APRIL 15, 2016 | HOLYOKE, MASSACHUSETTS

Final 2016 PV Forecast

Distributed Generation Forecast Working Group

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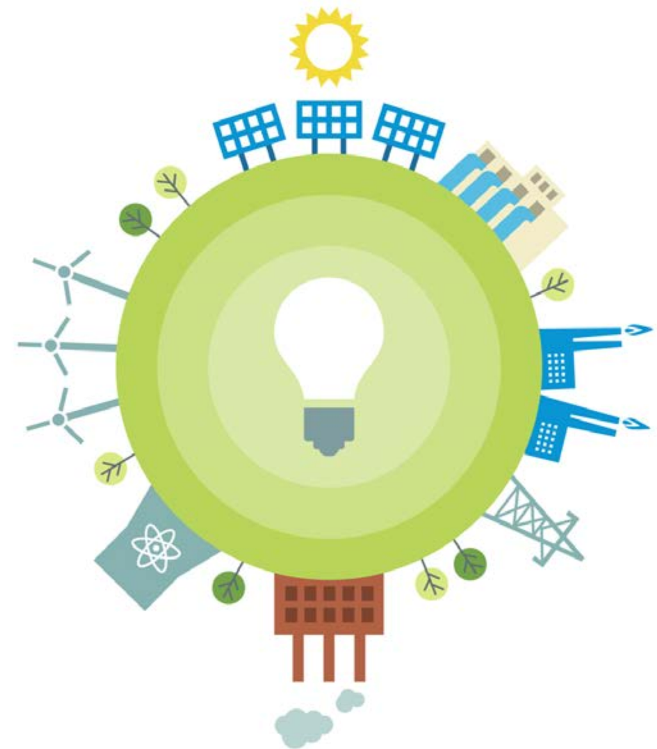
Presentation Outline

- Background and Forecast Process
- Changes to February 2016 Draft PV Forecast and Final 2016 PV Forecast
- 2016 PV Energy Forecast
- Behind-the-meter PV: Estimated Energy and Summer Peak Load Reductions
- Geographic Distribution of PV Forecast
- Summary and Next steps



BACKGROUND AND FORECAST PROCESS

Background and Forecast Review Process

- The ISO discussed the draft PV forecast with the DGFWG at the February 24, 2016 meeting
  - See: http://www.iso-ne.com/static-assets/documents/2016/03/2016_draftpvforecast_20160224revised.pdf
- Stakeholders provided many helpful comments on the draft forecast
  - See: http://www.iso-ne.com/committees/planning/distributed-generation/?eventId=129509
- The final PV forecast will be published in the 2016 CELT

CHANGES TO FEBRUARY 2016 DRAFT PV FORECAST AND FINAL 2016 PV FORECAST

Changes to the February 2016 Draft PV Forecast

State	Changes/Comments
Massachusetts	Made the MA forecast more "front-loaded" to reflect that the SREC program is close to fully subscribed and the recent faster-than-expected PV growth in MA. This change to the forecast resulted in the achievement of the SREC policy goal in 2018 rather than 2020.
Vermont	Adjusted VT's 2017 forecast value downward to reflect the implementation of the Renewable Energy Standard goals.

FINAL 2016 PV NAMEPLATE FORECAST

Draft 2016 PV Forecast – February 24, 2016

Nameplate Capacity, MW_{ac}

States	Annual Total MW (AC nameplate rating)											Totals
	Thru 2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	
CT	188.0	85.5	104.5	81.0	81.0	81.0	55.8	54.3	45.0	45.0	45.0	**866.1**
MA	947.1	122.7	122.7	77.5	77.5	77.5	43.0	43.0	43.0	43.0	43.0	**1,640.0**
ME	15.3	4.7	4.7	4.4	4.4	4.4	4.2	3.9	3.9	3.9	3.9	**57.9**
NH	26.4	13.3	7.6	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	**79.3**
RI	23.6	21.6	38.7	36.0	36.0	25.9	9.1	6.6	6.6	6.6	6.6	**217.2**
VT	124.6	30.2	30.2	22.5	22.5	22.5	21.3	20.0	20.0	20.0	20.0	**353.7**
Regional - Annual (MW)	**1325.0**	**277.9**	**308.3**	**225.4**	**225.4**	**215.3**	**137.5**	**131.8**	**122.5**	**122.5**	**122.5**	**3,214.3**
Regional - Cumulative (MW)	**1325.0**	**1602.9**	**1911.2**	**2136.6**	**2362.0**	**2577.3**	**2714.8**	**2846.6**	**2969.2**	**3091.7**	**3214.3**	**3,214.3**

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

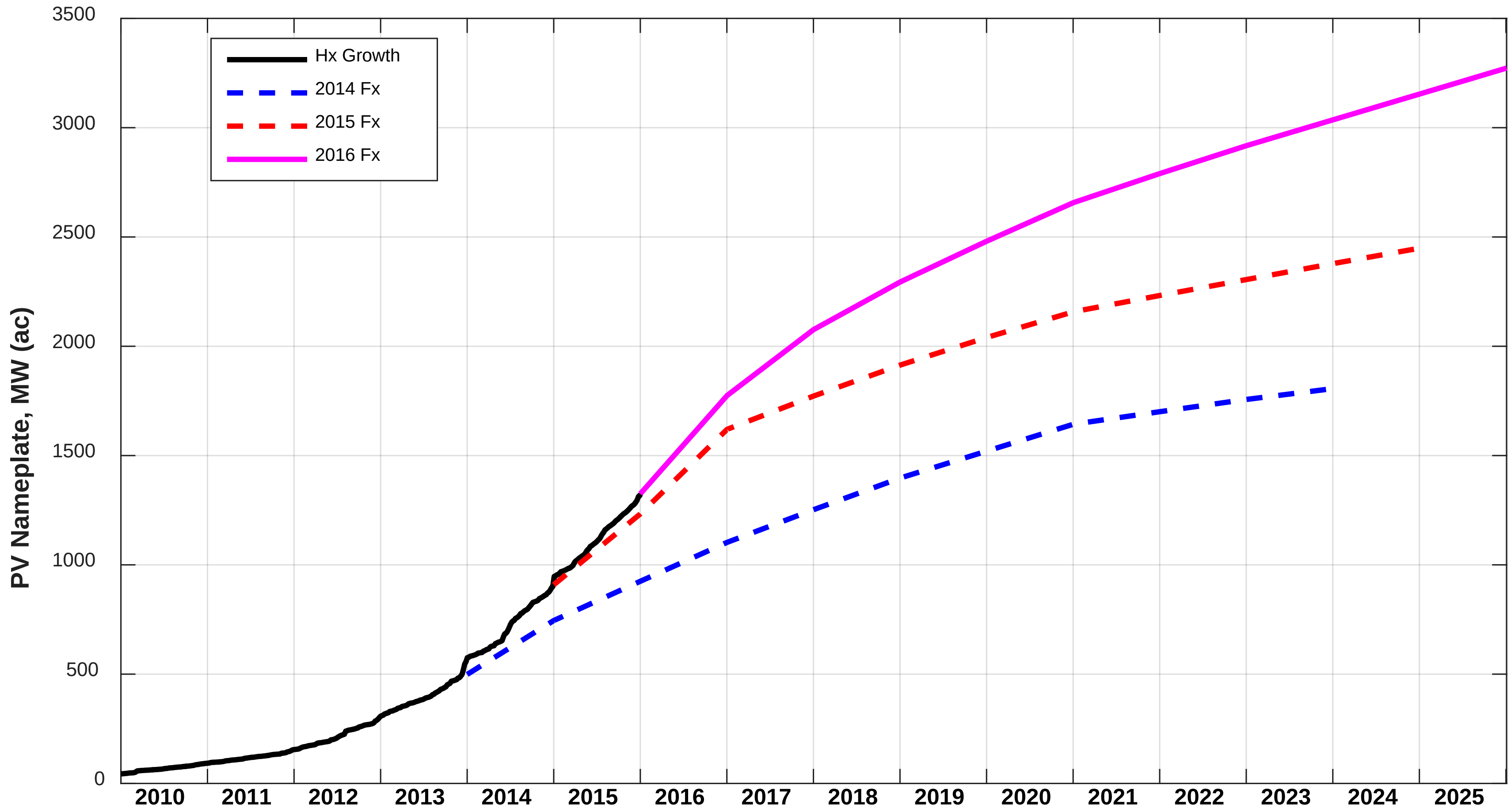
Final 2016 PV Forecast
Nameplate, MW_{ac}

Note: Values in **red boldface** have changed relative to the draft forecast

States	Annual Total MW (AC nameplate rating)											Totals
	Thru 2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	
CT	188.0	85.5	104.5	81.0	81.0	81.0	55.8	54.3	45.0	45.0	45.0	**866.1**
MA	947.1	**294.4**	122.7	**69.7**	**38.7**	**38.7**	**38.7**	**38.7**	**38.7**	**38.7**	**38.7**	**1,705.0**
ME	15.3	4.7	4.7	4.4	4.4	4.4	4.2	3.9	3.9	3.9	3.9	**57.9**
NH	26.4	13.3	7.6	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	**79.3**
RI	23.6	21.6	38.7	36.0	36.0	25.9	9.1	6.6	6.6	6.6	6.6	**217.2**
VT	124.6	30.2	**23.8**	22.5	22.5	22.5	21.3	20.0	20.0	20.0	20.0	**347.3**
Regional - Annual (MW)	**1325.0**	**449.6**	**301.9**	**217.7**	**186.7**	**176.5**	**133.2**	**127.5**	**118.2**	**118.2**	**118.2**	**3,272.8**
Regional - Cumulative (MW)	**1325.0**	**1774.7**	**2076.5**	**2294.2**	**2480.9**	**2657.4**	**2790.6**	**2918.1**	**3036.3**	**3154.6**	**3272.8**	**3,272.8**

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

PV Growth: Reported Historical vs. Forecast

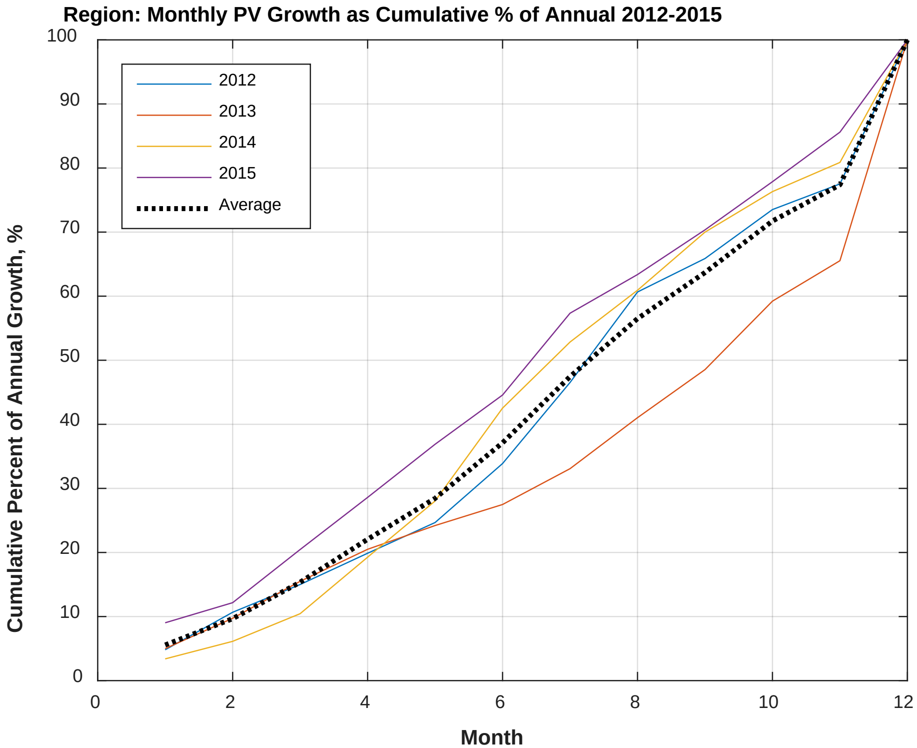


2016 PV ENERGY FORECAST

Development of PV Energy Forecast

- The 2016 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 2012 and 2015 were used to estimate intra-annual incremental growth over the forecast horizon (*see next slide*)
- The PV energy forecast was developed using a monthly nameplate forecast along with average monthly capacity factors from Yaskawa-Solectria data (*see slide 14*)
  - Annual capacity factor = 14.1%
  - Yaskawa-Solectria data is described further (*see slide 23*)

Historical Monthly PV Growth Trends, 2012-2015



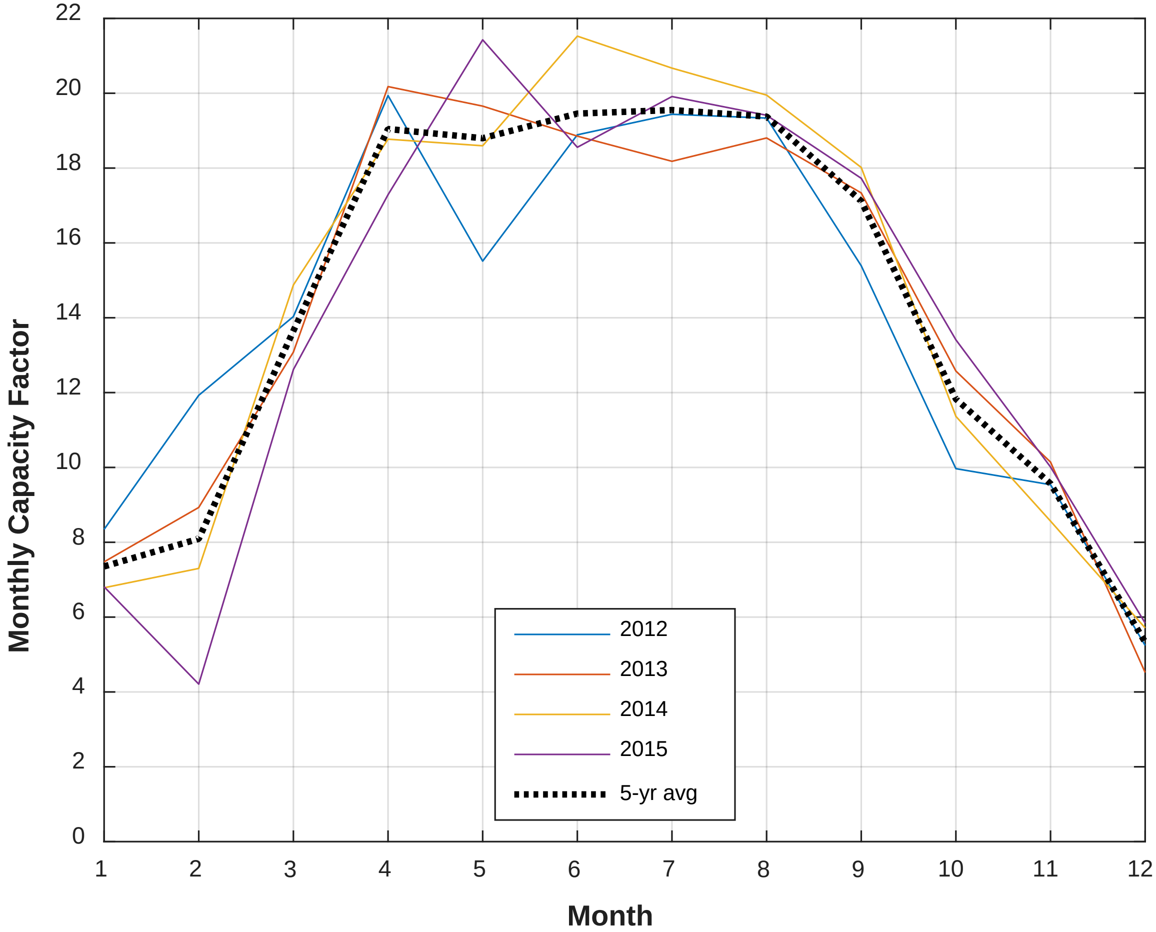
Average Monthly Growth Rates, % of Annual

Month	Monthly PV Growth (% of Annual)	Monthly PV Growth (Cumulative % of Annual)
1	6%	6%
2	4%	10%
3	6%	15%
4	7%	22%
5	6%	28%
6	9%	37%
7	10%	47%
8	9%	56%
9	7%	64%
10	8%	72%
11	6%	77%
12	23%	100%

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

Monthly PV Capacity Factors

Yaskawa-Solectria PV Site Data, 2012-2015



Source: http://www.solrenview.com/

Final 2016 PV Energy Forecast

All Resource Types, GWh

States	Total Estimated Annual Energy (GWh)									
	2016	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**
CT	287	409	535	642	749	844	917	984	1,043	1,103
MA	1383	1,692	1,829	1,907	1,958	2,009	2,060	2,111	2,162	2,213
ME	22	28	35	40	46	52	57	62	68	73
NH	41	56	64	69	75	80	85	91	96	101
RI	41	77	127	175	217	244	255	263	272	281
VT	178	215	246	275	305	334	361	388	414	440
Regional - Annual Energy (GWh)	**1953**	**2,477**	**2,836**	**3,109**	**3,350**	**3,563**	**3,735**	**3,899**	**4,055**	**4,211**

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) All values are grossed up by 6.5% to reflect avoided transmission and distribution losses

BREAKDOWN OF PV NAMEPLATE FORECAST INTO RESOURCE TYPES

Forecast Includes Classification by Resource Type

- In order to properly account for existing and future PV in planning studies and avoid double counting, ISO classified PV into three distinct types related to the resources assumed market participation/non-participation
- These market distinctions are important for the ISO's use of the PV forecast in a wide range of planning studies
- The classification process requires the estimation of hourly PV production that is behind-the-meter (BTM), i.e., PV that does not participate in ISO markets
  - This requires historical hourly BTM PV production data to reconstitute PV into the historical load data used to develop the long-term load forecast

Three Mutually Exclusive PV Resource Types

1. **PV as a resource in the Forward Capacity Market (FCM)**
   - Qualified for the FCM and have acquired a capacity supply obligations
   - Size and location identified and visible to the ISO
   - May be supply or demand-side resources
2. **Non-FCM Settlement Only Resources (SOR) 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

<u>Notes</u>:

For 2015 CELT, BTM was further subdivided into two categories, behind-the-Meter PV embedded in load (BTMEL) and behind-the-meter PV not embedded in load (BTMNEL); Full PV reconstitution allowed ISO to combine these two categories into one (BTM)

Determining PV Resource Type By State

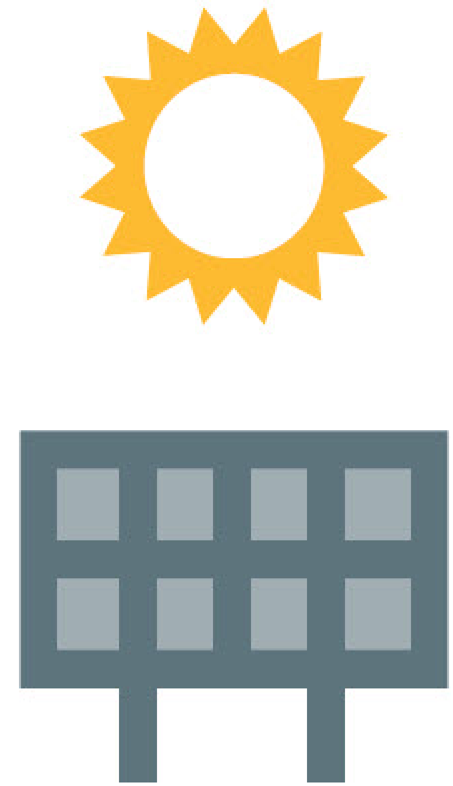
- Resource types vary by state
  - Can be influenced by state regulations and policies (*e.g.*, net metering requirements)
- The following steps were used to determine PV resource types for each state over the forecast horizon:
  1. **FCM**
     - Identify all Generation and Demand Response FCM PV resources for each Capacity Commitment Period (CCP) through FCA 10
  2. **Non-FCM SOR/Gen**
     - Determine the % share of non-FCM PV participating in energy market at the end of 2015 and assume this share remains constant throughout the forecast period
  3. **BTM**
     - Subtract the values from steps 1 and 2 from the annual state PV forecast, the remainder is the BTM PV

PV in ISO New England Markets

- **FCM**
  - ISO identified all PV generators or demand resources (DR) that have Capacity Supply Obligations (CSO) in FCM up through FCA 10
  - Assume aggregate total PV in FCM as of FCA 10 remains constant from 2019-2025
- **Non-FCM Gen/SOR (Energy Only Resources (EOR))**
  - ISO identified total nameplate capacity of PV in each state registered in the energy market as of 12/31/15
  - Assume % share of nameplate PV in energy market as of 12/31/15 remains constant throughout the forecast horizon
- Other assumptions:
  - Supply-side FCM PV resources operate as SOR/Gen prior to their first FCM commitment period (this has been observed in Massachusetts)
  - 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

- In order to estimate hourly BTM PV production, ISO developed hourly state PV profiles for the period 1/1/2012 –1/31/2015 using publicly-available historical production (*see slide 23*)
  - Data aggregated into normalized PV profiles for each state, which represent a per-MW-of-nameplate production profile for PV



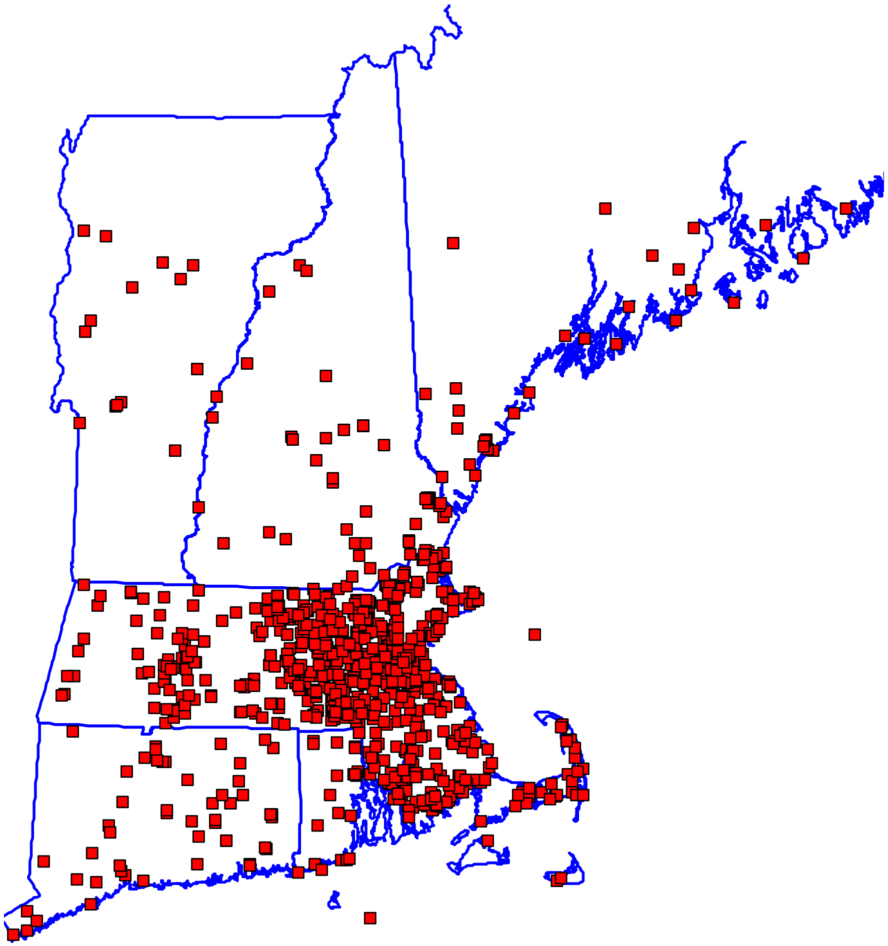
Estimation of Hourly BTM PV (*continued*)

- Using the normalized PV profiles, total state PV production was then estimated by scaling the profiles up to the total PV installed over the period according to recently-submitted distribution utility data
  - (Normalized Hrly Profile) x (Total installed PV Capacity) = Hourly PV production
- Subtracting the hourly PV settlements energy (where applicable) yields the total BTM PV energy for each state
  - BTM profiles were used for PV reconstitution in the development of the gross load forecast

Historical PV Profile Development and Analysis

- Hourly state PV profiles developed for four years (2012-2015) using production data using Yaskawa-Solectria Solar's web-based monitoring system, SolrenView*
  - Represents PV generation at the inverter or at the revenue-grade meter
- A total of more than 1,200 individual sites representing more than 125 MW_{ac} in nameplate capacity were used
  - Total nameplate capacity represents approximately 10% of installed PV capacity in the region as of 12/31/15
  - The site distribution throughout the region is sufficient for estimating profiles of all PV installations in New England
  - Site locations depicted on adjacent map

Yaskawa-Solectria Sites



*__Source:__ http://www.solrenview.com/

FINAL 2016 PV NAMEPLATE FORECAST BY RESOURCE TYPE

Final 2016 PV Forecast

Cumulative Nameplate, MW_{ac}

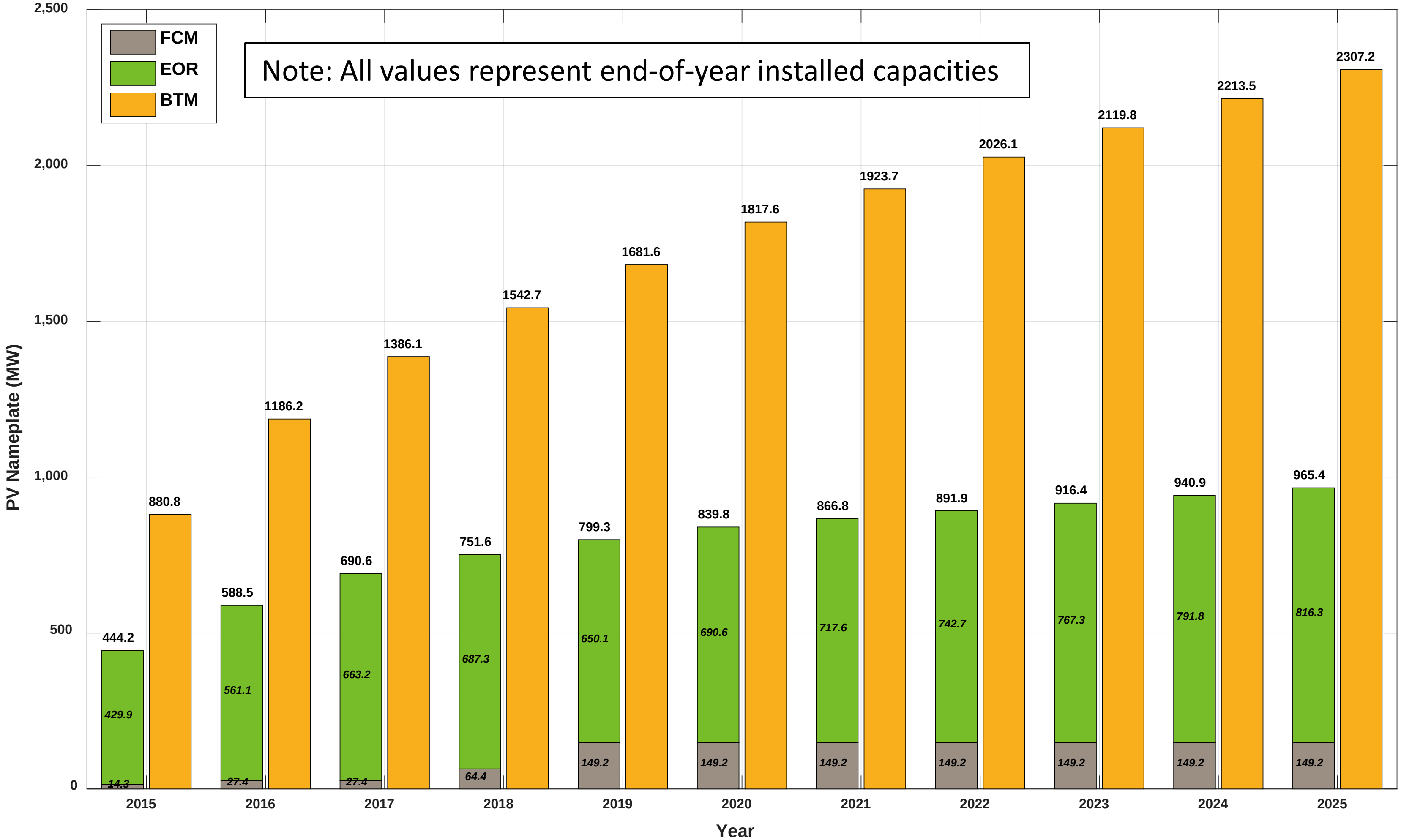
States	Cumulative Total MW (AC nameplate rating)										
	Thru 2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
CT	188.0	273.5	378.0	459.0	540.0	621.0	676.9	731.2	776.2	821.1	866.1
MA	947.1	1241.5	1364.2	1433.9	1472.6	1511.3	1550.1	1588.8	1627.6	1666.3	1705.0
ME	15.3	20.0	24.6	29.1	33.5	37.9	42.1	46.1	50.0	53.9	57.9
NH	26.4	39.7	47.3	51.3	55.3	59.3	63.3	67.3	71.3	75.3	79.3
RI	23.6	45.2	83.9	119.9	155.9	181.8	190.9	197.5	204.1	210.7	217.2
VT	124.6	154.8	178.5	201.0	223.5	246.0	267.3	287.3	307.3	327.3	347.3
Regional - Cumulative (MW)	**1325.0**	**1774.7**	**2076.5**	**2294.2**	**2480.9**	**2657.4**	**2790.6**	**2918.1**	**3036.3**	**3154.6**	**3272.8**

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

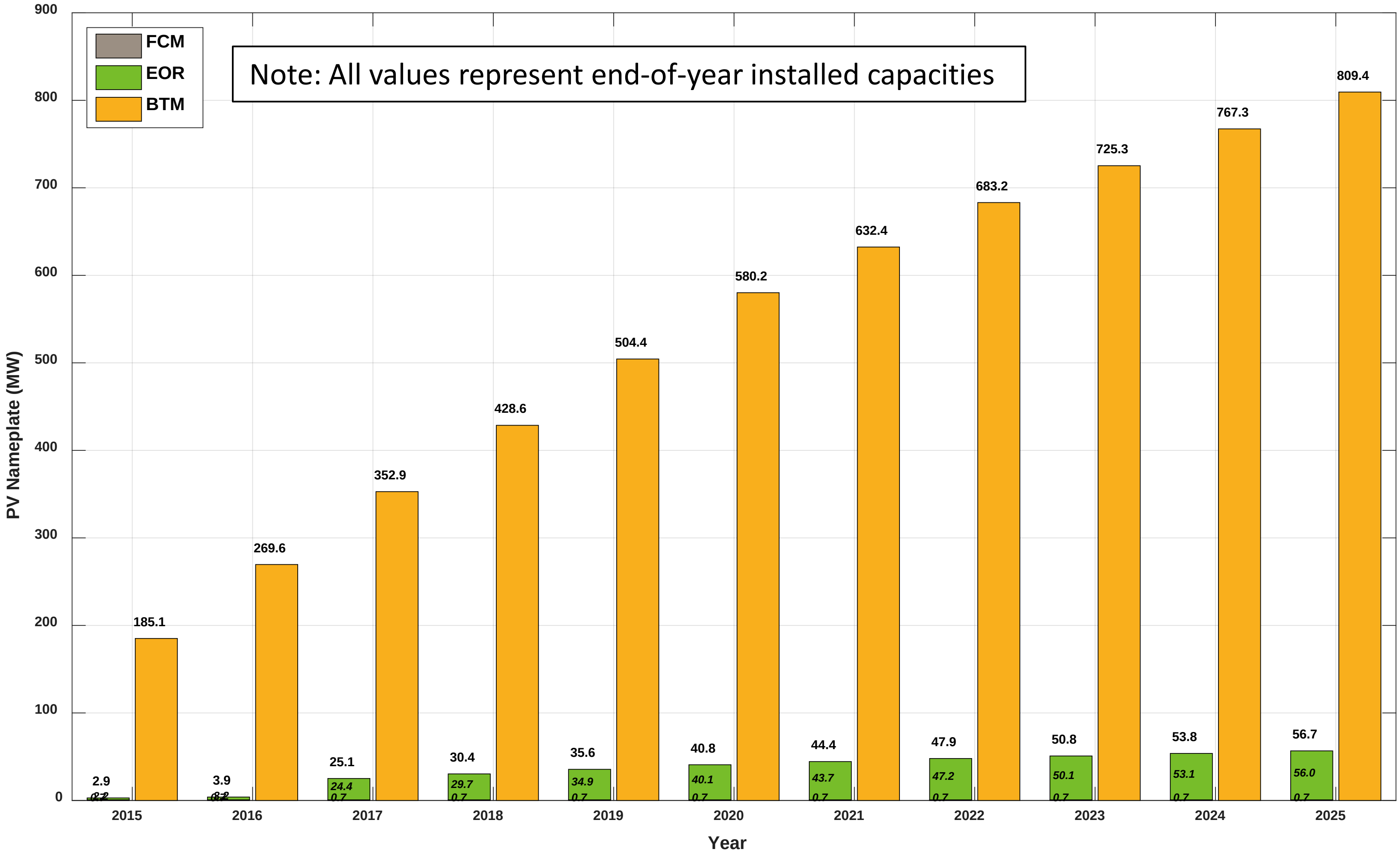
Final 2016 PV Forecast

Cumulative Nameplate, MW_{ac}



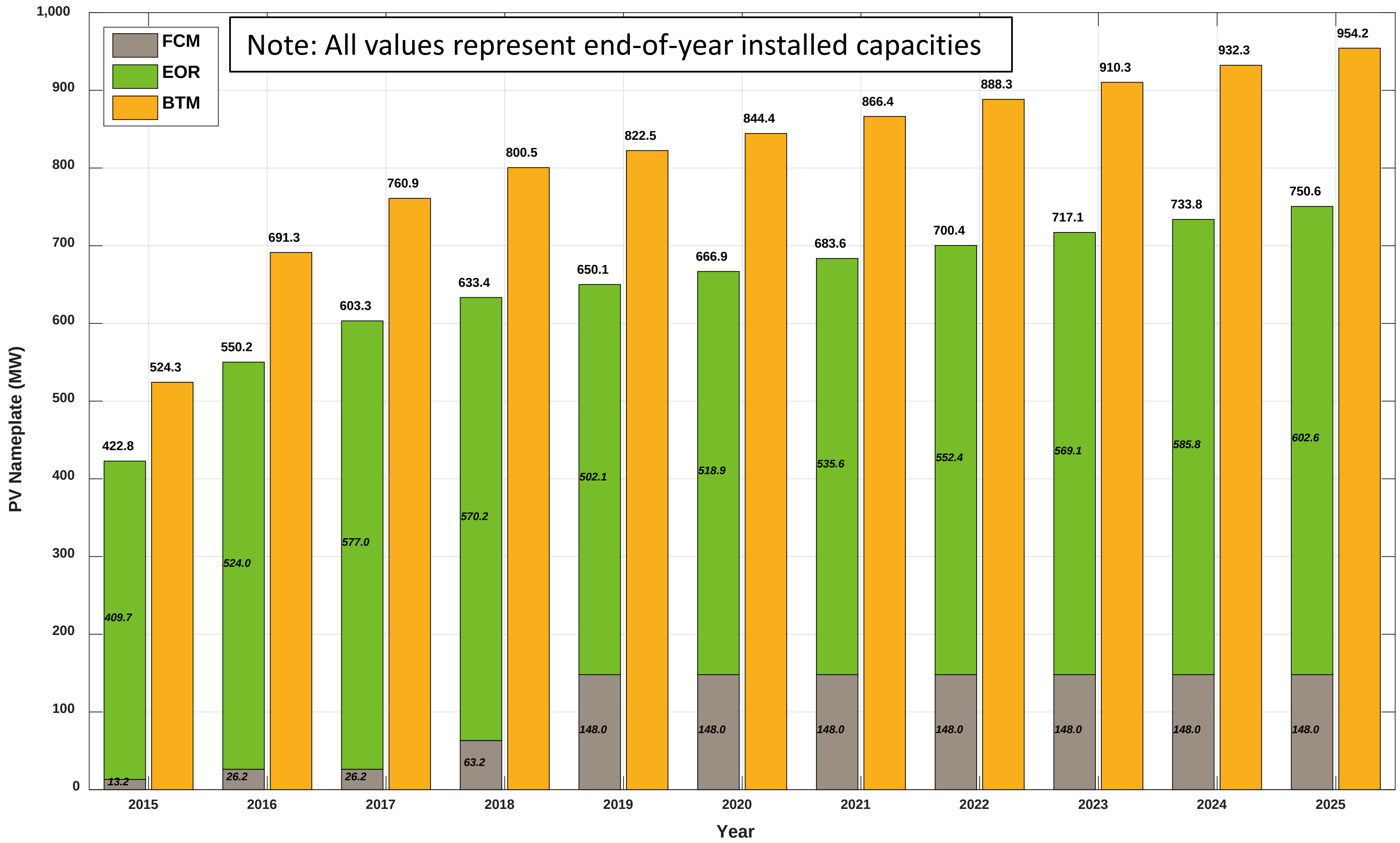
Cumulative Nameplate by Resource Type, MW_{ac}

Connecticut



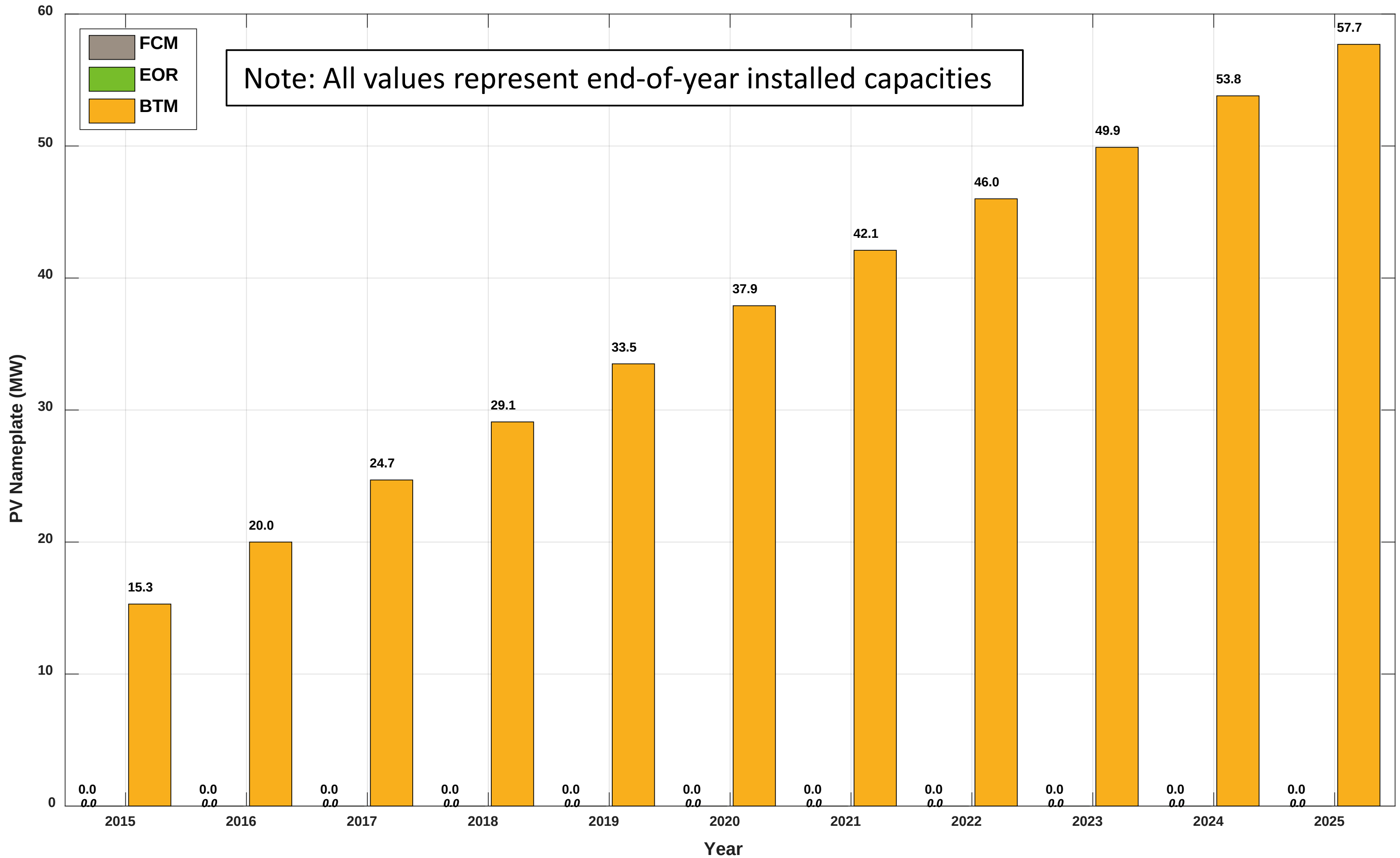
Cumulative Nameplate by Resource Type, MW_{ac}

Massachusetts



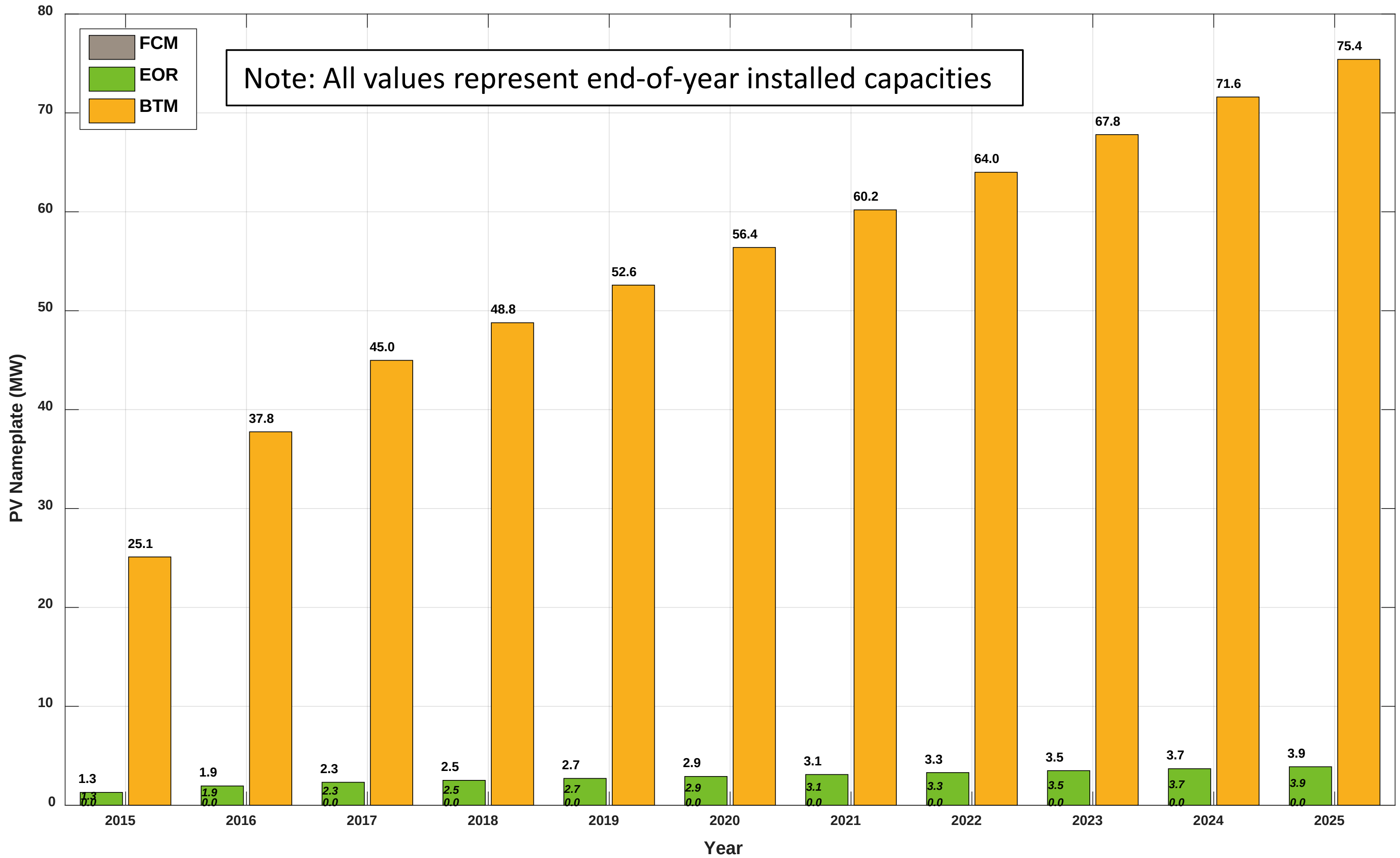
Cumulative Nameplate by Resource Type, MW_{ac}

Maine



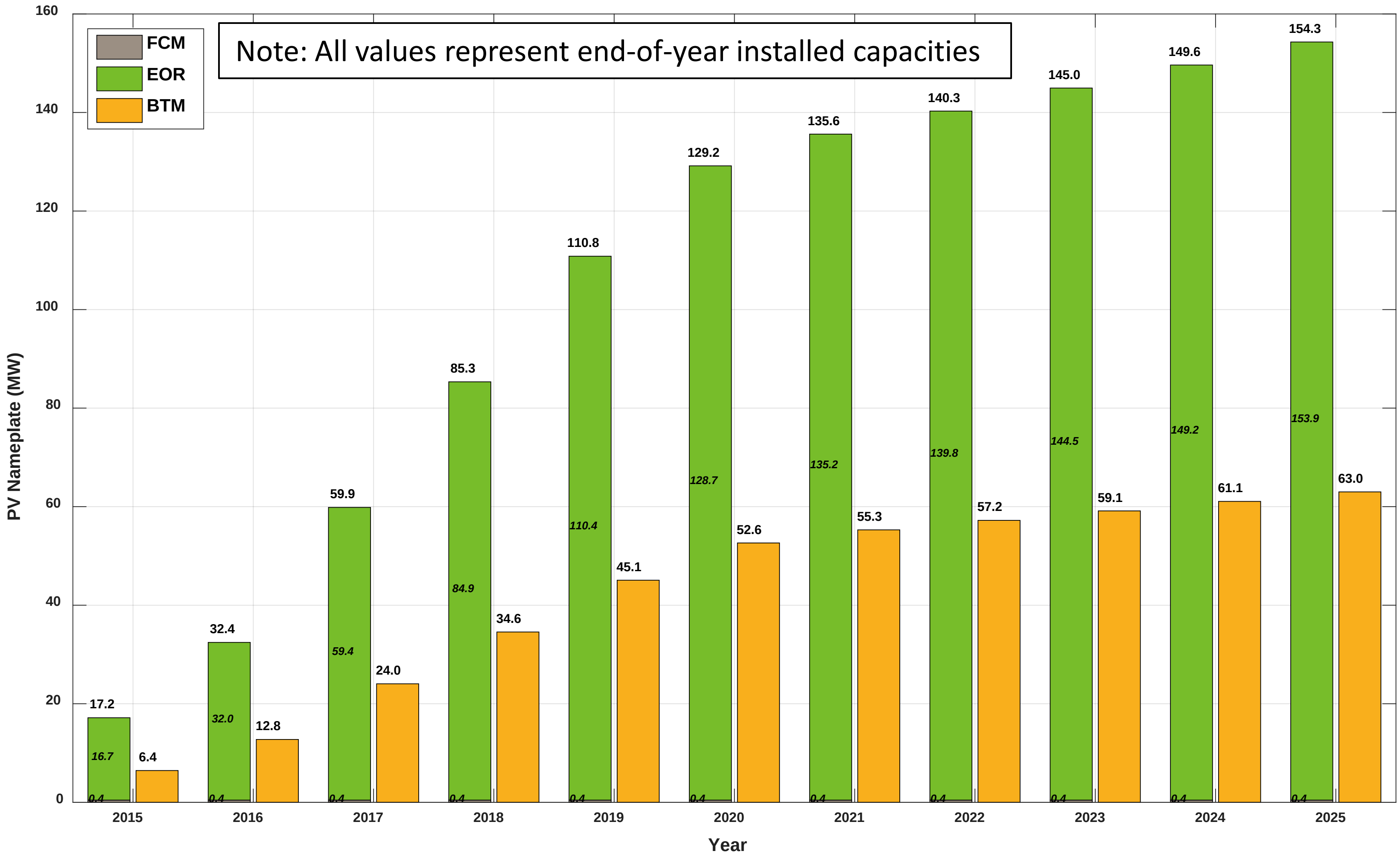
Cumulative Nameplate by Resource Type, MW_{ac}

New Hampshire



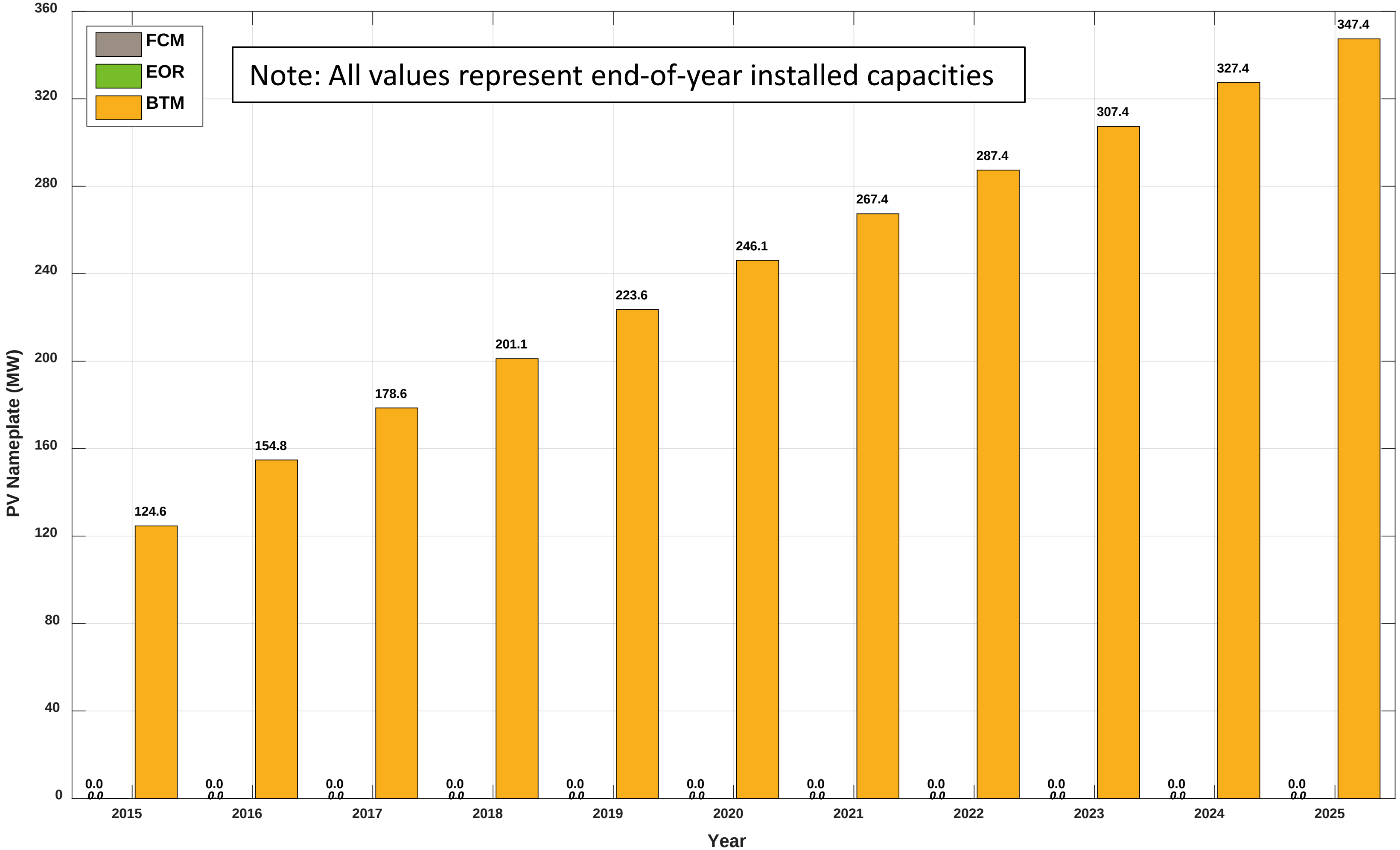
Cumulative Nameplate by Resource Type, MW_{ac}

Rhode Island



Cumulative Nameplate by Resource Type, MW_{ac}

Vermont



BTM PV: ESTIMATED ENERGY & SUMMER PEAK LOAD REDUCTIONS

BTM PV Forecast Used in CELT Net Load Forecast

- The 2016 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 2016 CELT net load forecast
  - PV does not reduce winter peak loads
- Values for expected summer peak load reductions from BTM PV incorporates the results of ISO's analysis discussed at the 2/24/16 DGFWG meeting
  - This analysis is described on slides 33-59 here: http://www.iso-ne.com/static-assets/documents/2016/03/2016_draftpvforecast_20160224revised.pdf

Final 2016 PV Energy Forecast

BTM PV, GWh

States	Total Estimated Annual Energy (GWh)									
	2016	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**
CT	283	394	500	600	699	788	857	919	975	1,030
MA	768	943	1,021	1,065	1,094	1,123	1,152	1,181	1,209	1,238
ME	22	29	35	40	46	52	57	62	68	73
NH	39	53	61	66	71	76	81	86	91	96
RI	11	22	37	50	63	71	74	76	79	81
VT	178	215	246	275	305	334	362	388	414	441
Regional - Annual Energy (GWh)	**1301**	**1,655**	**1,898**	**2,097**	**2,278**	**2,444**	**2,582**	**2,713**	**2,836**	**2,959**

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) All values are grossed up by 6.5% to reflect avoided transmission and distribution losses

Final 2016 Forecast

BTM PV: July 1st Estimated Summer Peak Load Reductions

States	Estimated Summer Peak Load Reduction - BTM PV (MW)									
	2016	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**
CT	**92.1**	123.9	153.6	181.0	207.7	230.6	247.6	262.8	275.7	288.2
MA	249.4	295.6	312.6	320.4	324.0	327.9	332.5	337.1	341.8	346.2
ME	7.3	9.0	10.6	12.2	13.7	15.2	16.6	17.8	19.1	20.3
NH	12.7	16.7	18.7	19.9	21.1	22.2	23.4	24.6	25.8	26.9
RI	3.7	7.0	11.3	15.2	18.7	20.6	21.3	21.8	22.3	22.7
VT	57.8	67.4	75.4	83.0	90.5	97.7	104.5	110.9	117.1	123.3
Regional - Cumulative Peak Load Reduction (MW)	**422.9**	**519.5**	**582.2**	**631.6**	**675.6**	**714.3**	**745.9**	**775.0**	**801.7**	**827.6**

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
(3) All values represent anticipated July 1st installed PV, and are grossed up by 8% to reflect avoided transmission and distribution losses
(4) Different planning studies may use values different that these estimated peak load reductions based on the intent of the study

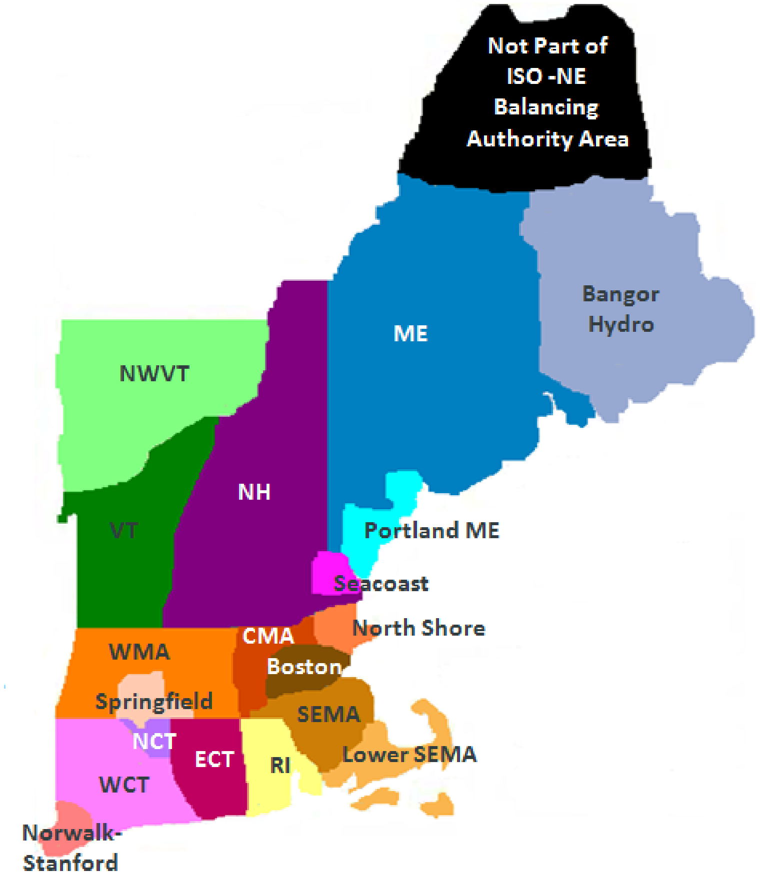
GEOGRAPHIC DISTRIBUTION OF PV FORECAST

Background

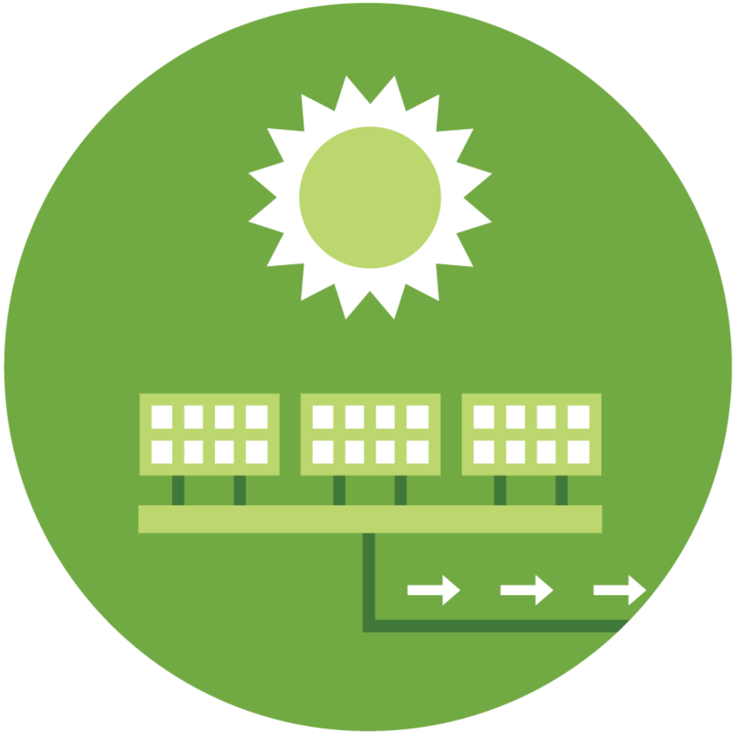
- A reasonable representation of the locations of existing and future PV resources is required for appropriate modeling
- The locations of most future PV resources are ultimately unknown
- Mitigation of some of this uncertainty (especially for near-term development) is possible via analysis of available data

Forecasting Solar By DR Dispatch Zone

- Demand Response (DR) Dispatch Zones were created as part of the DR Integration project
- These zones were created in consideration of electrical interfaces
- Quantifying existing and forecasted PV resources by Dispatch Zone (with nodal placement of some) will aid in the modeling of PV resources for planning and operations purposes



Geographic Distribution of PV Forecast



- Existing MWs:
  - Apply I.3.9 project MWs nodally
  - For remaining existing MWs, determine Dispatch Zone locations of projects already interconnected based on utility distribution queue data (town/zip), and apply MWs equally to all nodes in Zone
- Future MWs:
  - Apply I.3.9 project MWs nodally
  - For longer-term forecast, assume the same distribution as existing MWs

Dispatch Zone Distribution of PV

Based on December 31, 2015 Utility Data

State	Dispatch Zone	% Share
MA	SEMA	21.5%
	Boston	10.9%
	Lower SEMA	18.7%
	Central MA	15.3%
	Spfld	6.0%
	North Shore	4.9%
	Western MA	22.7%
CT	Eastern CT	18.8%
	Western CT	53.7%
	Northern CT	20.1%
	Norwalk-Stamford	7.5%
NH	New Hampshire	88.3%
	Seacoast	11.7%
VT	Northwest VT	62.9%
	Vermont	37.1%
RI	Rhode Island	100.0%
ME	Bangor Hydro	15.6%
	Maine	51.2%
	Portland	33.3%

SUMMARY AND NEXT STEPS

Stakeholder and State Regulator Input Has Resulted in Improved Forecast

- The 2016 PV nameplate and energy forecasts have been finalized
- ISO has classified the 2016 state and regional PV forecasts according to the three PV resource categories
- The ISO has updated its geographic distribution assumptions based on recent data
- The final PV forecast will appear in the 2016 CELT, which will be published by May 1st

Questions