Valuing Power Flow Control with PLEXOS®

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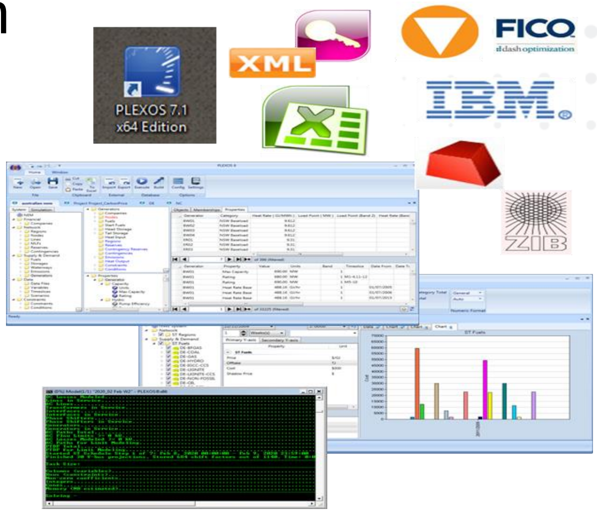
PLEXOS® Integrated Energy Model

- Proven power sector simulation tool - 36 Countries
- Uses mathematical programming, optimization and stochastic techniques (MIP, LP, SO)
  - Robust analytical framework, used by:
    - Energy Producers, Traders and Retailers
    - Transmission System/Market Operators
    - Energy Regulators/Commissions
    - Consultants, Analysts and Research Institutions
    - Power Plant Manufacturers and Construction Companies
- Power system model scalable to thousands of generators and transmission lines and nodes
- Multi-stage interleaved simulation from 1 min to 40 years



Power Flow Control Modelling in PLEXOS®

Challenge: Chronological Unit Commitment/Dispatch of Network Devices and Generators (conventional power flow snapshot analysis not sufficient for valuation)

- R&D for modeling the following devices/techniques:
  - Impedance-Control Devices
    - Mechanically-Switched Series Reactor (MSSR)
    - Distributed Series Reactor (DSR)
    - Magnetic Amplifier
  - Voltage-Injection Devices
    - Static Synchronous Series Compensator (SSSC)
    - Unified Power Flow Controller (UPFC)
    - Distributed Static Series Compensator (DSSC)
  - Phase-Angle Control Devices
    - Phase-shifting Transformer (PST)
    - Compact Dynamic Phase Angle Regulator (CDPAR)
  - Topology Control Techniques

LT Plan	• Step Size: 1-30+ years • Capacity Expansion
PASA	• Step Size:1 year at a time • Maintenance Planning
MT Schedule	• Step Size:1+ years at a time • Constraint Decomposition
ST Schedule	• Step Size: 5 minute – 1 week at a time • Chronological Simulation

- Production Cost – For short-term production studies, PLEXOS® will optimize the dispatch of the PFCs in the unit commitment.
- Capacity Planning – For long-term expansion studies, given a set of candidate lines and the types of PFCs to be deployed, PLEXOS® will produce an optimized build decision over the simulated horizon.

Transmission Modelling in PLEXOS®

- PLEXOS® uses a Linearized DC-OPF with both integrated and pre-computation of shift factors.
- Marginal Loss Modeling in PLEXOS®
- The SCUC algorithm in PLEXOS® computes contingency shift factors. These factors are used to monitor and enforce the contingency constraints.
- The SCUC in PLEXOS® can also support the "N-x" contingency analysis, that ensures "two or more simultaneous contingencies will not propagate into a cascading blackout".

Illustrative Formulation Generation Transmission Expansion Co-Optimization

$$\text{Minimize } \sum_{y=1}^{Y}\sum_{i=1}^{I}\left(BuildCost_i \times Build_{i,y}\right) + \sum_{t=1}^{T}\left(\sum_{i=1}^{I} ProdCost_i \times Prod_{i,t}\right) + ShortCost \times Shortage_t$$

subject to

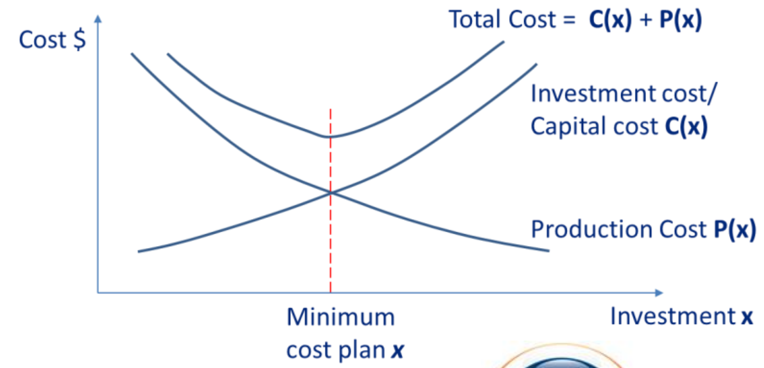
$$\text{Supply and Demand Balance: } \sum_{i=1}^{I} Prod_{i,t} + Shortage_t = Demand_t \quad \forall t$$

Production Feasible: $Prod_{i,t} \leq ProdMax_i \quad \forall i,t$

Expansion Feasible: $Build_{i,y} \leq BuildMax_{i,y} \quad \forall i,y$

Integrality: $Build_{i,y}$ $integer$

Reliability: $LOLP(Build_{i,y}) \leq LOLPTarget \quad \forall y$



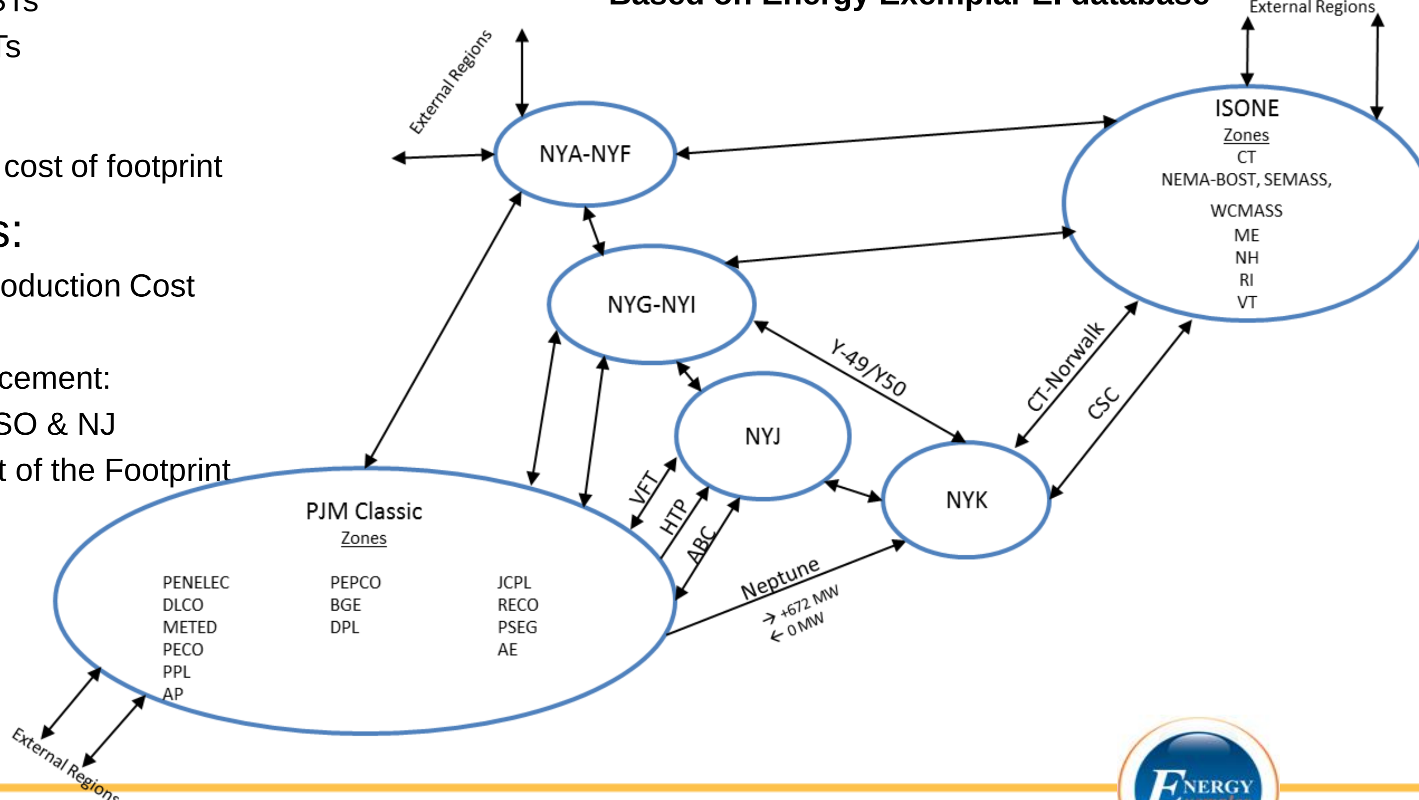
CHANGING WHAT'S POSSIBLE

Case Study: Deploying PFCs on two NYISO Interfaces

- PFC Valuation Case
  - Compare benefits with and without PFCs on the elements of the UPNY-ConED and UPNY-SENY interfaces.
- Interfaces
  - UPNY-ConED: 10 PSTs
  - UPNY-SENY: 25 PSTs
- Objective Function
  - Minimize operational cost of footprint
- Simulation Settings:
  - Hourly Day Ahead Production Cost
  - Horizon: 1 Year
  - Thermal Limits Enforcement:
    - 115 kV for NYISO & NJ
    - 345 kV for Rest of the Footprint

- System Model
  - Study Footprint: NYISO + Tier 1 Neighbors
  - Nodal Transmission Model
  - Detailed Generator Properties
  - Fuel Price Hourly Forecast
  - ISO Hourly Demand Forecasts
  - **Based on Energy Exemplar EI database**

2500 Gens
14,000 Nodes



Case Study: Economic Benefits of deploying Power Flow Controllers on the NYISO Interfaces

- Economic Benefits Metrics used in Planning Processes
  - B/C Ratio
  - Production Cost Savings
  - Congestion Savings
  - Other Savings
- Economic Metric used in Integrated Resource Plans
  - NPV Savings Least Capital and Operation Cost