ICF CONSULTING

Modeling Renewable Portfolio Standards and Demand Response or Energy Efficiency

Using the Integrated Planning Model (IPM™)

Summary

Policymakers have become increasingly interested in encouraging investments in renewable energy through the use of renewable portfolio standards (RPS). Several states have included RPS requirements in their restructuring rulemaking. Legislative proposals in Congress have included standards that require a minimum share of the electricity sales from renewable resources. These proposals sometimes come in concert with other environmental regulations and in the context of deregulated electricity markets.

Policymakers seeking to design optimal market structures for spurring investments in renewable energy must take into account both the incentives of deregulated electricity producers and a retail market structure base capable of responding more rapidly to consumer preferences. ICF Consulting's Integrated Planning Model™ (IPM™) provides policymakers the analytical framework for examining the impacts of renewable mandates and shifting consumer preferences, in isolation and/or in conjunction with other market or regulatory changes.

The Integrated Planning Model™

ICF Consulting's IPM™ is a well-established electric and industrial boiler sectors model that has been used for a wide range of applications by government and industry. The model represents and simulates economic activities in key components of energy markets – fuel markets, emission markets, capacity markets, electric and energy markets. Since the model captures the linkages in electricity markets, it is well suited for developing integrated analyses of the impacts of alternative regulatory policies, including renewable portfolio standards. IPM™ can be used to model electric power market issues for regional power markets, or for the contiguous United States. In the past, applications of IPM™ have included capacity planning, environmental policy analysis and compliance planning, wholesale price forecasting, and asset valuation.

IPM™ is a dynamic linear programming model with a perfect-foresight feature. It determines the least-cost method of meeting energy and peak demand requirements over a specified period (e.g. 2001 to 2030). In its solution, the model can consider any number of operating or regulatory constraints (e.g. emission limits, transmission capabilities, renewable generation requirements, fuel market constraints) that are placed on the power system. In particular, the model is well suited to consider complex treatment of emission regulations with trading, banking, command & control and progressive flow control.

ICF Consulting's Integrated Planning Model (IPM™) models twenty-one or more U.S. electric power markets. These regions correspond in most cases to the regions and sub-regions constituting the North American Electric Reliability Council (NERC) regions. IPM™ models the electric demand, generation, transmission, and distribution within each region as well as the inter-regional transmission grid. All existing utility power generation units, including renewable resources are modeled, as well as independent power producers and cogeneration facilities that sell electricity to the grid.

IPM™ also contains detailed representation of new power plant options, including fossil generating options (coal steam, gas-fired simple cycle combustion turbines and combined cycles) and renewable resources. Renewable resource options include wind resources, geothermal, solar thermal, solar photovoltaic resources and biomass.

Gas, coal and biomass fuel markets are modeled endogenously in IPM™. Coal supply is represented by 40 coal supply regions and over 15 coal types. Coal plants are assigned to coal demand regions identified delivery modes including barge, rail and truck. Natural gas markets are similarly represented in the model with a natural gas supply curve, a transportation matrix, and seasonal price adjustments. Biomass fuel markets are represented by regional biomass supply curves.

IPM™ provides estimates of air emission changes, regional energy and capacity prices, incremental electric power system costs, changes in fuel use, and capacity and dispatch projections.

Modeling Renewable Portfolio Standards

In IPM™ renewable portfolio standards are modeled as regulatory constraints on the power system and can simulate the incentive structure in electricity markets taking into account the geographic scope, time period and nature of the RPS requirement. IPM™ will provide a detailed representation of the impact of the RPS regulation on electric power system, emission levels and fuel markets.

In deregulated markets the incentive structure of existing and potential electric power producers shapes the tradeoffs between technologies and determines the selection of capacity and generation. These incentives are not only influenced by the nature of the RPS regulation, but also depends on the timing of the regulation, the geographic scope and relationship to other existing or potential regulations or changes.

IPM™ is capable of engaging the complex set of interactions in analyzing the impact of renewable portfolio standards. The model will simulate the incentives faced by existing and potential power producers that will drive the projections on outcome of the policy.

- Since IPM™ is a multi-region model, it is capable of handling RPS defined at the regional level or national level. State level policies may be simulated as well with some limiting assumptions. IPM™ captures inter regional linkages and will simulate the broader regional impacts on any renewable portfolio standards.
- Since IPM™ is a dynamic model, it will simulate inter-temporal tradeoffs and decisions. The model is capable of handling changing RPS requirements over time.
- Since IPM™ can handle multiple regulatory requirements, it will be able to capture the interactions between RPS and other regulations.
- IPM™ can capture the implication of differences in investment risk that may be caused by a regulation.
- Since fuel markets are endogenous to IPM™, the model can capture the impacts on fuel markets and fuel prices.

IPM™ outputs, at the regional or national level will contain detailed representation of the penetration of renewable electricity generating technologies. The model will also contain projection of air emission (NO_x, SO_2, mercury and carbon), energy prices, capacity prices, fuel consumption, fuel prices, capacity mix and pollution control decisions.

IPM™ contains detailed representation of renewable resource electricity generating options. These currently include solar (photovoltaic and thermal), wind, electricity generated from landfill gas, geothermal, fuel cells and biomass. Resource base constraints are explicitly taken into account by limiting the potential capacity for each technology by region. IPM™ appropriately captures the intermittent nature of some renewable technologies, like solar and wind with generation profiles that approximate the capability to generate in any given hour of the year, including the peak hours.

Modeling Demand Response

In the past, modeling the effects of regulations and policies on the demand for electricity was of secondary importance, due to the small magnitude of the effects of these regulations and policies on costs and the muting effects of electricity regulation on the passthrough of costs to consumer prices. The spread of price competition and the need to model national, regional and state level actions affecting multiple pollutants and other energy policies such as renewable portfolio standards, however, has raised the importance of demand impact modeling.

ICF has developed several ways to address the issue of demand response to price. First, IPM™ is capable of explicitly modeling end-use energy efficiency investments. Each technology (e.g., lighting) or program (e.g., load control) is characterized in terms of load shape impact, program or equipment costs, and administrative costs, etc. Penetration curves reflecting the market potential for a technology or program is also required. End-use energy efficiency is evaluated alongside supply-side options in meeting demand. As supply side resources become more constrained or expensive (e.g., due to environmental regulation) more energy efficiency resources are used.

In response to the increased importance of this issue in the context of deregulation, ICF has developed a method for assessing the impacts of cost increases and changing pricing structures on consumer prices and demands. Cost increases could be a result of deregulation, or specific environmental or other policies. This method is based upon an enhanced version of IPM™, referred to as Deregulated Retail Market IPM (with an acronym of DR-IPM). DRIPM includes a "post-processor" for IPM™ results that calculates retail prices based on wholesale energy prices, embedded generation costs, T&D costs, etc., and assumptions on the degree of competition and stranded cost recovery. It calculates the effects of cost increases (for energy and capacity) on retail prices, and uses these price changes along with price elasticity estimates to calculate changes in electricity demand. In an iterative process, these adjusted demands are then fed back into IPM™ to re-estimate the supply cost increases, and the readjusted cost increases are then used to revise the price and demand estimates. This continues until the global equilibrium between supply and demand is reached in all years, regions and segments of the load duration curves. DR-IPM also has an algorithm that calculates endogenously regional reserve margins based on a loss-of-load probability formulation and customer willingness-to-pay assumptions.

ICF is also developing a methodology for capturing some of the same effects without the need to iterate around multiple IPM™ runs using DRIPM. This approach redefines IPM's™ objective function in a simple way to maximize the net benefit of generating and using electricity, instead of minimizing the cost of meeting a given demand. To implement this change, we have defined a curve expressing the marginal benefits that consumers receive from consuming electricity at various levels – in other words, we have added a demand curve to IPM™.

Each of these approaches requires differing levels of effort and, more importantly, data in order to implement. Each is useful for different types of analysis. The first method allows a detailed assessment of technology- or program-based energy efficiency potential. The second is very useful for assessing changes in price signals (e.g., average pricing to marginal cost-based pricing) and time of use differentiated pricing, and also for assessing impacts of price signals and technology choice on reserve margins. The final approach is in affect a simplification of the second approach and is attractive because of its simplicity and transparency. The latter two approaches require assumptions on price elasticity of demand.

Any of these approaches could be used to answer a range of questions in support of policy analysis and debate. For example, the DRIPM approach would capture the costs (or benefits) of renewable resources on reserve margin requirements or capacity prices (due to their intermittent nature and smaller size). IPM™ will in all cases capture the unique impacts of all energy efficiency and renewable resources, given the units characteristics – specifically there specific load shape impacts or energy patterns, and their unique contribution at time of peak.

Further Information

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