ROBINSON BOWMAKER PAUL

Ontario Pathways to Decarbonization

Neighbouring Jurisdictional Review

May 10, 2022

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Contents

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Glossary

ATC – Around-the-clock
BESS – Battery Energy Storage System
BTM – Behind the meter
CAD – Canadian dollar
Client – Refers to Independent Electricity System Operator
CES – Clean Energy Standard
CHPE – Champlain Hudson Power Express
CLCPA – Climate Leadership and Community Protection Act
CO_2 – Carbon dioxide
COD – Commercial online date
CPNY – Clean Path New York
DA – Day-Ahead (Market)
DC – Direct Current
DEFR – Dispatchable emission-free resource
EV – Electric Vehicle
GHG – Greenhouse gas
HQ – Hydro Québec
HVDC – High Voltage Direct Current
IESO – Independent Electricity System Operator
IRP – Integrated Resource Plan
ISO – Independent system operator
ISO-NE – New England Independent System Operator
LMP – Locational marginal pricing
MH – Manitoba Hydro
MISO – Midcontinent Independent System Operator
NECEC – New England Clean Energy Connect
NREL – National Renewable Energy Laboratory
NYISO – New York Independent system operator
NYSERDA – New York State Energy Research & Development Authority
OSW – Off-Shore Wind
PA – PA Consulting Group Inc.
PG&E – Pacific Gas & Electric
PJM – Pennsylvania - New Jersey - Maryland Interconnection, LLC
PRD – Price responsive demand
REC – Renewable Energy Credit
REV – Reforming the Energy Vision
RGGI – Regional Greenhouse Gas Initiative
RPM – Reliability Pricing Model
RT – Real-Time (Market)
RTO – Regional transmission organization
SUFG – State Utility Forecasting Group
USD – US Dollar
ZEV – Zero emissions vehicle

01

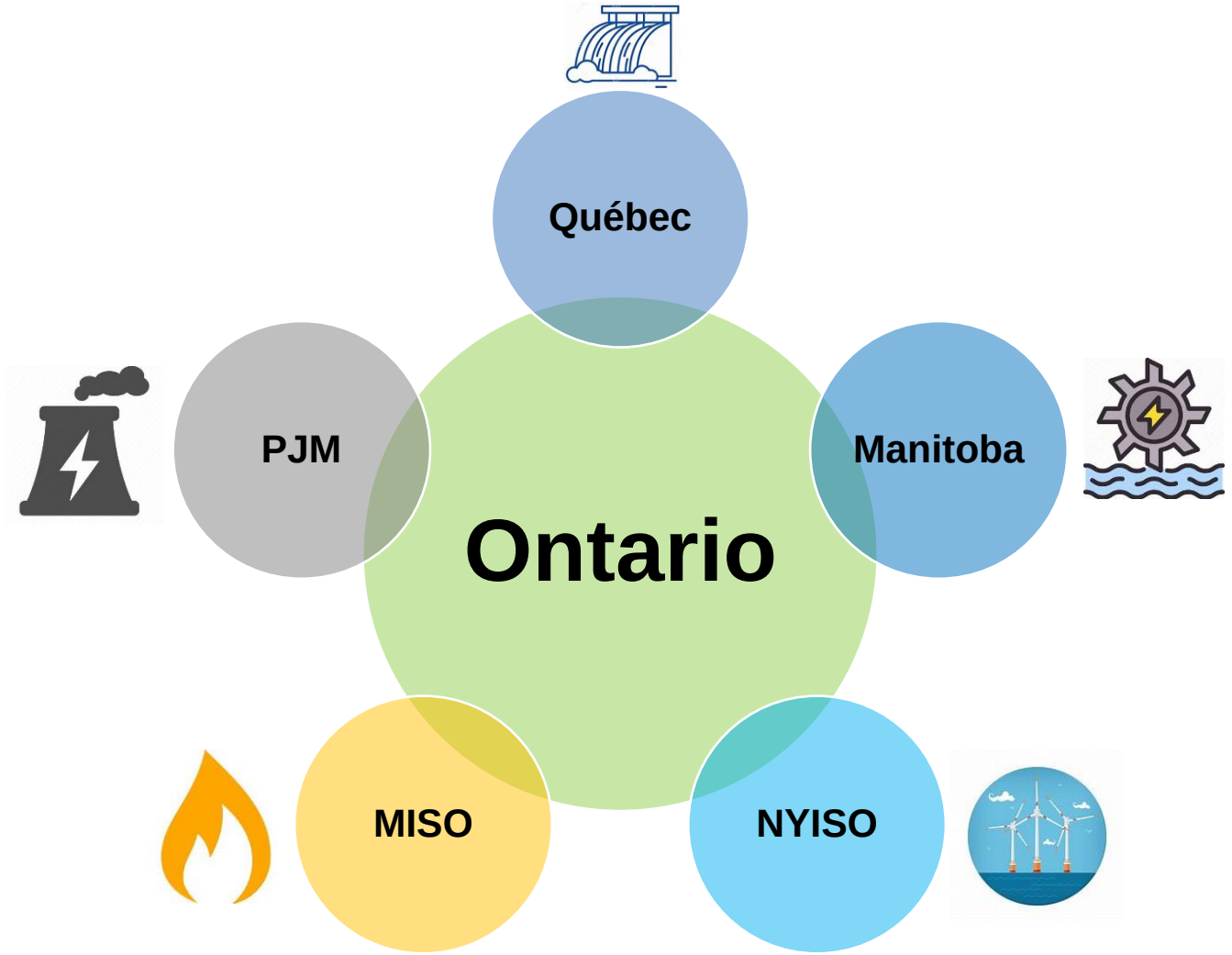
Executive Summary

Our Scope of Work

As part of the Pathways to Decarbonization initiative, the IESO would like to better understand the clean energy transition in Ontario's neighbouring jurisdictions and their ability to export clean energy.

The goals of this study provide a better understanding of neighbouring jurisdictions, at a high level, based on publicly available information:

- Where Ontario's neighbours see themselves in the future in terms of a decarbonized grid and the associated generation mix,
- Overview of the policies that are driving that future, and
- Planned export goals.

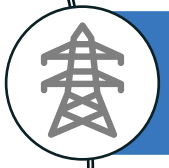


Key Takeaways

Given Manitoba and Québec's export commitments and load growth, clean energy exports are likely to decline until new capacity is built. Provincial renewable firming will take precedent potentially decreasing Ontario's opportunities.

New York state has played a lead role in clean energy policy, with a legislative target of 100% net-zero by 2045 for the power sector. The state will likely need all available clean energy MWs to help meet this target, but there could be excess supply at times of high generation/low load that could be exported to adjacent markets (such as Ontario).

PJM and MISO lag New York in terms of state-level clean energy policies and are expected, based on publicly available information, to still have significant amounts of fossil fueled power generation on their systems well into the 2030s making them unattractive for clean energy imports.



Load growth and supply commitments to U.S. HVDC transmission lines (e.g., NECEC and CHPE) is likely to decrease export flows from Québec and wheel-throughs via Ontario until Hydro-Québec builds new wind (3 GW by 2026) and hydro (2 GW by 2035). Hydro-Québec may seek to add more capacity in the late 2020's.

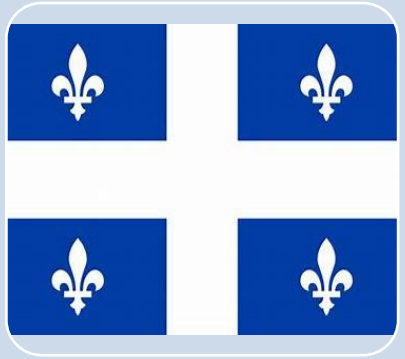
Interties between markets will play an important role in the future reliability of electric grids, as intermittent renewable generation increases and dispatchable thermal generation decreases. This will require new policy to incent deeper inter-regional integration and the associated transmission upgrades.

Manitoba Hydro's IRP is currently in progress, and while draft materials are not yet available the IRP is expected to promote clean energy sources of generation, electrification and energy efficiency consistent with the province of Manitoba's 2040 Strategy and its five pillars.

Strong policy at the federal and provincial/state level is needed to drive deeper integration across regions as well as potentially create a new regional body, that is unincumbered by the past, that oversees planning in collaboration with ISOs so as drive efficient investments and minimize regional system costs.

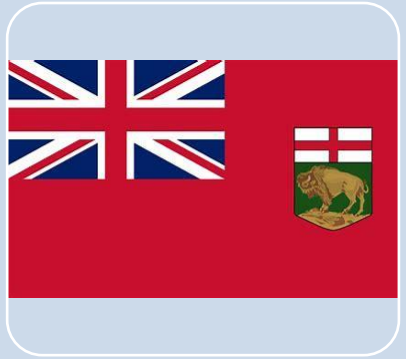
Clean Energy Policy

Policy is a key driver behind most decarbonization initiatives. Québec and Manitoba have over 90% clean energy and seek to decarbonize the economy while U.S. regions also need policy to firstly decarbonize their electricity grids.



Québec

- Economy-wide GHG emissions reduction of 37.5% by 2030 (vs. 1990)
- 2050 Carbon Neutrality
- HQ to convert 80% of it's off grid systems to carbon neutral sources by 2030



Manitoba

- 5 Pillar Strategy 2040,
  - Safe, Reliable Energy
  - Efficient, Digital Customer Service
  - Customer Choice
  - Maximize Clean Energy Value
  - Minimize Prices

NYISO

- Economy-wide GHG emissions reduction of 40% by 2030 (vs. 1990)
- 70% renewable energy by 2030
- Carbon neutral electricity grid by 2045
- Statewide net zero emissions by 2050

MISO

- State level clean energy policies are relatively weak
- Illinois leads the way with 2045 net zero electricity grid and statewide carbon neutrality by 2050
- Some states working via Public Utility Commission

PJM

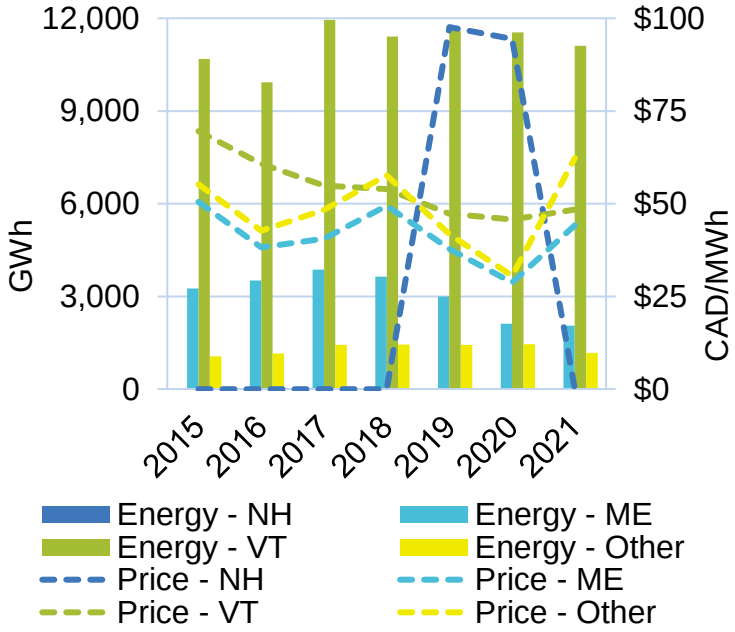
- Besides Illinois, Virginia has committed to carbon neutrality by 2050
- Maryland and New Jersey have more modest targets of 50% renewable energy by 2030

Inter-regional Power Flows

- Hydro-Québec and Manitoba Hydro's Export Revenues totaled CAD 1.6 B in 2021 and 611 M in 2021, respectively.
- In 2021, Hydro-Québec's total revenues were CAD 14.5 B and export revenues made up only ~11.4% but contributed to 32% of total net income further highlighting the value of exports.
- Hydro-Québec needs new capacity in the late 2020's and plans to build 3 GW of wind by 2026 and 2 GW of hydro by 2035.
- Hydro-Québec envisions procuring more capacity in the late 2020's.
- Surplus clean energy exports from Québec that may be available to Ontario are expected to decline in the coming years until new capacity is built.
- Manitoba is not expected to have substantial excess clean energy as significant capacity is not expected to be added.

[1] Source: Canada Energy Regulator, Electricity Trading – Tables 3A and 3B

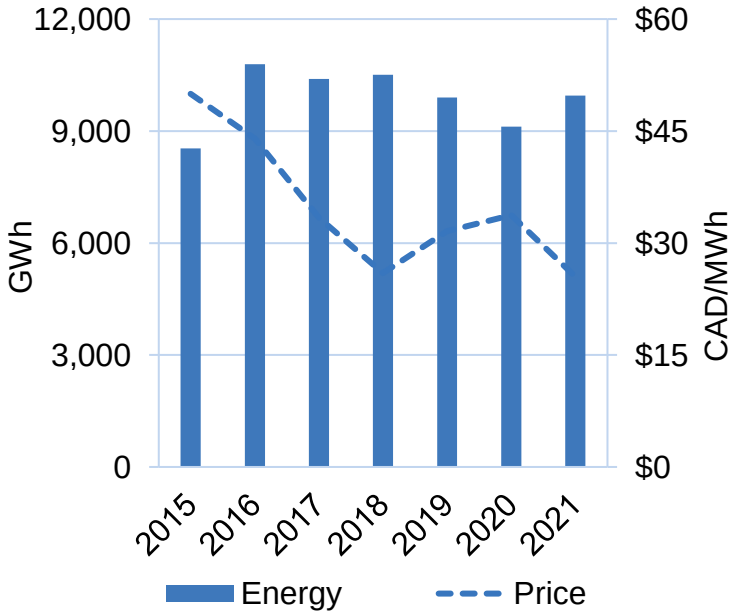
Exports from Québec to ISO-NE[1]



- After ISO-NE, Québec exports the most energy to NYISO which also has the second highest export price.
- Export prices from Québec have generally declined over time from a high of $50/MWh in 2015 to a low of $25/MWh 2021 though export volumes have remained relatively consistent.

- Québec exports more to ISO-NE than any other market. Higher export prices may be a contributing factor.
- Export prices have historically averaged between CAD 28-54/MWh, with the exception of exports to New Hampshire where prices have previously been above CAD 90/MWh.

Exports from Québec to NYISO[1]



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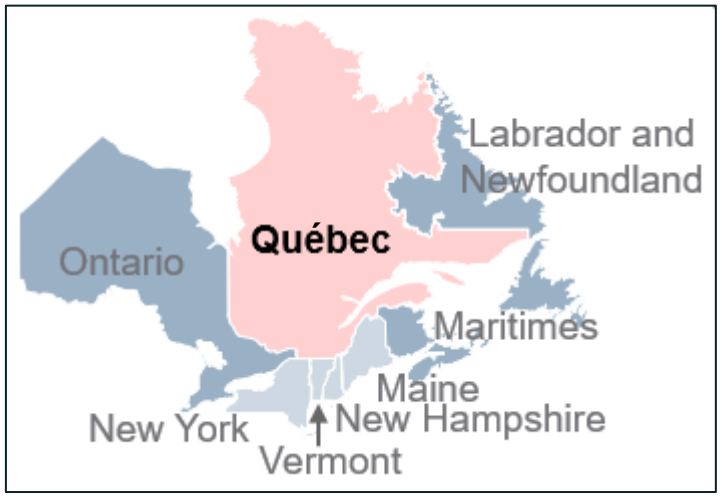
Québec Overview

Québec Power Market Overview

Québec operates under a single-buyer, bilateral market structure, with Hydro-Québec serving as the vertically integrated electric utility that owns and operates over 75% of power generation within the province.

- Hydro-Québec has aggressive clean energy export goals to neighboring jurisdictions to aid with their own decarbonization goals and become the "*Battery of the U.S. Northeast*".[1]
- Québec's transmission network is an isolated system, but it is linked with the U.S. and Ontario through DC interties.
- Transmission, distribution, and the majority of power generation is provided by the vertically integrated electric utility Hydro-Québec (HQ).
- The 2030 Plan for a Green Economy is Québec's medium-term decarbonization roadmap and calls for carbon neutrality by 2050.
- Hydro-Québec's latest strategic plan calls for 2 GW of new hydro by 2035 and 3 GW (nameplate) of new wind by 2026.

Regional Footprint[2]



	Summary
2021 Peak Demand (GW)	47.2 GW
2021 Supply (GW)	37.2 GW
Retail Electric Choice	☒
DA/RT Energy Market	☒
LMP	☒
Capacity Market	☒
Carbon Pricing	Cap-and-Trade program via Western Climate Initiative (WCI)
Renewable Demand	HQ plans for 3 GW of wind, and 2 GW of hydro by the mid-2030s
RECs	☒

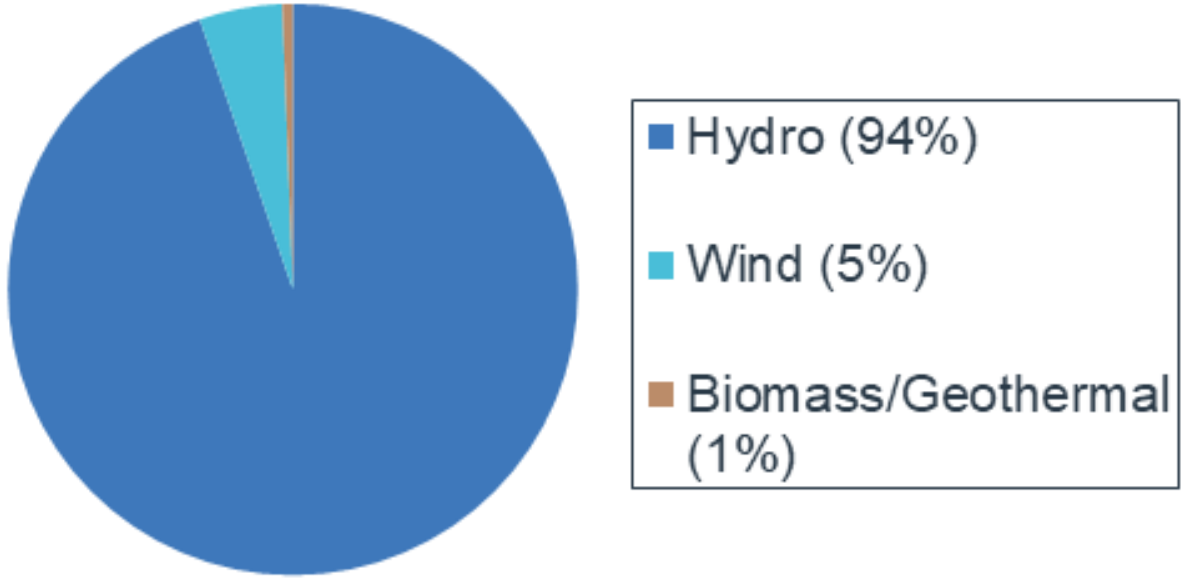
[1] Source: Hydro-Québec Annual Report 2020.
[2] Source: PA Consulting, Energy Velocity.

Current Energy Mix

Hydro makes up nearly 95% of Québec's energy mix and is used to serve both internal needs as well as exports to other markets such as NYISO, ISO-NE and Ontario.

- Québec's energy mix is almost entirely from hydro generation, 36.7 GW of which is owned and operated by Hydro-Québec.
  - As per the 2021 Annual Report, Hydro-Québec has 178.9 TWh of storage.
- In prior statements, Hydro-Québec has noted that energy production has surpassed the Province's needs by an annual average of 40 TWh, which has contributed to power sales into adjacent markets in Canada and the U.S.
- In 2022, the 245 MW Romain-4 hydro plant is expected to come online taking the total Romaine capacity to 1.55 GW.

2018 Energy Mix[1]



[1]Source: Canada's Energy Future 2020 report

Clean Energy and Electrification Targets

Hydro-Québec is committed to clean energy and achieving province wide carbon neutrality by 2050 while maintaining aggressive export goals to provide clean energy to neighboring regions to aid in their decarbonization journey.

2030 Green Economy Plan

Economy-wide **GHG emissions reduction targets** of **37.5%** by **2030** compared to 1990 levels. This includes 50%, 60% reduction of emissions related to heating for buildings and government buildings, respectively, by 2030.

Hydro-Québec to achieve **carbon neutrality** by **2030**. Targets 10% renewable natural gas (RNG) and 50% increase in bioenergy production by 2030 as well as clean energy supply from 70% of all off grid systems by 2025.

1.5 M electric vehicles in Québec by **2030**. **100% Zero Emission Vehicles (ZEVs) for passenger vehicles** by **2035** in line with federal policy. In addition, 55%, 65% of city and school buses, 100% of government vehicles, 25% of pick-up trucks to be electrified by 2030

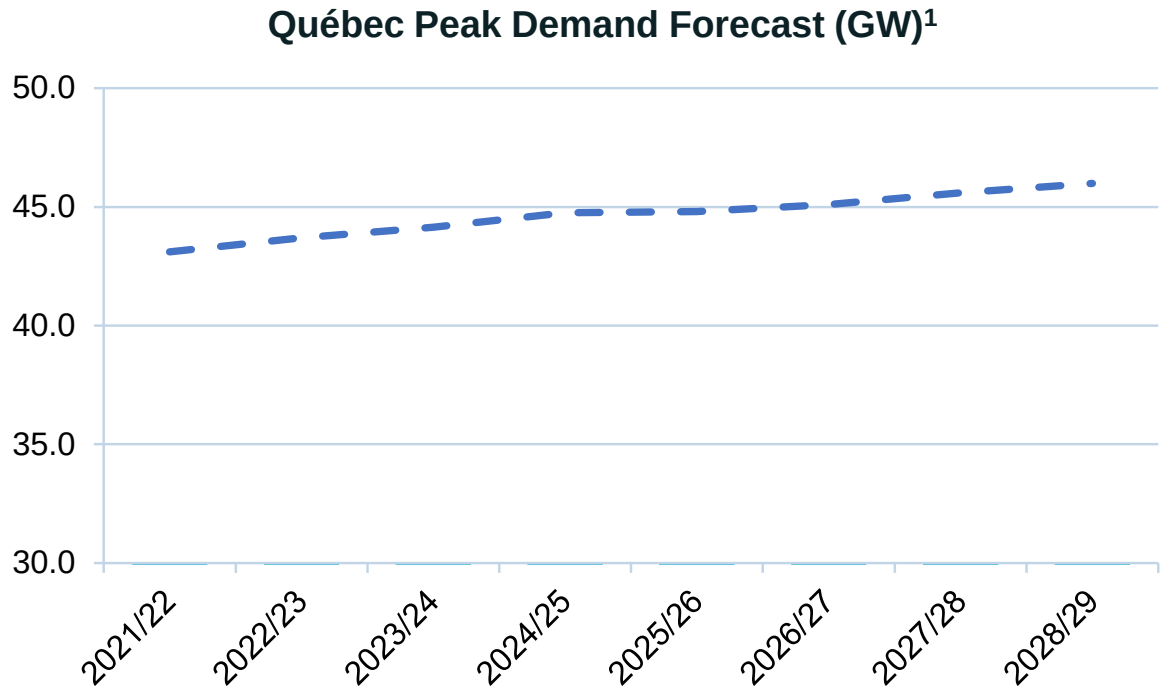
HQ Key Contributions

- Hydro-Québec plans to convert 80% of it's off grid systems that serve remote areas in northern Québec that are mostly thermal to clean energy sources by 2030. It is also working to connect many of these customers to the grid by 2030 thereby reducing the need for off grid systems.
- Hydro-Québec plans to convert 26% of its vehicle fleet to electric vehicles by 2026.
- The Electric Circuit represents Québec's largest public charging network with 3,400 charging stations, including 600 fast charging stations, at the end of 2021. Hydro-Québec plans to partner with local governments to add 4,500 new stations by 2028 and 2,500 fast charging stations by 2030. In addition, there are plans to deploy multi-vehicle charging stations in and around dense metro areas.
- Hydro-Québec is enhancing its energy efficiency efforts to achieve 4 TWh of savings by 2025 and 8.2 TWh by 2029.

Load Growth

Québec is a winter peaking system with a forecast annual peak demand growth of 1% over this decade that is primarily driven by increased electrification which is expected to require additional capacity in the later half of this decade.

- Québec already hosts a disproportionate share of energy-intensive facilities, such as data centers, due to the abundance of low-cost hydro generation.
- Hydro-Québec projects load growth driven by increasing population as well as factors associated with the 2030 Plan for a Green Economy like: electrification (space/water heating), new data centers, and hydrogen facilities.



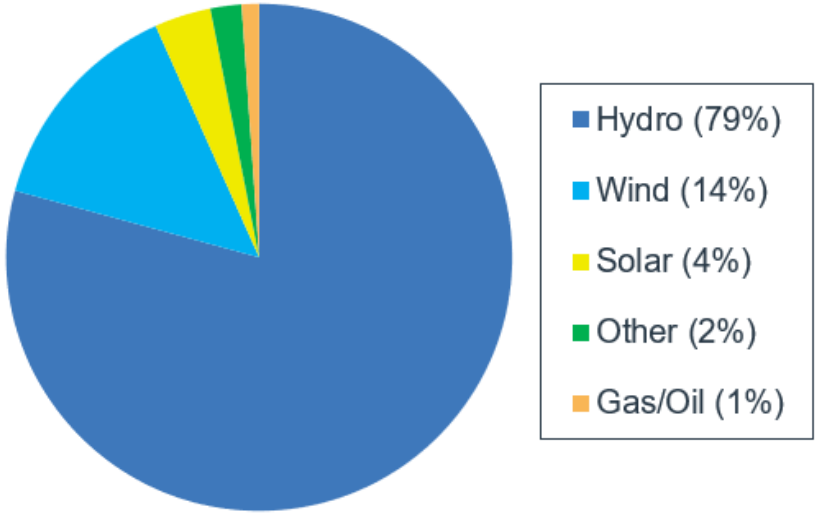
[1] Source: 2021 Progress Update to 2020-2029 Sourcing Plan.

Future Capacity Mix

In addition to Romaine-4, which will add 245 MW of hydro in 2022, Hydro-Québec has plans to add 3 GW of wind by 2026 and 2 GW of hydro by 2035 but may need to procure additional capacity in the late 2020's / 2030's.

- In addition to 245 MW of new hydro from Romaine-4, Hydro-Québec plans to add up to 3 GW of new wind by 2026 and 2 GW of new hydro by 2035.
  - Notably, the timing of the new hydro will be after the expected online dates for two U.S. HVDC transmission lines Hydro-Québec is supplying, namely Champlain Hudson Power Express and New England Clean Energy Connect (discussed on the following slide).
  - When combined with the province's expected load growth, this dynamic could, for a period of time, decrease the amount of clean energy that is available for export.
- As per the 2022-2026 strategic plan, Hydro-Québec expects that it may need to procure more capacity in the late 2020's and 2030's in addition to the current announcements.
- As intermittent renewable penetration increases (especially wind), Hydro-Québec will likely use some of its hydro storage to firm its own renewable generation – which will limit export opportunities to neighbouring jurisdictions.

2040 Nameplate Capacity Mix[1]



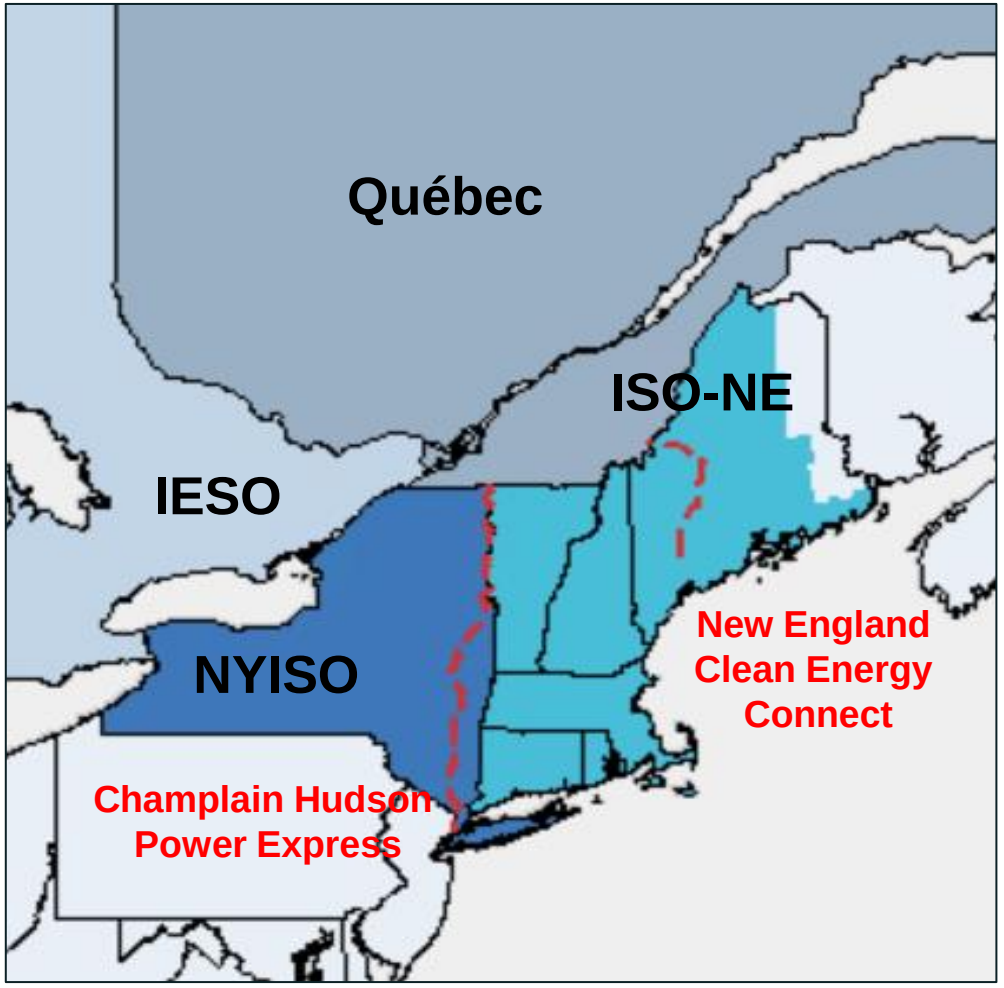
[1] Source: 2021 Canada Futures Report and HQ 2022-2026 Strategic Plan.

Québec – U.S. HVDC Transmission Lines

Hydro-Québec has recently signed contracts to supply clean energy to NYISO and ISO-NE via HVDC transmission lines which could potentially decrease the need for wheel throughs via Ontario.

- The NYISO transmission line, Champlain Hudson Power Express is discussed in the NYISO section of this report. The ISO-NE line, New England Clean Energy Connect (NECEC) is discussed as follows.
- In 2016, Massachusetts passed Section 83d requiring the procurement of an annual 9.45 TWh of clean energy.
- After the original winning project (Northern Pass, which connected in New Hampshire) was denied, Massachusetts selected NECEC – which interconnects with the ISO-NE system in Maine but is meant to help meet Massachusetts' clean energy needs.
- NECEC is owned by AVANGRID and designed to import 9.45 TWh of hydro generation into ISO-NE.
- Following the success of Ballot Question 1 in November 2021, the future of the line is in question and construction has stopped.
  - Question 1 asked voters if they wanted to ban the construction of high-impact electric transmission lines in the Upper Kennebec Region and to require the Legislature to approve all other such projects anywhere in Maine.

HVDC Transmission Overview[1]



[1] Source: PA Consulting, Energy Velocity.

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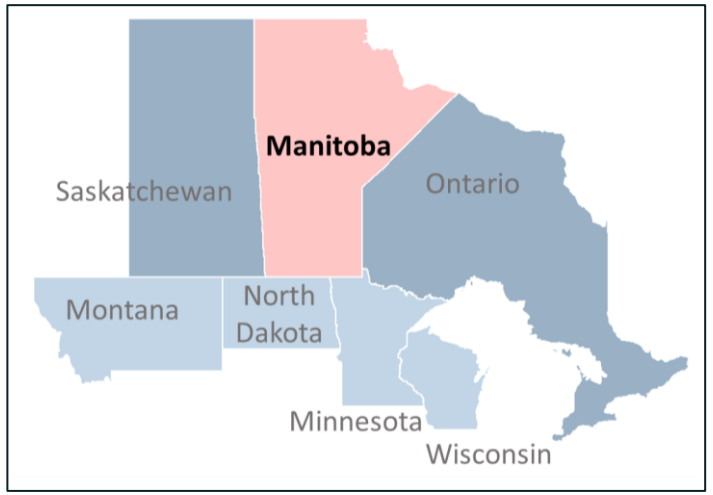
Manitoba Overview

Manitoba Power Market Overview

Like Québec, Manitoba operates under a single-buyer, bilateral market structure, with Manitoba Hydro serving as the vertically integrated electric utility that owns and operates almost all power generation within the province.

- Manitoba is a coordinating member of the U.S. RTO, MISO, which is responsible for reliability coordination, transmission settlements and administers the contingency reserve sharing group.
- Manitoba does not operate a wholesale market. Rather, the vertically integrated electric utility, Manitoba Hydro (MH), procures power generation via bilateral contracts.
- Manitoba Hydro's IRP is currently in progress. While draft materials are not yet available, it is expected to promote clean energy sources of generation, electrification and energy efficiency.

Regional Footprint[1]



	Summary
2021 Peak Demand (GW)	4.9
2021 Supply (GW)	5.6
Retail Electric Choice	☒
DA/RT Energy Market	☒
LMP	☒
Capacity Market	☒
Carbon Pricing	Federal fuel charge and output-based pricing
Renewable Demand	Under development as part of the new IRP and Strategy 2040
RECs	☒

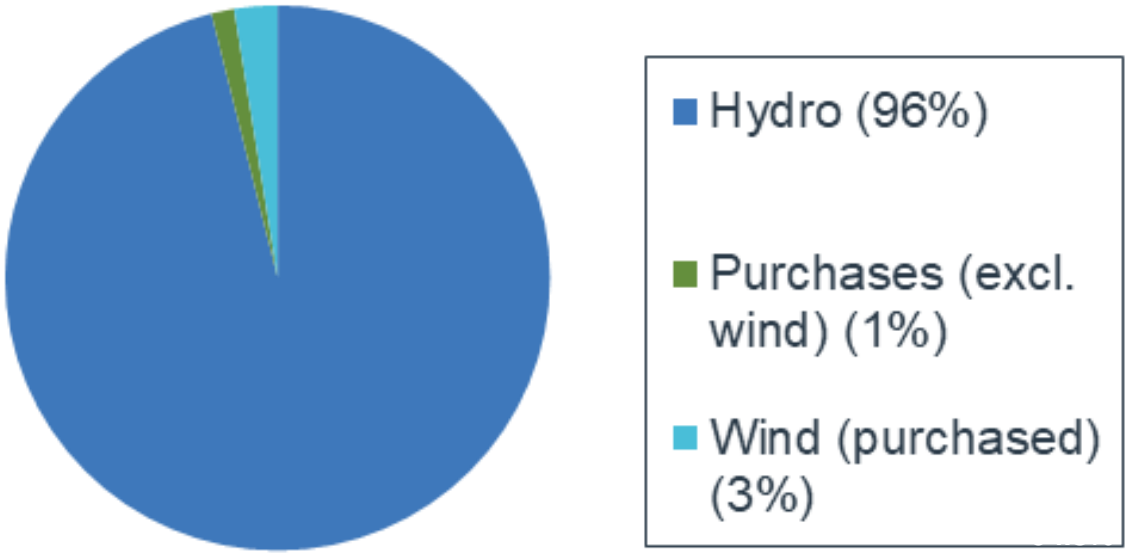
[1] Source: PA Consulting, Energy Velocity.

Current Energy Mix

Over 95% of Manitoba's energy is sourced for hydro. The 695 MW Keeyask hydro generation station is expected to come online in 2022 and the gas fired Selkirk 132 MW plant was retired in 2021 ending fossil fuel baseload generation.

- Manitoba's energy mix is almost entirely from hydro generation.
- In April 2021, Manitoba Hydro decommissioned the 132 MW Selkirk natural gas plant, one of the province's two natural gas-fired generators, marking the end of fossil fuel baseload generation.

2020 Energy Mix[1]



[1]Source: The Manitoba-Hydro Electric Board 70th Annual Report, for year ended March 21, 2020.

Clean Energy and Electrification Targets

Manitoba Hydro is developing long-term strategic plan that will focus on being prepared to compete and export in an evolving energy system while providing Manitobans with their energy at lowest possible cost.

- As the energy landscape evolves along with customer needs and expectations, Manitoba Hydro believes that mastering the three D's is key to the utility's future success.

Decarbonization

Leverage and build on an advantageous clean energy mix to help the province as well as neighbouring jurisdictions decarbonize.

Decentralization

Diversification in technology and market players, including BTM solutions such as rooftop solar and storage, to enhance consumer choice.

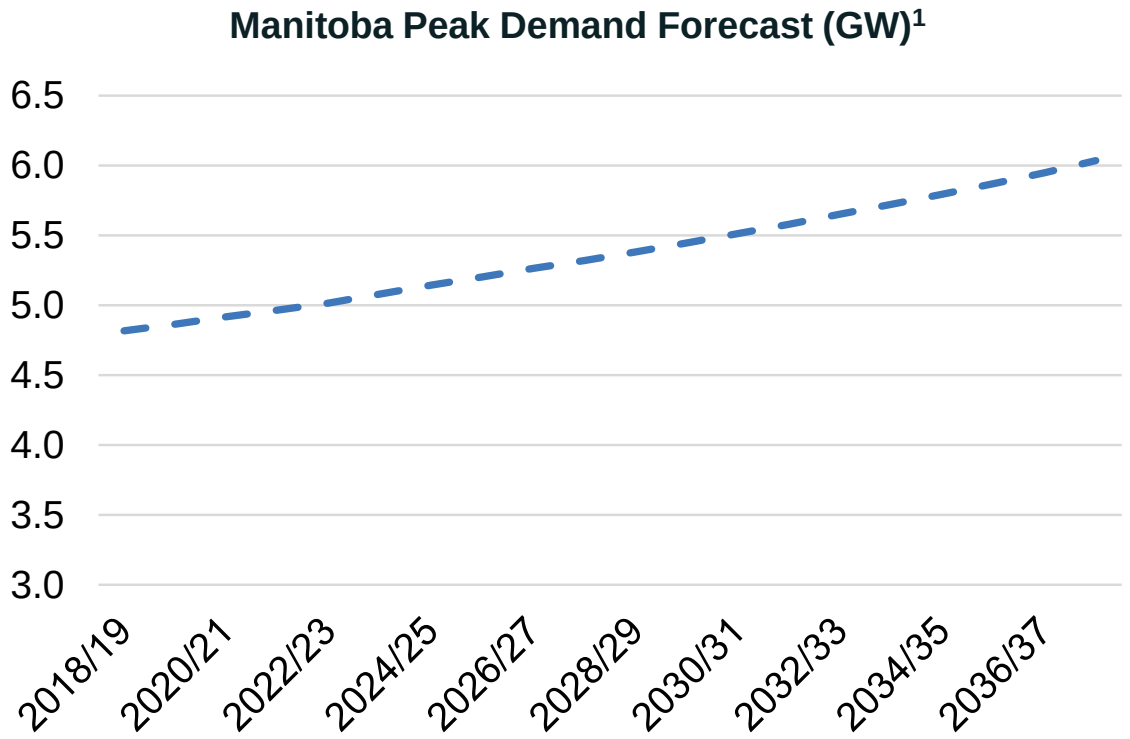
Digitization

Enable more efficient customer service, including self service options, as well asset management capabilities.

Load Growth

Manitoba's peak demand is forecasted to grow at about 1% annually over the next 15 years. However, an updated forecast is expected as part of the forthcoming IRP which is expected to factor in updated electrification plans.

- Manitoba's peak demand forecast is based on Manitoba Hydro 2019/20 Electric Rate Application, using a 2018 vintage forecast.
- Peak demand is projected to grow at 1% annually over the next 15 years.
- It should be noted that Manitoba Hydro is currently developing its next Integrated Resource Plan (IRP), which may result in a different forecasted peak demand that has larger impacts from electrification (both electric vehicles and heating).



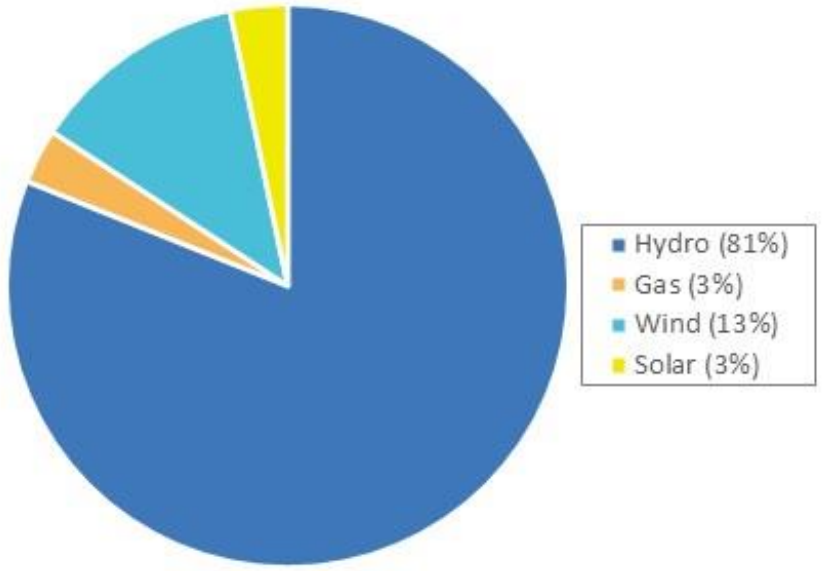
[1]Source: Manitoba Hydro 2019/20 Electric Rate Application, Appendix 15 - 2018 Electric Load Forecast

Future Capacity Mix

According to the 2021 Canada Energy Futures Report, nearly 750 MW of wind and over 250 MW of utility-scale solar is expected to be added by 2040.

- The first unit of the 695 MW Keeyask Generating Station entered service in February 2021 and the last unit is expected to come online in Spring 2022.
- According to the 2021 Canada Energy Future report, approximately 750 MW of wind and 250 MW of solar is expected to be added by 2040.
- Looking ahead, Manitoba Hydro's forthcoming IRP is likely to include many of the principles outlined in the province of Manitoba's 2040 strategy, which result in an emphasis on both new hydro and wind/solar.

Nameplate Capacity Mix - 2040[1]



[1]Source: Wind and solar additions based on Canada's Energy Future 2021 report.

04

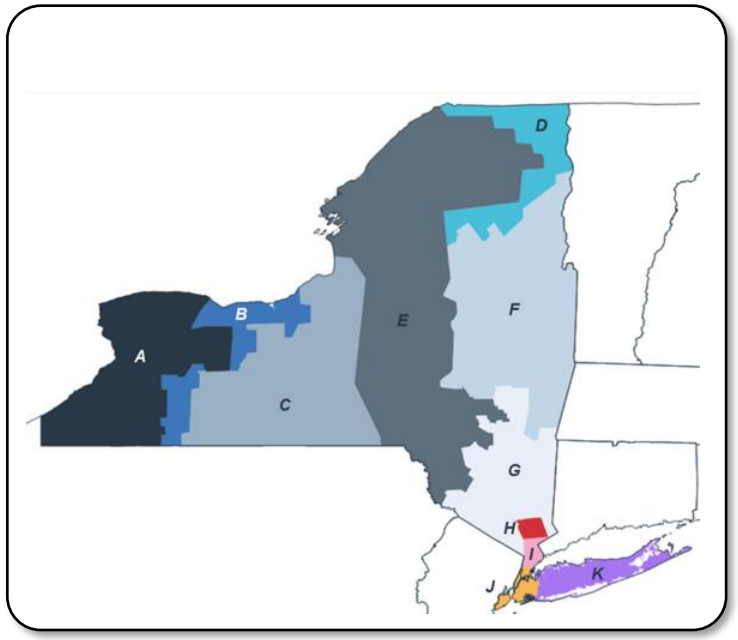
NYISO Overview

NYISO Power Market Overview

NYISO is a relatively small, single state, market with just over 30 GW of peak demand, but has very aggressive clean energy targets driven by New York state's clean energy policies, most notably the CLCPA.

- NYISO is contained entirely within the borders of New York state and is divided into 11 load zones (A through K), with Zone J (New York City) comprising over 30% of total load.
- NYISO operates centralized day-ahead and real-time nodal markets for energy and ancillary services, and a spot capacity market that clears on a monthly basis.
- New York has one of the most ambitious clean energy targets in the U.S. Under the Climate Leadership and Community Protection Act (CLCPA), passed in 2019, the state is legislatively required to achieve 70% renewable energy by 2030, 100% zero-carbon electricity by 2040, and net-zero economy-wide GHG emissions by 2050.

Transmission Zones[1]



	Summary
2021 Peak Demand (GW)	32
2021 Supply (GW)	40
Retail Electric Choice	☑
DA/RT Energy Market	☑ Day-Ahead and Real-Time Nodal Market
LMP	☑
Capacity Market	☑ Spot auction
Carbon Pricing	☑ RGGI
Renewable Demand	Very high (state-policy driven via the CLCPA)
RECs	State-level market (4 different tiers)

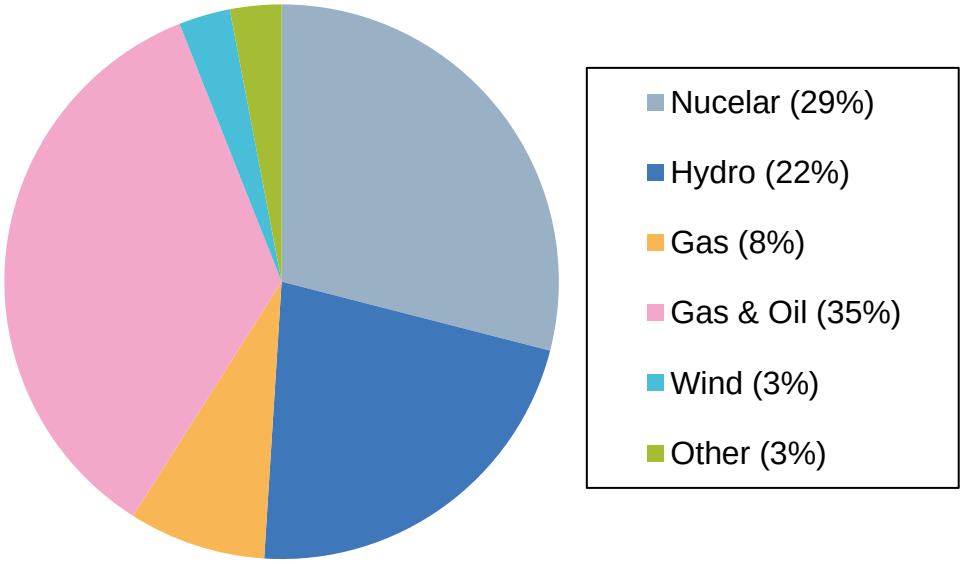
[1] Source: PA Consulting, Energy Velocity.

Current Energy Mix

In 2020, renewable generation (including hydro) along with Nuclear provided most of the baseload generation. Gas is on the margin during most hours making NYISO a less than ideal candidate from which to source clean energy imports.

- NYISO is unique within the U.S. due to its high concentration of hydro and nuclear generation, which combined made up over 50% of energy production in 2020.
  - It should be noted that Unit 2 at the Indian Point nuclear plant retired in April 2020, and Unit 3 retired in April 2021, which will decrease the contribution of nuclear generation to NYISO's energy mix in the future vs. the 2020 values provided below.
  - It should further be noted that no additional nuclear plant retirements are expected in New York state.
- Due to relatively poor resource quality, with capacity factors in the high-teens/low 20s, wind generation contributed less than 10% to energy production in 2020.

2020 Energy Mix[1]



[1]Source: NYISO 2021 Gold Book.

Clean Energy and Electrification Targets

New York's landmark 2019 policy, the Climate Leadership and Community Protection Act (CLCPA), orders the creation of the New York State Climate Action Council to implement aggressive statewide decarbonization targets.

CLCPA

- **GHG** — Economy-wide **GHG emissions reduction targets,** including (1) a minimum **40%** reduction in GHG emissions below 1990 levels by **2030;** and (2) net-zero emissions by **2050.**
- **CES** — Higher **Clean Energy Standard (CES) targets,** including (1) **70%** of statewide electricity sourced from **renewables** by **2030;** and (2) **100%** of statewide electricity sourced from **zero-carbon** resources by **2040.**
- **RFPs** — New state-mandated **resource procurement programs** to develop at least **6 GW** of **distributed PV** by **2025, 6 GW** of **storage** by **2030,** and **9 GW** of **offshore wind** by **2035.**

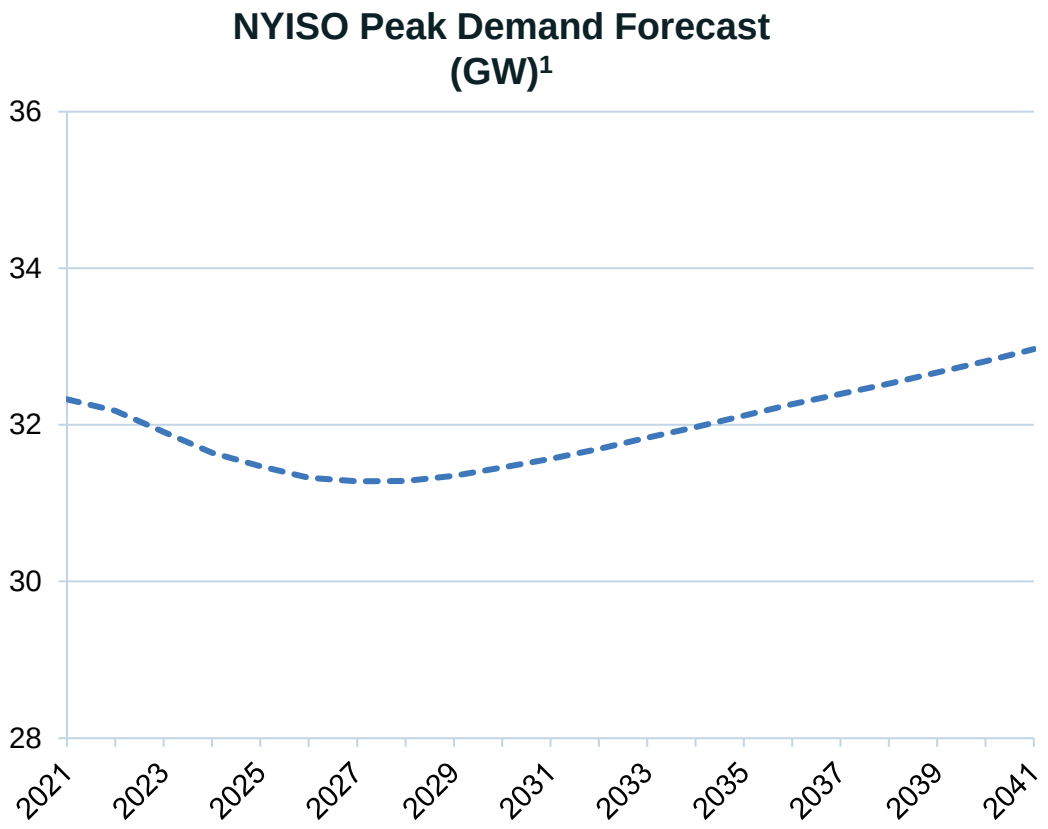
Other Key Energy Policies

- New York set a **NOx emissions limit** of 100 ppm by May 2023, decreasing further to 25 ppm and 42 ppm by 2025 for units using gaseous fuels and burning distillate oils (or other liquids), respectively. The requirement is expected to drive the retirement of several natural gas-fired peaking units in Zones J and K in the mid-2020s.
- New York City's **Local Law 97** caps emissions on buildings of at least 25,000 square feet; however, building owners can count RECs toward emissions reductions in instances where the resources are directly deliverable to Zone J, thereby effectively increasing near- and medium-term demand for renewable resources in the state.
- New York's **Reforming the Energy Vision (REV)** (initiated in 2014) is intended in part to reform the state's utility business model, such as by replacing cost-of-service rate recovery mechanisms (which typically incentivize capital deployment even when other options may improve reliability at lower costs) with performance-based metrics.

Load Growth

NYISO's load growth has been declining for the past few years but is projected to increase beginning in the late 2020s, as a result of multi-sector electrification.

- In the near-term, NYISO's market-wide peak demand forecast declines due to a combination of energy efficiency and behind-the-meter resources.
- However, beginning in the late 2020s load growth starts to increase driven by multi-sector electrification, and particularly space heating.
  - This electrification is itself driven by the policies of the CLCPA, and its 2050 economy-wide net-zero target.
- Notably, by 2041 NYISO is projected to become a winter peaking system.
- It should also be noted that the values presented on this slide are based on NYISO's Baseline, which does not assume 100% compliance with CLCPA policies.
  - 100% compliance would result in even higher load growth forecasts than what is presented here and result in NYISO becoming a winter peaking system by the 2030s.



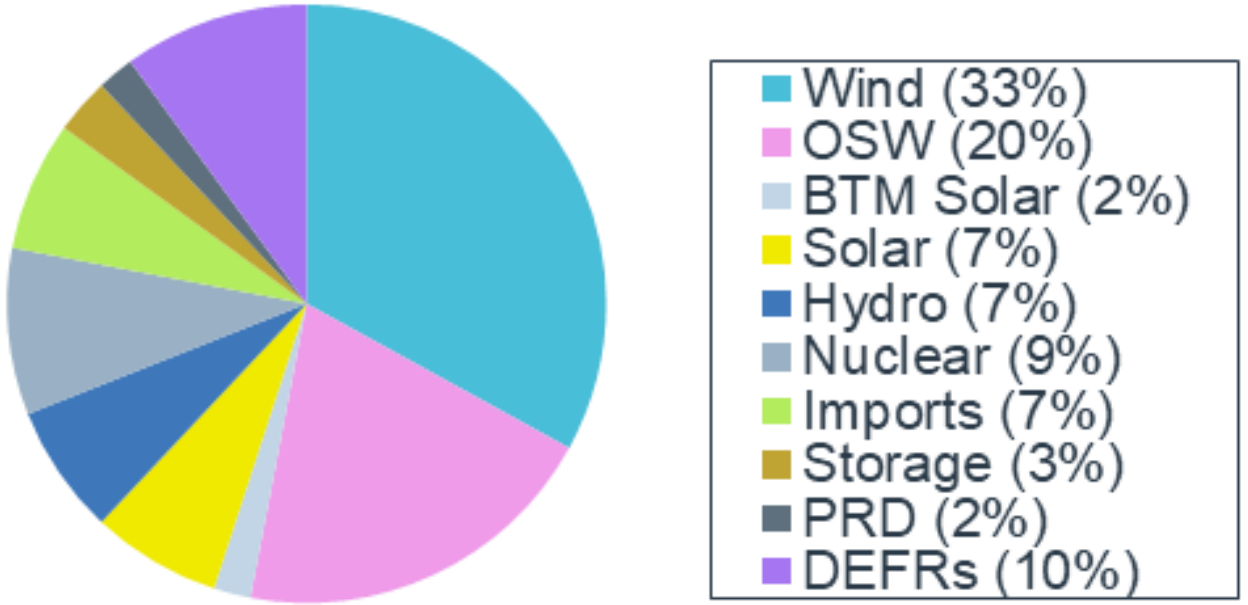
[1] Source: NYISO 2021 Gold Book.

Future Energy Mix

NYISO's forecast 2040 energy mix is heavily reliant on wind (on and off-shore) and a new resource category referred to as dispatchable emissions-free resources (DEFRs), a modelling plug, as well as clean energy imports from Québec.

- The values presented were included as part of a NYISO study entitled '*New York's Clean Grid of the Future*', which contemplated the hypothetical energy mix required for NYISO to reliable operate a zero-carbon electric grid.
- Notably, the study assumed over 50% of NYISO's energy mix would come from wind (on and offshore) with 7% from imports (which includes the Champlain Hudson Power Express HVDC transmission line) and 10% from a new resource category called DEFRs.
- DEFRs are, in effect, a modeling plug, as they represent fully dispatchable emissions-free resources.
- The levels of DEFRs are important to note and recognize because they suggestive of the potential issues that ISOs may have reliably operating a carbon-free electric grid.
- The DEFR (which is effectively a modelling plug), coupled with the state's aggressive clean energy targets, likely mean that NYISO will only have clean energy available for opportunistic spot sales.

Energy Mix - 2040[1]



[1]Source: New York Clean Energy Grid of the Future Report

Offshore Wind Development

New York has one of the most ambitious offshore wind targets and has selected five OSW projects though 2020. The latest solicitation was in February 2022 that concluded with 6 leases at a record cost of US$4.37 billion.

- To date, New York has selected five OSW projects, interconnecting with Zones J (New York City) and K (Long Island).
- Combined, these projects represent almost 4,500 MW of nameplate capacity, which is nearly 50% of New York state's 9,000 MW by 2035 target.
- Offshore wind solicitations are run by the state agency NYSERDA. NYSERDA is expected to launch its next OSW solicitation in 2022 for at least 2 GW (nameplate).
- One of the challenges facing NYISO with OSW integration is transmission congestion, as both Zones J and K are already heavily congested and will require significantly transmission upgrades to reliably and efficiently operate all of New York state's 9 GW OSW target.

Prior Offshore Wind Solicitations[1]

Solicitation	Project Name	Project Size (Nameplate-MW)	Transmission Zone
PSEG/LIPA	Deepwater Wind South Fork	96	K
2018	Empire 1 Offshore Wind	816	J
2018	Sunrise Wind	880	K
2020	Beacon Wind	1,230	J
2020	Empire 2 Offshore Wind	1,260	K

New York Bight Auction Results: The Bight auction concluded in February 2022, with a record $4.37 billion spent for six leases representing nearly 500,000 acres, with potential to support up to 7 GW (nameplate) of OSW.
Notably, the Bight lease areas are in U.S. Federal waters and could therefore be used for OSW projects in NYISO and/or PJM.

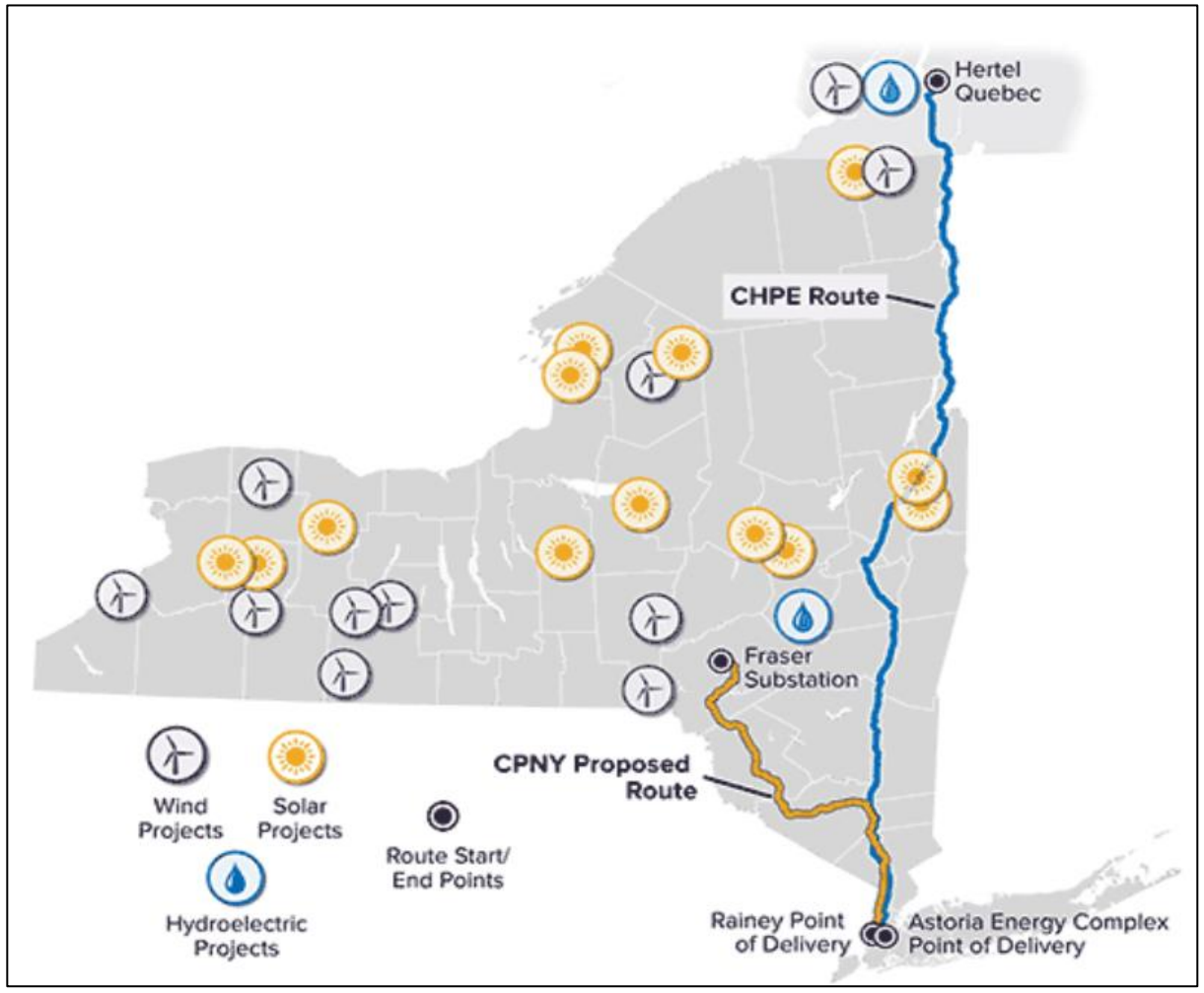
[1]Source: NYSERDA

HVDC Transmission Development

In addition to OSW, New York has selected two HVDC transmission projects through the Tier 4 REC program, namely the Champlain Hudson Power Express (CHPE) and Clean Path New York (CPNY) projects.

- The Tier 4 REC program is a newly created REC tier, established in Fall 2020, that is designed to attract new clean energy that is directly deliverable into New York's largest load center New York City (Zone J).
- Champlain Hudson Power Express (CHPE) and Clean Path New York (CPNY) were selected by NYSERDA in its inaugural Tier 4 REC solicitation, the results of which were released in September 2021. Notably, final contract awards are subject to the approval of the NY PSC, which is expected to render a decision in 2022.
  - **CHPE**: is a 1,250 MW project capable of delivering up to 10.4 TWh per year at Zone J's Astoria substation. The project will be anchored by hydrogeneration from Québec provided by Hydro-Québec. CHPE's planned COD is late 2025.
  - **CPNY**: is a 1,300 MW project capable of delivering up to 7.9 TWh per year at Zone J's Rainey substation. The project will be anchored by onshore wind and utility-scale solar located in upstate New York. CPNY's planned COD is mid-2027.

HVDC Transmission Developments[1]



[1] Source: NYSERDA.

05

MISO Overview

MISO Power Market Overview

MISO is the second largest RTO in the world, with over 120 GW of peak demand spanning from Manitoba and North Dakota down to Louisiana.

- While MISO has day-ahead and real-time energy and ancillary markets as well as a capacity market, capacity additions and retirements are largely based on electric utility IRP processes.
- MISO's current U.S. footprint was created when Entergy's service territory in the Southern U.S. (represented as MISO South in the map) merged with MISO in 2013.
- State-level clean energy policies across MISO are relatively weak but due to shareholder pressure, MISO's electric utilities are increasing their interest in and demand for clean energy to meet new load and replace retiring coal-fired generators.

Transmission Zones[1]

	Description
2021 Peak Demand (GW)	122
2021 Supply (GW)	135
Retail Electric Choice	☑ Only in MI (10%) and IL
DA/RT Energy Market	☑
LMP	☑
Capacity Market	☑ Most capacity is procured bilaterally
Carbon Pricing	☒
Renewable Demand	Varies (limited state policy, stronger electric utility targets)
RECs	Voluntary market

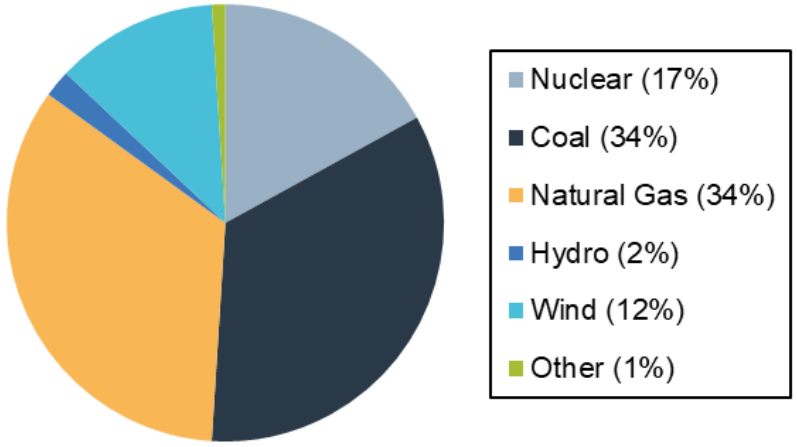
[1] Source: PA Consulting, Energy Velocity.

Current Energy Mix

Coal made up 35% of MISO's energy mix in 2020, with renewable generation (almost entirely wind) accounting for less than 15%, with gas mostly on the margin making MISO a less than ideal candidate for clean energy imports.

- MISO has lagged PJM in coal retirements, despite facing similar economic pressure from low natural gas prices, which is largely due to the ownership structure of coal-fired generators in MISO vs. PJM (i.e., regulated electric utilities in MISO vs. IPPs in PJM).
- MISO has some of the best wind resources in the U.S., especially in MISO Classic, which has led to significant build out of wind generation over the past decade.
- When new natural gas-fired generators have entered the market, they have done so largely to replace retiring coal-fired generators.
  - For example, the Blue Water combined cycle that is under construction is Michigan is replacing the retired Belle River coal generator.

2020 Energy Mix[1]



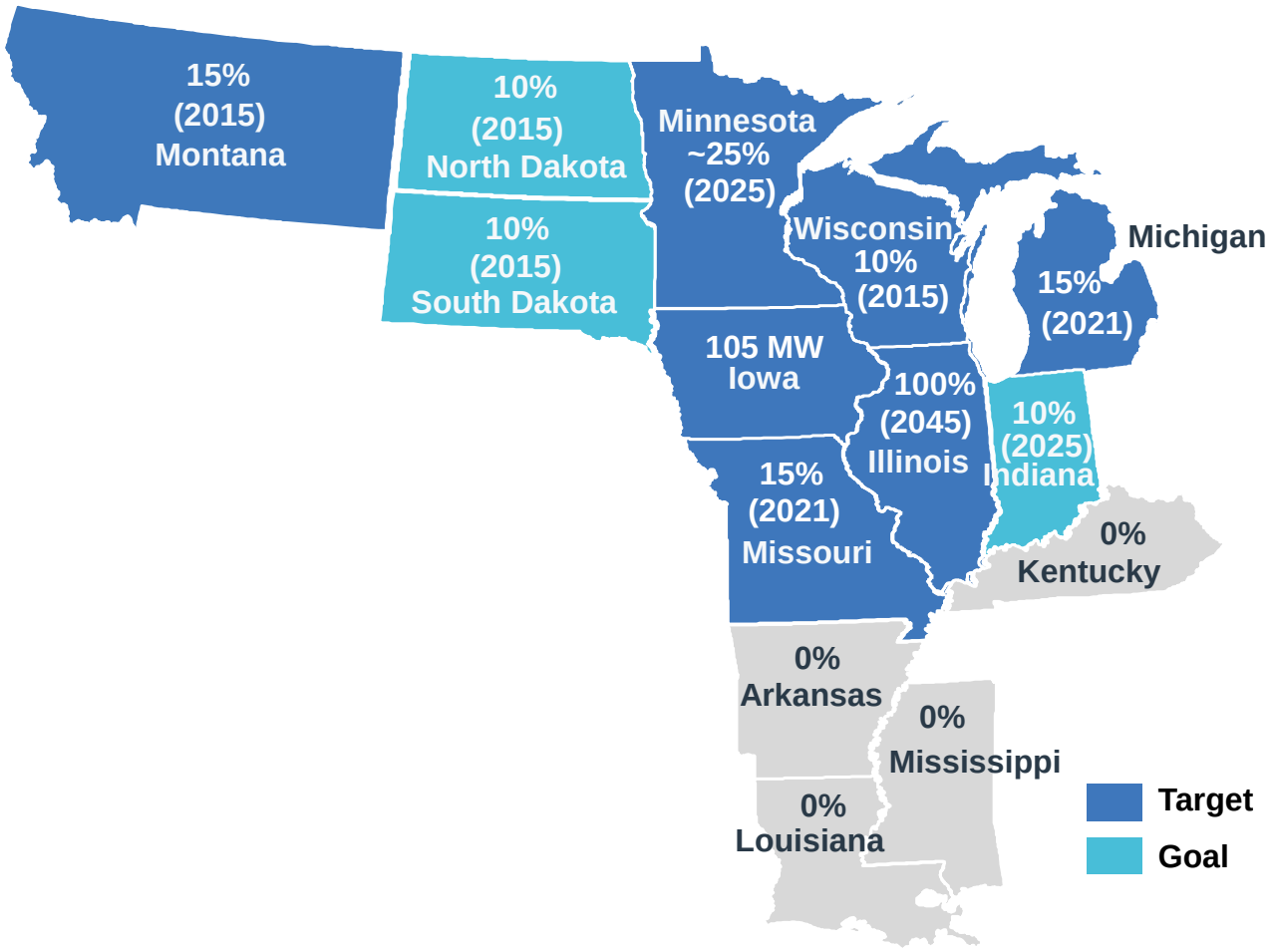
[1]*Source: 2020 State of the Market Report for the MISO Electricity Region. Prepared by Potomac Economics. May 7, 2021.*

Clean Energy and Electrification Targets

State clean energy policies in MISO are relatively weak and are led by the state of Illinois (which is spread across both MISO and PJM) with its 2045 power sector net-zero target.

- Despite very good wind resource quality in the Northern MISO states (e.g., Iowa, Minnesota, etc.), state-level clean energy policy is relatively weak in MISO.
- Illinois is the energy policy leader in MISO, with its 2045 net-zero generation target that was part of its recently passed Illinois Energy Transition Act in September 2021.
- Despite having relatively weak legislatively-mandated clean energy policies, some MISO states have started to promote strong decarbonization agendas through their Public Utility/Service Commissions.
  - For example, in Michigan, once the Blue Water combined cycle generator comes online in mid-2022, it is extremely unlikely any new carbon-emitting power generation will be built in the state.
  - Moreover, the Michigan PSC has pushed the state's two largest electric utilities (Consumers Energy and DTE Energy) to retire their coal and build new wind and solar generation through the state's IRP review and approval process.
    - Consumers Energy has committed to a net-zero target by 2040.

MISO State Clean Energy Policies[1]

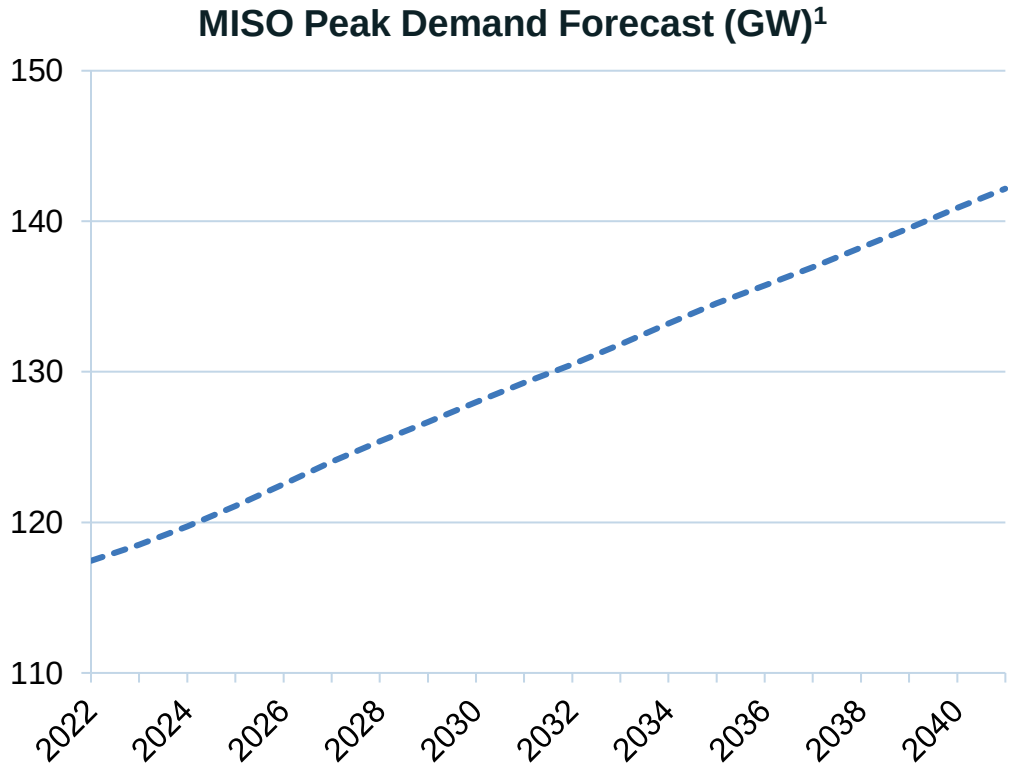


[1] Source: PA Consulting

Load Growth

MISO's peak demand is forecasted to grow at a modest 1% annually over the next 20 years. Unlike other regions, MISO's forecast does not forecast significant electrification related growth.

- MISO's most recent load growth forecast was released in November 2021 and prepared by the State Utility Forecasting Group (SUFG) on behalf of MISO. This is the 8th such forecast the SUFG has prepared.
- Over the next 20 years MISO's annual peak demand growth is forecasted to be 1%.
- Unlike some other ISO load forecasts (e.g., NYISO), the MISO forecast does not assume significant impacts from the electrification of vehicles nor heating.

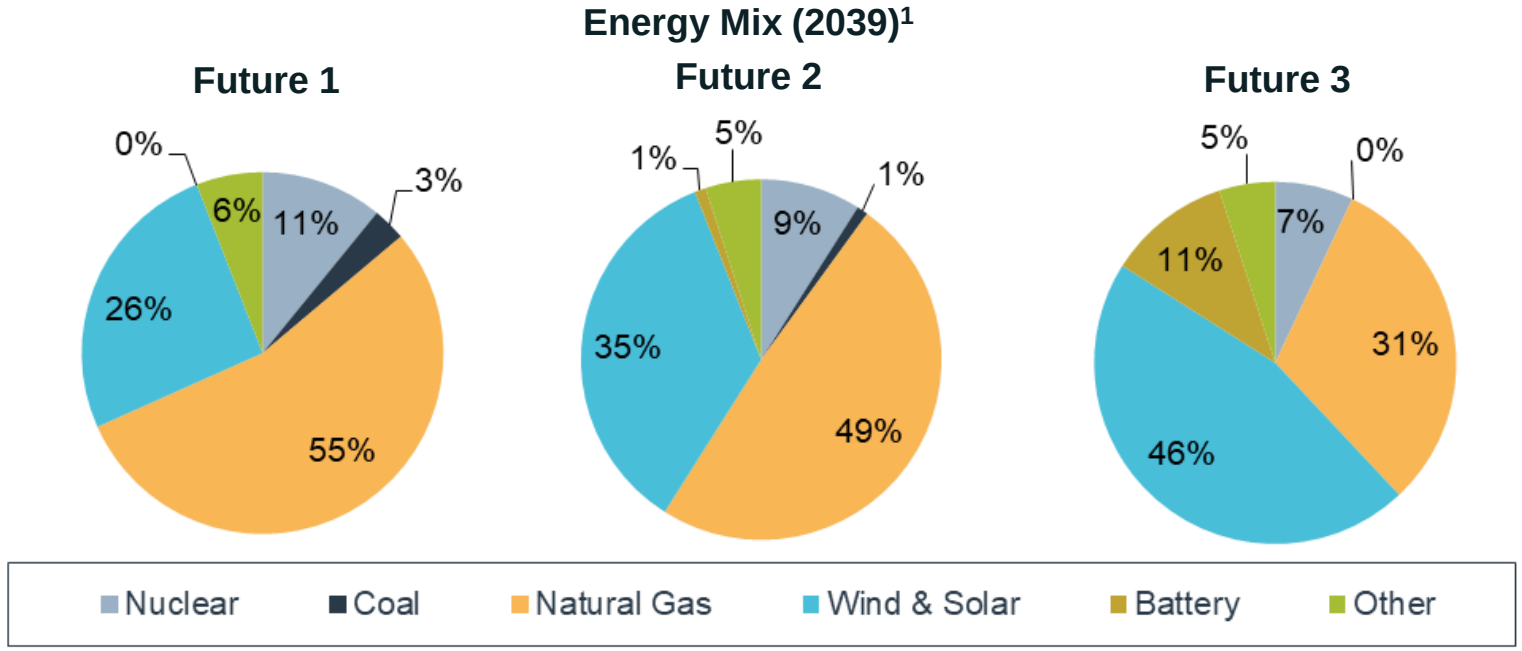


[1]Source: 2021 MISO Energy and Peak Demand Forecasting for System Planning.

Future Energy Mix

Across all three scenarios, coal is not expected to be a significant part of the future energy mix, but gas is expected to play a key role meaning that MISO will remain a less than ideal candidate from which to source clean energy imports.

- MISO's *Futures Report*, released in December 2021, contemplated the market's future energy mix under three scenarios:
  - Future 1 includes a 40% CO_2 reduction and 0.5% load growth,
  - Future 2 includes a 60% CO_2 reduction and 1.1% load growth, and
  - Future 3 includes an 80% CO_2 reduction and 1.7% load growth.
- Each scenario demonstrates the diminished role that coal-fired generation will play in MISO's future energy mix.
- However, even in the most aggressive scenario, Future 3, 30% of MISO's energy mix still comes from natural gas-fired generation. As a result, it is unlikely that Ontario will be able to secure clean energy imports from MISO.



[1]Source: MISO Futures Report

06

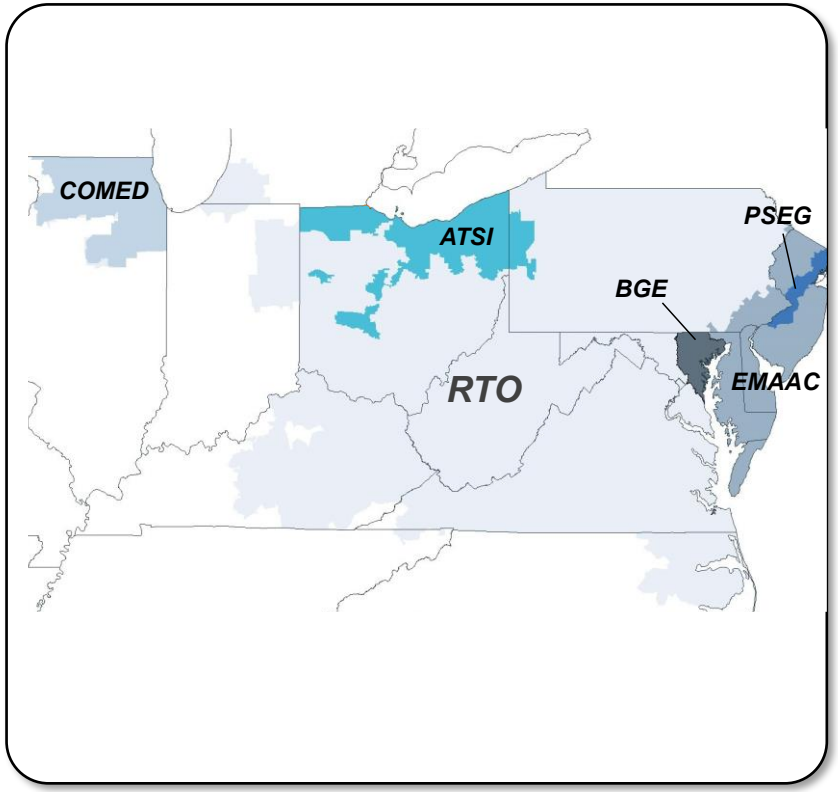
PJM Overview

PJM Power Market Overview

PJM is the largest RTO in the world, with a peak demand of approximately 150 GW, spanning 13 states with a very wide range of clean energy policies.

- PJM includes all or parts of 13 U.S. states and the District of Columbia, with a wide range of political views and socioeconomic conditions.
- PJM operates centralized day-ahead and real-time nodal markets for energy and ancillary services as well as a forward capacity market that clears on 12-month basis three years of delivery.
- Some PJM states (e.g., New Jersey, Delaware, Maryland, Virginia, and Pennsylvania) are subject to CO_2 emission allowance costs under the RGGI program.
- The states of Virginia and Illinois lead PJM in clean energy policies, and are state driven, while other states such as Kentucky and West Virginia (traditionally coal mining states) do not have clean energy policies.

Transmission Zones[1]



	Description
2021 Peak Demand (GW)	149
2021 Supply (GW)	193
Retail Electric Choice	☑
DA/RT Energy Market	☑
LMP	☑
Capacity Market	☑ Reliability Pricing Model
Carbon Pricing	☑ RGGI in some states
Renewable Demand	Varies (state energy policies range from very high to very low)
RECs	RTO-wide market

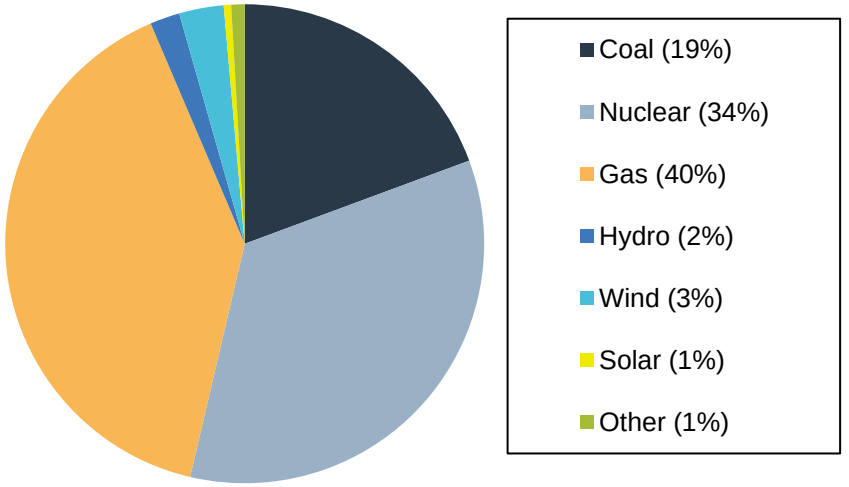
[1] Source: PA Consulting, Energy Velocity.

Current Energy Mix

Coal made up 20% of PJM's energy mix in 2020 with renewable generation accounting for less than 10% and gas being on the margin at most times making PJM a less than ideal candidate for clean energy imports.

- While the amount of coal-fired power generators has declined in PJM over the past decade, coal still made up nearly 20% of PJM's 2020 energy mix, though this is projected to decline in the future with continued coal retirements.
  - PA's analysis expects nearly 7 GW of coal retirements in 2022 and 2023, based on announced power generator plans.
- A large amount of PJM's natural gas-fired generators have come online within the past 10 years, which has coincided with the shale gas boom in the Marcellus and Utica shale gas plays and their associated abundant, low-cost natural gas supply. As such, most of the newer natural gas-fired generators in PJM are in the states of Ohio and Pennsylvania.
- Several nuclear generators have recently received payments from their states to ensure their continued operations (e.g., Exelon's Byron and Dresden facilities in Illinois), providing clean energy, jobs, and property tax payments. PA's analysis does not expect any future nuclear generator retirements in PJM.

2020 Energy Mix[1]



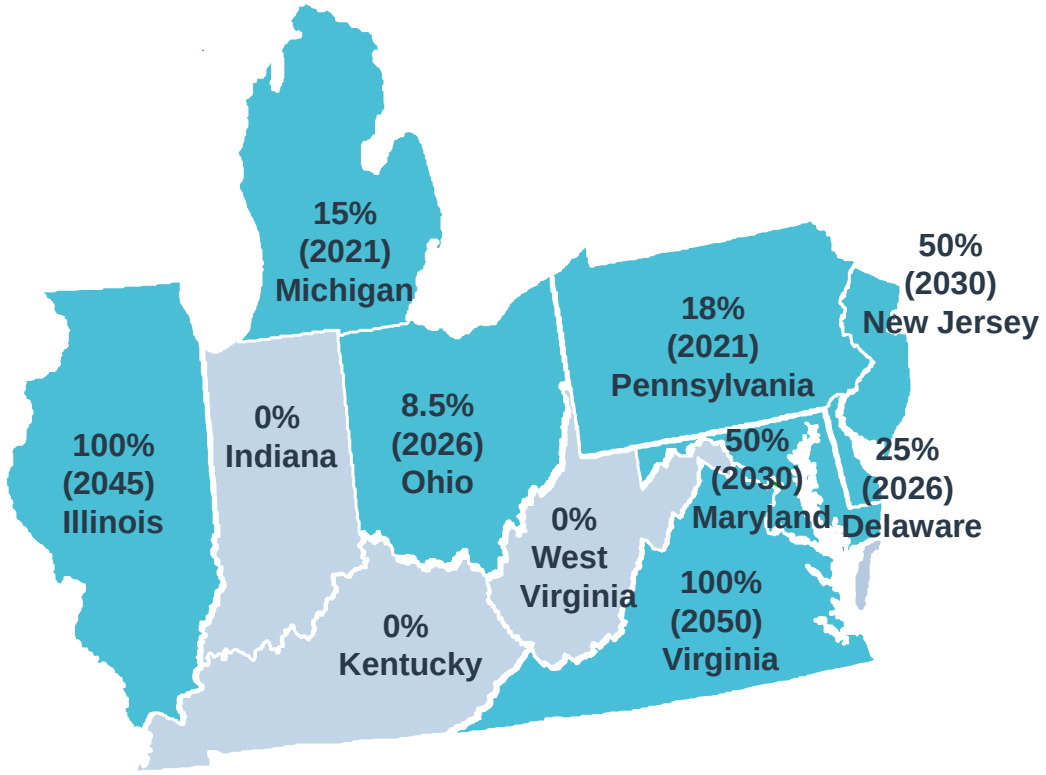
[1]Source: 2020 State of the Market Report for PJM. Prepared by Monitoring Analytics. March 29, 2021.

Clean Energy and Electrification Targets

The PJM states of Illinois and Virginia have the most aggressive clean energy policies, with electricity sector net-zero targets of 2045 and 2050, respectively. Other PJM states have relatively soft clean energy policies.

- Both Illinois and Virginia have committed to zero-carbon/100% renewable targets.
  - Illinois recently passed the Energy Transition Act, which will accelerate the retirement of coal and natural gas-fired generators in the state in general and especially in disadvantaged communities. The Act mandates 40% clean energy by 2030, 50% clean by 2040, and net-zero emissions electricity sector by 2045.
  - Virginia also has a net-zero target by 2050, with specific mandates for OSW (5.2 GW by 2034) and storage (3.1 GW by 2035)
- Maryland and New Jersey have more modest clean energy policies, 50% renewable energy by 2030 in both states, but strong OSW and storage mandates
  - New Jersey is targeting 7.5 GW (nameplate) of OSW by 2035, and Maryland 1.2 GW (nameplate) by 2030.
  - New Jersey is also targeting 2 GW (nameplate) of storage by 2030.

PJM State Clean Energy Policies[1]

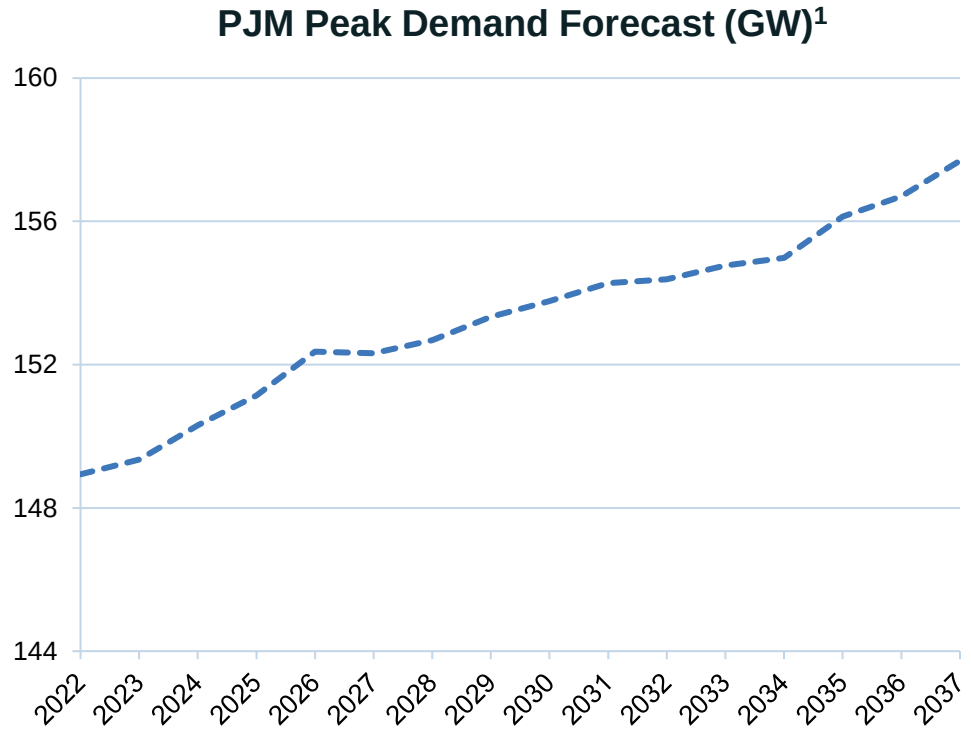


[1] Source: PA Consulting

Load Growth

PJM's peak demand is forecasted to grow at just under half a percentage point annually over the next 15 years, primarily driven by transportation electrification.

- PJM's most recent load growth forecast was released in January 2022 and prepared by the PJM ISO.
- Over the next 15 years, the term of PJM's forecast, annual peak demand growth is forecasted to be 0.4%.
- PJM's forecast does take into account impacts from electric vehicles but is limited in terms of heating demand impacts. It also includes the impact of data centers for certain states, such as Virginia.

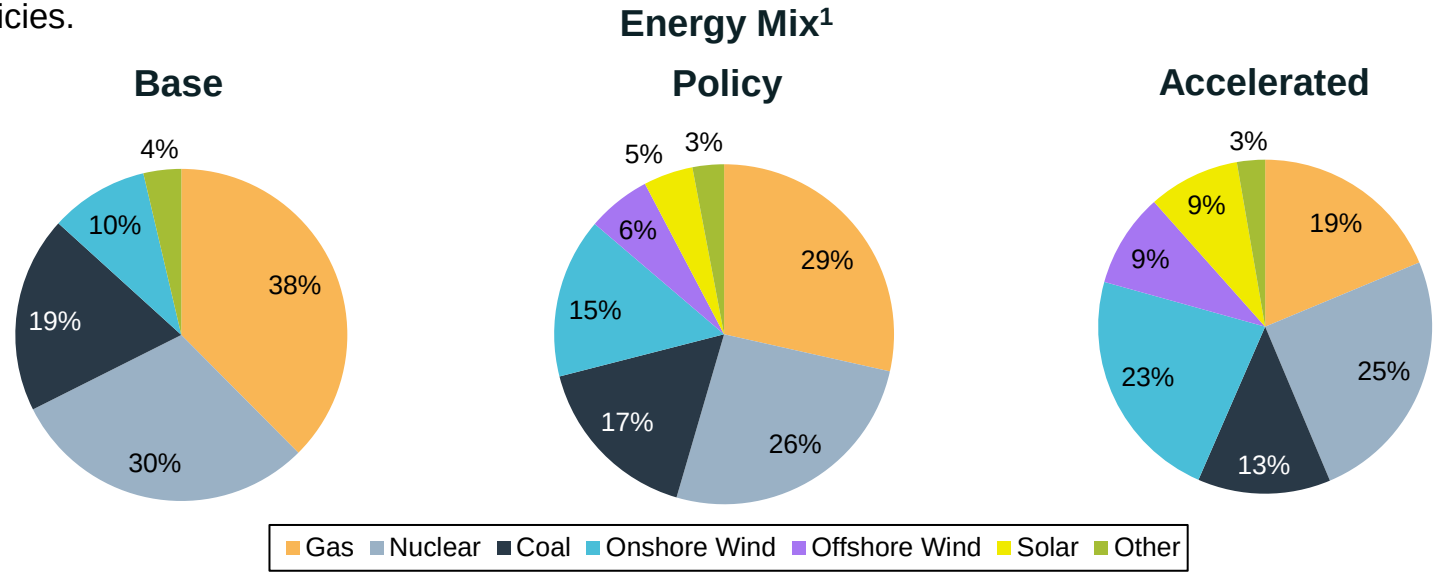


[1]Source: PJM 2022 Load Forecast Report, released January 2022.

Future Energy Mix

PJM's future energy mix is still expected to have a significant amount of coal and natural gas-fired generation meaning that it will remain a less than ideal candidate from which to source clean energy imports.

- The *Energy Transition in PJM: Frameworks for Analysis*, completed by the PJM ISO in December 2021, outlined three potential future scenarios for PJM's energy mix.
  - The Base Scenario considered resources anticipated in the 2021 Regional Transmission Expansion Plan for the mid-2020s.
  - The Policy Scenario referenced state and corporate clean energy targets (those in place as of April 2020) for 2035.
  - The Accel Scenario referenced additional state and corporate clean energy target for 2050.
- Each scenario demonstrated the decreasing role that coal, and natural gas-fired generation will play in PJM's future energy mix, as significant amounts of renewable generation come online.
- Even in the most aggressive scenario, Accel, over a third of PJM's energy mix still comes from coal and natural gas-fired generation.
- However, PA Consulting's analysis forecasts that most of PJM's coal fleet will leave the market by 2030 due to either poor economics or state-driven clean energy policies.



[1]Source: The Energy Transition in PJM: Frameworks for Analysis. December 2021.

07

Inter-region Power Flows

Québec and Manitoba Export Revenues

In 2021, exports accounted for 11% of Hydro-Québec's revenues, but 32% of its Net Income, and 26% of Manitoba Hydro's total revenues. Hydro-Québec has the stated goal of becoming the '*battery of the US Northeast*'.

- Hydro-Québec and Manitoba Hydro's Export Revenues totaled $1.6 billion in 2021 and $611 million in 2021, respectively.
- In 2021, Hydro-Québec's total revenues were $14.5 billion and export revenues made up only ~11.4% but contributed to 32% of total net income further highlighting the value of exports.
- The Canada Energy Regulator tracks trade between Canada and the U.S., both quantity and price, and is explored in detail in the following slides.

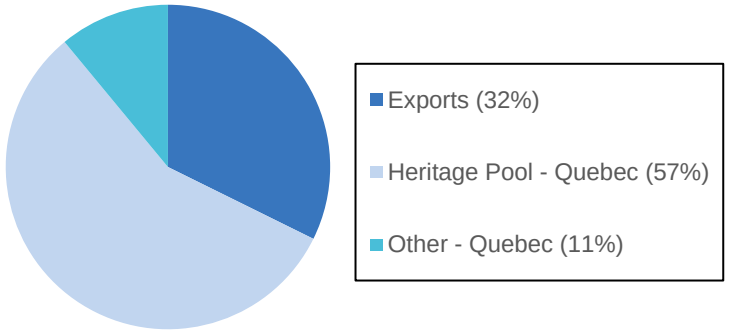
Manitoba Hydro <> SaskPower

- In 2020, an agreement was reached to provide 215 MW of hydropower beginning in 2022 for 30 years.
- This will bring total exports to 315 MW by 2022.

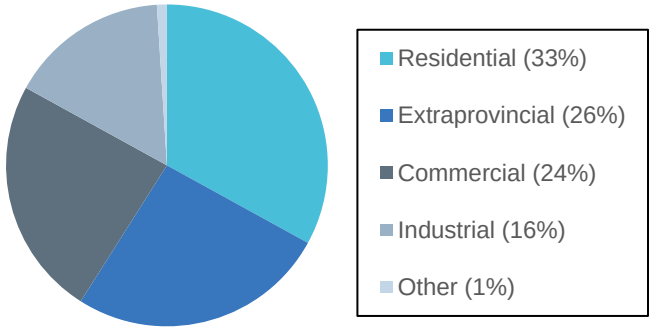
Hydro-Québec <> New Brunswick Power

- In 2020, an agreement was reached to provide an additional 47 TWh of hydropower by 2040, averaging a little over 2 TWh per year.

Hydro-Québec Net Income by Market 2021[1]



Manitoba Hydro Electric Revenue March 2020-21[2]



[1]Source: Annual Report 2021. Québec Hydro.
[2]Source: Strategically Adapting to our Changing Future, 70th Annual Report. Manitoba Hydro. March 31, 2021.

Québec <> ISO-NE

Québec exports more to ISO-NE than any other market. Higher export prices may be a contributing factor.

Export prices have historically averaged between $28-54/MWh, with the exception of exports to New Hampshire where prices have previously been above $90/MWh.

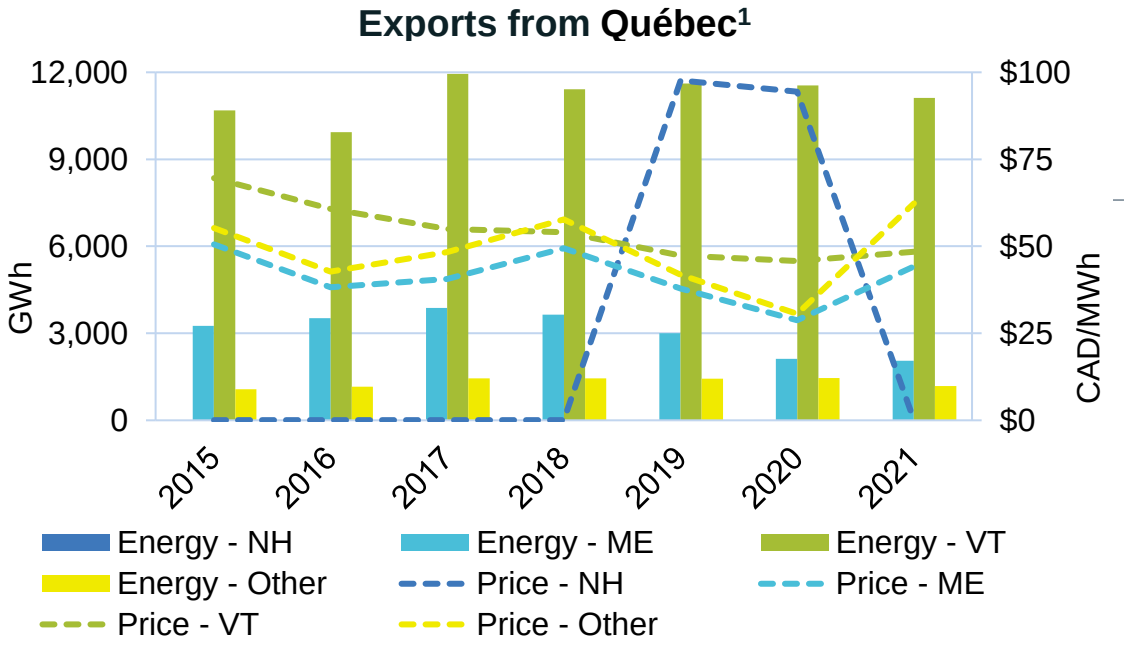
- Since 2015, Québec exported nearly 109 TWh to ISO-NE. Approximately 72% (over 78 TWh) went to Vermont. Second highest was Maine, around 20% (over 21 TWh).

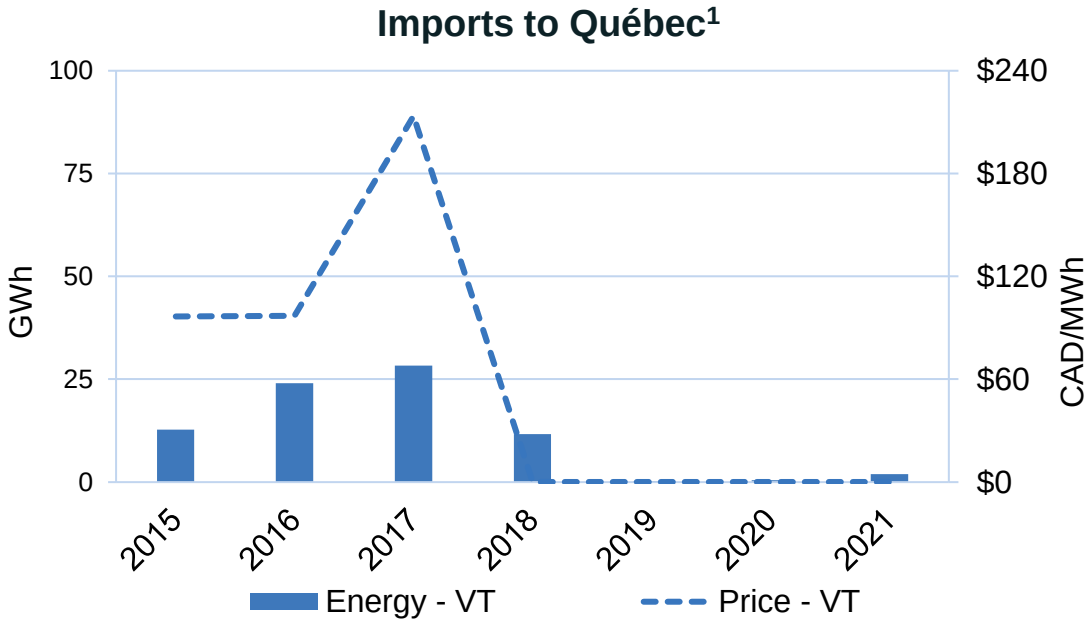
Import prices have traditionally been higher, peaking at $213/MWh in 2017 after which imports into Québec have declined significantly.

- Since 2015, Québec has imported roughly 79 GWh from ISO-NE, exclusively from the state of Vermont.
- Import prices were approximately $97/MWh in the mid 2000's but jumped to $213/MWh in 2017 and have since declined.

In 2021, Hydro-Québec and Massachusetts signed a $10 B deal wherein Québec will supply 9.45 TWh a year for 20 years to Massachusetts.

- The deal includes the construction of a new ~230-kilometre power line from the Appalaches sub-station in Saint-Adrien-d'Irlande, Québec to Lewiston, Maine.





[1] Source: Canada Energy Regulator, Electricity Trading – Tables 3A and 3B

Québec <> NYISO

After ISO-NE, Québec exports the most energy to NYISO which also has the second highest export price.

Export prices from have generally declined over time from a high of $50/MWh in 2015 to a low of $25/MWh 2021 though export volumes have remained relatively consistent.

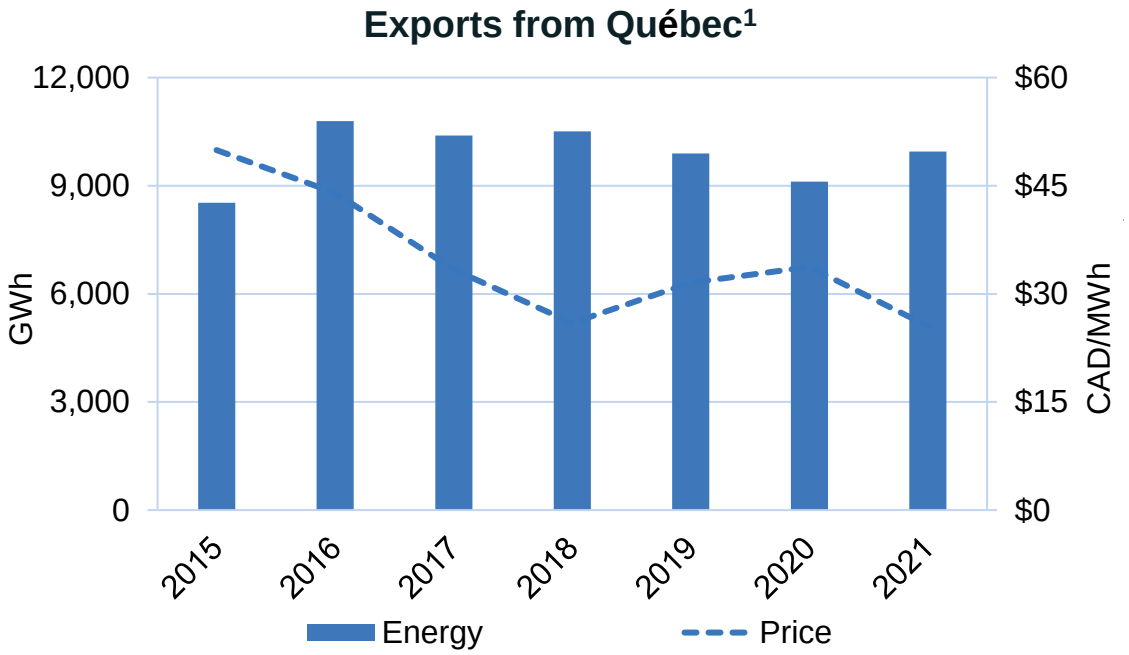
- Since 2015, Québec has exported over 69 TWh to NYISO.
- Though Québec is a net exporter to NYISO it has imported from the state of New York every year since 2015, albeit much smaller volumes.

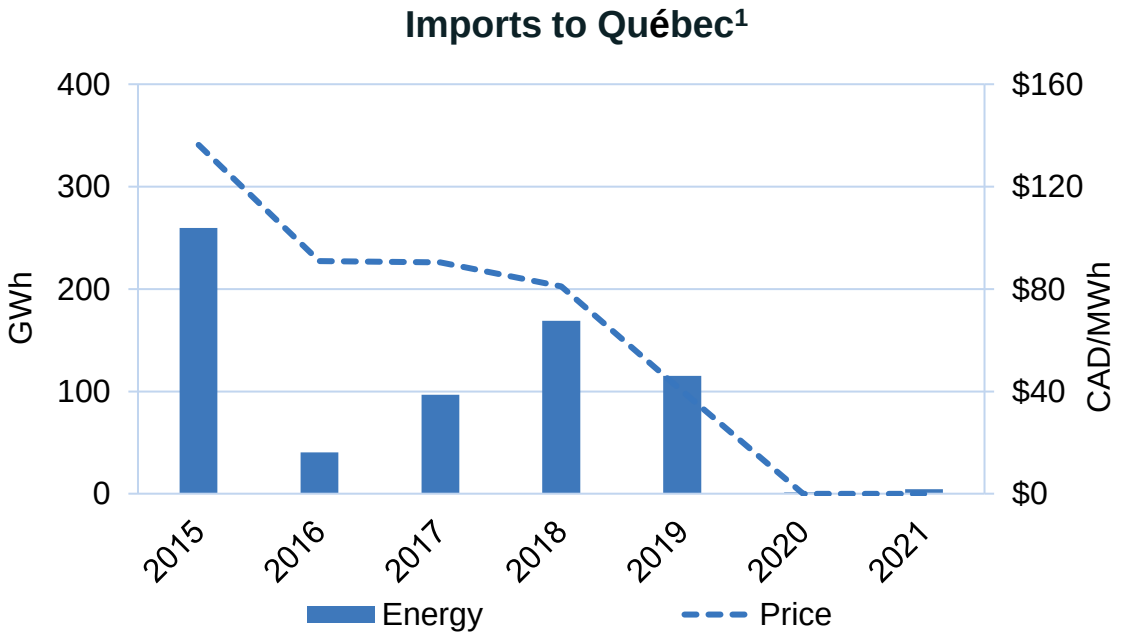
Import prices to Québec from New York have declined over time from a high of $136/MWh in 2014 to $40/MWh in 2019 but import volumes have fluctuated more than export volumes.

- Since 2015, Québec has imported roughly 687 GWh from New York.

In 2021, Hydro-Québec and New York signed a $20 billion deal wherein Québec will supply 10.4 TWh a year for 25 years to New York.

- The deal includes the construction of a new ~58-kilometre power line that will connect to the Champlain Hudson Power Express (CHPE) line, linking La Prairie, Québec to New York City.





[1] Source: Canada Energy Regulator, Electricity Trading – Tables 3A and 3B

Québec <> PJM

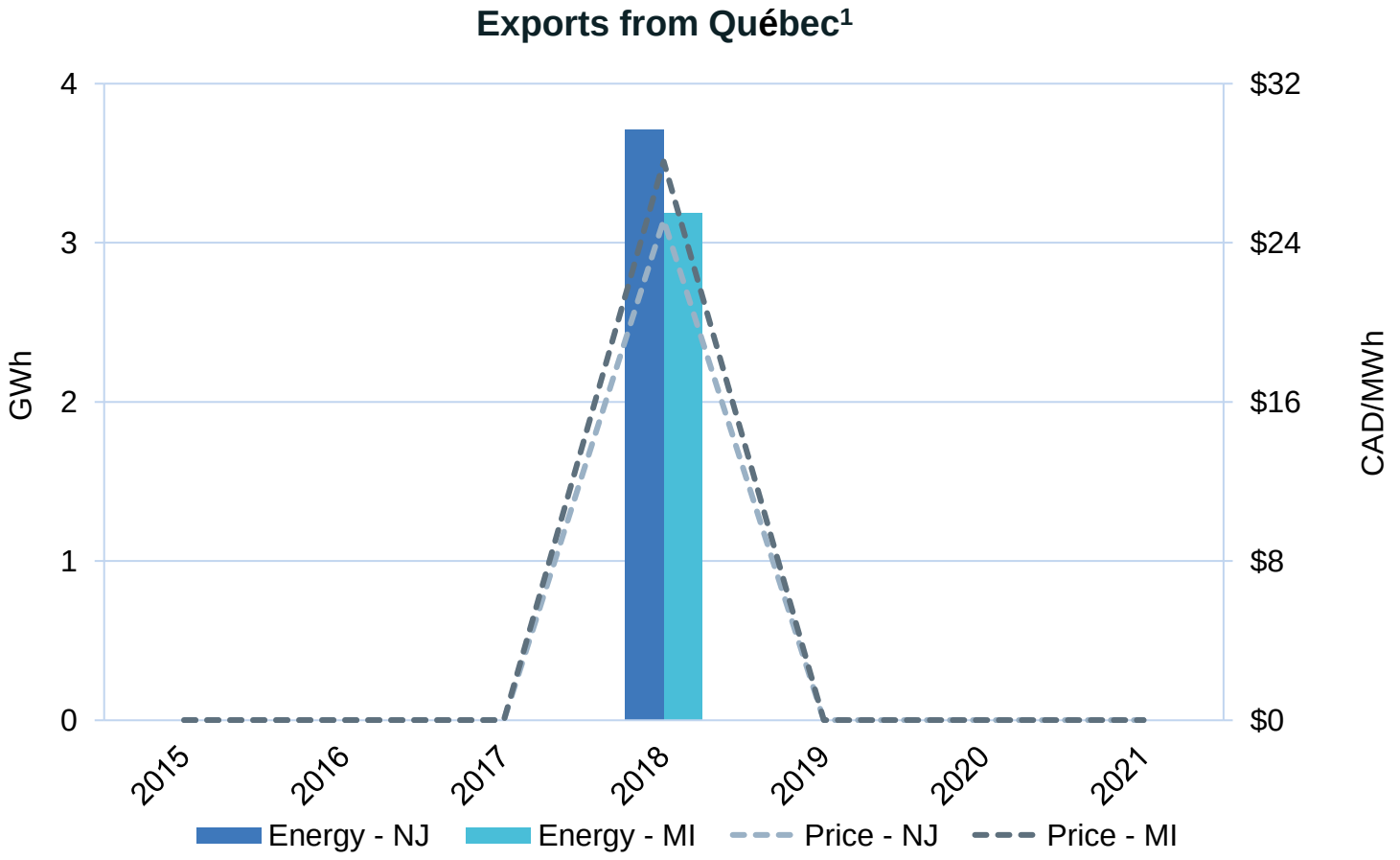
Historical exports to PJM have been minimal, with trade occurring only in 2018 over the recent past, with Michigan and New Jersey.

In the recent past, the electricity trading relationship between Québec and PJM has been exclusively an export trade with energy being exported from Québec.

- Specifically, Québec has only exported to the states of New Jersey and Michigan.
- The trading between Québec and these states has been minimal and only occurred once since 2015.

The export price to each state was also similar coming in at approximately $25/MWh to New Jersey and $28/MWh to Michigan.

- In 2018, Québec exported over 3 GWh to both New Jersey and Michigan.



[1] Source: Canada Energy Regulator, Electricity Trading – Tables 3A and 3B

[1] Source: Canada Energy Regulator, Electricity Trading – Tables 3A and 3B

Québec <> MISO

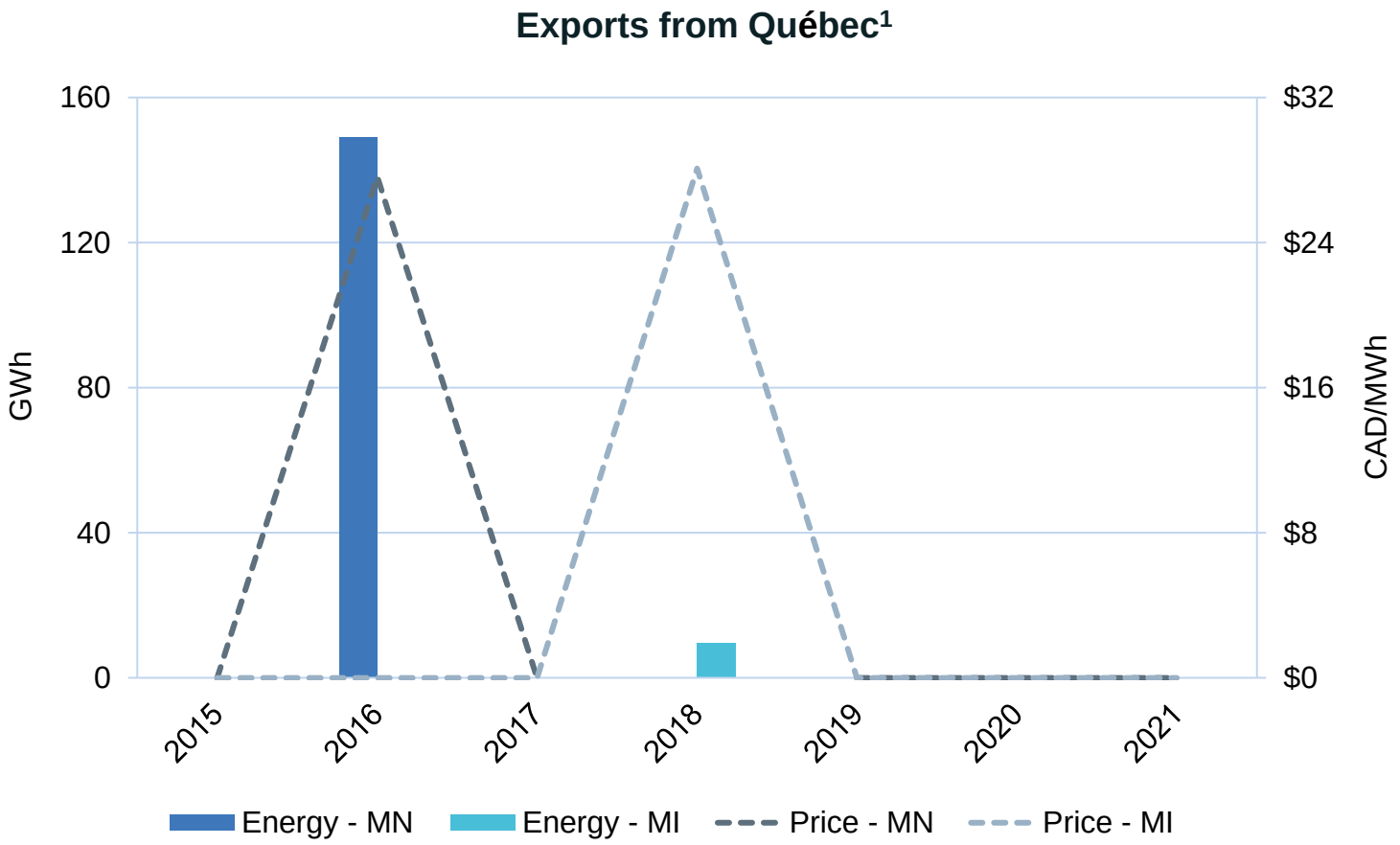
Like PJM, the relationship between MISO and Québec has been minimal with trade occurring only in 2016 and 2018, over the recent past, with Minnesota and Michigan respectively.

In the recent past, the electricity trading relationship between Québec and PJM has been exclusively an export trade with energy being exported from Québec.

- Specifically, Québec has only exported to the states of Michigan and Minnesota.
- The trading between Québec and these states has been minimal and only occurred once in each state since 2015.

The export price to each state was also similar coming in at approximately $25/MWh to New Jersey to $28/MWh from Michigan.

- In 2016, Québec exported approximately 149 GWh to Minnesota.
- In 2018, Québec exported over 9 GWh to Michigan.[1]



[1] Source: Canada Energy Regulator, Electricity Trading – Tables 3A and 3B

[1] Source: Canada Energy Regulator, Electricity Trading – Tables 3A and 3B

Manitoba <> MISO

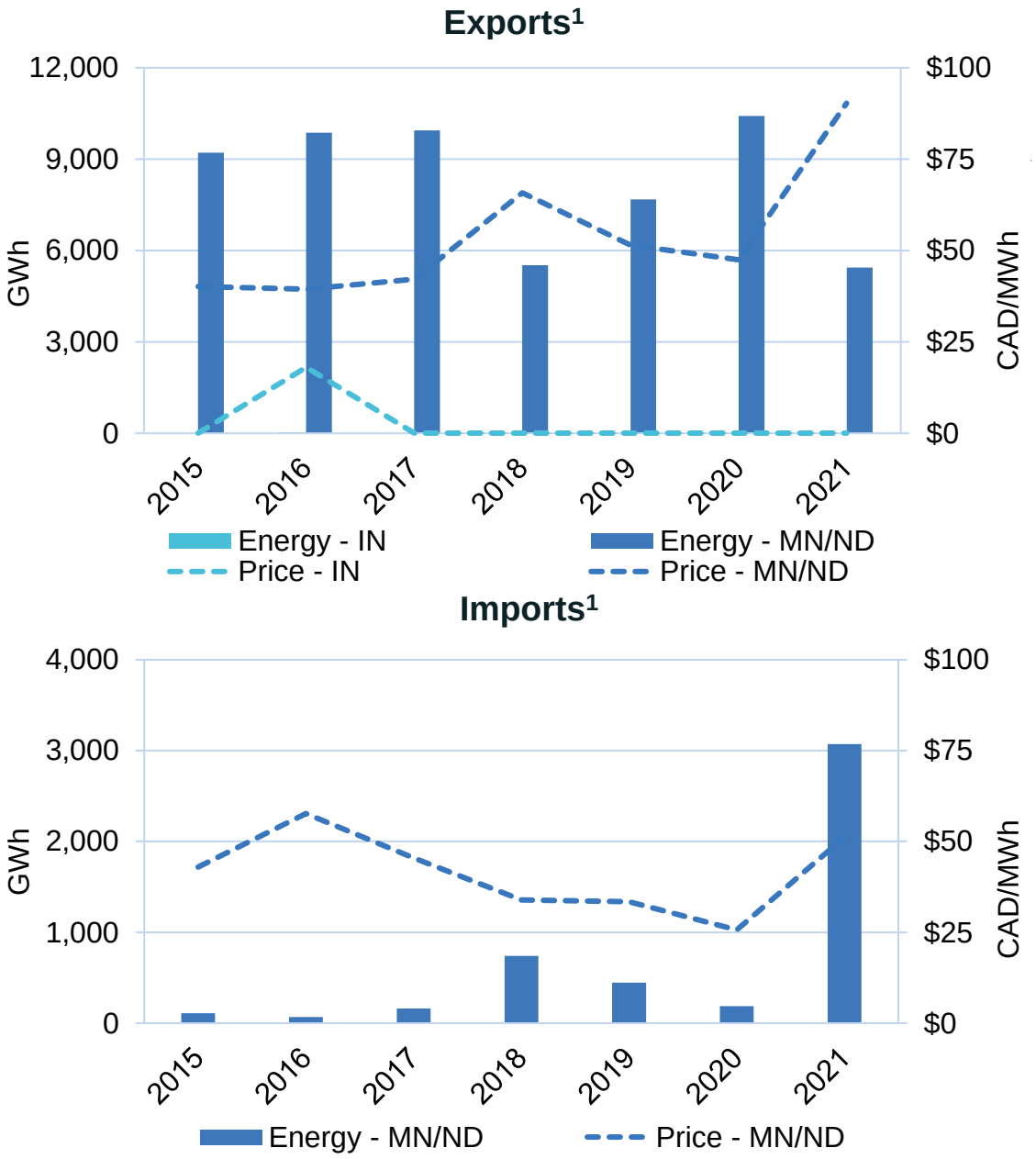
Manitoba has a strong exporting relationship with MISO, and recently an importing one too.

Export prices from Manitoba have generally increased from a low of $39/MWh in 2016 to over $90/MWh in 2021.

- The electricity trading relationship between Manitoba and MISO since 2015 has primarily been one of Manitoba being a net exporter to the Midwest.
- Over the past seven years, MISO has exported about 58 TWh to the states of Indiana and Minnesota / North Dakota.
- Over 99% of the exports from Manitoba to MISO in this time frame has been to Minnesota / North Dakota.

Import prices to Manitoba have generally declined over time from a high of $58/MWh in 2016 to a low of $26/MWh in 2020.

- However, prices rose significantly in 2021, as did imports, reaching $51/MWh.
- Since 2015, Manitoba has imported close to 5 TWh.



[1] Source: Canada Energy Regulator, Electricity Trading – Tables 3A and 3B

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For any questions, please contact us.

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Historical Wholesale Power Market Prices

ATC Power Prices ($/MWh)

	NYISO		MISO		PJM	
Year	Zone J	Average of Other Zones	Indiana	Average of Other Zones	West Hub	Average of Other Zones
2017	33.09	27.93	29.38	28.04	29.71	29.41
2018	39.79	34.25	33.14	30.92	36.34	35.76
2019	28.90	24.98	26.96	25.27	26.67	25.64
2020	21.34	18.95	22.95	21.16	20.90	19.93
2021	42.63	36.59	40.98	38.20	38.94	37.08

Capacity Prices ($/kW-yr)

	NYISO		MISO		PJM	
Year	Zone J	Average of Other Zones	Indiana	Average of Other Zones	RTO	Average of Other Zones
2017	80.66	46.48	11.27	7.33	50.36	34.58
2018	77.46	48.27	2.36	2.17	63.47	53.33
2019	95.01	27.75	2.16	2.48	54.74	46.41
2020	144.58	22.48	1.52	7.25	45.59	31.54
2021	70.82	46.74	1.83	5.37	56.61	41.45

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