Sustainable Transportation Energy Pathways (STEPS)

STEPS Lookback Analysis

December 9, 2015
STEPS Lookback Workshop

Julie Witcover, Ass’t Project Scientist
Lew Fulton, STEPS Co-Director
Alan Jenn, Postdoctoral Scholar
Rosa Dominguez-Faus, Postdoctoral Scholar

www.steps.ucdavis.edu
Project Overview

Big body of work

Many potential entrypoints

Objectives, methods, etc. for models and lookbacks

- Scenario types “forecasts,” “predictions,” “projections,” “storylines,” “policy what-ifs,” “how-to-hit-targets”
- Entrypoints outputs, scenario choice, input data (baseline data, embedded assumptions, behavioral parameters/elasticities), model structures

What can we add? Seek to...

- add clarity to communications on what {STEPS} models say
- derive lessons for improvement in light of real-world experience

- Step 1...
  - Learn from existing retrospective analyses (literature, in and outside STEPS)*
  - Scope out and classify models (publications, in and outside STEPS)
- Step 2...
  - How can we use the past to understand and improve modelling efforts (given stated objectives)?*
  - Case studies within STEPS*
- MAVRIC research thread tie-in (modeling comparison & robustness)
Day Overview

• Can we learn from others’ experiences with model evolution & retrospective analyses?
  – Motivation, approaches, insights and shortcomings, usefulness and prospects
  – Different model developers, users, objectives (academia, business, government, NGOs)

• Modeling team examples gateway for participation, discussion
  – a.m. lightning round models, interests, concerns
  – p.m. deep dive model evolution, retrospective analysis or prospects
  – participant-focused post-its!, exchanges are priority
  – throughout & after feedback, filled-out templates
Retrospective Analysis – what is it?

Resources for the Future projection (1960s, revisited 1980s)

Atomic Energy Commission (1963 report)

Source: *What can History Teach Us?...* (Craig et al 2002)
Retrospective Analysis – what is it good for?

Why?

Source: ...Plea for Retrospective Analysis (Koomey et al. 2003)

- Make models more useful at functions...track info, communicate, educate, bound or limit outcomes, aid thinking and hypothesizing, sell ideas
- Reinforce modesty
- Reveal biases, embedded assumptions e.g., benevolent v. malevolent hiding hand (Flyvberg & Sunstein 2015)
  - for model developers
  - for model users (understand & constructively critique)
- Uncover, explain uncertainties
A Flavor of Retrospective Analysis

• **Magnitude of Error.** EIA retrospectives (since 1996, mean absolute percent errors for key variables, reference scenario)
  
  – AEO lags macro trends assumption drag
  – Energy intensity overestimated, due to GDP underestimate (pre-2000), energy consumption overestimate (post-1998)

• **Reality outside stated confidence intervals** (Shlyakhter et al. 1994)

• **Decomposing errors**
  
  – Visible error = baseline + trend + variability (O’Neill & Desai 2005)
  – Directional consistency in errors by sector, time horizon (Fischer et al. 2009)

• **Explaining error**
  
  – EIA’s “asymmetric loss function” – as if cost 7 times higher to under- than overpredict energy intensity; “black box” GDP projections (Auffhammer 2007)
  – model inputs & structure by sector (Wilkerson et al. 2012)
  – backcasting runs to isolate impact of particular elements/modules (Huntington 1994)
Retrospectives - Topic Overview

**Motivations**
- Develop, evolve model
- Identify limits, domain
- Better understand, communicate
  - possible, actual, out-of-bounds
  - constructive feedback possible?*

**Uses**
- step-by-step improvement, blind spots*
- Retrospectives - Topic Overview

**Targets**
- Single component
  - outputs, inputs, scenarios, or structure
- Single modeling effort
  - may involve multiple models
- Single Topic
  - multiple modeling efforts

**Methods**
- “Error” analyses
  - define, measure error; describe or explain

**Insights/Drawbacks**
- Theoretical
  - model evaluation under ideal conditions
- Practical
  - team, resources ($, time), project motivation, model

---

simple complex

policy
Modeling overview

- We consider three “categories” of approaches to forward-looking modeling from *What Can History Teach Us?...* (Craig, Gadgil, Koomey 2002):
  - Trend based models—using past data to inform the future
  - Systems based models—disaggregation of a system into definable sectors that can be modeled, e.g., from the bottom-up
  - Expert elicitation—integration of specialized knowledge in the industry/field
Trend based models

- Incorporates any models relying on existing current/historical data to inform the future, e.g.
  - Straight line projections (bivariate)
  - Regression analysis (econometric approach, statistical predicted values)
Systems based models

- "Bottom-up" approaches
  - Understanding components: how they work and how they interact
  - Often disaggregation to end-uses
  - Can incorporate actual physical limitations
- Economic models
- Engineering models
- Models with multiple modules (incorporating economic, engineering, other system dynamics)
Mining capacity \rightarrow Steel production

Factory limits \rightarrow Worker productivity \rightarrow Vehicle production

Manufacturing technology
Expert elicitation

- Aggregation of the opinions of authorities on specific subjects
- Encompasses knowledge that is not readily accessible/distillable via other methods
- Useful in unknown/non-existent systems

Note: three approaches are not mutually exclusive (combined approaches)

- E.g., systems-based model with parameters from econometrics & expert knowledge
Applying retrospective analysis
Retrospective techniques

• From *Long-Range Energy Modeling: A Plea for Historical Retrospectives* (Koomey et al. 2003):
  • Disentangle input data issues from modeling issues (e.g., baseline data, exogenous trends, behavioral parameters/elasticities v. model structure, scenario choice, model objective)
  • Use historical decomposition techniques
  • Document everything
  • Identify and assess discontinuities
Mining capacity → Steel production → Vehicle production

Mining capacity → Manufacturing technology → Worker productivity → Vehicle production

Mining capacity → Factory limits
Mining capacity → Steel production → New Technological Process

Steel production → Worker productivity → Vehicle production

Worker productivity → Manufacturing technology

Manufacturing technology → Factory limits

Factory limits → Mining capacity
Potential Topics of Interest (entrypoints)

- Outcomes
- Inputs
- Structure
- Type (optimization, simulation, other)
- Purpose (predictive, policy analysis, etc.)
- Timeframe
- Uncertainty
- “Confidence Intervals”
- Scenario development
Lookback Analysis – Elements to consider

• **Modeling system**
  – simple/complex (implications for analysis, communications)
  – spatial issues
  – role in less-quantitative models

• **Practicalities**
  – model available or not
  – resources (team, time)
  – model longevity and ‘update’ frequency

• **Motivations & Methods**
  – Mistakes, small improvements v. blindspots
  – role for model comparisons
  – policy (for scenarios, to inform)
    • rising profile of policy lookbacks
Potential Topics of Interest (entrypoints)

- Outcomes
- Inputs
- Structure
- Type (optimization, simulation, other)
- Purpose (predictive, policy analysis, etc.)
- Timeframe
- Uncertainty
- “Confidence Intervals”
- Scenario development

Lookback Analysis – Elements to consider

- Modeling system
  - simple/complex (implications for analysis, communications)
  - spatial modeling issues
  - role in less-quantitative models
- Practicalities
  - model available or not
  - resources (team, time)
  - model longevity and ‘update’ frequency
- Motivations & Methods
  - mistakes v. blindspots
  - role for model comparisons
  - policy (in scenario development, potential use of output, rising profile of retrospective analysis of policy – including ex ante impact analysis)