New York ISO
Independent System Operator

System & Resource Outlook Update

Economic Planning Department

Electric System Planning Working Group (ESPWG)

Thursday March 24, 2022 – WebEx Teleconference

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Agenda

- Outlook Study Status
- Contract Case Congestion Analysis Results
- Policy Case Update
  - Capacity Expansion Baseline Model Update
  - Preliminary Capacity Expansion Scenario Results
- Next Steps

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Outlook Study Status

- September – October 2021: Finalize reference case assumptions*
- November - December 2021: Conduct simulations and analysis*
- January, February, March, April 2022 : Conduct Policy case simulations and analysis, issue draft report*
- April-May 2022: Finalize draft report, seek Business Issues Committee and Management Committee review and approval
- June 2022: Seek Board of Directors review and approval

* Collaborate with ESPWG and seek stakeholder input

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Contract Case:
Congestion Analysis

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Congestion Analysis

- Base Case "relaxed" simulations and congestion analysis presented at 2/9/2022 ESPWG Outlook Update
- Contract Case analysis complete and results posted to separate presentation here
- For any questions on results please email or bring to next ESPWG on 4/1/2022

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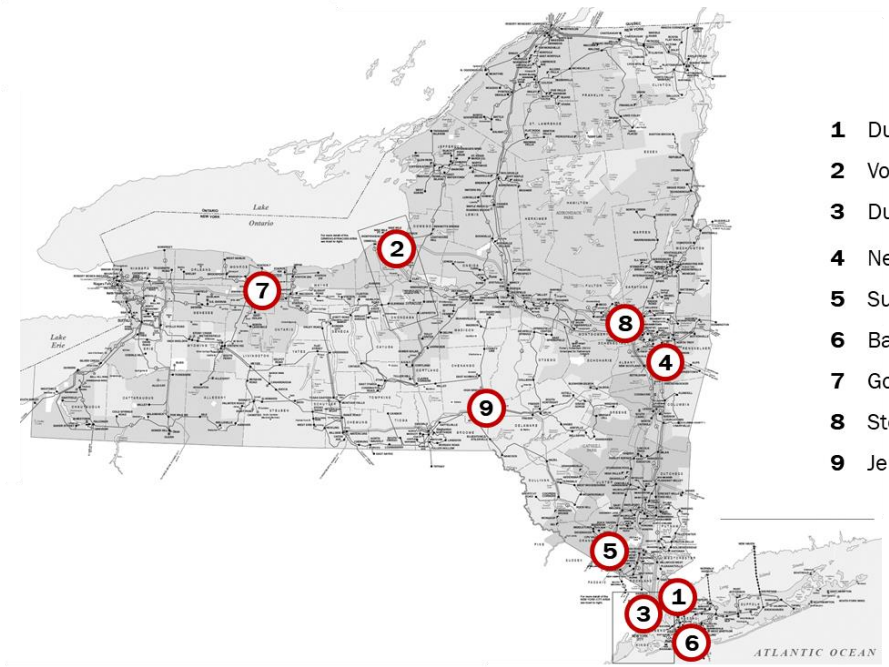
Summary of Results



Constraints Evaluated

1. Dunwoodie – Long Island 345 kV
2. Volney – Scriba 345 kV
3. Dunwoodie – Motthaven 345 kV
4. New Scotland – Knickerbocker 345 kV
5. Sugarloaf – Ramapo 138 kV
6. Barrett – Valley Stream 138 kV
7. Golah – Mortimer 115 kV
8. Stoner – Rotterdam 115 kV
9. Jennison – Sidney 115 kV

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Policy Case:
Capacity Expansion Baseline Model Update

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Requests from last ESPWG

- Adjust LCR for new transmission (AC transmission & CPNY)
- Increase downstate ESR capital cost multipliers
- Consider 6GW ESR target scenario
- Consider Base/Contract case load scenario
- Post zonal capacity expansion results
- Separate firm and economic capacity additions
- Split out DEFR build types in results
- Correct 2019 capacity chart
- Report capital and operating cost results
- Adjust DEFR allowable build year from 2035->2030

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Summary of Baseline Assumptions

- CLCPA Case load forecast from 2021 Gold Book, with adjustments to BTM-PV, energy storage, and electrification forecasts
  - BTM-PV is included in the load forecast and is not modeled as a candidate technology eligible for capacity expansion
- CLCPA targets enforced (see next slide for list of modeled constraints)
- UCAP equivalent of IRM and LCR requirements enforced, adjustments for future transmission
- Generation resource investment and operating costs as outlined in the capacity expansion assumptions matrix
  - Capital, fixed O&M and variable O&M costs assumed per 2021 EIA Energy Outlook
  - Fuel and emissions prices consistent with production cost database
  - DEFR capital, fuel, and operating costs informed by recent studies
- Delay start year of new builds of certain technology types
  - No fossil builds prior to 2025
  - No DEFR builds prior to 2030
  - No nuclear builds prior to 2035
- Max capacity limitations of UPV, LBW, and OSW aligned with 2040 limits per Appendix G: Annex 1: Inputs and Assumptions Climate Action Council draft scoping plan
- Declining capacity value curves for UPV, LBW, OSW, and ESR generators to model declining capacity value of these generators as a function of installed capacity

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Summary of Baseline Assumptions (cont.)

- **Candidate technologies eligible for capacity expansion:**
  - Land based wind
  - Offshore wind
  - Utility PV
  - 4-hour battery storage
  - Combined cycle
  - Combined cycle with 90% CCS
  - Nuclear
  - Internal combustion engine
  - Combustion turbine
  - Dispatchable Emission Free Resource (DEFR)

- **CLCPA targets and other state policy mandates modeled:**
  - 6 GW BTM-PV by 2025
  - 70% renewable energy by 2030
  - 3 GW energy storage by 2030
  - 10 GW BTM-PV by 2030
  - 9 GW offshore wind by 2035
  - 100% CO_2 emission free by 2040

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Summary of Baseline Assumptions (cont.)

Firm Installed Capacity in Policy Case

Firm Installed Capacity (MW)	Existing		Contract Additions	
	Initial		2030	
	A-E	F-K	A-E	F-K
Fossil	3,944	18,872	-	-
Nuclear	3,346	-	-	-
Other	116	205	-	-
Hydro	5,925	421	-	-
LBW	2,092	-	853	-
UPV	20	77	3,384	867
OSW	-	-	-	4,316
BTM-PV	1,199	2,095	-	-
ESR	240	1,180	-	-

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New Transmission IRM/LCR Impact Approximations

- **AC Transmission**
  - Calculation of G-J LCR Reduction
  - Appendix D in CRP (Figure 46)
  - $(I_{2023}/A_{2023}) - (I_{2024}/A_{2024}) \approx$ 10%
  - Test Cases w/ 4%, 8%, 12% for information
- **Champlain Hudson Power Express**
  - 1,250 MW summer capacity contribution
  - 0 MW winter capacity contribution
- **Clean Path New York**
  - Adjust Zone J LCR by 50% of line rating (0.5*1,300 MW = 650 MW)
  - Test Cases w/ 25%, 50%, and 75% for information

		Peak Load Forecast			
Line	Item	2022	2023	2024	2025
A	G-J Load Forecast	(15,311)	(15,231)	(15,163)	(15,120)
B	RECO Load	(397)	(397)	(397)	(397)
C	**Total Load (A+B)**	(15,708)	(15,628)	(15,560)	(15,517)
D	UPNY-SENY Limit (5)	3,200	3,200	5,725	5,725
E	ABC PARs to J	(11)	(11)	(11)	(11)
F	K - SENY	95	95	95	95
G	**Total SENY AC Import (D+E+F)**	3,284	3,284	5,809	5,809
H	Loss of Source Contingency	0	0	(980)	(980)
I	**Resource Need (C+G+H)**	(12,424)	(12,344)	(10,731)	(10,688)
J	*Resources needed after N-1-1 (C+G)*	(12,424)	(12,344)	(9,751)	(9,708)
K	G-J Generation (1)	14,434	13,603	13,602	12,988
L	Temperature Based Generation Derates	0	0	0	0
M	Net ICAP External Imports	315	315	315	315
N	**Total Resources Available (K+L+M)**	14,749	13,918	13,917	13,303
O	*Resources available after N-1-1 (H+N)*	14,749	13,918	12,937	12,323
P	**Transmission Security Margin (I+N)**	2,325	1,574	3,186	2,615
Q	SCRs (3), (4)	288	288	288	288
R	Forced Outages (2)	(1,339)	(1,182)	(1,182)	(1,098)
S	**Adjusted Transmission Security Margin (P+Q+R) (3)**	1,274	680	2,292	1,805

Disclaimer: capacity contribution and LCR impacts presented on this slide and used in the study are illustrative and do not represent future study work to be performed to calculate actual values

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Additional Capacity Expansion Scenarios Conducted to Test Impact of Baseline Model Updates

Scenario	Assumption Adjusted	Baseline Assumption	Scenario Assumption(s)
ESR Multipliers Zones J&K	Zonal multiplier for build cost and FOM cost for ESRs in Zones J & K	1.03 for Zones J&K	Zone J = 1.28, Zone K = 1.10 Multipliers based on ESR capital costs from 2021-2025 Demand Curve Reset
Start year for DEFR builds	DEFR allowable build year	2035 start year	2030 start year
Adjustments to G-J LCR due to AC transmission	G-J LCR	84.43% summer, 83.69% winter	-4%, -8%, and -12%
Capacity contribution from CPNY towards J and G-J LCRs	Capacity contribution from CPNY	0% of CPNY total line rating	25%, 50%, 75% of CPNY total line rating

Note: Assumption changes included in the scenarios are not an endorsement or estimate of the validity of the values modified from the baseline assumptions. Some scenarios (*e.g.*, Fixed Capacity Value Curves) do not represent realistic system performance but are helpful in identifying directional impacts and sensitivity to key variables.

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Capacity Expansion Baseline Testing Results

- The following 19 slides present results of testing incremental updates to the baseline case, which were recommended by stakeholders
- Each adjustment was studied individually
- All adjustments were made to the original baseline

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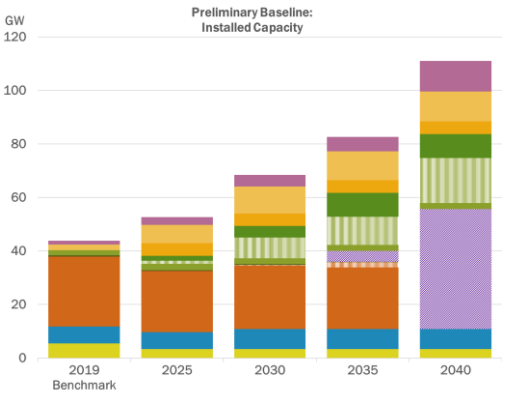
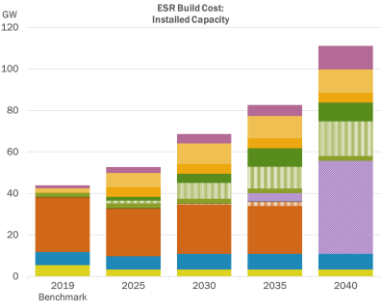
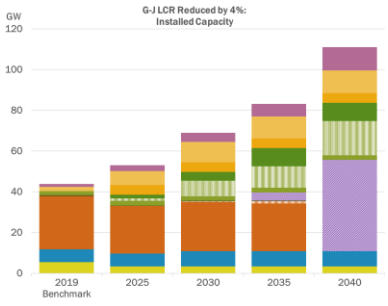
Preliminary Baseline Testing Results:

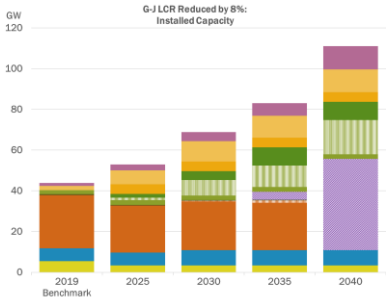
Capacity Overview

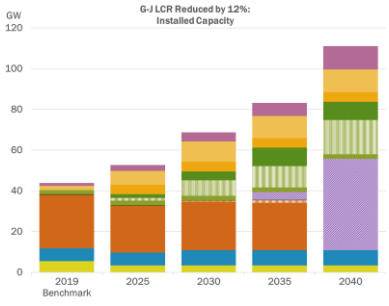


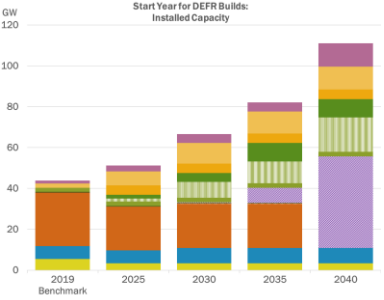
ExistingNuclear NewNuclear Hydro ExistingFossil NewFossil Other DEFR ExistingLBW NewLBW OSW UPV BTM-PV Storage

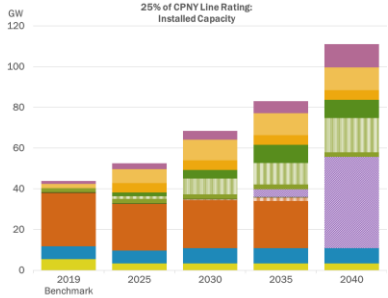


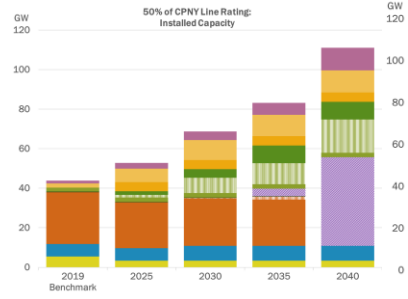


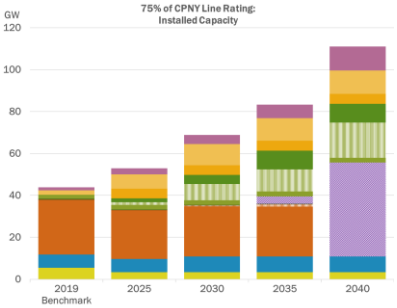












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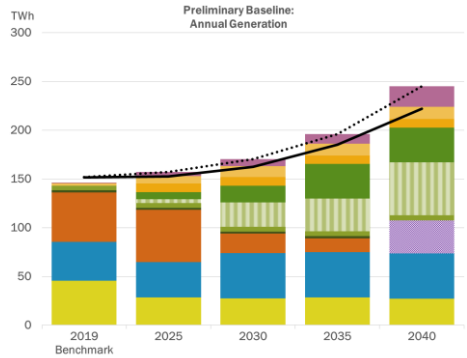
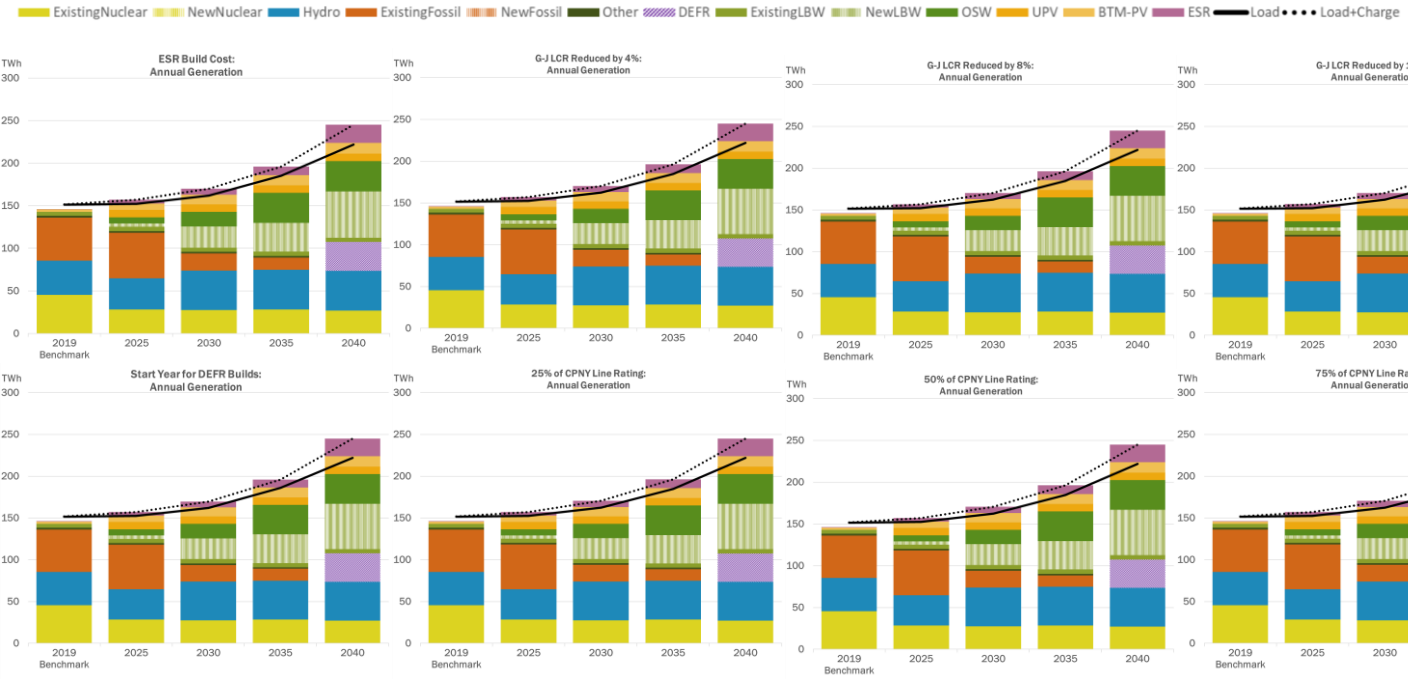
Preliminary Baseline Testing Results:

Energy Overview





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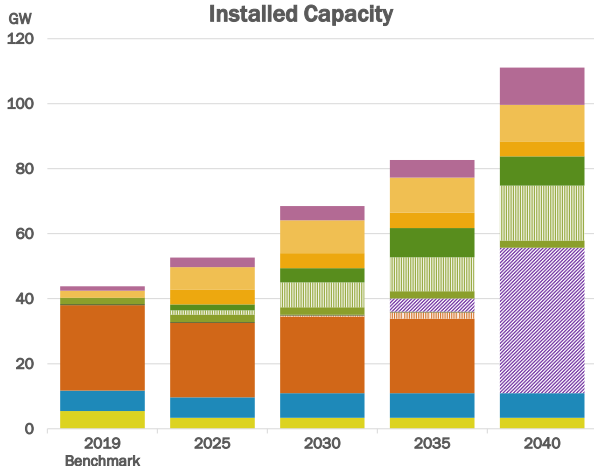
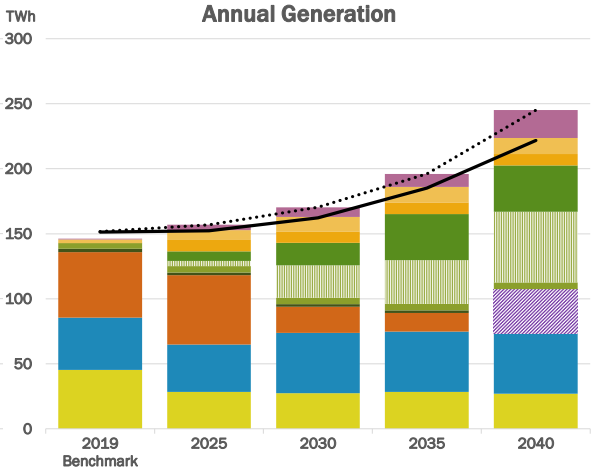
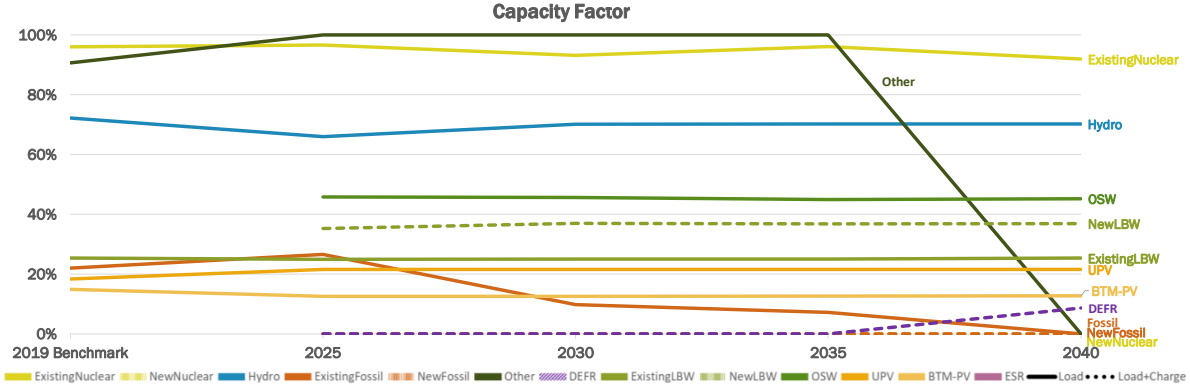
Preliminary Baseline







Installed Capacity (MW)	2019	2025	2030	2035	2040
Nuclear	5,400	3,346	3,364	3,364	3,364
Fossil	26,262	22,963	23,932	24,872	-
DEFR - HcLo	-	-	-	-	3,814
DEFR - McMo	-	-	-	-	-
DEFR - LcHo	-	-	-	4,043	40,937
Hydro	6,331	6,302	7,537	7,540	7,540
LBW	1,985	3,545	9,978	12,699	19,087
OSW	-	1,826	4,316	9,000	9,000
UPV	32	4,676	4,676	4,676	4,676
BTM-PV	2,116	6,834	10,055	10,828	11,198
Storage	1,405	2,910	4,410	5,398	11,447
Total	43,838	52,626	68,493	86,689	111,064

Generation (GWh)	2019	2025	2030	2035	2040
Nuclear	45,429	28,338	27,444	28,338	27,092
Fossil	50,520	53,488	20,098	14,433	-
DEFR - HcLo	-	-	-	-	33,504
DEFR - McMo	-	-	-	-	-
DEFR - LcHo	-	-	-	-	516
Hydro	40,034	36,418	46,342	46,392	46,377
LBW	4,416	8,880	29,909	38,582	59,362
OSW	-	7,331	17,248	35,460	35,647
UPV	51	8,817	8,816	8,817	8,819
BTM-PV	2,761	7,483	11,068	11,983	12,454
Storage	612	4,236	7,510	10,013	21,349
Total Generation	146,262	156,982	170,427	196,010	245,120
RE Generation	47,261	68,929	113,383	141,234	162,659
ZE Generation	93,301	101,502	148,337	179,585	245,120
Load	151,386	152,367	162,221	185,210	221,828
Load+Charge	151,773	156,982	170,427	196,011	245,120
% RE [RE/Load]	31%	45%	70%	76%	73%
% ZE [ZE/(Load+Charge)]	61%	65%	87%	92%	100%

Emissions (million tons)	2019	2025	2030	2035	2040
CO_2 Emissions	22.24	23.52	9.02	6.19	-

* Storage includes Pumped Storage Hydro and Batteries
* Utility solar (UPV) includes existing (77 MW) and new UPV
* Hydro includes hydro imports from Hydro Quebec
* Land-Based Wind (LBW), Offshore Wind (OSW), Zero Emissions (ZE)
* Dispachable Emission Free Resource (DEFR), High Captial Low Operating (HcLo)

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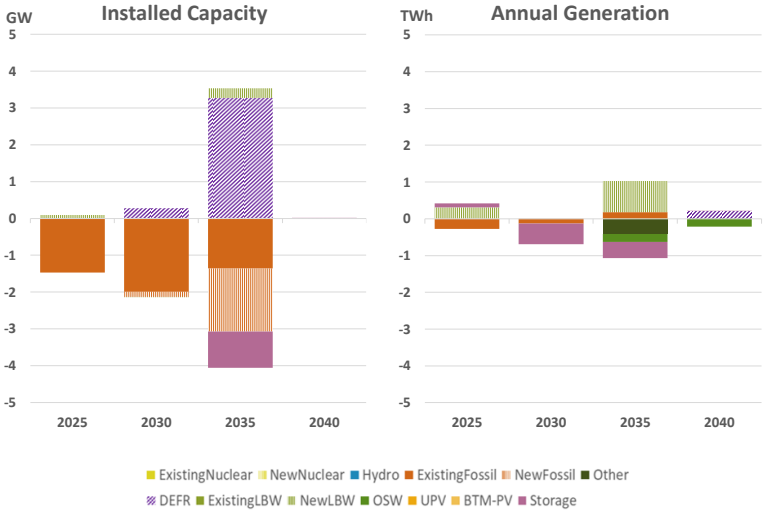
DEFR Builds Allowed Starting in 2030

- **Input Assumption Adjusted:**
  - First allowable year for DEFR builds advanced to 2030
- **Caveats:**
  - Significant uncertainty related to cost / availability of DEFR technologies, as well as regulatory definition of "zero-emissions" compliant technologies
  - Assumption is not based on estimate of realistic timeline for first potential DEFR additions
- **Observations:**
  - DEFR capacity build earlier on in model horizon, although comparable capacity builds by 2040
  - Decreased fossil capacity (*i.e.*, primarily earlier retirements and less new builds) offset by earlier DEFR capacity additions
- **Deltas:**



Installed Capacity (MW)	2025	2030	2035	2040
Nuclear	-	-	-	-
Fossil	(1,472)	(2,135)	(3,073)	-
Other	-	-	-	-
DEFR	-	278	3,275	(5)
Hydro	-	-	-	-
LBW	94	(5)	259	-
OSW	-	-	-	-
UPV	-	-	-	-
BTM-PV	-	-	-	-
Storage	-	-	(988)	18
Total	(1,377)	(1,863)	(528)	12

Generation (GWh)	2025	2030	2035	2040
Nuclear	-	-	(16)	-
Fossil	(274)	(127)	180	-
Other	-	-	(399)	-
DEFR	-	-	-	212
Hydro	-	-	-	-
LBW	310	-	852	-
OSW	-	-	(213)	(211)
UPV	-	-	-	-
BTM-PV	-	-	-	-
Storage	112	(566)	(440)	10
Total Generation	148	(693)	(35)	12

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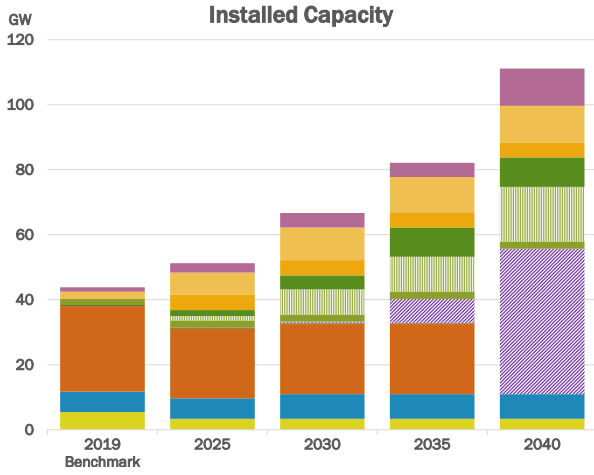
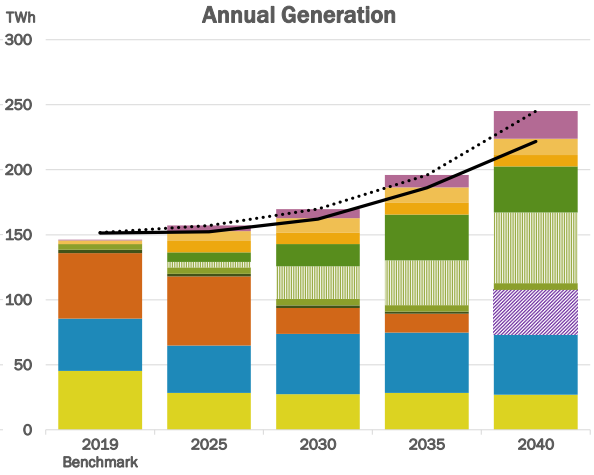
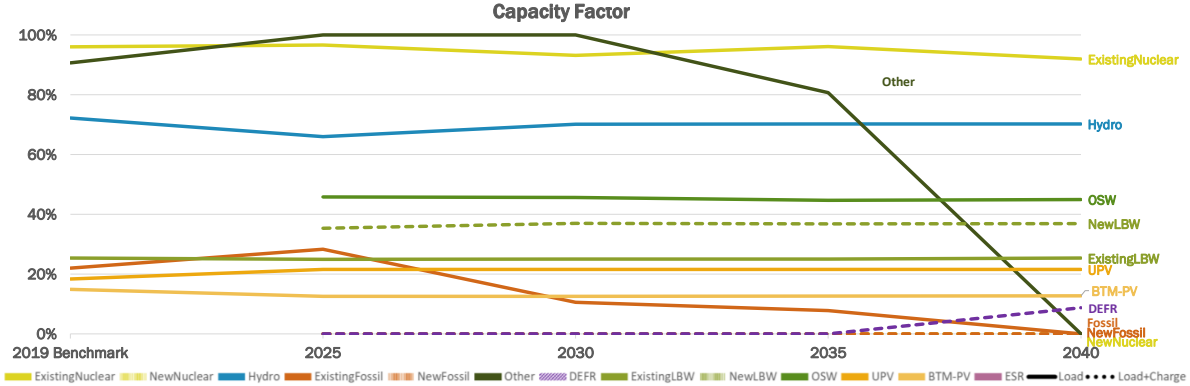
DEFR Builds Allowed Starting in 2030







Installed Capacity (MW)	2019	2025	2030	2035	2040
Nuclear	5,400	3,346	3,364	3,364	3,364
Fossil	26,262	21,491	21,797	21,799	-
DEFR - HcLo	-	-	-	-	3,839
DEFR - McMo	-	-	-	-	-
DEFR - LcHo	-	-	278	7,318	40,907
Hydro	6,331	6,302	7,537	7,540	7,540
LBW	1,985	3,639	9,973	12,957	19,087
OSW	-	1,826	4,316	9,000	9,000
UPV	32	4,676	4,676	4,676	4,676
BTM-PV	2,116	6,834	10,055	10,828	11,198
Storage	1,405	2,910	4,410	4,410	11,465
Total	43,838	51,248	66,908	89,436	111,076

Generation (GWh)	2019	2025	2030	2035	2040
Nuclear	45,429	28,338	27,444	28,323	27,092
Fossil	50,520	53,214	19,971	14,614	-
DEFR - HcLo	-	-	-	-	33,722
DEFR - McMo	-	-	-	-	-
DEFR - LcHo	-	-	-	-	511
Hydro	40,034	36,418	46,342	46,392	46,377
LBW	4,416	9,190	29,909	39,433	59,362
OSW	-	7,331	17,248	35,247	35,436
UPV	51	8,817	8,816	8,817	8,819
BTM-PV	2,761	7,483	11,068	11,983	12,454
Storage	612	4,348	6,944	9,573	21,360
Total Generation	146,262	157,130	169,734	195,975	245,132
RE Generation	47,261	69,239	113,383	141,873	162,448
ZE Generation	93,301	101,925	147,772	179,769	245,132
Load	151,386	152,409	162,103	186,093	221,828
Load+Charge	151,773	157,131	169,735	195,975	245,132
% RE [RE/Load]	31%	45%	70%	76%	73%
% ZE [ZE/(Load+Charge)]	61%	65%	87%	92%	100%

Emissions (million tons)	2019	2025	2030	2035	2040
CO_2 Emissions	22.24	23.18	8.50	6.31	-

* Storage includes Pumped Storage Hydro and Batteries
* Utility solar (UPV) includes existing (77 MW) and new UPV
* Hydro includes hydro imports from Hydro Quebec
* Land-Based Wind (LBW), Offshore Wind (OSW), Zero Emissions (ZE)
* Dispachable Emission Free Resource (DEFR), High Captial Low Operating (HcLo)

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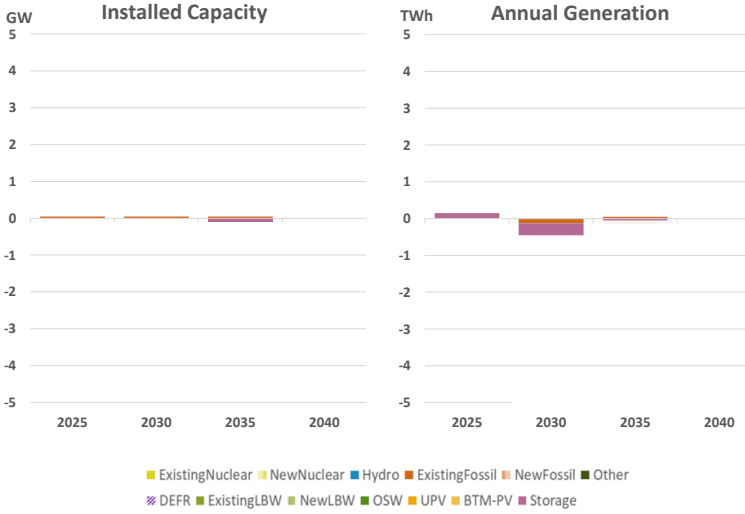
ESR Multipliers Zones J&K

- **Input Assumption Adjusted:**
  - Capital and Fixed O&M costs for ESRs in Zones J & K increased to reflect higher costs downstate; zonal multipliers are based on capital costs for ESRs from the 2021-2025 Demand Curve Reset
- **Caveats:**
  - Actual development and operation costs for ESR are uncertain but expected to have increased cost downstate relative to upstate
- **Observations:**
  - Minimal changes in results, but less ESR additions balanced by less existing fossil retirements
- **Deltas:**



Installed Capacity (MW)	2025	2030	2035	2040
Nuclear	-	-	-	-
Fossil	48	49	49	-
Other	-	-	-	-
DEFR	-	-	(1)	-
Hydro	-	-	-	-
LBW	-	-	-	-
OSW	-	-	-	-
UPV	-	-	-	-
BTM-PV	-	-	-	-
Storage	-	-	(110)	-
Total	48	49	(61)	-

Generation (GWh)	2025	2030	2035	2040
Nuclear	-	-	-	-
Fossil	13	(131)	49	-
Other	-	-	-	-
DEFR	-	-	-	-
			-	-
LBW	-	-	-	-
OSW	-	-	-	-
UPV	-	-	-	-
BTM-PV	-	-	-	-
Storage	135	(323)	(49)	-
Total Generation	149	(454)	(0)	-

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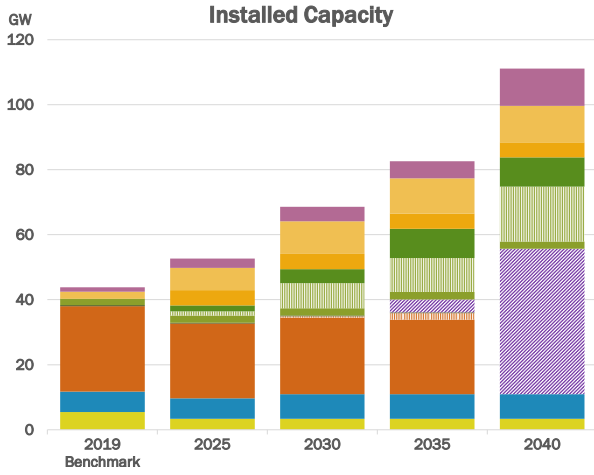
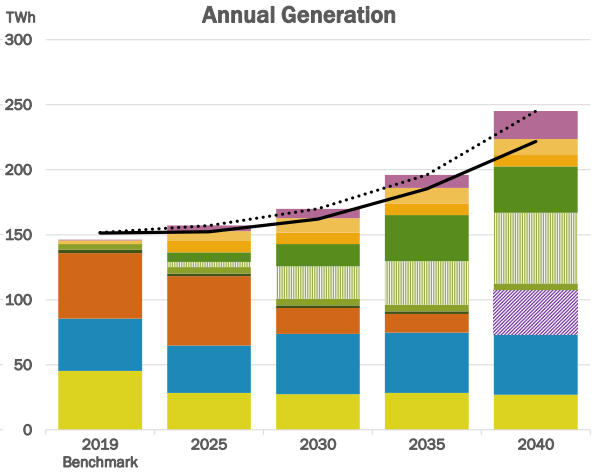
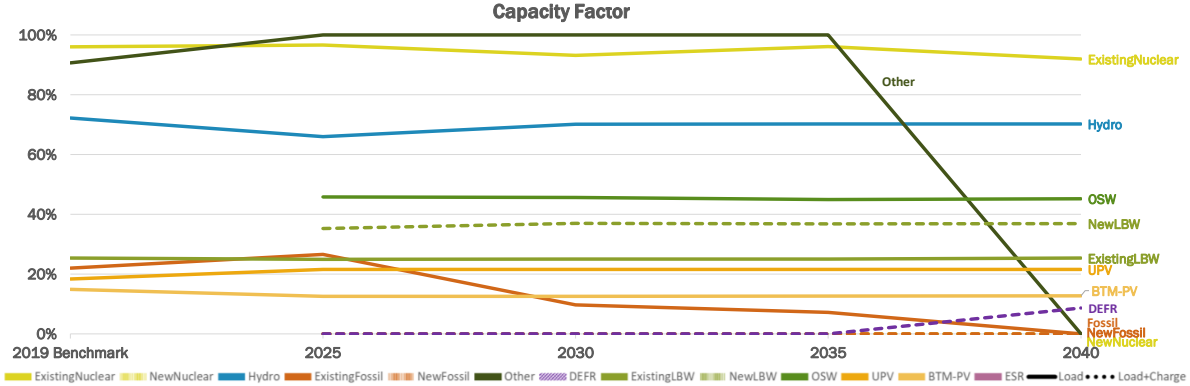
ESR Multipliers Zones J&K







Installed Capacity (MW)	2019	2025	2030	2035	2040
Nuclear	5,400	3,346	3,364	3,364	3,364
Fossil	26,262	23,011	23,981	24,921	-
DEFR - HcLo	-	-	-	-	3,814
DEFR - McMo	-	-	-	-	-
DEFR - LcHo	-	-	-	4,043	40,937
Hydro	6,331	6,302	7,537	7,540	7,540
LBW	1,985	3,545	9,978	12,699	19,087
OSW	-	1,826	4,316	9,000	9,000
UPV	32	4,676	4,676	4,676	4,676
BTM-PV	2,116	6,834	10,055	10,828	11,198
Storage	1,405	2,910	4,410	5,289	11,447
Total	43,838	52,674	68,542	86,627	111,064

Generation (GWh)	2019	2025	2030	2035	2040
Nuclear	45,429	28,338	27,444	28,338	27,092
Fossil	50,520	53,501	19,967	14,482	-
DEFR - HcLo	-	-	-	-	33,504
DEFR - McMo	-	-	-	-	-
DEFR - LcHo	-	-	-	-	516
Hydro	40,034	36,418	46,342	46,392	46,377
LBW	4,416	8,880	29,909	38,582	59,362
OSW	-	7,331	17,248	35,460	35,647
UPV	51	8,817	8,816	8,817	8,819
BTM-PV	2,761	7,483	11,068	11,983	12,454
Storage	612	4,371	7,187	9,964	21,349
Total Generation	146,262	157,130	169,973	196,010	245,120
RE Generation	47,261	68,929	113,383	141,234	162,659
ZE Generation	93,301	101,638	148,015	179,536	245,120
Load	151,386	152,363	162,049	185,309	221,828
Load+Charge	151,773	157,131	169,974	196,011	245,120
% RE [RE/Load]	31%	45%	70%	76%	73%
% ZE [ZE/(Load+Charge)]	61%	65%	87%	92%	100%

Emissions (million tons)	2019	2025	2030	2035	2040
CO_2 Emissions	22.24	23.51	9.00	6.22	-

* Storage includes Pumped Storage Hydro and Batteries
* Utility solar (UPV) includes existing (77 MW) and new UPV
* Hydro includes hydro imports from Hydro Quebec
* Land-Based Wind (LBW), Offshore Wind (OSW), Zero Emissions (ZE)
* Dispachable Emission Free Resource (DEFR), High Captial Low Operating (HcLo)

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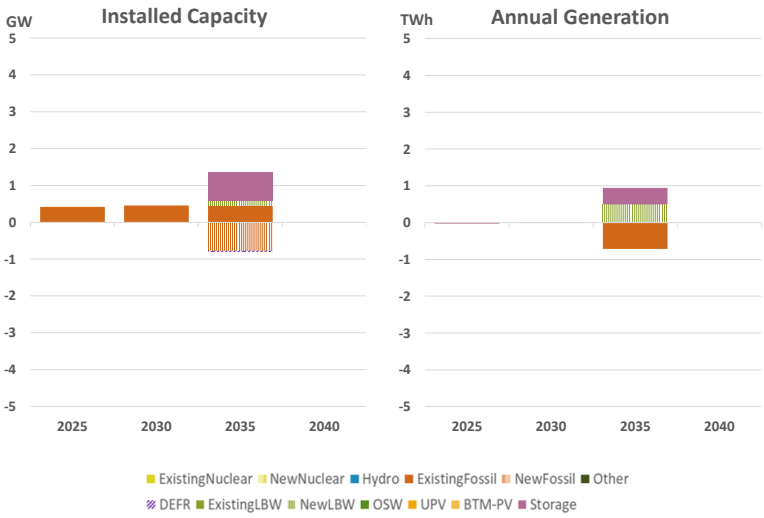
G-J LCR Reduced by 4%

- **Input Assumption Adjusted:**
  - Reduction in G-J LCR by 4% for all model years
- **Caveats:**
  - Simplified assumption to adjust one metric in interrelated ICAP market not reflective of market dynamics and only provides directional results
- **Observations:**
  - Decrease in fossil capacity additions results in increased capacity maintained from existing fossil units
  - Increase in ESR and LBW to offset decrease in fossil generation
- **Deltas:**



Installed Capacity (MW)	2025	2030	2035	2040
Nuclear	-	-	-	-
Fossil	417	452	(319)	-
Other	-	-	-	-
DEFR	-	-	(36)	0
Hydro	-	-	-	-
LBW	-	-	149	-
OSW	-	-	-	-
UPV	-	-	-	-
BTM-PV	-	-	-	-
Storage	-	-	764	-
Total	417	452	558	0

Generation (GWh)	2025	2030	2035	2040
Nuclear	-	-	-	-
Fossil	(9)	0	(716)	-
Other	-	-	-	-
DEFR	-	-	-	-
Hydro	-	-	-	-
LBW	-	-	493	-
OSW	-	-	-	-
UPV	-	-	-	-
BTM-PV	-	-	-	-
Storage	(18)	0	450	-
Total Generation	(26)	0	227	-

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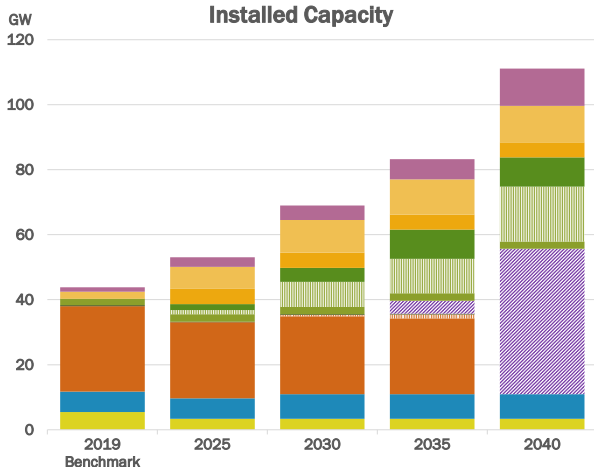
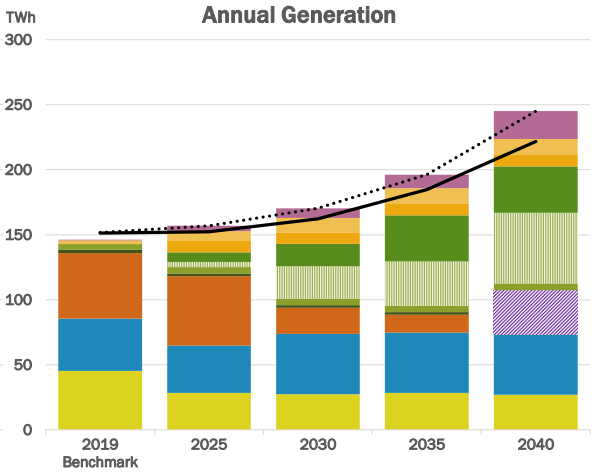
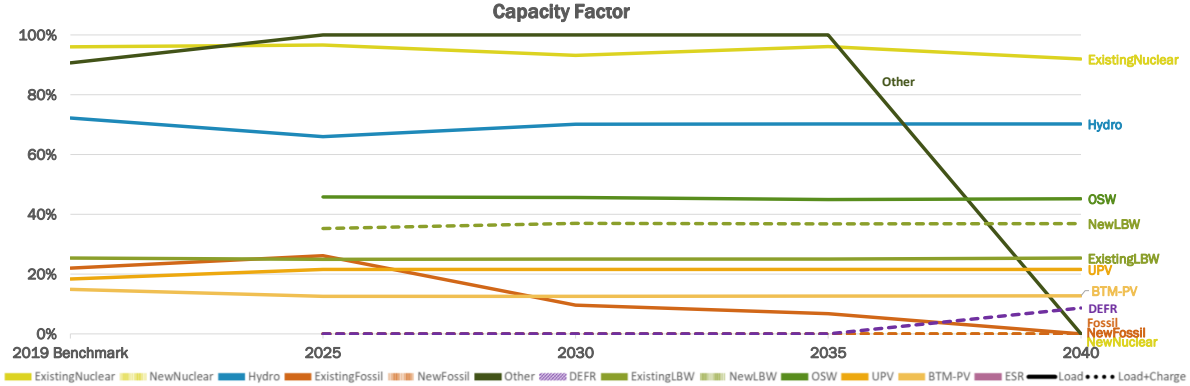
G-J LCR Reduced by 4%







Installed Capacity (MW)	2019	2025	2030	2035	2040
Nuclear	5,400	3,346	3,364	3,364	3,364
Fossil	26,262	23,380	24,384	24,553	-
DEFR - HcLo	-	-	-	-	3,814
DEFR - McMo	-	-	-	-	-
DEFR - LcHo	-	-	-	4,007	40,937
Hydro	6,331	6,302	7,537	7,540	7,540
LBW	1,985	3,545	9,978	12,848	19,087
OSW	-	1,826	4,316	9,000	9,000
UPV	32	4,676	4,676	4,676	4,676
BTM-PV	2,116	6,834	10,055	10,828	11,198
Storage	1,405	2,910	4,410	6,162	11,447
Total	43,838	53,043	68,945	87,211	111,064

Generation (GWh)	2019	2025	2030	2035	2040
Nuclear	45,429	28,338	27,444	28,338	27,092
Fossil	50,520	53,479	20,098	13,717	-
DEFR - HcLo	-	-	-	-	33,504
DEFR - McMo	-	-	-	-	-
DEFR - LcHo	-	-	-	-	516
Hydro	40,034	36,418	46,342	46,392	46,377
LBW	4,416	8,880	29,909	39,075	59,362
OSW	-	7,331	17,248	35,460	35,647
UPV	51	8,817	8,816	8,817	8,819
BTM-PV	2,761	7,483	11,068	11,983	12,454
Storage	612	4,218	7,510	10,463	21,349
Total Generation	146,262	156,955	170,427	196,237	245,120
RE Generation	47,261	68,929	113,383	141,727	162,659
ZE Generation	93,301	101,485	148,338	180,528	245,120
Load	151,386	152,355	162,221	184,697	221,828
Load+Charge	151,773	156,956	170,428	196,238	245,120
% RE [RE/Load]	31%	45%	70%	77%	73%
% ZE [ZE/(Load+Charge)]	61%	65%	87%	92%	100%

Emissions (million tons)	2019	2025	2030	2035	2040
CO_2 Emissions	22.24	23.52	9.02	5.87	-

* Storage includes Pumped Storage Hydro and Batteries
* Utility solar (UPV) includes existing (77 MW) and new UPV
* Hydro includes hydro imports from Hydro Quebec
* Land-Based Wind (LBW), Offshore Wind (OSW), Zero Emissions (ZE)
* Dispachable Emission Free Resource (DEFR), High Captial Low Operating (HcLo)

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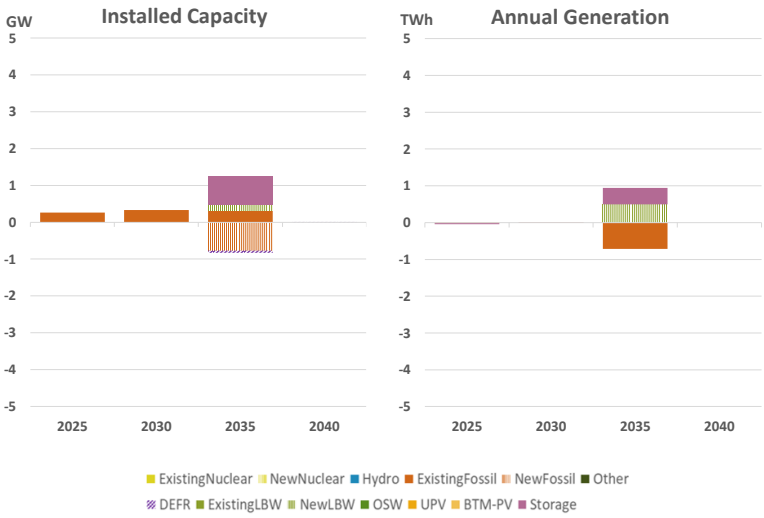
G-J LCR Reduced by 8%

- **Input Assumption Adjusted:**
  - Reduction in G-J LCR by 8% for all model years
- **Caveats:**
  - Simplified assumption to adjust one metric in interrelated ICAP market not reflective of market dynamics and only provides directional results
- **Observations:**
  - Results similar but less pronounced than G-J LCR Reduced by 4% case
- **Deltas:**



Installed Capacity (MW)	2025	2030	2035	2040
Nuclear	-	-	-	-
Fossil	262	333	(438)	-
Other	-	-	-	-
DEFR	-	-	(61)	0
Hydro	-	-	-	-
LBW	-	-	149	-
OSW	-	-	-	-
UPV	-	-	-	-
BTM-PV	-	-	-	-
Storage	-	-	764	-
Total	262	333	414	0

Generation (GWh)	2025	2030	2035	2040
Nuclear	-	-	-	-
Fossil	(14)	0	(716)	-
Other	-	-	-	-
DEFR	-	-	-	-
Hydro	-	-	-	-
LBW	-	-	493	-
OSW	-	-	-	-
UPV	-	-	-	-
BTM-PV	-	-	-	-
Storage	(27)	0	450	-
Total Generation	(41)	0	227	-

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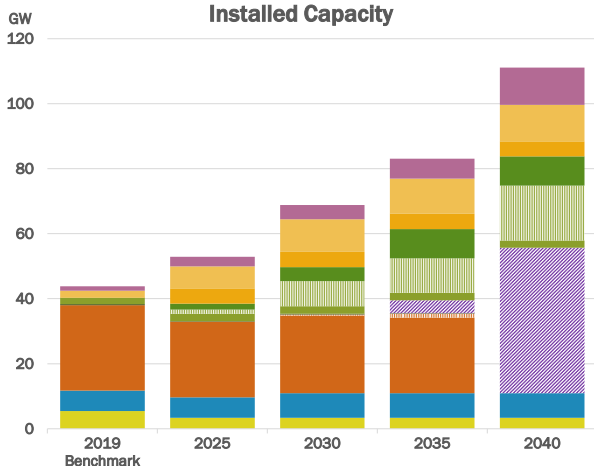
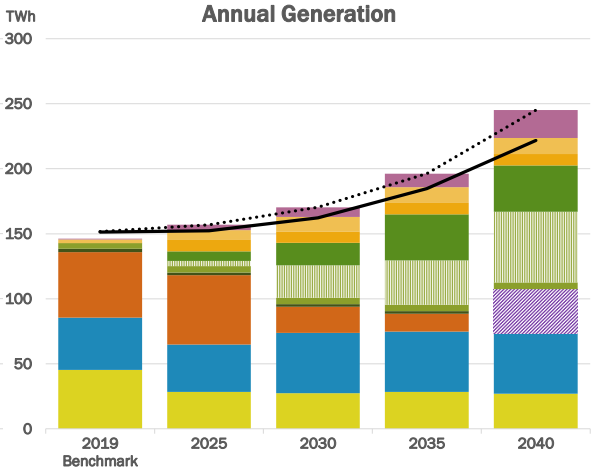
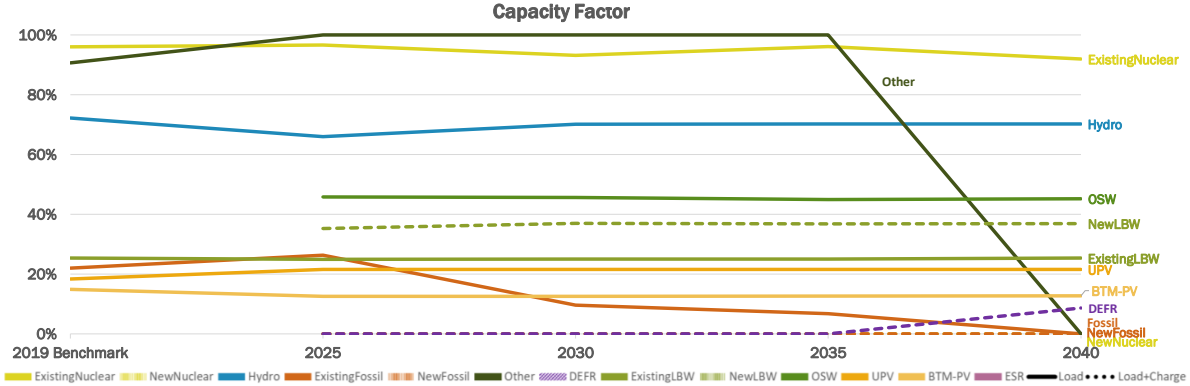
G-J LCR Reduced by 8%







Installed Capacity (MW)	2019	2025	2030	2035	2040
Nuclear	5,400	3,346	3,364	3,364	3,364
Fossil	26,262	23,224	24,265	24,434	-
DEFR - HcLo	-	-	-	-	3,814
DEFR - McMo	-	-	-	-	-
DEFR - LcHo	-	-	-	3,983	40,937
Hydro	6,331	6,302	7,537	7,540	7,540
LBW	1,985	3,545	9,978	12,848	19,087
OSW	-	1,826	4,316	9,000	9,000
UPV	32	4,676	4,676	4,676	4,676
BTM-PV	2,116	6,834	10,055	10,828	11,198
Storage	1,405	2,910	4,410	6,162	11,447
Total	43,838	52,888	68,826	87,043	111,064

Generation (GWh)	2019	2025	2030	2035	2040
Nuclear	45,429	28,338	27,444	28,338	27,092
Fossil	50,520	53,474	20,098	13,717	-
DEFR - HcLo	-	-	-	-	33,504
DEFR - McMo	-	-	-	-	-
DEFR - LcHo	-	-	-	-	516
Hydro	40,034	36,418	46,342	46,392	46,377
LBW	4,416	8,880	29,909	39,075	59,362
OSW	-	7,331	17,248	35,460	35,647
UPV	51	8,817	8,816	8,817	8,819
BTM-PV	2,761	7,483	11,068	11,983	12,454
Storage	612	4,208	7,510	10,463	21,349
Total Generation	146,262	156,941	170,427	196,237	245,120
RE Generation	47,261	68,929	113,383	141,727	162,659
ZE Generation	93,301	101,475	148,338	180,528	245,120
Load	151,386	152,348	162,221	184,697	221,828
Load+Charge	151,773	156,941	170,428	196,238	245,120
% RE [RE/Load]	31%	45%	70%	77%	73%
% ZE [ZE/(Load+Charge)]	61%	65%	87%	92%	100%

Emissions (million tons)	2019	2025	2030	2035	2040
CO_2 Emissions	22.24	23.51	9.02	5.87	-

* Storage includes Pumped Storage Hydro and Batteries
* Utility solar (UPV) includes existing (77 MW) and new UPV
* Hydro includes hydro imports from Hydro Quebec
* Land-Based Wind (LBW), Offshore Wind (OSW), Zero Emissions (ZE)
* Dispachable Emission Free Resource (DEFR), High Captial Low Operating (HcLo)

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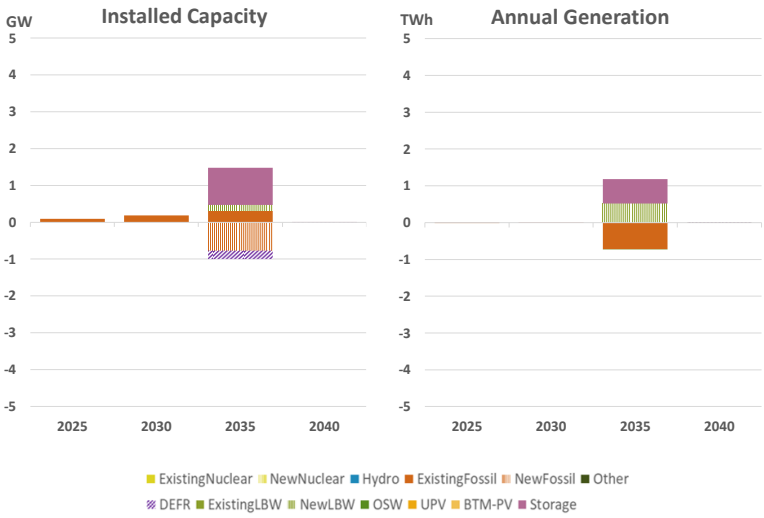
G-J LCR Reduced by 12%

- **Input Assumption Adjusted:**
  - Reduction in G-J LCR by 12% for all model years
- **Caveats:**
  - Simplified assumption to adjust one metric in interrelated ICAP market not reflective of market dynamics and only provides directional results
- **Observations:**
  - Results similar but less pronounced than G-J LCR Reduced by 4% case for impact on fossil, while observing larger relative impacts on ESR
- **Deltas:**



Installed Capacity (MW)	2025	2030	2035	2040
Nuclear	-	-	-	-
Fossil	96	186	(459)	-
Other	-	-	-	-
DEFR	-	-	(234)	(0)
Hydro	-	-	-	-
LBW	-	-	157	-
OSW	-	-	-	-
UPV	-	-	-	-
BTM-PV	-	-	-	-
Storage	-	-	1,011	0
Total	96	186	475	0

Generation (GWh)	2025	2030	2035	2040
Nuclear	-	-	-	-
Fossil	(10)	(0)	(720)	-
Other	-	-	-	-
DEFR	-	-	-	3
Hydro	-	-	-	-
LBW	-	-	522	-
OSW	-	-	(3)	(3)
UPV	-	-	-	-
BTM-PV	-	-	-	-
Storage	5	(1)	660	0
Total Generation	(6)	(1)	460	0

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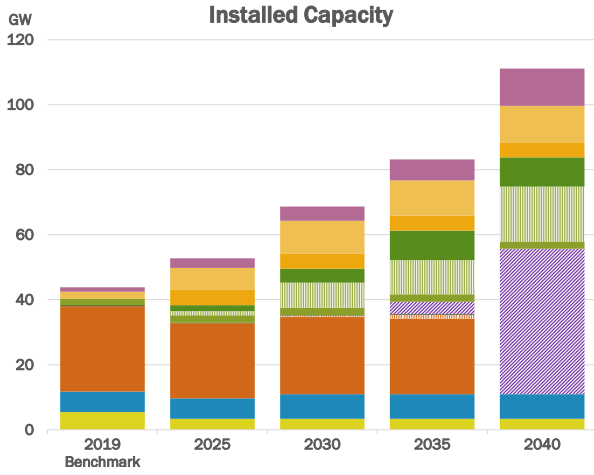
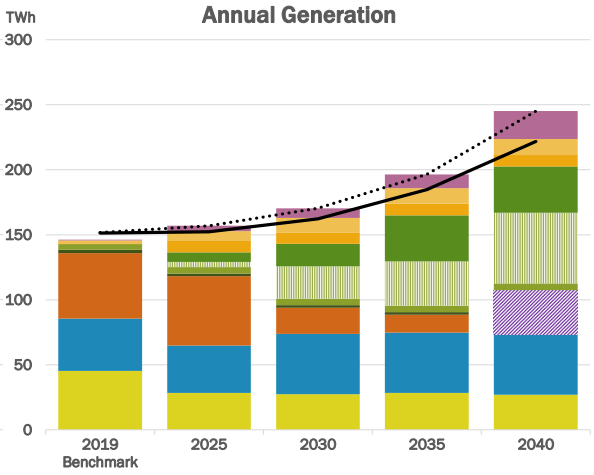
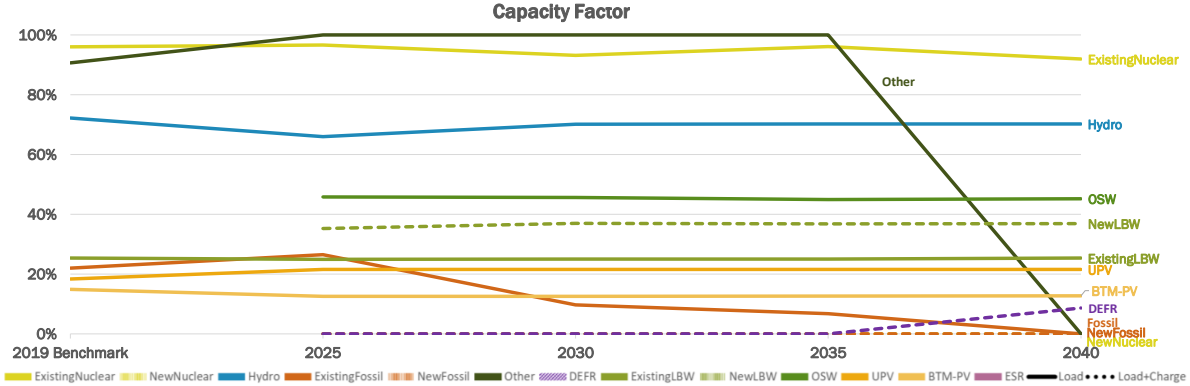
G-J LCR Reduced by 12%







Installed Capacity (MW)	2019	2025	2030	2035	2040
Nuclear	5,400	3,346	3,364	3,364	3,364
Fossil	26,262	23,059	24,118	24,413	-
DEFR - HcLo	-	-	-	-	3,815
DEFR - McMo	-	-	-	-	-
DEFR - LcHo	-	-	-	3,809	40,937
Hydro	6,331	6,302	7,537	7,540	7,540
LBW	1,985	3,545	9,978	12,856	19,087
OSW	-	1,826	4,316	9,000	9,000
UPV	32	4,676	4,676	4,676	4,676
BTM-PV	2,116	6,834	10,055	10,828	11,198
Storage	1,405	2,910	4,410	6,410	11,447
Total	43,838	52,722	68,679	86,930	111,064

Generation (GWh)	2019	2025	2030	2035	2040
Nuclear	45,429	28,338	27,444	28,338	27,092
Fossil	50,520	53,477	20,098	13,714	-
DEFR - HcLo	-	-	-	-	33,507
DEFR - McMo	-	-	-	-	-
DEFR - LcHo	-	-	-	-	516
Hydro	40,034	36,418	46,342	46,392	46,377
LBW	4,416	8,880	29,909	39,104	59,362
OSW	-	7,331	17,248	35,457	35,644
UPV	51	8,817	8,816	8,817	8,819
BTM-PV	2,761	7,483	11,068	11,983	12,454
Storage	612	4,240	7,509	10,673	21,349
Total Generation	146,262	156,976	170,426	196,470	245,120
RE Generation	47,261	68,929	113,383	141,753	162,656
ZE Generation	93,301	101,507	148,336	180,764	245,120
Load	151,386	152,348	162,221	184,697	221,828
Load+Charge	151,773	156,977	170,426	196,470	245,120
% RE [RE/Load]	31%	45%	70%	77%	73%
% ZE [ZE/(Load+Charge)]	61%	65%	87%	92%	100%

Emissions (million tons)	2019	2025	2030	2035	2040
CO_2 Emissions	22.24	23.50	9.02	5.95	-

* Storage includes Pumped Storage Hydro and Batteries
* Utility solar (UPV) includes existing (77 MW) and new UPV
* Hydro includes hydro imports from Hydro Quebec
* Land-Based Wind (LBW), Offshore Wind (OSW), Zero Emissions (ZE)
* Dispachable Emission Free Resource (DEFR), High Captial Low Operating (HcLo)

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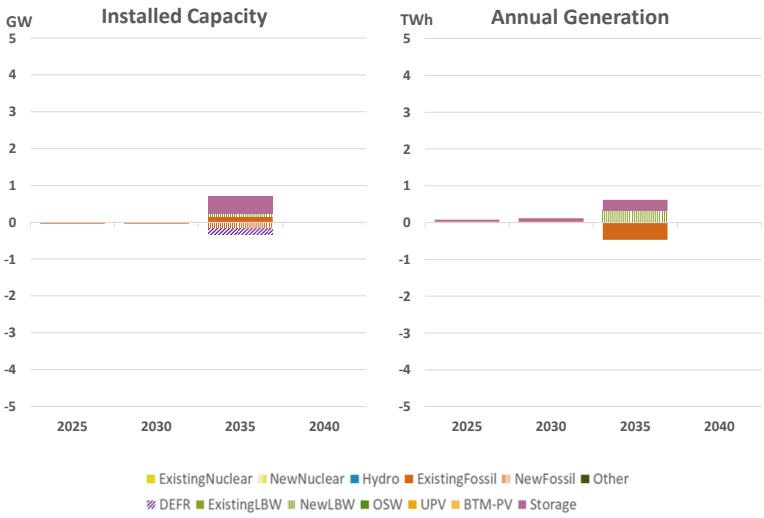
25% of CPNY Line Rating

- **Input Assumption Adjusted:**
  - Capacity contribution from CPNY increased from 0% to 25% of CPNY total line rating
- **Caveats:**
  - Capacity contribution from CPNY to be developed in future market design, therefore scenarios provide directional information across a range
- **Observations:**
  - NYCA wide capacity comparable to Preliminary Baseline results
  - DEFR and ESR capacity shifts occur between upstate and downstate zones, overall less capacity is built downstate due to partial capacity contribution from CPNY
- **Deltas:**



Installed Capacity (MW)	2025	2030	2035	2040
Nuclear	-	-	-	-
Fossil	(40)	(38)	(16)	-
Other	-	-	-	-
DEFR	-	-	(186)	-
Hydro	-	-	-	-
LBW	-	-	97	-
OSW	-	-	-	-
UPV	-	-	-	-
BTM-PV	-	-	-	-
Storage	-	-	466	-
Total	(40)	(38)	361	-

Generation (GWh)	2025	2030	2035	2040
Nuclear	-	-	-	-
Fossil	25	32	(471)	-
Other	-	-	-	-
DEFR	-	-	-	-
Hydro	-	-	-	-
LBW	-	-	319	-
OSW	-	-	-	-
UPV	-	-	-	-
BTM-PV	-	-	-	-
Storage	59	87	299	-
Total Generation	84	119	147	-

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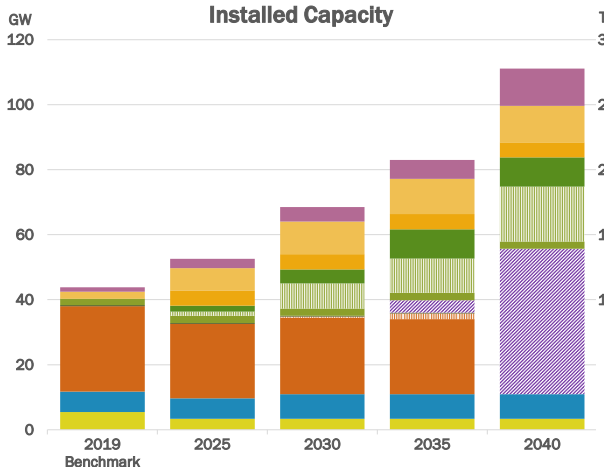
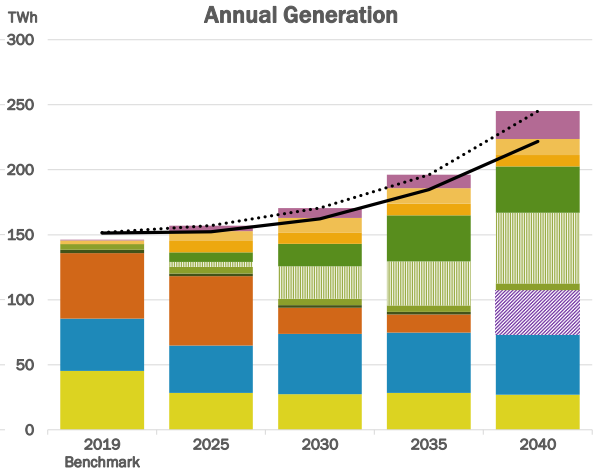
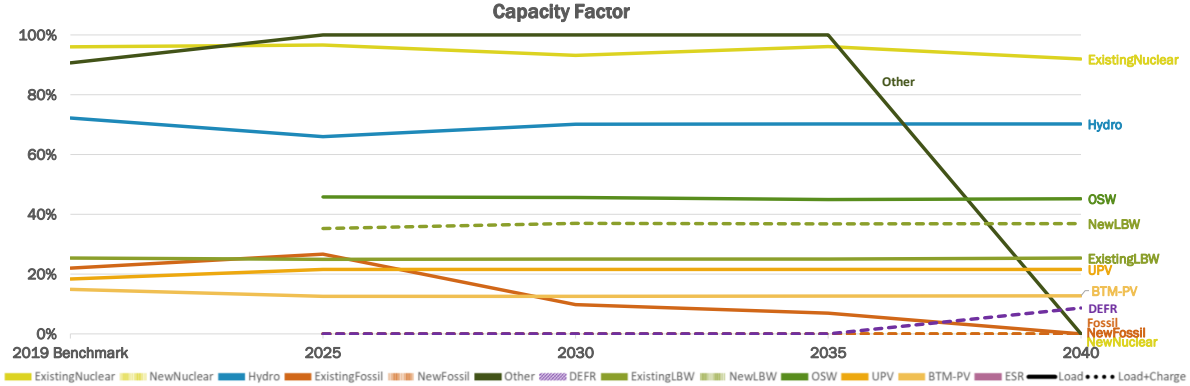
25% of CPNY Line Rating







Installed Capacity (MW)	2019	2025	2030	2035	2040
Nuclear	5,400	3,346	3,364	3,364	3,364
Fossil	26,262	22,922	23,894	24,856	-
DEFR - HcLo	-	-	-	-	3,814
DEFR - McMo	-	-	-	-	-
DEFR - LcHo	-	-	-	3,858	40,937
Hydro	6,331	6,302	7,537	7,540	7,540
LBW	1,985	3,545	9,978	12,795	19,087
OSW	-	1,826	4,316	9,000	9,000
UPV	32	4,676	4,676	4,676	4,676
BTM-PV	2,116	6,834	10,055	10,828	11,198
Storage	1,405	2,910	4,410	5,864	11,447
Total	43,838	52,586	68,455	86,865	111,064

Generation (GWh)	2019	2025	2030	2035	2040
Nuclear	45,429	28,338	27,444	28,338	27,092
Fossil	50,520	53,512	20,129	13,962	-
DEFR - HcLo	-	-	-	-	33,504
DEFR - McMo	-	-	-	-	-
DEFR - LcHo	-	-	-	-	516
Hydro	40,034	36,418	46,342	46,392	46,377
LBW	4,416	8,880	29,909	38,900	59,362
OSW	-	7,331	17,248	35,460	35,647
UPV	51	8,817	8,816	8,817	8,819
BTM-PV	2,761	7,483	11,068	11,983	12,454
Storage	612	4,295	7,597	10,312	21,349
Total Generation	146,262	157,065	170,546	196,157	245,120
RE Generation	47,261	68,929	113,383	141,552	162,659
ZE Generation	93,301	101,561	148,425	180,203	245,120
Load	151,386	152,399	162,255	184,839	221,828
Load+Charge	151,773	157,066	170,546	196,157	245,120
% RE [RE/Load]	31%	45%	70%	77%	73%
% ZE [ZE/(Load+Charge)]	61%	65%	87%	92%	100%

Emissions (million tons)	2019	2025	2030	2035	2040
CO_2 Emissions	22.24	23.36	8.86	5.98	-

* Storage includes Pumped Storage Hydro and Batteries
* Utility solar (UPV) includes existing (77 MW) and new UPV
* Hydro includes hydro imports from Hydro Quebec
* Land-Based Wind (LBW), Offshore Wind (OSW), Zero Emissions (ZE)
* Dispachable Emission Free Resource (DEFR), High Captial Low Operating (HcLo)

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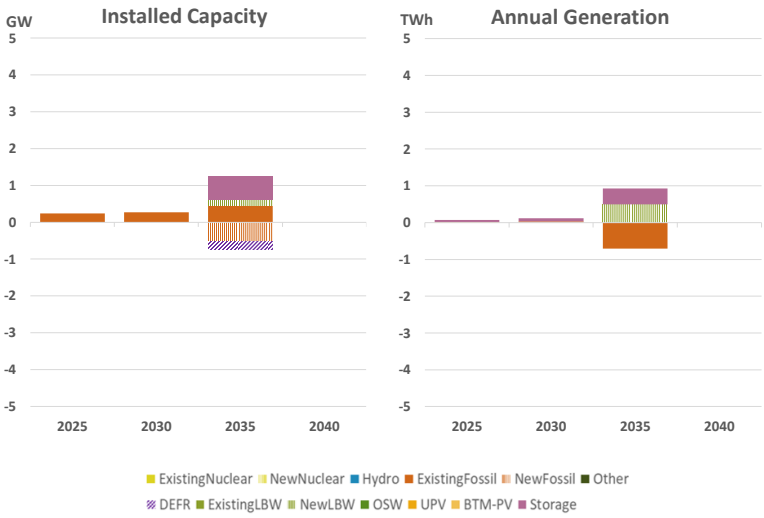
50% of CPNY Line Rating

- **Input Assumption Adjusted:**
  - Capacity contribution from CPNY increased from 0% to be 50% of CPNY total line rating
- **Caveats:**
  - Capacity contribution from CPNY to be developed in future market design, therefore scenarios provide directional information across a range
- **Observations:**
  - Results similar but more pronounced than 25% of CPNY Line Rating case for impact on DEFR and ESR capacity additions
- **Deltas:**



Installed Capacity (MW)	2025	2030	2035	2040
Nuclear	-	-	-	-
Fossil	237	269	(67)	-
Other	-	-	-	-
DEFR	-	-	(218)	-
Hydro	-	-	-	-
LBW	-	-	150	-
OSW	-	-	-	-
UPV	-	-	-	-
BTM-PV	-	-	-	-
Storage	-	-	640	-
Total	237	269	505	-

Generation (GWh)	2025	2030	2035	2040
Nuclear	-	-	-	-
Fossil	22	32	(703)	-
Other	-	-	-	-
DEFR	-	-	-	-
Hydro	-	-	-	-
LBW	-	-	493	-
OSW	-	-	-	-
UPV	-	-	-	-
BTM-PV	-	-	-	-
Storage	54	87	437	-
Total Generation	75	119	227	-

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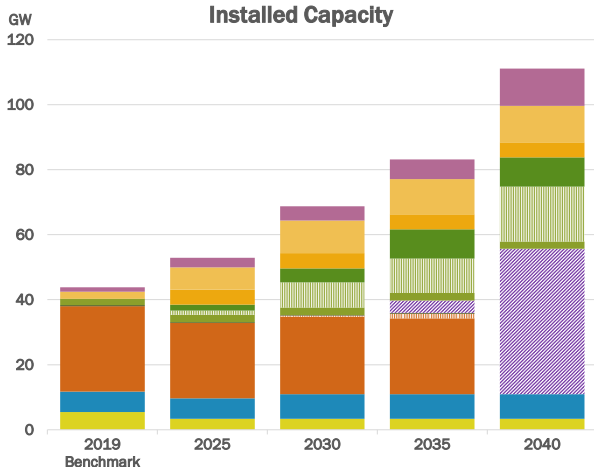
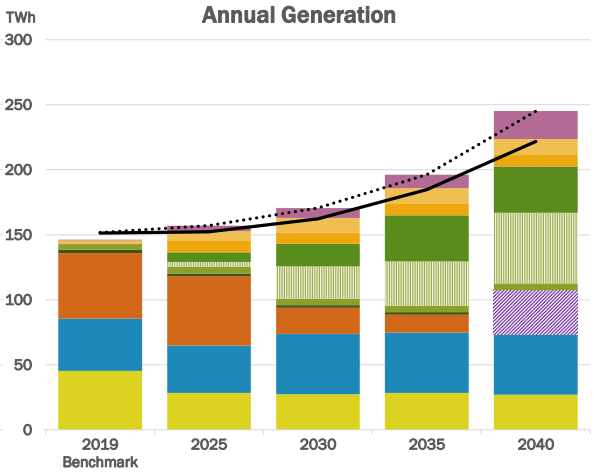
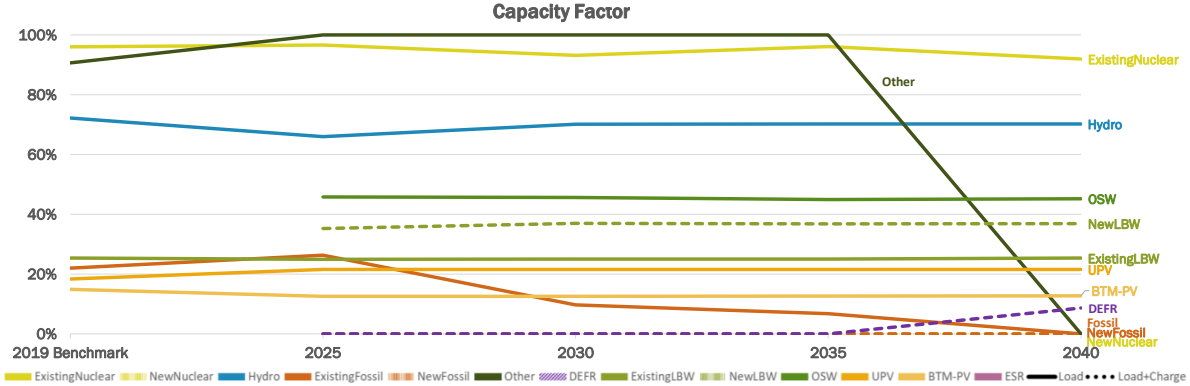
50% of CPNY Line Rating







Installed Capacity (MW)	2019	2025	2030	2035	2040
Nuclear	5,400	3,346	3,364	3,364	3,364
Fossil	26,262	23,200	24,201	24,805	-
DEFR - HcLo	-	-	-	-	3,814
DEFR - McMo	-	-	-	-	-
DEFR - LcHo	-	-	-	3,826	40,937
Hydro	6,331	6,302	7,537	7,540	7,540
LBW	1,985	3,545	9,978	12,848	19,087
OSW	-	1,826	4,316	9,000	9,000
UPV	32	4,676	4,676	4,676	4,676
BTM-PV	2,116	6,834	10,055	10,828	11,198
Storage	1,405	2,910	4,410	6,039	11,447
Total	43,838	52,863	68,762	86,977	111,064

Generation (GWh)	2019	2025	2030	2035	2040
Nuclear	45,429	28,338	27,444	28,338	27,092
Fossil	50,520	53,509	20,129	13,731	-
DEFR - HcLo	-	-	-	-	33,504
DEFR - McMo	-	-	-	-	-
DEFR - LcHo	-	-	-	-	516
Hydro	40,034	36,418	46,342	46,392	46,377
LBW	4,416	8,880	29,909	39,075	59,362
OSW	-	7,331	17,248	35,460	35,647
UPV	51	8,817	8,816	8,817	8,819
BTM-PV	2,761	7,483	11,068	11,983	12,454
Storage	612	4,289	7,597	10,450	21,349
Total Generation	146,262	157,057	170,546	196,237	245,120
RE Generation	47,261	68,929	113,383	141,727	162,659
ZE Generation	93,301	101,556	148,425	180,515	245,120
Load	151,386	152,395	162,255	184,710	221,828
Load+Charge	151,773	157,058	170,546	196,238	245,120
% RE [RE/Load]	31%	45%	70%	77%	73%
% ZE [ZE/(Load+Charge)]	61%	65%	87%	92%	100%

Emissions (million tons)	2019	2025	2030	2035	2040
CO_2 Emissions	22.24	23.36	8.86	5.88	-

* Storage includes Pumped Storage Hydro and Batteries
* Utility solar (UPV) includes existing (77 MW) and new UPV
* Hydro includes hydro imports from Hydro Quebec
* Land-Based Wind (LBW), Offshore Wind (OSW), Zero Emissions (ZE)
* Dispachable Emission Free Resource (DEFR), High Captial Low Operating (HcLo)

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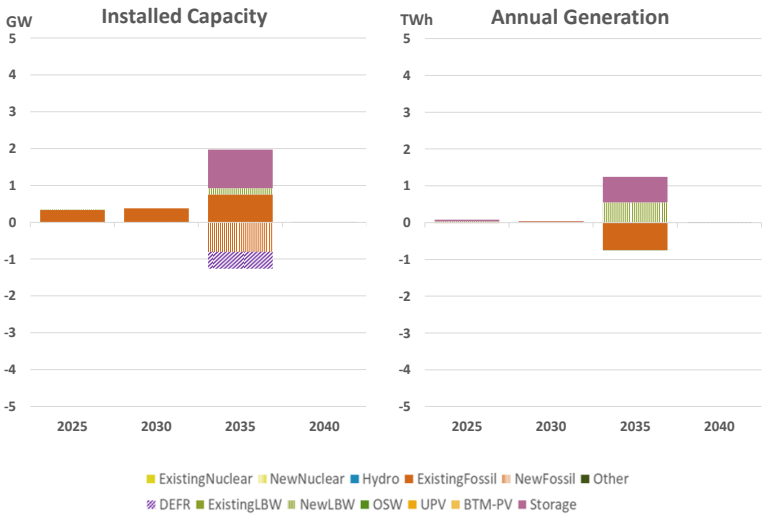
75% of CPNY Line Rating

- **Input Assumption Adjusted:**
  - Capacity contribution from CPNY increased from 0% to be 75% of CPNY total line rating
- **Caveats:**
  - Capacity contribution from CPNY to be developed in future market design, therefore scenarios provide directional information across a range
- **Observations:**
  - Results similar but more pronounced than 25% of CPNY Line Rating case for impact on DEFR and ESR capacity additions
- **Deltas:**



Installed Capacity (MW)	2025	2030	2035	2040
Nuclear	-	-	-	-
Fossil	334	376	(43)	-
Other	-	-	-	-
DEFR	-	-	(465)	(0)
Hydro	-	-	-	-
LBW	9	(1)	166	-
OSW	-	-	-	-
UPV	-	-	-	-
BTM-PV	-	-	-	-
Storage	-	-	1,044	0
Total	343	376	702	0

Generation (GWh)	2025	2030	2035	2040
Nuclear	-	-	-	-
Fossil	(13)	30	(745)	-
Other	-	-	-	-
DEFR	-	-	-	5
Hydro	-	-	-	-
LBW	31	-	553	-
OSW	-	-	(5)	(5)
UPV	-	-	-	-
BTM-PV	-	-	-	-
Storage	47	12	689	0
Total Generation	65	43	492	0

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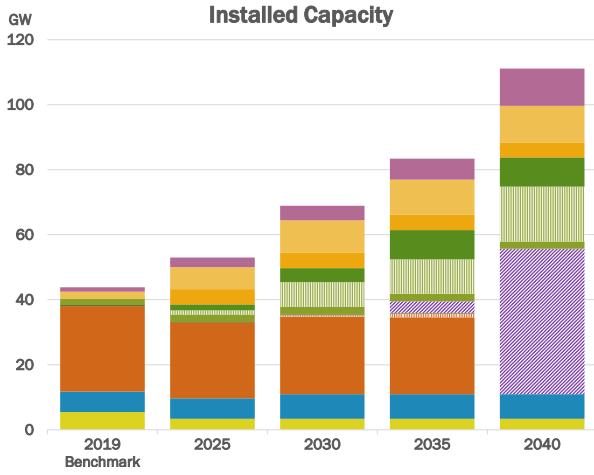
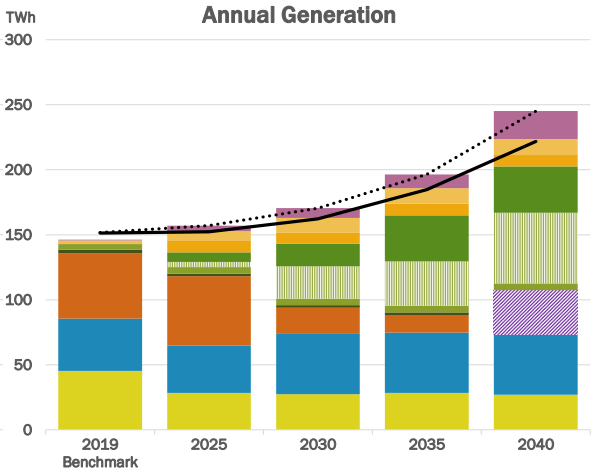
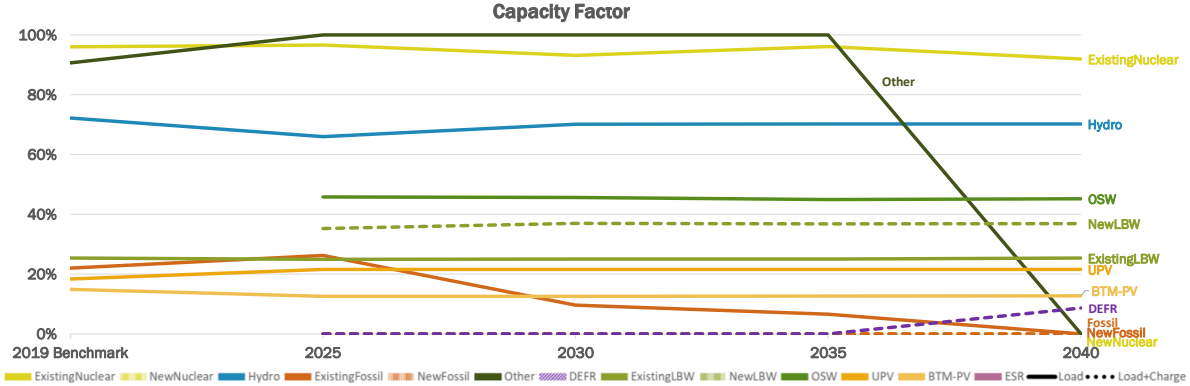
75% of CPNY Line Rating







Installed Capacity (MW)	2019	2025	2030	2035	2040
Nuclear	5,400	3,346	3,364	3,364	3,364
Fossil	26,262	23,296	24,308	24,829	-
DEFR - HcLo	-	-	-	-	3,815
DEFR - McMo	-	-	-	-	-
DEFR - LcHo	-	-	-	3,579	40,936
Hydro	6,331	6,302	7,537	7,540	7,540
LBW	1,985	3,554	9,977	12,865	19,087
OSW	-	1,826	4,316	9,000	9,000
UPV	32	4,676	4,676	4,676	4,676
BTM-PV	2,116	6,834	10,055	10,828	11,198
Storage	1,405	2,910	4,410	6,442	11,448
Total	43,838	52,969	68,869	86,927	111,065

Generation (GWh)	2019	2025	2030	2035	2040
Nuclear	45,429	28,338	27,444	28,338	27,092
Fossil	50,520	53,475	20,128	13,689	-
DEFR - HcLo	-	-	-	-	33,510
DEFR - McMo	-	-	-	-	-
DEFR - LcHo	-	-	-	-	516
Hydro	40,034	36,418	46,342	46,392	46,377
LBW	4,416	8,911	29,909	39,135	59,362
OSW	-	7,331	17,248	35,454	35,642
UPV	51	8,817	8,816	8,817	8,819
BTM-PV	2,761	7,483	11,068	11,983	12,454
Storage	612	4,283	7,522	10,702	21,350
Total Generation	146,262	157,047	170,469	196,502	245,121
RE Generation	47,261	68,959	113,383	141,781	162,653
ZE Generation	93,301	101,580	148,350	180,821	245,121
Load	151,386	152,390	162,267	184,697	221,828
Load+Charge	151,773	157,048	170,470	196,502	245,121
% RE [RE/Load]	31%	45%	70%	77%	73%
% ZE [ZE/(Load+Charge)]	61%	65%	87%	92%	100%

Emissions (million tons)	2019	2025	2030	2035	2040
CO_2 Emissions	22.24	23.28	8.80	5.95	-

* Storage includes Pumped Storage Hydro and Batteries
* Utility solar (UPV) includes existing (77 MW) and new UPV
* Hydro includes hydro imports from Hydro Quebec
* Land-Based Wind (LBW), Offshore Wind (OSW), Zero Emissions (ZE)
* Dispachable Emission Free Resource (DEFR), High Captial Low Operating (HcLo)

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Proposal For New/Updated "Baseline"

- **Combine incremental changes for ESR build costs, DEFR allowable build year, and LCRs as into a new "Baseline" version for the capacity expansion model**
  - Allow DEFR builds starting in 2030
  - Increase ESR capital cost multipliers in Zone J & K to 2021-2025 Demand Curve Reset based values
  - 10% reduction in Zone G-J LCR for AC Transmission projects
  - 650 MW reduction in Zone J & G-J LCR for Clean Path New York HVDC

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Policy Case:
Capacity Expansion Scenario Results

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Scenario Specific Caveats

- All scenarios were built upon the previous Baseline case
- The additional scenario results depicted on the following slides each reflect one change in assumptions based on the adjustments outlined on slides 39-41 of this presentation and are independent of other scenarios conducted
- The capacity expansion model is a projection of the future system mix and not an endorsement of outcomes under any specific set of assumptions. It is intended to inform NYISO studies and stakeholders of potential future generation buildouts under a multitude of scenarios
- Given uncertainty of future policy, technology, and costs, scenarios depicted on the following slides are intended to examine a range of values for a single assumption change
  - For example, multiple scenarios have been conducted on the load forecast to capture a range of potential future load conditions
  - Separately, multiple scenarios have been conducted to represent a range of DEFR costs (capital cost and fuel price) to capture a range of potential costs for the Dispatchable Emission Free Resource technologies
  - Combinations of presented scenario options may also be informative as some system changes may correlate or are reasonably likely to occur together

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Potential Capacity Expansion Scenarios

Legend
~~For Future Consideration~~
Under Consideration
Preliminary Results

NYISO Suggested Scenarios

- Candidate technologies available
- Nuclear re-licensing/retirement
- High/low renewable technology cost
- High/low/alternative load forecasts
- Low/ high gas prices
- Low/ high emission prices
- Enable/disable/accelerate retirements
- Include/exclude max capacity builds
- Relax/accelerate CLCPA targets
- Reduced hydroelectric energy output
- Fixed capacity value curves
- High/low DEFR technology cost
- High/low DEFR fuel prices

Stakeholder Suggested Scenarios

- Zone J remove all SCR Emergency Response Capacity
- Zone J retire any generator over 40 years old
- Transmission expansion (Copper Sheet)
- NYSERDA Integration Analysis: Scenario 2 load forecast
- ~~$0 REC bidding~~
- Distribution of OSW capacity between Zones J and K
- NYC steam heat converted to electric
- Accelerated winter peaking load profile
- Tier 4 project removal
- Reliability margin
- IRM/LCR study transmission limits
- ESR build cost
- Remove fossil & nuclear new build option
- Existing fossil refurbishment to DEFR in 2040

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Scenarios Presented at 3/8 ESPWG

Scenario	Assumption Adjusted	Value
High Natural Gas Price	Natural gas price forecast	2x
High CO_2	CO_2 price forecast	2x
Higher CO_2	CO_2 price forecast	10x
Low Renewable Technology Cost	Build cost for applicable technologies	Climate Action Council assumptions
Fixed Capacity Value Curves	Declining capacity value curves	Remove curves
Remove Zone J SCRs	Zone J SCR Capacity	Remove 430 MW Summer, 320 MW Winter

Note: Assumption changes included in the scenarios are not an endorsement or estimate of the validity of the values modified from the baseline assumptions. Some scenarios (e.g. Fixed Capacity Value Curves) do not represent realistic system performance but are helpful in identifying directional impacts and sensitivity to key variables.

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Capacity Expansion Preliminary Scenarios

Scenario	Assumption Adjusted	Value
Low load profile	Load forecast	Baseline forecast from 2021 GB (comparable to Base & Contract Cases)
Alternate load profile	Load forecast	Draft Climate Action Council Scoping Plan Analysis Forecast
Increase ESR policy target	ESR specific policy target	6 GW by 2030
Reduced Hydro Output	Monthly hydro energy output	10% decrease each month
Low UPV capital cost	Capital cost for CapEx UPV	0.5x
Low LBW capital cost	Capital cost for CapEx LBW	0.5x
Low OSW capital cost	Capital cost for CapEx OSW	0.5x
Low UPV, LBW, and OSW capital costs	Capital cost for CapEx UPV, LBW, and OSW units	0.5x

Note: Assumption included in the scenarios are not an endorsement or estimate of the validity of the values modified. Some scenarios do not represent realistic system performance but are helpful in identifying directional impacts and sensitivity to key variables.

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Capacity Expansion Preliminary Scenarios (cont.)

Scenario	Assumption Adjusted	Value
DEFR low capital costs	Capital cost for DEFR options	0.5x
DEFR high capital costs	Capital cost for DEFR options	2x
DEFR low operating costs	Operating costs for DEFR options	0.5x
DEFR high operating costs	Operating costs for DEFR options	2x
DEFR heat rate	Heat rate	Set to CapEx nuclear heat rate

Note: Assumption included in the scenarios are not an endorsement or estimate of the validity of the values modified. Some scenarios do not represent realistic system performance but are helpful in identifying directional impacts and sensitivity to key variables.

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Capacity Expansion Preliminary Scenarios (cont.)

Scenario	Assumption Adjusted	Value
No Fossil or Nuclear Builds Allowed	Max units allowed to build for applicable technologies	0
Nuclear Retirements	Retirement date for nuclear units	Set retirement date to relicense date
Age Based Fossil Retirements	Retirement date for fossil units	Climate Action Council Appendix D (*i.e.*, 47 years for GTs and 62 years for STs statewide)
Transmission Expansion (Copper sheet analysis)	Line, transformer, and interface limits	Infinite for interface limits, relax line limits
Unconstrained Renewable Builds	Max zonal capacity by renewable technology	Infinite max capacity by zone
OSW Distribution Zones J&K	Minimum amount of OSW capacity built in Zones J&K	At least 2/3 of total OSW capacity to be built in Zone J, remaining in Zone K

Note: Assumption included in the scenarios are not an endorsement or estimate of the validity of the values modified. Some scenarios do not represent realistic system performance but are helpful in identifying directional impacts and sensitivity to key variables.

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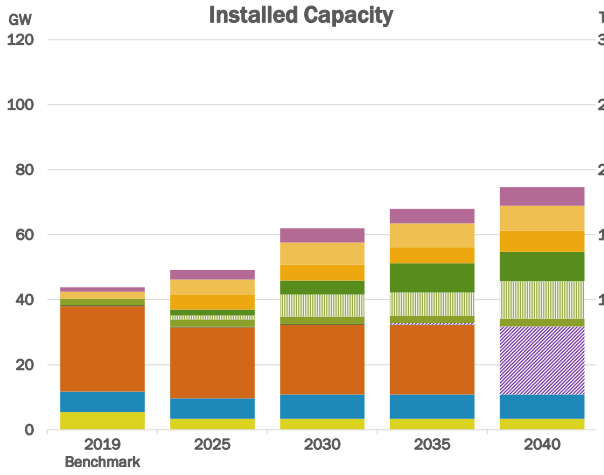
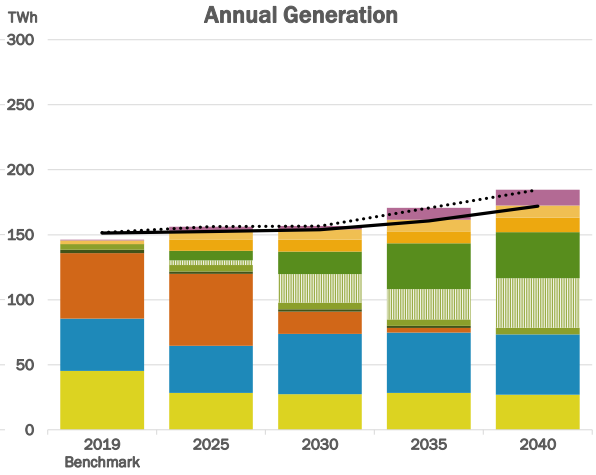
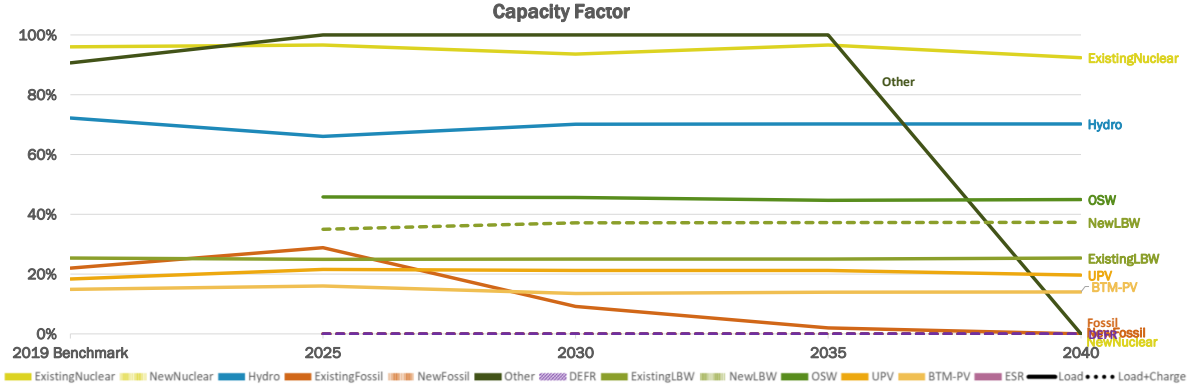
Lower Load Forecast







Installed Capacity (MW)	2019	2025	2030	2035	2040
Nuclear	5,400	3,346	3,346	3,346	3,346
Fossil	26,262	21,843	21,418	21,303	-
DEFR - HcLo	-	-	-	-	-
DEFR - McMo	-	-	-	-	-
DEFR - LcHo	-	-	-	490	20,934
Hydro	6,331	6,290	7,540	7,540	7,539
LBW	1,985	3,445	9,065	9,395	13,912
OSW	-	1,826	4,316	9,000	9,000
UPV	32	4,676	4,898	4,898	6,520
BTM-PV	2,116	4,580	6,794	7,355	7,623
Storage	1,405	2,910	4,410	4,410	5,747
Total	43,838	49,129	62,000	68,403	74,622

Generation (GWh)	2019	2025	2030	2035	2040
Nuclear	45,429	28,338	27,444	28,338	27,092
Fossil	50,520	55,186	17,117	3,726	-
DEFR - HcLo	-	-	-	-	-
DEFR - McMo	-	-	-	-	-
DEFR - LcHo	-	-	-	-	-
Hydro	40,034	36,405	46,341	46,391	46,391
LBW	4,416	8,553	27,074	28,193	43,039
OSW	-	7,331	17,248	35,247	35,436
UPV	51	8,817	9,105	9,105	11,208
BTM-PV	2,761	6,435	8,011	8,970	9,375
Storage	612	3,299	2,483	9,196	12,089
Total Generation	146,262	156,262	156,720	170,726	184,631
RE Generation	47,261	67,541	107,778	127,907	145,450
ZE Generation	93,301	99,178	137,705	165,441	184,631
Load	151,386	152,605	153,969	160,767	172,032
Load+Charge	151,773	156,262	156,721	170,726	184,631
% RE [RE/Load]	31%	44%	70%	80%	85%
% ZE [ZE/(Load+Charge)]	61%	63%	88%	97%	100%

Emissions (million tons)	2019	2025	2030	2035	2040
CO_2 Emissions	22.24	24.12	7.26	1.59	-

* Storage includes Pumped Storage Hydro and Batteries
* Utility solar (UPV) includes existing (77 MW) and new UPV
* Hydro includes hydro imports from Hydro Quebec
* Land-Based Wind (LBW), Offshore Wind (OSW), Zero Emissions (ZE)
* Dispachable Emission Free Resource (DEFR), High Captial Low Operating (HcLo)

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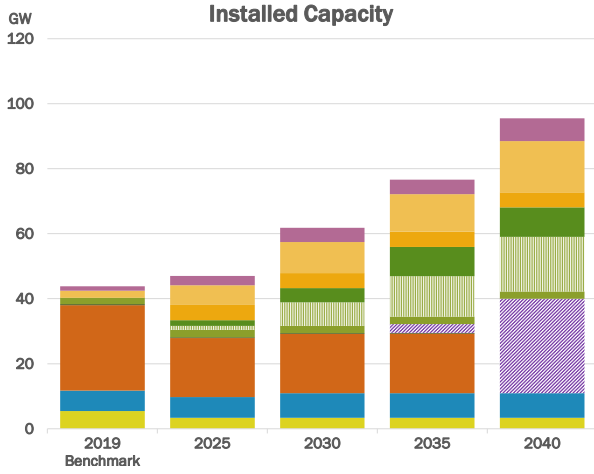
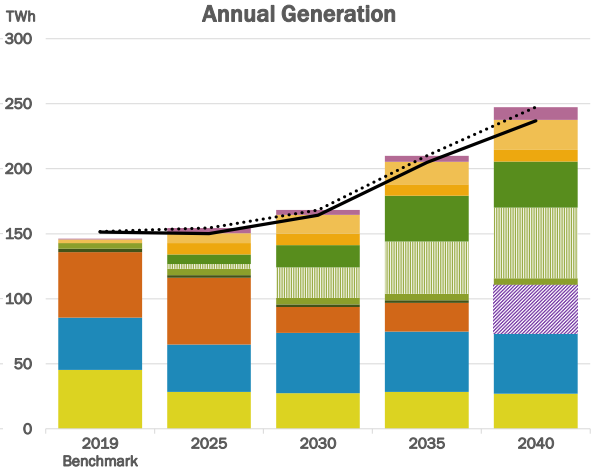
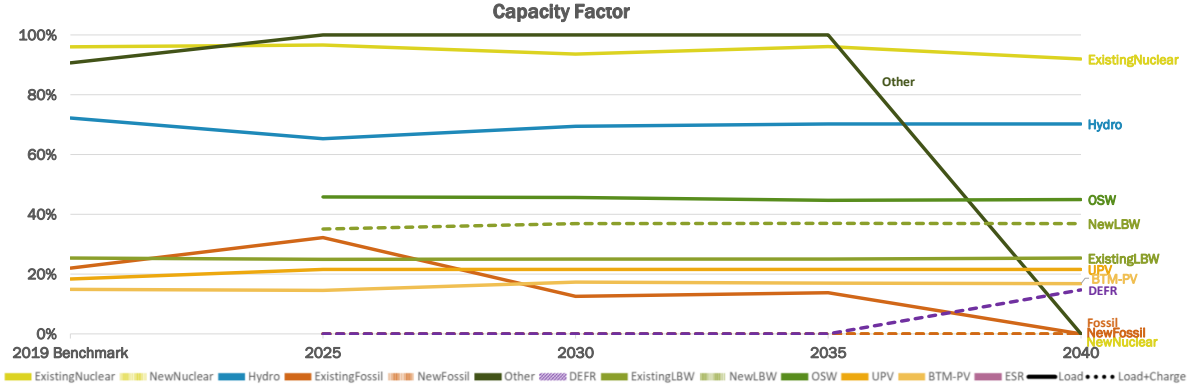
Alternate Load Forecast







Installed Capacity (MW)	2019	2025	2030	2035	2040
Nuclear	5,400	3,346	3,346	3,364	3,364
Fossil	26,262	18,197	18,197	18,366	-
DEFR - HcLo	-	-	-	-	4,234
DEFR - McMo	-	-	-	-	-
DEFR - LcHo	-	-	-	2,715	24,828
Hydro	6,331	6,370	7,616	7,539	7,540
LBW	1,985	3,457	9,521	14,699	19,087
OSW	-	1,826	4,316	9,000	9,000
UPV	32	4,676	4,676	4,676	4,676
BTM-PV	2,116	6,000	9,523	11,601	15,764
Storage	1,405	2,910	4,410	4,410	7,010
Total	43,838	47,006	61,829	79,311	95,504

Generation (GWh)	2019	2025	2030	2035	2040
Nuclear	45,429	28,338	27,444	28,338	27,092
Fossil	50,520	51,350	19,935	22,102	-
DEFR - HcLo	-	-	-	-	37,196
DEFR - McMo	-	-	-	-	-
DEFR - LcHo	-	-	-	-	140
Hydro	40,034	36,418	46,342	46,392	46,391
LBW	4,416	8,596	28,408	45,172	59,362
OSW	-	7,331	17,248	35,247	35,436
UPV	51	8,817	8,816	8,817	8,819
BTM-PV	2,761	7,631	14,461	17,223	23,220
Storage	612	3,936	3,619	4,667	9,741
Total Generation	146,262	154,409	168,265	209,951	247,397
RE Generation	47,261	68,793	115,276	152,851	173,228
ZE Generation	93,301	101,067	146,338	185,857	247,397
Load	151,386	150,047	164,255	204,847	236,882
Load+Charge	151,773	154,410	168,266	209,951	247,397
% RE [RE/Load]	31%	46%	70%	75%	73%
% ZE [ZE/(Load+Charge)]	61%	65%	87%	89%	100%

Emissions (million tons)	2019	2025	2030	2035	2040
CO_2 Emissions	22.24	22.03	8.22	9.15	-

* Storage includes Pumped Storage Hydro and Batteries
* Utility solar (UPV) includes existing (77 MW) and new UPV
* Hydro includes hydro imports from Hydro Quebec
* Land-Based Wind (LBW), Offshore Wind (OSW), Zero Emissions (ZE)
* Dispachable Emission Free Resource (DEFR), High Captial Low Operating (HcLo)

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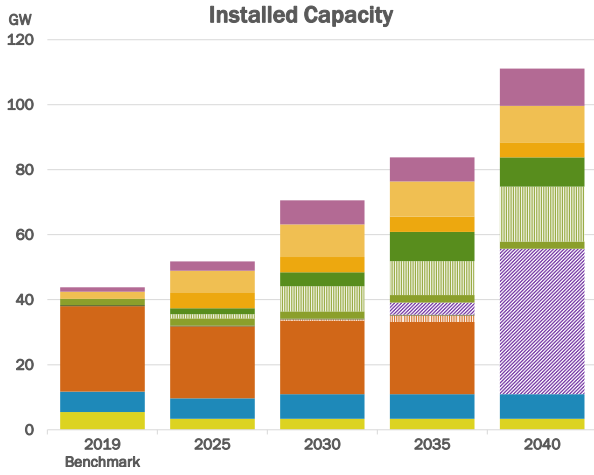
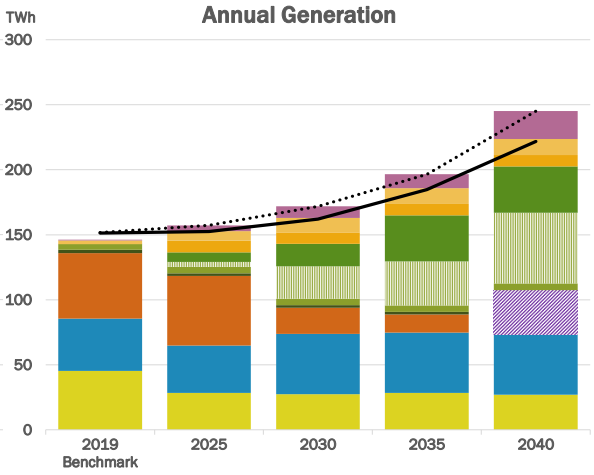
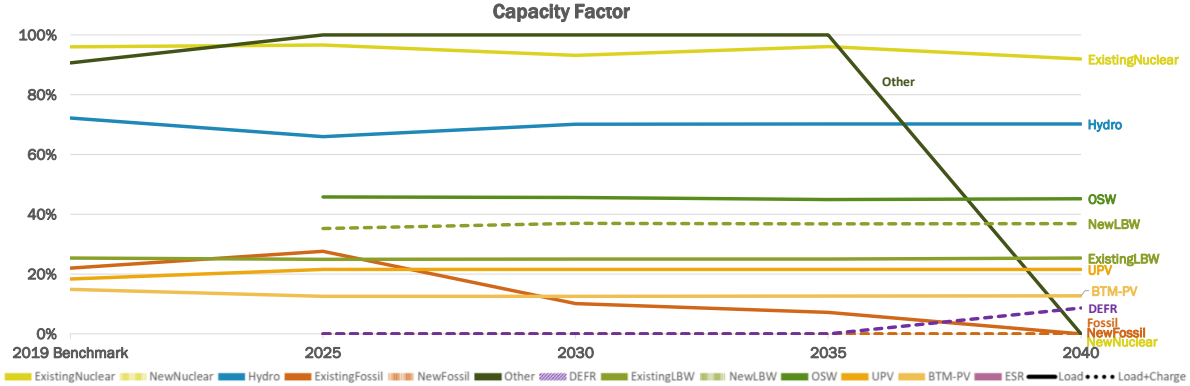
Increase ESR Policy Target







Installed Capacity (MW)	2019	2025	2030	2035	2040
Nuclear	5,400	3,346	3,364	3,364	3,364
Fossil	26,262	22,128	23,021	24,206	-
DEFR - HcLo	-	-	-	-	3,815
DEFR - McMo	-	-	-	-	-
DEFR - LcHo	-	-	-	3,793	40,937
Hydro	6,331	6,302	7,537	7,540	7,540
LBW	1,985	3,545	9,978	12,749	19,087
OSW	-	1,826	4,316	9,000	9,000
UPV	32	4,676	4,676	4,676	4,676
BTM-PV	2,116	6,834	10,055	10,828	11,198
Storage	1,405	2,910	7,410	7,410	11,447
Total	43,838	51,792	70,582	87,584	111,064

Generation (GWh)	2019	2025	2030	2035	2040
Nuclear	45,429	28,338	27,444	28,338	27,092
Fossil	50,520	53,579	20,125	14,059	-
DEFR - HcLo	-	-	-	-	33,507
DEFR - McMo	-	-	-	-	-
DEFR - LcHo	-	-	-	-	516
Hydro	40,034	36,418	46,342	46,392	46,377
LBW	4,416	8,880	29,909	38,752	59,362
OSW	-	7,331	17,248	35,457	35,644
UPV	51	8,817	8,816	8,817	8,819
BTM-PV	2,761	7,483	11,068	11,983	12,454
Storage	612	4,451	8,943	10,766	21,349
Total Generation	146,262	157,289	171,887	196,556	245,120
RE Generation	47,261	68,929	113,383	141,401	162,656
ZE Generation	93,301	101,718	149,771	180,505	245,120
Load	151,386	152,489	161,976	184,697	221,828
Load+Charge	151,773	157,290	171,888	196,556	245,120
% RE [RE/Load]	31%	45%	70%	77%	73%
% ZE [ZE/(Load+Charge)]	61%	65%	87%	92%	100%

Emissions (million tons)	2019	2025	2030	2035	2040
CO_2 Emissions	22.24	23.58	8.97	6.21	-

* Storage includes Pumped Storage Hydro and Batteries
* Utility solar (UPV) includes existing (77 MW) and new UPV
* Hydro includes hydro imports from Hydro Quebec
* Land-Based Wind (LBW), Offshore Wind (OSW), Zero Emissions (ZE)
* Dispachable Emission Free Resource (DEFR), High Captial Low Operating (HcLo)

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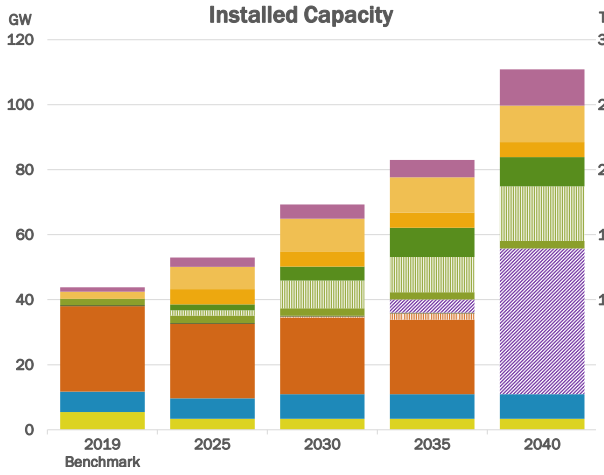
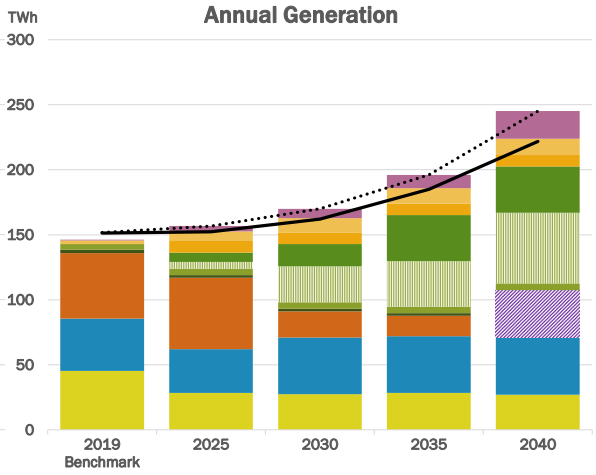
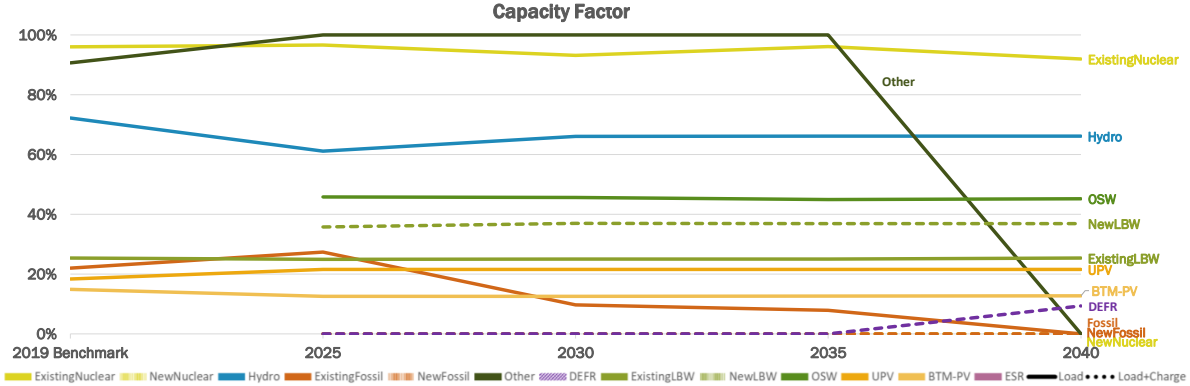
Reduced Hydro Output







Installed Capacity (MW)	2019	2025	2030	2035	2040
Nuclear	5,400	3,346	3,364	3,364	3,364
Fossil	26,262	22,962	23,932	24,871	-
DEFR - HcLo	-	-	-	-	4,121
DEFR - McMo	-	-	-	-	-
DEFR - LcHo	-	-	-	4,043	40,720
Hydro	6,331	6,302	7,537	7,540	7,540
LBW	1,985	3,896	10,798	13,095	19,087
OSW	-	1,826	4,316	9,000	9,000
UPV	32	4,676	4,676	4,676	4,676
BTM-PV	2,116	6,834	10,055	10,828	11,198
Storage	1,405	2,910	4,410	5,340	11,160
Total	43,838	52,977	69,313	87,027	110,866

Generation (GWh)	2019	2025	2030	2035	2040
Nuclear	45,429	28,338	27,444	28,338	27,092
Fossil	50,520	54,944	19,983	15,746	-
DEFR - HcLo	-	-	-	-	36,200
DEFR - McMo	-	-	-	-	-
DEFR - LcHo	-	-	-	-	514
Hydro	40,034	33,727	43,652	43,695	43,687
LBW	4,416	10,048	32,600	39,898	59,362
OSW	-	7,331	17,248	35,460	35,647
UPV	51	8,817	8,816	8,817	8,819
BTM-PV	2,761	7,483	11,068	11,983	12,454
Storage	612	4,111	7,202	10,151	21,365
Total Generation	146,262	156,791	170,004	196,080	245,138
RE Generation	47,261	67,406	113,383	139,853	159,968
ZE Generation	93,301	99,855	148,029	178,342	245,138
Load	151,386	152,273	162,070	185,047	221,828
Load+Charge	151,773	156,792	170,004	196,080	245,138
% RE [RE/Load]	31%	44%	70%	76%	72%
% ZE [ZE/(Load+Charge)]	61%	64%	87%	91%	100%

Emissions (million tons)	2019	2025	2030	2035	2040
CO_2 Emissions	22.24	24.12	8.98	6.74	-

* Storage includes Pumped Storage Hydro and Batteries
* Utility solar (UPV) includes existing (77 MW) and new UPV
* Hydro includes hydro imports from Hydro Quebec
* Land-Based Wind (LBW), Offshore Wind (OSW), Zero Emissions (ZE)
* Dispachable Emission Free Resource (DEFR), High Captial Low Operating (HcLo)

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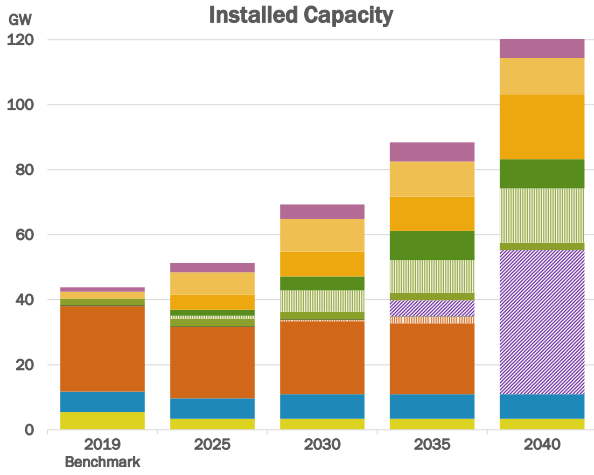
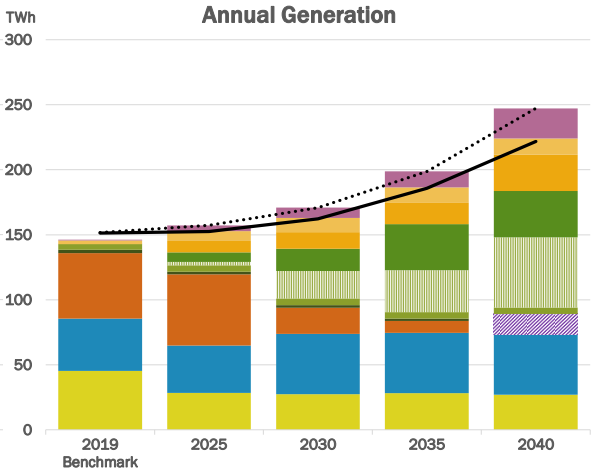
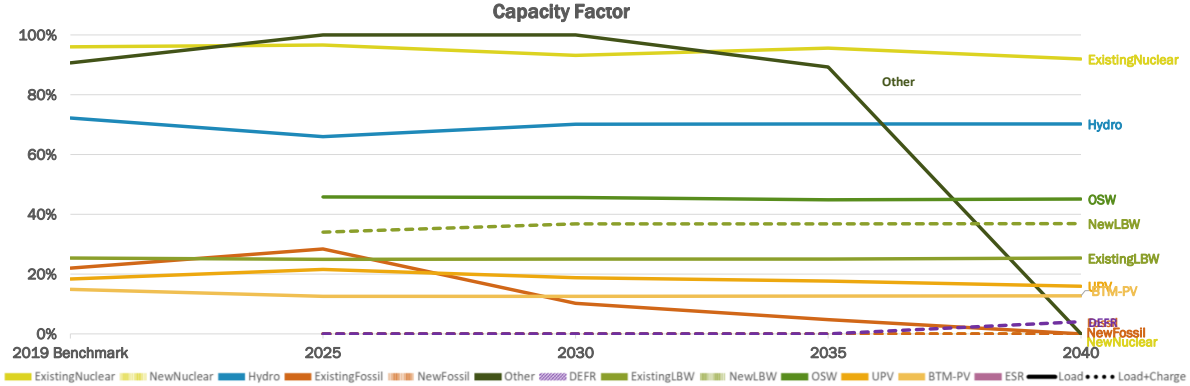
Low UPV Capital Cost







Installed Capacity (MW)	2019	2025	2030	2035	2040
Nuclear	5,400	3,346	3,364	3,364	3,364
Fossil	26,262	21,999	22,878	23,801	-
DEFR - HcLo	-	-	-	-	1,704
DEFR - McMo	-	-	-	-	-
DEFR - LcHo	-	-	-	4,892	42,627
Hydro	6,331	6,302	7,537	7,540	7,540
LBW	1,985	3,188	8,833	12,326	18,948
OSW	-	1,826	4,316	9,000	9,000
UPV	32	4,676	7,658	10,533	20,000
BTM-PV	2,116	6,834	10,055	10,828	11,198
Storage	1,405	2,910	4,410	5,922	12,810
Total	43,838	51,305	69,277	93,323	127,192

Generation (GWh)	2019	2025	2030	2035	2040
Nuclear	45,429	28,338	27,444	28,189	27,092
Fossil	50,520	54,740	20,192	9,109	-
DEFR - HcLo	-	-	-	-	14,972
DEFR - McMo	-	-	-	-	-
DEFR - LcHo	-	-	-	-	668
Hydro	40,034	36,418	46,342	46,392	46,377
LBW	4,416	7,688	26,122	37,368	58,933
OSW	-	7,331	17,248	35,348	35,536
UPV	51	8,817	12,604	16,313	27,942
BTM-PV	2,761	7,483	11,068	11,983	12,454
Storage	612	4,393	7,821	12,289	23,276
Total Generation	146,262	157,199	170,832	198,751	247,251
RE Generation	47,261	67,737	113,383	147,404	181,243
ZE Generation	93,301	100,468	148,648	187,882	247,251
Load	151,386	152,444	162,329	185,657	221,828
Load+Charge	151,773	157,200	170,832	198,752	247,251
% RE [RE/Load]	31%	44%	70%	79%	82%
% ZE [ZE/(Load+Charge)]	61%	64%	87%	95%	100%

Emissions (million tons)	2019	2025	2030	2035	2040
CO_2 Emissions	22.24	24.08	9.08	3.96	-

* Storage includes Pumped Storage Hydro and Batteries
* Utility solar (UPV) includes existing (77 MW) and new UPV
* Hydro includes hydro imports from Hydro Quebec
* Land-Based Wind (LBW), Offshore Wind (OSW), Zero Emissions (ZE)
* Dispachable Emission Free Resource (DEFR), High Captial Low Operating (HcLo)

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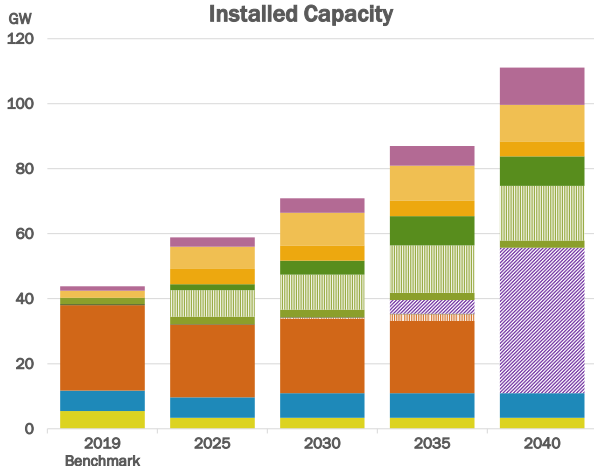
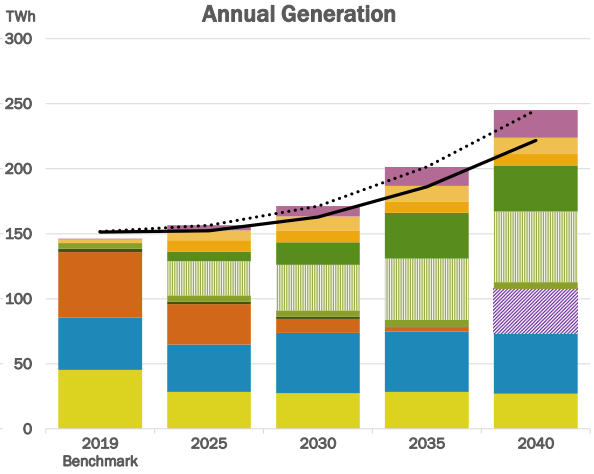
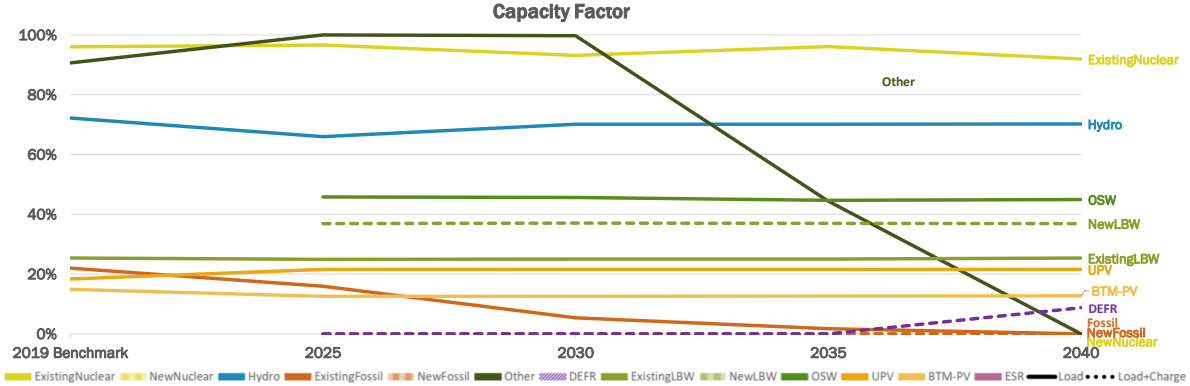
Low LBW Capital Cost







Installed Capacity (MW)	2019	2025	2030	2035	2040
Nuclear	5,400	3,346	3,364	3,364	3,364
Fossil	26,262	22,351	23,239	24,276	-
DEFR - HcLo	-	-	-	-	3,839
DEFR - McMo	-	-	-	-	-
DEFR - LcHo	-	-	-	4,195	40,907
Hydro	6,331	6,302	7,537	7,540	7,540
LBW	1,985	10,454	13,071	16,844	19,087
OSW	-	1,826	4,316	9,000	9,000
UPV	32	4,676	4,676	4,676	4,676
BTM-PV	2,116	6,834	10,055	10,828	11,198
Storage	1,405	2,910	4,410	6,073	11,465
Total	43,838	58,882	70,851	91,173	111,076

Generation (GWh)	2019	2025	2030	2035	2040
Nuclear	45,429	28,338	27,444	28,338	27,092
Fossil	50,520	31,224	10,764	3,272	-
DEFR - HcLo	-	-	-	-	33,722
DEFR - McMo	-	-	-	-	-
DEFR - LcHo	-	-	-	-	511
Hydro	40,034	36,418	46,342	46,359	46,377
LBW	4,416	31,403	40,057	52,206	59,362
OSW	-	7,331	17,248	35,247	35,436
UPV	51	8,817	8,816	8,817	8,819
BTM-PV	2,761	7,483	11,068	11,983	12,454
Storage	612	3,941	7,975	14,467	21,360
Total Generation	146,262	156,574	171,309	201,398	245,132
RE Generation	47,261	91,451	123,531	154,612	162,448
ZE Generation	93,301	123,730	158,950	197,418	245,132
Load	151,386	152,223	162,865	186,069	221,828
Load+Charge	151,773	156,575	171,309	201,399	245,132
% RE [RE/Load]	31%	60%	76%	83%	73%
% ZE [ZE/(Load+Charge)]	61%	79%	93%	98%	100%

Emissions (million tons)	2019	2025	2030	2035	2040
CO_2 Emissions	22.24	13.91	5.12	1.57	-

* Storage includes Pumped Storage Hydro and Batteries
* Utility solar (UPV) includes existing (77 MW) and new UPV
* Hydro includes hydro imports from Hydro Quebec
* Land-Based Wind (LBW), Offshore Wind (OSW), Zero Emissions (ZE)
* Dispachable Emission Free Resource (DEFR), High Captial Low Operating (HcLo)

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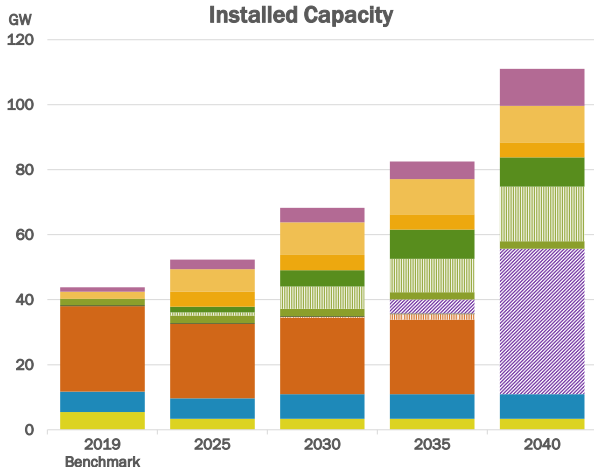
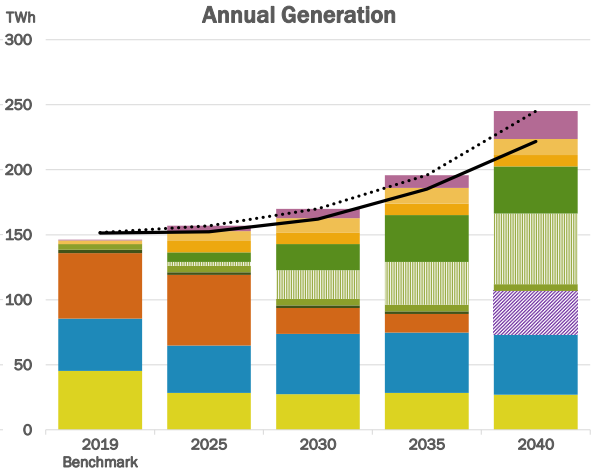
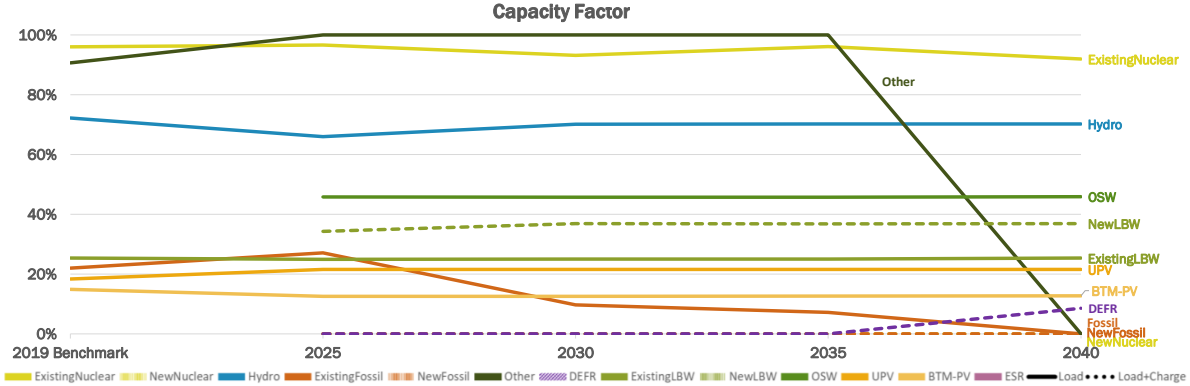
Low OSW Capital Cost







Installed Capacity (MW)	2019	2025	2030	2035	2040
Nuclear	5,400	3,346	3,364	3,364	3,364
Fossil	26,262	22,940	23,830	24,665	-
DEFR - HcLo	-	-	-	-	3,749
DEFR - McMo	-	-	-	-	-
DEFR - LcHo	-	-	-	4,241	41,016
Hydro	6,331	6,302	7,537	7,540	7,540
LBW	1,985	3,236	9,089	12,513	19,087
OSW	-	1,826	5,036	9,000	9,000
UPV	32	4,676	4,676	4,676	4,676
BTM-PV	2,116	6,834	10,055	10,828	11,198
Storage	1,405	2,910	4,410	5,441	11,401
Total	43,838	52,294	68,223	86,735	111,033

Generation (GWh)	2019	2025	2030	2035	2040
Nuclear	45,429	28,338	27,444	28,338	27,092
Fossil	50,520	54,500	19,973	14,476	-
DEFR - HcLo	-	-	-	-	32,934
DEFR - McMo	-	-	-	-	-
DEFR - LcHo	-	-	-	-	530
Hydro	40,034	36,418	46,342	46,392	46,377
LBW	4,416	7,854	26,971	37,961	59,362
OSW	-	7,331	20,186	36,017	36,200
UPV	51	8,817	8,816	8,817	8,819
BTM-PV	2,761	7,483	11,068	11,983	12,454
Storage	612	4,254	7,167	9,896	21,322
Total Generation	146,262	156,986	169,960	195,872	245,090
RE Generation	47,261	67,902	113,383	141,171	163,212
ZE Generation	93,301	100,494	147,995	179,404	245,090
Load	151,386	152,337	162,060	185,157	221,828
Load+Charge	151,773	156,986	169,960	195,873	245,090
% RE [RE/Load]	31%	45%	70%	76%	74%
% ZE [ZE/(Load+Charge)]	61%	64%	87%	92%	100%

Emissions (million tons)	2019	2025	2030	2035	2040
CO_2 Emissions	22.24	23.89	8.90	6.18	-

* Storage includes Pumped Storage Hydro and Batteries
* Utility solar (UPV) includes existing (77 MW) and new UPV
* Hydro includes hydro imports from Hydro Quebec
* Land-Based Wind (LBW), Offshore Wind (OSW), Zero Emissions (ZE)
* Dispachable Emission Free Resource (DEFR), High Captial Low Operating (HcLo)

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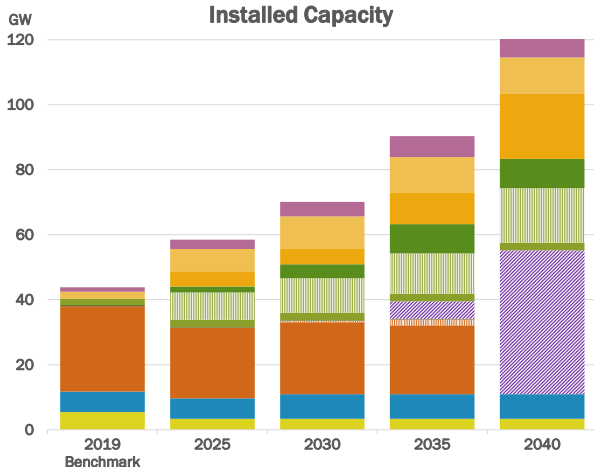
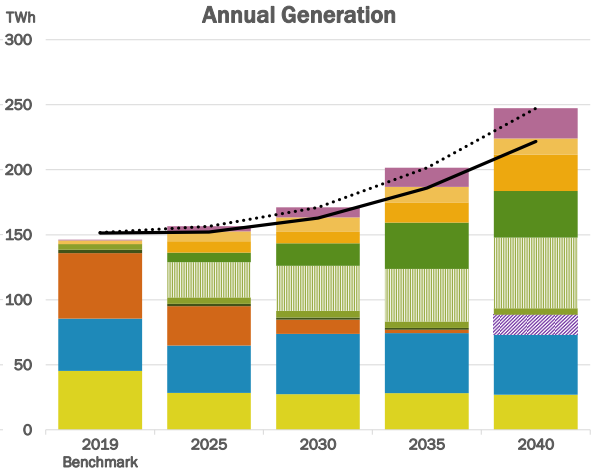
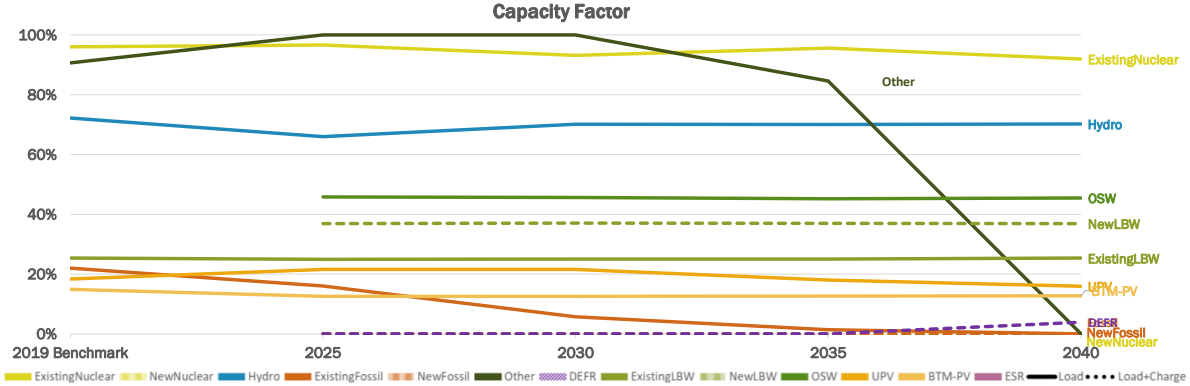
Low UPV, LBW, & OSW Capital Costs







Installed Capacity (MW)	2019	2025	2030	2035	2040
Nuclear	5,400	3,346	3,364	3,364	3,364
Fossil	26,262	21,711	22,541	23,028	-
DEFR - HcLo	-	-	-	-	1,629
DEFR - McMo	-	-	-	-	-
DEFR - LcHo	-	-	-	5,388	42,697
Hydro	6,331	6,302	7,537	7,540	7,540
LBW	1,985	10,702	12,992	14,753	19,087
OSW	-	1,826	4,316	9,000	9,000
UPV	32	4,676	4,676	9,765	20,000
BTM-PV	2,116	6,834	10,055	10,828	11,198
Storage	1,405	2,910	4,410	6,437	12,810
Total	43,838	58,490	70,073	95,672	127,326

Generation (GWh)	2019	2025	2030	2035	2040
Nuclear	45,429	28,338	27,444	28,182	27,092
Fossil	50,520	30,421	11,022	2,577	-
DEFR - HcLo	-	-	-	-	14,305
DEFR - McMo	-	-	-	-	-
DEFR - LcHo	-	-	-	-	665
Hydro	40,034	36,418	46,342	46,279	46,377
LBW	4,416	32,187	39,755	45,425	59,362
OSW	-	7,331	17,248	35,665	35,850
UPV	51	8,817	8,816	15,381	27,872
BTM-PV	2,761	7,483	11,068	11,983	12,454
Storage	612	3,953	7,813	14,666	23,308
Total Generation	146,262	156,566	171,118	201,508	247,287
RE Generation	47,261	92,235	123,229	154,734	181,916
ZE Generation	93,301	124,526	158,486	197,582	247,287
Load	151,386	152,186	162,844	185,867	221,828
Load+Charge	151,773	156,567	171,118	201,509	247,287
% RE [RE/Load]	31%	61%	76%	83%	82%
% ZE [ZE/(Load+Charge)]	61%	80%	93%	98%	100%

Emissions (million tons)	2019	2025	2030	2035	2040
CO_2 Emissions	22.24	13.54	5.18	1.08	-

* Storage includes Pumped Storage Hydro and Batteries
* Utility solar (UPV) includes existing (77 MW) and new UPV
* Hydro includes hydro imports from Hydro Quebec
* Land-Based Wind (LBW), Offshore Wind (OSW), Zero Emissions (ZE)
* Dispachable Emission Free Resource (DEFR), High Captial Low Operating (HcLo)

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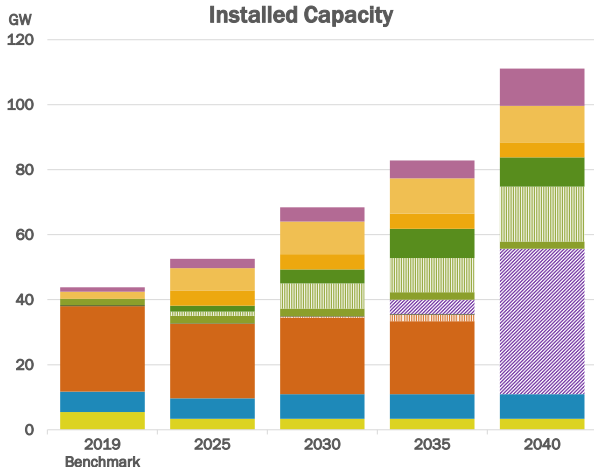
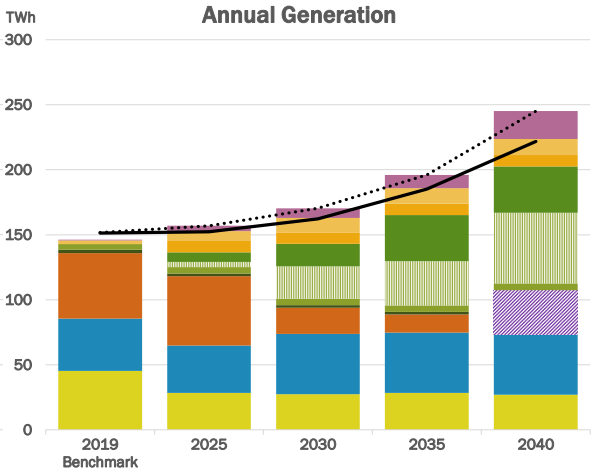
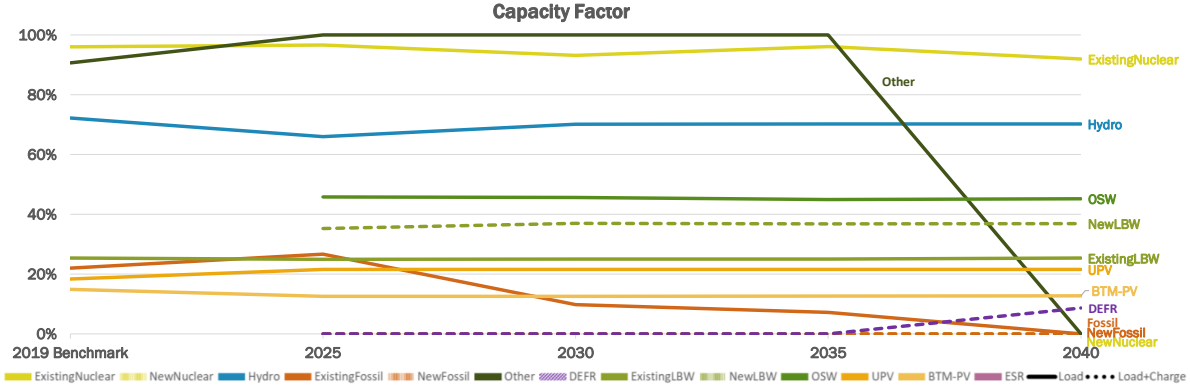
DEFR Low Capital Costs







Installed Capacity (MW)	2019	2025	2030	2035	2040
Nuclear	5,400	3,346	3,364	3,364	3,364
Fossil	26,262	22,909	23,877	24,381	-
DEFR - HcLo	-	-	-	-	3,814
DEFR - McMo	-	-	-	-	-
DEFR - LcHo	-	-	-	4,494	40,937
Hydro	6,331	6,302	7,537	7,540	7,540
LBW	1,985	3,545	9,978	12,795	19,087
OSW	-	1,826	4,316	9,000	9,000
UPV	32	4,676	4,676	4,676	4,676
BTM-PV	2,116	6,834	10,055	10,828	11,198
Storage	1,405	2,910	4,410	5,507	11,447
Total	43,838	52,572	68,438	87,304	111,064

Generation (GWh)	2019	2025	2030	2035	2040
Nuclear	45,429	28,338	27,444	28,338	27,092
Fossil	50,520	53,488	20,098	14,042	-
DEFR - HcLo	-	-	-	-	33,504
DEFR - McMo	-	-	-	-	-
DEFR - LcHo	-	-	-	-	516
Hydro	40,034	36,418	46,342	46,392	46,377
LBW	4,416	8,880	29,909	38,900	59,362
OSW	-	7,331	17,248	35,460	35,647
UPV	51	8,817	8,816	8,817	8,819
BTM-PV	2,761	7,483	11,068	11,983	12,454
Storage	612	4,236	7,510	10,115	21,349
Total Generation	146,262	156,982	170,427	196,040	245,120
RE Generation	47,261	68,929	113,383	141,552	162,659
ZE Generation	93,301	101,502	148,338	180,006	245,120
Load	151,386	152,367	162,221	185,061	221,828
Load+Charge	151,773	156,982	170,428	196,040	245,120
% RE [RE/Load]	31%	45%	70%	76%	73%
% ZE [ZE/(Load+Charge)]	61%	65%	87%	92%	100%

Emissions (million tons)	2019	2025	2030	2035	2040
CO_2 Emissions	22.24	23.52	9.02	5.88	-

* Storage includes Pumped Storage Hydro and Batteries
* Utility solar (UPV) includes existing (77 MW) and new UPV
* Hydro includes hydro imports from Hydro Quebec
* Land-Based Wind (LBW), Offshore Wind (OSW), Zero Emissions (ZE)
* Dispachable Emission Free Resource (DEFR), High Captial Low Operating (HcLo)

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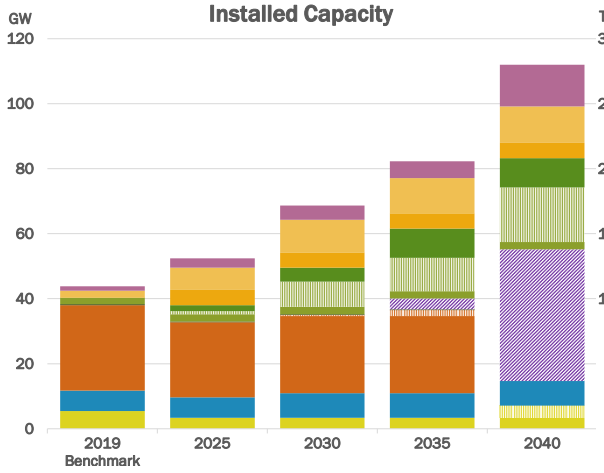
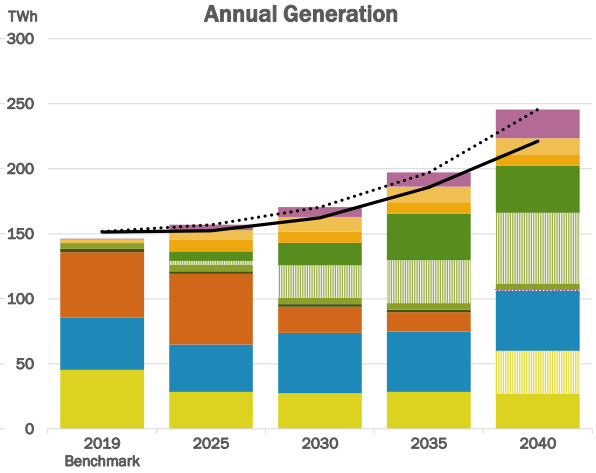
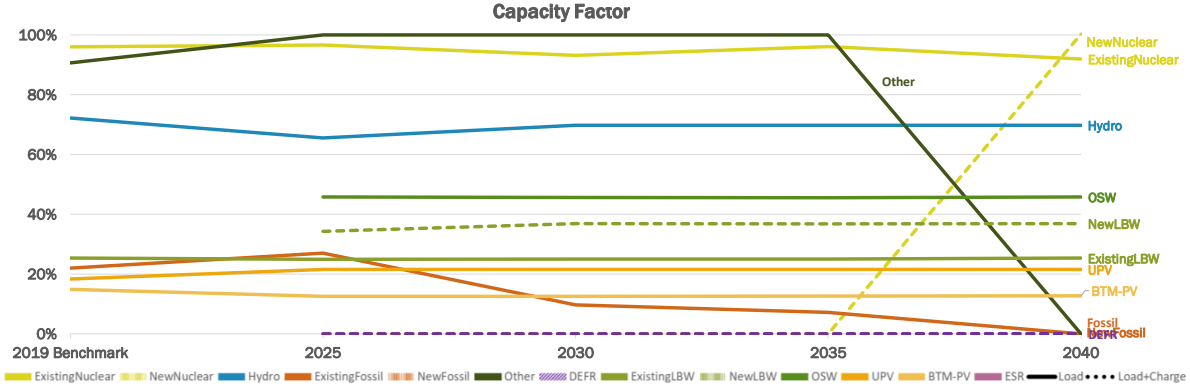
DEFR High Capital Costs







Installed Capacity (MW)	2019	2025	2030	2035	2040
Nuclear	5,400	3,346	3,364	3,364	7,119
Fossil	26,262	23,033	24,055	25,542	-
DEFR - HcLo	-	-	-	-	-
DEFR - McMo	-	-	-	-	-
DEFR - LcHo	-	-	-	3,323	40,466
Hydro	6,331	6,346	7,581	7,584	7,584
LBW	1,985	3,236	9,996	12,513	19,087
OSW	-	1,826	4,316	9,000	9,000
UPV	32	4,676	4,676	4,676	4,676
BTM-PV	2,116	6,834	10,055	10,828	11,198
Storage	1,405	2,910	4,410	5,174	12,810
Total	43,838	52,432	68,678	85,552	111,940

Generation (GWh)	2019	2025	2030	2035	2040
Nuclear	45,429	28,338	27,444	28,338	60,071
Fossil	50,520	54,510	20,114	14,955	-
DEFR - HcLo	-	-	-	-	-
DEFR - McMo	-	-	-	-	-
DEFR - LcHo	-	-	-	-	362
Hydro	40,034	36,418	46,342	46,392	46,391
LBW	4,416	7,854	29,909	37,961	59,362
OSW	-	7,331	17,248	35,909	36,092
UPV	51	8,817	8,816	8,817	8,819
BTM-PV	2,761	7,483	11,068	11,983	12,454
Storage	612	4,251	7,591	10,795	22,030
Total Generation	146,262	156,993	170,524	197,142	245,581
RE Generation	47,261	67,902	113,383	141,062	163,118
ZE Generation	93,301	100,491	148,419	180,195	245,581
Load	151,386	152,356	162,234	185,698	221,283
Load+Charge	151,773	156,993	170,525	197,142	245,581
% RE [RE/Load]	31%	45%	70%	76%	74%
% ZE [ZE/(Load+Charge)]	61%	64%	87%	91%	100%

Emissions (million tons)	2019	2025	2030	2035	2040
CO_2 Emissions	22.24	23.92	9.00	6.82	-

* Storage includes Pumped Storage Hydro and Batteries
* Utility solar (UPV) includes existing (77 MW) and new UPV
* Hydro includes hydro imports from Hydro Quebec
* Land-Based Wind (LBW), Offshore Wind (OSW), Zero Emissions (ZE)
* Dispachable Emission Free Resource (DEFR), High Captial Low Operating (HcLo)

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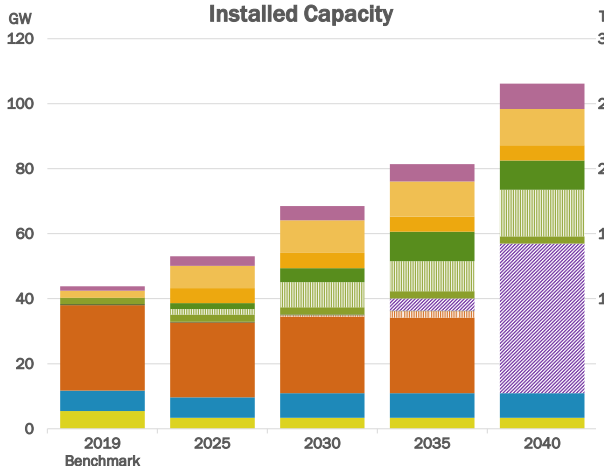
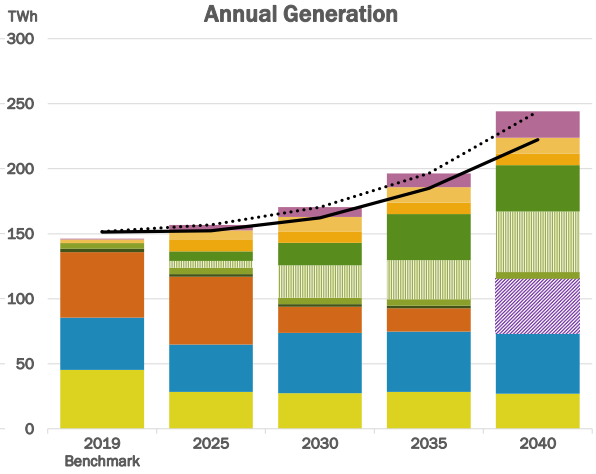
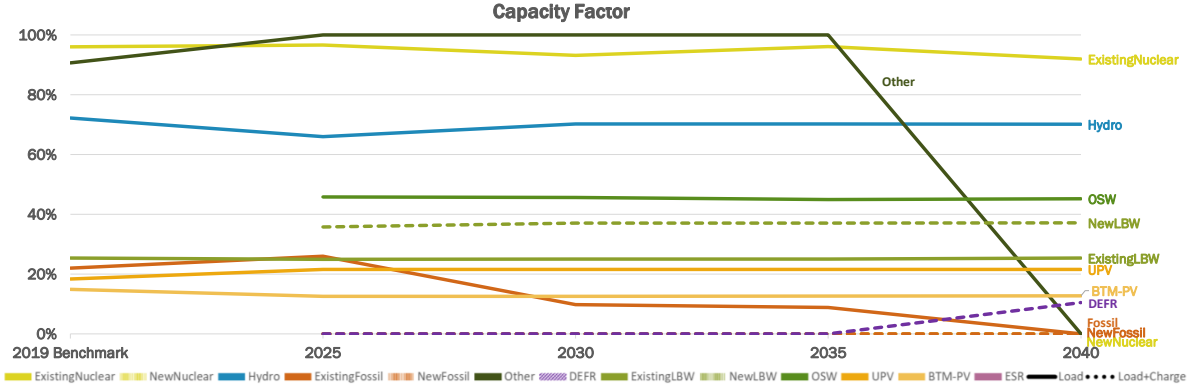
DEFR Low Fuel Price







Installed Capacity (MW)	2019	2025	2030	2035	2040
Nuclear	5,400	3,346	3,364	3,364	3,364
Fossil	26,262	23,011	23,981	25,234	-
DEFR - HcLo	-	-	-	-	4,477
DEFR - McMo	-	-	-	-	-
DEFR - LcHo	-	-	-	3,680	41,534
Hydro	6,331	6,302	7,537	7,540	7,540
LBW	1,985	3,896	9,951	11,528	16,591
OSW	-	1,826	4,316	9,000	9,000
UPV	32	4,676	4,676	4,676	4,676
BTM-PV	2,116	6,834	10,055	10,828	11,198
Storage	1,405	2,910	4,410	5,352	7,744
Total	43,838	53,025	68,515	85,107	106,124

Generation (GWh)	2019	2025	2030	2035	2040
Nuclear	45,429	28,338	27,444	28,338	27,092
Fossil	50,520	52,271	20,129	17,938	-
DEFR - HcLo	-	-	-	-	39,326
DEFR - McMo	-	-	-	-	-
DEFR - LcHo	-	-	-	-	2,743
Hydro	40,034	36,418	46,342	46,392	46,303
LBW	4,416	10,048	29,909	35,034	51,586
OSW	-	7,331	17,248	35,443	35,630
UPV	51	8,817	8,816	8,817	8,819
BTM-PV	2,761	7,483	11,068	11,983	12,454
Storage	612	4,143	7,558	10,501	20,143
Total Generation	146,262	156,840	170,507	196,437	244,097
RE Generation	47,261	70,097	113,383	137,669	154,792
ZE Generation	93,301	102,578	148,385	176,508	244,097
Load	151,386	152,297	162,263	184,970	222,381
Load+Charge	151,773	156,841	170,507	196,438	244,097
% RE [RE/Load]	31%	46%	70%	74%	70%
% ZE [ZE/(Load+Charge)]	61%	65%	87%	90%	100%

Emissions (million tons)	2019	2025	2030	2035	2040
CO_2 Emissions	22.24	23.01	9.04	7.92	-

* Storage includes Pumped Storage Hydro and Batteries
* Utility solar (UPV) includes existing (77 MW) and new UPV
* Hydro includes hydro imports from Hydro Quebec
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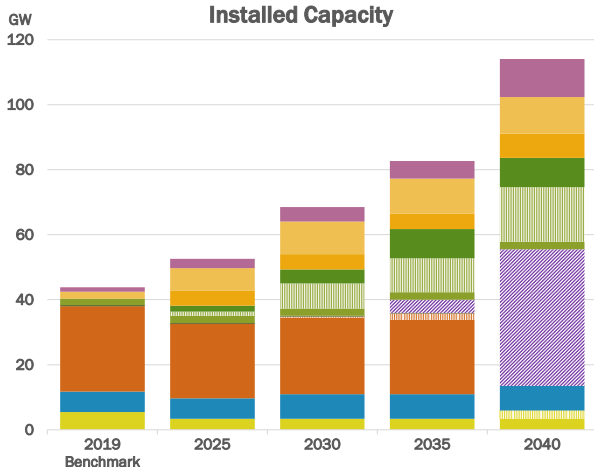
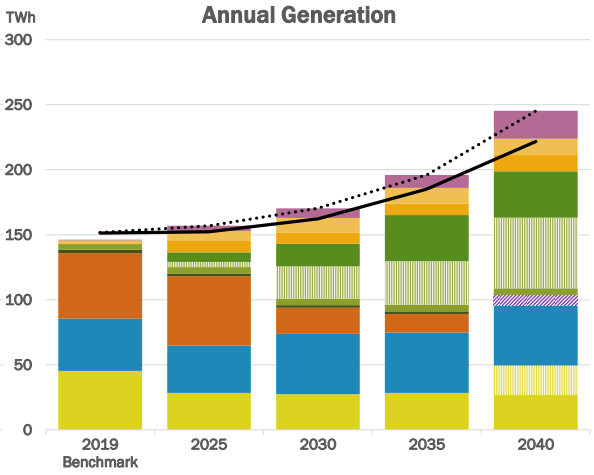
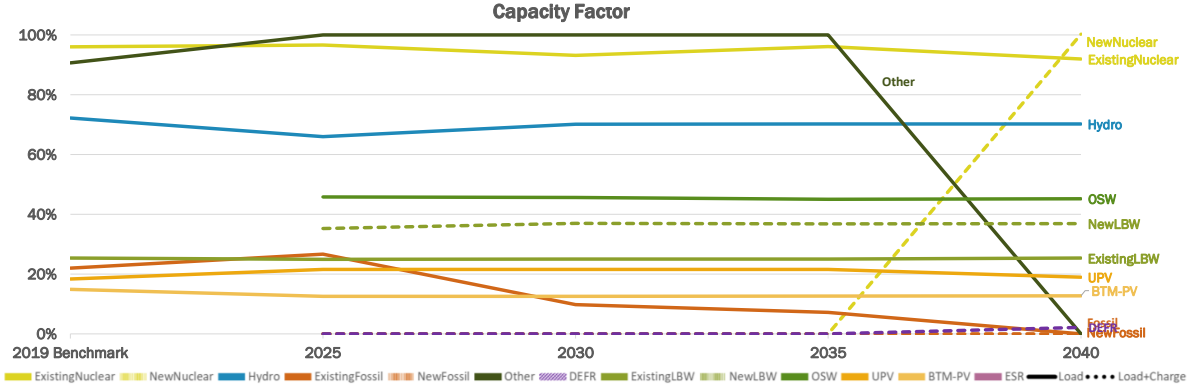
DEFR High Fuel Price







Installed Capacity (MW)	2019	2025	2030	2035	2040
Nuclear	5,400	3,346	3,364	3,364	5,926
Fossil	26,262	22,926	23,895	24,832	-
DEFR - HcLo	-	-	-	-	836
DEFR - McMo	-	-	-	-	-
DEFR - LcHo	-	-	-	4,047	41,211
Hydro	6,331	6,302	7,537	7,540	7,540
LBW	1,985	3,545	9,978	12,699	19,087
OSW	-	1,826	4,316	9,000	9,000
UPV	32	4,676	4,676	4,676	7,492
BTM-PV	2,116	6,834	10,055	10,828	11,198
Storage	1,405	2,910	4,410	5,482	11,703
Total	43,838	52,589	68,456	86,739	113,995

Generation (GWh)	2019	2025	2030	2035	2040
Nuclear	45,429	28,338	27,444	28,338	49,599
Fossil	50,520	53,488	20,098	14,388	-
DEFR - HcLo	-	-	-	-	7,343
DEFR - McMo	-	-	-	-	-
DEFR - LcHo	-	-	-	-	536
Hydro	40,034	36,418	46,342	46,392	46,377
LBW	4,416	8,880	29,909	38,582	59,362
OSW	-	7,331	17,248	35,469	35,656
UPV	51	8,817	8,816	8,817	12,459
BTM-PV	2,761	7,483	11,068	11,983	12,454
Storage	612	4,236	7,510	10,053	21,489
Total Generation	146,262	156,982	170,427	196,014	245,274
RE Generation	47,261	68,929	113,383	141,243	166,308
ZE Generation	93,301	101,502	148,338	179,634	245,274
Load	151,386	152,367	162,221	185,139	221,828
Load+Charge	151,773	156,982	170,428	196,015	245,274
% RE [RE/Load]	31%	45%	70%	76%	75%
% ZE [ZE/(Load+Charge)]	61%	65%	87%	92%	100%

Emissions (million tons)	2019	2025	2030	2035	2040
CO_2 Emissions	22.24	23.52	9.02	6.17	-

* Storage includes Pumped Storage Hydro and Batteries
* Utility solar (UPV) includes existing (77 MW) and new UPV
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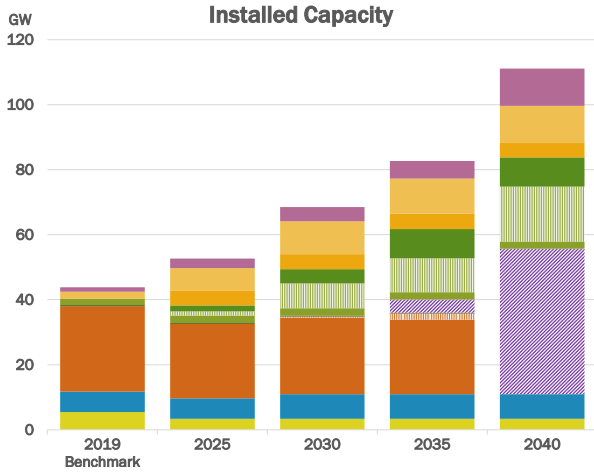
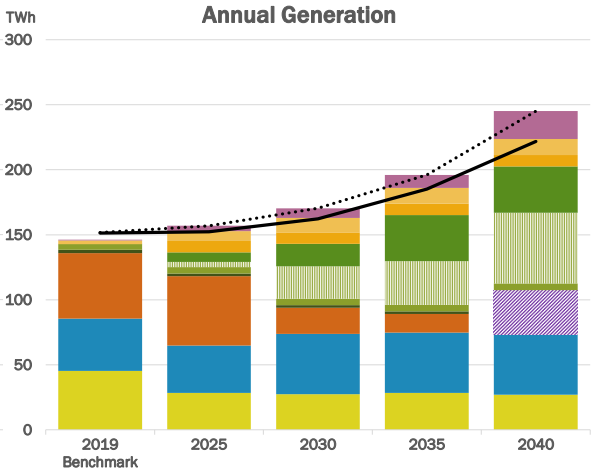
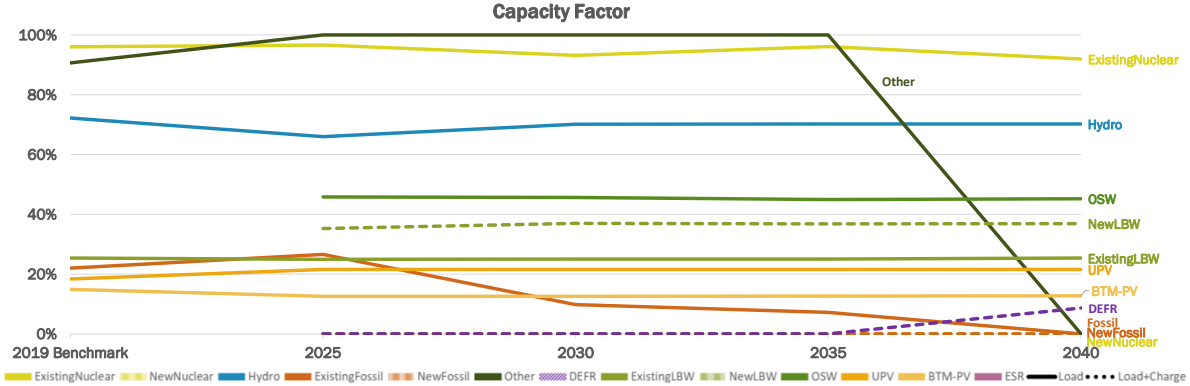
DEFR High Heat Rate







Installed Capacity (MW)	2019	2025	2030	2035	2040
Nuclear	5,400	3,346	3,364	3,364	3,364
Fossil	26,262	22,960	23,929	24,869	-
DEFR - HcLo	-	-	-	-	3,814
DEFR - McMo	-	-	-	-	-
DEFR - LcHo	-	-	-	4,043	40,937
Hydro	6,331	6,302	7,537	7,540	7,540
LBW	1,985	3,545	9,978	12,699	19,087
OSW	-	1,826	4,316	9,000	9,000
UPV	32	4,676	4,676	4,676	4,676
BTM-PV	2,116	6,834	10,055	10,828	11,198
Storage	1,405	2,910	4,410	5,405	11,447
Total	43,838	52,623	68,490	86,693	111,064

Generation (GWh)	2019	2025	2030	2035	2040
Nuclear	45,429	28,338	27,444	28,338	27,092
Fossil	50,520	53,488	20,098	14,431	-
DEFR - HcLo	-	-	-	-	33,504
DEFR - McMo	-	-	-	-	-
DEFR - LcHo	-	-	-	-	516
Hydro	40,034	36,418	46,342	46,392	46,377
LBW	4,416	8,880	29,909	38,582	59,362
OSW	-	7,331	17,248	35,460	35,647
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BTM-PV	2,761	7,483	11,068	11,983	12,454
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Load	151,386	152,367	162,221	185,205	221,828
Load+Charge	151,773	156,982	170,427	196,011	245,120
% RE [RE/Load]	31%	45%	70%	76%	73%
% ZE [ZE/(Load+Charge)]	61%	65%	87%	92%	100%

Emissions (million tons)	2019	2025	2030	2035	2040
CO_2 Emissions	22.24	23.52	9.02	6.19	-

* Storage includes Pumped Storage Hydro and Batteries
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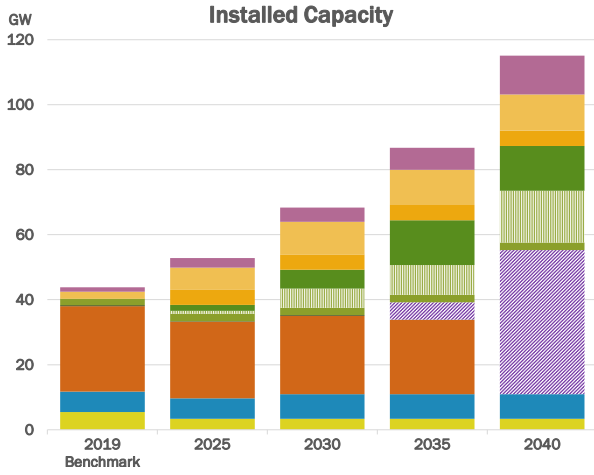
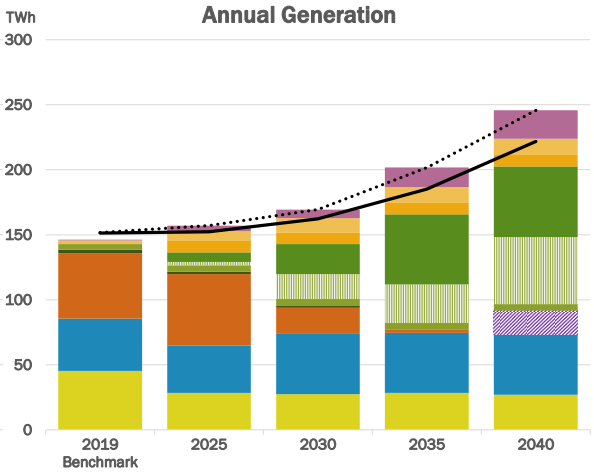
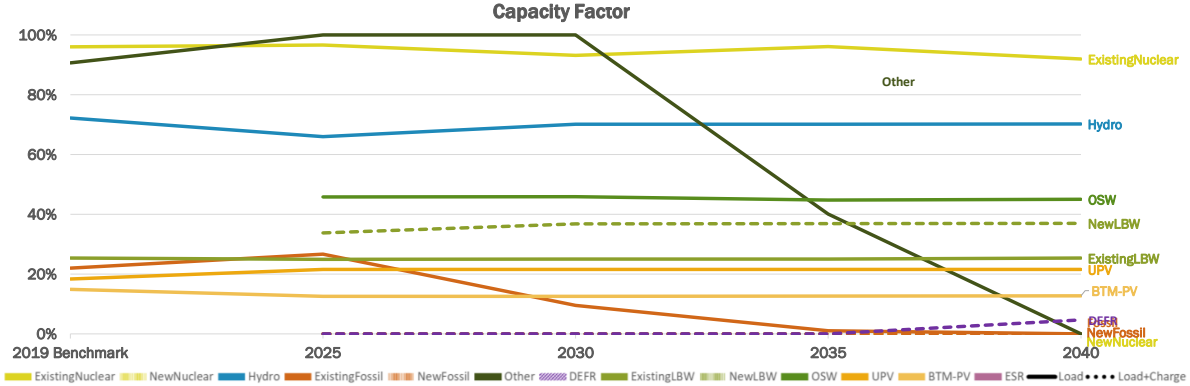
No Fossil or Nuclear Builds Allowed







Installed Capacity (MW)	2019	2025	2030	2035	2040
Nuclear	5,400	3,346	3,364	3,364	3,364
Fossil	26,262	23,543	24,153	22,860	-
DEFR - HcLo	-	-	-	-	2,025
DEFR - McMo	-	-	-	-	-
DEFR - LcHo	-	-	-	5,347	42,377
Hydro	6,331	6,302	7,537	7,540	7,540
LBW	1,985	3,138	8,182	11,465	18,186
OSW	-	1,826	5,756	13,776	13,776
UPV	32	4,676	4,676	4,676	4,676
BTM-PV	2,116	6,834	10,055	10,828	11,198
Storage	1,405	2,910	4,410	6,802	11,891
Total	43,838	52,789	68,348	92,108	115,033

Generation (GWh)	2019	2025	2030	2035	2040
Nuclear	45,429	28,338	27,444	28,320	27,092
Fossil	50,520	54,967	20,067	2,037	-
DEFR - HcLo	-	-	-	-	17,787
DEFR - McMo	-	-	-	-	-
DEFR - LcHo	-	-	-	-	422
Hydro	40,034	36,418	46,342	46,359	46,377
LBW	4,416	7,518	24,033	34,669	56,569
OSW	-	7,331	23,123	54,015	54,302
UPV	51	8,817	8,816	8,817	8,819
BTM-PV	2,761	7,483	11,068	11,983	12,454
Storage	612	4,323	6,616	15,177	21,843
Total Generation	146,262	157,091	169,408	201,737	245,666
RE Generation	47,261	67,567	113,383	155,842	178,522
ZE Generation	93,301	100,227	147,443	199,340	245,666
Load	151,386	152,390	162,171	185,248	221,828
Load+Charge	151,773	157,092	169,409	201,738	245,666
% RE [RE/Load]	31%	44%	70%	84%	80%
% ZE [ZE/(Load+Charge)]	61%	64%	87%	99%	100%

Emissions (million tons)	2019	2025	2030	2035	2040
CO_2 Emissions	22.24	24.27	9.20	0.84	-

* Storage includes Pumped Storage Hydro and Batteries
* Utility solar (UPV) includes existing (77 MW) and new UPV
* Hydro includes hydro imports from Hydro Quebec
* Land-Based Wind (LBW), Offshore Wind (OSW), Zero Emissions (ZE)
* Dispachable Emission Free Resource (DEFR), High Captial Low Operating (HcLo)

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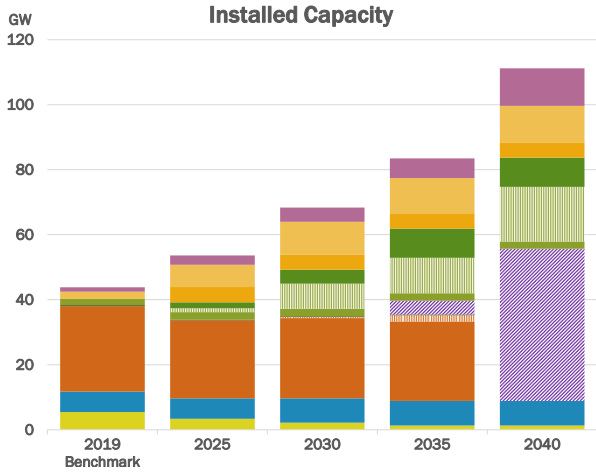
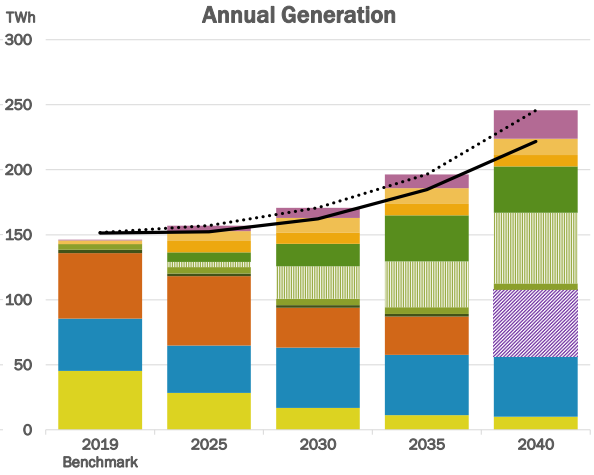
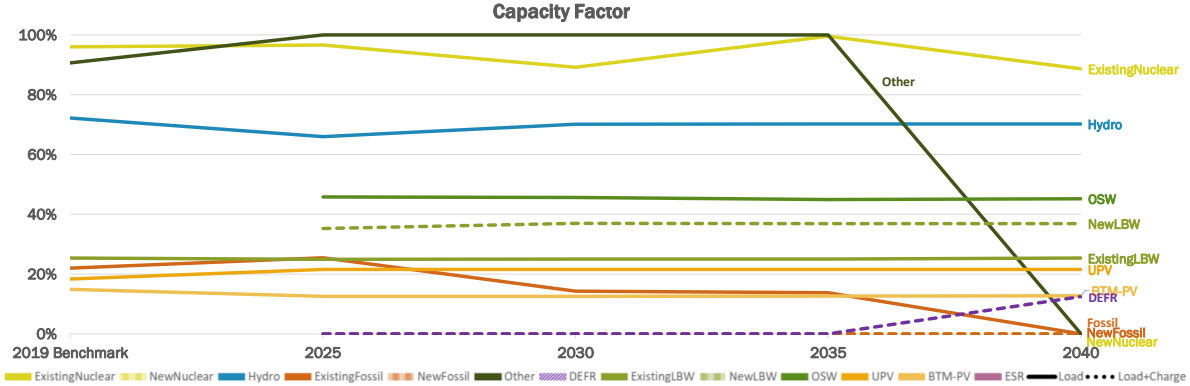
Nuclear Retirements at Relicensing Date







Installed Capacity (MW)	2019	2025	2030	2035	2040
Nuclear	5,400	3,346	2,154	1,299	1,299
Fossil	26,262	23,970	25,004	26,390	-
DEFR - HcLo	-	-	-	-	5,757
DEFR - McMo	-	-	-	-	-
DEFR - LcHo	-	-	-	4,242	41,049
Hydro	6,331	6,302	7,537	7,540	7,540
LBW	1,985	3,545	9,978	13,224	19,087
OSW	-	1,826	4,316	9,000	9,000
UPV	32	4,676	4,676	4,676	4,676
BTM-PV	2,116	6,834	10,055	10,828	11,198
Storage	1,405	2,910	4,410	6,029	11,563
Total	43,838	53,634	68,355	87,696	111,170

Generation (GWh)	2019	2025	2030	2035	2040
Nuclear	45,429	28,338	16,829	11,330	10,086
Fossil	50,520	53,480	30,763	29,482	-
DEFR - HcLo	-	-	-	-	50,565
DEFR - McMo	-	-	-	-	-
DEFR - LcHo	-	-	-	-	517
Hydro	40,034	36,418	46,342	46,392	46,377
LBW	4,416	8,880	29,909	40,326	59,362
OSW	-	7,331	17,248	35,460	35,647
UPV	51	8,817	8,816	8,817	8,819
BTM-PV	2,761	7,483	11,068	11,983	12,454
Storage	612	4,267	7,859	10,688	21,873
Total Generation	146,262	157,006	170,825	196,470	245,700
RE Generation	47,261	68,929	113,383	142,978	162,659
ZE Generation	93,301	101,534	138,071	164,996	245,700
Load	151,386	152,348	162,242	184,697	221,828
Load+Charge	151,773	157,007	170,826	196,471	245,700
% RE [RE/Load]	31%	45%	70%	77%	73%
% ZE [ZE/(Load+Charge)]	61%	65%	81%	84%	100%

Emissions (million tons)	2019	2025	2030	2035	2040
CO_2 Emissions	22.24	23.50	13.48	12.75	-

* Storage includes Pumped Storage Hydro and Batteries
* Utility solar (UPV) includes existing (77 MW) and new UPV
* Hydro includes hydro imports from Hydro Quebec
* Land-Based Wind (LBW), Offshore Wind (OSW), Zero Emissions (ZE)
* Dispachable Emission Free Resource (DEFR), High Captial Low Operating (HcLo)

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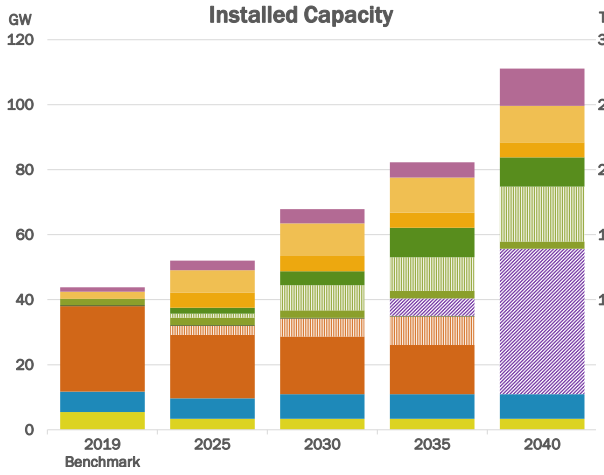
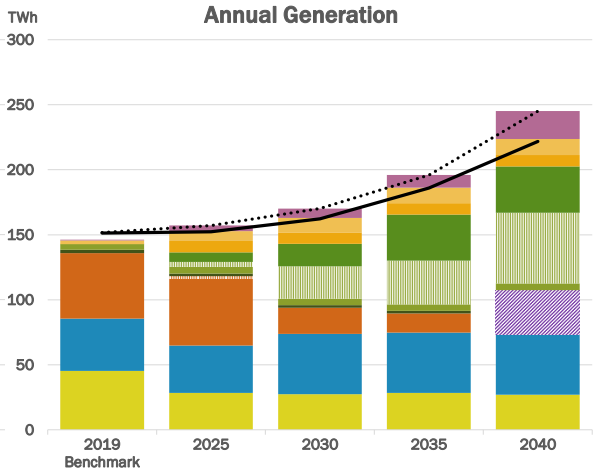
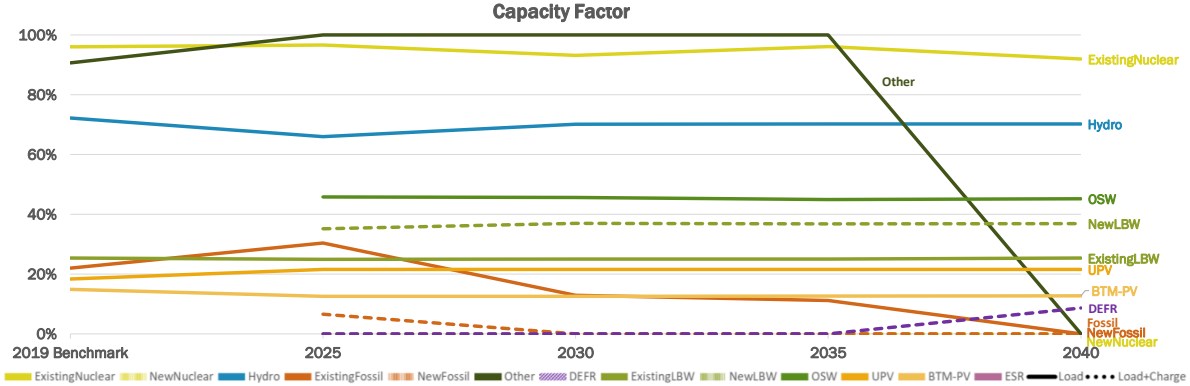
Age Based Fossil Retirements







Installed Capacity (MW)	2019	2025	2030	2035	2040
Nuclear	5,400	3,346	3,364	3,364	3,364
Fossil	26,262	22,317	23,309	23,912	-
DEFR - HcLo	-	-	-	-	3,814
DEFR - McMo	-	-	-	-	-
DEFR - LcHo	-	-	-	5,351	40,937
Hydro	6,331	6,302	7,537	7,540	7,540
LBW	1,985	3,536	9,978	12,690	19,087
OSW	-	1,826	4,316	9,000	9,000
UPV	32	4,676	4,676	4,676	4,676
BTM-PV	2,116	6,834	10,055	10,828	11,198
Storage	1,405	2,910	4,410	4,688	11,447
Total	43,838	51,972	67,870	87,625	111,064

Generation (GWh)	2019	2025	2030	2035	2040
Nuclear	45,429	28,338	27,444	28,338	27,092
Fossil	50,520	53,523	20,049	14,803	-
DEFR - HcLo	-	-	-	-	33,504
DEFR - McMo	-	-	-	-	-
DEFR - LcHo	-	-	-	-	516
Hydro	40,034	36,418	46,342	46,392	46,377
LBW	4,416	8,851	29,909	38,552	59,362
OSW	-	7,331	17,248	35,460	35,647
UPV	51	8,817	8,816	8,817	8,819
BTM-PV	2,761	7,483	11,068	11,983	12,454
Storage	612	4,351	7,266	9,659	21,349
Total Generation	146,262	157,102	170,135	195,997	245,120
RE Generation	47,261	68,899	113,383	141,204	162,659
ZE Generation	93,301	101,588	148,094	179,201	245,120
Load	151,386	152,355	162,181	185,937	221,828
Load+Charge	151,773	157,103	170,135	195,997	245,120
% RE [RE/Load]	31%	45%	70%	76%	73%
% ZE [ZE/(Load+Charge)]	61%	65%	87%	91%	100%

Emissions (million tons)	2019	2025	2030	2035	2040
CO_2 Emissions	22.24	23.51	9.04	6.36	-

* Storage includes Pumped Storage Hydro and Batteries
* Utility solar (UPV) includes existing (77 MW) and new UPV
* Hydro includes hydro imports from Hydro Quebec
* Land-Based Wind (LBW), Offshore Wind (OSW), Zero Emissions (ZE)
* Dispachable Emission Free Resource (DEFR), High Captial Low Operating (HcLo)

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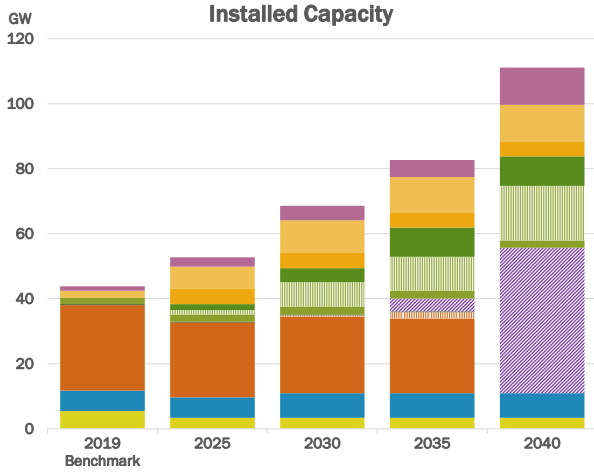
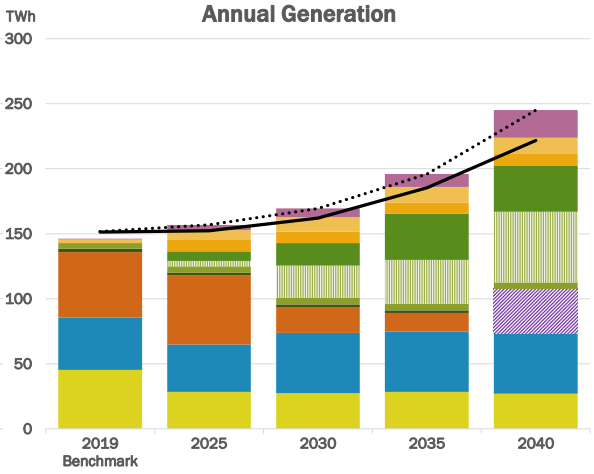
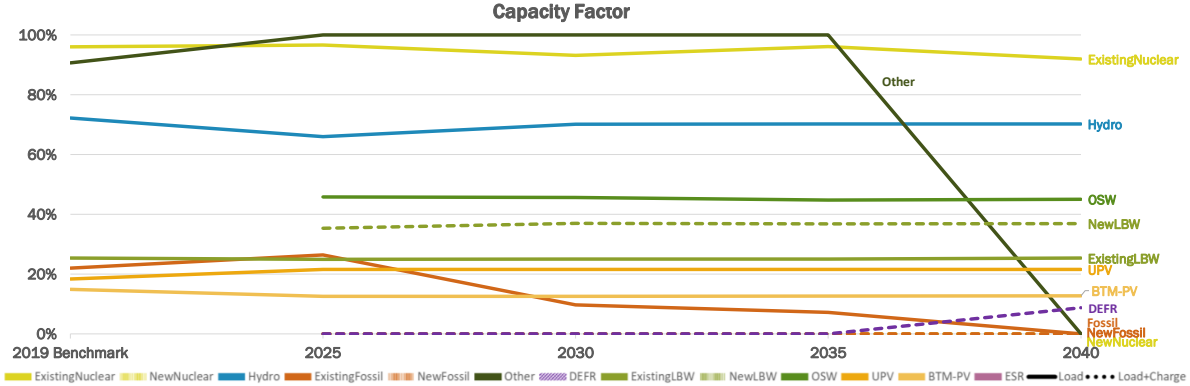
Coppersheet Analysis







Installed Capacity (MW)	2019	2025	2030	2035	2040
Nuclear	5,400	3,346	3,364	3,364	3,364
Fossil	26,262	22,994	23,990	24,924	-
DEFR - HcLo	-	-	-	-	3,831
DEFR - McMo	-	-	-	-	-
DEFR - LcHo	-	-	-	4,032	40,916
Hydro	6,331	6,302	7,537	7,540	7,540
LBW	1,985	3,639	9,973	12,793	19,087
OSW	-	1,826	4,316	9,000	9,000
UPV	32	4,676	4,676	4,676	4,676
BTM-PV	2,116	6,834	10,055	10,828	11,198
Storage	1,405	2,910	4,410	5,290	11,459
Total	43,838	52,752	68,547	86,705	111,073

Generation (GWh)	2019	2025	2030	2035	2040
Nuclear	45,429	28,338	27,444	28,338	27,092
Fossil	50,520	53,160	19,953	14,335	-
DEFR - HcLo	-	-	-	-	33,655
DEFR - McMo	-	-	-	-	-
DEFR - LcHo	-	-	-	-	512
Hydro	40,034	36,415	46,342	46,392	46,377
LBW	4,416	9,190	29,909	38,892	59,362
OSW	-	7,331	17,248	35,312	35,500
UPV	51	8,817	8,816	8,817	8,819
BTM-PV	2,761	7,483	11,068	11,983	12,454
Storage	612	4,141	6,671	9,943	21,357
Total Generation	146,262	156,867	169,443	196,004	245,128
RE Generation	47,261	69,236	113,383	141,396	162,512
ZE Generation	93,301	101,715	147,498	179,677	245,128
Load	151,386	152,348	162,125	185,301	221,828
Load+Charge	151,773	156,868	169,444	196,005	245,128
% RE [RE/Load]	31%	45%	70%	76%	73%
% ZE [ZE/(Load+Charge)]	61%	65%	87%	92%	100%

Emissions (million tons)	2019	2025	2030	2035	2040
CO_2 Emissions	22.24	23.16	8.97	6.11	-

* Storage includes Pumped Storage Hydro and Batteries
* Utility solar (UPV) includes existing (77 MW) and new UPV
* Hydro includes hydro imports from Hydro Quebec
* Land-Based Wind (LBW), Offshore Wind (OSW), Zero Emissions (ZE)
* Dispachable Emission Free Resource (DEFR), High Captial Low Operating (HcLo)

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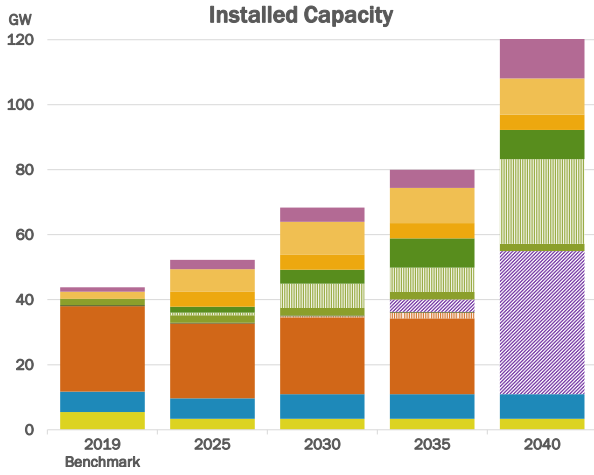
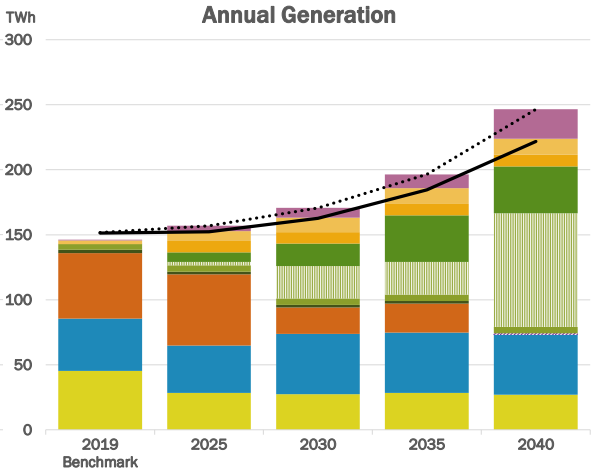
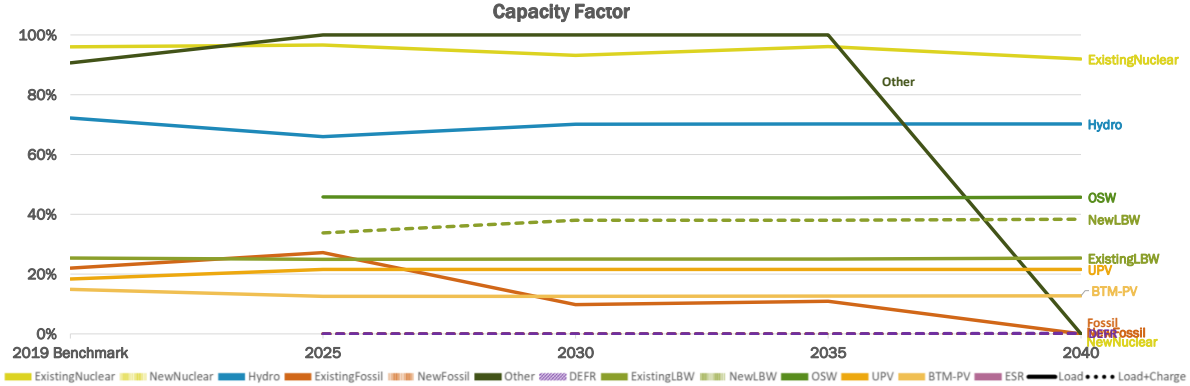
Unconstrained Renewable Builds







Installed Capacity (MW)	2019	2025	2030	2035	2040
Nuclear	5,400	3,346	3,364	3,364	3,364
Fossil	26,262	23,028	24,022	25,143	-
DEFR - HcLo	-	-	-	-	48
DEFR - McMo	-	-	-	-	-
DEFR - LcHo	-	-	-	3,782	43,981
Hydro	6,331	6,302	7,537	7,540	7,540
LBW	1,985	3,138	9,758	9,821	28,286
OSW	-	1,826	4,316	9,000	9,000
UPV	32	4,676	4,676	4,676	4,676
BTM-PV	2,116	6,834	10,055	10,828	11,198
Storage	1,405	2,910	4,410	5,564	12,535
Total	43,838	52,284	68,364	83,724	120,628

Generation (GWh)	2019	2025	2030	2035	2040
Nuclear	45,429	28,338	27,444	28,338	27,092
Fossil	50,520	54,836	20,306	22,258	-
DEFR - HcLo	-	-	-	-	418
DEFR - McMo	-	-	-	-	-
DEFR - LcHo	-	-	-	-	275
Hydro	40,034	36,418	46,342	46,392	46,377
LBW	4,416	7,518	29,909	30,125	92,396
OSW	-	7,331	17,248	35,872	36,056
UPV	51	8,817	8,816	8,817	8,819
BTM-PV	2,761	7,483	11,068	11,983	12,454
Storage	612	4,256	7,556	10,667	22,613
Total Generation	146,262	156,989	170,681	196,444	246,501
RE Generation	47,261	67,567	113,383	133,189	196,103
ZE Generation	93,301	100,161	148,383	172,194	246,501
Load	151,386	152,339	162,611	184,660	221,791
Load+Charge	151,773	156,990	170,682	196,445	246,501
% RE [RE/Load]	31%	44%	70%	72%	88%
% ZE [ZE/(Load+Charge)]	61%	64%	87%	88%	100%

Emissions (million tons)	2019	2025	2030	2035	2040
CO_2 Emissions	22.24	24.08	9.07	9.68	-

* Storage includes Pumped Storage Hydro and Batteries
* Utility solar (UPV) includes existing (77 MW) and new UPV
* Hydro includes hydro imports from Hydro Quebec
* Land-Based Wind (LBW), Offshore Wind (OSW), Zero Emissions (ZE)
* Dispachable Emission Free Resource (DEFR), High Captial Low Operating (HcLo)

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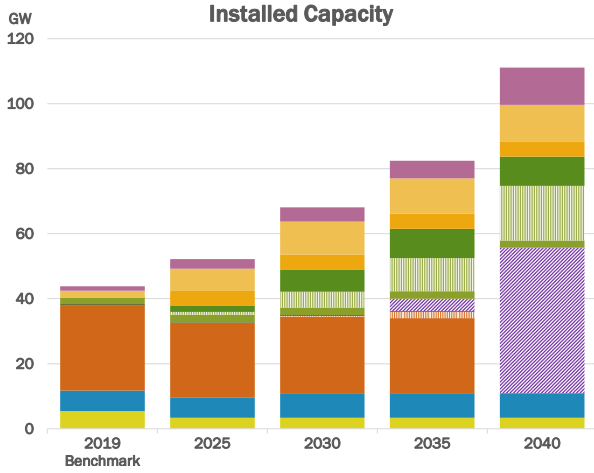
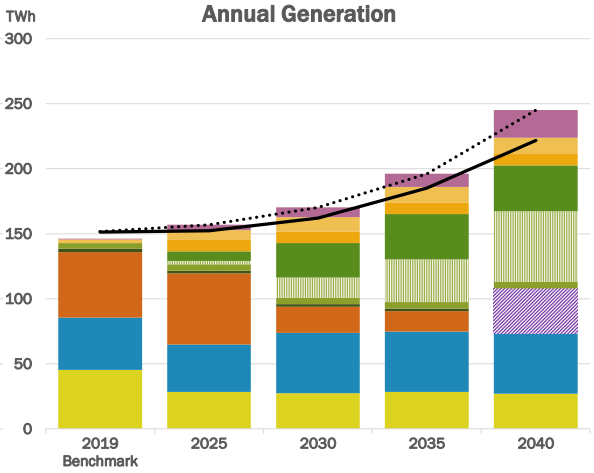
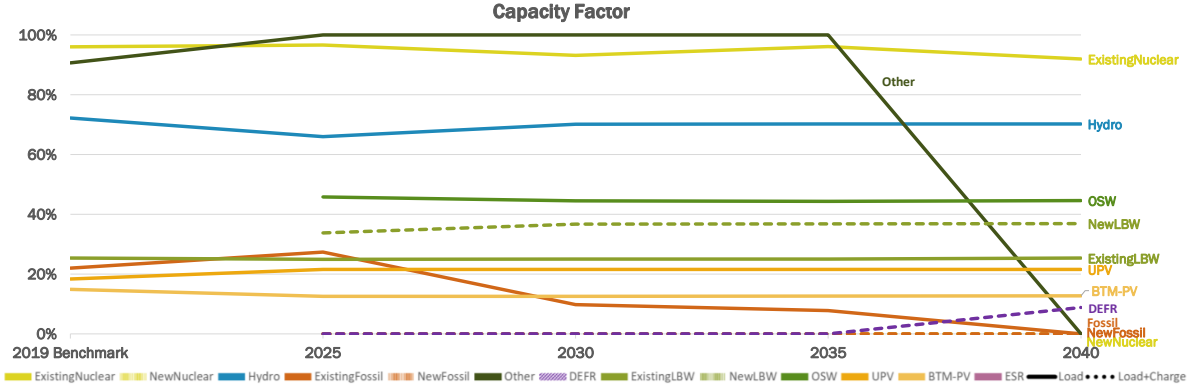
OSW Distribution Zones J&K







Installed Capacity (MW)	2019	2025	2030	2035	2040
Nuclear	5,400	3,346	3,364	3,364	3,364
Fossil	26,262	22,901	23,871	25,055	-
DEFR - HcLo	-	-	-	-	3,874
DEFR - McMo	-	-	-	-	-
DEFR - LcHo	-	-	-	3,827	40,864
Hydro	6,331	6,302	7,537	7,540	7,540
LBW	1,985	3,138	7,144	12,465	19,087
OSW	-	1,826	6,810	9,000	9,000
UPV	32	4,676	4,676	4,676	4,676
BTM-PV	2,116	6,834	10,055	10,828	11,198
Storage	1,405	2,910	4,410	5,449	11,489
Total	43,838	52,157	68,092	86,256	111,093

Generation (GWh)	2019	2025	2030	2035	2040
Nuclear	45,429	28,338	27,444	28,338	27,092
Fossil	50,520	54,836	20,024	15,752	-
DEFR - HcLo	-	-	-	-	34,026
DEFR - McMo	-	-	-	-	-
DEFR - LcHo	-	-	-	-	503
Hydro	40,034	36,418	46,342	46,392	46,377
LBW	4,416	7,518	20,622	37,796	59,362
OSW	-	7,331	26,534	34,949	35,141
UPV	51	8,817	8,816	8,817	8,819
BTM-PV	2,761	7,483	11,068	11,983	12,454
Storage	612	4,256	7,392	10,154	21,374
Total Generation	146,262	156,989	170,236	196,174	245,148
RE Generation	47,261	67,567	113,383	139,938	162,153
ZE Generation	93,301	100,160	148,220	178,430	245,148
Load	151,386	152,339	162,112	185,203	221,828
Load+Charge	151,773	156,989	170,236	196,175	245,148
% RE [RE/Load]	31%	44%	70%	76%	73%
% ZE [ZE/(Load+Charge)]	61%	64%	87%	91%	100%

Emissions (million tons)	2019	2025	2030	2035	2040
CO_2 Emissions	22.24	23.99	8.91	6.85	-

* Storage includes Pumped Storage Hydro and Batteries
* Utility solar (UPV) includes existing (77 MW) and new UPV
* Hydro includes hydro imports from Hydro Quebec
* Land-Based Wind (LBW), Offshore Wind (OSW), Zero Emissions (ZE)
* Dispachable Emission Free Resource (DEFR), High Captial Low Operating (HcLo)

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Recommendations

- **Based on baseline testing and scenario results the following modeling adjustments are recommended:**
  - Disable new fossil and nuclear builds in new baseline case in addition to adjustments recommended in baseline test
  - Preliminary thought on two scenarios for production cost modeling:
    - Case #1 – updated baseline
    - Case #2 – updated baseline + alternative load

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Next Steps

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Next Steps

- Simulate new baseline and scenarios
- Comments due by 3/28
- 4/1 TPAS/ESPWG
  - Capacity expansion scenario preliminary results update
  - Contract Case
    - Congestion & Relaxation Analysis Questions
    - Renewable generation pocket identification
    - Energy deliverability results

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Questions, Feedback, Comments?

- Email additional feedback to: JFrasier@nyiso.com

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2021-2040 Outlook Data Catalog

ESPWG/TPAS Presentations

May 20, 2021
- Model Benchmark Results

September 22, 2021
- System & Resource Outlook Update

October 25, 2021
- Capacity Expansion Model Primer
- System & Resource Outlook Update

November 19, 2021
- System & Resource Outlook Update

December 19, 2021
- System & Resource Outlook Update

January 25, 2022
- System & Resource Outlook Update

February 9, 2022
- System & Resource Outlook Update
- Base & Contract Case Results

February 25, 2022
- System & Resource Outlook Update

March 8, 2022
- System & Resource Outlook Update

Final Reports

2022 Release

Data Posted to ESPWG

- Assumptions Matrix v1
- Capacity Expansion Assumptions Matrix v1
- Contract Case Renewable Projects
- Emissions Price Forecast
- Fuel Price Forecast
- Capacity Expansion Assumptions Matrix v2 (Redline)
- Capacity Expansion Assumptions Matrix v3 (Redline)
- Production Cost Assumptions Matrix v2 (Redline)
- Capacity Expansion Assumptions Matrix v4 (Redline)
- Capacity Expansion Assumptions Matrix v5 (Redline)

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Our Mission & Vision

Mission

Ensure power system reliability and competitive markets for New York in a clean energy future

Vision

Working together with stakeholders to build the cleanest, most reliable electric system in the nation

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Appendix

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Capacity Expansion Model Overview

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Capacity Expansion Model Framework

- **Capacity expansion models simulate investment and retirement of resources to meet load, policy targets, and other operational/capacity constraints by optimizing over the entire 20-year study period for the NYCA only**
  - The capacity expansion model assumes linear expansion, which allows for partial build/retirement decisions
    - Capacity builds are assumed at the zonal level, such that a single generator by technology type can be built in each applicable zone
    - Economic retirements are enabled such that individual generators could retire in part or in its entirety within the overall optimization
- **The NYISO capacity expansion model uses 17 time slices per year to represent the 8,760-hour load and generation profiles**
  - For each year, 16 of the load blocks are represented by splitting hours of the year by season (Spring, Summer, Fall, Winter) and time of day (overnight, morning, afternoon, evening) and the 17th load block represents a period of peak load hours
  - The time slices capture seasonal and diurnal variation in wind, solar, and load profile
- **PLEXOS creates a reduced "pipe-and-bubble" model by performing a nodal to zonal reduction of the transmission system**

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Capacity Expansion Model Limitations

- The capacity expansion model was developed as an initial reasoned trade-off between balancing model fidelity, runtime, and future uncertainty/knowledge of input assumptions (characterized by scenario testing) to produce representations of outcomes of the future NY generation fleet and operations
- The capacity expansion modeling framework employed will not capture curtailment of renewable resources due to specific transmission constraints. Curtailments will be reported as part of the Policy Case production cost model results.
- Ongoing work will continue to refine the methods, assumptions, and reporting in the years to come

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Capacity Expansion Model Caveats

- The capacity expansion model is a projection of the future system mix and not an endorsement of outcomes under any specific set of assumptions. It is intended to inform NYISO studies and stakeholders of potential future generation buildouts under a multitude of scenarios
- The results of capacity expansion models are sensitive to the input assumptions related to cost and performance of resources and the modeling framework used to represent chronology and nodal/zonal representations
- The capacity expansion model does not capture capacity market dynamics beyond simplified assumptions of satisfying current published IRM and LCR requirements on an unforced capacity basis

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Capacity Expansion Model Caveats (cont.)

- A set of proxy generic Dispatchable Emission Free Resources (DEFRs) was used to approximate a range of capital and operating costs given uncertainty of future technology pathways to serve this role
- All DEFRs are modeled as highly flexible resources with operational parameters (*i.e.*, heat rate, ramp rate, reserve contribution, start time, etc.) similar to a new natural gas combined cycle (but with zero emission rate)
- While these proxy DEFR options may ultimately prove to not be representative of actual future technologies, they were used as a modeling framework to highlight the operational needs that would have to be met by the DEFRs when performing production cost simulations

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