

# Design of New England's Wholesale Electricity Market

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## Outline

- Conclusion
- Objective
- Background
- Recommendations
- Reasons for recommendations

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# Conclusion

- Can open markets on December 1st
- But improvements are needed for long run success
  - Switch to a multi-settlement system
  - Introduce demand-side bidding
  - Fix pricing of ten minute spinning reserves
  - Adopt location-based congestion pricing
- *Must have agreement on concepts and tentative timetable by start date (December 1)*
  - Changes after start date will be more difficult

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## Objective of Design

# 1. Efficiency

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# Properties of Efficient Market Rules

- Do the rules send the right price signals?
- Do the rules minimize opportunities for gaming?
- Do the rules mitigate opportunities for collusive behavior?
- Do the rules mitigate market power?
- Do the rules reduce entry barriers?
- Are the rules compatible with neighboring markets?
- Do the rules encourage system reliability?
- Are the rules neutral with respect to bilateral transactions?

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## Description of ISO's Markets

- Energy market
- Ancillary services
  - Ten-minute spinning reserves
  - Ten-minute non-spinning reserves
  - Thirty-minute operating reserves
  - Automatic generation control
- Capacity markets
  - Installed capability market
  - Operable capability market

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# Energy Market

- Residual market
  - Only difference between resources and obligations traded (not self-scheduled bilaterals)
- Hourly bids (\$/MWh) submitted day-ahead
- Basis for day-ahead schedule
- Paid real-time spot price (ex post clearing)
  - Shadow price on energy in 5-minute dispatch LP
  - Out-of-merit-order dispatch paid its bid

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## Recommendations



Do before start date



Do as soon as possible



Already done

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*Recommendation #1*  
Adopt a  
Multi-Settlement System

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## Alternative Settlement Approaches

- Single-settlement system
  - day-ahead bids are used for scheduling
  - ex post settlement at real-time spot price
- Multi-settlement system
  - day-ahead bids financially binding at day-ahead clearing price
  - hour-ahead deviations priced at hour-ahead clearing price
  - real-time deviations priced at spot price

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# Single-Settlement System

- Bids and schedules are submitted day-ahead
- ISO schedules units for the next day to minimize costs, given the bids, forecasts, operating and transmission constraints, and bilateral schedules
- ISO may accept bid/schedule changes up to an hour before real time
- ISO dispatches units in real time at least cost, given the bids and forecasts for subsequent hours
- ISO determines real-time spot prices as shadow prices from the actual real-time LP optimization of dispatch
- Real-time spot prices are used for all settlements to pay generators and charge load
- Compliance penalties are assessed against those failing to perform as scheduled

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# Multi-Settlement System

- Bids and bilateral schedules are submitted day-ahead
- ISO schedules dispatchable units for the next day to minimize costs, given the bids, bilateral schedules, and forecasts
- ISO determines the prices associated with the day-ahead schedule as shadow prices obtained from the day-ahead LP optimization
- *The day-ahead prices and scheduled quantities are used in the first settlement*
- ISO may accept bid/schedule changes up to an hour before real time
- ISO dispatches units in real time at least cost, given the bids, schedules, and forecasts for subsequent hours
- ISO determines real-time spot prices from the actual dispatch
- *Deviations from day-ahead schedules are settled at the real-time spot prices (second settlement)*

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# Benefits of a Multi-Settlement System

- Two-settlement system (day-ahead and spot)
- Three-settlement system (day-head, hour-ahead, spot)
  - Participants have more opportunities to respond to uncertainty
- Market incentives for participants to respond efficiently to uncertain demand and supply
  - Deviations from day-ahead schedules are priced by market
- Mitigates incentives for gaming
  - Reduces bidder uncertainty
- Eliminates gaming of short-notice transactions
- Multiple settlements, self-scheduling, and day-ahead commitments are complements
  - Can't be implemented piecemeal

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## *Recommendation #2* Introduce Demand-Side Bidding

- Essential for long-run efficiency
- Mitigate supplier market power
- Incentives for power management
- Not too complex

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## Example of Settlement System: Generator 2 Fails to Supply

	Forward Commitment (MWh)	Actual Dispatch (MWh)	Difference or Imbalance (MWh)	Forwards Market Revenue or (payment)	Spot Market Revenue or Payment	Total Revenue Or Payment
Gen. 1	50	90	<b>40</b>	$50 \times 30 = \$1500$	<b><math>40 \times 45 = \\$1800</math></b>	\$3300
Gen. 2	40	0	<b>-40</b>	$40 \times 30 = \$1200$	<b><math>-40 \times 45 = -\\$1800</math></b>	<b>(\$600)</b>
Load A	-50	-50	0	$-50 \times 30 = (\$1500)$	0	(\$1500)
Load B	-40	-40	0	$-40 \times 30 = (\$1200)$	0	(\$1200)
Price(\$/MWh)	\$30	\$45				

- Increases spot price to \$45 from \$30 forward
- Gen. 1 increases supply to balance load
- Gen. 2 pays the increase in price caused by its failure

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## Example of Settlement System: Load B Underestimates Demand

	Forward Commitment (MWh)	Actual Dispatch (MWh)	Difference or Imbalance (MWh)	Forwards Market Revenue or (payment)	Spot Market Revenue or Payment	Total Revenue Or Payment
Gen. 1	50	50	0	$50 \times 30 = \$1500$	0	\$1500
Gen. 2	40	50	<b>10</b>	$40 \times 30 = \$1200$	<b><math>10 \times 40 = \\$400</math></b>	\$1600
Load A	-50	-50	0	$-50 \times 30 = (\$1500)$	0	(\$1500)
Load B	-40	-50	<b>-10</b>	$-40 \times 30 = (\$1200)$	<b><math>-10 \times 40 = -\\$400</math></b>	(\$1600)
Price(\$/MWh)	\$30	\$40				

- Reduces price in forward market
- Increases price in spot market
- Load B buys 10 extra units at higher spot price

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# Example of Settlement System: Load A Overestimates Demand

	Forward Commitment (MWh)	Actual Dispatch (MWh)	Difference or Imbalance (MWh)	Forwards Market Revenue or (payment)	Spot Market Revenue or Payment	Total Revenue Or Payment
Gen. 1	50	50	0	$50 \times 40 = \$2000$	0	\$2000
Gen. 2	50	40	-10	$50 \times 40 = \$2000$	$-10 \times 30 = -\$300$	\$1700
Load A	-50	-40	10	$-50 \times 40 = (\$2000)$	$10 \times 30 = \$300$	(\$1700)
Load B	-50	-50	0	$-50 \times 40 = (\$2000)$	0	(\$2000)
Price(\$/MWh)	\$40	\$30				

- Increases price in forward market
- Reduces price in spot market
- Load A sells 10 extra units at lower spot price (Gen. 2 “buys back” extra units)

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## Single-Settlement System is Vulnerable

- Day-ahead market is cleared ex post
- Creates strong incentives to manipulate the spot price
- Easy to do with short notice transactions and reschedules
- Difficult for ISO to establish reliable, stable, feasible schedule

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# Spot-Price System is Problematic

- 5-min LP optimization inconsistent with day-ahead optimization
  - intertemporal constraints
  - allowance for forecast errors
- Not being paid for day-ahead commitments
  - peak prices are biased too low
  - disadvantages flexible resources
- Absence of demand-side bidding biases prices too high

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# Day-Ahead Energy Market is Less Efficient with Single Settlement

- Encourages self-scheduled bilateral contracts
- ISO left to manage real-time balancing and reserves
  - physical feasibility will be more precarious
  - real-time balancing will be more difficult
  - spot price will be more volatile
- Harms efficiency of bilateral contracting and electricity market

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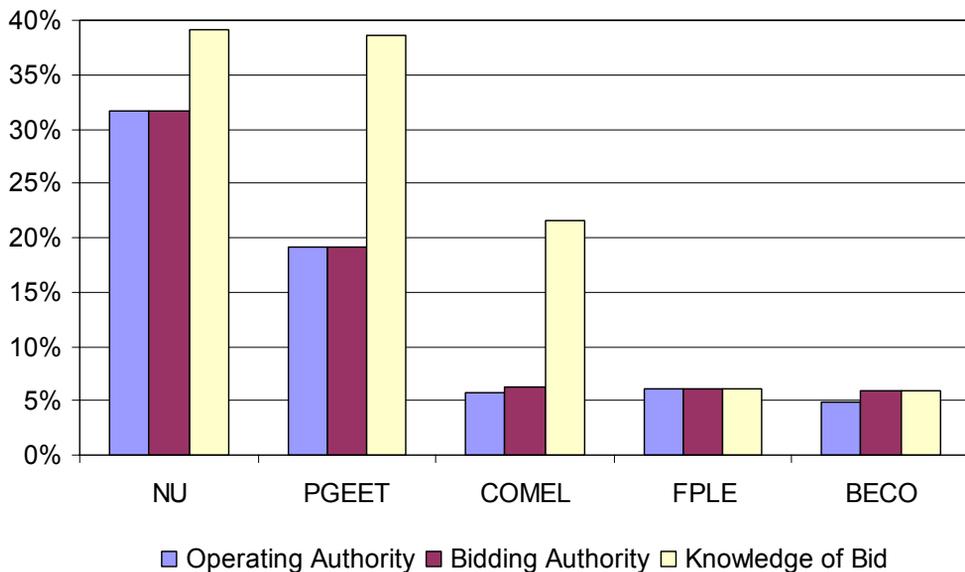


# Reveal Market Prices Only

- Risk of tacit collusion
  - Top-two firms control over 50% of market; 65% of bid knowledge
  - Hydro, TMSR, AGC are even more concentrated
  - Market is repeated daily
- Efficiency gains from extra information not too large
- Establish independent market surveillance committee with access to all bids
  - Can make reports and recommendations without approvals from the ISO or NEPOOL
- Have plan in place for analyzing bids to identify market power problems

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## Market Shares of Largest Bidders *All Generation*



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## *Recommendation #4* Adopt Location-Based Congestion Pricing

- Location-based pricing needed for short-run efficiency
  - Especially regarding imports/exports
  - Reduced gaming
- Improved incentives for generation and transmission siting and expansion
- More stable spot price

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## Absence of Location-Based Congestion Pricing is Inefficient

- Don't pay costs you impose on system
- Especially a problem for imports/exports
- Paying out-of-merit-order generators their bids invites gaming
  - Distort bids to get constrained-on payments
- Poor incentives for location of new generation/transmission

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## Eliminate Installed and Operable Capability Markets

- Incentives for capacity are provided by energy and reserve markets
- Installed capacity market does not appear to be an effective capacity planning tool
- Operable capability market ineffective in avoiding gaming of maintenance schedules
- If installed capability market is retained, desirable to allow iterative bidding

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## Set Firm Date for ISO Independence

- Reliance on NEPOOL to devise and submit amendments to FERC will be cumbersome and subject to dispute
- In first months of operation, amendments often will be necessary
  - California and PJM experience

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# Background

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## Ten-Minute Spinning Reserve

- Full requirements market
  - All TMSR is traded through ISO market
- Hourly bids (\$/MW) submitted day-ahead
- TMSR selected to minimize total costs
- Ex post settlement: payment = bid + 2×  
max {0, energy spot price – energy bid}  
plus energy spot price for energy delivered
- Only hydro can bid, others bid 0

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# Ten-Minute Non-Spinning Reserve

- Full requirements market
  - All TMNSR is traded through ISO market
- Hourly bids (\$/MW) submitted day-ahead
- TMNSR selected to minimize total costs
- Ex post settlement: payment = clearing price plus energy spot price for energy delivered

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# Thirty-Minute Operating Reserve

- Full requirements market
  - All TMOR is traded through ISO market
- Hourly bids (\$/MW) submitted day-ahead
- TMOR selected to minimize total costs
- Ex post settlement: payment = clearing price + energy spot price for energy delivered

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# Automatic Generation Control

- Full requirements market
  - All AGC is traded through ISO market
- Hourly bids (\$/reg) submitted day-ahead
- AGC selected to minimize total costs
- Ex post settlement: payment = clearing price + opportunity cost + production change + energy spot price for energy delivered

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# Installed Capability Market

- Residual market
  - Only difference between resources and obligations traded
- Monthly bids (\$/MW-month) submitted month-ahead
- Ex post settlement: payment = clearing price

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# Operable Capability Market

- Residual market
  - Only difference between resources and obligations traded
- Hourly bids (\$/MW) submitted day-ahead
- Ex post settlement: payment = clearing price

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## Settlement Systems in Practice

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# PJM

- Single settlement system
  - supply-side and demand-side bidding
  - tentative scheduling done day ahead
  - real time Locational Marginal Prices (LMPs) determined for each node every 5 minutes.
- Plans to move to a multi-settlement system with day-ahead and hour-ahead markets in addition to the real time spot market

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# New York ISO

- Proposed Multi-settlement system
  - Supply-side and demand-side bidding
  - Bids for energy only
  - Day-ahead and real time markets with binding Location Based Marginal Prices (LBMPs)
  - Hour-ahead balancing market settled at the real time LBMP

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# California

- California ISO
  - Real time market for energy
  - Day-ahead and hour-ahead markets for ancillary services
    - Supply-side bidding only
    - Multi-settlement system: day-ahead and hour-ahead contracts are financially binding
  - Real time market for zonal transmission congestion charges
- California PX
  - Day-ahead energy market
    - Supply-side and demand-side bidding
    - Forms a multi-settlement system along with ISO real time market
  - Plans to offer an hour-ahead energy market
- Automated Power Exchange
  - Market for energy futures
    - Supply-side and demand-side bidding
    - Bids placed for specific hours in the week ahead

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## National Grid Company (England and Wales)

- Single settlement system
  - Day ahead bidding
  - Startup and no-load components accepted
  - Single settlement at the real time price
  - No demand-side bidding
  - Most transactions are hedged with Contracts for Differences (CfDs)
- Plans to move to a multi-settlement system<sub>38</sub>

# National Grid Company (England and Wales)

- Planned multi-settlement system
  - Day-ahead market
  - Four-hour-ahead market
  - “The core elements address the fundamental concerns of customers and others. They would address the current distortions that work against flexible generation plant and in favour of other plant, and help to provide a level playing field between different fuel sources.”

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## Nord Pool (Norway and Sweden)

- Single settlement system
  - Spot market (Elspot)
    - supply-side and demand-side bidding
    - scheduled day-ahead
  - Forward market (Eltermin)
    - run by Nord Pool
    - purely financial

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# Alberta Power Pool

- Single settlement system
  - Supply-side and demand-side bidding
  - Scheduling is done a day in advance
  - hourly pool price is calculated from actual dispatch orders

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## Ontario

- Proposed voluntary fully operational day-ahead market in addition to the spot market
- Hour ahead market to be introduced if the day-ahead market is successful
- Supply-side and demand-side bidding

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