



Hydroelectric Facilities and Power Markets



*DRBC Regulated Flow Advisory Committee Meeting
February 16, 2017*

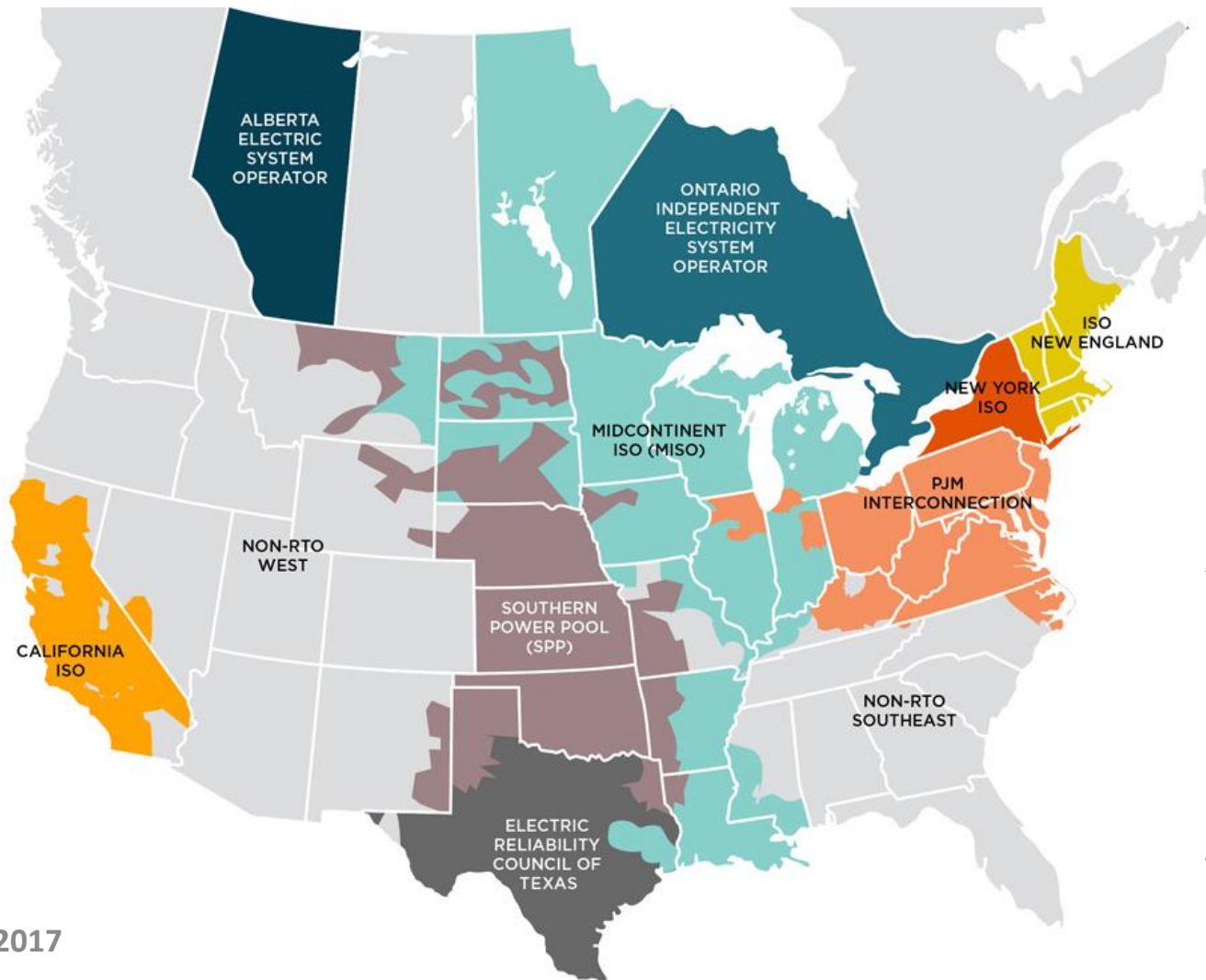
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*Presented to the DRBC Regulated Flow Advisory Committee on Feb. 16, 2017.
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Regional Power Markets Overview

Nine regional power markets (Independent System Operators or Regional Transmission Organizations) in North America

- Delaware River watershed is in NYISO and PJM



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Functions of the ISO/RTO

NYISO lists reliability first, followed by open and fair competitive wholesale markets:



(source: NYISO stakeholder training slide)

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Wholesale market components

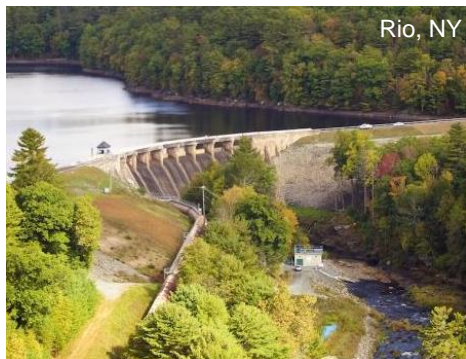
<i>Energy</i>	Market based on cost of next MWh of generation needed in that location
<i>Ancillary Services</i>	
<i>Regulation/Frequency Response</i>	Market-based service automatically following demand on 5-6 second basis
<i>Reserves</i>	Market-based service for backup power in standby mode
<i>Black Start</i>	Cost-based service to restore grid from blackout
<i>Reactive Power/Voltage Support</i>	Cost-based service to ensure consistent voltage on grid
<i>Capacity</i>	Market to ensure sufficient inventory of power plants on long-term basis
<i>Local Reliability</i>	(not really a market component) Allows local utility to request support outside market

Types of Hydroelectric Facilities



Run-of-River

- Majority of small hydro
- No authority to alter elevation of upstream pond, so power output is dependent on instantaneous river flow
- Also includes “run-of-reservoir” such as proposed facilities on NYCDEP reservoirs (pond level control is for other purposes; hydro has no authority to control pond for energy purposes)
- Act as price takers in energy and capacity markets; operations not influenced by market conditions



Dispatchable

- Also known as Ponding or Storage (not to be confused with Pumped Storage)
- Varying levels of storage in reservoir; could be a few hours to weeks worth of operation
- Includes Wallenpaupack and Mongaup River System
- Submit bids into energy, ancillary service, and capacity markets; dispatched by regional system operator (NYISO or PJM)



Pumped Storage

- Like Dispatchable but with ability to use electricity to pump water back upstream

Dispatchable Facility Market Participation

Capacity Market

- Facility offers at a price into auction
- If offer is accepted, facility incurs an obligation to offer energy at a reasonable price into energy market every day

Day-Ahead Energy and Ancillary Market

- Facility offers energy and regulation and standby capabilities hourly for all of next operating day
- System operator selects offers from participants based on “co-optimization” for lowest cost to meet total system energy, regulation, and reserves needs
- Facilities selected have obligation to produce or be available at similar offer price in real time

Real-Time Energy Market

- Facilities committed in Day-Ahead market can be dispatched above or below Day-Ahead schedule based on balance of supply and demand

Real-Time Ancillary Services

- Regulating facility output controlled by system operator within a band on 5- or 6-second signal
- Reserves facilities called upon in case of system contingency

Dispatchable Hydro Energy Market Participation

Fossil fuel facilities energy bids generally based on marginal operating cost

- Fuel, other consumables, maintenance based on run time (fuel is the largest of these costs)

Does this apply to hydroelectric facilities with zero fuel cost?

Run-of-River: Yes
(up to water available)

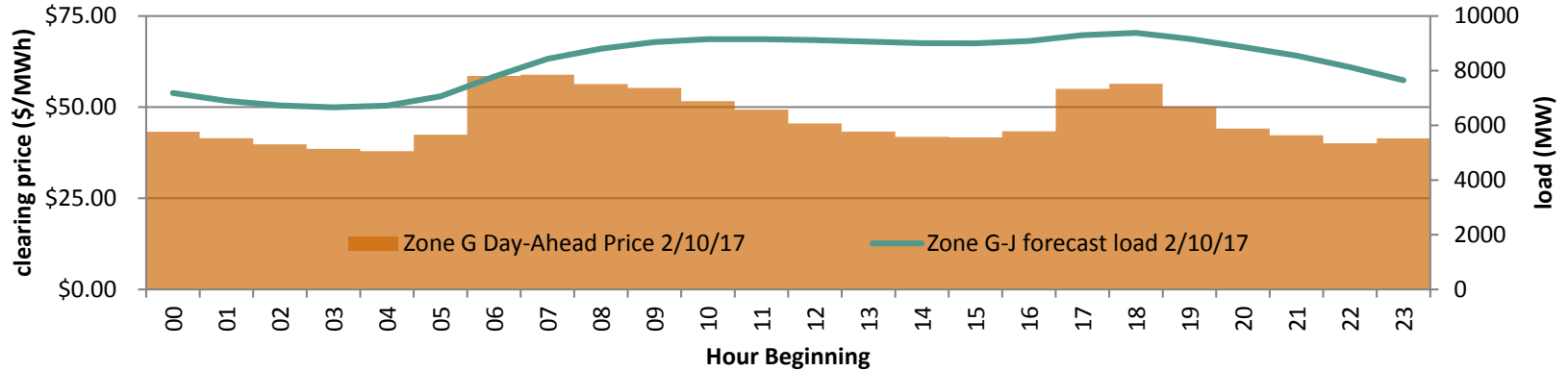
Dispatchable: No
(need to add *opportunity cost*)

Dispatchable hydro bids are based on opportunity cost and are therefore not at bottom of supply curve like run-of-river hydro, solar, wind, etc.

- Unlike fuel-based plants, storage hydro has a fixed amount of potential generation for the year; opportunity cost is the value of using that fixed amount of water at a time other than now
- Opportunity cost is based on amount of water in storage, available space in storage, expected inflows into storage, expected future market pricing, etc.

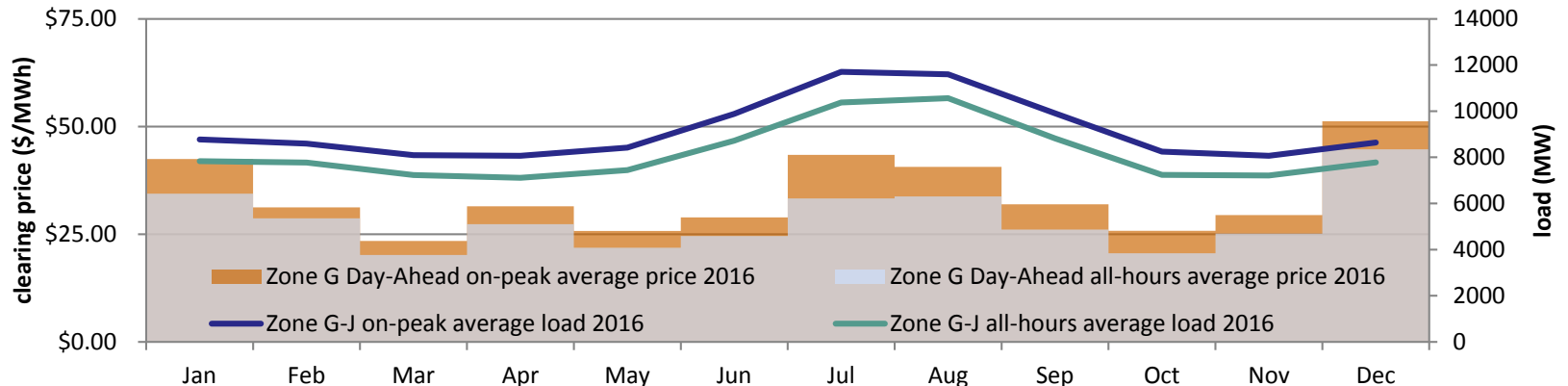
Energy Pricing Examples

Energy pricing varies during the day based on demand



- What if generator offers energy at \$50/MWh? Offer accepted for 8 hours on 2/10

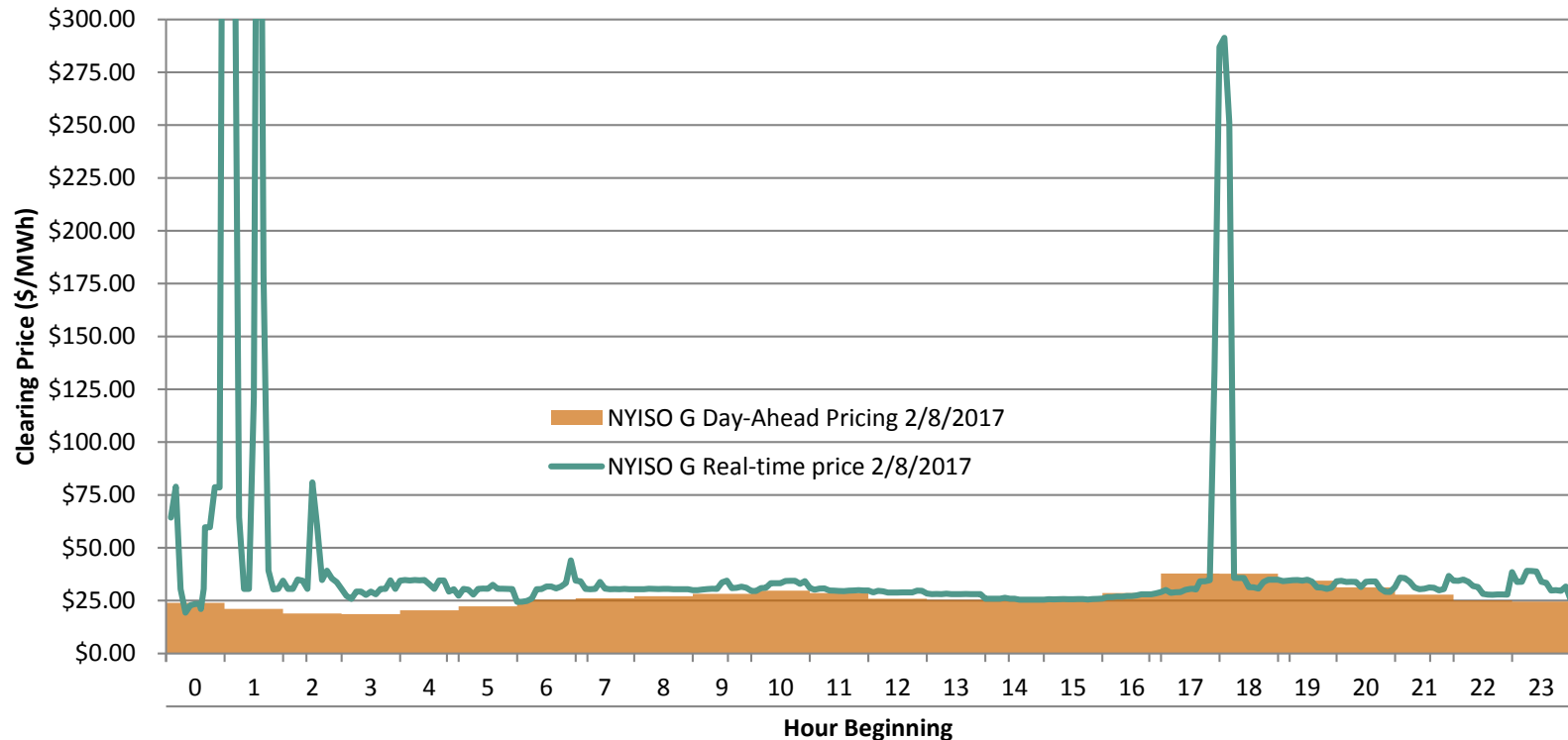
Energy Pricing also varies seasonally



Real-Time Energy Pricing

While Day-Ahead energy pricing may be fairly predictable based on weather, real-time pricing responds to unforeseen events

- Either divergence between actual and forecast load or problems with generation or transmission in real time



- What if generator is offered at \$50/MWh in Real-Time market?

Local Reliability Support

NYISO and PJM dispatch ensures reliable operation of bulk electric grid

Certain parts of grid are not centrally controlled

- Distribution network; certain radial transmission lines controlled by local utility

Utility has ability to request generation “out of merit”

- System operator will dispatch generator at local utility request even if otherwise not part of economic market solution

Mongaup River System located on a radial portion of ORU 69 kV transmission

- In certain maintenance or outage situations, local generation is required for contingency support

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Hydro dispatch vs. other fuel types

Primary characteristics driving dispatch of main fuel types:

Natural Gas

- Marginal cost depends on gas price; highest in extreme cold
- Able to ramp up and down and provide ancillary services

Coal

- Relatively stable marginal cost
- Slow ramping; not suited for load following

Nuclear

- Very low marginal cost
- Slow ramping; not suited for load following

Hydro

- Marginal cost weather related but not correlated with gas
- Able to ramp up and down and provide ancillary services

Comparison of Hydro vs. Natural Gas:

Hydro runs when:

- energy pricing is higher than expected near to medium term future pricing (Dec-Feb; Jul-Aug)
- Water is abundant (Apr-May)

Natural Gas runs when:

- Energy price is at a relative high compared with gas price (if gas is marginal fuel as in PJM and NYISO, gas-fired facilities produce year round)

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