**	**2020**
2									

- The template is used for all scenario databases hosted by IIASA
- More than 20 research teams around the world implemented tools to export their model results to the IAMC format
- The template was used in numerous projects over the last decade

see data.ene.iiasa.ac.at/databases
for details and more application

The IAMC template for timeseries data (II)

Required columns in the IAMC data format:

- **Model**: the model name, should include a version identifier
  - ⇒ e.g., "MESSAGEix-GLOBIOM 1.0"
- **Scenario**: the scenario name, ideally a descriptive name
  - ⇒ e.g., "baseline", "carbon_tax_50"
- **Region**: the region name
- **Variable**: the identifier of the timeseries data
  - The variable name allows to implement a semi-hierarchical structure using the "|" character to distinguish multiple levels of sub-categories
    - ⇒ e.g., "Primary Energy|Natural Gas|Conventional"
  - The format does not require strict aggregation for a sub-category
    - ⇒ e.g., possible to have "Final Energy|Coal" and "Final Energy|Transport" within the "variable tree" definitions of a project
- **Unit**: the timeseries unit using consistent naming conventions
- **Years**: each column has the timeseries data for a specific year

Using the IAMC data template for your own analysis

- How to get from model output to standardized results?

  ⇒ Illustrative example workflows for GAMS, R and Java
  github.com/IAMconsortium/reporting_workflows

  But this is not the topic of today's workshop...

- The second half of the workshop will focus on tools
  to analyze model results once they are in the IAMC format

  ⇒ The open-source Python package "pyam"
  by Matthew Gidden and Daniel Huppmannn @ IIASA
  open-source code available at github.com/IAMconsortium/pyam
  documentation pages at software.ene.iiasa.ac.at/pyam

  ⇒ An R tool to generate model factsheets for the CD-LINKS project
  by Heleen van Soest @ PBL
  code available at github.com/CD-LINKS/factsheet

Workshop agenda

Introduction

14:00-14:30 | Introduction, *Daniel Huppmann* @ IIASA

Adding new features, extending system boundaries of existing models

14:30-15:15 | LCA tools, *Gunnar Luderer* @ PIK

15:15-16:00 | Non-CO2 gases & linkages to agricultural phase of bioenergy crops, *Alex Köberle* @ COPPE & Imperial

Tools for analysis of standardized model results

16:30-17:15 | pyam – an open-source Python package for IAM scenario analysis, *Daniel Huppmann* @ IIASA

17:15-18:00 | R visualisation and country fact sheets, Heleen van Soest @ PBL

Conclusions

18:00-18:15 | Conclusions and wrap up

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Thank you very much for your attention!

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