Final 2022 PV Forecast

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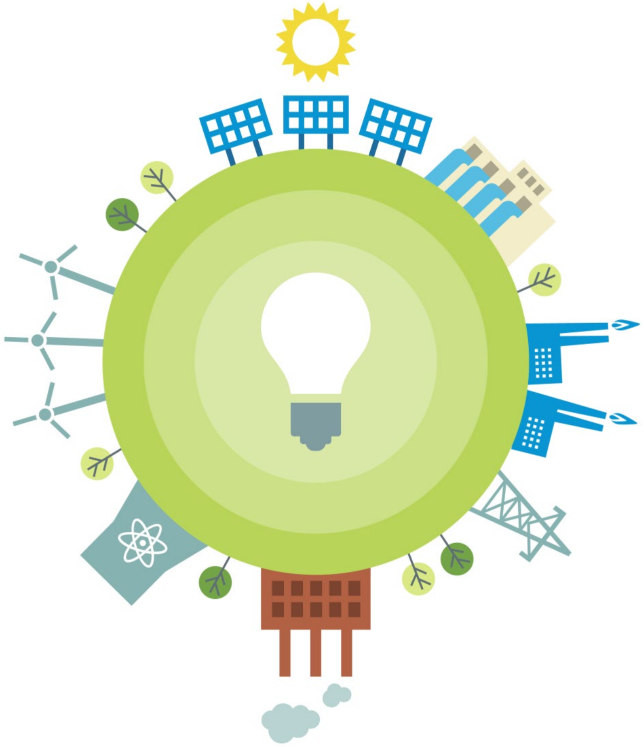
- Geographic Distribution of PV Forecast
- Appendix: Example Calculation of Estimated Summer Peak Load Reductions from BTM PV



BACKGROUND & OVERVIEW

Introduction

- The majority of state-sponsored distributed PV does not participate in wholesale markets, but reduces the system load observed by ISO
- The long-term PV forecast helps the ISO determine future system load characteristics that are important for the reliable planning and operation of the system
- To properly account for PV in long-term planning, the finalized PV forecast will be categorized as follows:
    1. PV as a capacity resource in the Forward Capacity Market (FCM)
    2. Non-FCM Energy Only Resources (EOR) and Generators
    3. Behind-the-meter PV (BTM PV)

Similar to energy efficiency (EE), behind-the-meter PV is reconstituted into historical loads*

The 2022 gross load forecast reflects loads without PV load reductions

**Existing BTM PV decreases the historical loads seen by the ISO, which are an input to the gross load forecast*

Background

- Many factors influence the future commercialization potential of PV resources, some of which include:
  - Policy drivers:
    - Feed-in-tariffs (FITs)/Long-term procurement
    - State RPS programs
    - Net energy metering (NEM)
    - Federal Investment Tax Credit (ITC)
  - Other drivers:
    - Role of private investment in PV development
    - PV development occurs using a variety of business/ownership models
    - Future equipment and installation costs
    - Future wholesale and retail electricity costs

Background

PV Forecast Focuses on DG

- The focus of the DGFWG is distributed generation projects:
  - "…defined as those that are typically 5 MW or less in nameplate capacity and are interconnected to the distribution system (typically 69 kV or below) according to state-jurisdictional interconnection standards."
- Therefore, the forecast does not consider policy drivers supporting larger-scale projects (i.e., those >5 MW)
  - E.g., projects planned as part of the three-state Clean Energy RFP
- Large projects are generally accounted for as part of ISO's interconnection process and participate in wholesale markets

The PV Forecast Incorporates State Public Policies and Is Based on Historical Data

- The PV forecast process is informed by ISO analysis and by input from state regulators and other stakeholders through the Distributed Generation Forecast Working Group (DGFWG)
- The forecast is meant to be a reasonable projection of the anticipated growth of out-of-market, distributed PV resources to be used in ISO's System Planning studies, consistent with its role to ensure prudent planning assumptions for the bulk power system
- A policy-based forecasting approach has been chosen to reflect the observation that trends in distributed PV development are in large part the result of policy programs developed and implemented by the New England states
- The ISO makes no judgment regarding state policies, but rather utilizes the state goals as a means of informing the forecast

Background and Forecast Review Process

- The ISO discussed the draft 2022 PV forecast with the DGFWG at the February 14, 2022 meeting
- The final PV forecast is published in the 2022 CELT (Section 3):
  - See: https://www.iso-ne.com/system-planning/system-plans-studies/celt/

2021 PV GROWTH: FORECAST VS. REPORTED

2021 PV Growth

Total Nameplate Capacity

- Comparison of the state-by-state 2021 forecast PV growth and the growth for 2021 reported by utilities is tabulated below
  - Values include FCM, EOR, and BTM PV projects
- Regionally, 2021 growth reported by utilities totaled 771.1 MW, which is 23 MW lower than the forecast growth
  - Results vary by state

State	2021 Reported Growth	2021 Forecast Growth	Difference
CT	126.8	108.1	18.8
MA	451.1	454.3	-3.2
ME	56.2	138.8	-82.6
NH	31.6	19.1	12.4
RI	64.6	49.1	15.5
VT	40.8	24.7	16.1
Region	771.1	794.1	-23.0

Larger-Scale PV

Projects >5 MW_{ac}

- Tabulated below is a summary of in-service, larger-scale (i.e., non-DG) PV projects included as part of Distribution Owner survey data responses
- These projects are not included in the PV forecast, and are excluded from installed PV totals reported herein

State	# Projects Listed	Total Nameplate (MW_{ac})
CT	3	66.4
MA	-	-
ME	1	9.9
NH	-	-
RI	13	102.5
VT	-	-
Total	**17**	**178.8**

DISTRIBUTION OWNER SURVEY RESULTS

Installed PV – December 2021

Determining Cumulative PV Totals

December 2021 Distribution Owner Survey Data

- ISO requested distribution owners to provide the total nameplate of all individual PV projects (in MW_{AC}) that is already installed and operational within their respective service territories as of December 31, 2021
  - PV projects include FCM, EOR, and BTM PV projects

- The following Distribution Owners responded:

CT	CL&P, CMEEC, UI
ME	CMP, Emera
MA	Braintree, Chicopee, Reading, National Grid, NSTAR, Shrewsbury, Unitil, WMECO
NH	Liberty, NHEC, PSNH, Unitil
RI	National Grid
VT	Burlington, GMP, Stowe, VEC, VPPSA, WEC

- Thank you to all respondents for providing timely information

- Based on respondent submittals, installed and operational PV resource totals by state and distribution owner are listed on the next slides

December 2021 Cumulative PV Totals

State-by-State

The table below reflects statewide aggregated PV data provided to ISO by regional Distribution Owners. The values represent installed nameplate as of 12/31/21.

State	Installed Capacity (MW_{AC})	No. of Installations
Massachusetts*	2,953.43	130,040
Connecticut	809.08	63,735
Vermont*	434.24	17,296
New Hampshire	156.88	12,186
Rhode Island	288.38	12,641
Maine	125.05	7,403
New England	**4,767.06**	**243,301**

* Includes values based on MA SREC data or VT SPEED data

December 2021- Cumulative PV Totals (1 of 2)

Summary of Distribution Owner PV Data

State	Utility	Installed Capacity (MW_{AC})	No. of Installations
CT	Connecticut Light & Power	627.53	46,726
	Connecticut Municipal Electric Energy Co-op	13.43	7
	United Illuminating	168.11	17,002
	Total	**809.08**	**63,735**
MA	Braintree Electric Light Department	5.47	35
	Chicopee Electric Light	13.17	38
	Unitil (FG&E)	43.26	2,123
	National Grid	1,608.59	69,114
	NSTAR	820.18	43,101
	Reading Municipal Lighting Plant	8.25	195
	Shrewsbury Electric & Cable Operations	6.46	115
	SREC I	54.21	589
	SREC II	96.60	1,672
	Western Massachusetts Electric Company	297.24	13,058
	Total	**2,953.43**	**130,040**
ME	Central Maine Power	114.29	6,309
	Emera	10.77	1,094
	Total	**125.05**	**7,403**

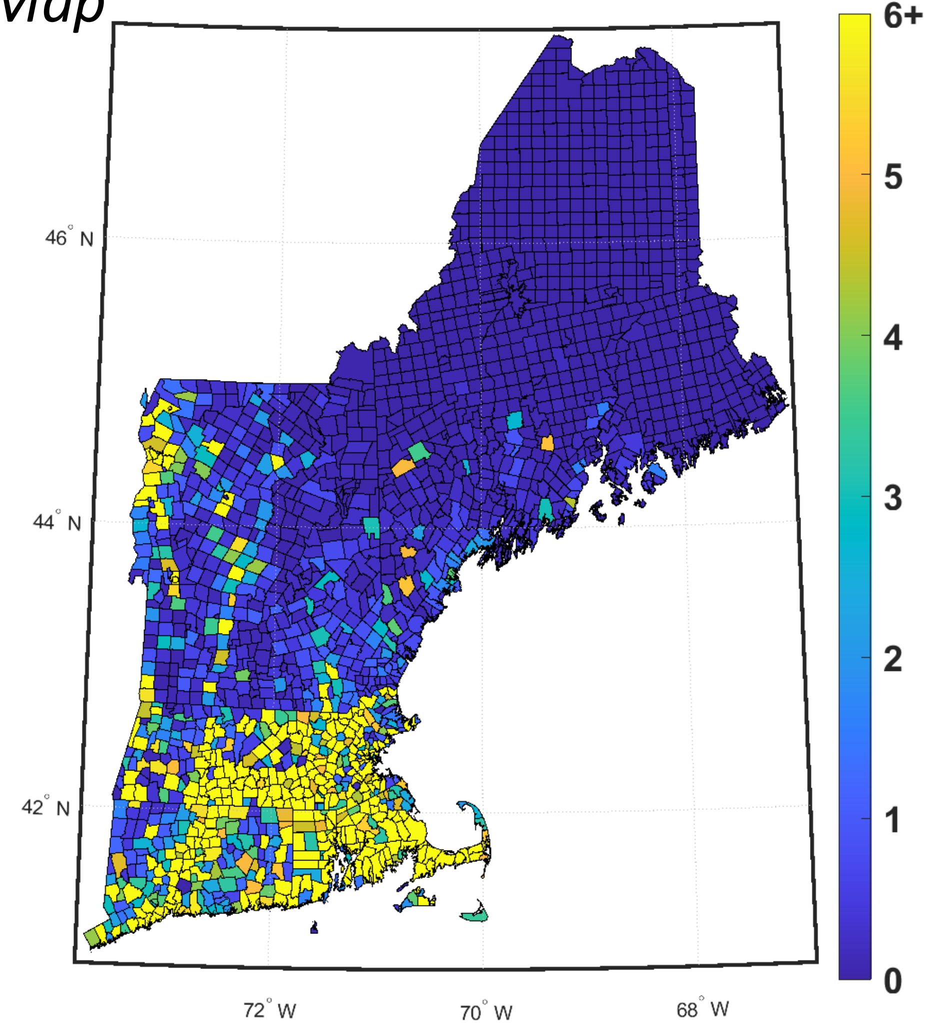
December 2021 Cumulative PV Totals (2 of 2)

Summary of Distribution Owner PV Data

State	Utility	Installed Capacity (MW_{AC})	No. of Installations
NH	Liberty Utilities	12.57	831
	New Hampshire Electric Co-op	15.54	1,398
	Public Service of New Hampshire	115.46	8,779
	Unitil (UES)	13.31	1,178
	Total	**156.88**	**12,186**
RI	National Grid	288.38	12,641
	Total	**288.38**	**12,641**
VT	Burlington Electric Department	8.81	343
	Green Mountain Power	358.28	13,398
	Stowe Electric Department	2.74	113
	Vermont Electric Co-op	38.36	2,085
	Vermont Public Power Supply Authority	18.12	668
	Washington Electric Co-op	7.93	689
	Total	**434.24**	**17,296**
New England		**4,767.06**	**243,301**

Installed PV Capacity as of December 2021

Regional Heat Map

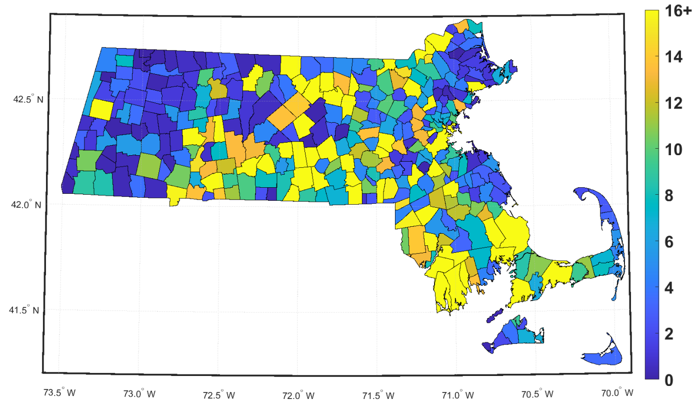


<u>Note</u>: Legend to the right of heat map shows color scale of nameplate megawatts per town

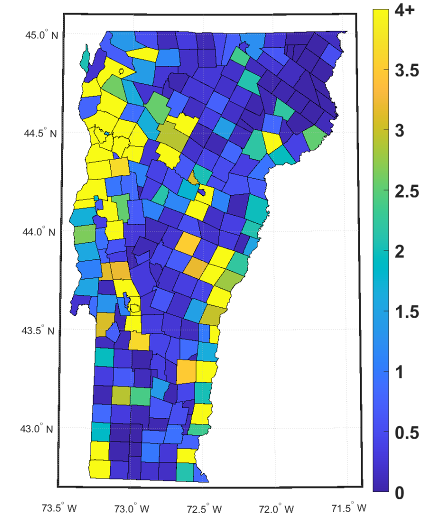
Installed PV Capacity as of December 2021

State Heat Maps

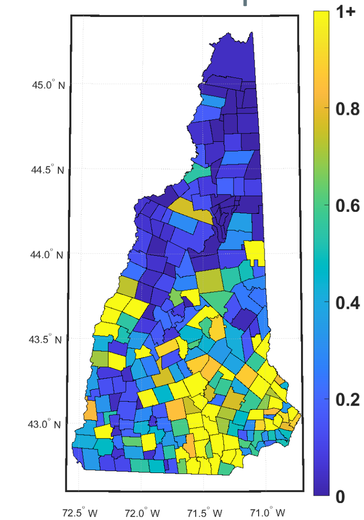
Massachusetts



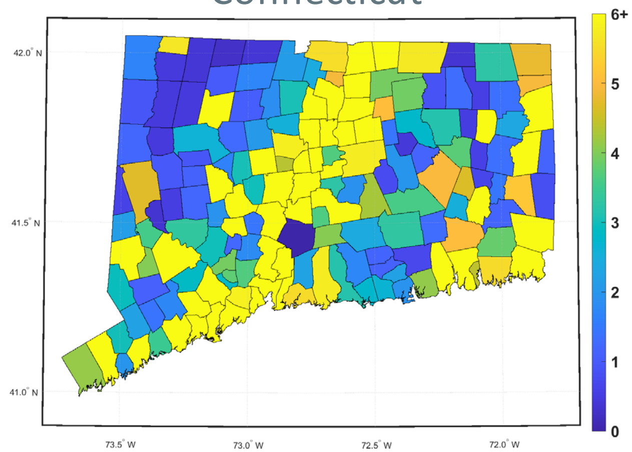
Vermont



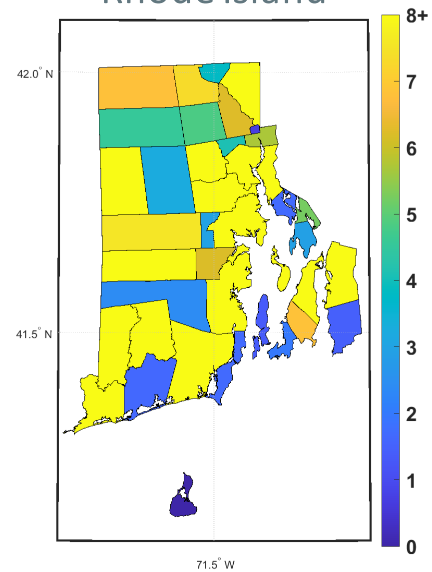
New Hampshire



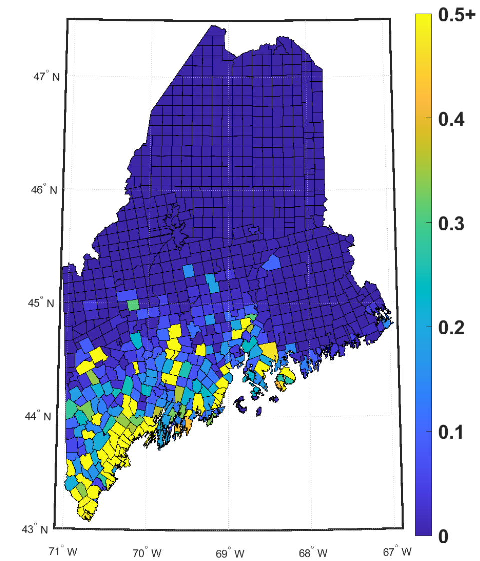
Connecticut



Rhode Island



Maine



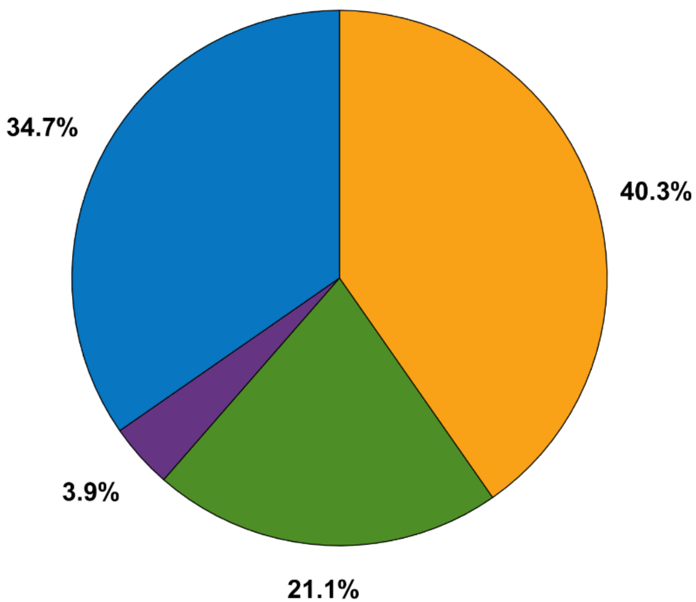
Note: Legend to the right of each state plot shows color scale of nameplate megawatts per town

Installed PV Capacity as of December 2021

ISO-NE by Size Class

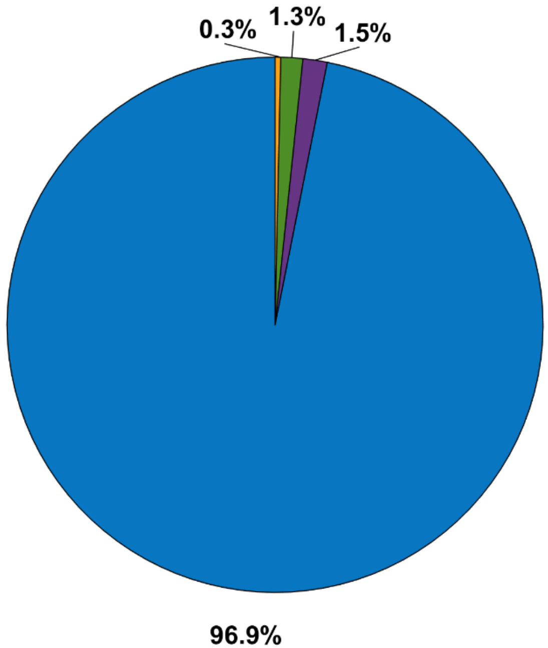
Installed Capacity (MW_{AC})

Total = 4,767 MW_{AC}



Number of Sites

Total = 243,301



<25kW | 25kW-<100kW | 100kW-<1000kW | >=1000kW

TOTAL NAMEPLATE CAPACITY FORECAST ASSUMPTIONS AND INPUTS

Federal Investment Tax Credit

- The federal residential and business Investment Tax Credit (ITC) is a key driver of PV development in New England
  - Congress extended the ITC for two years in December 2020
- Department of Energy guidance is available for both the Residential ITC and Business ITC

Residential ITC

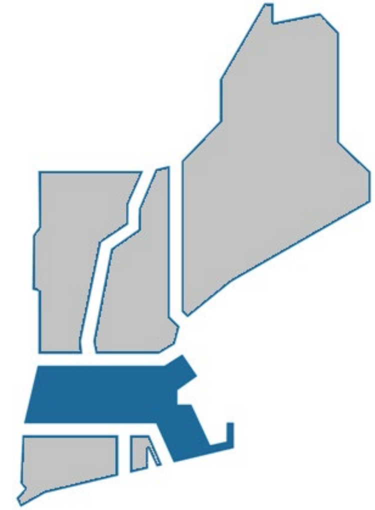
Maximum Allowable Residential ITC	
Year	Credit
2020	30%
2021-2022	26%
2023	22%
Future Years	0%

Business ITC

ITC by Date of Construction Start	
Year construction starts	Credit
2020-2022	26%
2023	22%
Future Years	10%

Sources: http://programs.dsireusa.org/system/program/detail/658 and http://programs.dsireusa.org/system/program/detail/1235

Massachusetts Forecast Assumptions

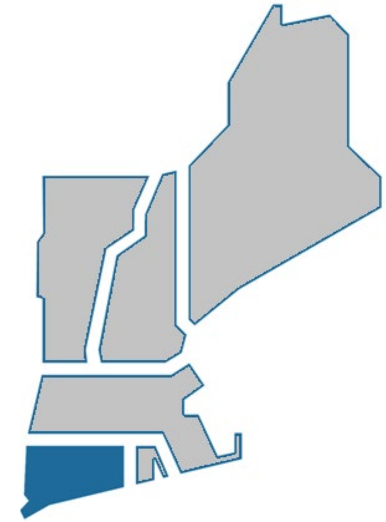


- MA DPU's 12/6/21 DGFWG presentation serves as primary source for MA policy information
- MA Distribution Owners survey results:
  - 2,953.4 MW_{AC} installed by 12/31/21
- Solar Massachusetts Renewable Target (SMART) Program
  - Program goal of 3,200 MW_{AC} goal achieved over the period 2021-2027 (7 years)
  - 713.6 MW_{AC} installed by end of 2021; 2,813.3 MW_{AC} remaining
    - Assume program capacity is divided over years as tabulated below

Year	Thru 2021	2022	2023	2024	2025	2026	2027	Total
% Remaining		19	19	19	19	19	5	100
MW	713.6	472.4	472.4	472.4	472.4	472.4	124.3	3,200

- Post-policy development assumed to occur such that a total of 472.4 MW is carried forward from 2027 onward at constant rate throughout the remaining years of the forecast period, and post-policy discount factors are applied

Connecticut Forecast Assumptions

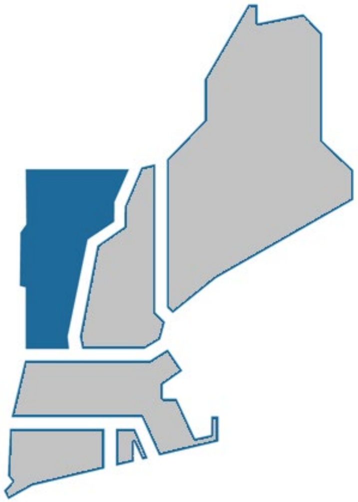


- CT DEEP's 12/6/21 DGFWG presentation serves as primary source for CT policy information
- CT Distribution Owner survey results
  - 809.1 MW_{AC} installed by 12/31/21
- Existing LREC/ZREC program assumptions
  - Assume a total of 175 MW divided over 3 years, 2022-2024, as tabulated below

Year	2022	2023	2024
MW	58.33	58.33	58.33

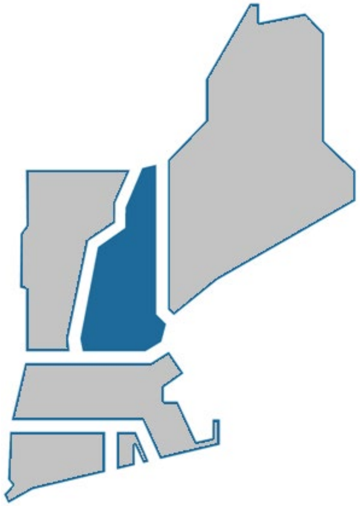
- Non-Residential Tariff will result in 47.5 MW/year (95% of 50 MW annual procurement) over the period 2024-2029
- Residential Solar Investment Program (RSIP) and subsequent Residential Renewable Energy Solutions program will promote 51 MW_{AC}/year (60 MW_{DC}) through year 2031
- Shared Clean Energy Facility (SCEF)
  - Successor SCEF program: Promotes 25 MW/year over the period 2021-2027
- At the end of Non-Residential Tariff and SCEF successor programs, all MWs from last year of each program are carried forward until 2031 at a constant rate, and post-policy discount factors are applied

Vermont Forecast Assumptions



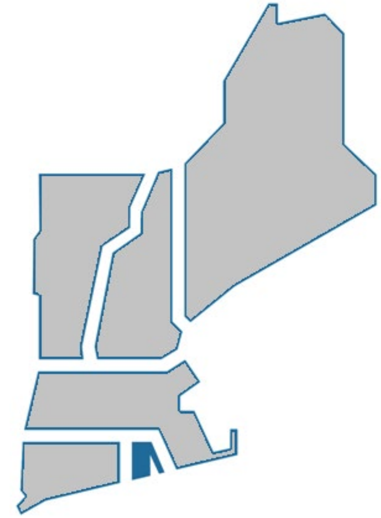
- VT DPS' 12/6/21 DGFWG presentation serves as the primary source for VT policy information
- VT Distribution Owner survey results
  - 434.2 MW_{AC} installed by 12/31/21
- A total of 30 MW/year is forecast in VT due to the DG carve-out of the Renewable Energy Standard (RES) and its supporting policies (Standard Offer Program, net metering)
  - All forward-looking renewable energy certificates (RECs) from Standard Offer and net metered projects will be sold to utilities and count towards RES DG carve-out

New Hampshire Forecast Assumptions



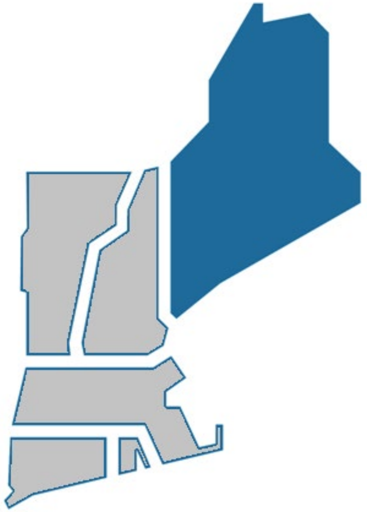
- [NH PUC's 12/6/21 DGFWG presentation] serves as the primary source for NH policy information
- NH Distribution Owners survey results
  - 156.9 MW_{AC} installed by 12/31/21
  - 31.56 MW_{AC} installed in 2021
- Assume the Net Energy Metering Tariff continues to support the 2021 rate of growth throughout the forecast horizon
  - No limit on state-wide aggregate net metered capacity

Rhode Island Forecast Assumptions



- RI OER's 12/6/21 DGFWG presentation serves as the primary source for RI policy information
- RI Distribution Owner survey results
  - 288.4 MW_{AC} installed by 12/31/21
  - 64.6 MW installed in 2021 (not including projects > 5 MW nameplate capacity)
- Renewable Energy Growth Program (REGP)
  - Assume REGP supports 36 MW_{DC}/year of PV through 2029
    - Convert: 36 MW_{DC} = 29.88 MW_{AC} (83% AC-to-DC ratio assumed)
- Renewable Energy Development Fund, Net Metering, and Virtual Net Metering (VNM)
  - No limit on state-wide aggregate net metered capacity
  - Assumed to yield 25 MW/year of projects < 5 MW in size over the forecast horizon
- At the end of existing REGP, all MWs from last year of program are carried forward until 2031 at a constant rate, and post-policy discount factors are applied

Maine Forecast Assumptions



- ME PUC's 12/6/21 DGFWG presentation serves as the primary source for ME policy information
- ME Distribution Owner survey results
  - 125.1MW$_{AC}$ installed by 12/31/21
  - 56.2 MW installed in 2021
- Net Energy Billing (NEB) Rule (per L.D. 1711) assumptions
  - A total of 1,175 MW of projects in the NEB queue will be developed from 2021-2026 as tabulated below
    - Total represents the average of the conservative and middle scenarios described by ME PUC (see slide 7 of ME PUC presentation)
  - NEB will continue to support 30 MW/year of growth starting in 2027

Year	Thru 2021	2022	2023	2024	2025	2026
% remaining		10	22	22	23	23
MW	40	113.5	249.7	249.7	261.05	261.05

Discount Factors

- Discount factors are:
  - Developed and incorporated into the forecast to ensure a degree of uncertainty in future PV commercialization is considered
  - Developed for two types of future PV inputs to the forecast, and all discount factors are applied equally in all states
  - Applied to the forecast inputs (see slide 30) to determine total nameplate capacity for each state and forecast year

Policy-Based *PV that results from state policy*	**Post-Policy** *PV that may be installed after existing state policies end*
Discounted by values that increase over the forecast horizon up to a maximum value of 15%	**Discounted by a higher amount due to the high degree of uncertainty associated with possible future expansion of state policies and/or future market conditions required to support PV commercialization in the absence of policy expansion**

Discount Factors Used in Final Forecasts

Policy-Based

Forecast	Final 2021	Final 2022
2022	10%	5%
2023	15%	10%
2024	15%	15%
2025	15%	15%
2026	15%	15%
2027	15%	15%
2028	15%	15%
2029	15%	15%
2030	15%	15%
2031	N/A	15%

Post-Policy

Forecast	Final 2021	Final 2022
2022	36.7%	30.0%
2023	38.3%	31.1%
2024	40.0%	32.2%
2025	41.7%	33.3%
2026	43.3%	34.4%
2027	45.0%	35.6%
2028	46.7%	36.7%
2029	48.3%	37.8%
2030	50.0%	38.9%
2031	N/A	40.0%

Final 2022 Forecast Inputs

Pre-Discounted Nameplate Values

States	Pre-Discount Annual Total MW (AC nameplate rating)											Totals
	Thru 2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	
CT	809.1	119.3	124.3	178.7	123.5	123.5	123.5	123.5	123.5	123.5	123.5	**2,095.9**
MA	2953.4	472.4	472.4	472.4	472.4	472.4	472.4	472.4	472.4	472.4	472.4	**7,677.5**
ME	125.1	113.5	249.7	249.7	261.1	261.1	30.0	30.0	30.0	30.0	30.0	**1,410.1**
NH	156.9	31.6	31.6	31.6	31.6	31.6	31.6	31.6	31.6	31.6	31.6	**472.4**
RI	288.4	54.9	54.9	54.9	54.9	54.9	54.9	54.9	54.9	54.9	54.9	**837.2**
VT	434.2	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	**734.2**
Pre-Discount Annual Policy-Based MWs	**4767.1**	**821.7**	**962.9**	**1017.3**	**973.4**	**973.4**	**394.3**	**269.9**	**244.9**	**167.6**	**167.6**	**10,759.9**
Pre-Discount Annual Post-Policy MWs	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**348.1**	**472.4**	**497.4**	**574.8**	**574.8**	**2,467.5**
Pre-Discount Annual Total (MW)	**4767.1**	**821.7**	**962.9**	**1017.3**	**973.4**	**973.4**	**742.3**	**742.3**	**742.3**	**742.3**	**742.3**	**13,227.4**
Pre-Discount Cumulative Total (MW)	**4767.1**	**5,588.7**	**6,551.6**	**7,568.9**	**8,542.3**	**9,515.7**	**10,258.0**	**11,000.4**	**11,742.7**	**12,485.1**	**13,227.4**	**13,227.4**

Notes:

(1) The above values **are not the forecast**, but rather pre-discounted inputs to the forecast (see slides 22-27 for details)
(2) Yellow highlighted cells indicate that values contain post-policy MWs
(3) All values include FCM Resources, non-FCM Settlement Only Generators and Generators (per OP-14), and load reducing PV resources
(4) All values represent end-of-year installed capacities

FINAL 2022 PV NAMEPLATE FORECAST

Final 2022 PV Forecast

Nameplate Capacity, MW_{ac}

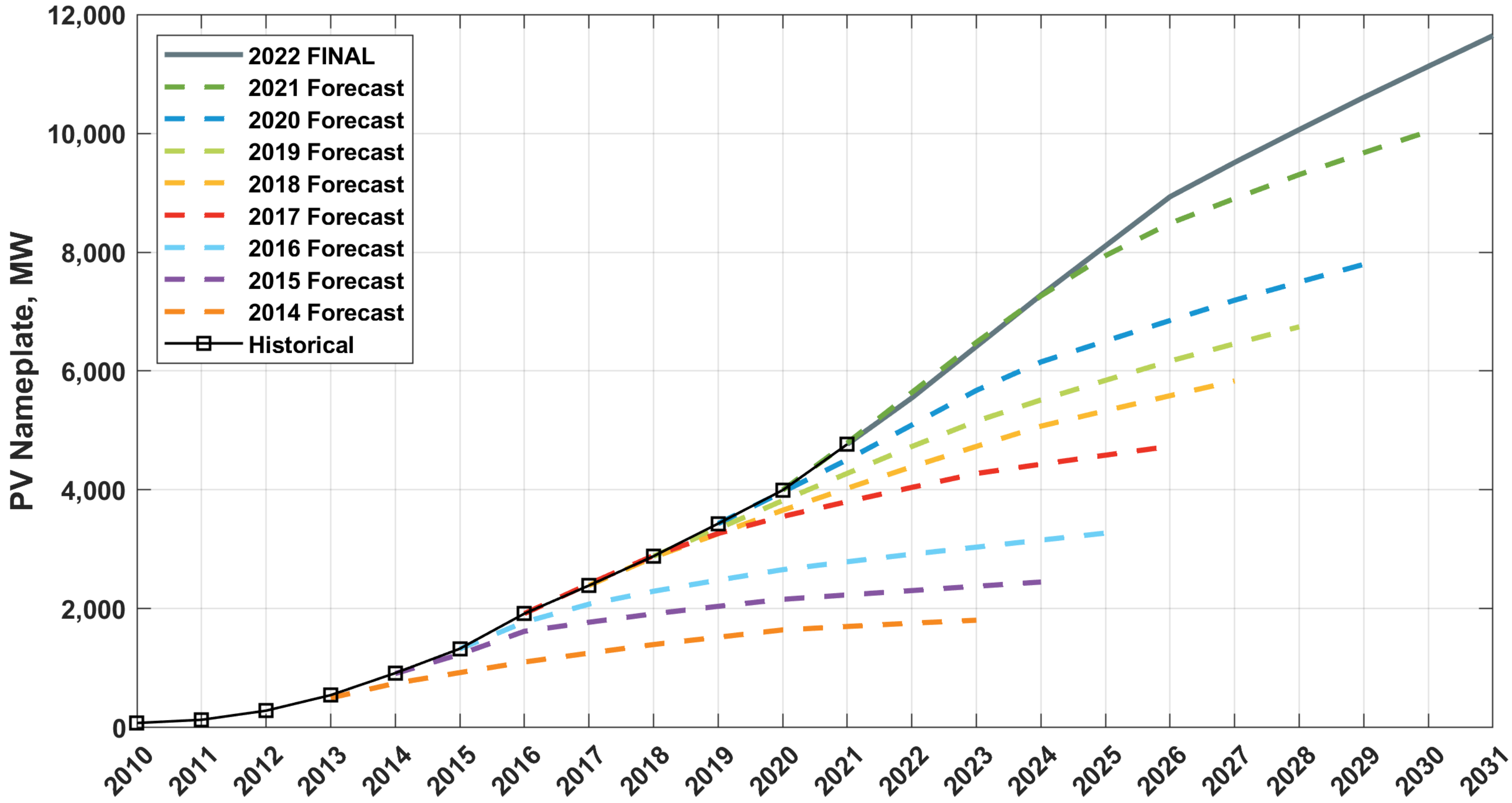
States	Annual Total MW (AC nameplate rating)											Totals
	Thru 2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	
CT	809.1	113.4	111.9	151.9	105.0	105.0	105.0	105.0	99.3	87.7	86.9	**1,879.9**
MA	2953.4	448.8	425.2	401.6	401.6	401.6	330.0	299.2	293.9	288.7	283.4	**6,527.3**
ME	125.1	107.8	224.7	212.2	221.9	221.9	25.5	25.5	25.5	25.5	25.5	**1,241.1**
NH	156.9	30.0	28.4	26.8	26.8	26.8	26.8	26.8	26.8	26.8	26.8	**429.8**
RI	288.4	52.1	49.4	46.6	46.6	46.6	46.6	46.6	46.6	39.5	39.2	**748.5**
VT	434.2	28.5	27.0	25.5	25.5	25.5	25.5	25.5	25.5	25.5	25.5	**693.7**
Regional - Annual (MW)	**4767.1**	**780.6**	**866.6**	**864.7**	**827.4**	**827.4**	**559.4**	**528.6**	**517.7**	**493.7**	**487.3**	**11,520.4**
Regional - Cumulative (MW)	**4767.1**	**5547.6**	**6414.2**	**7278.9**	**8106.3**	**8933.7**	**9493.1**	**10021.8**	**10539.5**	**11033.1**	**11520.4**	**11,520.4**

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}



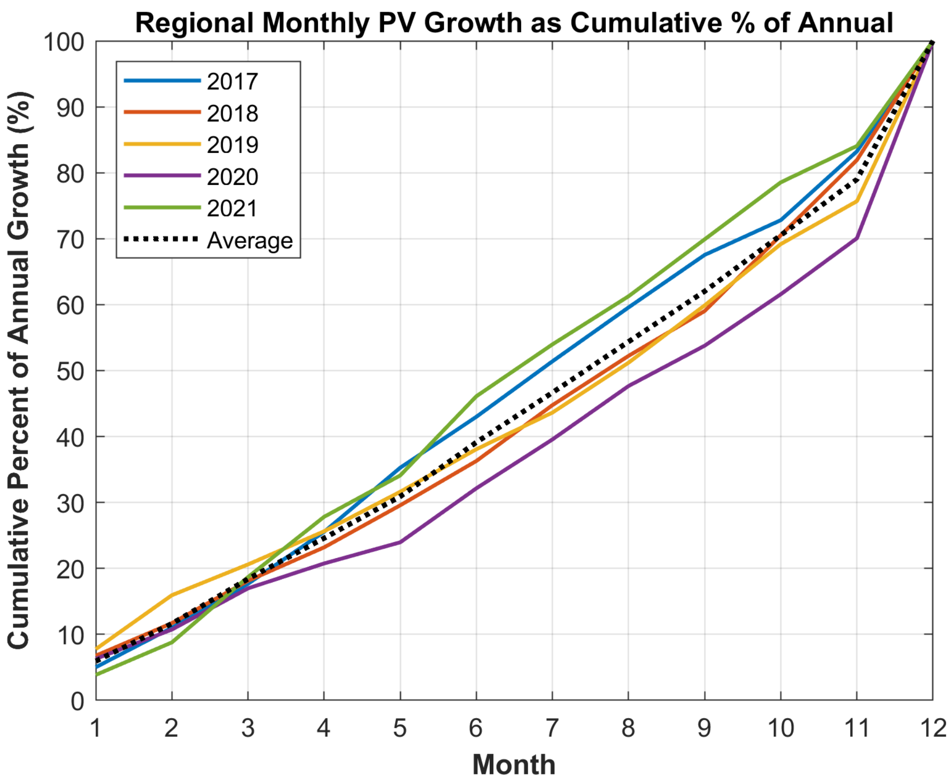
2022 PV ENERGY FORECAST

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 2017 and 2021 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 8 years of PV performance data (2014-2021)
  - Resulting state and regional CFs are tabulated to the right, and plots of individual monthly capacity factors in each state are shown on slide 37

State	Average CF, %
CT	14.5
ME	14.6
NH	14.0
RI	14.7
VT	13.6
MA	14.2
ISO-NE	**14.3**

Historical Monthly PV Growth Trends, 2017-2021



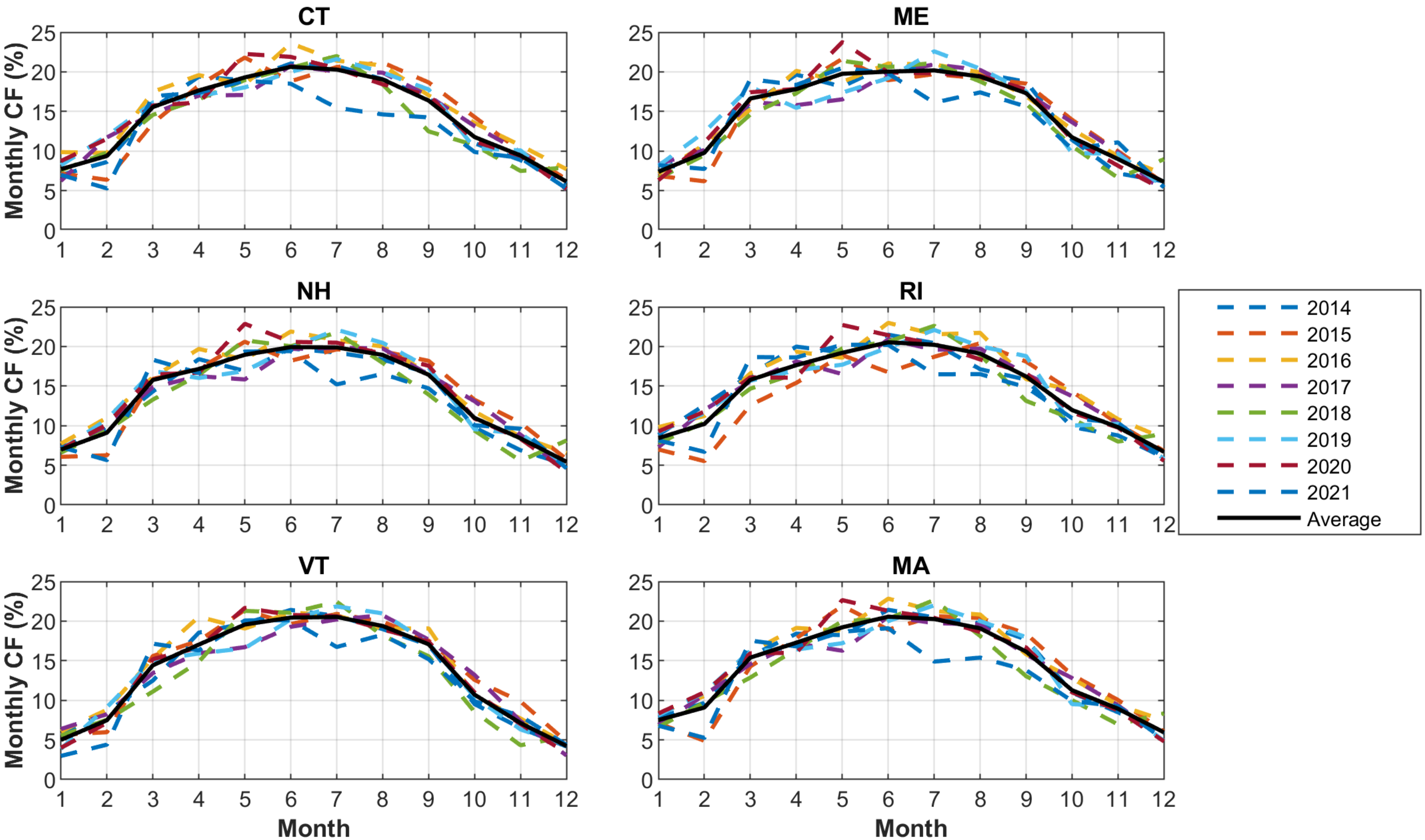
Average Monthly Growth Rates, % of Annual

Month	Monthly PV Growth (% of Annual)	Monthly PV Growth (Cumulative % of Annual)
1	6%	6%
2	6%	12%
3	7%	18%
4	6%	25%
5	6%	31%
6	8%	39%
7	8%	47%
8	8%	54%
9	8%	62%
10	8%	71%
11	8%	79%
12	21%	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, 2014-2021



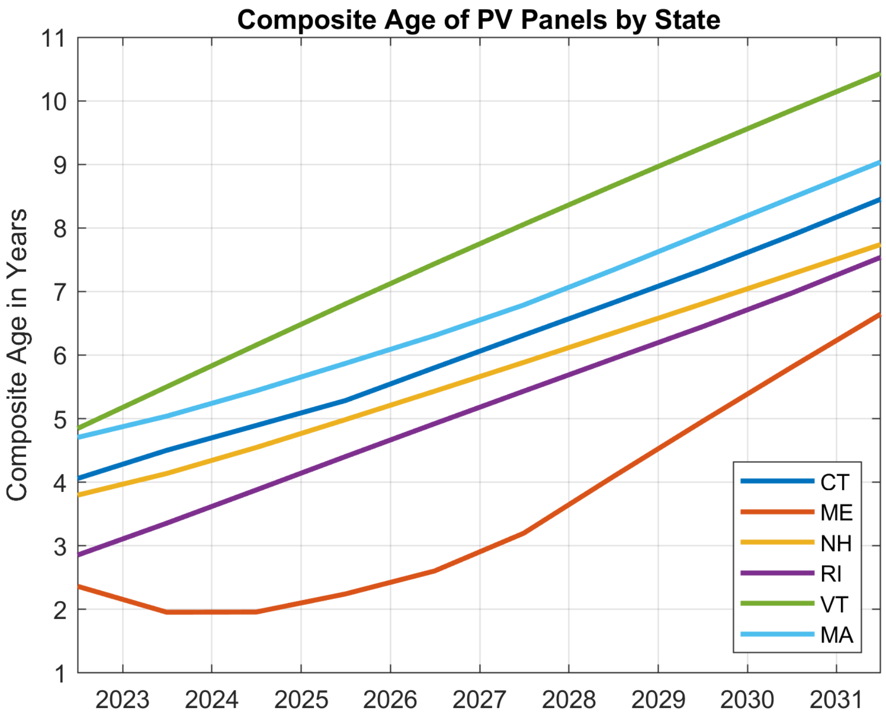
PV Panel Degradation Factors

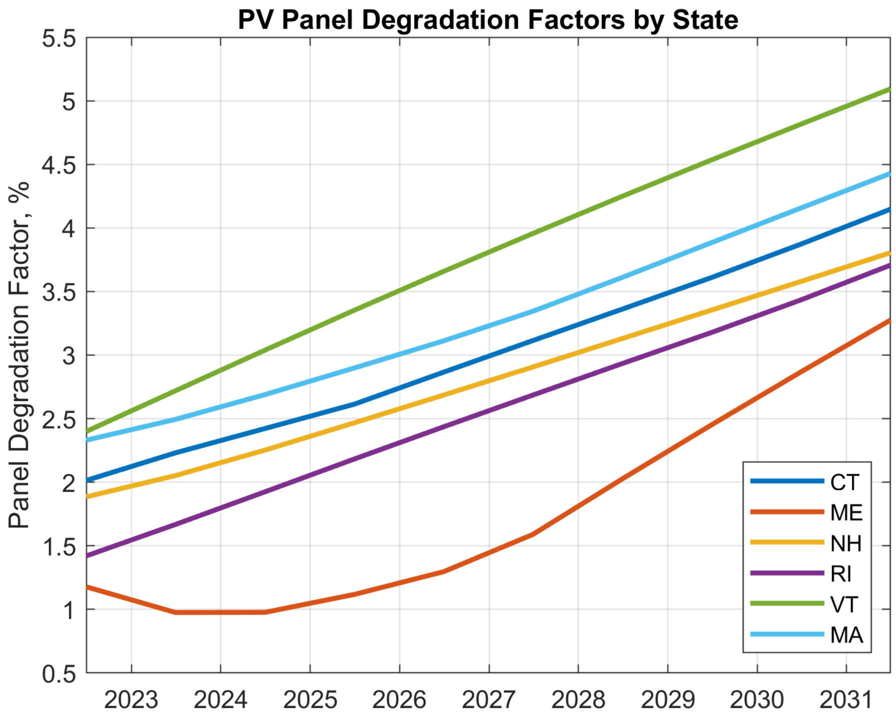
- No changes to the methodology to account for panel degradation were made since last year's forecast
- Forecasts of BTM PV energy and estimated summer peak load reductions include the effects of a 0.5%/year panel degradation rate to account for the expected declining conversion efficiency of solar panels 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 2022 PV Energy Forecast

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

States	Total Estimated Annual Energy (GWh)										
	2021	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
CT	979	1,129	1,275	1,444	1,611	1,743	1,876	2,010	2,135	2,250	2,356
MA	3,610	4,066	4,625	5,159	5,655	6,157	6,616	7,014	7,360	7,709	8,049
ME	122	230	443	739	1,027	1,322	1,502	1,532	1,556	1,583	1,610
NH	181	217	254	289	322	355	388	422	454	487	519
RI	345	418	485	549	609	669	729	790	849	904	953
VT	512	551	583	615	643	672	701	731	758	787	815
Regional - Annual Energy (GWh)	**5,748**	**6,611**	**7,665**	**8,794**	**9,866**	**10,919**	**11,812**	**12,499**	**13,111**	**13,719**	**14,302**

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 16
  2. **Non-FCM EOR/Gen**
     - Determine the % share of non-FCM PV participating in energy market at the end of 2021
  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

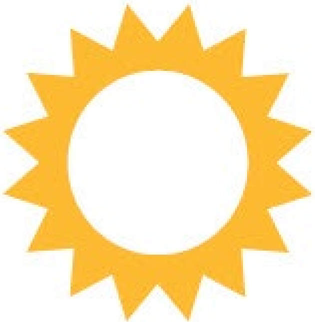
PV in ISO New England Markets

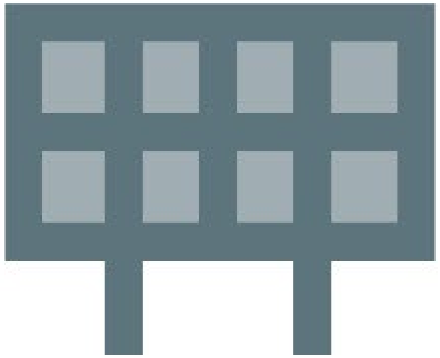
Data and Assumptions

- **FCM**
  - ISO identified all PV generators or demand resources (DR) that have Capacity Supply Obligations (CSO) in FCM up through FCA 16
    - Maintain separate accounting for FCM_{supply} and FCM_{DR}
  - Assume aggregate total PV in FCM as of FCA 16 remains constant from 2025-2031
- **Non-FCM Gen/EOR**
  - ISO identified total nameplate capacity of PV in each state registered in the energy market as of 12/31/21
  - Assume the ($EOR+FCM_{supply}$) share of total PV at the end of 2021 in each state *<u>except Maine</u>* 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
- BTM PV data and supporting documentation are available [here on the ISO New England website]





CLASSIFICATION OF FINAL 2022 PV FORECAST

Final 2022 PV Forecast

Cumulative Nameplate, MW_{ac}

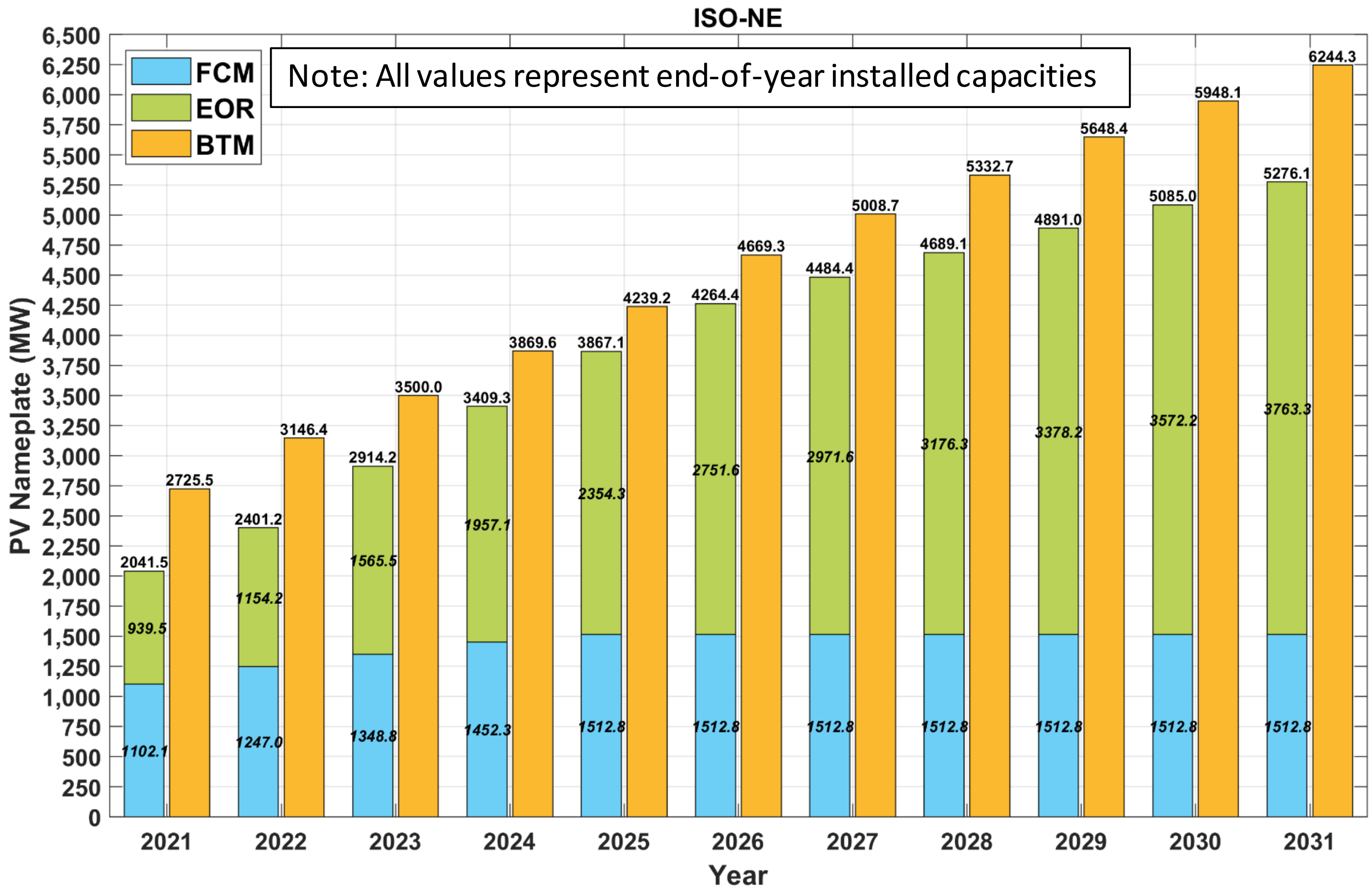
States	Cumulative Total MW (AC nameplate rating)										
	Thru 2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
CT	809.1	922.4	1,034.3	1,186.2	1,291.2	1,396.2	1,501.2	1,606.1	1,705.4	1,793.1	1,879.9
MA	2,953.4	3,402.2	3,827.4	4,228.9	4,630.5	5,032.0	5,362.0	5,661.2	5,955.2	6,243.9	6,527.3
ME	125.1	232.9	457.6	669.9	891.7	1,113.6	1,139.1	1,164.6	1,190.1	1,215.6	1,241.1
NH	156.9	186.9	215.3	242.1	268.9	295.7	322.5	349.4	376.2	403.0	429.8
RI	288.4	340.5	389.9	436.6	483.2	529.9	576.5	623.1	669.8	709.3	748.5
VT	434.2	462.7	489.7	515.2	540.7	566.2	591.7	617.2	642.7	668.2	693.7
Regional - Cumulative (MW)	**4,767.1**	**5,547.6**	**6,414.2**	**7,278.9**	**8,106.3**	**8,933.7**	**9,493.1**	**10,021.8**	**10,539.5**	**11,033.1**	**11,520.4**

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

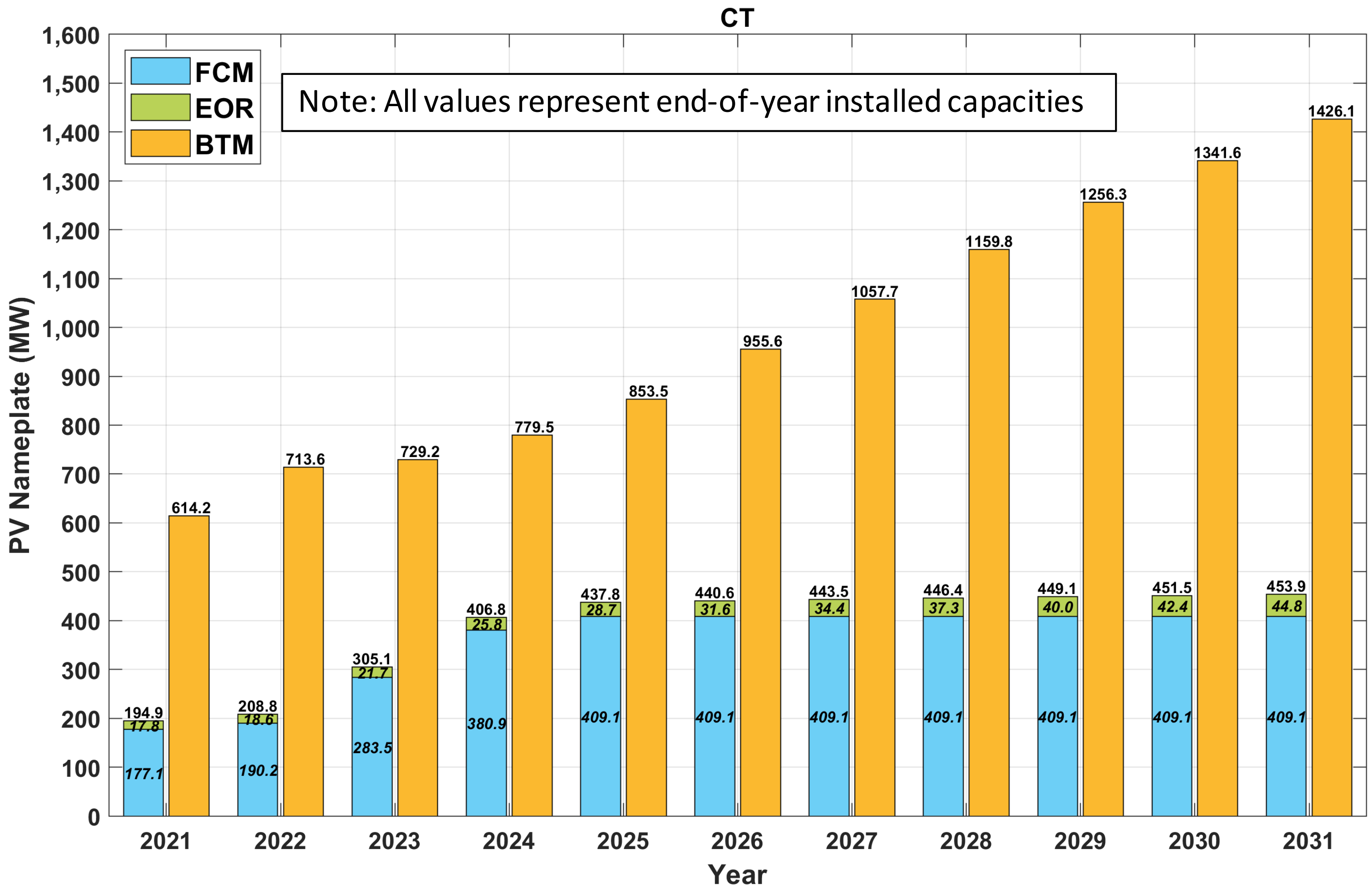
Final 2022 PV Forecast – New England

Cumulative Nameplate by Category, MW_{ac}



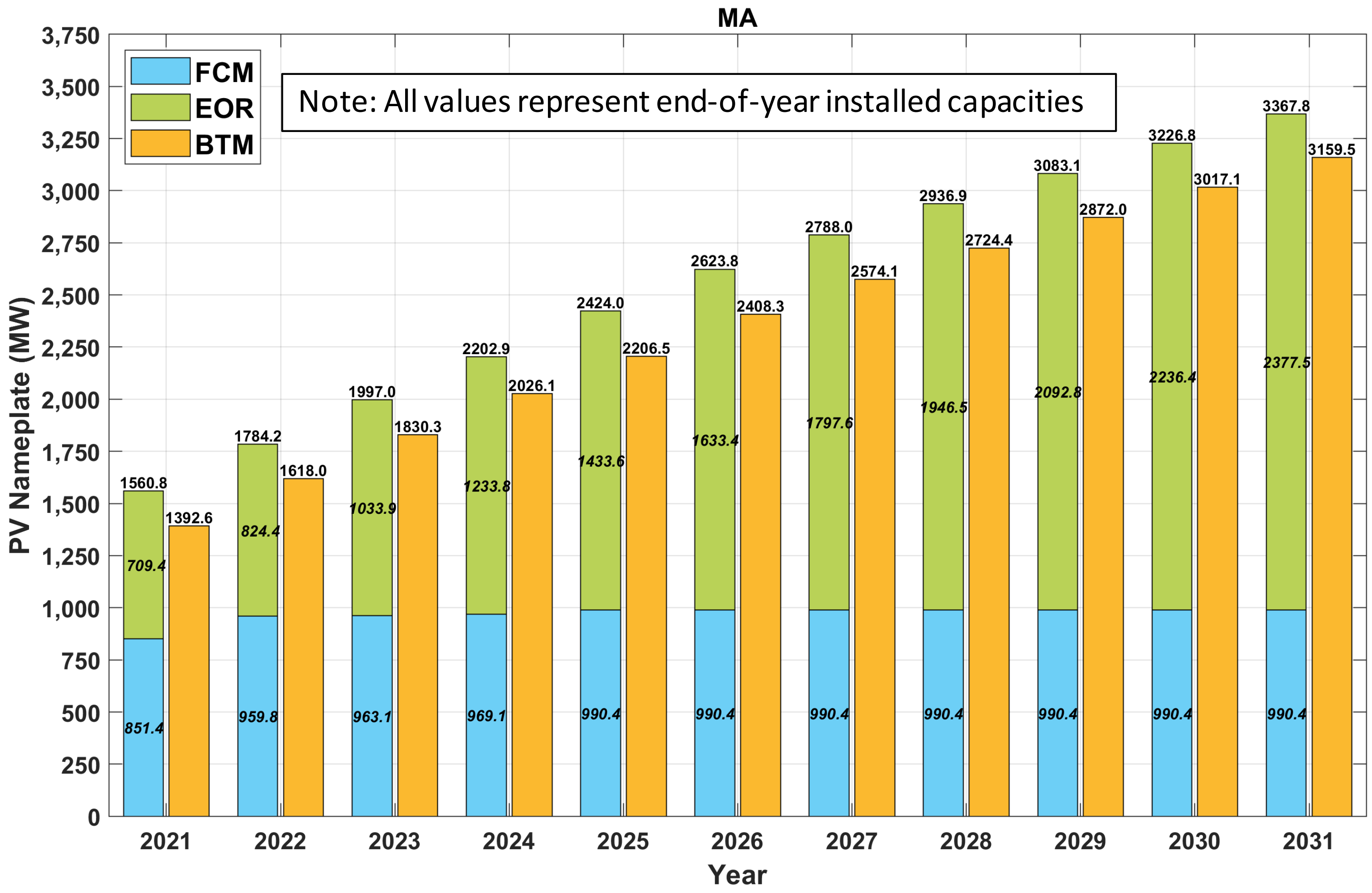
Final 2022 PV Forecast – Connecticut

Cumulative Nameplate by Category, MW_{ac}



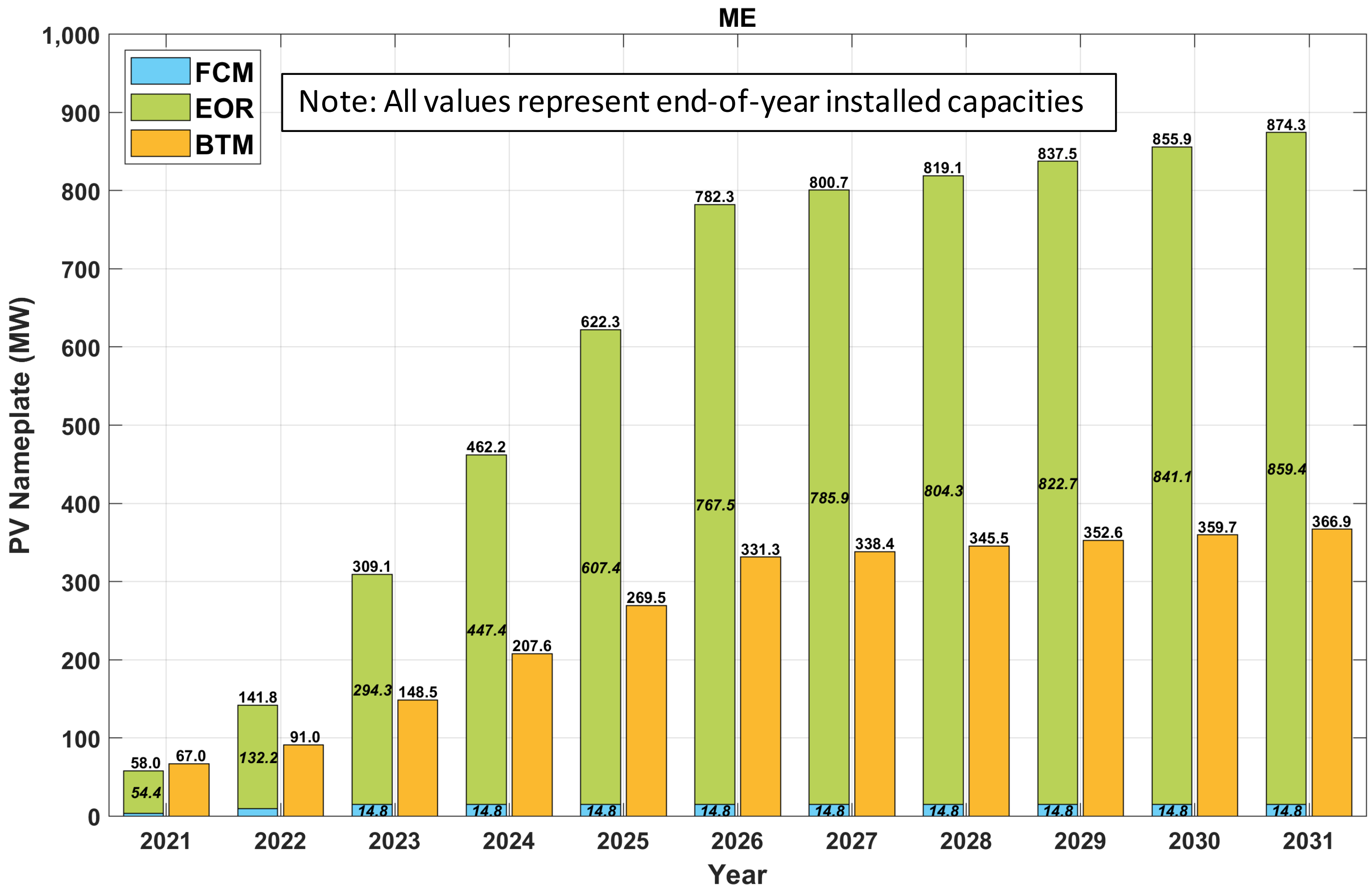
Final 2022 PV Forecast – Massachusetts

Cumulative Nameplate by Category, MW_{ac}



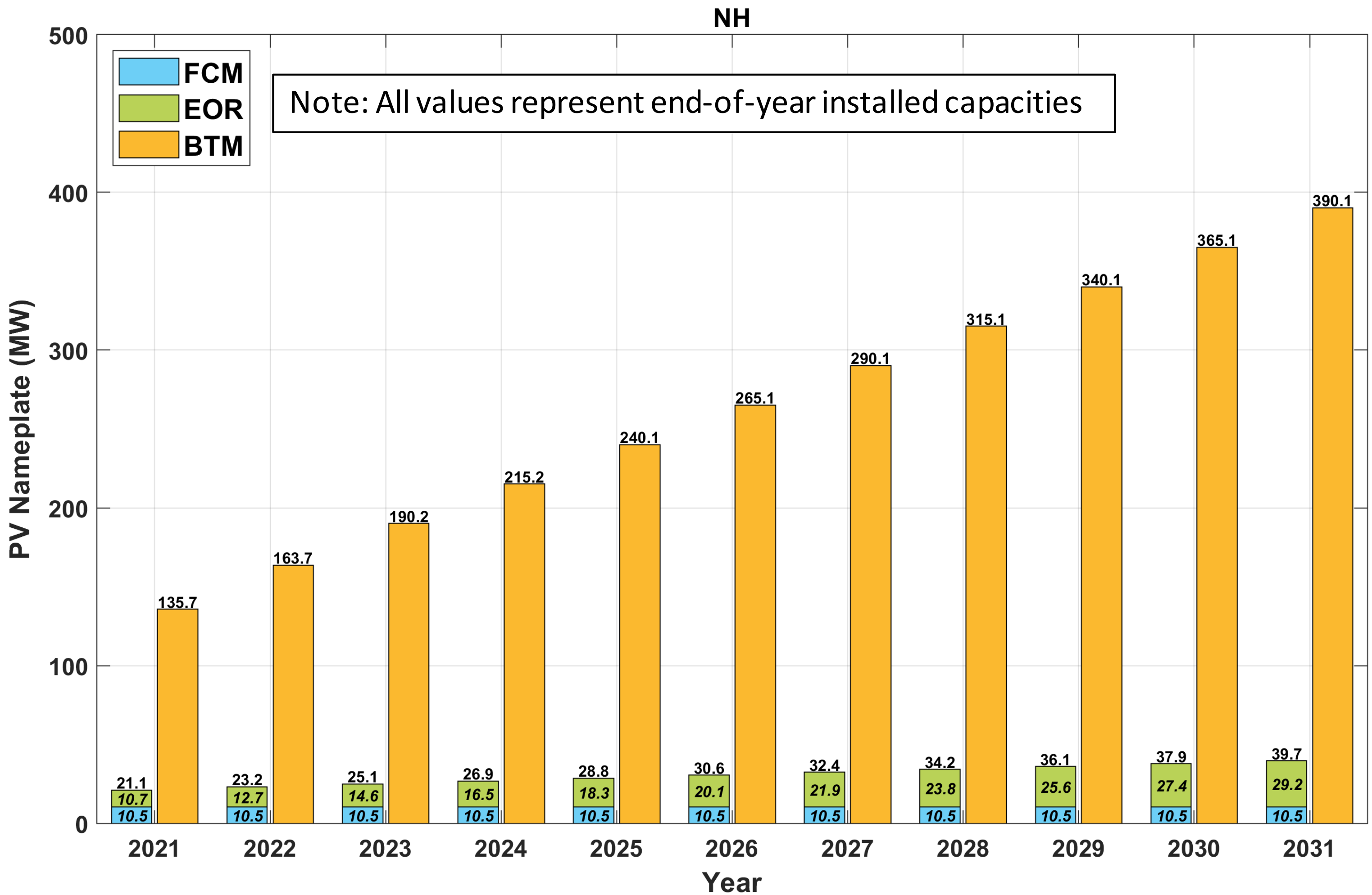
Final 2022 PV Forecast – Maine

Cumulative Nameplate by Category, MW_{ac}



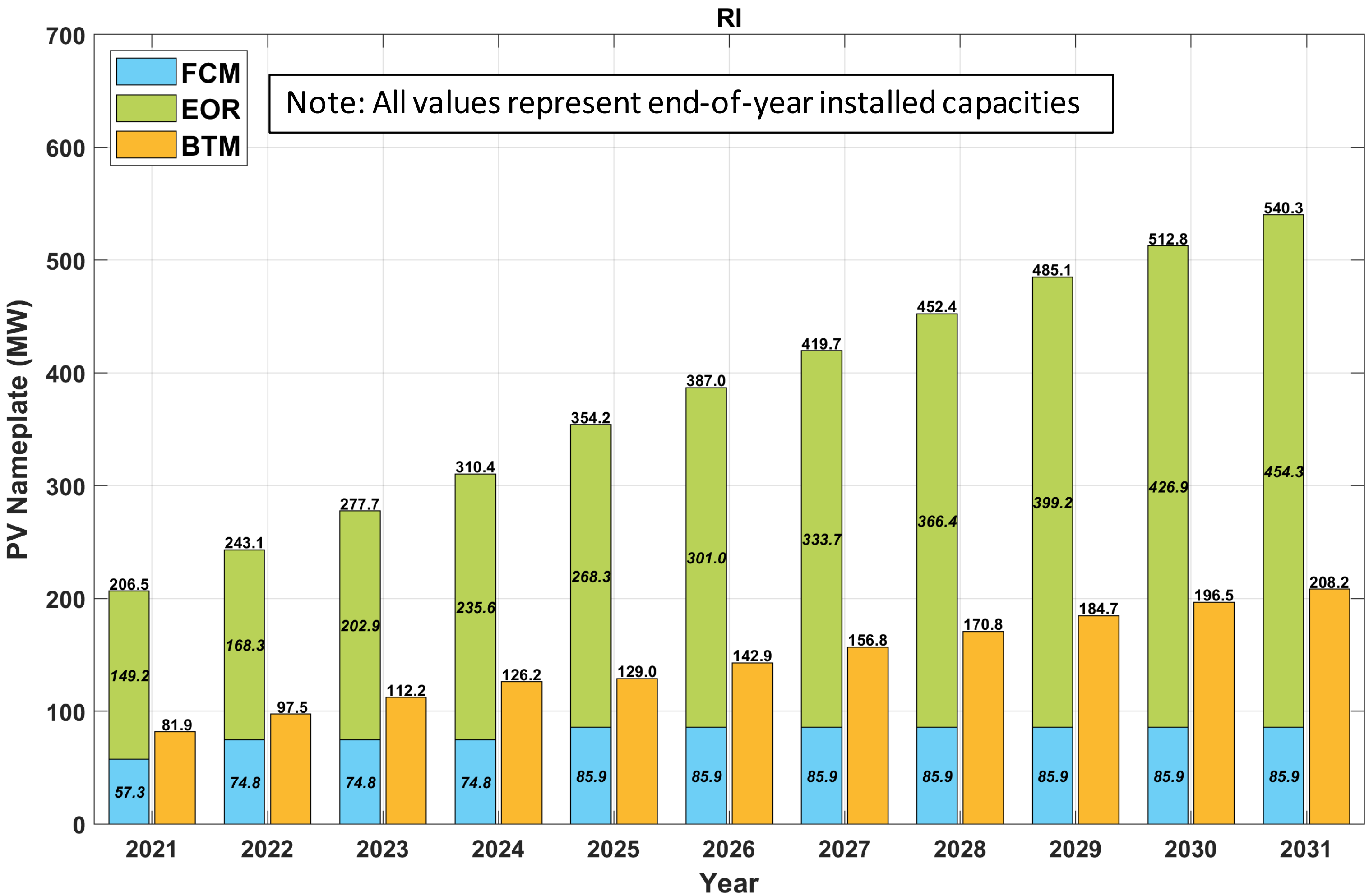
Final 2022 PV Forecast – New Hampshire

Cumulative Nameplate by Category, MW_{ac}



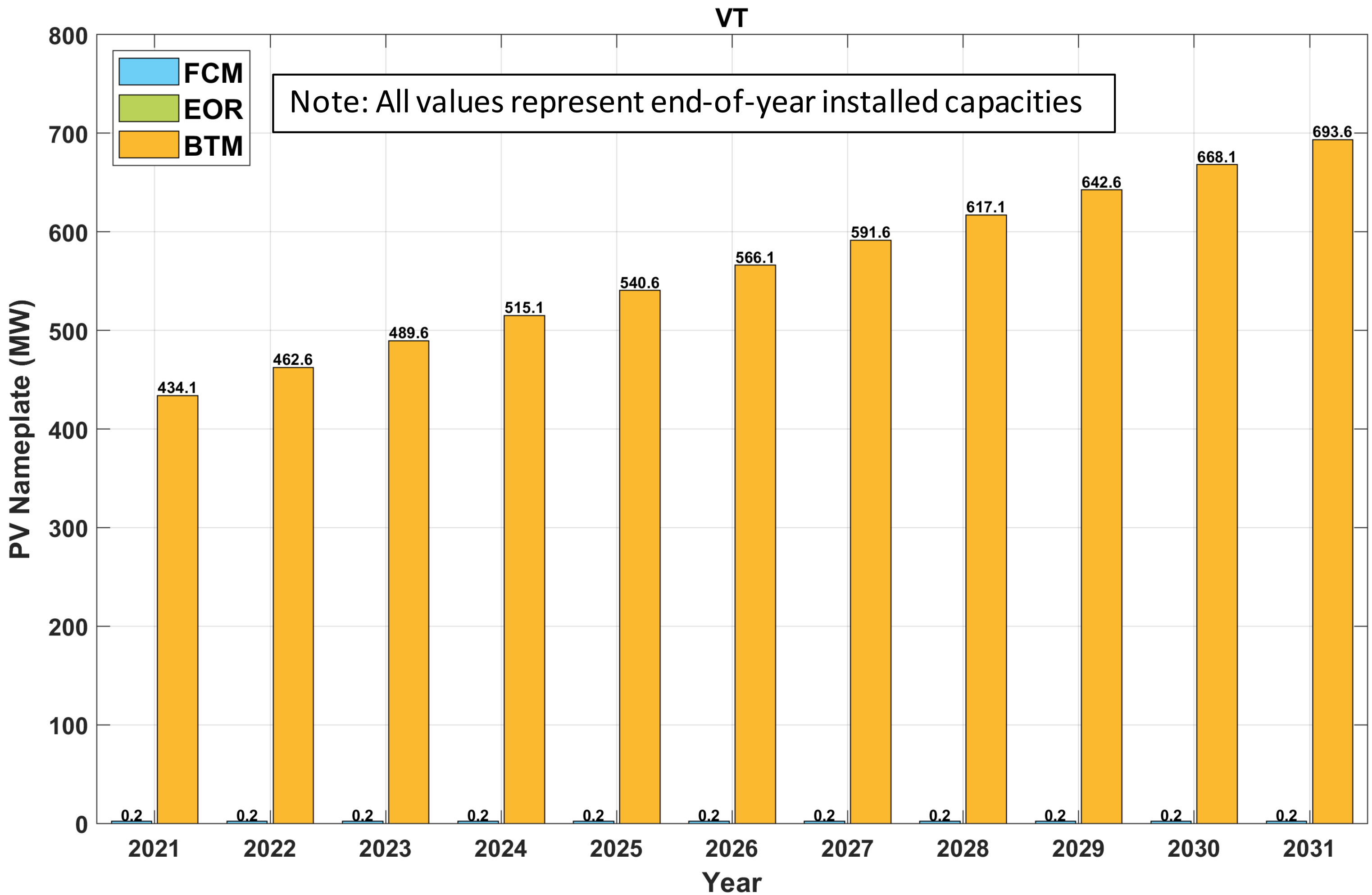
Final 2022 PV Forecast – Rhode Island

Cumulative Nameplate by Category, MW_{ac}



Final 2022 PV Forecast – Vermont

Cumulative Nameplate by Category, MW_{ac}



BTM PV Forecast Used in CELT Net Load Forecast

- The 2022 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 2022 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 2022 BTM PV Energy Forecast

GWh

Category	States	Estimated Annual Energy (GWh)										
		2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Behind-the-Meter PV	CT	694	861	912	942	1,051	1,171	1,301	1,432	1,555	1,669	1,774
	MA	1,237	1,925	2,205	2,467	2,695	2,940	3,171	3,371	3,545	3,721	3,892
	ME	74	102	154	234	314	397	447	455	461	469	476
	NH	159	189	223	256	287	318	349	380	410	440	471
	RI	55	119	139	158	166	179	197	216	233	250	264
	VT	496	551	583	614	643	672	701	730	758	786	815
Behind-the Meter Total	**Regional Total**	**2,714**	**3,747**	**4,216**	**4,671**	**5,155**	**5,676**	**6,165**	**6,584**	**6,963**	**7,335**	**7,692**

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 2022 BTM PV Forecast

July 1st Estimated Summer Peak Load Reductions

Category	States	Cumulative Total MW - Estimated Summer Seasonal Peak Load Reduction										
		2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Behind-the-Meter PV	CT	189.6	203.0	192.1	184.5	197.5	208.9	219.8	231.9	241.9	249.0	253.4
	MA	430.5	463.2	492.4	510.1	520.2	534.1	545.3	554.7	560.0	563.0	563.8
	ME	21.5	23.5	32.2	46.6	58.8	69.8	74.8	72.9	71.0	69.1	67.1
	NH	41.0	46.2	50.8	54.0	56.5	58.8	61.0	63.6	65.9	67.8	69.4
	RI	23.5	27.8	30.2	31.8	30.3	31.6	32.9	34.4	35.7	36.7	37.2
	VT	138.1	139.6	137.0	133.7	130.8	128.2	126.4	126.1	125.5	124.7	123.7
Total	**Cumulative**	844.3	903.3	934.6	960.7	994.1	1,031.4	1,060.3	1,083.6	1,100.1	1,110.2	1,114.6
% of BTM PV AC nameplate capacity		31.8%	29.7%	27.6%	25.6%	23.9%	22.4%	21.2%	20.3%	19.4%	18.6%	17.8%

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

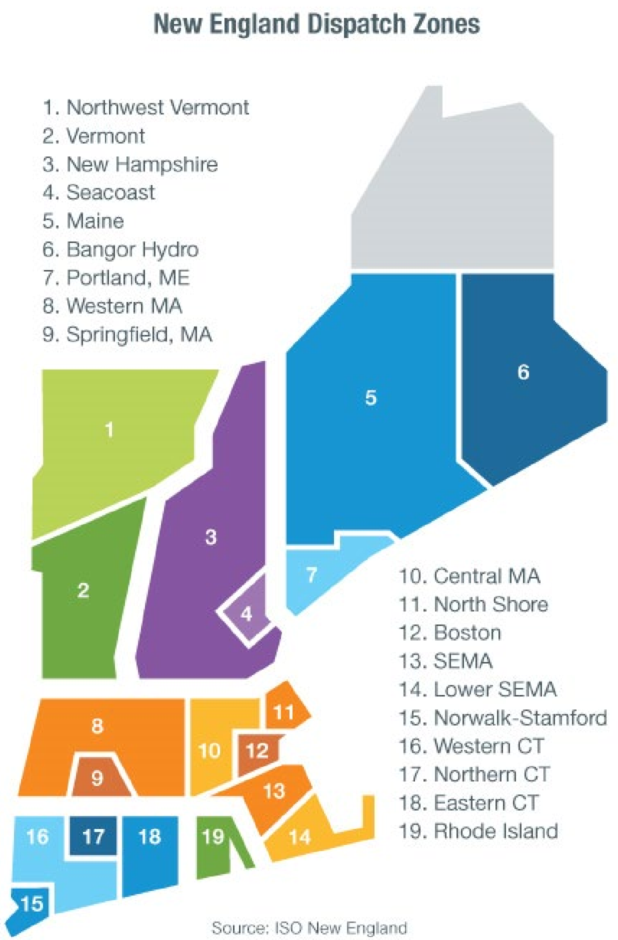
Overview

- 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 12/31/2021 by Dispatch Zone is included on the next slide
- Note: 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, 2021 Distribution Owner Data Submittals

State	Load Zone	Dispatch Zone	% of State
CT	CT	EasternCT	19.0%
	CT	NorthernCT	18.1%
	CT	Norwalk_Stamford	7.3%
	CT	WesternCT	55.6%
ME	ME	BangorHydro	8.9%
	ME	Maine	54.8%
	ME	PortlandMaine	36.4%
MA	NEMA	Boston	10.9%
	NEMA	NorthShore	13.6%
	SEMA	LowerSEMA	14.6%
	SEMA	SEMA	5.1%
	WCMA	CentralMA	20.1%
	WCMA	SpringfieldMA	7.3%
	WCMA	WesternMA	28.4%
NH	NH	NewHampshire	88.0%
	NH	Seacoast	12.0%
RI	RI	RhodeIsland	100.0%
VT	VT	NorthwestVermont	62.6%
	VT	Vermont	37.4%



APPENDIX

Example Calculation of BTM PV Estimated Summer Peak Load Reduction

Introduction

- The following slides describe an example calculation of estimated summer peak load reductions published in CELT
- The example calculation shown is for Massachusetts in July 2025

Description of Example Calculation Steps & Inputs

Massachusetts BTM PV July 2025 Summer Peak Load Reduction

1. State monthly BTM PV nameplate forecast
   – Find BTM PV share of total end-of-year nameplate forecast based on state accounting for categories (FCM, non-FCM EOR, and BTM) – see slide 51
   – Input uses the conversion of cumulative end-of-year state nameplate forecast (slide 48) into monthly forecast using monthly capacity growth rates (slide 36)
2. % of nameplate contribution to summer peak
   – Value is determined by finding the intersection point of total PV nameplate with sloped line shown on next slide
3. Panel degradation multiplier
   – Assumed annual degradation rate (ADR) = 0.5% per year
   – Based on forecasted composite age (CA) in years using equation below
   – State composite ages are plotted on slide 39

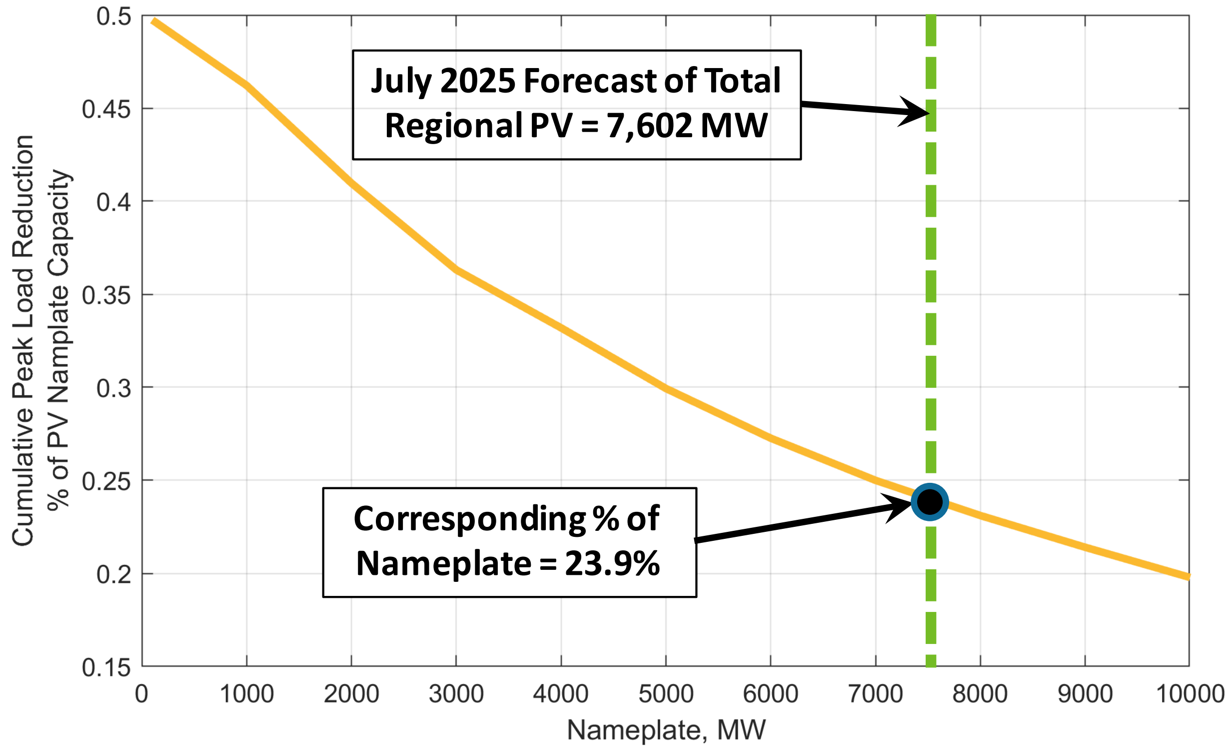
$$DegradeMultiplier = (1 - ADR)^{CA}$$

4. Gross-up for assumed transmission & distribution losses
   – Value of 8% is used

Estimated Summer Peak Load Reductions

July 2025 Example

- The orange line is the load-weighted peak load reductio[n] as a percent of PV nameplat[e] capacity
- These percent values are use[d] to calculate BTM PV peak loa[d] reductions according to the equation below
- Details of underlying analysis used to develop the orange line is available at: [http://www.iso-ne.com/static-assets/documents/2020/04/fina[l]btm_pv_peak_reduction.pdf](http://www.iso-ne.com/static-assets/documents/2020/04/final_btm_pv_peak_reduction.pdf)



- Equation to estimate BTM PV summer peak load reductions (in MW) is as follows:

BTM PV Peak Load Reduction, MW = (BTM PV Installed Capacity) * (% PV Nameplate)

Final Calculation

Massachusetts BTM PV July 2025 Summer Peak Load Reduction

Calculation Line Item	Relevant Region	
July 2025 Total Nameplate PV Forecast (MW)	ISO-NE	7602.6
July 2025 BTM PV Nameplate Forecast (MW)	MA	2083.7
% of Nameplate (from previous slide)	ISO-NE	0.239
Panel Degradation Multiplier	MA	0.97
Peak Gross Up Factor	ISO-NE	1.08
Final BTM PV Summer Peak Load Reduction (MW)	MA	**520.2**

Final estimated peak load reduction calculated by multiplying all values highlighted in yellow

Note: Tabulated values are rounded to the precision shown.