A 10-Year Retrospective and Prospective Assessment of Trends: Electricity Supply and Demand and Associated Water Consumption in the Great Lakes St. Lawrence Region

5/29/25 Webinar

Susan Fancy, Managing Director
sfancy@umich.edu

GLOBAL CO_2 INITIATIVE
UNIVERSITY OF MICHIGAN

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Study: Questions Asked by GSGP

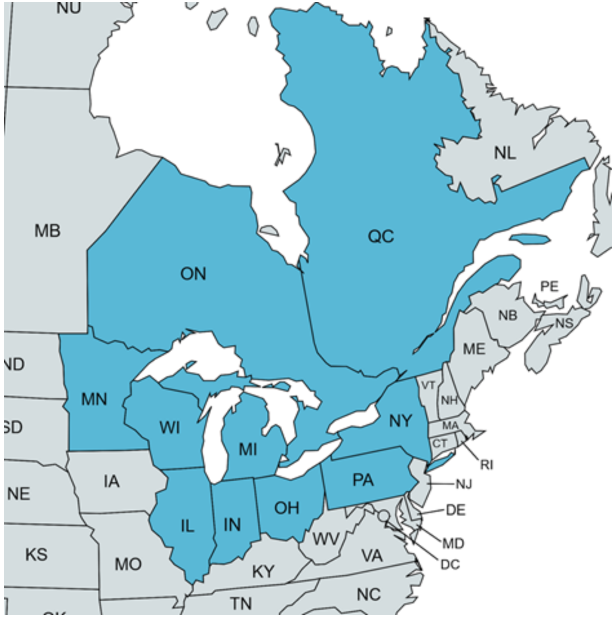
GREAT LAKES ST. LAWRENCE GOVERNORS & PREMIERS

How much electricity is generated in the Region, **and what is the fuel mix** including renewables such as wind, hydroelectric, and solar?

How is the Region meeting its renewable energy demand? Local production or by importing from other areas to fulfill state-and provincial-level clean energy targets?

What is the net import or export of electricity into or from the Region, and what are the main sources? Is there a surplus of energy that could support the development of new industries and future growth? Which states or provinces are the largest exporters?

Over the next decade, what are the projected changes in electricity consumption, fuel mix, and water usage under various scenarios?



University of Michigan Study Team

Xin Shen
Civil Engineering

Jeremy Bricker
Civil Engineering

Curt Wolf
Civil Engineering

Jon W. Allan
School of Environment and Sustainability

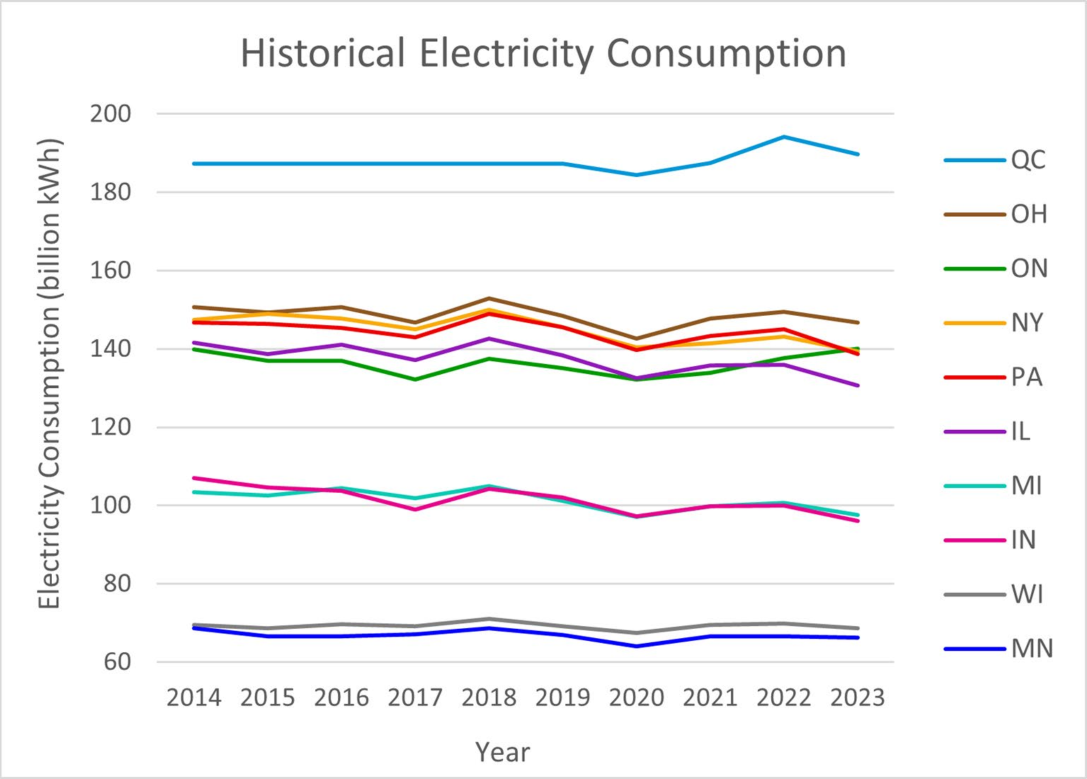
Dan Cooper
Global CO_2 Initiative, Mechanical Engineering

Susan Fancy
Global CO_2 Initiative, Mechanical Engineering

Key Study Conclusions: 2014 to 2023 Timeframe

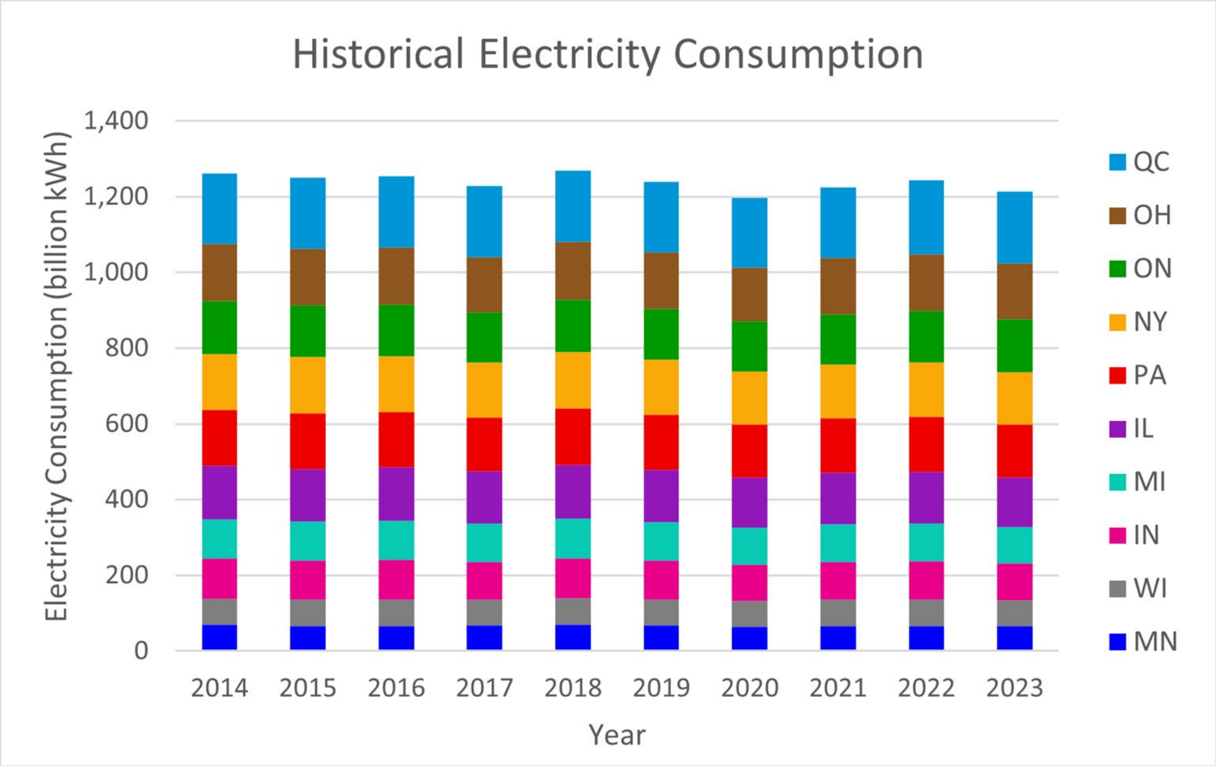
- With the Region’s **shift from coal and nuclear to gas, solar and wind, energy production has been significantly decarbonized and uses less water, while supporting an increase in regional real GDP**
- **The region is exporting an excess of 5.7% of total electricity generated.** If used to support mid-sized data centers at 50 MW, there is capacity for 181 in the Region
- **Water consumption has decreased 24%**
- The dual benefit of more efficient energy production and decreased water use offers **new potential economic opportunities for the Region - continue to export and sell power? Or use it for new purposes? Data centers, polysilicon for usage in solar and electronics, or product manufacture that use waste carbon dioxide as a feedstock are just a few possibilities**

Historical Electricity Consumption: Time Series



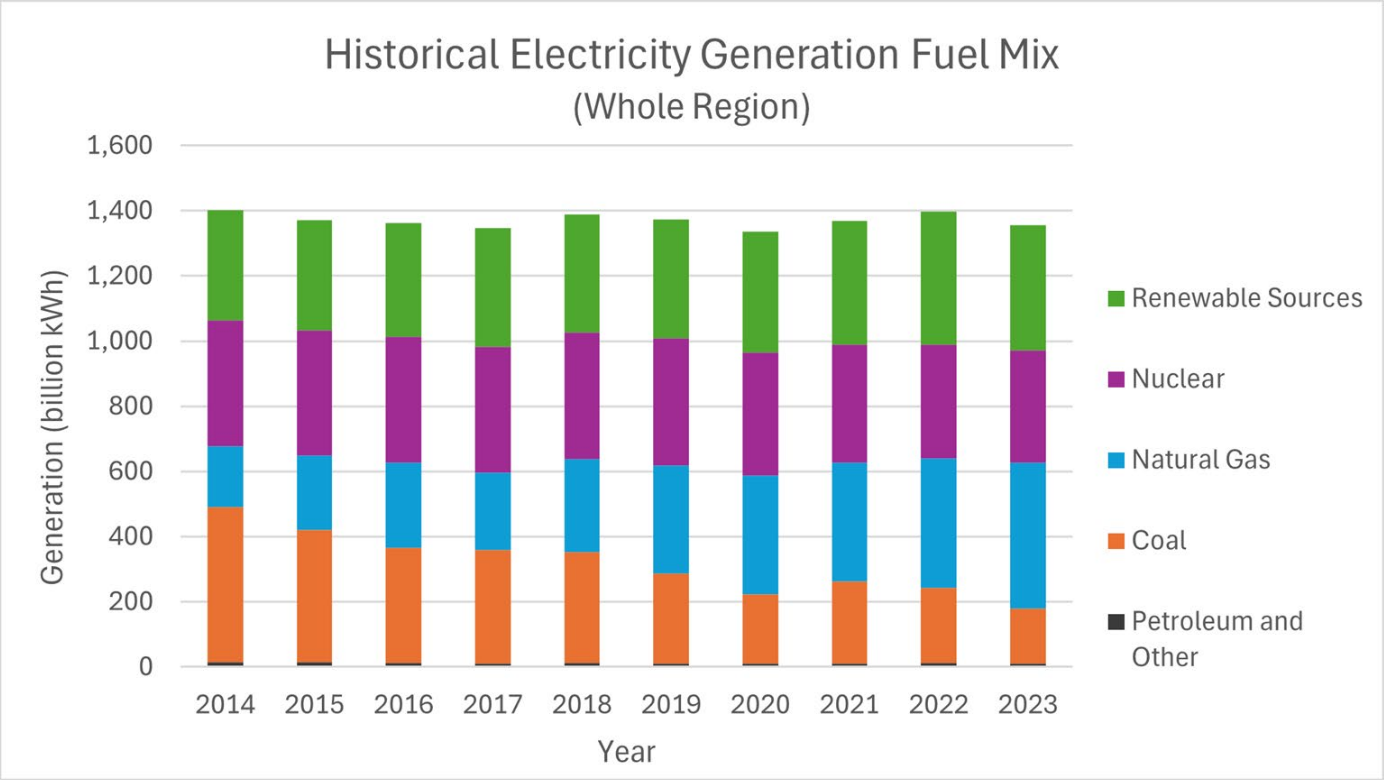
Data source: State Energy Data System (SEDS): 1960-2022 Ontario: Historical Demand Quebec: History of electricity demand in Québec

Historical Electricity Consumption: Share of Each Region



Data source: State Energy Data System (SEDS): 1960-2022 Ontario: Historical Demand Quebec: History of electricity demand in Québec

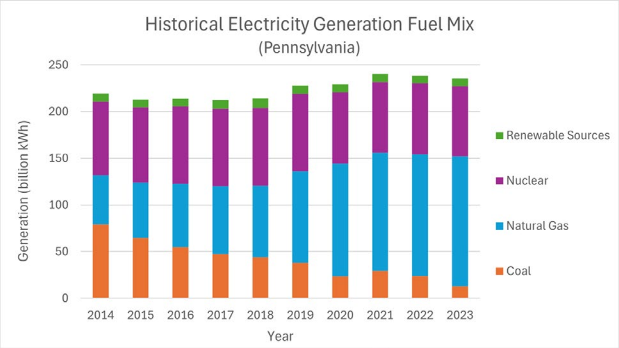
Historical Electricity Generation Fuel Mix: Whole Region

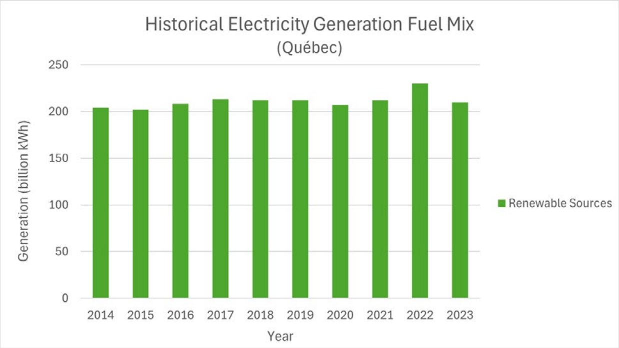


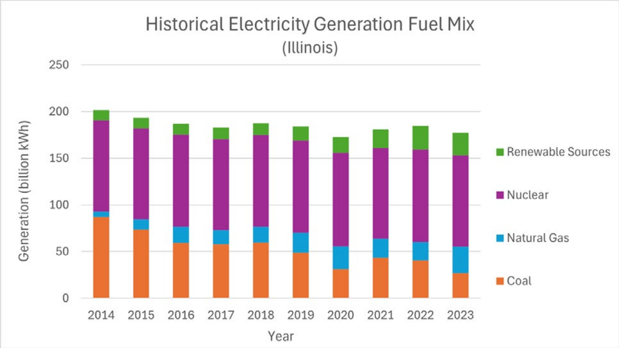
Data source: Electricity Data Browser Macro Indicators - Canada.ca 2023 Year in Review
Hydro-Québec – Annual Report 2023 Hydro-Québec – Annual Report 2022 Energy Fact Book 2024-2025

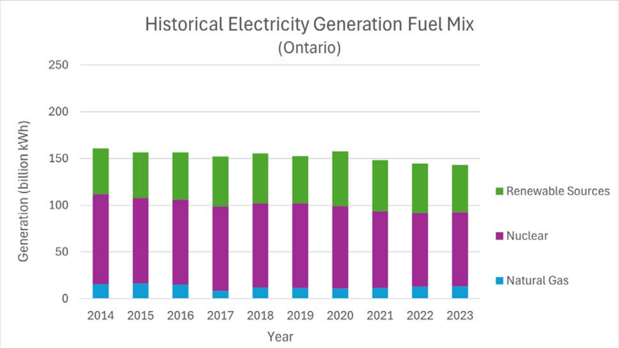
Historical Electricity Generation Fuel Mix By Province or State

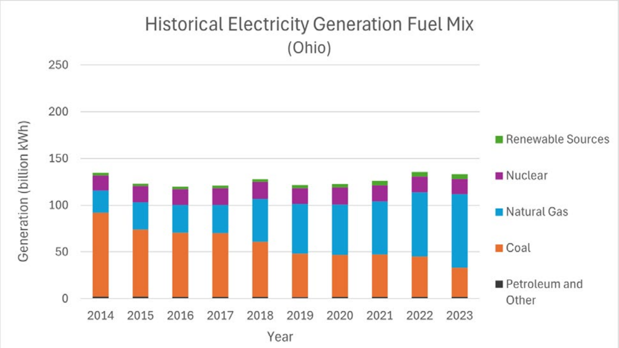
Highest → *Lowest*

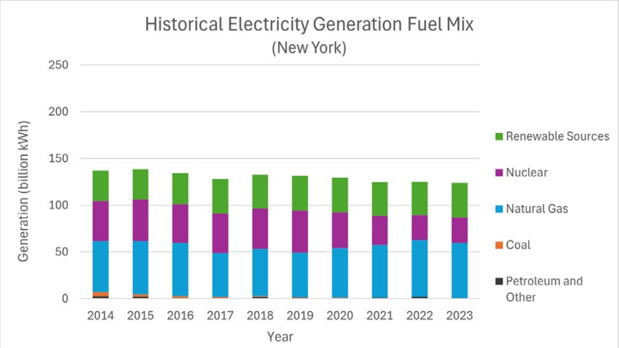






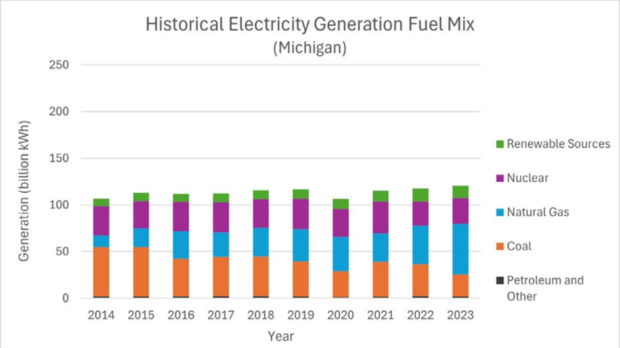


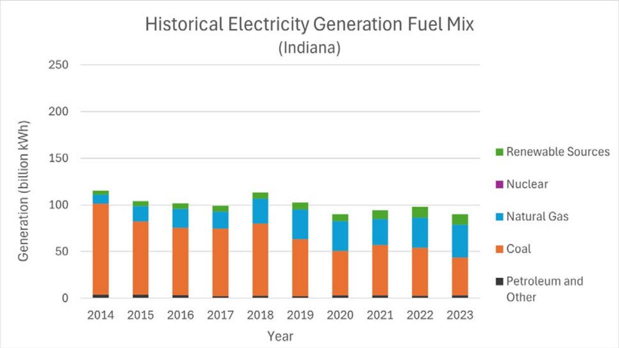


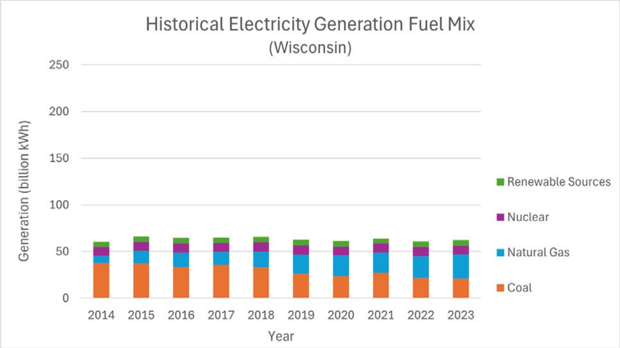


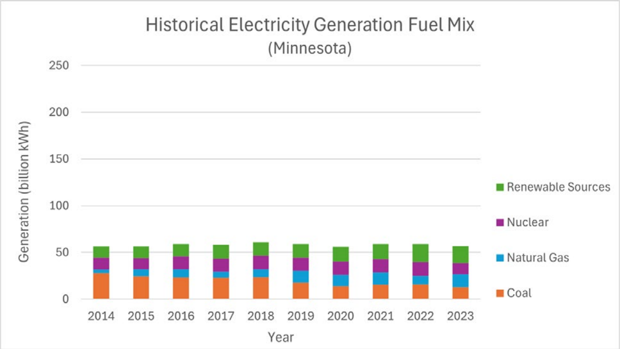
Historical Electricity Generation Fuel Mix By Province or State

Highest → *Lowest*

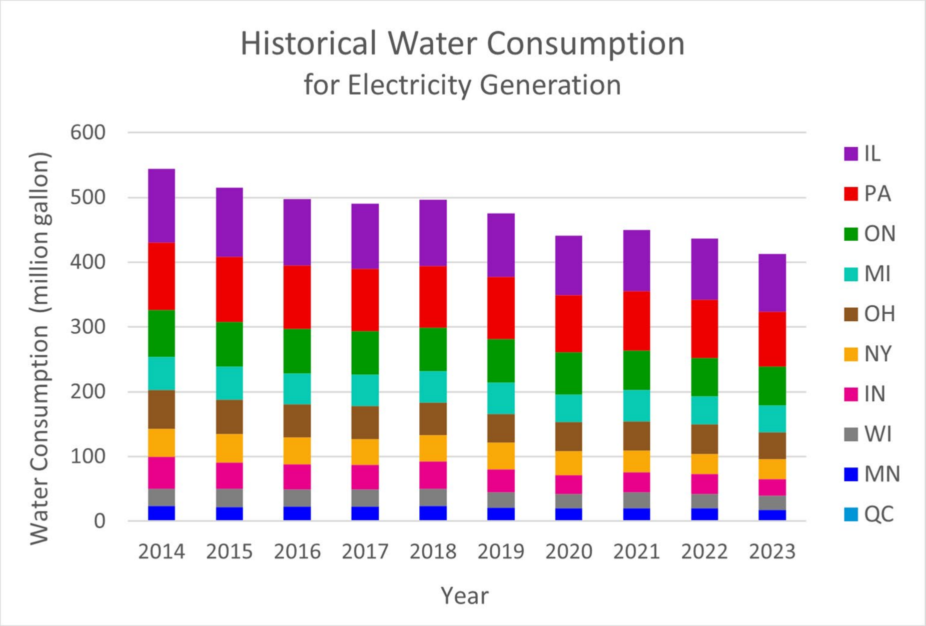


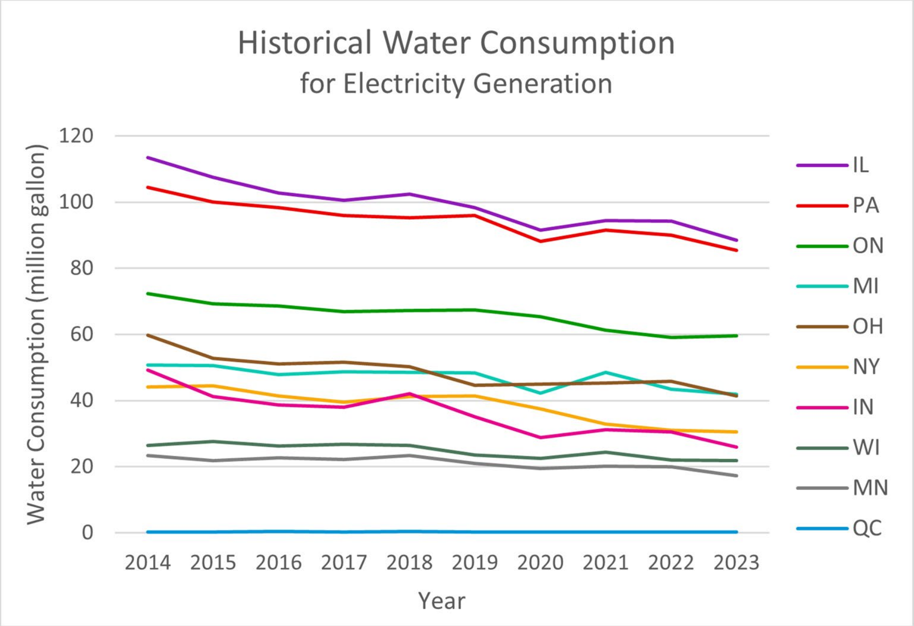






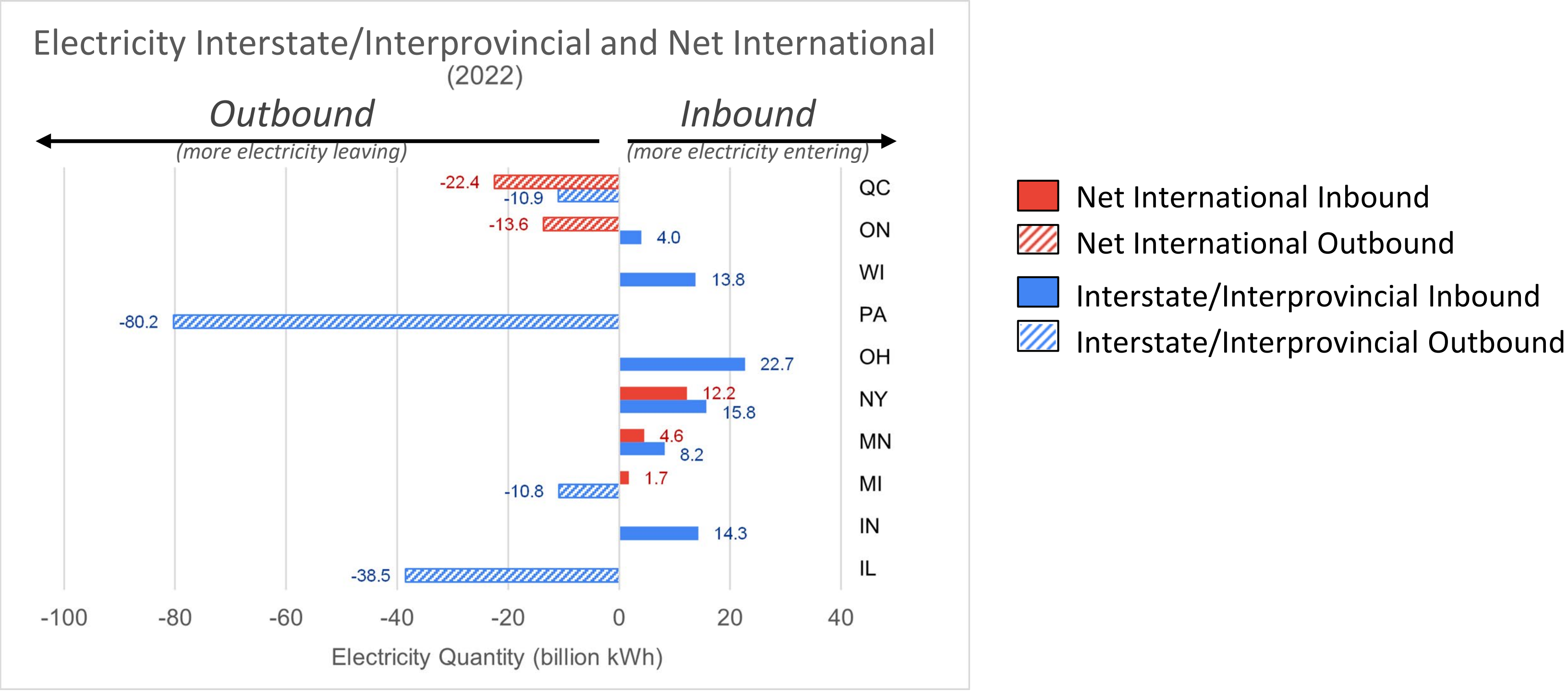
Historical Water Consumption for Electricity Generation



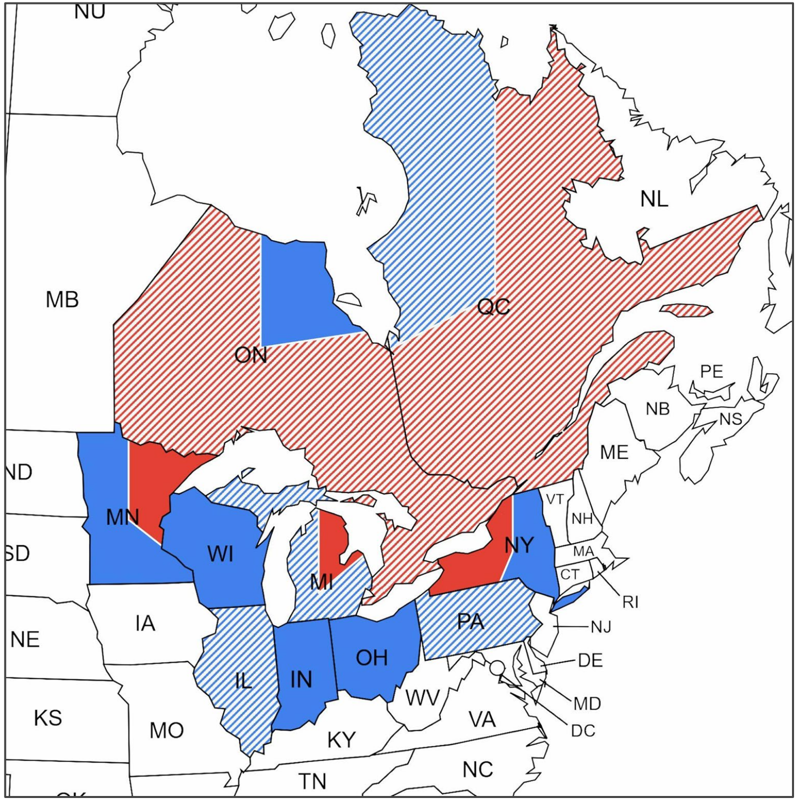


Electricity Interstate/Interprovincial & Net International 2022

Region	IL	IN	MI	MN	NY	OH	PA	WI	ON	QC
Interstate	-38.5	14.3	-10.8	8.2	15.8	22.7	-80.2	13.8	4.0	-10.9
International	0.0	0.0	1.7	4.6	12.2	0.0	0.0	0.0	-13.6	-22.4

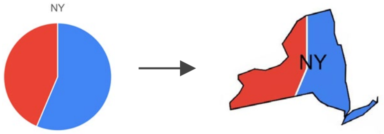


Electricity Interstate/Interprovincial and Net International



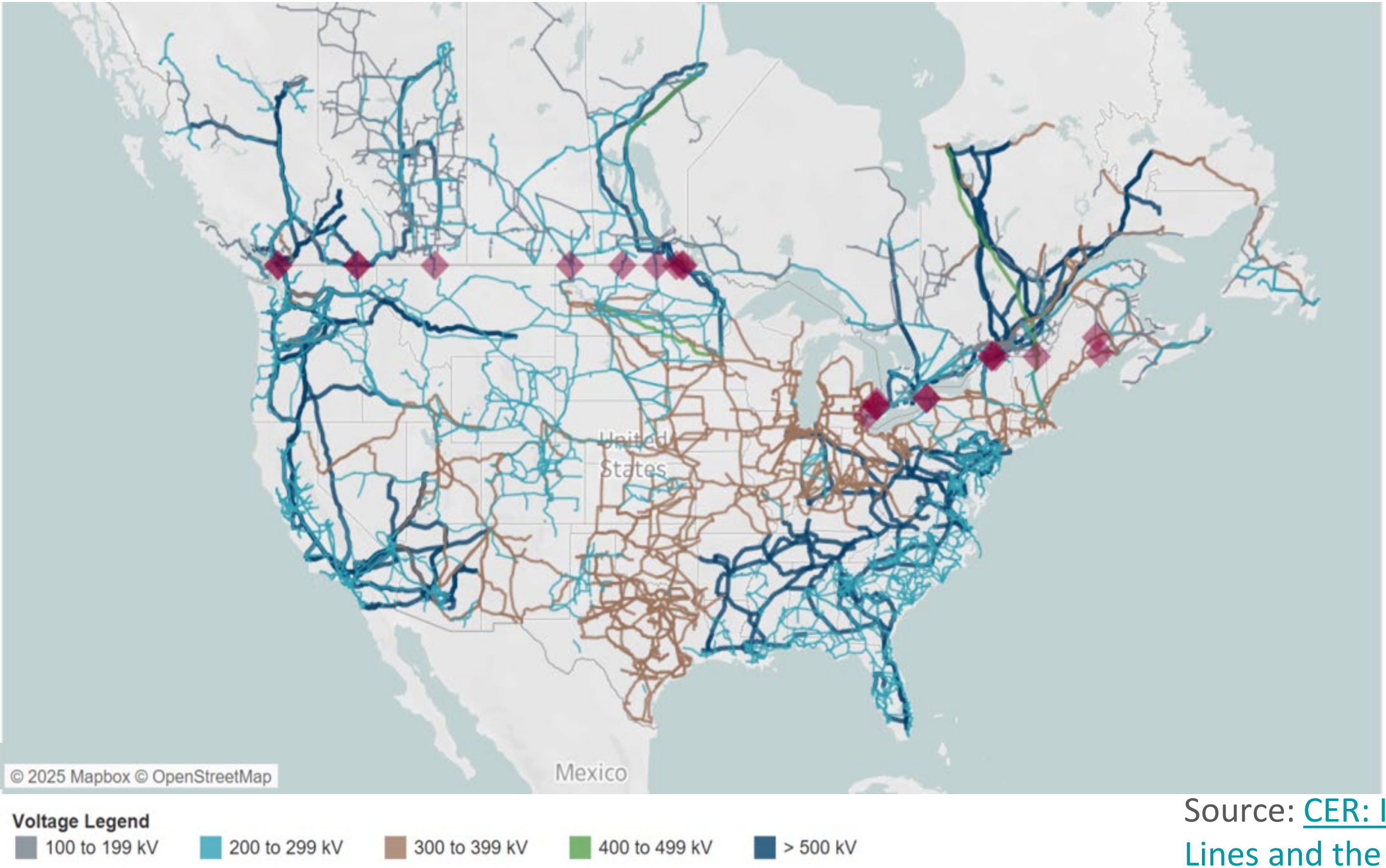
unit: billion kWh (2022)

- International Inbound
- International Outbound
- Interstate/Interprovincial Inbound
- Interstate/Interprovincial Outbound



Pie chart extended to regional footprint; shows share of local electricity flow

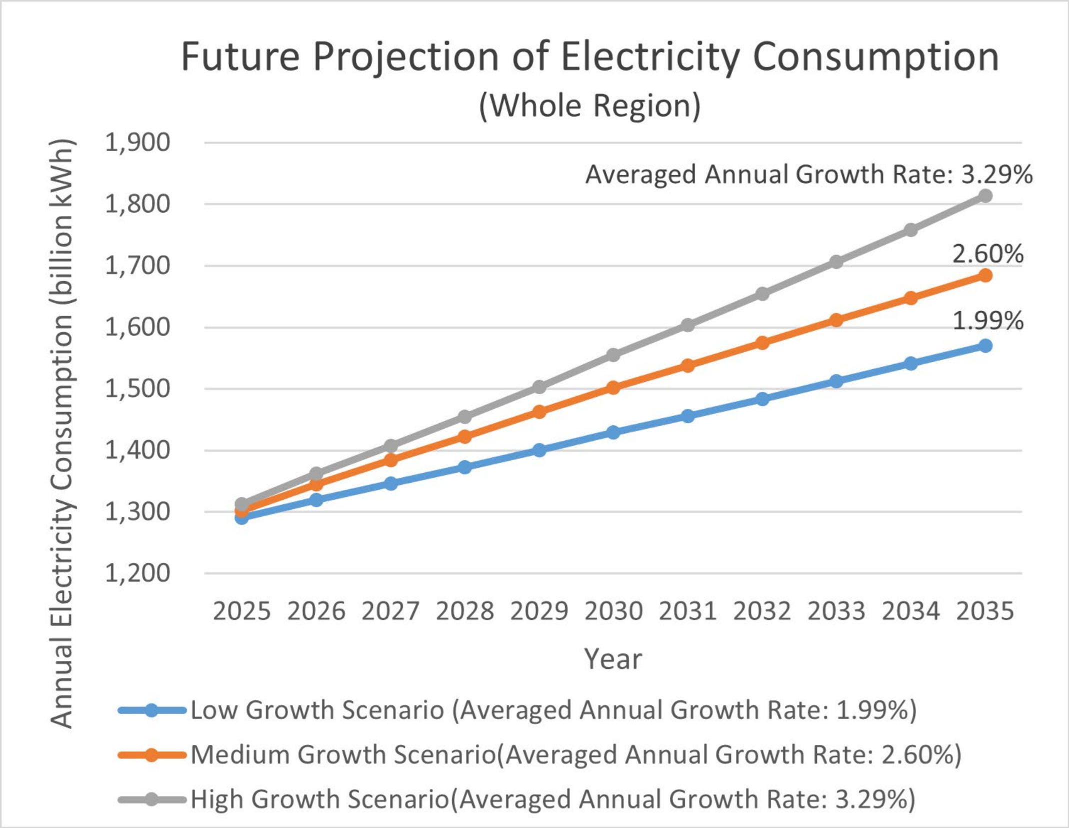
Major Transmission Lines of North America



Source: [CER: International Power Lines and the Canada-U.S. Grid]

Future Projection of Electricity Consumption

High, Medium and Low Economic Growth Scenarios

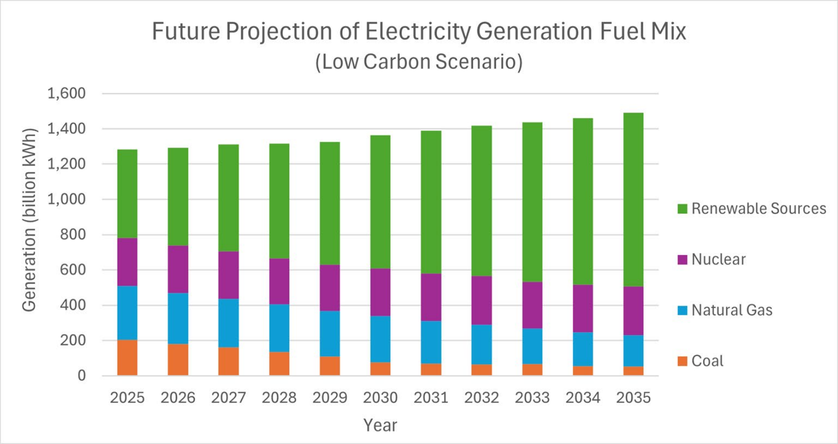


Drivers behind increases:

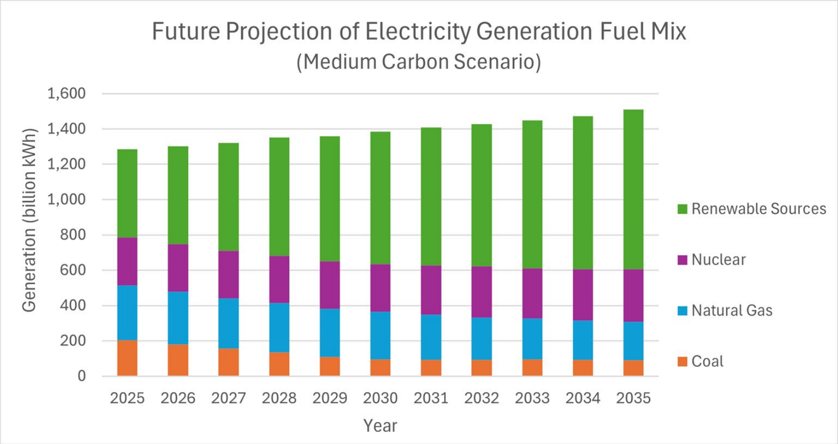
- Building electrification
- Electric vehicles
- New industries such data centers and chip manufacturing
- Province-and-state-specific loads, such as more greenhouses in Ontario
- Population growth

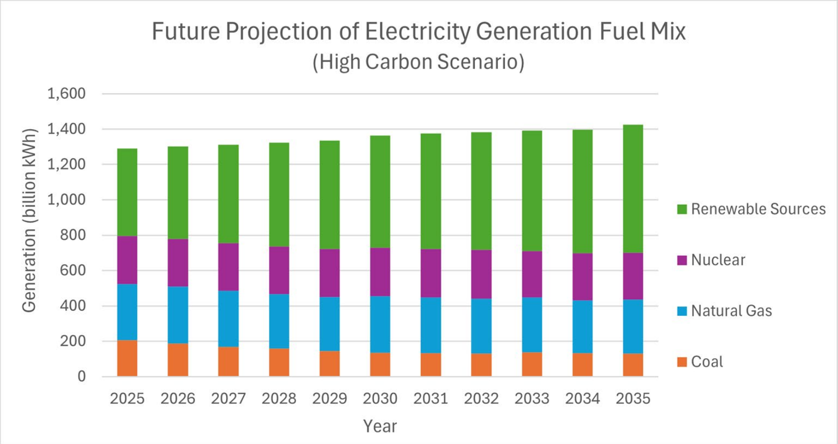
Data source: Power Trends - NYISO
MISO 2024 Load Forecast and Process Enhancements Workshop
Report: Transmission Planning for PJM's Future Load and Generation
Annual Planning Outlook
Action Plan 2035 | Hydro-Québec

Future Projection of Electricity Generation Fuel Mix: Scenarios

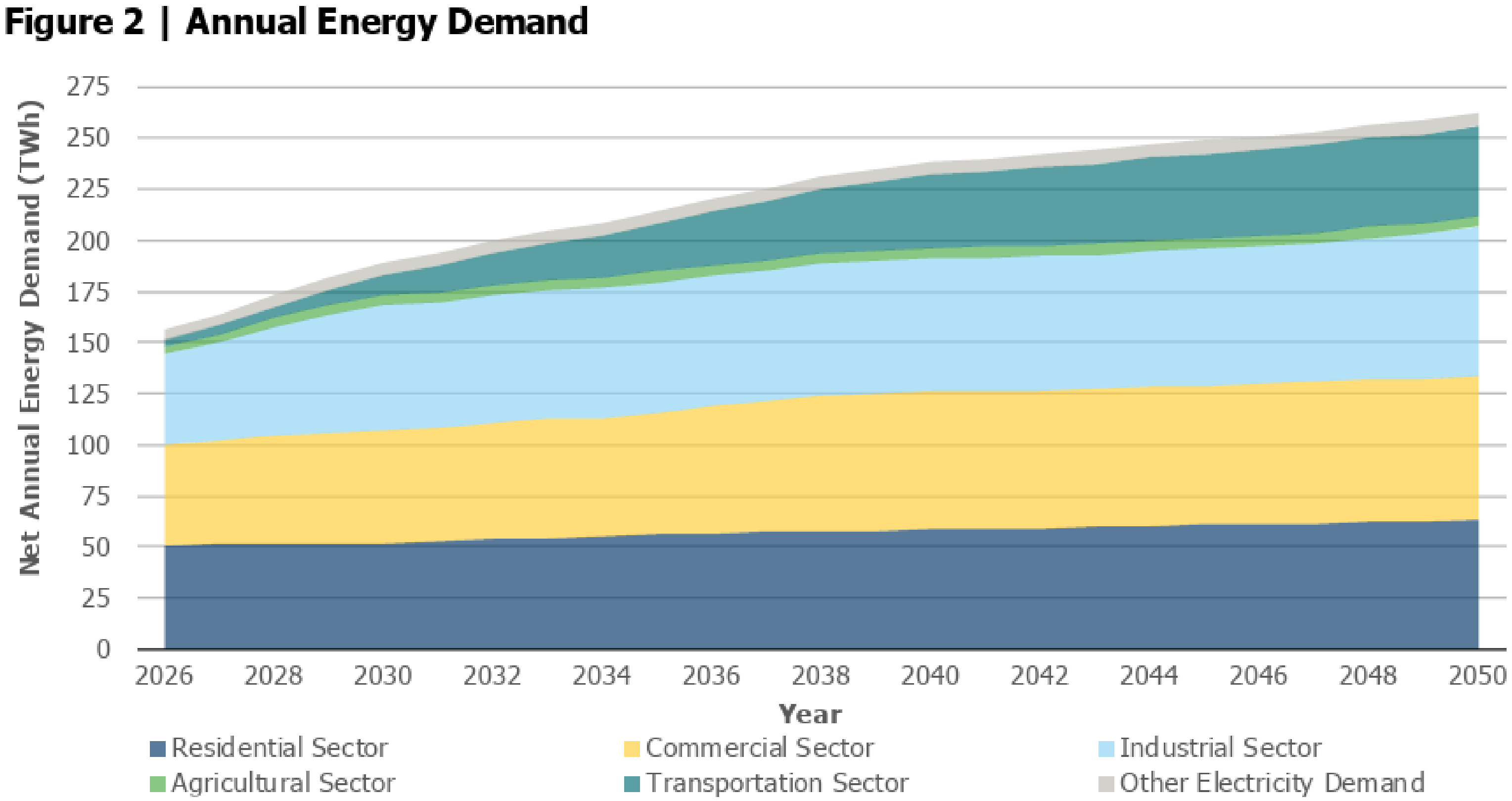


Differences in low, medium and high scenarios are due to the proportion of clean energy sources in the fuel mix and the related level of carbon emissions



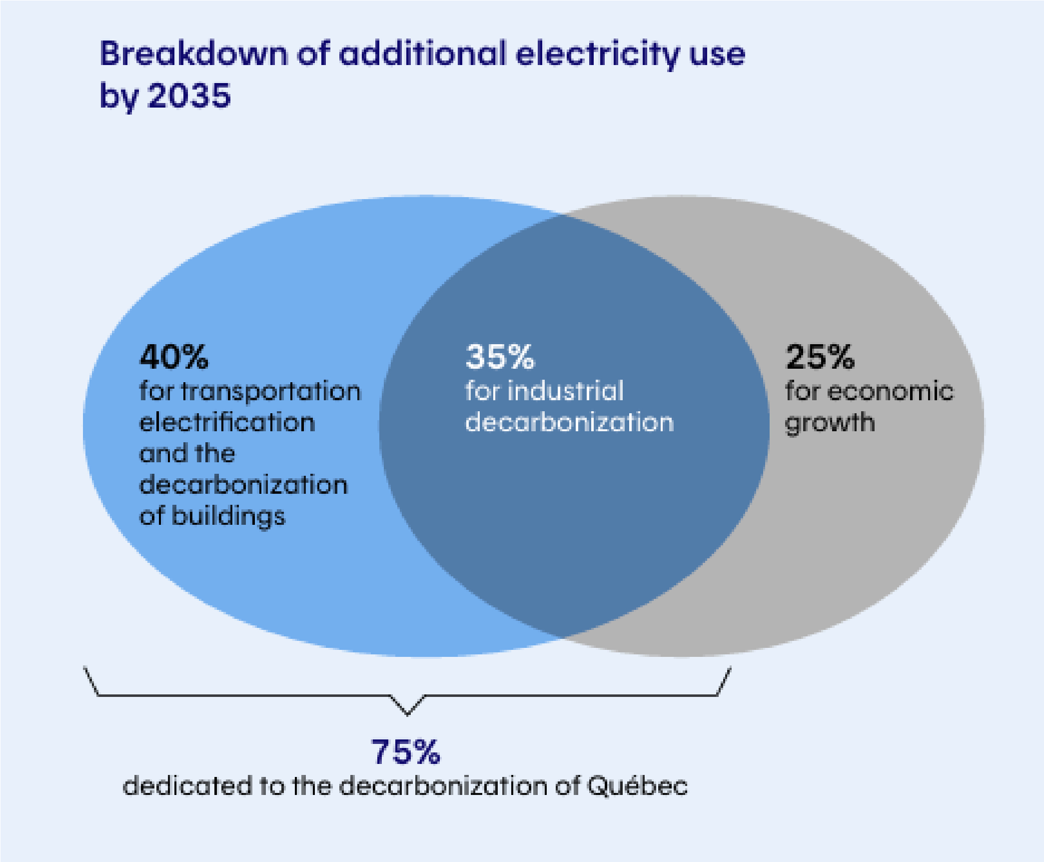


Example of Future Electricity Demand Drivers: Ontario



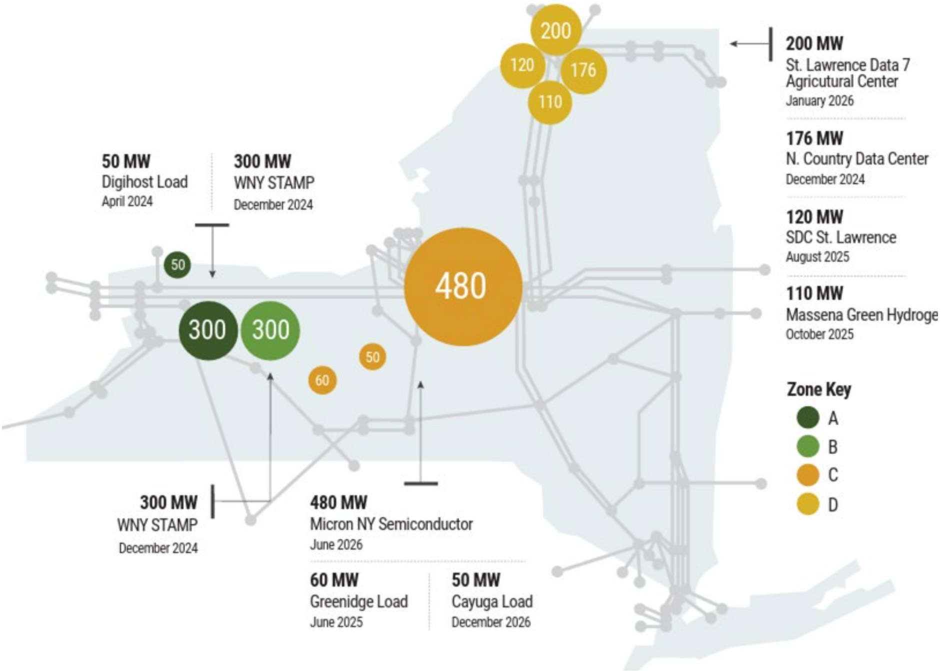
Source: IESO [Annual Planning Outlook]

Example of Future Electricity Demand Drivers: Québec

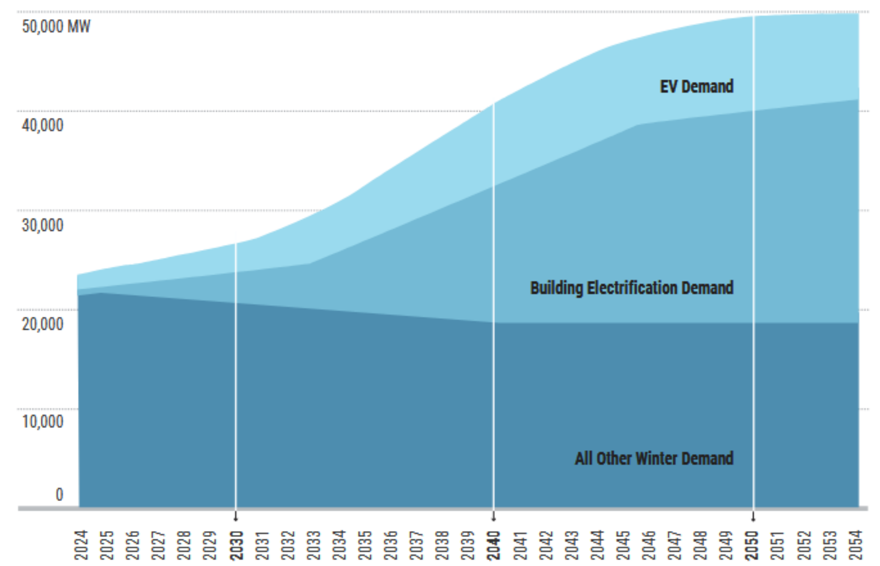


Example of Future Electricity Demand Drivers: NY

NEW LARGE LOAD PROJECTS IN NEW YORK STATE

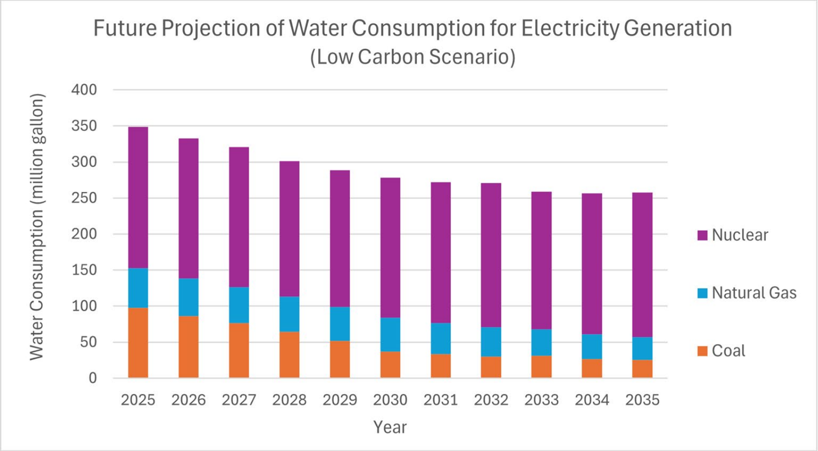


EXPECTED IMPACT OF ELECTRIFICATION ON STATEWIDE WINTER PEAK DEMAND (MW)



Data source: [Power Trends - NYISO]

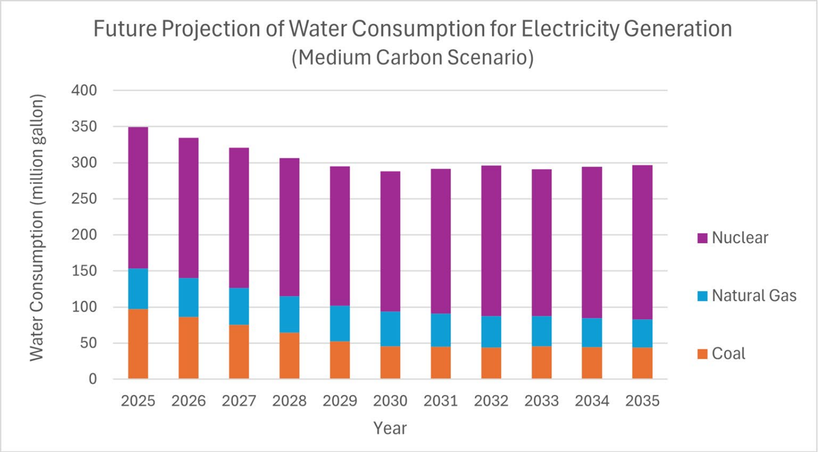
Future Projection of Water Consumption: Scenarios

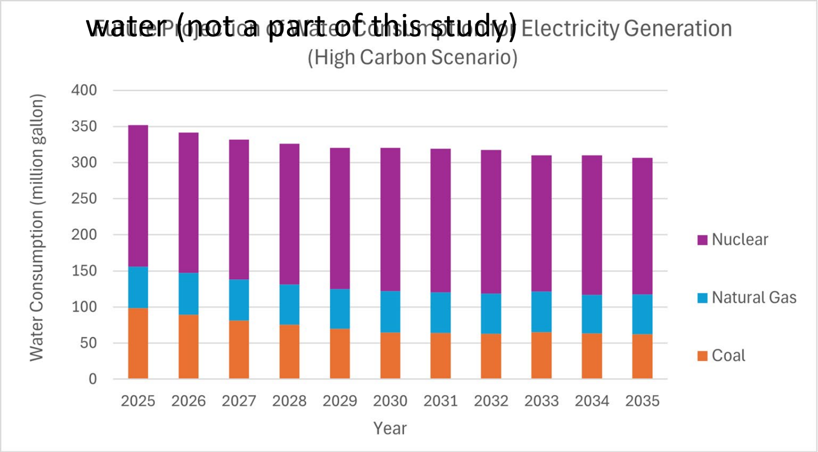


Differences in low, medium and high scenarios are due to the proportion of clean energy sources in the fuel mix and the related level of carbon emissions

Note that renewable energy sources do not generate consumptive water losses

Data centers typically use large amounts of cooling water (not a part of this study)





Additional Study Conclusions

- **Energy consumption for the Region over the last 10 years has been largely stable, while province and state level real GDP has grown.** Energy consumption for the Region has remained relatively flat within year to year variability, ranging from 1,262 billion kWh in 2014 to 1,213 kWh in 2023. Over the same timeframe, GDP for Ontario, Québec, and the U.S. Great Lakes States increased in the low single digit percentages annually, typically 1-4%. Net GDP gains for the decade include a 2020 decrease in GDP from covid

- **Significant opportunities exist for additional low to zero emission energy generation** in wind, solar, and anaerobic digestion to produce either natural gas or electricity

- **For energy storage, there is also significant capacity for pumped hydro systems*,** although these would need to account for complexities in siting on highly desirable shoreline, availability of supporting infrastructure and community receptivity

**Pumped hydroelectric storage is a method of storing energy by using surplus electricity when available to pump water from a lower reservoir to a higher reservoir, then releasing the water through turbines to generate electricity later on. It's essentially a "water battery" that can be charged and discharged to balance electricity supply and demand. The Ludington Michigan plant, built in 1973, is 2,172 MW capacity*

Appendices

Historical Electricity Consumption: Data Table

Historical Electricity Consumption [unit: billion kilowatthours]										
State/Province	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
QC	187.4	187.4	187.4	187.4	187.4	187.4	184.3	187.5	194.2	189.7
OH	150.7	149.2	150.6	146.6	152.9	148.5	142.6	147.7	149.5	146.6
ON	139.8	137.0	137.0	132.1	137.4	135.1	132.2	133.8	137.6	140.0
NY	147.4	148.9	147.8	145.0	149.9	145.6	140.4	141.4	143.2	139.4
PA	146.7	146.3	145.3	143.0	149.0	145.6	139.7	143.3	145.0	138.7
IL	141.5	138.6	141.1	137.2	142.7	138.3	132.5	135.7	135.9	130.6
MI	103.3	102.5	104.5	101.9	104.9	101.2	97.0	99.8	100.6	97.6
IN	106.9	104.5	103.7	99.0	104.2	102.1	97.2	99.7	100.0	96.0
WI	69.5	68.7	69.7	69.1	71.0	69.2	67.4	69.4	69.9	68.6
MN	68.7	66.6	66.5	67.2	68.7	67.0	64.1	66.6	66.6	66.2
Total	1,261.9	1,249.8	1,253.6	1,228.4	1,268.0	1,240.0	1,197.4	1,225.0	1,242.7	1,213.5

Data source: State Energy Data System (SEDS): 1960-2022 (complete)
Ontario: Historical Demand
Quebec: History of electricity demand in Québec

Historical Electricity Generation Fuel Mix

Whole Region Data Table

Historical Generation Fuel Mix of The Whole Region (unit: billion kWh)										
Source Key	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Coal	476.7	405.5	354.2	347.8	339.7	276.1	213.4	253.0	231.4	169.8
Petroleum	7.9	7.6	5.1	4.5	6.2	3.7	3.4	4.3	5.8	3.7
Natural Gas	186.4	229.9	261.0	237.9	285.6	331.0	365.6	363.8	397.5	446.5
Nuclear	385.5	382.9	386.6	386.6	388.2	391.3	376.0	362.3	348.3	345.5
Renewable Sources	338.0	337.5	347.9	364.6	363.4	365.0	370.9	378.4	407.4	383.2
Other	6.7	7.1	6.6	6.5	6.7	6.7	6.1	6.5	6.2	6.6
All Fuel	1,401.1	1,370.4	1,361.2	1,347.7	1,389.6	1,373.8	1,335.6	1,368.1	1,396.7	1,355.2

Data source: Electricity Data Browser Macro Indicators - Canada.ca 2023 Year in Review
Hydro-Québec – Annual Report 2023 Hydro-Québec – Annual Report 2022 Energy Fact Book 2024-2025

Historical Water Consumption for Electricity Generation

Historical Water Consumption for Electricity Generation (unit: million gallon)										
Region	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
IL	113.4	107.4	102.7	100.5	102.4	98.4	91.6	94.4	94.2	88.4
PA	104.5	100.0	98.4	96.0	95.3	95.9	88.1	91.6	89.9	85.5
ON	72.3	69.3	68.6	66.8	67.3	67.4	65.3	61.3	59.1	59.5
MI	50.6	50.5	47.8	48.7	48.4	48.3	42.3	48.6	43.4	41.8
OH	59.7	52.8	51.1	51.5	50.3	44.6	45.0	45.2	45.8	41.4
NY	44.0	44.4	41.3	39.5	41.1	41.3	37.4	32.9	31.1	30.5
IN	49.2	41.1	38.7	38.0	42.1	35.0	28.8	31.2	30.5	26.0
WI	26.4	27.6	26.2	26.7	26.4	23.6	22.5	24.3	22.1	21.7
MN	23.3	21.9	22.7	22.2	23.3	21.0	19.4	20.1	19.9	17.2
QC	0.3	0.3	0.3	0.2	0.3	0.3	0.3	0.3	0.3	0.2
Total	543.7	515.4	497.8	490.3	496.9	475.7	440.6	449.8	436.2	412.4

Future Projection of Electricity Consumption Data Table

Low Growth Scenario (unit: billion kWh)											
Operator	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
NYISO	148.5	149.4	149.7	149.8	150.4	151.6	153.6	156.4	159.6	162.8	166.1
PJM	337.1	346.5	355.9	365.3	374.7	384.1	391.7	399.3	406.9	414.5	422.2
MISO	443.2	452.8	462.4	472.0	481.7	491.3	500.9	510.5	520.1	529.7	539.4
IESO	153.1	158.4	160.7	163.4	167.4	171.1	174.0	177.2	180.7	184.2	188.5
HQT	208.1	212.7	217.3	221.9	226.6	231.2	235.8	240.4	245.0	249.6	254.2
Total	1290.0	1319.8	1346.0	1372.5	1400.7	1429.2	1456.0	1483.8	1512.4	1540.9	1570.3
Annual Growth Rat		2.31%	1.99%	1.97%	2.05%	2.04%	1.87%	1.91%	1.92%	1.89%	1.91%
										Averaged Annual Growth Rate	1.99%

Medium Growth Scenario (unit: billion kWh)											
Operator	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
NYISO	151.0	153.0	154.5	155.1	156.7	159.1	162.4	166.5	171.4	176.0	180.6
PJM	341.5	355.3	369.2	383.0	396.8	410.7	419.3	428.0	436.7	445.3	454.0
MISO	448.058	462.534	477.009	491.485	505.96	520.435	534.911	549.386	563.862	578.337	592.813
IESO	153.9	160.7	165.5	170.3	176.5	180.9	185.3	189.9	194.1	198.1	202.6
HQT	208.1	212.7	217.3	221.9	226.6	231.2	235.8	240.4	245.0	249.6	254.2
Total	1302.5	1344.2	1383.5	1421.8	1462.5	1502.2	1537.7	1574.2	1611.0	1647.4	1684.3
Annual Growth Rat		3.20%	2.92%	2.76%	2.86%	2.72%	2.36%	2.38%	2.34%	2.26%	2.24%
										Averaged Annual Growth Rate	2.60%

High Growth Scenario (unit: billion kWh)											
Operator	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
NYISO	154.8	159.1	163.0	167.0	171.3	176.5	182.5	189.4	196.9	204.8	213.2
PJM	343.0	358.3	373.6	388.9	404.2	419.5	431.4	443.3	455.2	467.1	479.0
MISO	453.5	473.5	493.4	513.4	533.3	553.3	573.2	593.2	613.1	633.0	653.0
IESO	152.7	158.1	160.0	162.8	168.0	174.4	180.9	188.0	195.9	204.1	213.9
HQT	208.1	212.7	217.3	221.9	226.6	231.2	235.8	240.4	245.0	249.6	254.2
Total	1312.0	1361.6	1407.3	1454.0	1503.4	1554.9	1603.8	1654.3	1706.1	1758.7	1813.3
Annual Growth Rat		3.78%	3.36%	3.32%	3.40%	3.42%	3.15%	3.15%	3.13%	3.08%	3.10%
										Averaged Annual Growth Rate	3.29%

Data source: Power Trends - NYISO
MISO 2024 Load Forecast and Process Enhancements Workshop
Report: Transmission Planning for PJM's Future Load and Generation
Annual Planning Outlook
Action Plan 2035 | Hydro-Québec

Future Projection of Electricity Generation Fuel Mix Data Table

Future Projection of Fuel Mix at High Carbon Scenario (unit: billion kWh)										
Source Key	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**
Coal	205.02	186.52	168.89	157.92	145.43	134.54	133.67	130.78	136.37	132.00	129.61
Petroleum	2.04	1.71	1.62	1.72	1.45	1.37	1.15	1.13	1.15	1.13	1.12
Natural Gas	317.97	321.55	317.46	308.32	305.08	319.03	313.37	309.30	311.87	298.62	306.97
Nuclear	272.50	269.59	268.78	270.49	271.64	275.53	275.90	276.82	261.66	267.71	263.11
Renewable Sources	495.55	524.50	555.71	586.49	612.70	634.85	651.63	666.07	681.99	698.86	725.85

Future Projection of Fuel Mix at Medium Carbon Scenario (unit: billion kWh)											
Source Key	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**
Coal	202.83	180.24	157.26	134.40	109.70	94.85	93.38	91.45	95.28	92.85	91.16
Petroleum	2.03	1.69	1.57	1.62	1.31	1.20	0.98	0.97	0.99	0.98	0.97
Natural Gas	309.81	296.92	283.60	280.21	272.52	268.86	254.28	240.62	232.35	222.86	216.91
Nuclear	272.31	269.83	269.69	266.31	268.65	269.64	279.34	290.07	282.40	290.96	297.18
Renewable Sources	501.15	555.43	610.81	670.28	707.64	751.45	781.42	805.23	838.28	866.59	904.41

Future Projection of Fuel Mix at Low Carbon Scenario (unit: billion kWh)											
Source Key	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**
Coal	203.96	180.06	159.90	134.79	108.53	76.77	69.38	62.98	65.40	55.26	52.92
Petroleum	2.04	1.69	1.58	1.63	1.31	1.14	0.90	0.87	0.89	0.85	0.83
Natural Gas	305.93	289.06	276.37	268.82	258.40	261.40	239.59	225.95	202.38	190.05	176.01
Nuclear	272.14	269.88	269.83	261.44	263.75	269.68	271.35	277.90	265.27	271.75	278.73
Renewable Sources	501.51	552.68	605.11	651.51	695.41	756.32	808.54	850.24	904.42	944.29	983.45

Data source: (US)AEO Data Browser
(CA)Canada's Energy Future 2023: CER's first long-term Outlook modeling Net-Zero by 2050

Example of Future Electricity Demand Drivers: MISO (Midwest US)

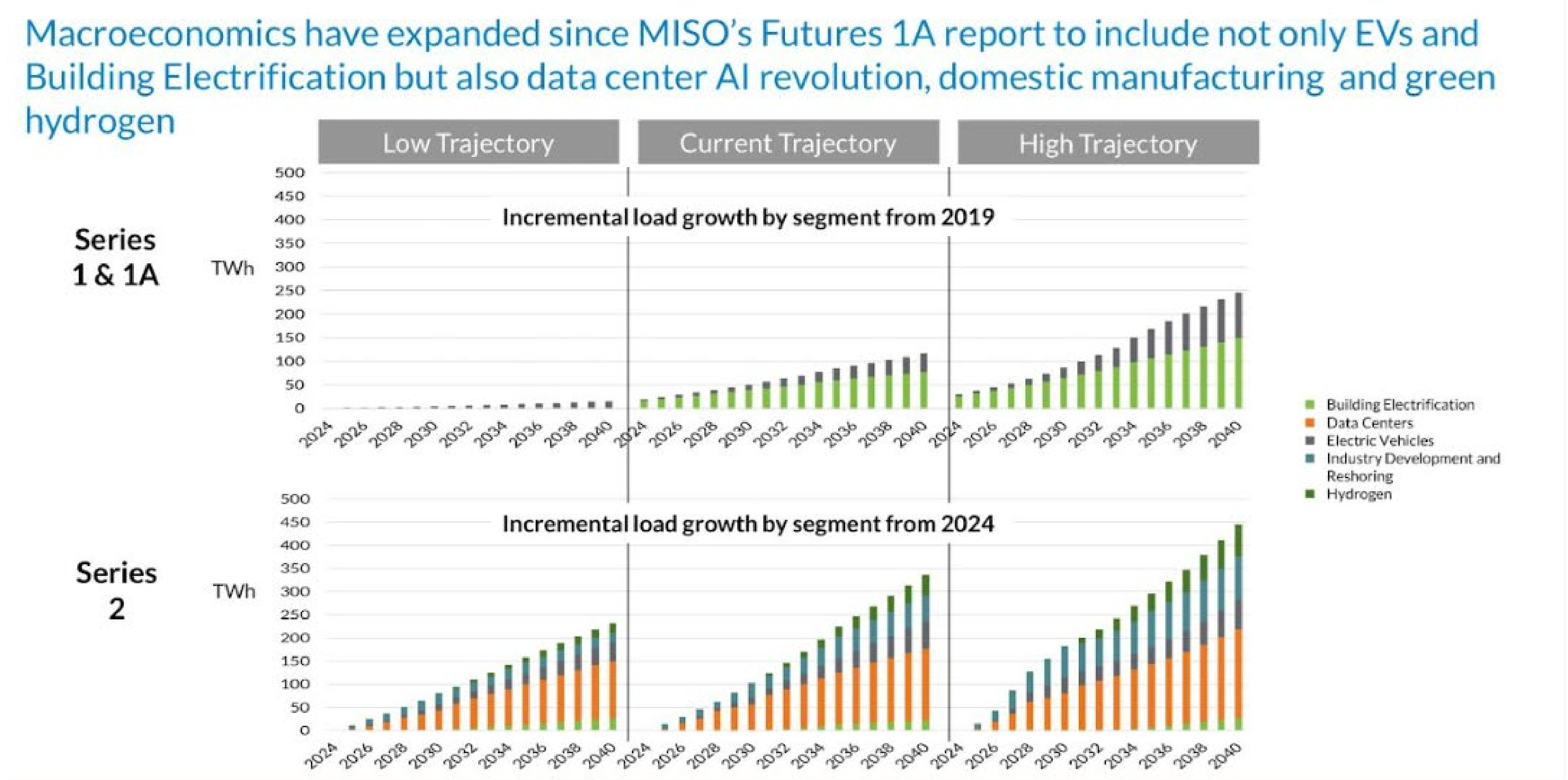
The Series 2 load growth assumptions represent a key driver for the new Futures series; these are based on the data discussed in the December 2024 load forecasting workshop

	Lower Load Growth		*Stated Policy*		*Higher Load Growth*		*Supply Shift*
	FUTURE 1		**FUTURE 2**		**FUTURE 3**		**FUTURE 4**
	Series 1 & 1A	*Series 2 (New)*	*Series 1 & 1A*	*Series 2 (New)*	*Series 1 & 1A*	*Series 2 (New)*	*Series 2 (New)*
Load Growth	Consistent with current trends (0.35% CAGR)	Consistent with low-end projections (1.1% CAGR)	30% energy increase (0.8% CAGR)	Consistent with anticipated values (1.6% CAGR)	50% energy increase (1.1% CAGR)	Consistent with high-end projections (2.1% CAGR)	Consistent with anticipated values (1.6% CAGR) – additional Demand Response if needed

Assumption Variables

FUTURE 1	FUTURE 2	FUTURE 3	FUTURE 4
Account for a modest driver growth that aligns to reduced technology adoption patterns in building electrification and electric vehicles	Account for technology adoption trends, existing policy incentives and an increase in data centers, domestic manufacturing and green hydrogen facilities	Accelerated electric vehicle adoption and additional buildouts of data centers, domestic manufacturing and green hydrogen facilities	Future 2 load growth with use of additional demand response if needed

Example of Future Electricity Demand Drivers: MISO (Midwest US)



Source: MISO Load Forecasting Workshop 2024

Future Projection of Water Consumption Data Table

High Carbon Scenario:											
Future Projection of Water Consumption of The Whole Region (unit: million gallon)											
Source Key	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**
Coal	98.4	89.5	81.1	75.8	69.8	64.6	64.2	62.8	65.5	63.4	62.2
Petroleum	1.0	0.8	0.8	0.8	0.7	0.7	0.6	0.5	0.6	0.5	0.5
Natural Gas	57.2	57.9	57.1	55.5	54.9	57.4	56.4	55.7	56.1	53.8	55.3
Nuclear	196.2	194.1	193.5	194.7	195.6	198.4	198.6	199.3	188.4	192.8	189.4
Renewable Sources	-	-	-	-	-	-	-	-	-	-	-

Medium Carbon Scenario:											
Future Projection of Water Consumption of The Whole Region (unit: million gallon)											
Source Key	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**
Coal	97.4	86.5	75.5	64.5	52.7	45.5	44.8	43.9	45.7	44.6	43.8
Petroleum	1.0	0.8	0.8	0.8	0.6	0.6	0.5	0.5	0.5	0.5	0.5
Natural Gas	55.8	53.4	51.0	50.4	49.1	48.4	45.8	43.3	41.8	40.1	39.0
Nuclear	196.1	194.3	194.2	191.7	193.4	194.1	201.1	208.9	203.3	209.5	214.0
Renewable Sources	-	-	-	-	-	-	-	-	-	-	-

Low Carbon Scenario:											
Future Projection of Water Consumption of The Whole Region (unit: million gallon)											
Source Key	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**
Coal	97.9	86.4	76.8	64.7	52.1	36.9	33.3	30.2	31.4	26.5	25.4
Petroleum	1.0	0.8	0.8	0.8	0.6	0.5	0.4	0.4	0.4	0.4	0.4
Natural Gas	55.1	52.0	49.7	48.4	46.5	47.1	43.1	40.7	36.4	34.2	31.7
Nuclear	195.9	194.3	194.3	188.2	189.9	194.2	195.4	200.1	191.0	195.7	200.7
Renewable Sources	-	-	-	-	-	-	-	-	-	-	-

State/Province Renewable Portfolio Standards (RPS) [1] [2]

· **Ontario** has no official RPS goal, but instead aims to reduce greenhouse gas emissions by 80% below 1990 levels by 2050 [8]

· **Québec** aims for 100% renewable energy use in buildings by 2040 [9], and plans to achieve net-zero greenhouse gas emissions by 2050 [10]

· **Illinois** aims to achieve 40% of its energy from renewable sources by 2030, 50% by 2040, and 100% clean energy by 2050 [5]

· **Indiana** has no official clean energy goal, but instead has a voluntary[b] target of 10% clean energy by 2025 [1]

· **Michigan** has a clean energy standard of 80% by 2035 and 100% by 2040 [4]

· **Minnesota** aims for 55% renewable energy under its RPS by 2035 [1], along with carbon-free electricity targets of 80% by 2030, 90% by 2035, and 100% clean energy by 2040 [2] [7]

State/Province Renewable Portfolio Standards (RPS) [1] [2]

· **New York** sets nation-leading goals for achieving 70% renewably sourced electricity by 2030 and a zero-emission electric grid by 2040 [3]

· **Ohio** has no official clean energy goal, but instead has a target of 8.5% alternative[a] energy 2026 [1]

· **Pennsylvania** has no official clean energy goal, but instead has a target of 18% alternative[a] energy by 2020–2021 [1]

· **Wisconsin** aims to be 100% carbon-free in electricity by 2050 [6]

[a] *Alternative Energy Resource Standard*

[b] *Voluntary Clean Energy Portfolio Standard Program*

References

[1]https://www.ncsl.org/energy/state-renewable-portfolio-standards-and-goals#:~:text=Details:%20In%202021%2C%20the%20state,and%2055%25%20from%20photovoltaic%20projects

[2] https://www.cesa.org/projects/100-clean-energy-collaborative/guide/table-of-100-clean-energy-states/

[3]https://www.nyserda.ny.gov/Impact-Renewable-Energy#:~:text=Leading%20New%20York's%20Clean%20Energy%20Transition&text=%2C%20which%20sets%20nation%2Dleading%20goals,emission%20electric%20grid%20by%202040

[4] https://www.michigan.gov/mpsc/commission/workgroups/2023-energy-legislation/clean-energy-standard

[5] https://www.illinois.gov/news/press-release.23893.html

[6] https://osce.wi.gov/pages/cleanenergyplan.aspx

[7] https://climate.state.mn.us/next-step-our-clean-energy-transition

[8] https://docs.ontario.ca/documents/4928/climate-change-strategy-en.pdf

[9] https://montreal.citynews.ca/2024/11/18/quebec-plans-to-achieve-100-renewable-energy/

[10] https://renewablesassociation.ca/canrea-provides-innovative-recommendations-for-quebecs-energy-future/