Final 2021 PV Forecast

Distributed Generation Forecast Working Group

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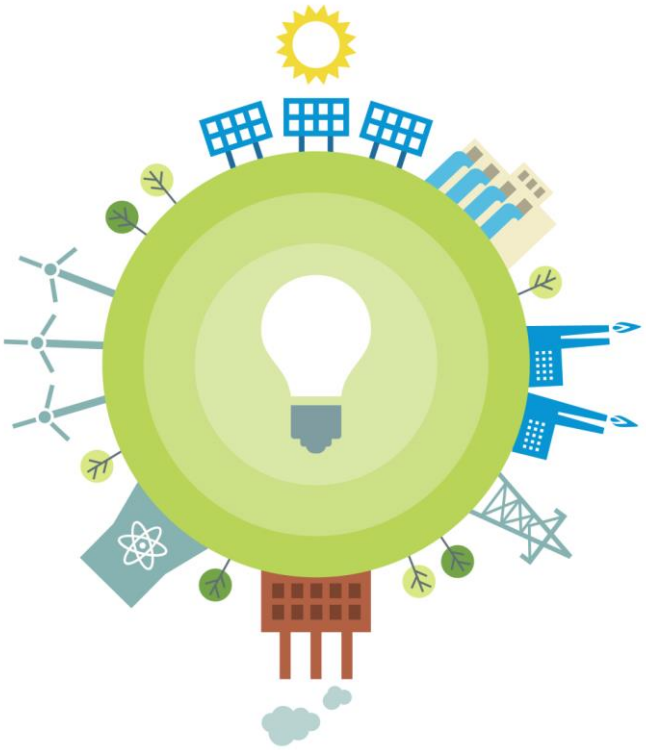
Presentation Outline

- Updates to Draft 2021 PV Forecast
- Final 2021 PV Nameplate Forecast
- 2021 PV Energy Forecast
- Classification of PV Forecast
  - Background and Methods
- Classification of 2021 PV Forecast
- 2021 CELT BTM PV Forecast
  - Estimated Energy & Summer Peak Load Reductions
- Geographic Distribution of PV Forecast
- Summary and Next steps



Forecast Review Process

- The ISO discussed the draft 2021 PV forecast with the DGFWG at the February 22, 2021 meeting
- Stakeholders provided comments on the draft forecast
  - See: https://www.iso-ne.com/event-details?eventId=144737
- The final PV forecast will be published in the 2021 CELT

FINAL 2021 PV NAMEPLATE FORECAST

Final 2021 PV Forecast

Nameplate Capacity, MW_{ac}

States	Annual Total MW (AC nameplate rating)											Totals
	Thru 2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	
CT	682.3	108.1	131.6	147.6	91.1	91.1	91.1	91.1	83.2	55.4	53.6	**1,626.0**
MA	2502.3	454.3	430.4	406.5	406.5	406.5	358.7	232.1	225.1	218.0	211.0	**5,851.5**
ME	68.8	138.8	199.0	209.2	201.7	97.8	12.8	12.8	12.8	12.8	12.8	**979.1**
NH	125.3	19.1	18.1	17.1	17.1	17.1	17.1	17.1	17.1	17.1	17.1	**299.4**
RI	223.8	49.1	46.5	42.4	42.4	42.4	42.4	42.4	42.4	42.4	42.4	**658.5**
VT	393.5	24.7	23.4	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	**618.4**
Regional - Annual (MW)	**3995.9**	**794.1**	**849.1**	**844.9**	**781.0**	**677.0**	**544.1**	**417.5**	**402.6**	**367.8**	**358.9**	**10,032.9**
Regional - Cumulative (MW)	**3995.9**	**4790.0**	**5639.1**	**6484.0**	**7264.9**	**7941.9**	**8486.1**	**8903.6**	**9306.2**	**9674.0**	**10032.9**	**10,032.9**

Notes:

(1) Forecast values include FCM Resources, non-FCM Energy Only Generators, and behind-the-meter PV resources

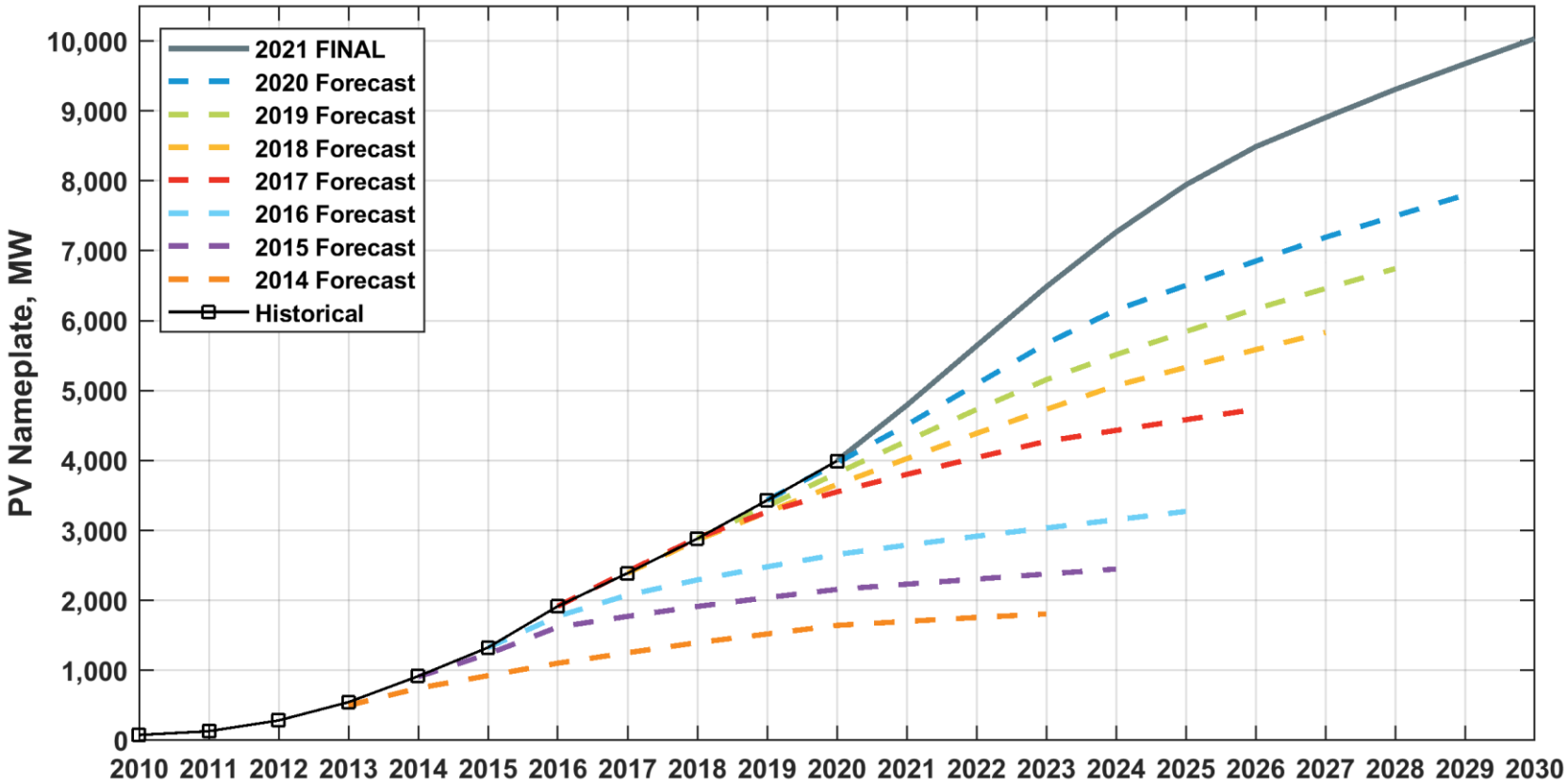
(2) The forecast values are net of the effects of discount factors applied to reflect a degree of uncertainty in the policy-based forecast

(3) All values represent end-of-year installed capacities

(4) Forecast does not include forward-looking PV projects > 5MW in nameplate capacity

Total PV Nameplate Capacity Growth

Reported Historical vs. Forecast (FCM+EOR+BTM), MW_{ac}



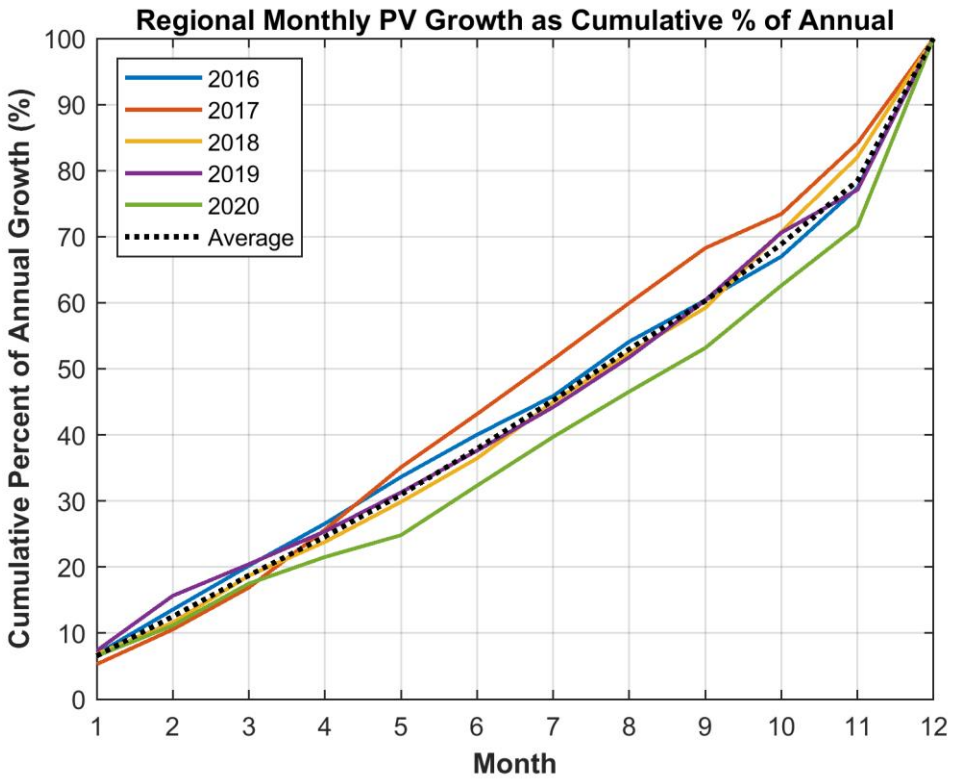
2021 PV ENERGY FORECAST

Development of PV Energy Forecast

- The PV nameplate forecast reflects end-of-year values
- Energy estimates in the PV forecast are inclusive of incremental growth during a given year
- ISO assumed that historical PV growth trends across the region are indicative of future intra-annual growth rates
  - Growth trends between 2016 and 2020 were used to estimate intra-annual incremental growth over the forecast horizon (*see next slide*)
- The PV energy forecast was developed at the state level, using state monthly nameplate forecasts and state average monthly capacity factors (CF) developed from 7 years of PV performance data (2014-2020)
  - Resulting state and regional CFs are tabulated to the right, and plots of individual monthly capacity factors in each state are shown on slide 10

State	Average CF, %
CT	14.7
ME	14.6
NH	14.2
RI	14.8
VT	13.7
MA	14.5
ISO-NE	**14.5**

Historical Monthly PV Growth Trends, 2016-2020



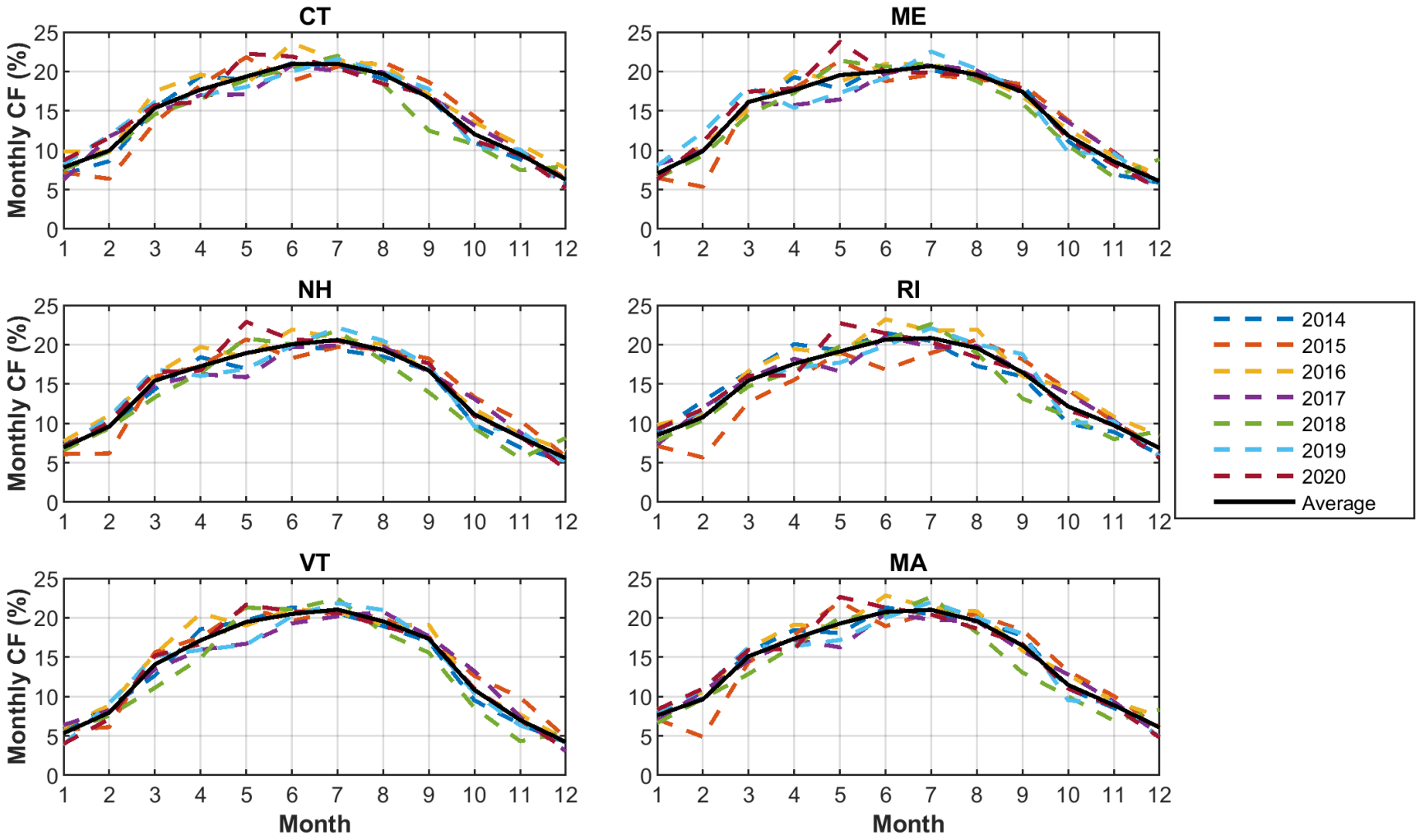
Average Monthly Growth Rates, % of Annual

Month	Monthly PV Growth (% of Annual)	Monthly PV Growth (Cumulative % of Annual)
1	7	6
2	6	12
3	6	19
4	6	25
5	6	31
6	7	38
7	7	45
8	8	53
9	7	60
10	9	69
11	10	78
12	22	100

Note:
Monthly percentages represent end-of-month values, and may not sum to total due to rounding

Monthly PV Capacity Factors by State

PV Production Data, 2014-2020



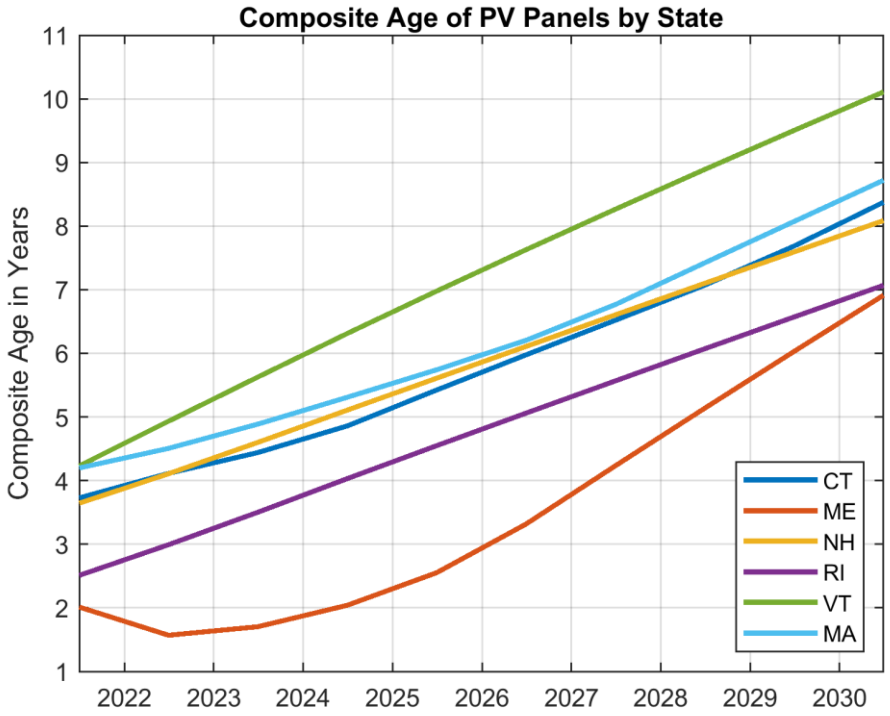
PV Panel Degradation Factors

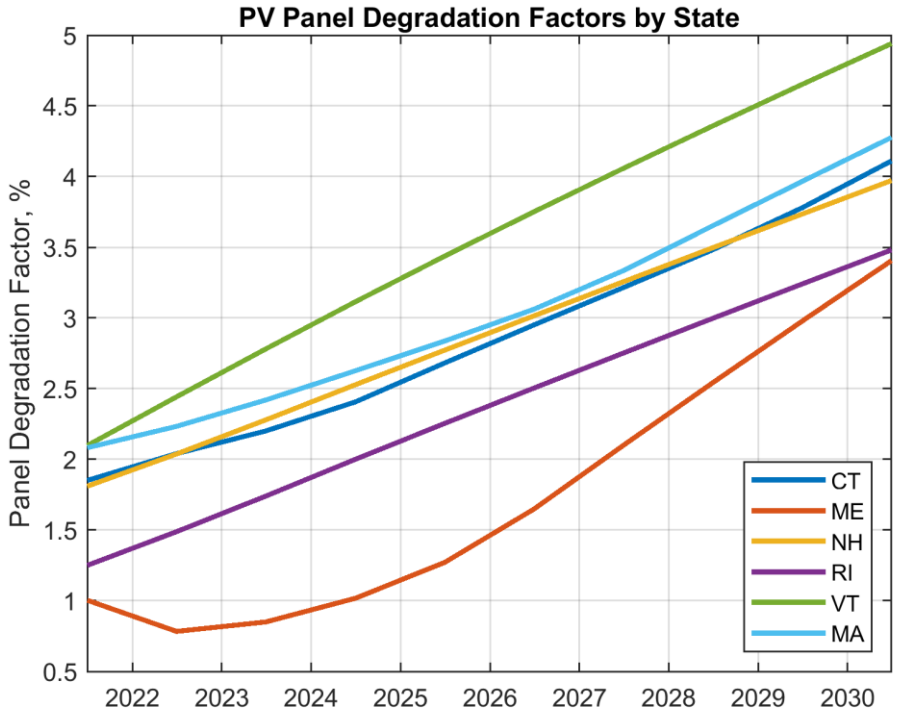
- No changes to the methodology to account for panel degradation were made since last year's forecast
- Forecasts of BTM PV energy and estimated summer peak load reductions include the effects of a 0.5%/year panel degradation rate to account for the expected declining conversion efficiency of solar panels over time
  - Accounting for this degradation becomes more important as the region's PV panels age
- Long-term panel degradation is often caused by:
  - Degradation of silicon or solder joints
  - Problems with the encapsulant that cause delamination, increased opacity, or water ingress
- Based on research by the National Renewable Energy Laboratory (NREL), the median rate of degradation is 0.5%/year, and is assumed to be linear over time
  - More information available here: https://www.nrel.gov/pv/lifetime.html
- The ISO estimated the capacity-weighted composite age of the forecasted PV fleet to develop appropriate degradation factors to use for the forecast

PV Panel Degradation Factors

Composite Age (left) & Degradation Factors (right) by State

- The resulting capacity-weighted, composite age of all PV in each state (left plot) and corresponding degradation factors (right plot) over the forecast horizon are plotted below
- The degradation factors are the assumed percent reduction of PV performance over time that reflect the anticipated degradation of PV panels





Final 2021 PV Energy Forecast

All Forecast PV (FCM+EOR+BTM), GWh

States	Total Estimated Annual Energy (GWh)										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
CT	838	976	1,132	1,315	1,480	1,594	1,710	1,826	1,940	2,025	2,089
MA	3,026	3,544	4,121	4,664	5,195	5,705	6,194	6,572	6,859	7,111	7,364
ME	82	171	392	664	940	1,146	1,224	1,235	1,249	1,258	1,269
NH	149	172	196	218	240	261	282	303	325	345	366
RI	235	333	397	456	513	568	624	679	735	788	843
VT	468	504	532	559	585	610	635	660	686	709	734
Regional - Annual Energy (GWh)	**4,798**	**5,700**	**6,771**	**7,877**	**8,953**	**9,884**	**10,669**	**11,275**	**11,794**	**12,236**	**12,664**

Notes:

(1) Forecast values include energy from FCM Resources, non-FCM Energy Only Generators, and behind-the-meter PV resources

(2) Monthly in service dates of PV assumed based on historical development

(3) Values include the effects of an assumed 0.5%/year PV panel degradation rate

(4) All values are grossed up by 6% to reflect avoided transmission and distribution losses

CLASSIFICATION OF PV FORECAST: BACKGROUND & METHODS

Classification Needed to Determine BTM PV

- Ultimately, the ISO needs to determine the amount of PV that is not expected to participate in wholesale markets, and instead reduces load
  - This is the amount of BTM PV that is reflected in the long-term load forecast
- In order to properly account for existing and future PV in planning studies and avoid double counting, ISO classifies PV into three distinct categories related to its assumed market participation/non-participation
- Accounting for these market distinctions is performed for both installed nameplate capacity (historical and forecast) and estimates of hourly energy production (historical), and is important for the ISO's use of the PV forecast for load forecasting and a wide range of planning studies

Three Mutually Exclusive Categories

1. **PV as a resource in the Forward Capacity Market (FCM)**
   - Qualified for the FCM and have acquired capacity supply obligations
   - Size and location identified and visible to the ISO
   - May be supply or demand-side resources
2. **Non-FCM Energy Only Resources (EOR) and Generators**
   - ISO collects energy output
   - Participate only in the energy market
3. **Behind-the-Meter (BTM) PV**
   - Not in ISO Market
   - Reduces system load
   - ISO has an incomplete set of information on generator characteristics
   - ISO does not collect energy meter data, but can estimate it using other available data

Nameplate Classification By State

- Classification varies by state
  - Market disposition of PV projects can be influenced state policies (*e.g.*, net metering requirements)
- The following steps were used to determine PV resource types for each state over the forecast horizon:
  1. **FCM**
     - Identify all Generation and Demand Response FCM PV resources for each Capacity Commitment Period (CCP) through FCA 15
  2. **Non-FCM EOR/Gen**
     - Determine the % share of non-FCM PV participating in energy market at the end of 2020
  3. **BTM**
     - Net the values from steps 1 and 2 from the annual state PV forecast according to assumptions detailed on the next slide; the remainder is the BTM PV

PV in ISO New England Markets

Data and Assumptions

- **FCM**
  - ISO identified all PV generators or demand resources (DR) that have Capacity Supply Obligations (CSO) in FCM up through FCA 15
    - Maintain separate accounting for FCM_{supply} and FCM_{DR}
  - Assume aggregate total PV in FCM as of FCA 15 remains constant from 2024-2030
- **Non-FCM Gen/EOR**
  - ISO identified total nameplate capacity of PV in each state registered in the energy market as of 12/31/20
  - Assume the (EOR+FCM_{supply}) share of total PV at the end of 2020 in each state ***except Maine*** remains constant throughout the forecast horizon
    - For Maine, assume (EOR+FCM_{supply}) share is 75% over the forecast horizon to reflect how new policies prompting the majority of future PV growth require participation in wholesale markets
- Other assumptions:
  - FCM_{supply} PV resources operate as EOR/Gen prior to their first FCM commitment period (this has been observed in MA and RI)
  - Planned PV projects known to be > 5 MW_{ac} nameplate are assumed to trigger OP-14 requirement to register in ISO energy market as a Generator

Estimation of Hourly BTM PV For Reconstitution

- Historical BTM PV production estimates are developed at the hourly level for reconstitution in the development of the long-term gross load forecast
  - Estimates cover the historical period starting January 1, 2012
- The ISO estimates historical hourly BTM PV using:
  1. Historical BTM PV performance data
  2. Installed capacity data submitted by utilities
  3. Historical energy production of market-facing PV
- The method used to develop the historical BTM PV profiles is described in slides 21-31 of this September 25, 2020 Load Forecast Committee presentation

CLASSIFICATION OF FINAL 2021 PV FORECAST

Final 2021 PV Forecast

Cumulative Nameplate, MW_{ac}

States	Cumulative Total MW (AC nameplate rating)										
	Thru 2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
CT	682.3	790.3	921.9	1,069.5	1,160.6	1,251.7	1,342.8	1,433.9	1,517.1	1,572.5	1,626.0
MA	2,502.3	2,956.6	3,387.1	3,793.6	4,200.1	4,606.6	4,965.3	5,197.4	5,422.5	5,640.5	5,851.5
ME	68.8	207.6	406.6	615.8	817.6	915.3	928.1	940.8	953.6	966.3	979.1
NH	125.3	144.4	162.5	179.6	196.7	213.8	231.0	248.1	265.2	282.3	299.4
RI	223.8	272.8	319.3	361.7	404.1	446.5	488.9	531.3	573.7	616.1	658.5
VT	393.5	418.2	441.6	463.7	485.8	507.9	530.0	552.1	574.2	596.3	618.4
Regional - Cumulative (MW)	**3,995.9**	**4,790.0**	**5,639.1**	**6,484.0**	**7,264.9**	**7,941.9**	**8,486.1**	**8,903.6**	**9,306.2**	**9,674.0**	**10,032.9**

Notes:

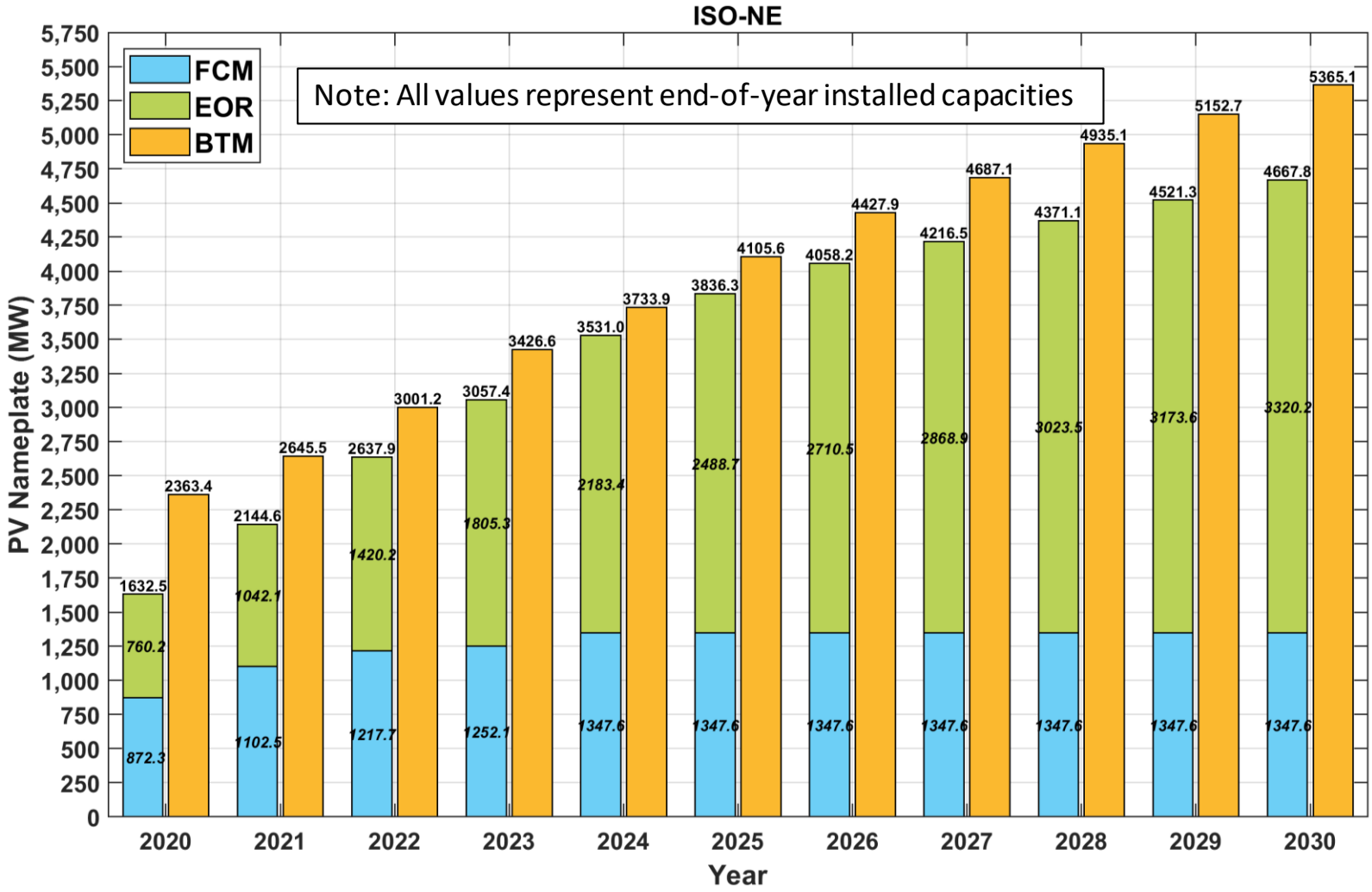
(1) Forecast values include FCM Resources, non-FCM Energy Only Generators, and behind-the-meter PV resources

(2) The forecast reflects discount factors to account for uncertainty in meeting state policy goals

(3) All values represent end-of-year installed capacities

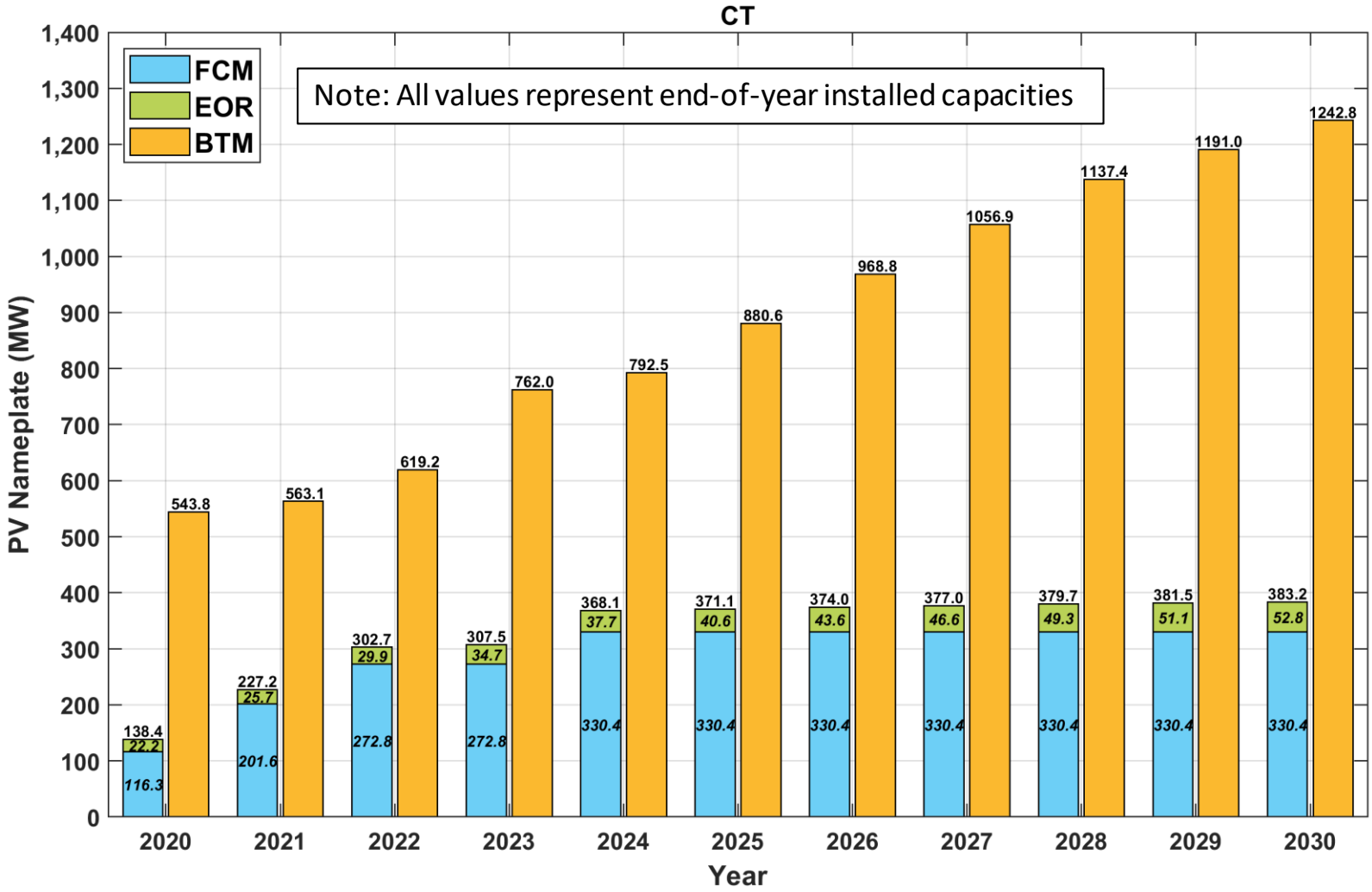
Final 2021 PV Forecast – New England

Cumulative Nameplate by Category, MW_{ac}



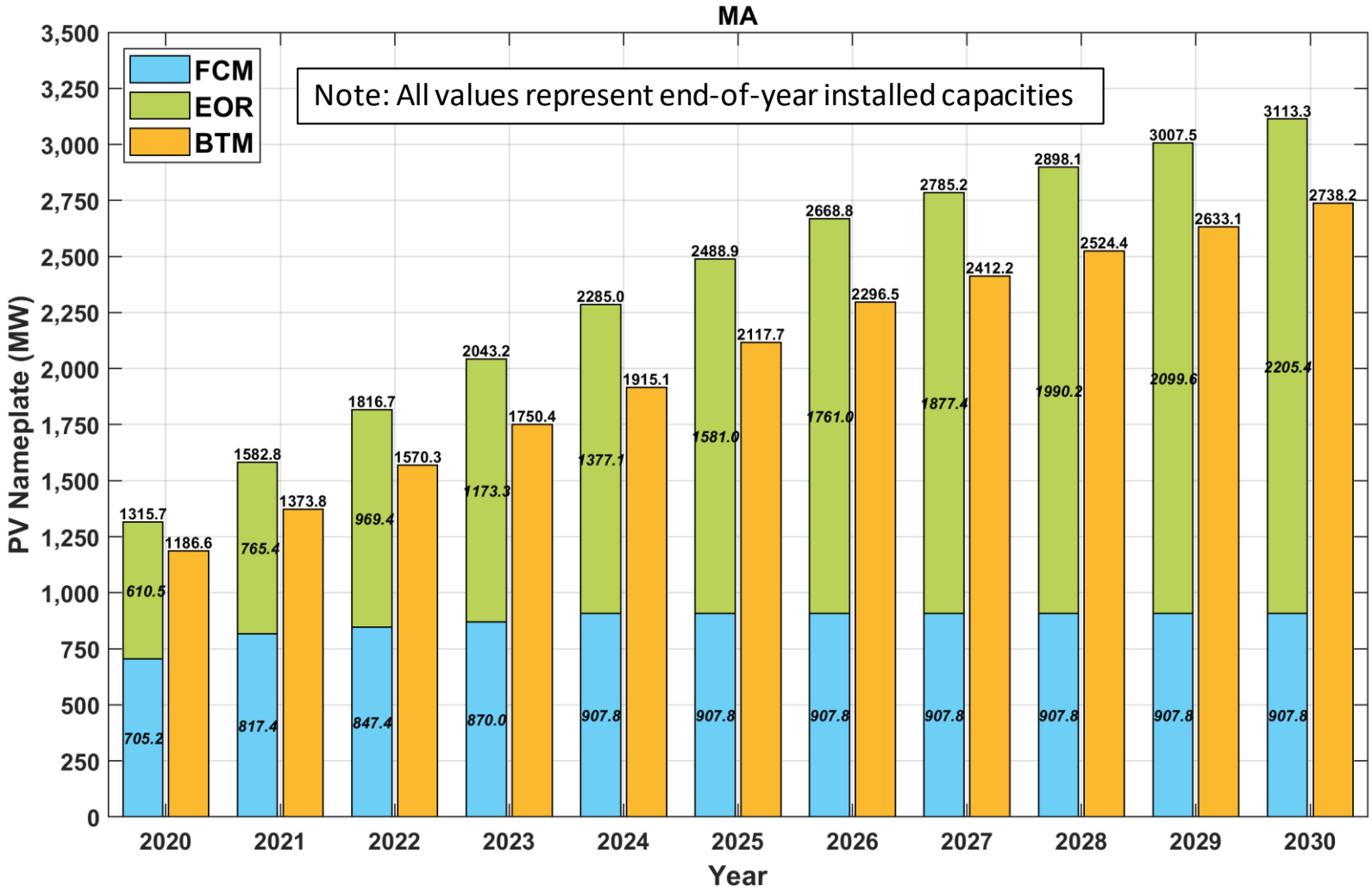
Final 2021 PV Forecast – Connecticut

Cumulative Nameplate by Category, MW_{ac}



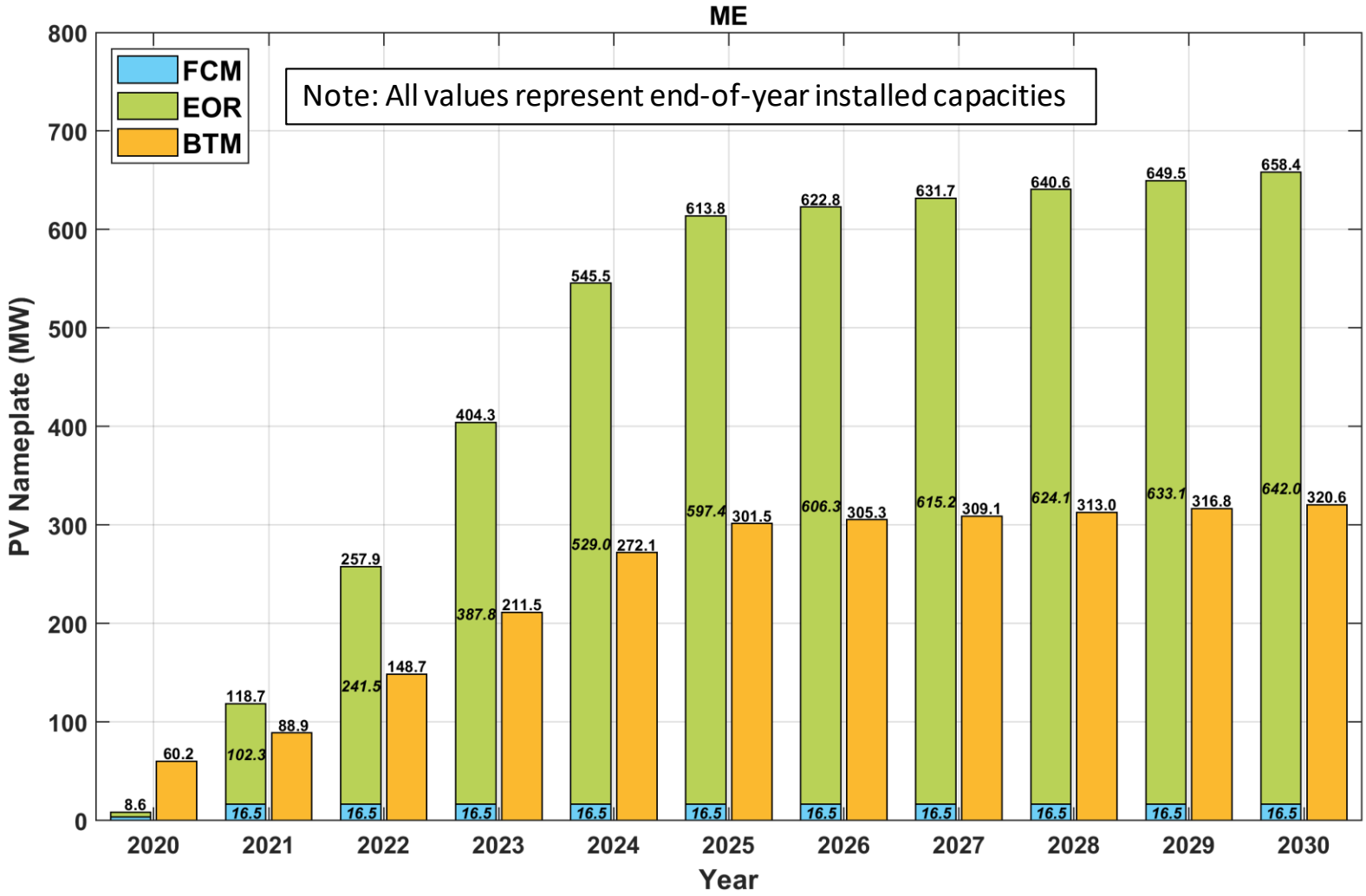
Final 2021 PV Forecast – Massachusetts

Cumulative Nameplate by Category, MW_{ac}



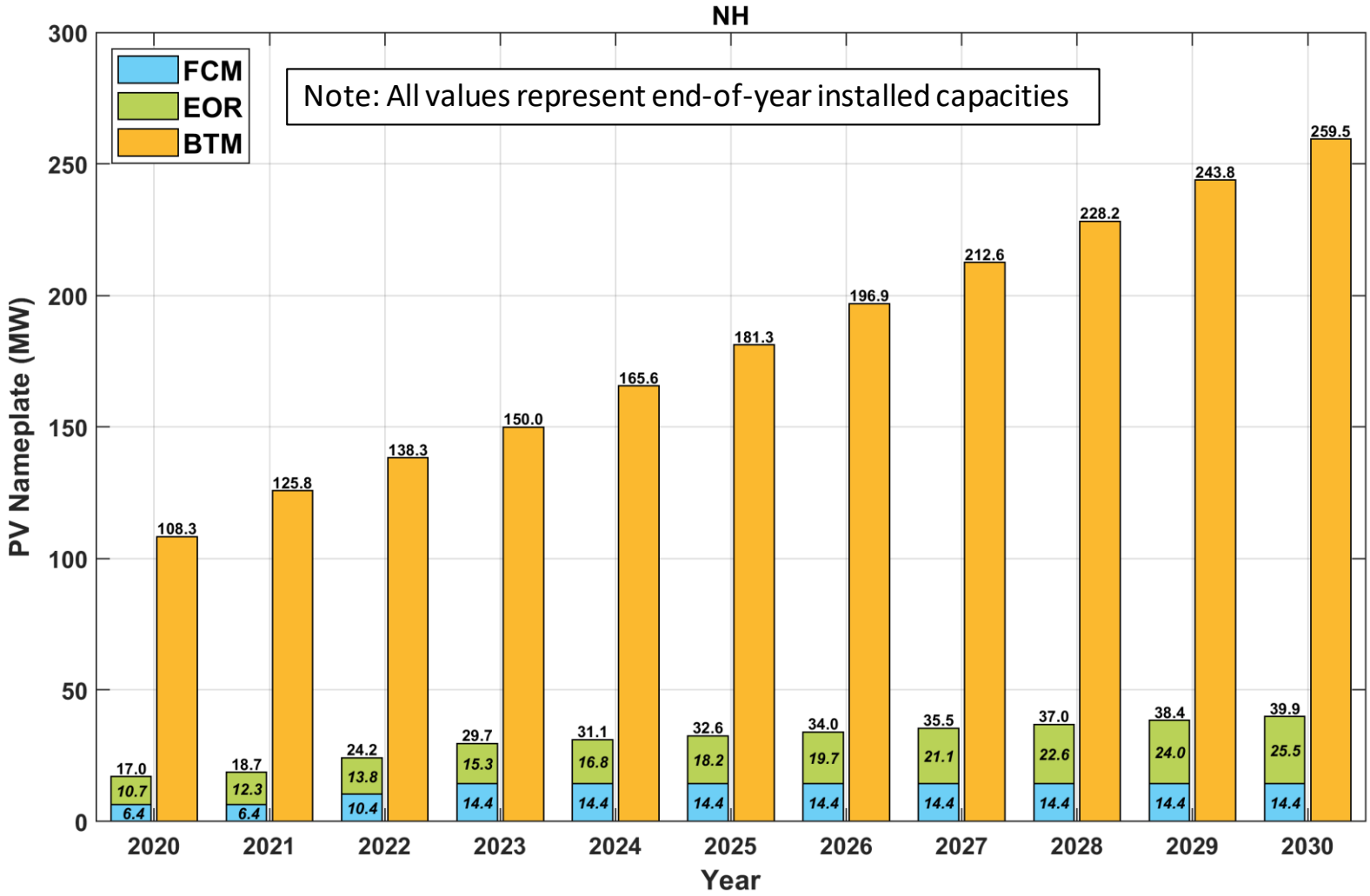
Final 2021 PV Forecast – Maine

Cumulative Nameplate by Category, MW_{ac}



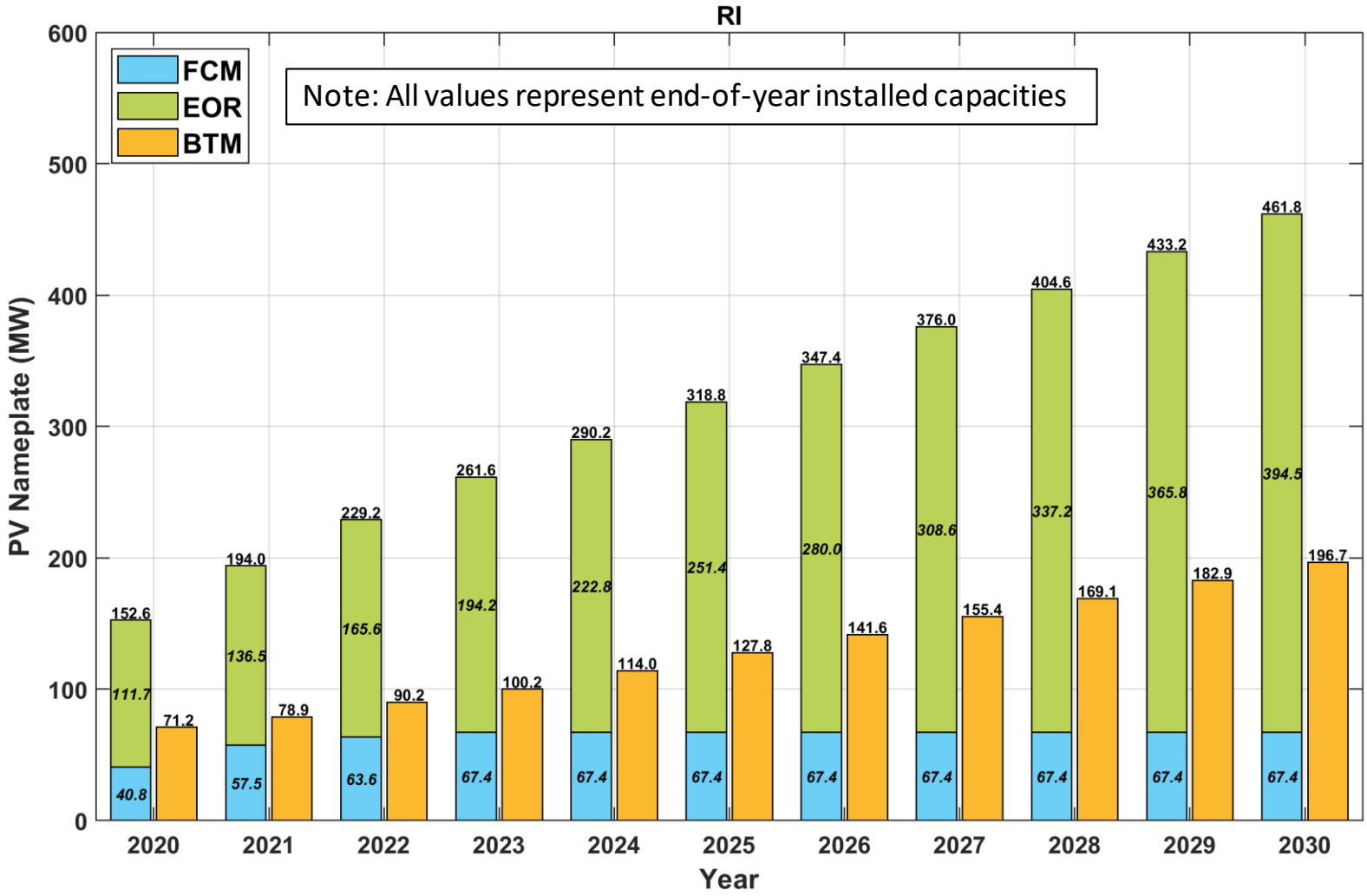
Final 2021 PV Forecast – New Hampshire

Cumulative Nameplate by Category, MW_{ac}



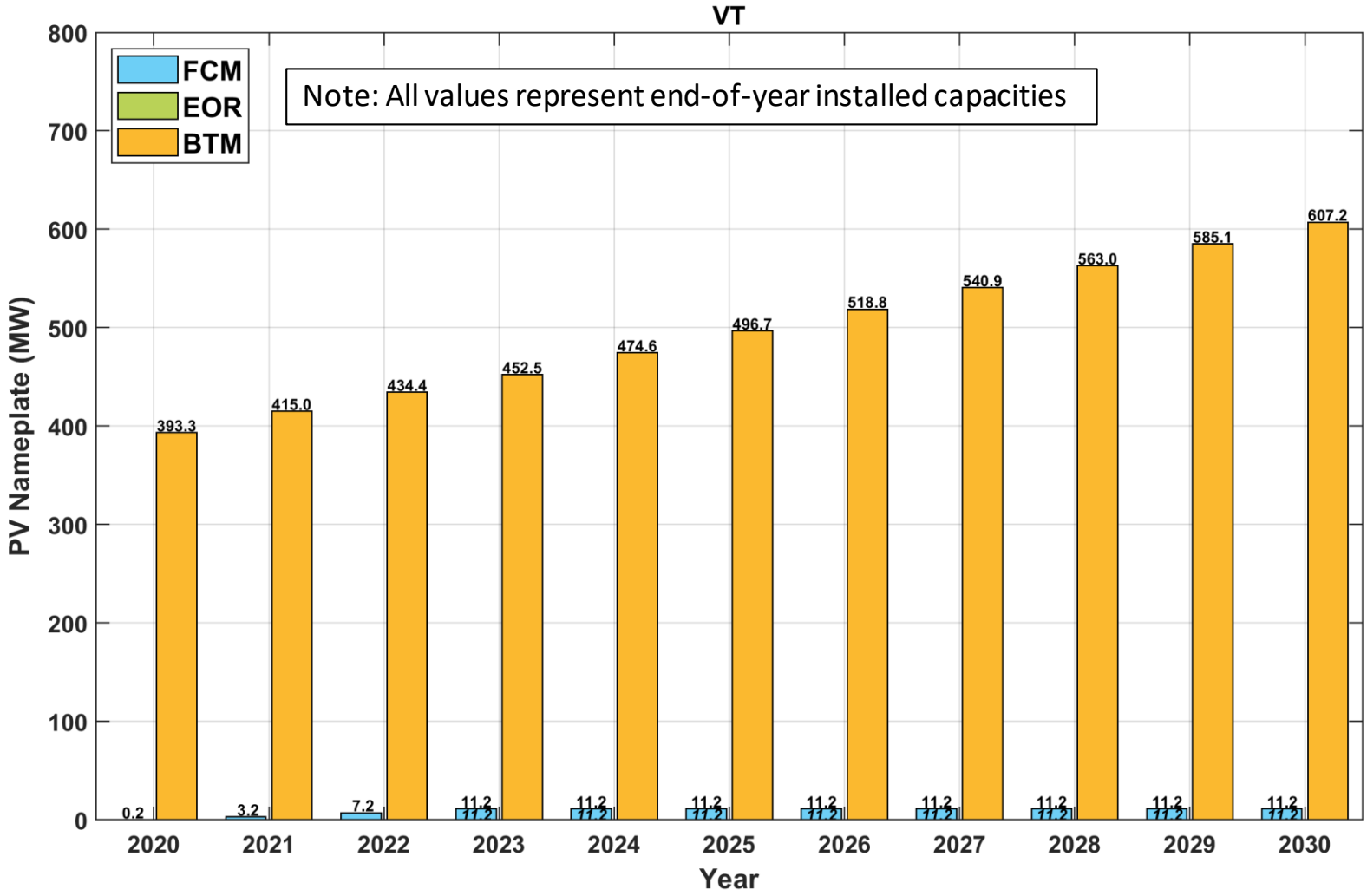
Final 2021 PV Forecast – Rhode Island

Cumulative Nameplate by Category, MW_{ac}



Final 2021 PV Forecast – Vermont

Cumulative Nameplate by Category, MW_{ac}



CELT BTM PV FORECAST: ESTIMATED ENERGY & SUMMER PEAK LOAD REDUCTIONS

BTM PV Forecast Used in CELT Net Load Forecast

- The 2021 CELT net load forecast will reflect deductions associated with the BTM PV portion of the PV forecast
- The following slides show values for annual energy and summer peak load reductions anticipated from BTM PV that will be reflected in the 2021 CELT
  - PV does not reduce winter peak loads, which occur after sunset
- The ISO has maintained the methodology for estimating summer peak load reduction associated with BTM PV over the forecast horizon
    - Discussion of the relevant methodology is available here: https://www.iso-ne.com/static-assets/documents/2020/04/final_btm_pv_peak_reduction.pdf

Final 2021 BTM PV Energy Forecast

GWh

		Estimated Annual Energy (GWh)										
Category	**States**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Behind-the-Meter PV	CT	712	755	758	908	1,013	1,103	1,217	1,330	1,441	1,525	1,589
	MA	1,467	1,658	1,906	2,149	2,370	2,611	2,855	3,044	3,188	3,314	3,441
	ME	77	94	153	235	318	380	403	406	410	413	416
	NH	144	149	167	183	201	220	240	259	279	297	316
	RI	55	106	112	126	143	161	179	197	216	233	251
	VT	477	502	525	546	571	596	621	646	672	696	720
Behind-the Meter Total		**2,932**	**3,265**	**3,622**	**4,148**	**4,616**	**5,071**	**5,515**	**5,883**	**6,205**	**6,478**	**6,733**

Notes:

(1) Forecast values include energy from behind-the-meter PV resources only

(2) Monthly in service dates of PV assumed based on historical development

(3) Values include the effects of an assumed 0.5%/year PV panel degradation rate

(4) All values are grossed up by 6% to reflect avoided transmission and distribution losses

Final 2021 BTM PV Forecast

July 1st Estimated Summer Peak Load Reductions

		Cumulative Total MW - Estimated Summer Seasonal Peak Load Reduction										
Category	**States**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Behind-the-Meter PV	CT	182.1	188.7	168.3	193.9	197.4	207.8	218.5	230.3	241.4	248.8	251.9
	MA	406.0	423.0	448.6	467.5	478.6	500.9	522.1	537.0	543.7	549.7	554.6
	ME	21.1	22.4	35.2	50.3	63.7	72.3	73.3	71.2	69.5	67.9	66.5
	NH	35.8	39.3	40.1	40.5	41.8	43.2	44.8	46.6	48.5	50.3	52.1
	RI	19.3	26.5	25.4	26.5	28.4	30.2	32.0	33.9	35.8	37.7	39.4
	VT	134.9	136.5	131.1	126.0	122.9	120.9	119.9	120.2	120.9	121.6	122.4
Total	**Cumulative**	799.2	836.3	848.6	904.8	932.7	975.3	1,010.6	1,039.2	1,059.8	1,076.1	1,086.9
% of BTM AC nameplate		34.4%	32.2%	29.6%	27.4%	25.5%	24.0%	22.9%	22.0%	21.3%	20.7%	20.1%

Notes:

(1) Forecast values are for behind-the-meter PV resources only

(2) Values include the effect of diminishing PV production as increasing PV penetrations shift the timing of peaks later in the day; details of the methodology used to determine the estimated peak demand reductions are available at: http://www.iso-ne.com/static-assets/documents/2020/04/final_btm_pv_peak_reduction.pdf

(3) Values include the effects of an assumed 0.5%/year PV panel degradation rate

(4) All values represent anticipated July 1st installed PV, and are grossed up by 8% to reflect avoided transmission and distribution losses

(5) Different planning studies may use values different that these estimated peak load reductions based on the intent of the study

GEOGRAPHIC DISTRIBUTION OF PV FORECAST

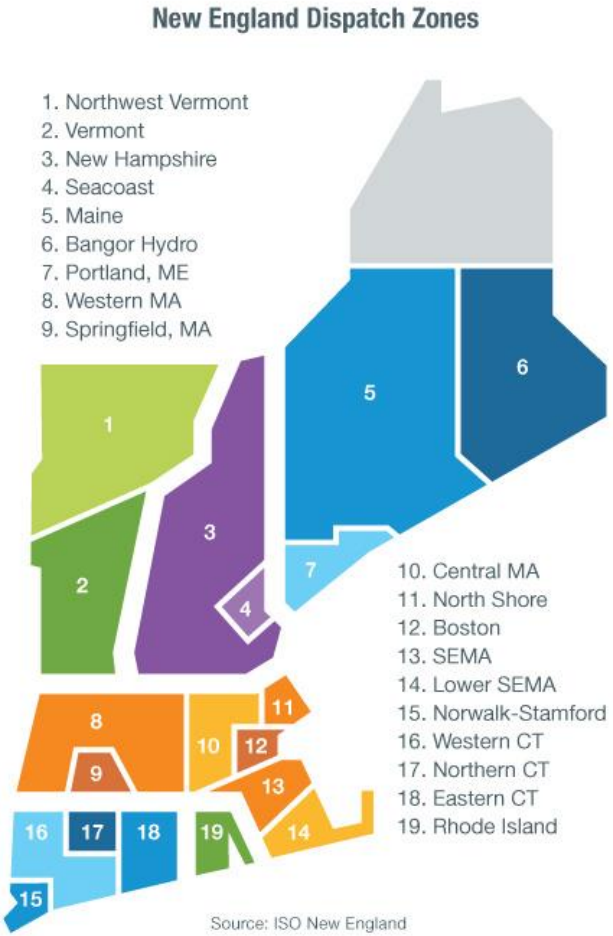
Overview

- A reasonable representation of the locations of existing and future PV resources is required for appropriate modeling
  - The locations of most future PV resources are ultimately unknown
  - Mitigation of some of this uncertainty is possible via analysis of available data
- ISO geographically distributes forecasted PV according to existing geographical distribution at the end of the last historical year of data provided by Distribution Owners for the following sub-regions:
  - Load Zones
  - Dispatch Zones
  - RSP Subareas
- The breakdown of total PV reflected in Distribution Owner data submittals as of 12/31/2020 by Dispatch Zone is included on the next slide
- Beginning with the 2020 forecast, all classification of PV (FCM, EOR, and BTM) is performed uniquely for each sub-region to ensure proper accounting for various system planning studies

Dispatch Zone Distribution of PV

Based on December 31, 2020 Distribution Owner Data Submittals

State	Load Zone	Dispatch Zone	% of State
CT	CT	EasternCT	18.8%
	CT	NorthernCT	18.4%
	CT	Norwalk_Stamford	7.4%
	CT	WesternCT	55.4%
ME	ME	BangorHydro	13.4%
	ME	Maine	49.8%
	ME	PortlandMaine	36.8%
MA	NEMA	Boston	11.3%
	NEMA	NorthShore	5.3%
	SEMA	LowerSEMA	14.0%
	SEMA	SEMA	20.2%
	WCMA	CentralMA	13.3%
	WCMA	SpringfieldMA	8.0%
	WCMA	WesternMA	27.8%
NH	NH	NewHampshire	88.0%
	NH	Seacoast	12.0%
RI	RI	RhodeIsland	100.0%
VT	VT	NorthwestVermont	62.5%
	VT	Vermont	37.5%



SUMMARY AND NEXT STEPS

Summary and Next Steps

- The 2021 PV nameplate and energy forecasts have been finalized
- The ISO has categorized the 2021 state and regional PV forecasts according to the three PV resource categories
- The ISO has maintained its geographic distribution assumptions based on updated recent data
- The final PV forecast will appear in the 2021 CELT, which will be published by May 1, 2021

Questions