Overview of EE394V
Restructured Electricity Markets:
Locational Marginal Pricing

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www.ece.utexas.edu/~baldick/classes/394V/EE394V.html
Outline

- Focus of class
- Challenges
- Importance
- Approach
- Main topics
- Teaching this class
Focus of class

- Rigorously develop and understand the “locational marginal pricing” model of “centralized” day-ahead and real-time electricity markets at the graduate level:
  - LMP in place in Eastern and Midwest United States, California, and the Electric Reliability Council of Texas, (ERCOT).
  - ERCOT used as main example, but
  - features of other markets, such as capacity markets, also discussed, so that class is relevant nationally.
Challenges

- Class synthesizes material from power systems, optimization, and economics:
  - Typical students do not have background in all three areas,
  - First third of semester is rapid review of background material,
  - Students assumed to have undergraduate background in at least two areas, with expectation that they will spend additional time outside of class reviewing other area.
Importance

- Operation of organized electricity markets has significant economic implications,
- Personnel at Independent System Operator (ISO) and market participants need understanding of *purpose* and *principles* of operation of organized markets,
- No direct counterpart of organized market in other industries and no textbooks cover all relevant material.
Approach in one semester class

- Review background,
- Discuss pricing in organized electricity markets in the absence of transmission constraints.
- Then introduce transmission constraints and their implications.
- Also discuss a number of other topics including energy and transmission price risk hedging, network models, and capacity adequacy.
Background topics

- History of restructuring in Texas:
  - instructors from other areas should substitute,
- Solution of non-linear simultaneous equations,
- Power flow,
- Optimization,
- Economic dispatch,
- Microeconomics,
- Economic decision-making.
Main topics

- Offer-based economic dispatch without transmission constraints:
  - Surplus, Feasible production set, Need for centralized coordination, Optimization formulation, Generation offers, Demand specification, Demand bids, Dispatch calculation, Pricing rule, Incentives, Dispatch supporting prices, Value of lost load and implications for pricing and incentives, Generalizations, Ancillary services: reserves and regulation.
Main topics

- Locational marginal pricing:
  - Optimal power flow, DC optimal power flow, Offer-based optimal power flow, Examples, Properties of locational marginal prices, Congestion rent (merchandising surplus) and congestion cost, Contingency (or security) constraints, Reactive power and losses, Decomposition and linearization.
Main topics

- **Unit commitment:**
  - Temporal issues, Formulation, Lagrangian relaxation, Duality gaps, Mixed integer programming, Dispatch supporting prices and make-whole payments, Anonymity of prices, Implications for investment decisions, Transmission constraints, Day-ahead and real-time markets, Representation of reserves, value of lost reserves, and reserve constraints.
Main topics

- Hedging of energy and transmission price risk:
  - Volatility of energy prices, Forward markets, Contracts for differences, Relationship to capital formation, Generation adequacy, Transmission prices, Financial transmission rights, Revenue adequacy.
Teaching this class

- Detailed slides, including in-class review questions and homework exercises are available at:
  [http://users.ece.utexas.edu/~baldick/classes/394V/EE394V.html](http://users.ece.utexas.edu/~baldick/classes/394V/EE394V.html)

- Solutions to homework exercises will be made available to instructors on request.
Summary

- Class presents rigorous derivation of locational marginal pricing model,
- Purpose and principles are discussed,
- Background material accommodates students from engineering, optimization, and economics.