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Product Overview

Promod IV Technical Overview

Promod IV® is the premier integrated electric generation and transmission market simulation system.

Introduction

Promod IV is recognized in the industry for its flexibility and breadth of technical capability, incorporating extensive details in generating unit operating characteristics and constraints, transmission grid topology and constraints, generation analysis, unit commitment/operating conditions, and market system operations.

For 30 years, energy firms have been using Promod IV for a variety of applications that include locational marginal price (LMP) forecasting, financial transmission right (FTR) valuation, environmental analysis, asset valuations (generation and transmission), transmission congestion analysis, and purchased power agreement evaluations.

Promod IV provides valuable information on the dynamics of the marketplace through its ability to determine the effects of transmission congestion, fuel costs, generator availability, bidding behavior, and load growth on market prices. Promod IV performs an 8760-hour commitment and dispatch recognizing both generation and transmission impacts at the nodal level. Promod IV forecasts hourly energy and congestion and loss prices, unit generation, revenues and fuel consumption, external market transactions, transmission flows.

The heart of Promod IV is an hourly chronological dispatch algorithm that minimizes costs (or bids) while simultaneously adhering to a wide variety of operating constraints, including generating unit characteristics, transmission limits, fuel and environmental considerations, transactions, and customer demand. The Promod IV data inputs, simulation methodologies, and outputs are described in detail below.

Generation Types

Promod IV may be configured to model any number and type of generating units. Fossil-fired generators such as steam turbines, simple-cycle combustion turbines, and combined-cycle turbines are committed and dispatched based on operating costs and characteristics. Nuclear plants are typically modeled as must-run units that always operate at, or near, full available capacity. Hydro units may have both a minimum capacity or run-of-river portion and a peak-shaving capacity that is distributed to hours with the highest load levels.

Non-dispatchable resources with established generation patterns such as wind farms or certain co-generation facilities may be modeled as must-take with on-peak/off-peak energy distributions or as an hourly profile. Promod IV is also capable of modeling compressed air energy storage units. Any number of user-specified unit additions can be modeled in Promod IV.

Generator Operating Characteristics

The operating range for generators is defined with Minimum Capacity and Maximum Operating Capacity inputs. Capacity blocks or segments may be defined between the minimum and maximum capacities, for which distinct bids or operating costs may be calculated. An Emergency Capacity may be specified above the Maximum Operating Capacity and will only be dispatched in a loss-of-load situation. A total of seven segments (including the minimum and emergency segments) can be modeled for each generator.

Heat rates may be defined using incremental rates (MMBtu/MWh) for each capacity segment, or using an input/output curve expressed as either an exponential equation or a fifth-order polynomial. Heat Rates are grouped into profiles and assigned to generators on a monthly basis, making it easy to set up seasonal heat rates for each generator.

Generators may be input with a specific start-up fuel (which may be different than one used during normal operation), and start-up thermal energy requirements. An additional $/start up cost adder may be included, if desired. In order to prevent excessive cycling of units, minimum runtimes and minimum downtimes may be input. These are used in Promod IV's commitment logic to control how often generators are started up and shut down. Both ramp up rate and ramp down rate limits (input as MW/hour) are enforced in the hourly dispatch decision.

Generator Outages

Planned maintenance may be input into Promod IV using predefined dates, or may be automatically scheduled based on reliability criteria and individual generator maintenance requirements. Specific maintenances may be entered with predefined dates; they may be full or partial (with a MW deration), and may be specified as day, night and/or weekend only.

Promod IV uses a Monte Carlo technique to simulate the uncertainty of generator availability. Each generator's availability is based on inputs for forced outage rate and mean time to repair.

Using these inputs, Promod IV will randomly determine "black out" dates during which the generator will not be available if called upon. Generators will initially be committed for a week assuming they will not experience a forced outage. If an outage occurs, the generator may be recommitted once it returns to service.

Partial unit outages can also be modeled in Promod IV by creating the appropriate data assumptions for the available ratings on individual capacity blocks (rather than assuming the entire availability rating applies to the max capacity). If the user assigns an availability rating to individual capacity blocks, the Monte Carlo algorithm will also consider partial outages.

A unique availability schedule for each generation resource is generated for each Monte Carlo "draw", and the entire simulation is repeated. Promod IV features an Intellidraw function that will adjust annual outages determined from the initial Monte Carlo draw process to match the input forced outage rate in order to achieve convergence with fewer draws. This occurs by lengthening or shortening each outage proportionally until convergence is achieved. The availability schedules for each Monte Carlo draw are saved in a library and can be used in future simulations, thereby ensuring repeatability of results.

Transactions

Promod IV supports a comprehensive set of buy/sell transactions: forward products (fixed volume and price), options, spot transactions (hourly or block, price sensitive or index-based), a variety of scheduled transactions (peak reducing, valley fill, on-peak, off-peak, etc.) and more. External market areas can also be modeled as buy/sell transactions with hourly price spreads and time-varying capacity limits.

Load

Load by market area includes an hourly shape with annual peak and energy forecasts. Area loads typically represent control areas but are user-defined so that individual customer classes can also be modeled. Area loads are allocated down to load buses based on the load levels for the individual bus derived from the imported power flow case.

Interruptible loads may be modeled as a resource of last resort (before load shedding), or as a dispatchable resource with an associated bid price. Interruptible loads may contribute to ancillary services by user designation.

Environmental Modeling

Environmental constraints can be modeled in three levels of detail within Promod IV:

1. Environmental production by unit can be reported on and accounted for

2. Environmental costs/constraints can be considered in determining the dispatch rate or bid for a unit

3. The system can be dispatched such that an environmental limitation (e.g., seasonal NOx limitations) will not be violated

As many as nine different effluents (such as SO2, CO2, NOx, and Hg) can be modeled, with unique production rates, specified by unit, which may vary over time.

Unit Commitment

The unit commitment logic realistically models generator constraints for minimum runtime and minimum downtime, along with start-up costs, capacity bids and energy bids. This process starts with an initial unit commitment loading order for the week, and then performs a full hourly dispatch with either zonal transmission or a full DC load flow for each hour of the week. Checking for violations of minimum runtime and minimum downtime constraints on each unit, the logic looks for alternative commitment decisions that improve the economic performance of the system, and calculates bid adders to ensure that the cost of startup and minimum runtimes are taken into account. Once the commitment schedule is determined, another full hourly dispatch is performed to produce the final results.

This process uniquely integrates the unit commitment decision with full transmission analysis, so that a true security-constrained unit commitment optimization is achieved.

Unit Dispatch, Bids & Costs

Promod IV calculates dispatch lambdas for each unit capacity segment based on its variable costs, which include fuel (commodity, handling, transportation, etc.), emissions, O&M, and fuel auxiliaries. These may be further modified to represent bid strategies using price markups, fixed cost adders, and explicit bid overrides.

Bids for startup-cost, minimum loading and incremental dispatch capacity may be defined. Additionally, a fixed component representing all or some portion of fixed costs may be entered; this bid will be added to the minimum loading bid.

Based on the reactance of the connected transmission lines, shift factors are calculated for each bus, so that generation injected will flow into the system adhering to the physical characteristics of the grid. Promod IV incorporates each generator's bids, shift factors, and ramp rate limits into a linear program to optimize the dispatch across the entire system for each hour, honoring transmission constraints, for a full security-constrained economic dispatch.

Transmission

Promod IV has two methodologies for considering transmission constraints: a transportation-type model and a linearized AC load flow ("DC load flow").

Promod IV can use a transportation model to represent the transmission system. This option allows users to capture the high level impacts of area-to-area (market zone or sub-zone) transmission constraints without requiring detailed bus-level transmission data and in-depth knowledge of the transmission system. The solution utilizes a linear program that solves a load balance equation forcing the sum of the generation, load, import, and export energy, and losses to equal zero for each area. If generation shortages or transmission constraints lead to the inability to meet demand, emergency energy is created to achieve balance in a given area. Individual line flows and interface flows are monitored. Bi-directional tariff charges may be entered as economic hurdles to power exchange, as well as a loss factor for capturing the effect of transmission losses.

With the addition of the Transmission Analysis Module (TAM) to Promod IV, the program captures the constraints and limitations inherent in electric power transmission using a DC load flow algorithm. All major transmission equipment may be modeled, including voltage transformers, phase-angle regulators, DC ties, generation buses, load buses, and transmission lines with reactance and resistance inputs. This transmission topology is fully integrated with the commitment and dispatch algorithm, so that generators are scheduled, started and cycled while enforcing actual transmission constraints. Promod IV simultaneously optimizes the transmission and generation commitment and dispatch for all 8760 hours to provide the most accurate security-constrained unit commitment and economic dispatch possible.

Promod IV also models transmission interfaces ("flowgates") enforcing bi-directional limits on groups of lines.

Promod IV models both summer and winter normal-state ratings on power flow branches and interfaces to enforce normal flow limits on the transmission system. In addition, Promod IV recognizes contingency constraints, so that the dispatch will still be feasible if any of a set of contingency events or combination of events occurs. A single defined contingency may represent multiple transmission lines or generator outages (N-1, N-2 and more contingencies). Emergency ratings (summer and winter) on power flow branches and interfaces can be used to define additional energy that may flow on lines during contingency events. There are no program-imposed limitations on the number of contingencies or monitored lines.

Shadow prices are calculated by hour for each monitored transmission element. Flowgate sensitivity (shadow) prices, reflecting the decremental value to relieve a constraint by 1 MW, may be reported by hour. Additionally, flowgate sensitivity prices and the number of hours in which the flowgate was binding are reported by month and year.

Economic ("soft") constraints may be specified by the user for any transmission monitored element, to incorporate unusual generator re-dispatch incremental costs. Dated transmission outages may be specified for each individual transmission line. These may represent planned maintenance, current outage conditions, or assumptions regarding future forced outages.

Promod IV uses an iterative approach to accurately quantify marginal transmission losses. In each hour, actual dynamic losses are calculated line-by-line using a non-linear solution, generators are penalized based on their incremental contribution to losses, and the simulation is repeated until the convergence tolerance is satisfied. Promod IV calculates the incremental loss at each bus and incorporates that marginal loss component into the bus LMP. Promod IV's marginal loss calculation is compatible with existing markets that incorporate marginal loses (such as New York ISO).

Data from a solved AC power flow may be imported into Promod IV from a PSS/E RAW format or a PSLF EPC format. The system can store multiple power flow scenarios and new cases can be imported on demand.

The user can also modify the existing transmission topography by using Promod IV's graphical user interface. Additionally, Promod IV will output a change case file based on its dispatch of the system, allowing more detailed AC analysis that reflects forward-looking assumptions.

System Reliability

Individual generators may be designated as must-run, so that they always operate at minimum capacity when available, regardless of cost. Additionally, security regions may be defined, which may be met with a set of generators.

Promod IV considers operating reserve requirements in its commitment and dispatch algorithm. The operating reserve requirement can consist of both a spinning & non-spinning requirement. This requirement can be specified as a percent of load, percent of large steam unit, or flat MW value. Additionally, individual generating units as well as transactions can be flagged to contribute to either spinning reserve, non-spinning reserve, or not contribute to reserve at all. If a unit contributes to either reserve, the unit contribution can also be limited as a percent of maximum capacity or undispatched remaining capacity, or both.

Outputs

Promod IV utilizes ReportAgent™ as the primary method of extracting results from each simulation. With ReportAgent, users may select from monthly, weekly or hourly variables and use a multitude of filtering techniques to send output data directly to Excel, Access, HTML, or the Ventyx Pivot Cube (similar in functionality to Excel Pivot Tables.) Templates can be constructed during this process to create custom reports, graphs, charts, and pivot tables. Once the templates and initial reports are created, they can be reused each time a simulation is complete without rebuilding any reporting structures. ReportAgent output reports can be automatically generated at the completion of the simulation or "run on demand".

Hourly locational marginal prices (LMP) may be output for any bus. Zones and hubs may be defined as a collection of buses. Zonal prices may then be calculated based on load-weighted averages, generation-weighted averages, or user-specified ratios of the locational marginal prices of these buses.

All generating unit revenues, costs and operating statistics (including number of startups, MWh output, runtime, capacity factor, fuel consumption and cost, emissions production and cost, variable and fixed O&M, profit, revenue, etc.), as well as area and system information (such as total cost by subperiod by bus/zone/system), are available through ReportAgent. Revenue is computed hour by hour as the dispatched generation times the LMP at its bus (or buses).

Generator and system information may be reported hourly, weekly, monthly or annually. For transactions, energy, capacity, energy and capacity costs (revenues) are available hourly, subperiod, weekly, monthly and annually. For markets operating in a zonal or nodal structure, payments by load serving entities will be reported weekly and monthly. These payments are calculated at each bus, hour by hour, as the load at the bus times the zonal price or LMP at the bus.