Market Efficiency Process

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Market Efficiency Process Enhancement Task Force – Education Session

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Overview

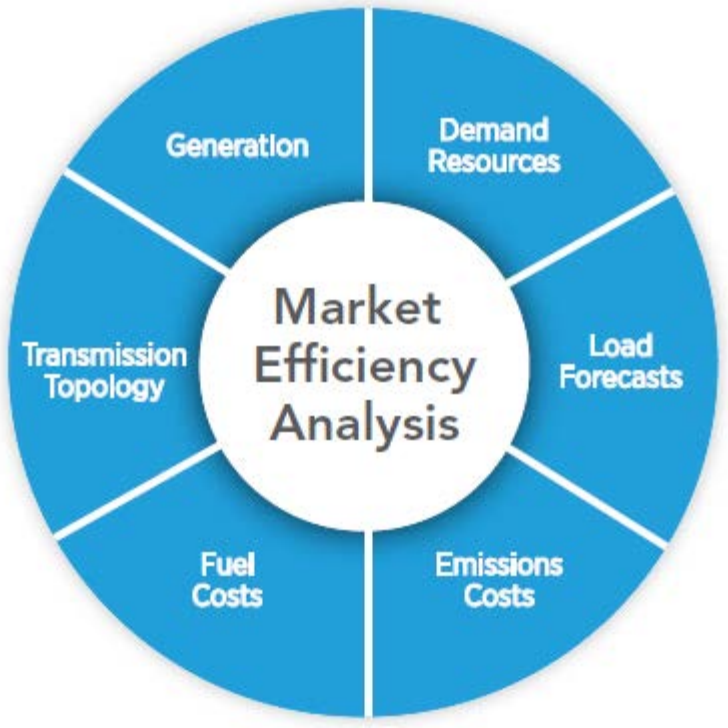
- Section 1: Market Efficiency Window Process
- Section 2: Critical Modeling Inputs
- Section 3: Project Selection Process

Section 1: Market Efficiency Window Process

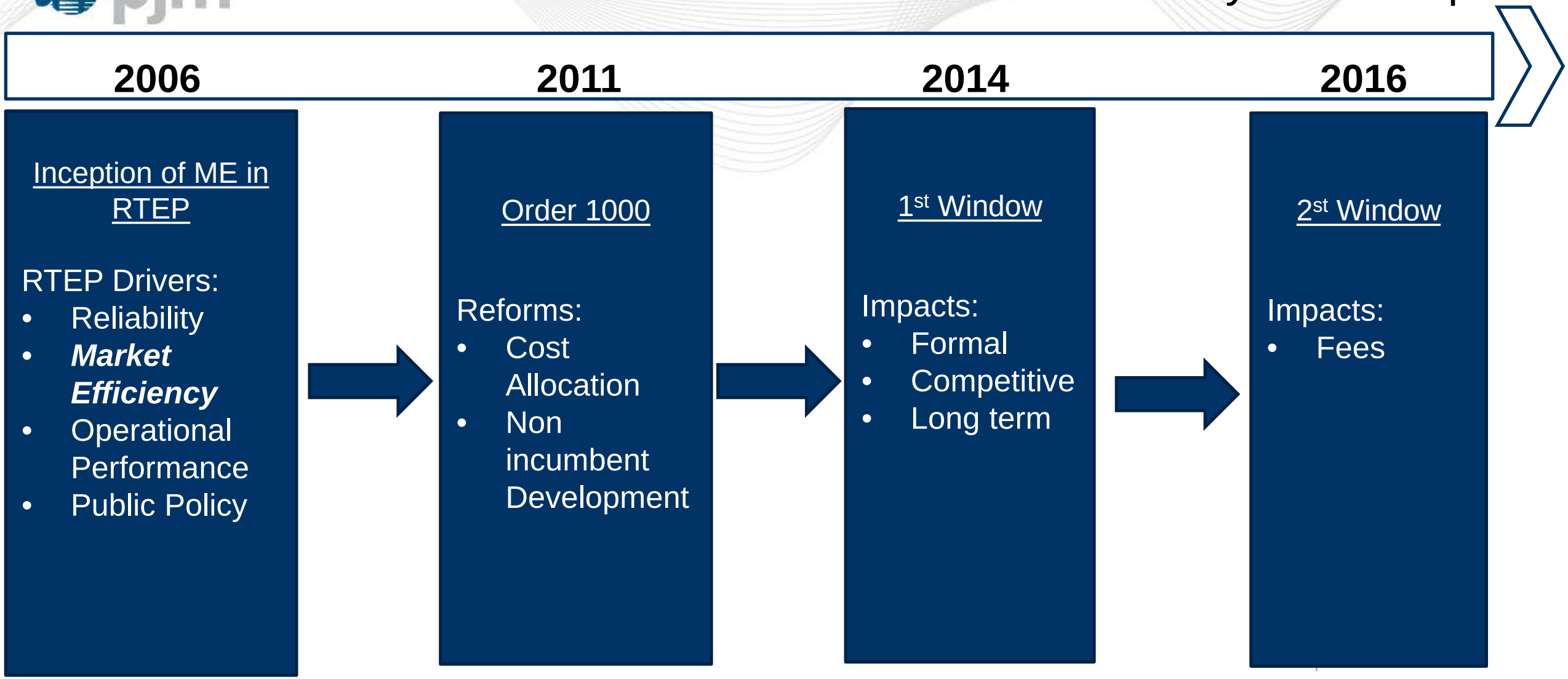
Market Efficiency Goals and Model

- Goals
  - Asses future energy and capacity market congestion
  - Solicit and approve projects to relieve congestion
  - Strategic multi driver project development
    - Address both reliability and congestion
  - Accelerate beneficial reliability projects

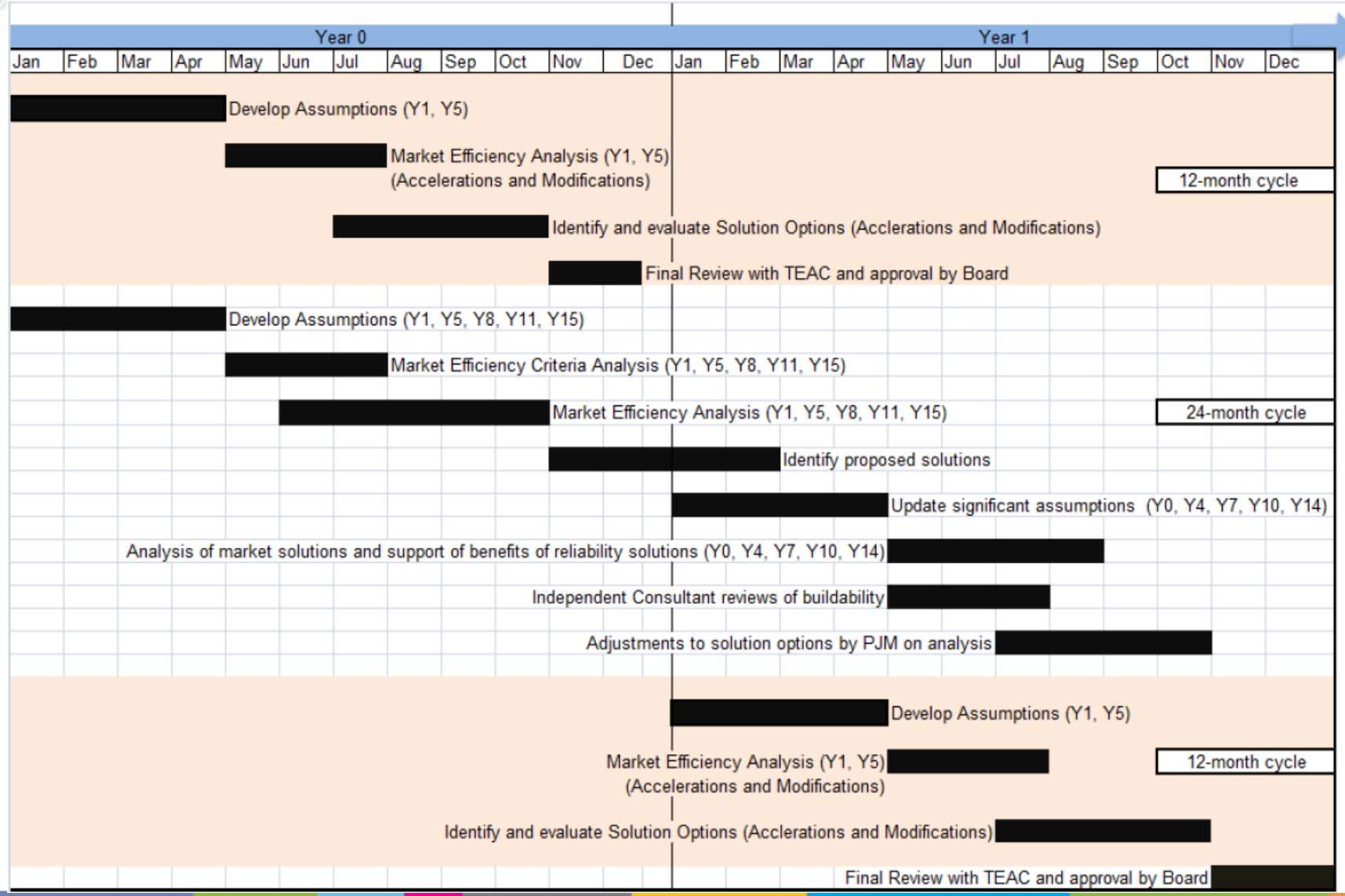
- PJM Model
  - Sponsorship model



Market Efficiency Road Map



Market Efficiency Cycle Timeline

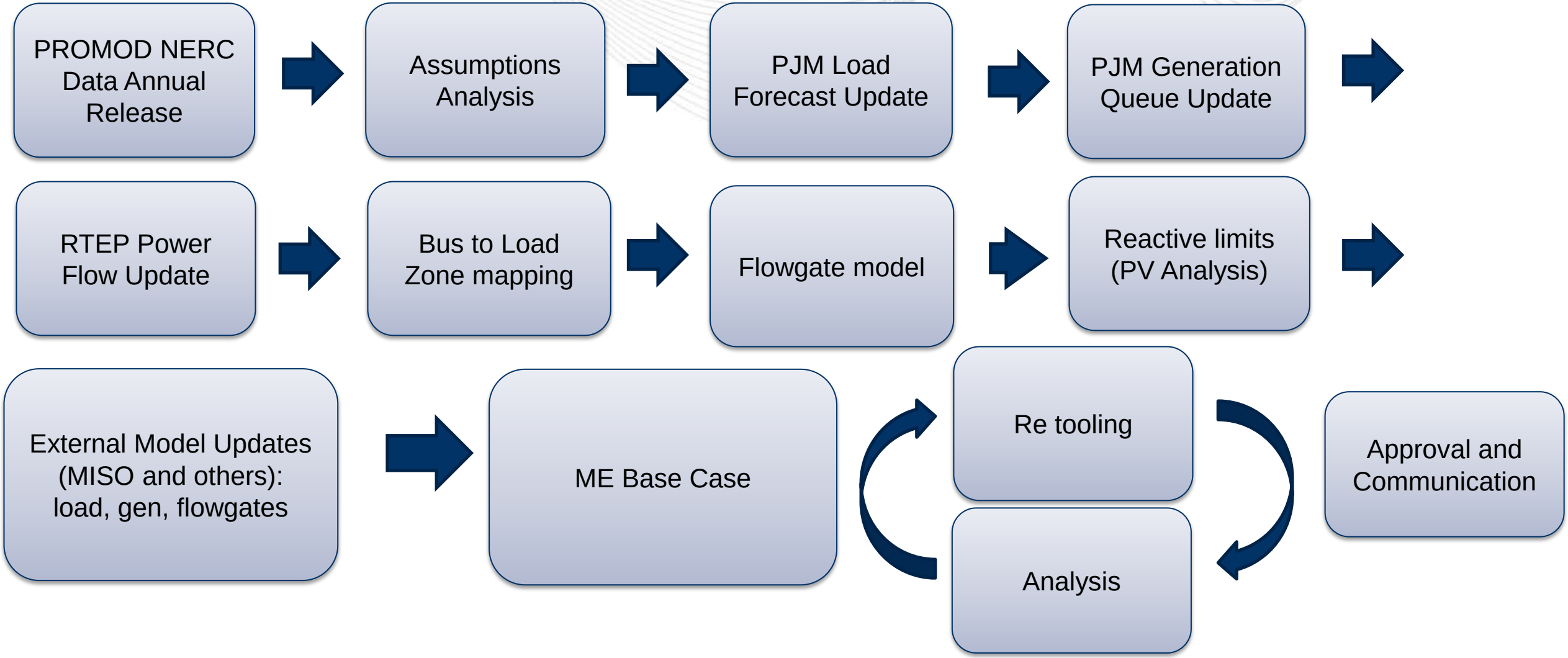


- 12 Month Cycle
  - Acceleration
- 24 Month Cycle
  - Input assumptions
  - Base case development
  - Develop target congestion
  - Proposal submission
  - Evaluation
  - Approval

Market Efficiency Statistics

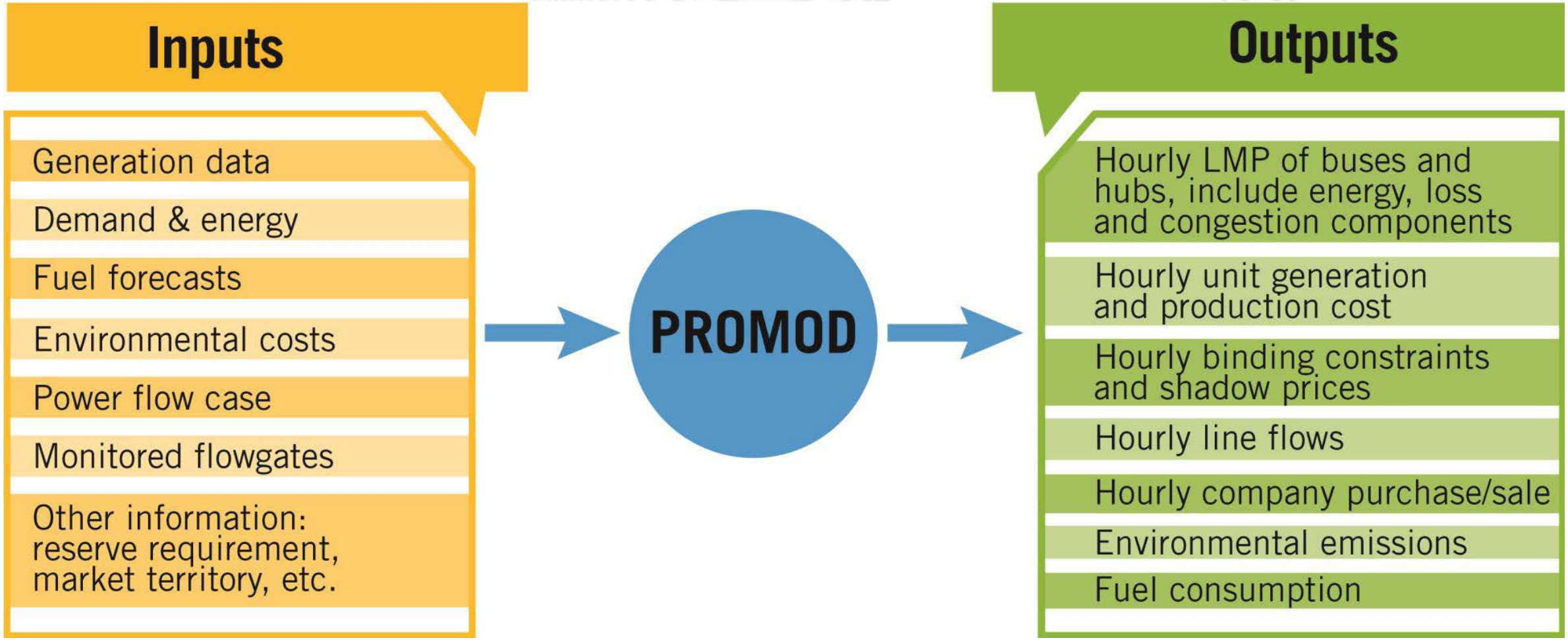
Cycle	Proposed Projects	Analyzed Projects	Approved Projects
Prior to 14/15	25 projects (2010, 2011) 17 projects (2012) 17 projects (2013)	25+ projects (with combinations) 17 projects(2012) 17 projects (2013)	2010, 2011 – 1 project approved 2012 - No project approved 2013 – 1 project approved
2014/15 Window	93 projects	110+ projects (with combinations) 2400+ PROMOD runs, 50,000+ runtime hrs.	14 projects
2016/17 Window	96 projects	120+ projects (with combinations and reevaluations) 3500+ PROMOD Runs, 90,000+ runtime hrs.	In-progress

Market Efficiency Work Flow



Section 2: Critical Modeling Inputs

Market Efficiency Analytical Software



Market Efficiency Inputs – Overview 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

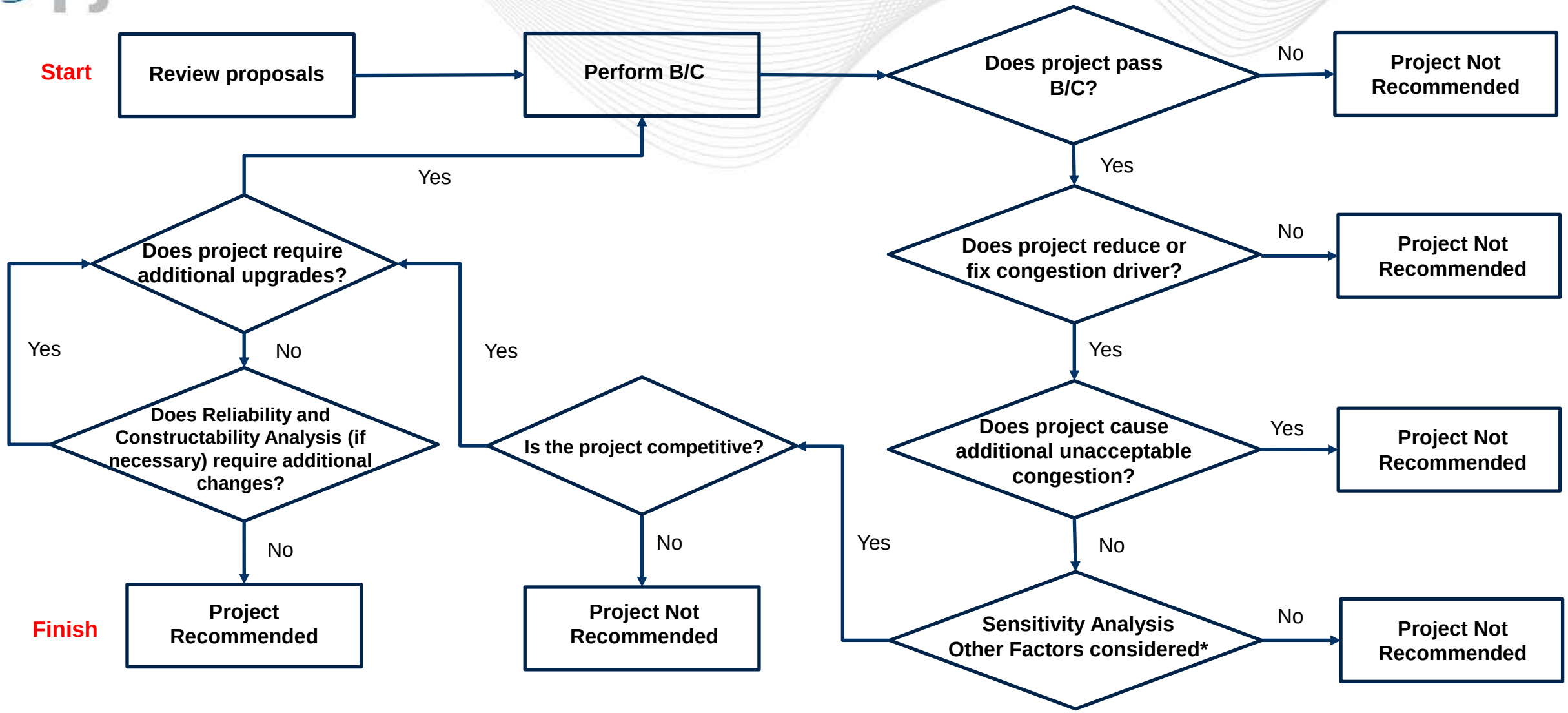
- MISO and NY Updates: GenExp, load forecast, wind profiles, major upgrades, flowgates, transactions with SPP/MRO, imports Canada
- Pool Interaction Modeling: M2M flowgates, pseudo-ties, DC schedules, hurdle rates, import/export limits, inactive pools

Reporting Inputs

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

Section 3: Project Selection Process

Market Efficiency Project Selection Flowchart



Other factors considered such as PJM Overall Production Cost, load Payments, and congestion

Market Efficiency Process – Congestion Drivers

- PROMOD simulations are used for determining future congestion drivers
- PJM solicits projects for posted congestion drivers

Market Efficiency Process – Proposal Analysis

- Each valid proposal is tested for Benefits/Cost >1.25
  - Total Benefits = Energy Benefits + RPM Benefits

    (for more details, see *PJM Market Efficiency Benefits Calculation* education session)

- Candidates passing B/C tests:
  - Congestion driver reductions
  - Other factors: overall PJM congestion changes, PJM Load Payments, PJM Production Costs
  - Perform Sensitivities
    - Gas Sensitivity
    - Load Sensitivity
    - Other sensitivities as needed (Examples: gen exp, renewable penetration, carbon tax, imports/exports, etc.)

Market Efficiency Process – Other Analyses

- Reliability Analysis
  - Additional reliability upgrades
- Independent Cost Analysis
  - Projects exceeding $50M Independent cost analysis
- Constructability Analysis
  - Verification of proposed schedule duration
  - Other risks to both cost and schedule
- Project Combinations
  - Combination of components of multiple projects
  - Incremental or multiple projects

Market Efficiency Process – Approval & Communication

- Selected projects require PJM board approval
- Approved projects are communicated at TEAC meetings
- Letter from PJM notifying construction responsibility

Appendix A – Market Efficiency Inputs Modeling

Market Efficiency Inputs – PJM Generation Modeling

- Forecasted generation includes:
  - In-service generation
  - Active queue generation with Interconnection Service (ISA) and Facility Service (FSA) agreements
  - Expected future deactivations

- Modeled inputs:
  - Operational: summer/winter capacity, heat rate, min runtime/downtime, must run status, emission rates
  - Cost: startup cost, variable O&M, curtailment price

Market Efficiency Inputs – PJM Load Forecast

- PJM Load Forecast Report
  - Peak Load and Annual Energy adjusted by Energy Efficiency cleared in RPM Auction
  - Load forecast mapped to PROMOD Areas
- ABB synthetic demand shapes
  - Based on the average of several years of load shapes
  - Hourly load shapes merged to match PJM load zones
- Demand Response
  - Modeled as discrete units
  - Amount based on the level cleared in the RPM BRA auction

Demand Response Modeling

- Level of Demand Response (DR) is based on the level cleared in the RPM BRA auction by delivery year, zone and product type.
- Demand Response is modeled as discrete units.
- Locations (zip codes) of Demand Response are based on registration data submitted through PJM DR Hub system.
- MW by Product Type are mapped to nearest BES facility.
- Strike price is modeled to ensure that DR is called at a level consistent with history and contractual requirements for the product type.

Market Efficiency Inputs – PJM Fuel Forecast

- Forecast prices developed by the ABB fuels group
  - Gas and Oil Price Forecasts
    - Prices derived from NYMEX (short term) and the EIA Annual Energy Forecast (long term)
  - ABB's Coal Forecast model
    - Mining costs, emission price forecasts, transportation routes and pricing, coal quality

- Additional input from IHS Energy
  - Alternative view on Gas Price forecast
  - Used to create high/low gas sensitivity scenarios

Market Efficiency Inputs - Emissions Forecast

- Emissions prices developed by ABB
  - Three major effluents modeled: SO2, NOx, and CO2
  - Effluents (by trading program) assigned to generators based on location and release rates
  - Sources:
    - EPA CEMS data
    - ABB's proprietary Emission Forecast Model (EFM)
- PJM checks
  - Consistency with expected emissions legislation affecting PJM Generators
  - Mapping of generating units to emissions price
  - Validate installation of emissions reduction equipment and removal rates for generating units (if necessary)

Market Efficiency Inputs - Transmission Topology

- Same topology used for all study years
  - To evaluate a project expected to be in service in 2019, the same topology is used in the pre-2019 study years simulated in PROMOD IV.
  - The generation (i.e. in-service or retired), fuel and emissions pricings will change by study year, but the topology is held constant.

- RTEP system topology
  - All approved baseline upgrades
  - All FSA network and direct interconnection upgrades

- External world topology
  - Derived from Eastern Interconnection Reliability Assessment Group (ERAG) Multi-Regional Modeling Working Group (MMWG) Series

Market Efficiency Inputs - Flowgates

- Thermal Flowgates
  - Historical market constraints
  - NERC Book of Flow-gates
  - Removed constraints with very low likelihood of binding in any future year simulation
  - Added constraints with increasing likelihood of binding
- Transmission Ratings Modeling
  - Summer 95 degree day-time rating for Normal and Long-term Emergency
  - Winter 32 degree day-time rating for Normal and Long-term Emergency
- Reactive Limits
  - PV Analysis to develop summer and winter MW transfer limits for commercially significant interfaces in PJM
  - Modeled interfaces: AEP-DOM, AP South, BCPEP, Black Oak Bedington, 5004/5005, Central Interface, Cleveland, COMED, Eastern Interface, Western Interface

Appendix B – 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