U.S. EPA Regional MARKAL Model & Modeling to Generate Alternatives

Presentation to ETSAP
Laxenburg, Austria
June 23, 2003

Ken Harrison
ORISE-Funded Participant in the
U.S. Environmental Protection Agency (U.S. EPA)
Postdoctoral Research Program
Office of Research and Development (ORD)

Two mini-talks

- U.S. EPA regional MARKAL project
  (contact: Elizabeth Wilson, U.S. EPA ORD)
- Modeling to Generate Alternatives (MGA)

Regional MARKAL – motivation

- Decisions about technology and impacts from technology choice occur at regional/local scales
- Climate and air quality relevant policy actions are being taken at regional/local scales
    - e.g., GHG mitigation, criteria air pollutants, technology portfolio standards, systems benefits charges, etc.
    - States and local entities need tools to assess energy-technology-environment policies.

New England pilot project

- Six states – each to be modeled as own region
- Population ~14 million, 5% U.S. total pop.
- Significant energy differences from Rest of U.S.:
    - little resource production
    - greater reliance on oil for heat and electricity generation
    - major industries are paper and chemicals
- Particularly concerned about air quality and climate issues and policies
    - Eastern Canadian Premiers/New England Governors Climate Change Action Plan, 2001
- Northeast States for Coordinated Air Use Management (NESCAUM) – interstate air quality modeling and policy analysis organization

New England model project plan

- NESCAUM coordinating, hosting, and running model
- Begin with national model data for current Reference Energy System (RES)
- State Air and Energy offices reviewing/revising national model data, substituting state-specific data where available
- Stakeholder process for development of future scenarios begins this summer
  - Engage regional stakeholders
  - Assess available data and fill gaps
  - Assess regional GHG mitigation actions

Anticipated Outcomes

- New England pilot project will help us to
  - Determine what data are readily available at state and regional level and what gaps must be filled
  - Prepare structures for handling regional model data
  - Test the model development and utilization process
  - Provide a working example of the value a regional model can offer

Evaluation and extension?

- Does the process work?
- How difficult is it to develop a state-level model from the national model?
- How valuable is it?
- How different are the results obtained from the regional model vs. a scaled-down national model?
- Should we extend it to other regions? How?

Project contact information

Have you worked with a regional model?
Have questions about our project?
We'd love to hear from you. Please contact:

Elizabeth Wilson
Wilson.Elizabeth@epa.gov
U.S. EPA Office of Research and Development
Mail Drop E-305-02
Research Triangle Park, NC 27711
1-919-541-1949

Two mini-talks

- U.S. EPA regional MARKAL project
  (contact: Elizabeth Wilson, U.S. EPA ORD)
- Modeling to Generate Alternatives (MGA)

Look beyond "optimal" solution!

- Un-modeled considerations are important
  - Other objectives; e.g., social and political desirability
  - Phenomena that MARKAL does not capture
- Alternatives w/ nearly the same cost and environmental performance typically exist

Alternatives

- Goal: Obtain manageable set of meaningful alternatives (7 or 8 alternatives)
- Manually identification is difficult & time-consuming

Modeling to Generate Alternatives (MGA)

- Method: Reformulate optimization problem

Decision variables: **x**

Min Cost = c*x

subject
to:

Model equations
Energy Balance

Constraints
Meet demands
b***x** < GHE limit

Decision variables: **x**

Min b*x

(where b = value of x in the least cost solution)

+value of x in Alternative 1

+value of x in Alternative 2

subject
to:

Model equations
Energy Balance

Constraints
Cost = c*x < 1.1* Previous cost
Meet demands
b*x < GHE limit

Alternative 3

Modeling to Generate Alternatives (MGA)

- Can quickly generate maximally different alternatives similar to modeled objectives
- Alternatives can serve as good starting points for series of additional runs

Plan

- Work with someone who knows the code well to add an MGA extension to MARKAL
- If interested, let me know harrison.kennethat@epa.gov.
- References:
  - Brill, E.D., S. Chang, and L.D. Hopkins. Modeling to generate alternatives: The HSJ approach and an illustration using a problem in land use planning. *Management Science*, vol. 28, no. 3, pp. 221-225. March 1982.
  - Brill, E.D., Jr, J.M. Flach, L.D. Hopkins and S. Ranjithan. MGA: A decision support system for complex, incompletely defined problems. *IEEE Transactions Systems, Man, and Cybernetics*. Vol. 20, No. 4, July/August 1990.

MGA

- True optimal solution likely lies in the "inferior" region

What if cost were only modeled objective?

Environment protection

Infeasible region

Inferior region

Cost reduction
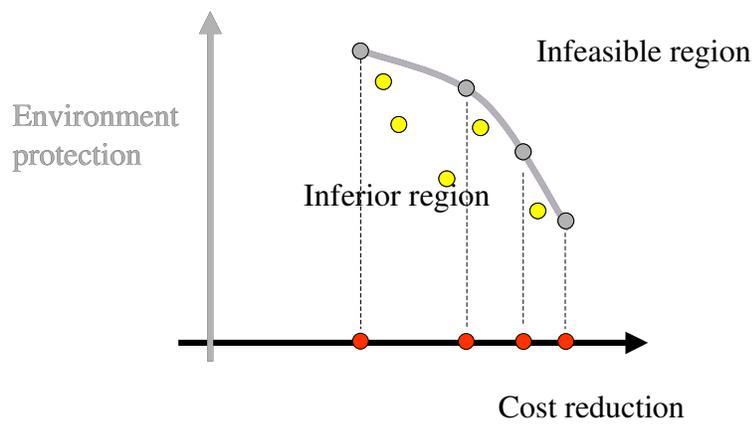
Modeling to Generate Alternatives (MGA)

- "Distinctly different choices of ... technologies for different [energy needs] are expected to lead to strategies with different characteristics that may perform differently with respect to different unmodeled criteria."

  – C. Anastasiou, August 5, 2002