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Using Models in Energy Policymaking

Computer models use mathematical representations of real world systems to gain insights into complex processes, linkages between elements in a system, and how changes to a system might affect outcomes. Such models have become commonplace in many spheres of activity, including energy policymaking. Models are simplified representations of the real world. Simplification—along with bias, outdated and inaccurate assumptions, and other factors—can limit a model's accuracy. Accordingly, models are frequently revised to improve their predictive accuracy. Well-honed models may provide useful insights for policymakers.

This analysis provides an overview of energy system models and considerations for how Members of Congress might use models to inform their policy positions. Examples from past policy debates are included.

Overview of Energy System Models

Energy system models estimate energy supply, demand, prices, and related factors over defined time periods. Energy system models are not one-size-fits-all decisionmaking tools. Model developers design models to address different questions. Additionally, model design choices represent a trade-off between complexity, speed, and cost.

The federal government supports some energy system models, including the Department of Energy National Energy Modeling System (NEMS) maintained by the U.S. Energy Information Administration (EIA). Data and computer code associated with federally-supported models are generally available for free to the public. Private companies, academic researchers, policy advocates, and others also develop and maintain models. Some of these modelers may provide some data or code to the public, but they often limit access.

Model Design Elements

Many models currently used in energy policymaking are energy economic models that seek economic optimization. This occurs when the supply of energy goods and services exactly fulfills demand, taking into account the cost of producing energy goods and services and what consumers are willing to pay for them. Factors that are difficult to assign a dollar value to (e.g., health impacts of pollution) may be difficult for energy economic models to assess.

Models vary in the amount of detail they provide, known as their resolution. Models have different time, or temporal, resolution. For example, they might cover changes over hours, months, or years. Many models intended to support policymaking examine the energy system over two or three decades. Models also have different spatial resolution. For example, they might cover changes within individual energy facilities, states, or countries.

Model resolution is typically "hard-wired" into the mathematical equations that comprise the model and the computer code that solves those equations. Increasing model resolution to provide greater levels of temporal or spatial detail frequently requires rewriting the underlying computer code, a time-intensive process that may also require additional computing resources. Decreasing the resolution to provide less detail, however, tends to be less burdensome. Many energy system model outputs are reported in aggregated form (i.e., with less resolution). For example, a model might estimate monthly values but a summary report might only provide annual values.

Models require inputs in the form of numerical data at a resolution that generally matches the model. For example, if a model is built to provide monthly estimates, the input data should have at least monthly values. Weekly or daily values could also serve as inputs, but typically such data would be aggregated first. Likewise, if a model is built to provide state-level estimates, national-level input data would often be insufficient. Inputs typically include historical data about energy systems and related factors.

Models include both exogenous (outside the model) and endogenous (inside the model) factors. Exogenous variables are provided as input to a model and may include key drivers of an energy system (e.g., economic activity, population), specific energy system developments (e.g., future energy prices), or relationships between variables. Endogenous factors in an energy system are determined by solving the mathematical equations that comprise the model.

Energy system models vary in the extent to which they rely on exogenous variables. A greater reliance typically allows for cheaper and faster models with greater transparency. However, a large reliance on exogenous variables can also increase the extent to which model results are biased by modelers' assumptions, potentially reducing the utility of the model.

Interpreting Model Results

The U.S. energy system is large and complex. Thousands of energy producers interact with millions of consumers in ways shaped by market forces, policies, and other factors. Models contain mathematical equations that try to capture the cause-and-effect relationship between parts of the energy system. Accordingly, models can help identify the sometimes counterintuitive effects that changes in one part of an energy system can cause in another.

In other words, models can follow causal relationships throughout an energy system to identify potential outcomes. Other forms of analysis sometimes attribute effects to the wrong causes. This often occurs when events or trends are merely correlated (i.e., they occur at the same time or are driven by the same factors) but are incorrectly believed to have a causal relationship.

Models can also provide insight into potential policy outcomes by allowing for "experimentation" which may not be possible or desirable in the real world. For example, by varying input parameters, models can help inform decisionmaking by modeling outcomes resulting from policy choices.

While models attempt to predict the future, their results are inherently uncertain. Experience has shown that models can be, and frequently are, wrong due to changing developments in energy markets and the broader economy, as well as other factors. To some extent, modelers can improve the predictive accuracy of models (i.e., reduce the difference between model forecasts and actual outcomes) by increasing their complexity. Many sources of uncertainty, though, are hard to eliminate. In addition, model results can be very sensitive to their underlying data and assumptions. Inaccuracies or biases in model input data, as well as inconsistencies or mistakes in the computer code, can negatively affect model results.

The complexity and data-intensive nature of energy system models can limit their transparency to policymakers and the public, especially regarding input data and assumptions. A key point for policymakers is that understanding model assumptions is often critical to interpreting the results.

An oft-cited guidance for using models for policymaking is "modeling is for insights, not numbers." This saying summarizes the idea that there is inherent uncertainty in modeling, and that models are often more useful in identifying trends than for making specific predictions.

Selected Examples

As noted above, models can be useful to policymakers by identifying trends and by estimating policy outcomes before policies are implemented. The following examples demonstrate how models can inform policy debate.

As part of the Energy Policy Act of 2005 (P.L. 109-58), Congress reauthorized a research program in methane hydrates, a potential source of natural gas. Congress included in the law a finding that "a shortfall in natural gas supply from conventional and unconventional sources is expected to occur in or about 2020." (U.S.C. 30 §2001) In this case, models identified dual trends of increasing U.S. natural gas consumption and decreasing U.S. natural gas production. The expectation of a natural gas shortage, based on model projections, contributed to Congress's policy decision to support research into a new source of natural gas. In this case, the projection was unable to predict a systemic shift in U.S. natural gas supply due to advances in hydraulic fracturing and related practices that would occur in the following few years.

As part of the Consolidated Appropriations Act, 2016 (P.L. 114-113), Congress repealed a prohibition on most crude oil exports that had stood since 1975. A focus of the debate was the effect that removing the ban would have on prices for consumer goods such as gasoline. Modeling efforts helped address some of these questions. Many models determined that repealing the ban would likely have little or no effect on gasoline prices.

Considerations for Congressional Use of Models

Models are increasingly common, but they are just one of many decisionmaking tools available to Members of Congress. Other tools, such as stakeholder engagement, might be better suited to identify some policy outcomes of congressional interest. For example, a model might identify an energy sector that is likely to experience a large growth or decline, but stakeholder engagement might identify the possible impacts of that trend within a congressional district. Members of Congress might choose to what extent they wish to base policy choices on model results, and how models might complement other decisionmaking tools.

The U.S. energy system is changing. In some cases, data collection may lag industry developments, such as new ways to produce and transport fuels or new forms of electricity generation and storage. Models require relevant data to accurately represent such industry changes.

Several organizations conduct model analysis by congressional request. EIA is one of these. Past examples of congressional requests for EIA model analysis include repealing the crude oil export ban, federal regulation of greenhouse gas emissions, and extending a production tax credit for wind generators. EIA's models do not address all potential areas of interest in energy policy. EIA's models are designed to provide estimates of the price and quantity of energy goods and services. EIA's models do not estimate changes in employment associated with policy proposals or estimate all environmental impacts.

In addition, other types of models (i.e., other than energy system models) might be relevant to congressional debate on energy policies. For example, integrated assessment models examine the combined economic and environmental outcomes associated with different policies. Such models are often used in debates about greenhouse gas emissions and climate change impacts. Macroeconometric models, such as those used by the Congressional Budget Office, examine macroeconomic factors like employment, wages, and inflation rates. Such models are often used in debates about energy tax policy and policies to promote energy sector employment.

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