Power Systems & Markets

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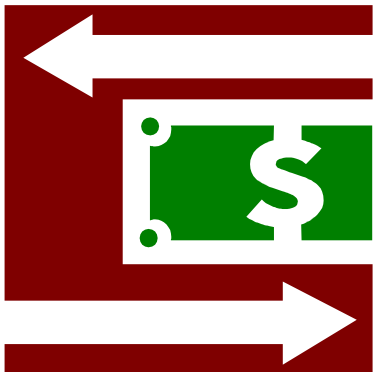
Introduction to Electricity Markets



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Learning Objectives

- Market operations
- Basic market structures, models, and participating entities
- Introduce concepts such as forward and real-time markets
- Standard market design (SMD)
- Overview of two US markets

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Market Operations

- Market Operations goals:
  - Ensure a reliable and secure grid operation
  - Facilitating a competitive and economical operation
- Security is the most important aspect of the grid operation (regulated operation or not)
- Competitive and economical operations assumes that the cost of electricity will be reduced

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Electricity Market Models

- Pool Model: centralized marketplace that clears the market for buyers and sellers of energy
  - Sellers compete to sell energy to the grid (not to specific customer)→ if their bid is too high, they might not be able to sell
  - Buyers compete to buy energy from the grid → if their bid is too low, they might not be able to buy
- Bilateral Contracts: buyer and seller trade energy independently of the ISO
- Hybrid: combination of both models, it permits bilateral contracts but also provides a marketplace (ISO) for buyers/sellers that do not have bilateral contracts

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Market Entities

- *Independent System Operator (ISO)*
- *Generating Companies (GENCOs)*
- *Transmission Companies (TRANSCOs)*
- *Load Serving Entity (LSE)*
- *Others: Distribution Companies (DISCOs), Marketers, Power Exchange, RETAILCOs,…*

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Independent System Operator (ISO)

- Administer FERC tariff
- Ensures a secured and reliable operation of the system
- Facilitates a competitive market
- Coordinates maintenance schedules
- Run market operations
- Provides schedules and prices in day-ahead (DA) and real-time (RT) markets

Generating Companies (GENCO)

- Operates and maintains existing generators
- They can offer:
  - Energy (MW)
  - Operating reserves
  - Regulation
  - Installed Capacity
  - Reactive power for voltage support (MVAr)
  - Black-start (blackout recovery generator)

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Transmission Companies (TRANSCOs)

- Operate and own the transmission system
- Build and maintain local systems
- Offer transmission for sale
- Operate local Control Centers
- Perform "System Restoration”, and act as a backup for main control center (ISO)

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Marketers

- Buy and sell energy
- Participate in virtual energy market (as a virtual generator or load)
- Participate in FTR market (buy/sell)
- Arrange transmission services between parties

Energy Market

- Centralized mechanism that facilitates trading of energy between buyers and sellers
- Managed and operated by the ISO:
  - Accepts bids (price/quantity pair, i.e. $/MW-h) to buy (loads) and sell (generators) energy
  - Determines a market clearing price (LMP) and provides commitments and schedules based on security-constrained unit commitments

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Ancillary Services Market (AS)

- AS are needed for the system to operate reliably
- They are unbundled from the energy market and procured through the market competitively
- Different AS could be cleared sequentially or simultaneously
- Main types of AS: reserves and regulation

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Transmission Market

- Commodity traded is the “transmission right”, i.e., the right to transfer, inject, and withdraw power into the network (TCC, CRR, FTR)
- The transmission right holder can either physically transfer power or let others use the right for using the transmission network with appropriate compensation
- Transmission rights allow for holders to hedge against congestion charges through congestion credits

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Transmission Market (cont.)

- Transmission rights are sold and bought in centralized auctions conducted by the ISO
- The objective is to maximize auction revenues within available transfer capability of the network
- Bids include amount of transmission rights (MW), selling/buying price, and point of injection and withdrawal from the network
- Obtaining transmission rights:
  - Annual auctions based on estimated peak load
  - Firm point-to-point transmission services
  - Through monthly secondary auctions

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Forward Markets

- Most electricity markets include a day-ahead (DA) *forward* market for scheduling resources for each hour of the following day
- Both energy and AS can be traded
- Energy and AS are optimized either sequentially or simultaneously
- Prices (LMP) are calculated hourly, schedules are financially binding

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Forward Markets (cont.)

- Allows for the option to “lock in” scheduled DA MW at DA prices
- Market design should provide incentives for generators and loads to submit day-ahead schedules

Real-Time Markets

- Also called *balancing* market, it allows for balancing DA schedules of load and generation with real-time (RT) values
- Resources utilized for RT energy imbalances are classified according to their response time:
  - regulating units receive and respond to signals every 5 - 6 seconds
  - spinning and non-spinning reserves respond to signals every 10 - 30 minutes
- Prices are usually calculated at 5 minute intervals
- Market design should provide incentives for generators to follow RT dispatch instructions from ISO

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Two Settlements

- First market settlement: DA schedules
  - *Scheduled load & generation (including virtual schedules) become **forward** sales and purchase contracts, that are financially binding*
- Second market settlement: RT dispatch
  - Based on RT prices and on actual (RT) schedule deviations from DA hourly quantities

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Balancing the Market

- Load scheduled in DA:
  - pays day-ahead LMP for DA MW scheduled
  - If RT load *exceeds* DA schedule, it will pay RT LMP for actual MW *above* scheduled
  - If RT load is *less* than DA schedule, it will get paid RT LMP for actual MW *below* scheduled
- Generation scheduled in DA
  - paid day-ahead LMP for DA MW scheduled
  - paid real-time LMP for actual MW *above* scheduled
  - pays real-time LMP for actual MW *below* scheduled

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Balancing the Market: Example 1

- DA load is less than RT (actual) demand
  - DA load = 100 MW, LMP = $10
  - RT load = 110 MW, LMP = $20
- Settlement:
  - Load pays in DA: (100 x 10) = $1,000
  - Load pays in RT: (110-100) x 20 = $200
  - Note: if load had bid in DA = 110 MW, then load would have paid (110 x 10) = $1,100, while as bid, it pays $1,200

Balancing the Market: Example 2

- DA generator schedule is greater than RT (actual) MW
  - DA schedule = 200 MW, LMP = $10
  - RT schedule = 150 MW, LMP = $15
- Settlement:
  - Gen is paid in DA: (200 x 10) = $2,000
  - Gen pays in RT: (150-200) x 15 = $750
  - Note: generator replaces the energy (50 MW) that is not produced in RT at a higher price

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NY Market Overview

- Generating capacity: 36,000 MW, peak load = 30,980 MW, market size: ~$7 billion (2003)
- DA and RT markets for energy and AS
- Bid-based markets for energy, reserve, and regulation
- Contract-based system for voltage support and black start
- Bids (market products): generation, price-sensitive loads, reserves (per type of class), virtual load and generation, imports, exports, and wheel-throughs
- Other markets: Installed Capacity, Transmission Congestion Contracts (TCC)
- Ex-ante LMP pricing based upon “scheduled” generator output, not “actual”

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NY Market Overview (cont.)

- Market Structure allows for:
  - Bilateral contracts
  - Scheduling of energy-limited resources
  - Accommodating existing transmission agreements
  - Market participants, municipal, and price-responsive load customers
- Simultaneous optimization of energy and reserve for least-cost solution
- DA Multi-pass Security Constrained Unit Commitment (SCUC) process which permits reliability requirements and market mitigation

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PJM Market Overview

- Generation Capacity: 66,000 MW
- Peak load: 62,400 MW
- Both forward (DA) and real time markets
- Pricing is based on physical flows (ex-post pricing)
- Bids (market products): generation, price-sensitive loads, reserves, regulation, virtual load and generation, imports, exports, and wheel-throughs

PJM Market Overview (cont.)

- DA energy market includes regulation and reserve constraints
- Lost opportunity cost is included in the pricing of regulation and reserve
- Other markets: Financial Transmission Rights (FTR), Installed Capacity (ICAP)
- Market structure supports bilateral transactions and self scheduling of generators

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Standard Market Design (SMD)

- SMD is FERC's proposal to standardize the structure and operation of competitive wholesale power markets nationally
- According to FERC, *"inconsistent rules across the US would:*
  - *Raise energy costs for customers*
  - *Hamper investment in infrastructure*
  - *Allow discrimination by transmission owners*
  - *Allow market manipulation"*

Goals and Principles of SMD

- Goals of SMD
  - Reduce wholesale prices
  - Provide incentives for investment in infrastructure and new technologies
  - Protect the environment
- Basic Principles:
  - Set uniform rules for all users of the network
  - Favors market power mitigation measures for detecting and mitigating market power
  - Provides clarification of transmission pricing as well as planning criteria for grid expansion

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SMD and Market Structure

- FERC favors the hybrid approach: bilateral contracts plus forward and real-time markets for energy and ancillary services
- ISO runs the market operations and is responsible for securing the grid
- Market operations software: security-constrained unit commitment and dispatch
- Congestion is managed via LMP
- Bids caps are enforced

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What goes into Market Operations Software

- ***Market Data:*** bids for energy, reserve, and regulation, bilateral transactions
- ***Market Design:*** Pricing methodology for each bid type, scarcity condition representation, objective function of optimization routine
- ***System Security***: facilities and interface ratings, load forecast, reserve requirements, contingency list, monitor element list, Area Scheduled Interchange, scheduled outages, and network model

Market Operations Software

- ***Schedules***: generation, demand, (energy, reserve, and regulation) ASI (tie schedules), imports, exports, and wheel-throughs
- ***Prices*** (LMP)
- Binding transmission constraints, constraint shadow prices

References

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- FERC website: http://www.ferc.gov
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