**Standardized tools for
long term economic modeling of
energy markets and technologies**

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CONTENT

- Decision makers

- different analyses with common tools - ETSAP

- The MARKAL-TIMES model generators

- New developments: experience at EIA with SAGE

- A proposal

Decision makers asked

- RD&D: what? Together? How much?
- QELROS: What? when? How much?
- Security: what? How much? Who?
- A 20 years forecast of global energy markets

The analysts

Initial failure to address separately the common problem

The need to cooperate: ETSAP

The development of a common tool: MARKAL

The use of consistent coding conventions

For the construction of country specific models

And the accomplishment of analyses

National and co-operative

What kind of tool?

- Not a model, but a generator of models
- Not only energy supply but energy services (RES)
- Representing energy markets as well as technologies
- With static and dynamic equilibria
- And an extended concept of system costs
- Not an executable but an open source code

That research tool has progressed in:

- Decision making scope
- System Scope
- Economic rationale
- Technologies Representation
- Platforms, Languages, solvers
- Users' interfaces and supporting DB

1 – Decision making scope:

Global single region

Global multi-region

   co-operative equilibrium

   Nash equilibrium (in preparation)

Why? the decision making process is not global

2 – Wider System Scope

- the Village in South Africa and the globe
- 3 to 30000 commodities and processes
- energy and materials and emissions, etc.
- 3 to 100 years

3 – Economic equilibrium

- Intra-period or Static, for commodities
- Inter-period or Dynamic, for each capital good
- Deterministic vs. stochastic
- System forecasts vs. systems analyses
- Partial vs. general
- Market vs. public goods

4 – Technology Representation

- Many more technologies than commodities
- Distinction among different vintages of the same technology
- Technology specific hurdle rates
- Exogenous and Endogenous Technology Learning
- Lumpy investments

6 – Users' Interfaces and DBs

Large technological models imply huge amounts of data in input and output, with problems of consistency, performance and synthesis.

Present MARKAL – TIMES users' interfaces, such as ANSWERS and even more VEDA, handle half a million variable models and make use of external DBs - energy balances and technology repositories - multidimensional spreadsheet feature (drag and drop), etc.

New International Model: SAGE

- For reference case forecasts by region, fuel, sector
    - Including Trade in energy products and carbon permits
- For policy-based scenarios including:
    - Technology: regulatory-based, market-based, R&D-based

Choice of MARKAL Framework

- 2-years ago we (EIA) asked John Weyant et. al. what to do and he told us to start with MARKAL and we did.

  •Long history of technology based modeling, stable platform for a wide variety of models

  • RES is defined by the 'data' entered and after reviewing several existing regional models it was obvious we had to define an RES where each region has the same set of possible RES's
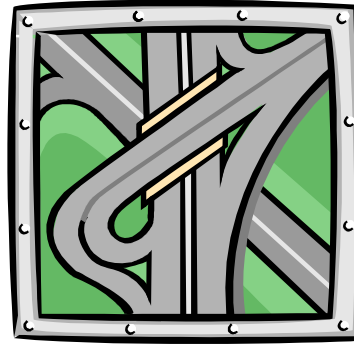
SAGE style MARKAL

- Focus on predictive rather than prescriptive
  - Energy, Technology, Carbon markets evolving through time not over time.
    - Time-stepped MARKAL modification. (In period 2 your stuck with the investment decisions made in period 1 *based on knowledge in period 1*
    - User-defined market share behavior *by Technology Market.* Concepts: Close enough least cost, sensitivity to cost, how much to reallocate

Sharpen the Tool

- SAGE is firmly linked to MARKAL, large user community, continuing development
- MARKAL RES is data driven
  - each of our 15 regional model RES's are potentially the same. Differences are based on user input—a region that has no indigenous coal resources does not have an RES node for mining coal.
  - Common technology and process name and description conventions across regional models is the basis of inter-regional communication and powerful results analysis capability

Sharpen the tool, cont.

- Without a common model 'family' with enough users to support the development and maintenance of software to develop scenarios and analyze results SAGE would have been impossible.
  - Developing a simple scenario for all 15 regions, (increasing regional GDP growth) took me 4 days to implement last year. Today with VEDA-SAGE *[TIMES, etc.]* it takes 10 minutes and **perhaps most importantly I have the energy to carefully review the results**.
  - Flexible results analysis software with VEDA-BE lets me play detective—I have access to the results of all scenarios at the same time, I can track down an anomaly by mouse clicking my way to exactly the information I need in minutes.

Some concluding remarks

Tools and analyses described above are modest compared to what I've listened here

It has been a great meeting, I've learnt a lot from the analyses and even more from the questions

I've seen progress in analyses and tools

However …

… more progress in analyses and tools is desirable or needed. Why?

Energy markets continue to grow,

But the system looks unsustainable

Technologies seem to grow less, RD&D decrease

There seems to be a regress in security

A proposal

Analysts would like to devote more time to analyses and far less in tailoring tools

The groups represented here could join forces, which globally are large but ineffective when split among groups, to develop better tools, a flexible set of portable tools, with compatible DBs, transparent rules, open for research and development.

Representatives of interested groups might convene, for instance here at IIASA, and draw a development program, a common path for improved tools

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Grazie