

# THE EVALUATION AND DIAGNOSIS OF INTEGRATED ASSESSMENT MODELS

**RICHARD A. ROSEN  
TELLUS INSTITUTE**

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## EVALUATION MUST BE RELATIVE TO DEFINED GOALS

- What should be the goals of IAMs?
- 1. Assisting policy makers in mitigating climate change, while achieving other social goals. (A multi-objective problem with boundaries.)
- 2. Create interestingly different scenarios to achieve #1 above, which clearly illustrate the policy choices and decisions that are needed, and when. The substantial uncertainties inherent in the future earth system must be reflected in scenarios.
- 3. Illustrate trade-offs between key policy choices, where economic trade-offs are at most just one type.
- 4. Illustrate impacts on climate, water use, land-use, etc., of a wide variety of key input parameters that can “bend or break” past trends, including changes in values. For example, a future of very high fossil fuel prices is never considered even though fairly likely.

## What should not be the goals of IAMs?

- 1. Creating “accurate” reference case forecasts for the global economy. Forecasting for 50 years, or more, is impossible for complex systems.
- 2. Estimating the net costs of mitigating climate change. Since we can not forecast a reference case for the economy to any reasonable degree of accuracy, we can not know the net costs of mitigating climate change, contrary to the claims of many published papers. In fact, the net costs of mitigating climate change could be negative.
- 3. Producing accurate estimates of the future costs of new technologies, e.g. renewable energy technologies.
- 4. Producing spatially accurate estimates of greenhouse gas emissions sources, e.g. for small “grid squares”. This wastes computing time.

# MODEL EVALUATION AND DIAGNOSIS REQUIRES RESEARCH TRANSPARENCY

- 1. Most IAM documentation is poor in detail, and incomplete. There is a strong need for IAM teams, as scientists, to produce better documentation and not only focus on running the IAMs. This will help external reviewers better understand both the basis for the results of, and the validity from, the models.
- 2. For example, model structures (including all important equations) are not usually fully described. And how these equations were derived, or fitted to historical data, is never described. Finally, the data to which the equations were fitted is not generally made available to other scientists.
- 3. The numerical values for many key parameters and the coefficients for each equation, including economic production functions, are never presented. This seems to be true even in peer-reviewed papers – leading me to wonder what’s the point of peer review.

## EVALUATION AND DIAGNOSIS - continued

- 4. For example, an outside reviewer can not determine how the update to 2005 base year data has affected each IAM. I received no responses from the IAMC teams to my request for information as to changes to equations and/or coefficients. Nor can one determine if key cost and technology inputs were updated after 2005.
- 5. Even parameter values that are easy to provide, such as basic cost assumptions for technologies or fossil fuels, are often not even provided in model documentation or research articles.
- 6. Attempting to diagnose models by comparing the “same”, or similar, scenario outputs produced by different models, can not be done, if the key numerical input assumptions are not harmonized to the extent allowed for by differences in model structures. Therefore, many papers on model comparisons do not further one’s understanding of individual model strengths and weaknesses.

## RELEVANCE OF MODEL STRUCTURE TO POLICY MAKING AND SCENARIO CONSTRUCTION

- 1. Insufficient disaggregation implies one can not analyze many key policies for climate change mitigation, e.g. the role of energy efficiency improvements or mode shifting for transportation. All transportation modes, or all building types, can not be included in a single equation for the “transportation” sector or the “buildings” sector.
- 2. Even though economic analysis is stressed in most IAMs, they do not model the economics of investments in enhanced energy efficiency in competition with investments in energy supplies. (This fact alone makes the projections of the net costs of climate mitigation invalid.)
- 3. Current IAMs can not model shifts in the composition of the economy not reflected in past trends. Thus, the impact of changes in values, which lead to changes in consumption patterns, can not even be included in scenarios. Similarly, the dematerialization of the economy, as advocated by many, can not be modeled.

## RELEVANCE OF MODEL STRUCTURE - Continued

- 4. Most IAMs still do not model the impact of diet on the mix of agricultural products, and, therefore, on land-use patterns and carbon emissions from land. To model diet one needs to model all basic agricultural products, and their land and water requirements. This limits the policy relevance of most existing IAMs.
- 5. Model structures must, in general, allow different new technologies on the demand side within industries to penetrate the market at different rates in different scenarios.
- 6. Most importantly, since most IAMs optimize on cost or utility or some similar economic parameter, they can not readily achieve multiple social goals in addition to reaching climate change targets.

# OPTIMIZATION vs. SIMULATION vs. BACKCASTING

- 1. If one wants to forecast the future, one would need a simulation model, not one which optimizes on cost or utility, nor one which backcasts. But, again, IAMs should not attempt to forecast.
- 2. Since most IAMs optimize on cost, or reach equilibrium on prices, the scenarios they produce may be unrealistic for the purpose of developing real world policy guidance. This is especially true since the initial state modeled is not close to being optimal.
- 3. Backcasting from the future achievement of multiple social goals simultaneously is a useful methodology that should be more widespread. Note that achieving a scenario like the RCP 2.6 necessarily involved backcasting from the radiative forcing level specified in 2100.



# SUGGESTIONS AND CONCLUSIONS

- 1. Making substantial changes to the structure of IAMs used for future climate assessments is necessary to make the models more policy relevant.
- 2. New versions of IAMs must allow for a greater variety of scenarios reflecting system uncertainty, especially those which allow for dramatically different trends relative to the past for many key input assumptions and results. Continuity with past trends will not likely allow society to reach most, if any, of its social goals.
- 3. When conclusions regarding mitigating climate change are stated in papers and reports, all authors must clearly state the major assumptions under which those conclusions hold and do not hold, given the inherent limitations in the IAMs from which the conclusions are developed. Otherwise, the policy making process could end up being based on unfortunate misunderstandings.

# CONCLUSIONS - Continued

- 4. More dis-aggregated IAMs, that do not optimize on economic parameters, are often more policy relevant for mitigating climate change. This is, in part, because they can more easily be used to backcast from the achievement of multiple social goals in the future. In addition, important policies leading to shifts in demand within and between sub-sectors of the economy can be better represented.
- 5. It is essential for proper IAM evaluation, validation, and diagnosis to have more comprehensive and complete documentation of each IAM available to the scientific community. Research articles and reports also ought to contain all key numerical assumptions for each scenario run for appropriate peer review.