Resource Adequacy in a Net Zero Environment

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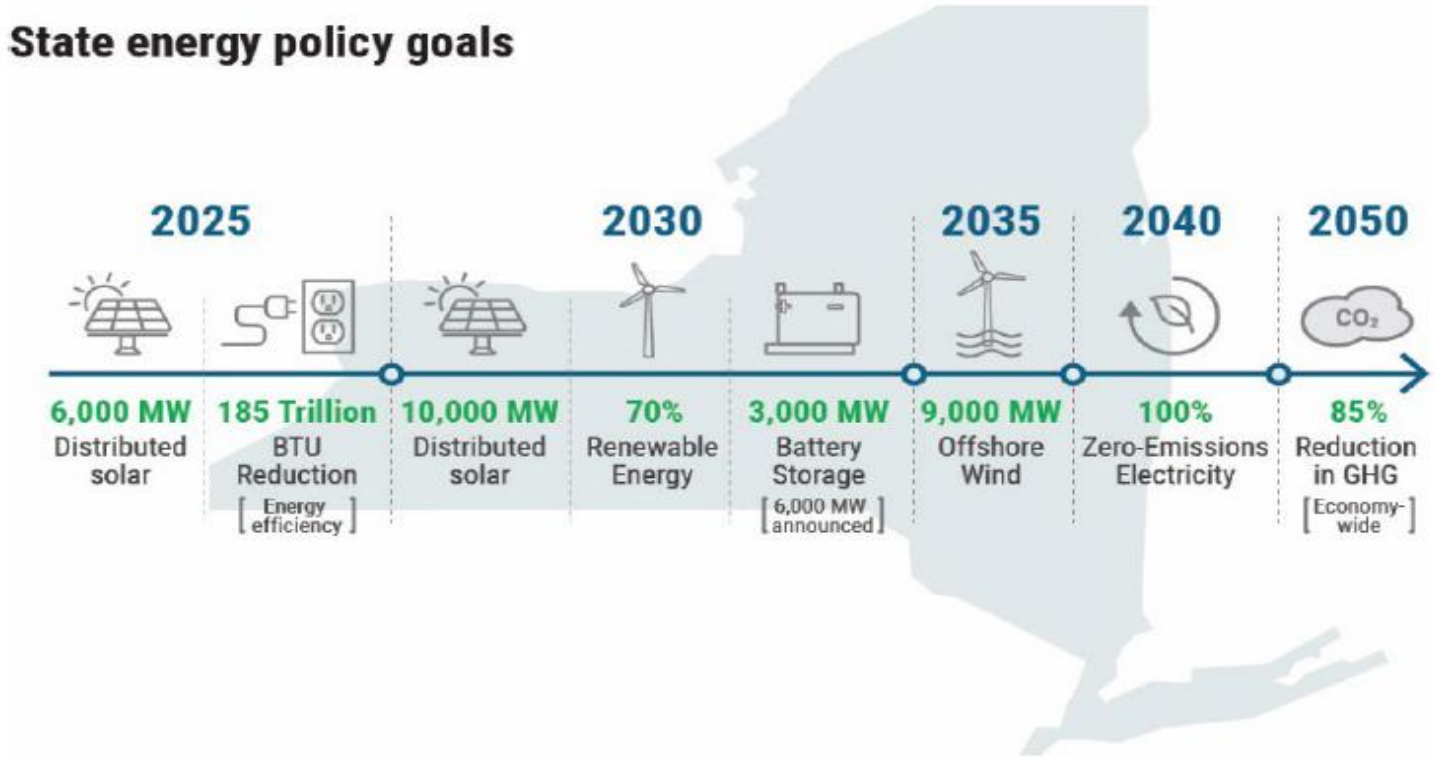
New York Clean Energy Mandate: 2019:
Climate Leadership and Community Protection Act (CLCPA):
(https://climate.ny.gov)

The CLCPA targets include:

- 185 trillion BTU reduction (energy efficiency) by 2025
- 6,000 MW of distributed solar PV by 2025
- 10,000 MW distributed solar by 2030
- 3,000 MW of energy storage by 2030
- 70% renewable energy by 2030
- 9,000 MW of offshore wind by 2035
- 100% zero-emissions electricity by 2040
- 85% reduction in Greenhouse Gas Emissions by 2050



Future Resource Mix with Clean Energy (NYISO Modeling)

https://www.nyiso.com/documents/20142/43295775/07_03012024_ESPWG_2023-2042_System&Resource_Outlook_REposting.pdf/7f6932d6-96e0-832b-2268-070b6bcb6e6a

Capacity (Summer MW)	2021	2025	2030	2035	2040	2042
Nuclear	4,378	3,342	3,342	3,342	3,342	3,342
Fossil	26,345	23,007	22,867	22,461	-	-
DEFR - HcLo	-	-	-	-	4,114	4,331
DEFR - McMo	-	-	-	-	-	-
DEFR - LcHo	-	-	-	-	22,239	24,792
Hydro	4,868	6,381	7,665	7,665	7,665	7,665
LBW	2,227	3,291	3,881	4,570	11,095	11,095
OSW	-	136	6,990	9,000	9,000	9,000
UPV	32	3,135	8,422	10,381	12,499	12,572
BTM-PV	2,116	7,097	10,153	12,644	14,444	14,988
Storage	1,405	2,905	4,405	4,405	6,892	6,892
Total	41,686	49,490	67,805	74,548	91,290	94,677

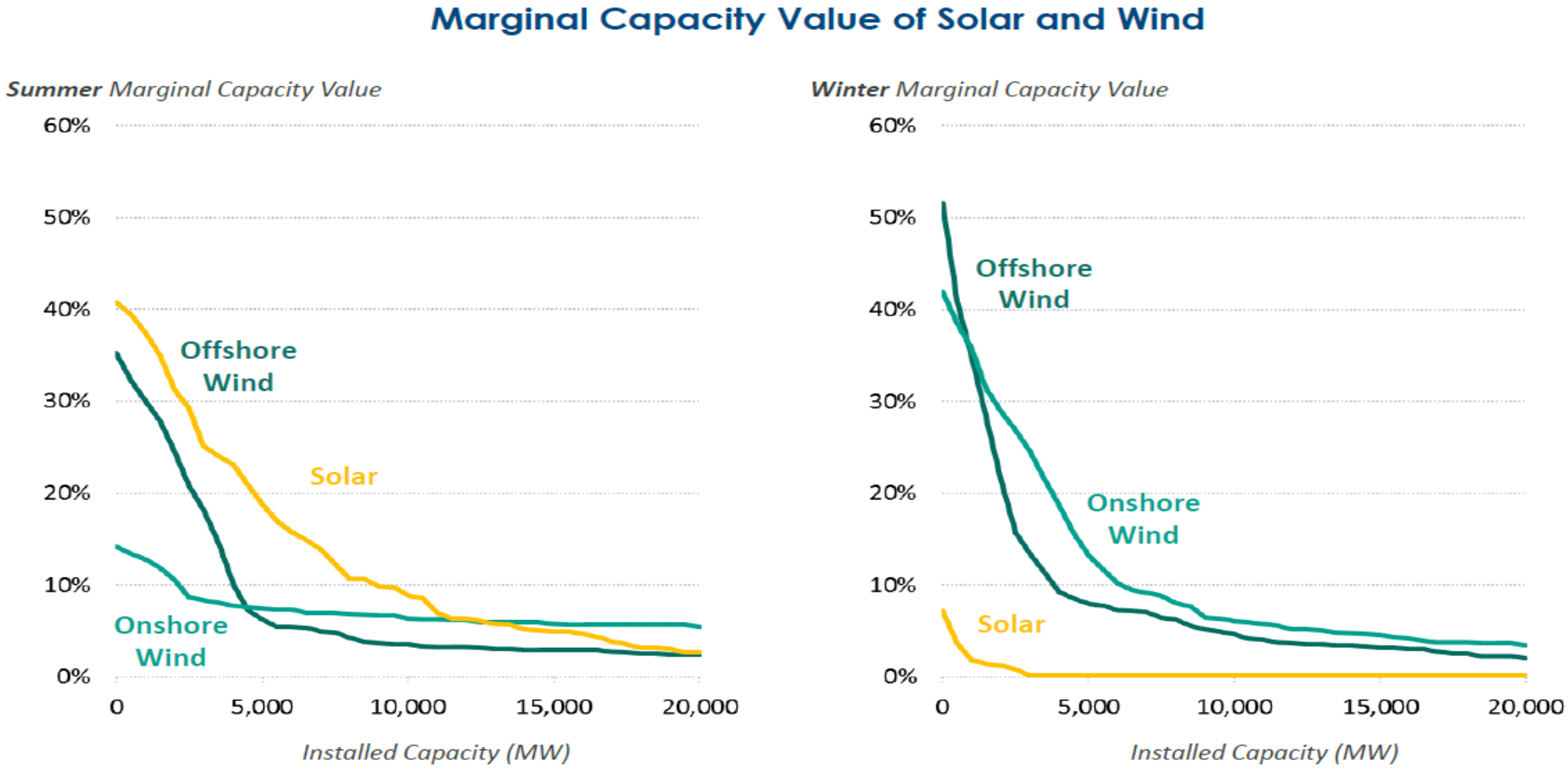
Generation (GWh)	2021	2025	2030	2035	2040	2042
Nuclear	31,609	29,276	28,831	27,940	26,552	26,438
Fossil	59,154	50,788	24,400	37,089	-	-
DEFR - HcLo	-	-	-	-	29,034	35,114
DEFR - McMo	-	-	-	-	-	-
DEFR - LcHo	-	-	-	-	3,117	5,012
Hydro	27,379	33,281	43,688	43,687	43,455	43,686
LBW	4,024	8,841	10,700	12,738	31,162	31,048
OSW	-	549	32,708	37,607	37,758	37,601
UPV	51	6,528	15,991	19,843	23,942	24,016
BTM-PV	2,761	7,718	12,024	15,232	17,582	18,311
Storage	355	1,009	2,722	2,963	7,782	10,317
Total Generation	127,930	139,712	171,669	197,750	220,383	231,543
RE Generation	34,215	56,917	115,110	129,107	153,898	154,662
ZE Generation	65,824	86,192	143,941	157,047	212,602	221,226
Load	151,979	157,528	163,222	184,439	212,121	220,946
Load+Charge	152,334	158,684	166,426	188,001	221,339	232,956
% RE [RE/Load]	23%	36%	71%	70%	73%	70%
% ZE [ZE/(Load+Charge)]	43%	55%	88%	85%	100%	100%

Emissions (million tons)	2021	2025	2030	2035	2040	2042
CO_2 Emissions	22.24	21.47	10.21	15.72	-	-

* Storage includes Pumped Storage Hydro and Batteries
* Utility solar (UPV) includes existing and new UPV
* Hydro includes hydro imports from Hydro Quebec
* Land-Based Wind (LBW), Offshore Wind (OSW), Renewable (RE), Zero Emissions (ZE)
* Dispachable Emission Free Resource (DEFR), High Capital Low Operating (HcLo), Medium Capital Medium Operating (McMo), Low Capital High Operating (LcHo)

Marginal Capacity Value of Solar and Wind:

Brattle Study 2020:
https://www.nyiso.com/documents/20142/13245925/Brattle%20New%20York%20Electric%20Grid%20Evolution%20Study%20-%20June%202020.pdf/69397029-ffed-6fa9-cff8-c49240eb6f9d



Attributes for Reliability

https://dps.ny.gov/system/files/documents/2023/12/zero-by-2040-tech-conference-presentations-day-1.pdf

1. Dependable Fuel Sources that are carbon free and allow these resources to be brought online when required
2. Non-Energy Limited and capable of providing energy for multiple hours and days regardless of weather, storage, or fuel constraints
3. Dispatchable to follow instructions to increase or decrease output on a minute-to-minute basis.
4. Quick-Start to come online within 15 minutes
5. Flexibility to be dispatched through a wide operating range with a low minimum output
6. Fast Ramping to inject or reduce the energy based on changes to net load which may be driven by changes to load or intermittent generation output
7. Multiple starts so resources can be brought online or switched off multiple times through the day as required based on changes to the generation profile and load
8. Inertial Response and frequency control to maintain power system stability and arrest frequency decline post-fault
9. Dynamic Reactive Control to support grid voltage
10. High Short Circuit Current contribution to ensure appropriate fault detection and clearance.

Attributes of Sample Technologies

https://dps.ny.gov/system/files/documents/2023/12/zero-by-2040-tech-conference-presentations-day-1.pdf

		2023 NYCA Summer Capacity (MW)	Energy Attributes						Other Reliability Attributes			
			Carbon Free	Dependable Fuel Source	Non-Energy Limited	Dispatchable	Quick Start	Flexible	Multi Start	Inertial Response	Dynamic Reactive Control	High Short Circuit Current
Sample Technology	Fossil	25,667	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Hydro	4,265	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Pumped Storage	1,407	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Hydrogen Fuel Cell	0	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No
	Hydrogen Combustion	0	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Nuclear	3,305	Yes	Yes	Yes	No	No	No	No	Yes	Yes	Yes
	Modular Nuclear	0	Yes	Yes	Yes	No	No	Yes	No	Yes	Yes	Yes
	Battery	0	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	No
	Solar	154	Yes	No	No	No	Yes	Yes	Yes	No	Yes	No
	Wind	2,051	Yes	No	No	No	Yes	Yes	Yes	No	Yes	No
	Demand Response	1,234	Yes	Yes	No	No	No	Yes	No	No	No	No
	Synchronous Condenser	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Yes	Yes	Yes	Yes

Illustration of Reliability Metrics

https://www.nysrc.org/wp-content/uploads/2023/03/RAWG-Report-No.-3-Draft-2-26-224075.pdf

Illustration of Using a Risk Profile to Get a Good Picture of Recent Loss of Load Events[5]

LOL Event Characteristic	Metric	California Aug 2020	Texas Feb 2021
Number of Events	LOLE	2 events	1 event
Number of Days	LOLE	2 days	3 days
Number of Hours	LOLH	6 hours	71 hours
Unserved Energy	EUE	2,700 MWh	990,000 MWh
Max Shortfall	-	1,072 MW	20,000+ MW