PJM PROMOD Overview

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Market Analysis Software PROMOD

- PROMOD is a fundamental electric market simulation solution
  - It incorporates future demand, generating unit operating characteristics, transmission grid topology and constraints
  - It produces a unit commitment and security constrained economic dispatch while optimizing bid production costs

- For over 40 years, energy industry relied on PROMOD for a variety of applications
  - Locational Marginal Price (LMP) forecasting
  - Financial Transmission Right (FTR) analysis
  - Transmission Congestion Analysis.

Key PROMOD Features

- LMP forecasting for selected nodes, user-defined hubs, or load-weighted or generator-weighted zones.
- Financial Transmission Right (FTR) valuation for quantifying market prices, identifying binding constraints, and evaluating the economic impacts of constraints significant to the business.
- Economic Transmission Analysis to quickly evaluate the economic benefit/cost, the increase/decrease in hourly/monthly congestion, and the increase/decrease in reliability metrics associated with transmission expansion and outage scheduling.

PJM Market Efficiency Analysis

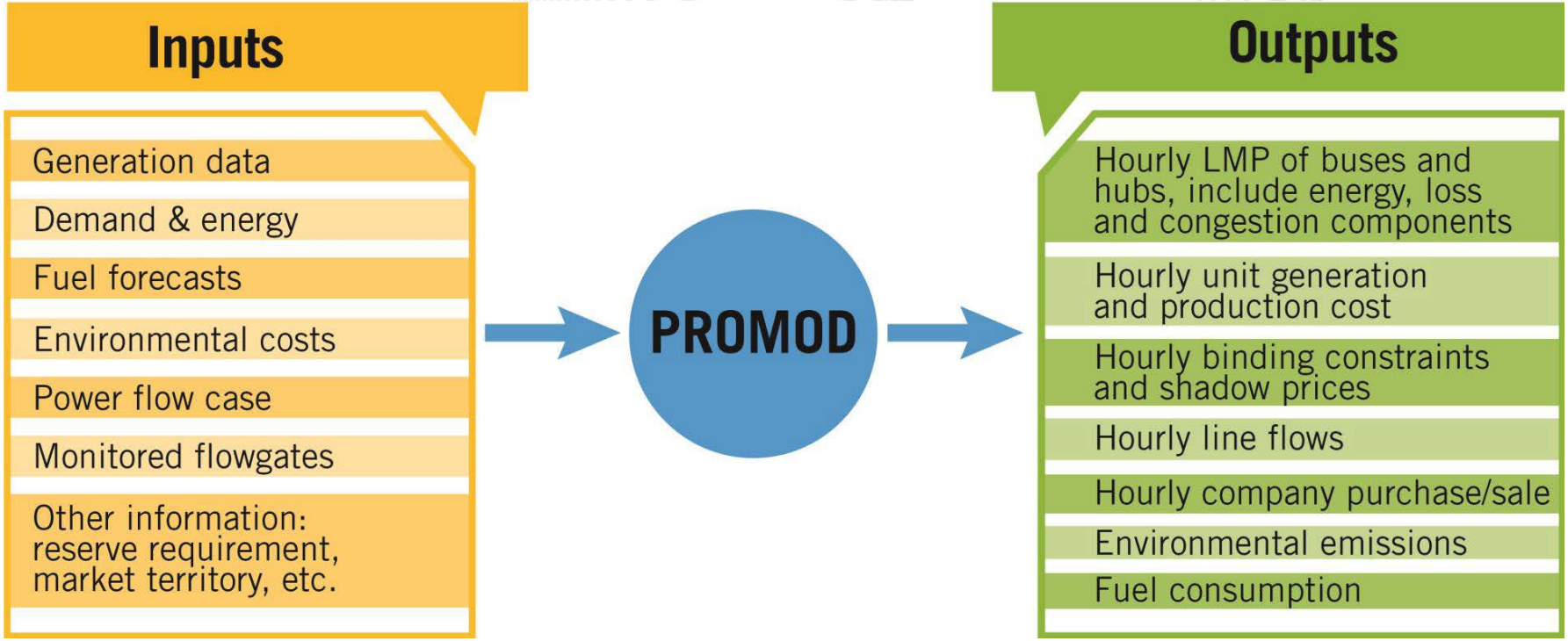
- PROMOD analysis is a critical component of the PJM Regional Transmission Expansion Process (RTEP):
  - It drives the Market Efficiency RTEP Planning Component
  - Over 2,400 PROMOD simulations performed during the 2014/15 RTEP window (~50,000 hrs. computer run time)

PJM Congestion Benchmarking Analysis

- In 2014, PJM studied PROMOD congestion simulation data against actual congestion
  - On average PROMOD congestion was ~90% of the actual congestion from 2009-2013

- Recently PJM compared its PROMOD congestion results against most recent FTR annual auction results and they aligned reasonably

PROMOD Inputs/Outputs



Overview Market Efficiency Base Case Inputs

PROMOD SCED Simulation

- Generation Expansion Plan (ISA/FSA)
- Demand Response Forecast
- Intermittent resource hourly shapes
- Transmission Topology (As-Is, RTEP)
- Fuel Price Forecast: Natural Gas,Coal, Oil-H, Oil-L
- Topology Mapping: Bus-Area, BusLoad-Demand, Gen-Bus (As-Is, RTEP)
- Emissions Price Forecast: CO2 (National, RGGI), SO2, Nox (seasonal,annual)
- Reactive Interface PV Analysis
- Demand Forecast: Annual Peak Load and Energy, Hourly shapes
- Monitored lines and contingencies, interfaces and nomograms, PARs

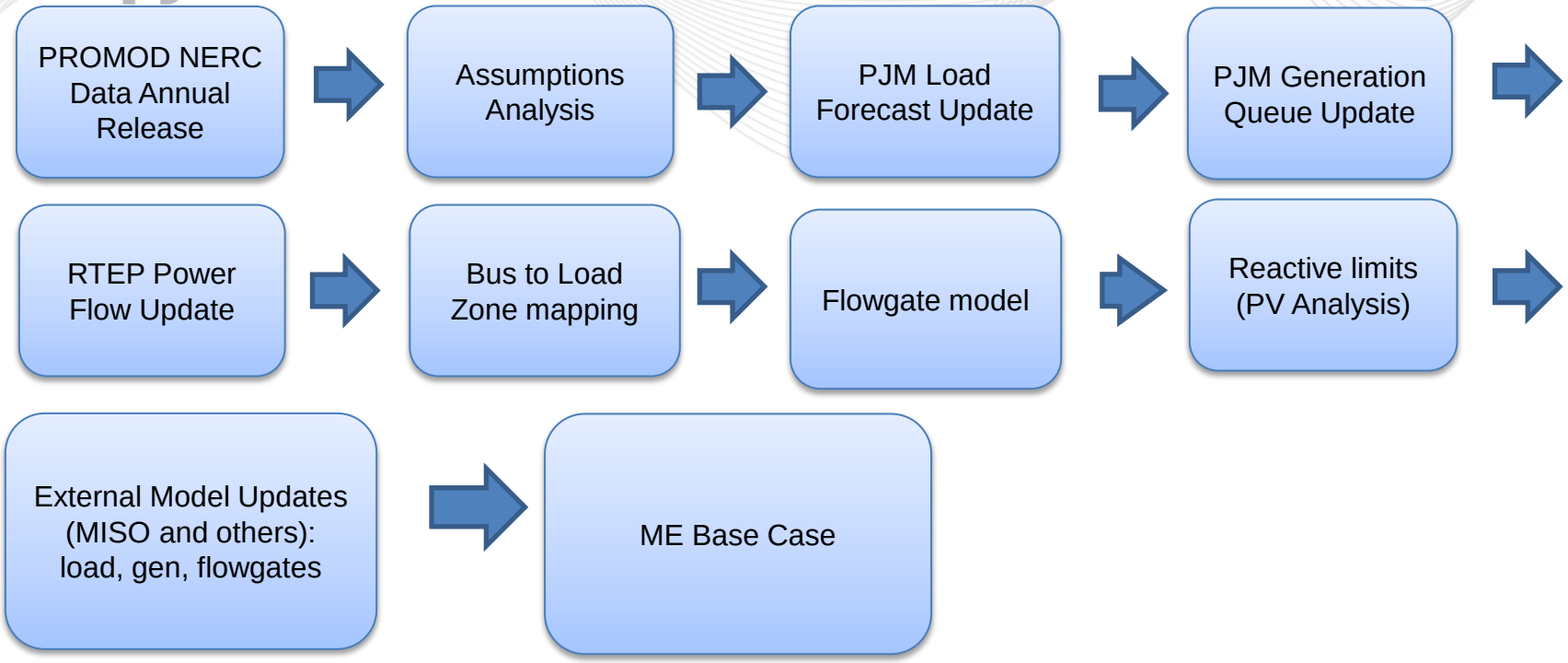
Interregional Inputs

- MISO and NY Updates: GenExp, load forecast, wind profiles, major upgrades, flowgates, transactions with SPP/MRO, imports Canada
- Pool Interaction Modeling: M2M flowgates, pseudo-ties, DC schedules, hurdle rates, import/export limits, inactive pools

Reporting Inputs

- RTO Weighted Average Cost of Capital
- RTO Fixed Carrying Charge Rate
- ARR Source Sink Paths and Cleared MW
- Project Cost and ISD

Market Efficiency Inputs Update Process



Appendix 1 – Operating Agreement & Manual References

References

- Scope, PJM requirements & Member requirements
- http://www.pjm.com/about-pjm/member-services.aspx

- PJM Manual 14B, Section 2.6: http://www.pjm.com/~/media/documents/manuals/m14b.ashx

- PJM Operating Agreement, Schedule 6, Section 1.5.7: http://www.pjm.com/media/documents/merged-tariffs/oa.pdf

- PJM Market Efficiency Practices http://www.pjm.com/~/media/planning/rtep-dev/market-efficiency/pjm-market-efficiency-modeling-practices.ashx