Scenario Adjustment with GCAM

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Session Overview

Part 1

- What are scenarios?
- What's included (and not included) in GCAM's reference scenario?
- Designing scenarios

Part 2

- Setting up scenarios
  - Pre-existing XMLs
  - gcamdata
  - R script outside of gcamdata

- Example scenarios
  - Socioeconomics
  - Technology cost
  - Carbon price / emission constraint
  - Share weights

- Reviewing results (did your scenario Do What it Said it Would Do?)

DISCUSSION

What is a scenario?

- "**Scenario: A plausible description of how the future may develop** based on a **coherent and internally consistent set of assumptions** about key driving forces (e.g., rate of technological change (TC), prices) and relationships."
    - "Note that scenarios are neither predictions nor forecasts, but are used to provide a view of the implications of developments and actions."

- "**Scenario storyline**: A **narrative description** of a scenario (or family of scenarios), highlighting the main **scenario characteristics**, relationships between **key driving forces** and the dynamics of their **evolution**."

- IPCC, 2021: Annex VII: Glossary. *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* doi:10.1017/9781009157896.022
    - https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_AnnexVII.pdf

What is a Reference scenario?

- "**Reference scenario:** Scenario used as starting or reference point for a comparison between two or more scenarios.**"**

  - "Note 1: In many types of climate change research, **reference scenarios reflect specific assumptions about patterns of socioeconomic development and may represent futures that assume no climate policies or specified climate policies**, for example those in place or planned at the time a study is carried out. Reference scenarios may also represent futures with limited or no climate impacts or adaptation, to serve as a point of comparison for futures with impacts and adaptation. These are also referred to as baseline scenarios in the literature."

- IPCC, 2021: Annex VII: Glossary. *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* doi:10.1017/9781009157896.022

  - https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_AnnexVII.pdf

GCAM's Reference scenario

- Includes no explicit representation of policy
  - but the impact of existing policies may influence calibration parameters
  - NOTE: GCAM-USA is an exception. It includes limited representation of current policies, such as a representation of Clean Air Act Section 111 (b) New Source Performance Standards

- Does not include climate impacts
  - e.g., configuration_ref.xml calls HDDCDD_constdd_no_GCM.xml, which assumes flat Heating Degree Days (HDD) and Cooling Degree Days (CDD) beyond 2015
  - although this is an active area of research and debate at JGCRI

ELSEVIER

Energy Strategy Reviews

Volume 32, November 2020, 100551

ENERGY
STRATEGY

Evaluating long-term model-based scenarios of the energy system

Matthew Binsted [a] , Gokul Iyer [a], Ryna Cui [a b], Zarrar Khan [a], Kalyn Dorheim [a], Leon Clarke [a b]

Designing Scenarios

- Studies employing integrated, multi-sector models like GCAM often begin with a counterfactual "reference" scenario which is compared against a range of alternative scenarios, including alternative social, technical, or policy futures

- How many scenarios to consider?
  - Fewer scenarios are easier to explain and visualize
  - More scenarios allow exploration of a broader range of influences and outcomes

- Single perturbations vs. multiple changes
  - Introducing a single change helps isolate the impact of that change on future results
  - Introducing multiple changes simultaneously can reveal interesting interactions and quantify cumulative impacts

- Global vs. region-specific changes
  - Remember: "coherent and internally consistent set of assumptions"

- Ultimately, these decisions will be driven by a study's research question(s)

Part 2

Setting Up Scenarios

- There's more than one way to peel a potato
    - Pre-existing XMLs
    - gcamdata
    - R script outside of gcamdata

- Hand-editing XMLs
    - Generally not advisable
    - Difficult to trace
    - Be kind to future you (Will you remember exactly what you changed?)

Setting Up Scenarios – Pre-existing XMLs

- **input/gcamdata/xml**
  - **Socioeconomics**: socioeconomics_SSP[1-5], socioeconomics_gSSP[1-5]
  - **Elasticities**: [aluminum, cement, chemicals, iron_steel, Off_road, other_industry] _incelas_[g]ssp[1-5]
  - **Buildings energy demands**: building_SSP[1-5]
  - **Technology cost**: [geo, nuclear, wind, solar]_adv, [geo, nuclear, wind, solar]_low
  - **Transportation**: transportation_UCD_[CORE, SSP1, SSP3, SSP5]
  - **Resources**: resources_SSP[1-5]
  - **CCS / carbon storage**: ccs_supply_high, ccs_supply_low, ccs_supply_lowest, no_offshore_ccs, high_cost_ccs, turn_off_ccs.xml (new as of GCAM X.X)
  - **DAC**: dac_ssp[1-5]
  - **HDD / CDD**: variety of CGMs
  - **Ag productivity**: ag_prodchange_ssp[1-5]_IRR_MGMT

- **input/policy**
  - Carbon price trajectories
  - Radiative forcing targets
  - SPAs

- **Mind your internal consistency**

Setting Up Scenarios – *gcamdata*

- Many changes can be implemented through *gcamdata*
  - Fast & automated: updates to input files flow through to all impacted XMLs
  - Some changes are easier to implement than others
    - ✓ Changes using existing technologies / parameters are easier (data processing already exists)
    - ✓ Adding new technologies or sectors is more involved, but *gcamdata* contains a lot of functionality to make life easier
  - driver_drake is your friend (and a major time-saver)

- NOTE: when re-running driver_drake(), existing XMLs will be overwritten for those that are updated by the new changes
  - When running driver(), all XMLs and output files are deleted

- Example – increasing battery electric vehicle (BEV) and fuel cell electric vehicle (FCEV) share weights for freight trucks

Other Training Sessions – *gcamdata*

- **Session 2, Breakout 2: How to run gcamdata & renv package management**
  - How to get data system up and running, driver_drake, renv
  - Lead: Ellie Lochner

- **Session 3, Breakout 2: Creating XMLs and using user-modification functions**
  - General XML structure, modifying gcamdata, using headers, demonstrating user modification capability
  - Lead: Pralit Patel

# Setting Up Scenarios – leveraging *gcamdata* functions outside *gcamdata*

- Many useful *gcamdata* functions are available when you simply library("gcamdata"), without having to load the full project
  - left_join_error_no_match()
  - repeat_add_columns()
  - approx_fun()
  - gdp_deflator()
  - XML functions: create_xml(), add_xml_data(), run_xml_conversion()
- This provides the ability to quickly transform data in R and generate XML files, without some of the overhead associated with *gcamdata* chunks
  - However, some input data flows through multiple *gcamdata* chunks to multiple XML outputs, and operating outside of *gcamdata* may miss some of these data interdependencies
    - ✓ Use dstrace(), RStudio Find in Files (ctrl+shift+F), etc. to understand how data flows through *gcamdata* and avoid missing important interdependencies
- Example – Updating USA population and GDP to match AEO 2023

Example Scenarios

- **Socioeconomics**: Updating USA population and GDP to match AEO 2023 (outside gcamdata)

- **Technology cost**: advanced nuclear (pre-existing XML; input/gcamdata/xml/nuclear_adv.xml)

- **Policy**: global carbon price (pre-existing XML; input/policy/carbon_tax_25_5.xml)

- **Share weights**: freight truck BEV and FCEV share weights (gcamdata)

Reviewing Results

- Did your scenario Do What it Said it Would Do?
  - If not, why? Mistake in implementation? One scenario component counteracting another? Unexpected insight from the model?
  - If yes, what do these changes mean for other regions, sectors, technologies, etc.?
- Can check results using:
  - ModelInterface
  - rgcam
  - gcamextractor
- Other Training Sessions – reviewing results
  - Session 3, Breakout 1: Querying, rgcam, and dealing with GCAM output
    - Introduction to Model Interface, result querying, how to use rgcam, and interpreting outputs
    - Lead: Maridee
  - Session 3, Breakout 4: Data Visualization Package
    - overviews of gcamextractor, Rmap, and Rchart including live demos;
    - Community engagement and feedback on new Foresight Dashboard
    - Leads: Taryn Waite & Zarrar Khan
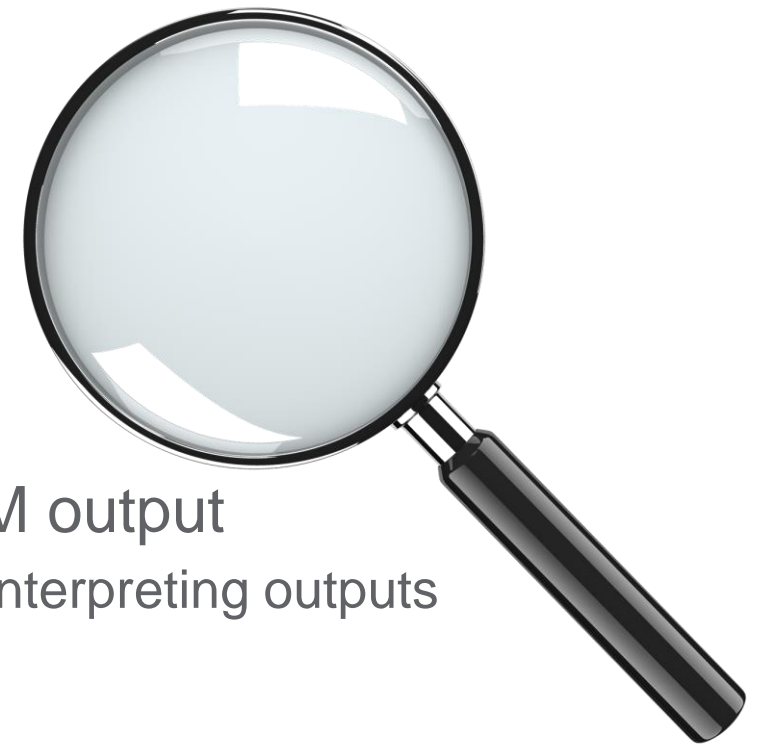
Concluding Thoughts

- Scenarios are:
  - plausible descriptions of the future
    - ✓ not predictions nor forecasts
  - based on a narrative about how systems may evolve
  - entail a coherent and internally consistent set of assumptions
  - often used in comparison with a reference scenario in counterfactual analysis
- Scenario design decisions will be driven by a study's research question(s)
- There's several ways to set up scenario inputs
  - Pre-existing XMLs
  - gcamdata
  - R script outside of gcamdata
- Make sure your scenario Does What it Said it Would Do
- Ultimately, scenario development is an iterative process
  - Feedback from stakeholders or other experts
  - Different ways of implementing scenario components in the model