Knowledge based investigation of energy system scenarios

A new approach to Global energy systems modeling

*Kinesis* (noun): movement in a cell or organism in response to an external stimulus
Outline

● The need for a new approach to model development
● Knowledge-based modeling
● Model design and deployment
● Examples
Motivation

● The need for energy system modeling has never been greater
  ○ Rapid transitions across the energy system
  ○ Cross-sector interactions are crucial to system change
  ○ Urgent short-term needs in long-term context
  ○ Multiple intersecting uncertainties

● We need to be able to *envision, explore, and communicate about* disruptive scenarios - futures that look nothing like the past

● These are precisely the capabilities of TIMES…

● So why isn’t everyone using TIMES?
How hard is it to use a TIMES model?

- Takes a long time to build
- Enhancements and updates need a lot of effort
- Difficult for even other TIMES modelers to understand
- Practically inaccessible to non-TIMES modelers

- In other words, effective model users are those who have built those models themselves. There is no clear path to become a good model user, without becoming a “TIMES expert” first.
Broadening TIMES use and decision relevance

- The core modeling team can no longer monopolize the process of extracting insights from model results
  - Wider engagement brings diverse perspectives
  - Stakeholders use the insights to guide actions much more efficiently if they have the option to engage with models directly
  - *Of course, without investing the time it takes to become a “TIMES expert”*
Rethinking model aggregation and data structures

- Many questions need global models with different regional focus
  - Global hydrogen scenarios
  - LNG supply, demand, and trade
  - Energy security in Europe-Central Asia region

- A single model with static regional aggregation is not the best way to address these questions

- *More temporal and technology flexibility would also be convenient*
Knowledge-based energy system modeling

- Typically models are built by first deciding on a regional structure, then seeking or aggregating/disaggregating data to fit that structure
  - Changing regional structure later can be a major undertaking
  - And similarly with structuring model data in time
- In a knowledge-based system, data is stored in a relational database at the most granular level available
  - Country or state/province level
  - Individual plant/unit level
  - Hourly
- Database queries are designed to aggregate/disaggregate data in the desired structure, creating inputs for a model instance
- Multiple model instances with different time/space/technology aggregations can be developed readily from the same knowledge database
KINESYS - Model development and deployment

*Knowledge based investigation of energy system scenarios*

- Knowledge-based model framework built upon the former TIAM global model
  - Flexible aggregation allows rapid reconfiguration of model regions/technologies/timeslices to suit analysis needs
  - Also supports creation of country “starter” models
- Deployed in the VEDA-Online framework
  - Engage stakeholders directly in results review
  - Participants can learn as much or as little about the underlying model details as they choose *while doing meaningful analysis*
- Updates to the framework are available to improve all KINESYS models
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Knowledgebase data operations

- Aggregation
- Disaggregation based upon assigned weighting variables
- Assignment of default data
- Assignment of missing data from model regions/technologies
Several regional aggregations have been created

https://vedaonline.cloud/kanors/kinesys.html
Deploying KINESYS models in VEDA-Online

1. **Build confidence** by verifying calibration and comparing results to external scenarios
2. Begin analysis by **reviewing results** from a suite of scenarios that stress the model, examining fuel and technology switches across a spectrum of abatement levels and pathways
3. **Engage stakeholders in using results review** to prioritize input refinements and policy scenario development
Example: Gas infrastructure disruption
Western Europe in 2023
Western Europe in 2023 – Sankey Diff view

More in gf-NoEU.

More in gf-Ref.
Example: Hydrogen trade – Imports into Japan
Example: Country starter models

- KINESYS was used to create country starter models for Egypt and Indonesia within the Net Zero World initiative.
- The countries were broken out as individual regions and could be run within the global model or standalone with global fuel market prices taken from the global model.
- Used to develop and explore Net Zero pathways in Indonesia and assess Egypt’s competitiveness for hydrogen exports to Europe under global Net Zero scenarios.
Example: Mark-to-model valuation

- Conducted in the Net Zero World Indonesia model
- Analysis takes the perspective of an investor contemplating investment in power plant, subject to future carbon price risk
- Investment in each project is forced and lifetime discounted cash flows are computed
- ROI and other investment valuation measures can be computed
Example: Indonesia country model
Example: Indonesia country model
Final thoughts

The combination of a knowledge based approach to model development and deployment in VEDA-Online helps us quickly get to the point where we are:

- Reviewing results with model stakeholders
- Designing and answering what-if questions with them
- Collaboratively generating insights on questions of real interest to them