

Electricity Markets: Sectors in Transition



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AQPER 2019 Symposium

Electricity Markets: Sectors in Transition

1. Electricity Market Trends
2. Challenges and Opportunities in North American Electricity Markets
3. Potential Implications for Québec

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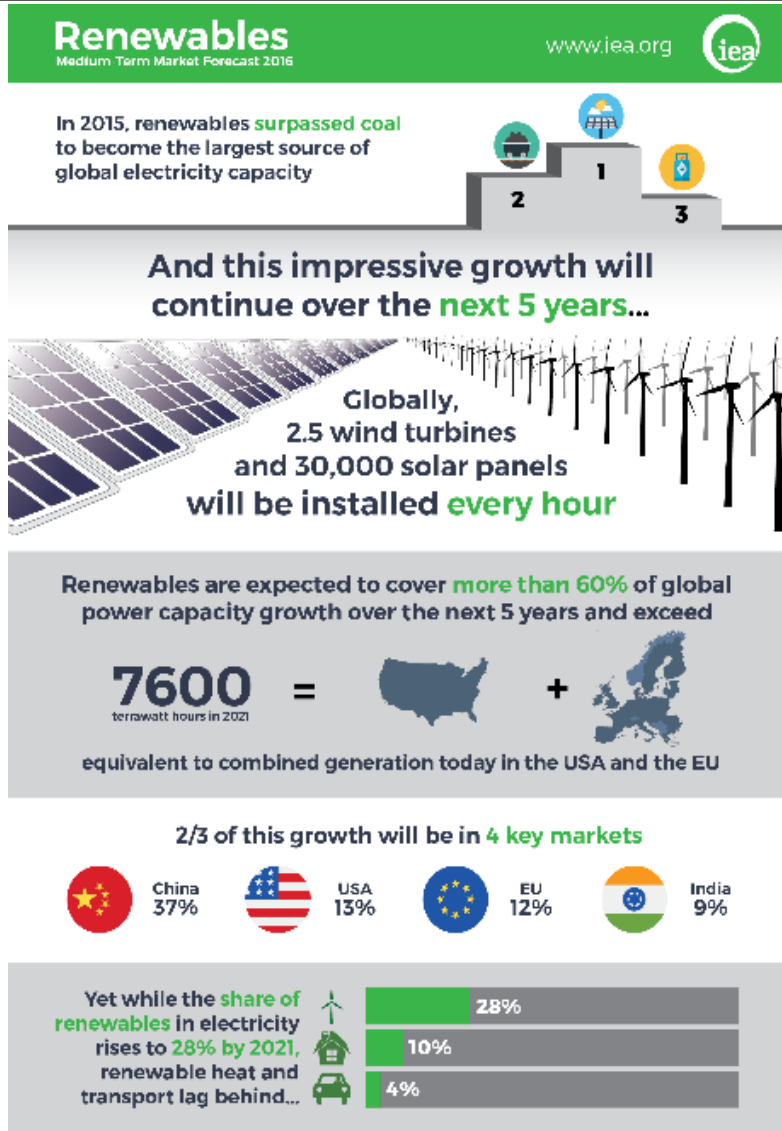
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1. Electricity Market Trends

Increasing Renewable Energy Supply

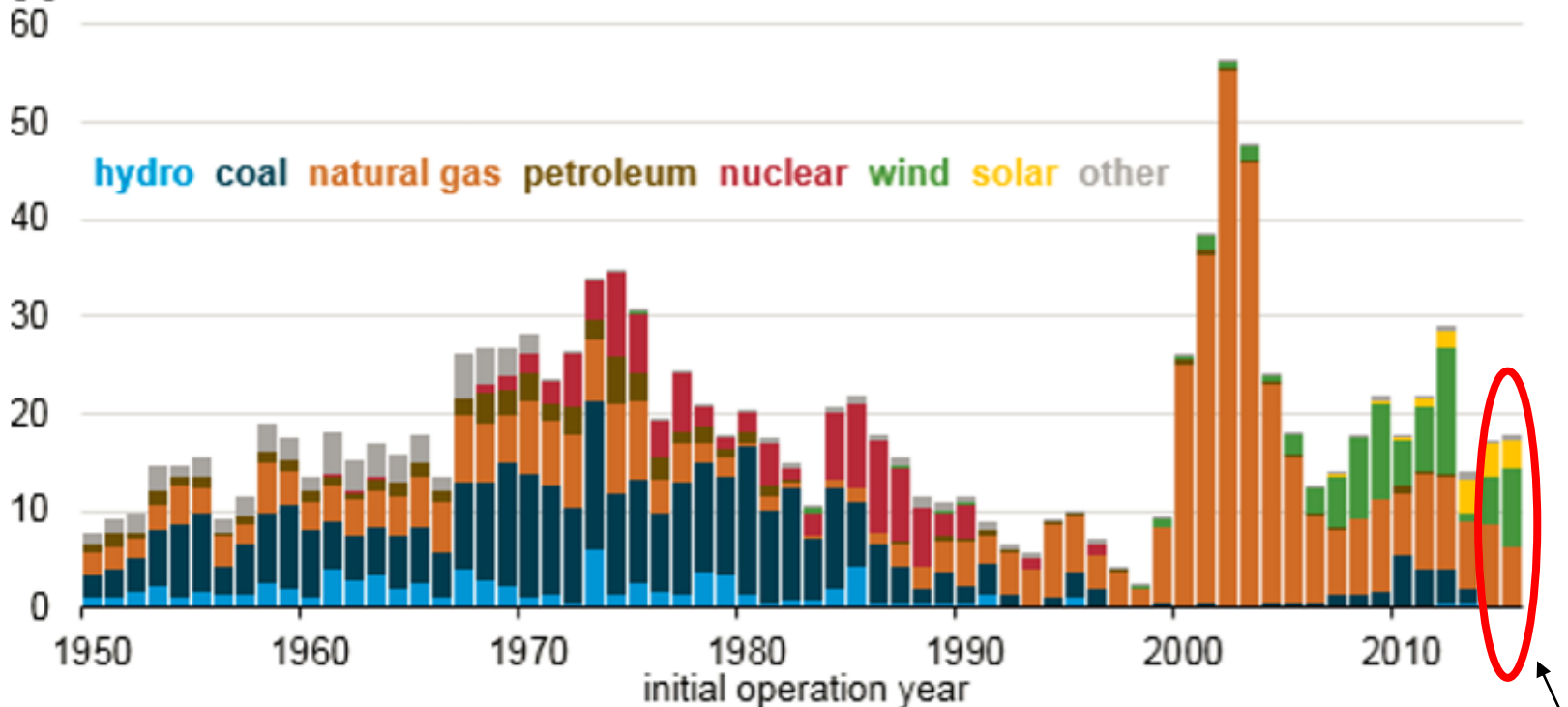


- Renewable energy growing faster than other resources, costs becoming competitive with fossil-fuel generators (International Energy Agency (IEA))
- Renewable energy projects will account for half of growth in global supply over next 20 years
- Changing supply mix towards renewable energy will force changes to wholesale electricity markets

Increasing Renewable Energy Supply

Electric generation capacity additions by technology (1950-2015)

gigawatts

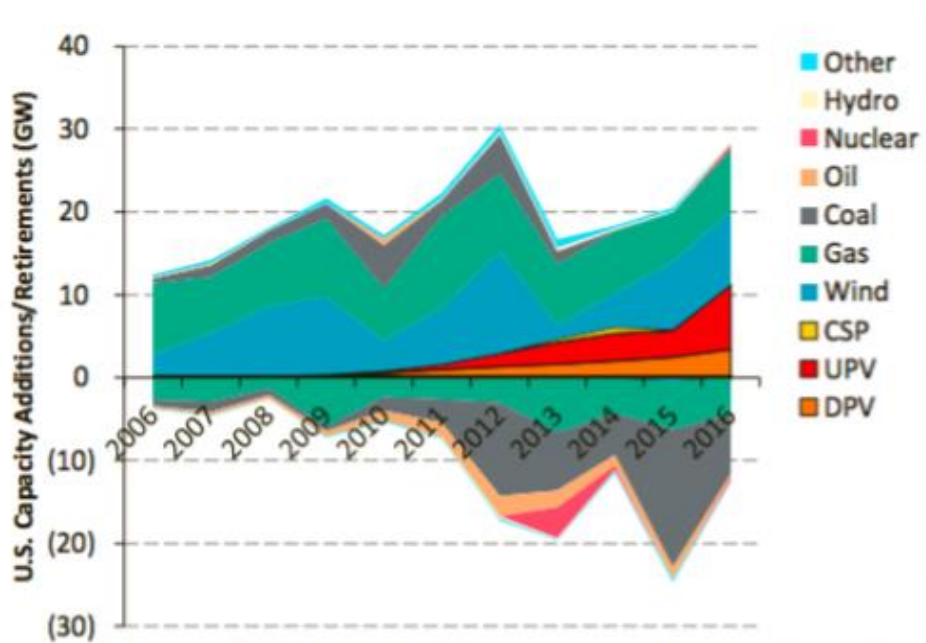


2015: gas fell to second place behind wind / solar – new era in US capacity additions.

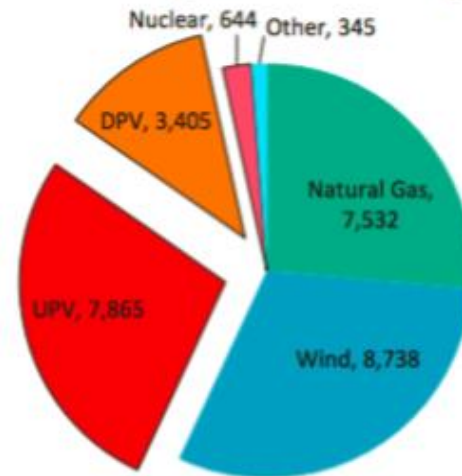
- US supply trends: coal (1950s-1980s); nuclear (1970s-1980s); natural gas (1990s-2000s); renewables (2010s+)



Increasing Renewable Energy Supply



U.S Generation Capacity Additions, 2016 (Total 28.5 GW)

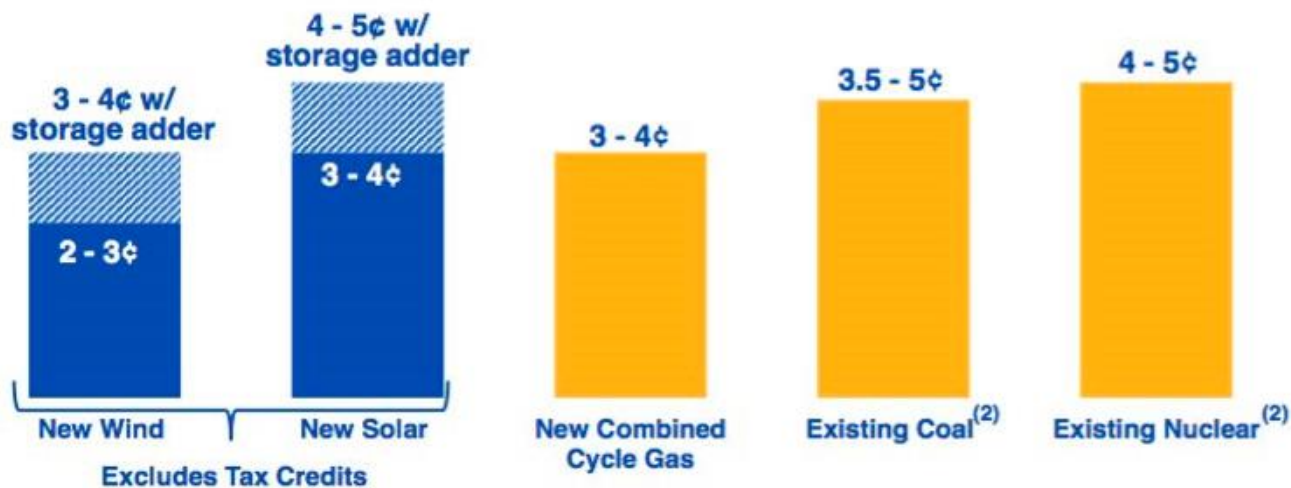


- In 2016, for the first time in U.S. history, solar was the largest source of new electricity generation capacity, with approximately 40% of all new generation capacity.
- Wind and solar combined for 70% of new generation.

- Increasing wind and solar energy supply partially driving increasing energy storage development

Supply Resource Cost Projections – NextEra Energy June 22, 2017 Investor Conference

Estimated Costs of Generation Resources Post – 2020⁽¹⁾ (cents/kWh)



Wind and solar combined with storage to firm and shape production is expected to compete economically with other generation in the next decade

- Some U.S. jurisdictions project wind and solar energy plus storage to be cost competitive with other supply, projecting to continue increasing development of these supply resources

Xcel Energy RFP – Announced Results (December 2017)

RFP Responses by Technology

Generation Technology	# of		# of	Project	Median Bid	
	Bids	Bid MW			Projects	MW
Combustion Turbine/IC Engines	30	7,141	13	2,466	\$ 4.80	\$/kW-mo
Combustion Turbine with Battery Storage	7	804	3	476	6.20	\$/kW-mo
Gas-Fired Combined Cycles	2	451	2	451		\$/kW-mo
Stand-alone Battery Storage	28	2,143	21	1,614	11.30	\$/kW-mo
Compressed Air Energy Storage	1	317	1	317		\$/kW-mo
Wind	96	42,278	42	17,380	\$ 18.10	\$/MWh
Wind and Solar	5	2,612	4	2,162	19.90	\$/MWh
Wind with Battery Storage	11	5,700	8	5,097	21.00	\$/MWh
Solar (PV)	152	29,710	75	13,435	29.50	\$/MWh
Wind and Solar and Battery Storage	7	4,048	7	4,048	30.60	\$/MWh
Solar (PV) with Battery Storage	87	16,725	59	10,813	36.00	\$/MWh
IC Engine with Solar	1	5	1	5		\$/MWh
Waste Heat	2	21	1	11		\$/MWh
Biomass	1	9	1	9		\$/MWh
Total	430	111,963	238	58,283		

- Xcel Energy (Colorado) 2017 Request for Proposals (RFP) received responses for wind, wind+solar, wind+storage, and wind+solar+storage, etc.

Hawaiian Electric Co. RFP – Announced Results (October 2018)

Solar

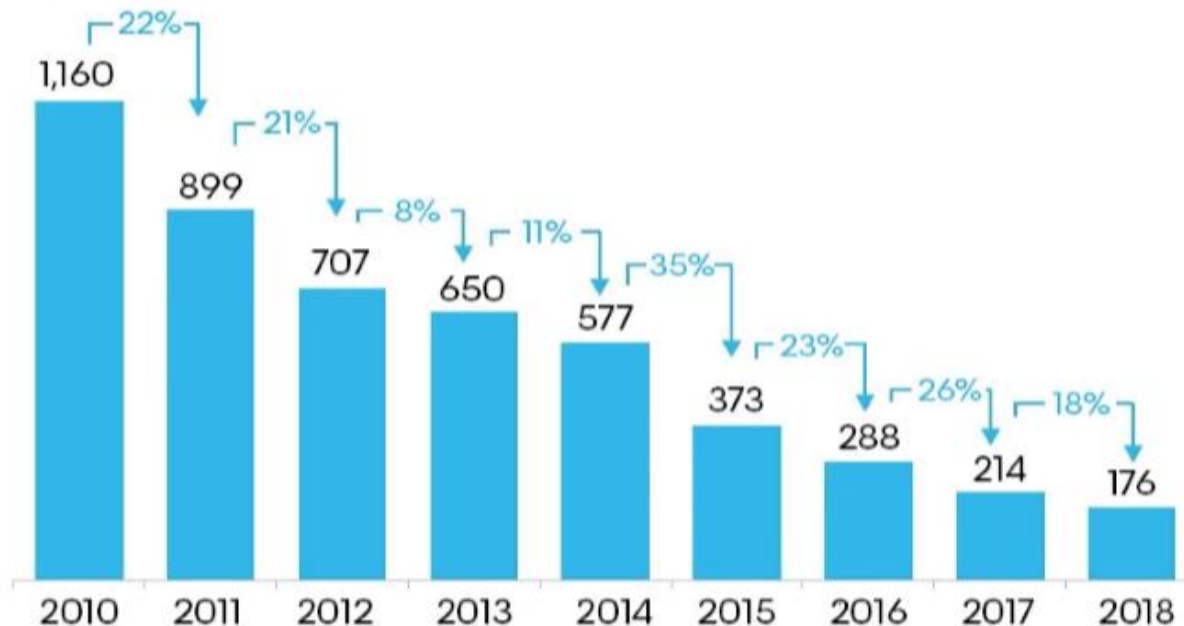
Project name	Island	Developer	Size	Storage	Cost per KWh
Waikoloa Solar	Hawai'i	AES	30 MW	120 MWh	\$0.08
Hale Kuawehi	Hawai'i	Innergex	30 MW	120 MWh	\$0.09
Kuihelani Solar	Maui	AES	60 MW	240 MWh	\$0.08
Paeahu Solar	Maui	Innergex	15 MW	60 MWh	\$0.12
Hoozana	O'ahu	174 Power Global	52 MW	208 MWh	\$0.10
Mililani I Solar	O'ahu	Clearway	39 MW	156 MWh	\$0.09
Waiawa Solar	O'ahu	Clearway	36 MW	144 MWh	\$0.10

- Hawaiian Electric Co. set records for lowest solar+storage
 - Range of \$8/MWh to \$12/MWh (\$US) for solar+storage projects

Energy Storage Cost Declines – Trending Similar to Solar Cost Declines

Lithium-ion battery price survey results: volume-weighted average

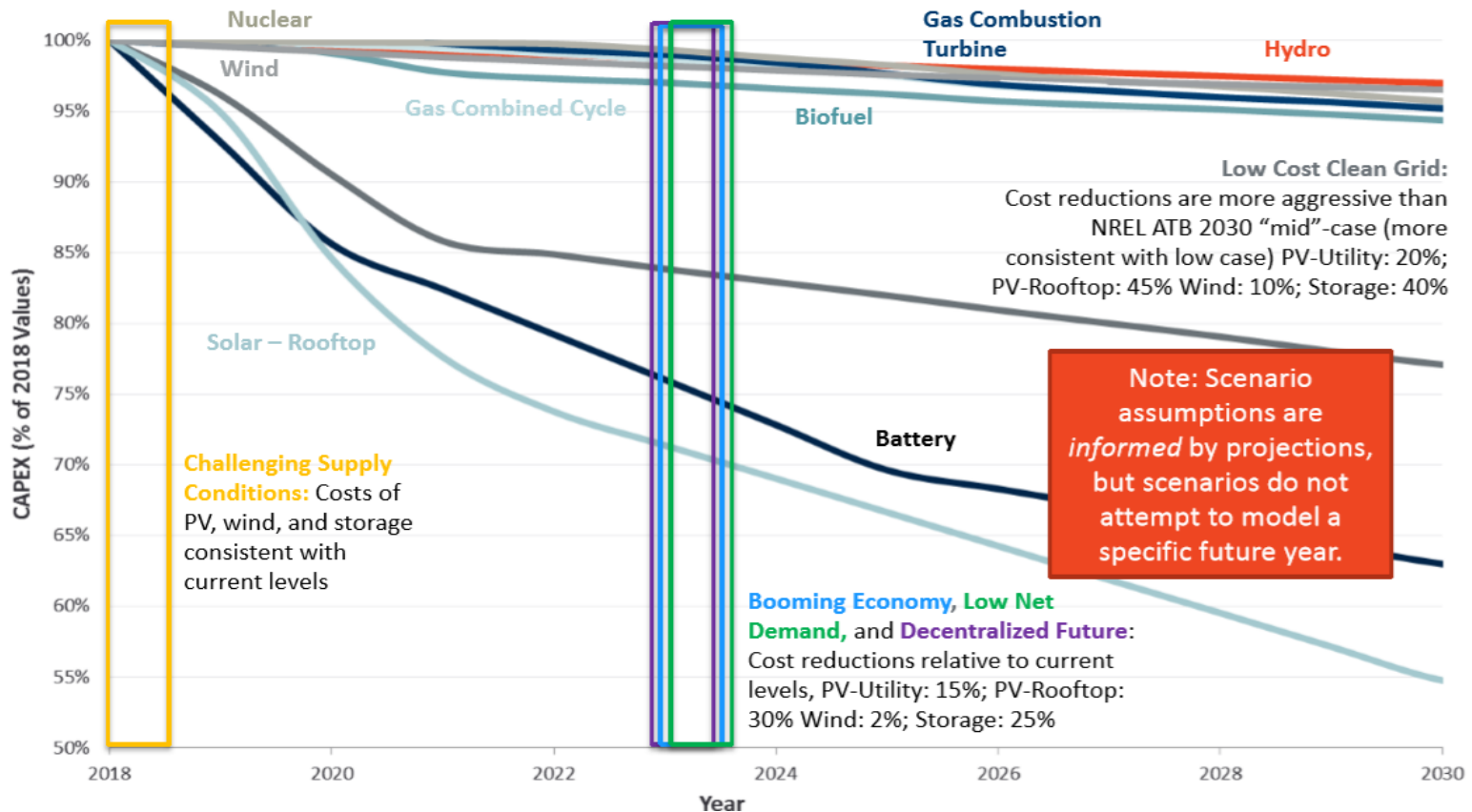
Battery pack price (real 2018 \$/kWh)



Source: BloombergNEF. Note: The data in this chart has been adjusted to be in real 2018 dollars.

- Costs of energy storage technologies (e.g., lithium-ion) declining dramatically, and projected to continue declining in future

Declining Costs – Solar, Storage, etc.



NREL 2018 Annual Technology Baseline http://www.nrel.gov/analysis/data_tech_baseline.html.

- Projections of declining costs (especially solar and battery storage) used by Ontario IESO to model different future market scenarios

2. Challenges and Opportunities in North American Electricity Markets

Government Policies, Regulatory Reforms, and Wholesale Markets – Need to Evolve Based on Changing Supply Mix



Emerging issues without present consensus

1. Are markets adequately accommodating public policy goals? What regulatory and market design changes would further enable deployment of resources that achieve goals of reliability, affordability, innovation, resource mix?
2. What are the market impacts of environmental regulations that further constrain deployment of needed resources?
3. What are the market impacts of integrating higher levels of non-emitting and distributed resources?
4. Are today's markets and regulatory frameworks adequately designed to acquire needed resources to better integrate multiple resources (e.g., distributed resources)?

Government Policies, Regulated Markets, Wholesale Electricity Markets – Balancing Innovation within Fundamental Changes

Alberta

- Coal-fired generation closure by 2030
- REP Round 1 to 3 – ‘cheap’ contracted wind generation
- Capacity Market planned implementation for 2020

Ontario

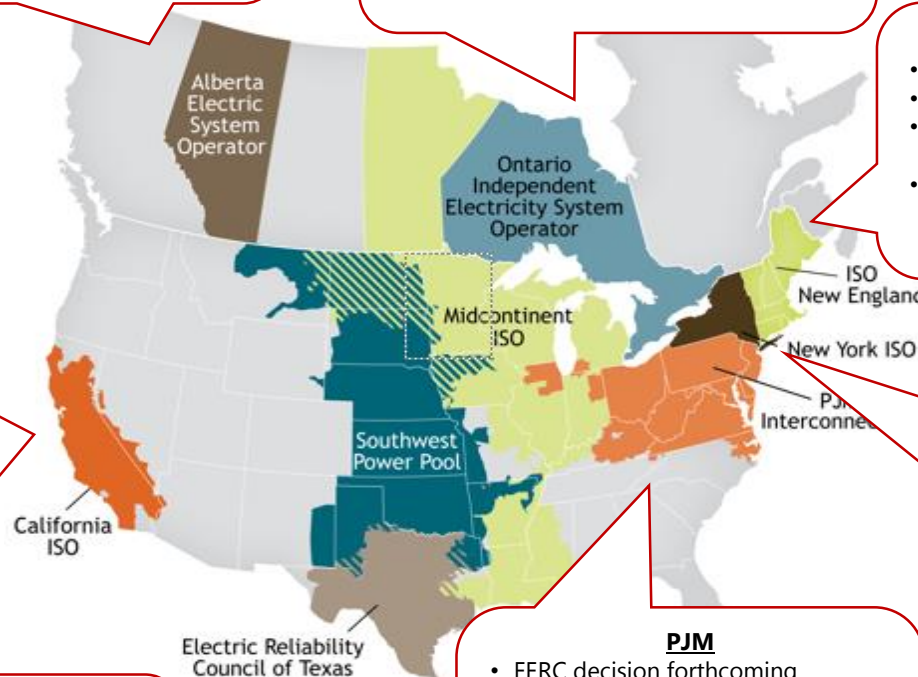
- Market Renewal Program (Locational Marginal Pricing, Day-Ahead Market, Capacity Market)
- OEB Modernization Review Panel

New England

- Aggressive state targets for renewables
- Relatively high customer rates
- Controversial FERC approved changes to Capacity Market
- Likely FERC approval for controversial ‘out of market’ contract for reliability-based generation

California and Southwest U.S.

- Aggressive state policies (e.g., renewables, innovation, etc.)
- Dialogue to expand Energy Imbalance Market (EIM) across multiple states
- Significant penetration of Distributed Energy Resources (DERs), causing review of regulatory frameworks (e.g., rate design, etc.) and wholesale market design



Texas

- Shortage pricing through Operating Reserve Demand Curve and very high Maximum Market Clearing Price (\$9,000/MWh)

PJM

- FERC decision forthcoming regarding ‘out of market’ payments to nuclear and coal-fired generation and impacts to wholesale markets
- PJM following New England’s lead with proposed Capacity Market changes

3. Potential Implications for Québec

Québec and Electricity Markets in Transition



- Relatively low electricity rates for Québec customers
 - Majority from Hydro-Québec (HQ) patrimonial supply
- Despite technology improvements and declining costs for solar, storage, etc., slower uptake in Québec
- Exports from Québec to US markets to continue ... but will face competition as costs of wind, solar, storage continue declining
 - e.g., competition from off-shore wind energy projects
- Québec has winter supply needs, opportunities for Independent Power Producers (IPPs)
 - Especially if New England Clean Energy Connect transmission project built
- IPPs with expiring Power Purchase Agreements (PPAs) with HQ need to be aware of supply options



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