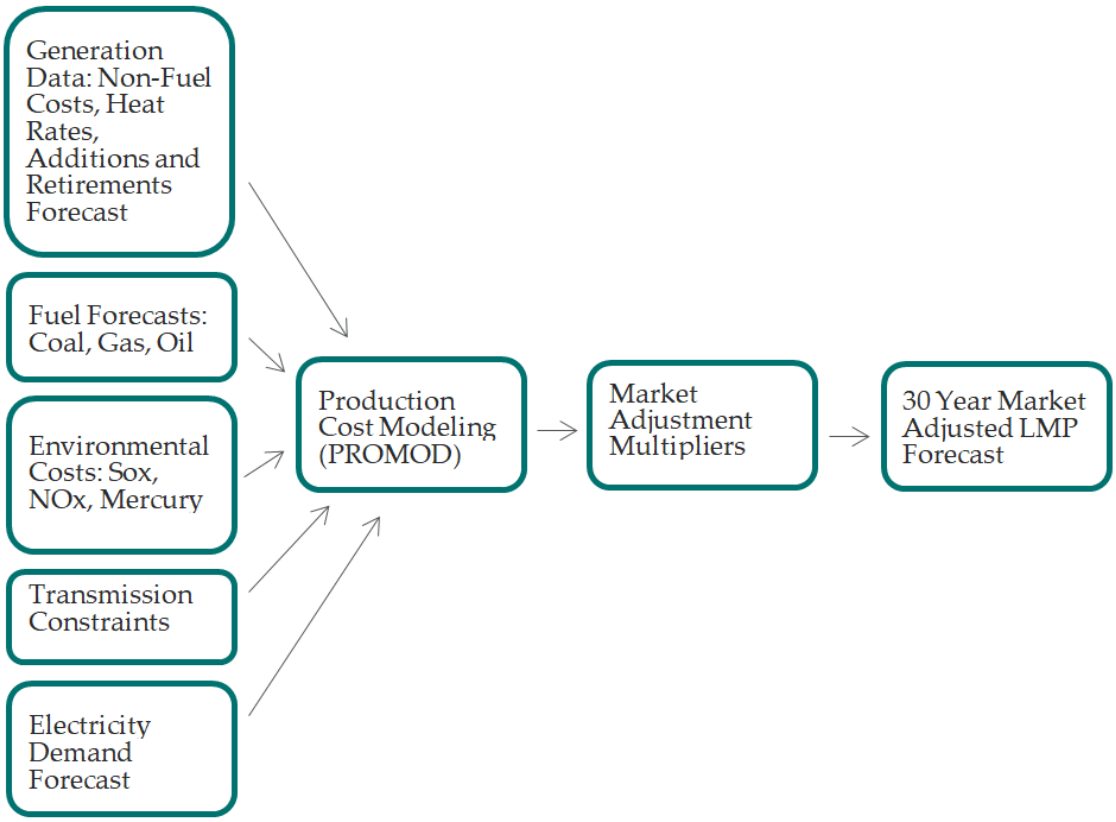
30 Year LMP Forecast Methodology



Overview

Navigant produces a 30-Year hourly LMP forecast for all major hubs, zones, and pricing points using the production cost modeling software, PROMOD. The inputs for this model are listed above and include plant operating parameters (heat rates, minimum up/down times, ramp rates, start times), non-fuel costs, fuel costs, environmental cost forecasts, transmission constraints, and demand and energy forecasts, as depicted above. The model also incorporates Navigant's proprietary capacity expansion plan for both transmission and generation and utilizes Navigant's fully integrated natural gas price forecast.

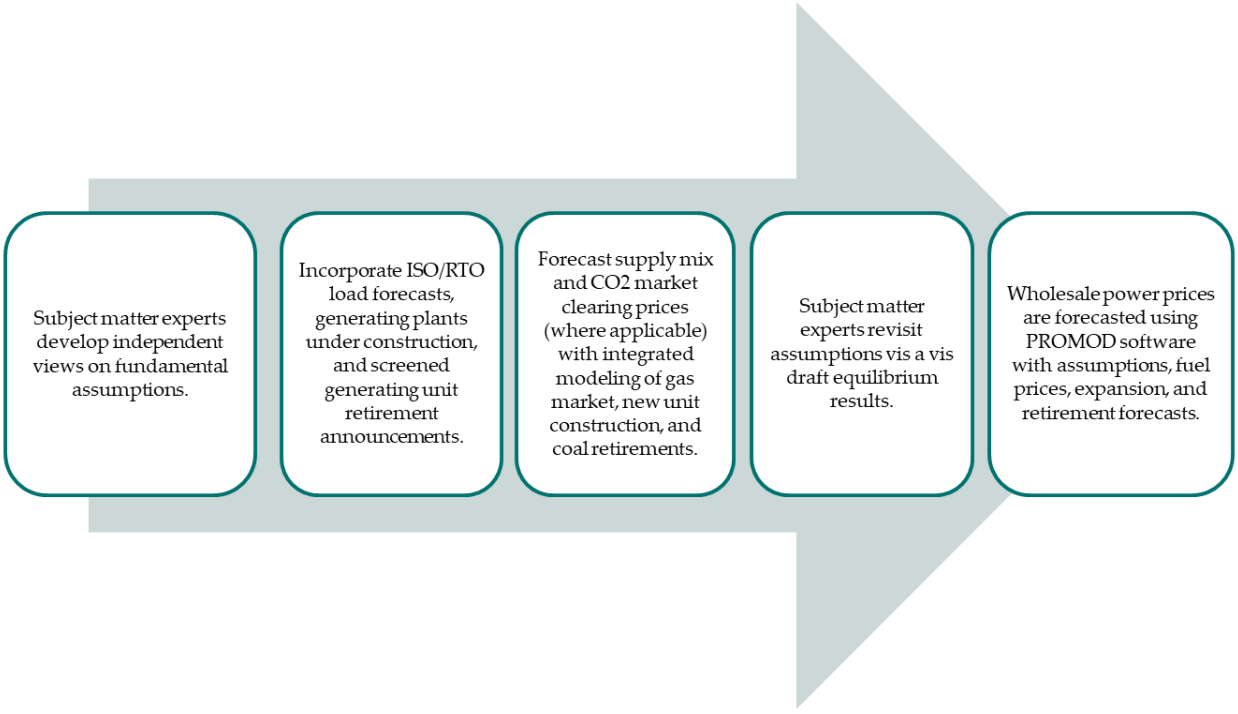
The initial structural forecast produced by PROMOD represents prices under conditions of perfect foresight about market conditions. They lack price volatility stemming from fuel price, emissions price and demand volatility, as well as deviations in market bidding away from marginal cost bidding. To account for this, Navigant performs back casts for previous years where actual historical inputs (demand, fuel prices, etc…) are run through PROMOD to get back casts for those years. Those back cast prices are then compared to actual historical prices, and forecast prices are adjusted based on those differences.

Navigant runs the model at the nodal level with a full transmission representation. These nodal hourly prices are then aggregated into the monthly and annual prices in this forecast.

A diagram showing Navigant's energy market forecast methodology can be seen below, along with a detailed methodology explanation.

Generator New Build and Retirement Forecast

After our subject matter experts provide input on fundamental assumptions and ISO/RTO load forecasts, and planned additions and announced retirements are incorporated, a proprietary linear optimization model developed by Navigant called the Portfolio Optimization Model (POM) is used to forecast long-term capacity expansion. POM simulates economic investment decisions and power plant dispatch on a zonal basis subject to capital costs, reserve margin planning requirements, RPS, fuel costs, fixed and variable operations and maintenance costs, emissions allowance costs, and zonal transmission interface limits. This model incorporates the same generation base, demand forecasts, fuel prices, other operating costs, and plant parameters that are utilized throughout the market simulation modeling process. The model simultaneously performs least-cost optimization of the electric power system expansion and dispatch in multi-decade time horizons. POM can perform multivariate optimization, which can consider value propositions other than cost minimization, such as sustainability, technological innovation, or impacts on other sectors, such as natural gas.



Fuel Cost Forecast

Navigant also uses GPCM, a commercial linear-programming model of the North American gas marketplace and infrastructure, to develop our Reference Case Gas Price Forecast. Navigant applies its own analysis to provide macroeconomic outlook and natural gas supply and demand data for the model, including infrastructure additions and configurations, and its own supply and demand elasticity assumptions. Forecasts are based upon the breadth of Navigant's view, insight, and detailed knowledge of the US and Canadian natural gas markets. Adjustments are made to the model to reflect accurate infrastructure operating capability and the rapidly changing market environment regarding economic growth rates, energy prices, gas production growth levels, demand by sector and natural gas pipeline, storage, and LNG terminal system additions and expansions. To capture current expectations for the gas market, this long-term monthly forecast is combined with near-term New York Mercantile Exchange average forward prices for the first two years of the forecast.

Production Cost Modeling

Once the POM forecast of generation expansion and applicable CO2 market clearing prices and the GPCM forecast of gas prices are complete, Navigant uses PROMOD, a commercially-available software, to develop its wholesale energy market price and plant performance forecasts. PROMOD is a detailed energy production cost model that simulates hourly chronological operation of generation and transmission resources on a nodal basis in wholesale electric markets. PROMOD dispatches generating resources to match hourly electricity demand, dispatching the least expensive generation first. The choice of generation is determined by the generator's total variable cost given operating constraints such as ramp rates (for fossil resources) or water availability (for hydraulic resources), and transmission constraints. The total variable cost of the marginally dispatched unit in each hour sets the hourly market clearing price. All generators in the same market area that are selected to run receive the same hourly market clearing price adjusted for losses and congestion, regardless of their actual costs. The LMP's produced by PROMOD compose Navigant's structural market price forecasts. Navigant does not employ bid-adders or other exogenous adjustments to prices in the PROMOD forecast.

Within PROMOD, production costs are calculated based upon heat rate, fuel cost, and other operating costs, expressed as a function of output. Physical operating limits related to expected maintenance and forced outage, start-up, unit ramping, minimum up time and downtime, and other characteristics are factored into the simulation. Supply offer prices are simulated for each unit within PROMOD that correspond to the minimum price the unit owner is willing to accept to operate the unit. For most generation resources, offer prices are composed primarily of incremental production costs. Incremental production cost is calculated as each unit's fuel price multiplied by the incremental heat rate, plus variable operations, emissions, and variable maintenance costs.

Where relevant (primarily for thermal units), the unit offer price also incorporates the unit's start-up and no-load costs. The start cost component includes fuel costs and other operating costs encountered in starting the generating unit, beyond those reflected in the heat rate and variable operating cost assumptions. The no-load cost reflects the difference between average and incremental fuel costs for generating stations that are dispatched at less than full output.

PROMOD has several distinguishing features that qualify it for application in electric power forecasting and related studies. These features include the following:

- Individual transmission line modeling
- Detailed and flexible unit commitment and dispatch modeling
- Modeling of operational transmission constraints (e.g., operating nomograms)
- Calculation of security-constrained dispatch schedules
- Hourly modeling of loads and resource operation

Volatility Adders

When preparing market price forecasts, Navigant first forecasts a fundamental, or structural, hourly energy price series for the applicable node or zone using PROMOD. Structural prices represent expected day-ahead market clearing prices under conditions of perfect foresight about load, generator and transmission availability, and fuel costs. As such, they lack information about additional price volatility in the market that can stem from intra-month volatility in fuel and emissions prices, stochastic variations in demand, and deviations of market bidding away from marginal cost bidding. In order to account for this missing volatility and any model error, Navigant incorporates adjustment factors to correlate power price

volatility from simulated ex post “backcasts” in PROMOD with historical volatility experienced in the market. Using benchmarks derived from historical data for a rolling three-year period, the PROMOD hourly price forecasts are adjusted to account for the relative difference between actual market prices and PROMOD’s (simulated) prices by season and time period. The actual prices and the simulated prices are grouped and averaged in 18 time blocks differentiated by season (summer, winter, shoulder) and time-of-day (4 hour blocks corresponding to off-peak and peak periods). After eliminating historical price spikes deemed to be unpredictable (two standard deviations outside the time-block average), time-block ratios of actual prices to simulated prices are used to adjust the PROMOD forecast to produce Navigant’s Reference Case Energy Price forecast.