# Integrated Planning Model (IPM®) Overview

September 2010

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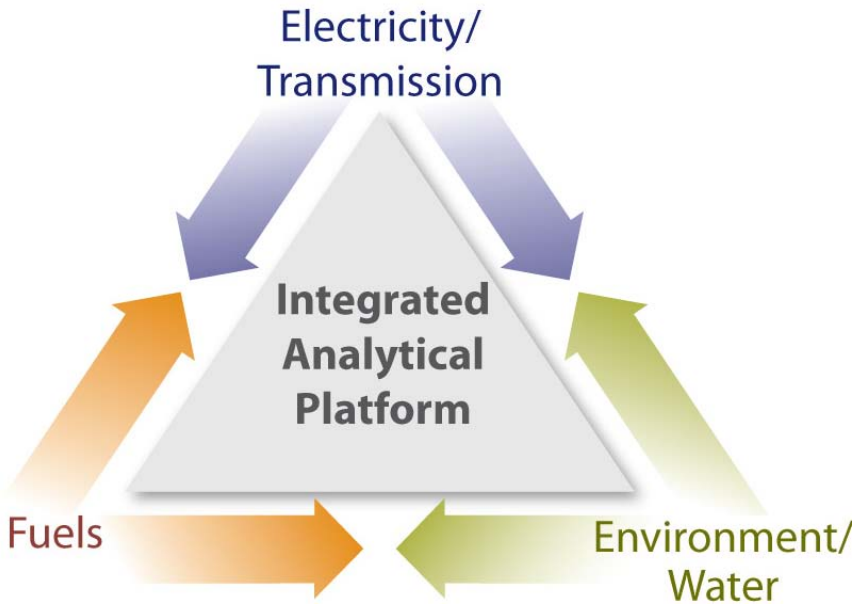
# The Role of Fundamentals-Based Power Market Analysis

- The goal of power market analysis is to develop a projection of market energy, allowance and fuel prices that will inform decision makers.
- The expected lifetimes of most investments in the power sector require that a forecast cover 20 to 30 years into the future to be useful. That time horizon requires that interested parties make assumptions about many drivers of power markets.
- ICF's Integrated Planning Model (IPM®) provides an integrated, fundamentals-based analysis to generate from those assumptions an internally consistent forecast of power market behavior.

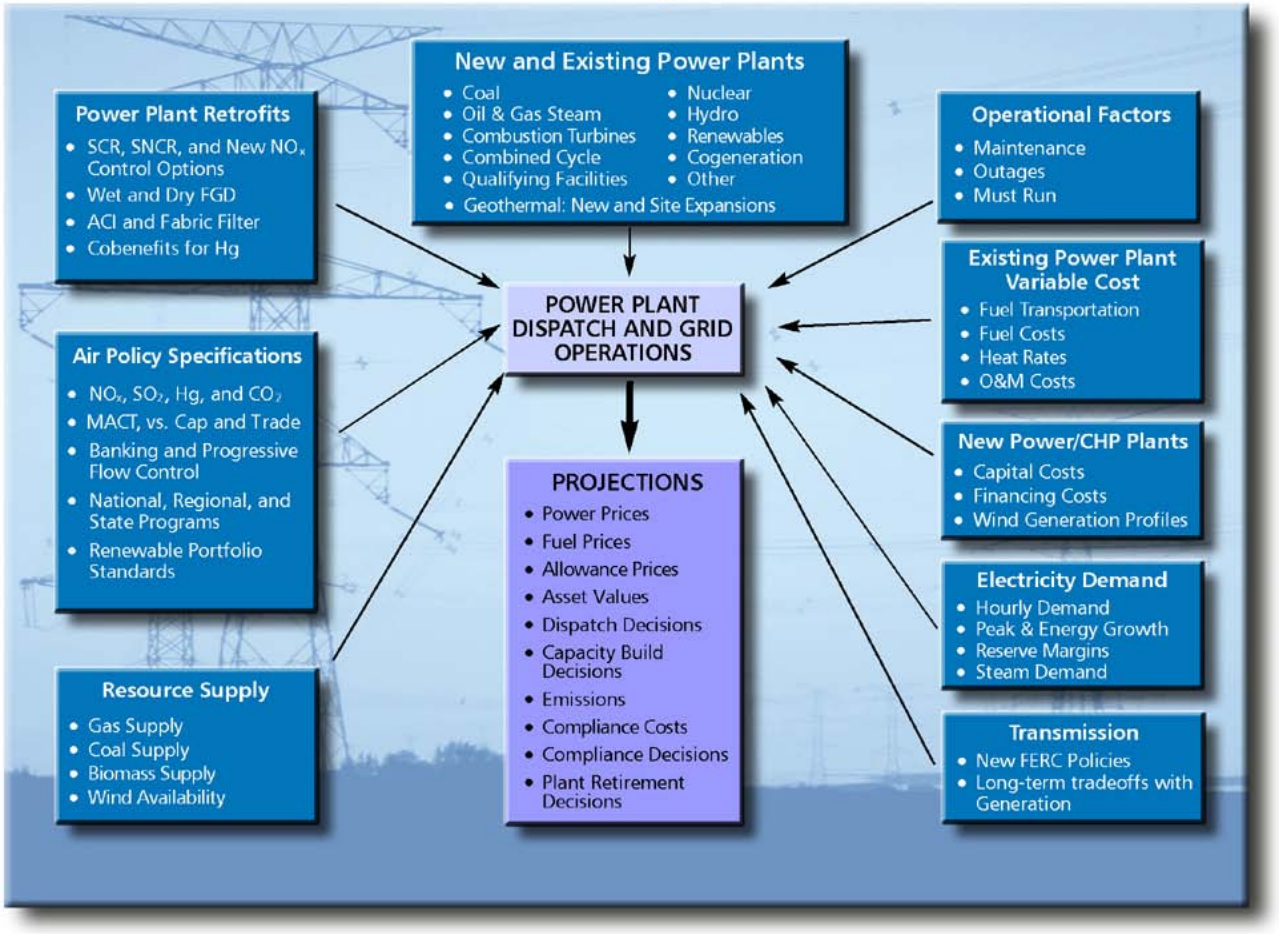


# Analytic Approach Using IPM®

- IPM® is a production cost simulation model focused on analyzing wholesale power markets and assessing environmental compliance and competitive market prices of electrical energy based on an analysis of the fundamentals relating to supply and demand.
- All major factors affecting wholesale electricity prices are covered in the model, including detailed modeling of existing and planned units, coal and gas markets, environmental compliance and allowance prices, and operating constraints.
- The model projects plant generation levels, new power plant construction, fuel consumption, and inter-regional transmission flows using a linear programming optimization routine with dynamic effects (i.e., it looks ahead at future years and simultaneously evaluates decisions over specified years).
- IPM® also determines the least-cost means of meeting the environmental regulatory requirements, such as $CO_2$ emissions caps, and forecasts allowance prices for each cap and trade market and compliance costs, unit dispatch, and retrofit decisions for each boiler and generator.
- Based on looking at the supply/demand balance in the context of the various factors discussed above, IPM® projects the spot price of electric energy in each model region. IPM® also projects the annual "pure" capacity price.
- The figure on the following slide shows the key inputs and outputs of IPM®.
  - The blue boxes on the top and sides of the diagram list the primary inputs.
  - The box in the bottom-middle lists the key model projections.

# IPM® Analytic Framework

## IPM® Modeling Structure



# The Challenge of Modeling Future Power Sector Behavior

- Modeling is extremely useful in determining directionality and cause and effect.
- Modeling serves the need to address inherently uncertain issues that have definitive impacts on the future operation of the power system
- No one model projection is going to be “right” because no one has a crystal ball regarding many of the key underlying issues
- Through sensitivity analysis, key points of uncertainty can be examined to bound the analysis.

# IPM® Model Region Representation

- ICF uses a national version of IPM® specifically designed for simulating the effect of environmental regulations in the electricity sector.
- ICF divides regions based on known transmission bottlenecks (i.e., sub-regions in which spot prices are expected to diverge significantly).
  - IPM® currently includes over 110 regions in North America.
- All IPM® regions have a representation of the electric transmission system that connects them to neighboring regions. The inter-regional transmission connections allow for the transfer of both capacity and energy and for broad price equilibration when transmission capacity is available.

# Demand in IPM®

- Demand is represented in IPM® by a combination of the following variables:
  - **Model Demand Regions** – The geographic level at which demand and supply are equilibrated to determine dispatch and prices. Each demand region acts as a power pool with a supply stack of units and a market clearing price.
  - **Peak Demand** – The maximum power load (MW) requirement for a demand region, defined by the top Demand Segment of each Season.
  - **Energy Demand** – The total energy requirement (MWh) for a demand region, defined annually.
  - **Hourly Load Profiles** – The 24-hour shape of demand level, defined for 8760 hours of a base year, for each demand region, scaled to meet peak and energy demand. Hourly load files are created from the historical load data filed by each region's utilities for a weather normal year.
  - **Seasons and Segments** – IPM® maps annual demand, defined by hourly load profiles scaled to peak and energy demand, then breaks it into seasonal loads, defined by month. Seasonal load is further subdivided by segment. IPM® creates a dispatch stack and solves for the market clearing-price for each segment of each season in each region for each year.

# Supply in IPM®

- Supply in IPM® is defined by a combination of the following variables:
  - **Existing Capacity** – The amount of MW generating capacity currently available to the grid.
  - **Unit Types, and Characteristics** – The classification of different generator types by fuel use, heat rate, operating costs, availability, environmental performance, and so on.
  - **Firmly Planned and Potential Capacity** – The two options for brining new capacity to the system within the model.
  - **New Build Cost and Performance** – The specifications for new potential capacity types, including assumptions about technology improvement over time.
  - **Financing** – The financial backing a new power project can support, based on equity costs, book life, tax rates, debt to equity ratios, and so on.
  - **Renewable Power** – Renewable power generators, along with special specifications for their costs and operational characteristics.
  - **Transmission** – The representation of the transmission system linkages, costs, line losses in IPM®.