Classification of PV Forecast Into Four Types

Distributed Generation Forecast Working Group

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Outline

- Objective
- Background
- Description of methods used to classify the 2015 PV forecast according to the four market participation types
- Description of behind-the-meter profile development
- Description of PV reconstitution – methods and results
- Summarize resulting classification of 2015 PV forecast by type over the forecast horizon
  - At both the regional and state level

Objective

- ISO is providing this information to the DGFWG to explain the methodologies used to classify PV into market participation types, and to receive feed back on the process and data used
- This information will be shared with the appropriate NEPOOL committee/subcommittee for consideration in how it may be used in planning studies

PV Forecast Classification of Market Type By State

Background

- In order to properly account for existing and future PV in planning studies and avoid double counting, ISO must classify PV by its market participation (or lack thereof)
  - The four market types are defined on the next slide
- These market distinctions will become important as the ISO looks to use the PV forecast in a wider range of studies
  - Further and more detailed discussions will take place in other stakeholder meetings
- The classification process required the estimation of hourly PV production that is behind-the-meter (BTM), i.e., PV that does not participate in ISO markets
  - E.g., determining the amount of PV which is already embedded in the long-term load forecast requires historical hourly BTM PV production data
  - DGFWG stakeholders have indicated that actual hourly PV production data is limited in the region

Market Participation Types

Mutually Exclusive to Prevent Double Counting PV

- PV as a capacity resource in the Forward Capacity Market (FCM)
  - Qualified for the FCM
  - Have capacity supply obligations
  - Size and location identified and visible to the ISO
  - May be supply or demand-side resources
- Non-FCM Settlement only Resources (SOR) and Generators (per OP-14)
  - ISO collects energy output
  - Participate only in the energy market
- Behind-the-Meter (BTM) PV
  - 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
  - Can be further divided into two categories:
    - Behind-the-Meter PV Embedded in Load (BTMEL)
      - The portion of BTM that is captured in the historical load forecast
      - Can be estimated via reconstitution of hourly historical BTM PV production
    - Behind-the-Meter PV Not Embedded in Load (BTMNEL)
      - The portion of BTM that is not captured in the historical load forecast (i.e., not embedded)

Determining Market Type By State

Methodology Overview

- Relative market participation varies by state
  - Can be influenced by state regulation (e.g., net metering requirements)
- The following steps were used to determine PV market types for each state over the forecast horizon:
  1. FCM: Identify all Generation and Demand Response FCM PV resources for each Capacity Commitment Period
  2. Non-FCM SOR/Gen: Determine the % share of non-FCM PV participating in energy market at the end of 2014 and assume this share remains constant throughout the forecast period
  3. BTMEL: Estimate and reconstitute the hourly BTM PV into the historical loads and determine the amount of PV that is embedded in the load forecast
  4. BTMNEL: Subtract the values from steps 1-3 from the annual state PV forecast, the remainder is the BTM PV not embedded in the load forecast
- These steps are described in greater detail in subsequent slides

SOLAR PV PARTICIPATING IN ISO MARKETS

PV in ISO Markets

- FCM
  - ISO identified all PV generators or demand resources (DR) that have cleared in FCM from FCA5-FCA9
  - Assume aggregate total PV in FCM as of FCA9 remains constant from 2019-2014
- Non-FCM Gen/SOR
  - ISO identified total nameplate capacity of PV in each state registered in the energy market as of 12/31/14
  - Assume % share of nameplate PV in energy market as of 12/31/14 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 MA
  - Planned PV projects known to be > 5 MW_{ac} nameplate is assumed to trigger OP-14 requirement to register in ISO energy market as a Generator

BEHIND-THE-METER PV

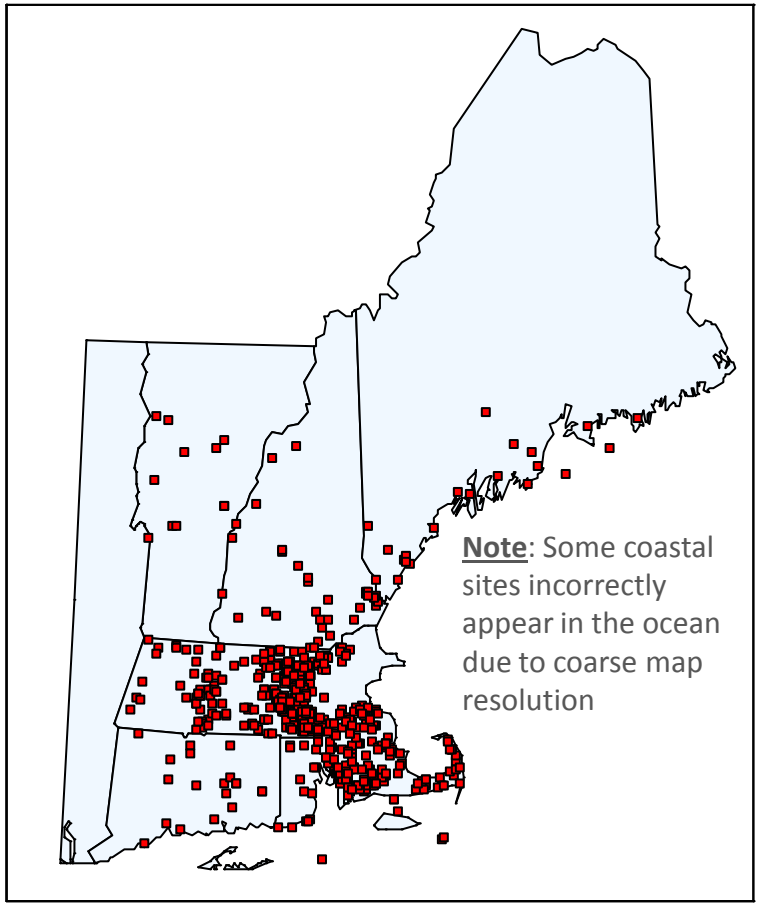
Methodology Used To Estimate Hourly BTM PV

- 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 next slide)
  - Data were aggregated into normalized state PV profiles for each state, which represent a per-MW PV production profile
- 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
- Slides describing validation of the resulting estimated PV production are included in the Appendix

Historical PV Profile Development and Analysis

- Hourly state PV profiles were developed using production data from PV projects using Solectria Renewables' web-based monitoring system, SolrenView™
- These data represent PV generation at the inverter or at the revenue-grade meter
- A total of 665 individual sites representing 82 MW_{ac} in nameplate capacity were used
  - Total capacity represents approximately 9% of installed PV capacity in the region as of 12/31/14
  - Site locations depicted in map on right
- The geographical site distribution throughout New England and is sufficient for estimating profiles of all PV installations in New England
- The project size distribution (see next slide) is sufficiently consistent with that of PV projects currently installed across the region

SolrenView™ Site Locations



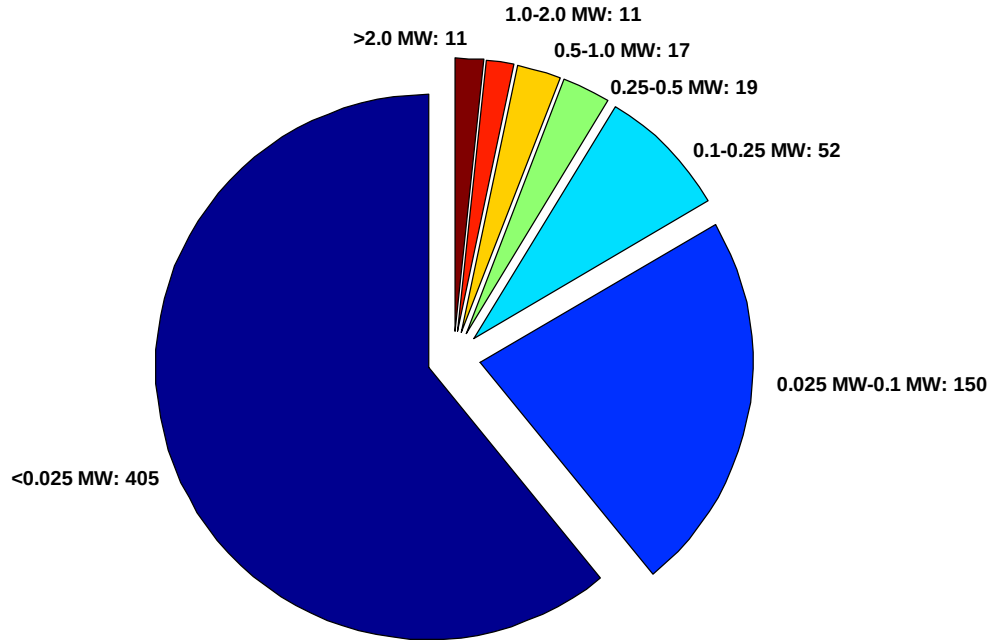
Source: http://www.solrenview.com/

SolrenView™ PV Sites

Project Size Distribution

 # PV Sites

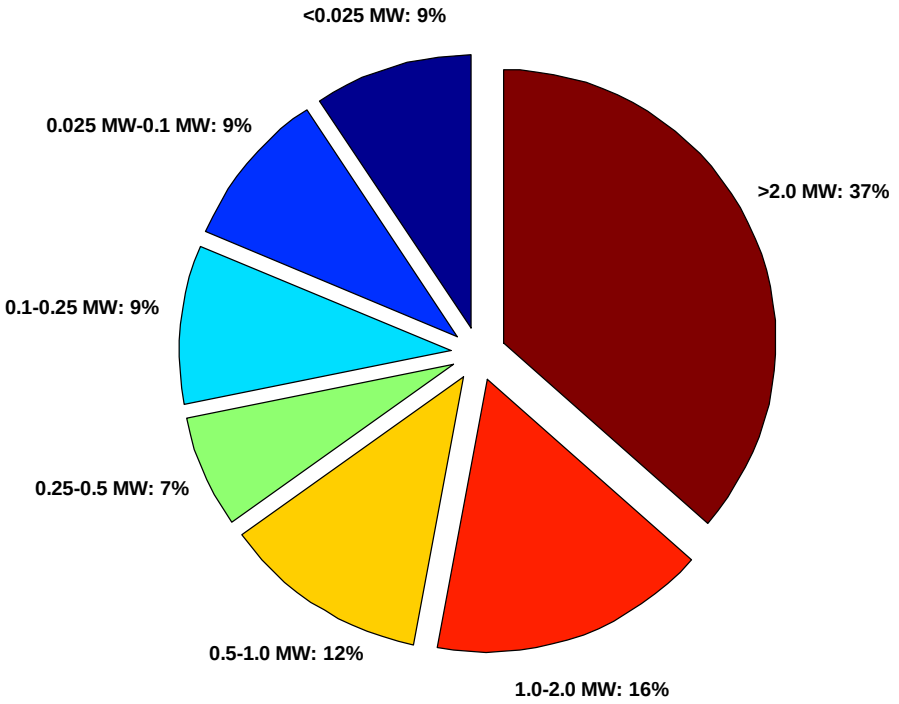
(665 total sites)



Project Size Distribution

% of Total Capacity

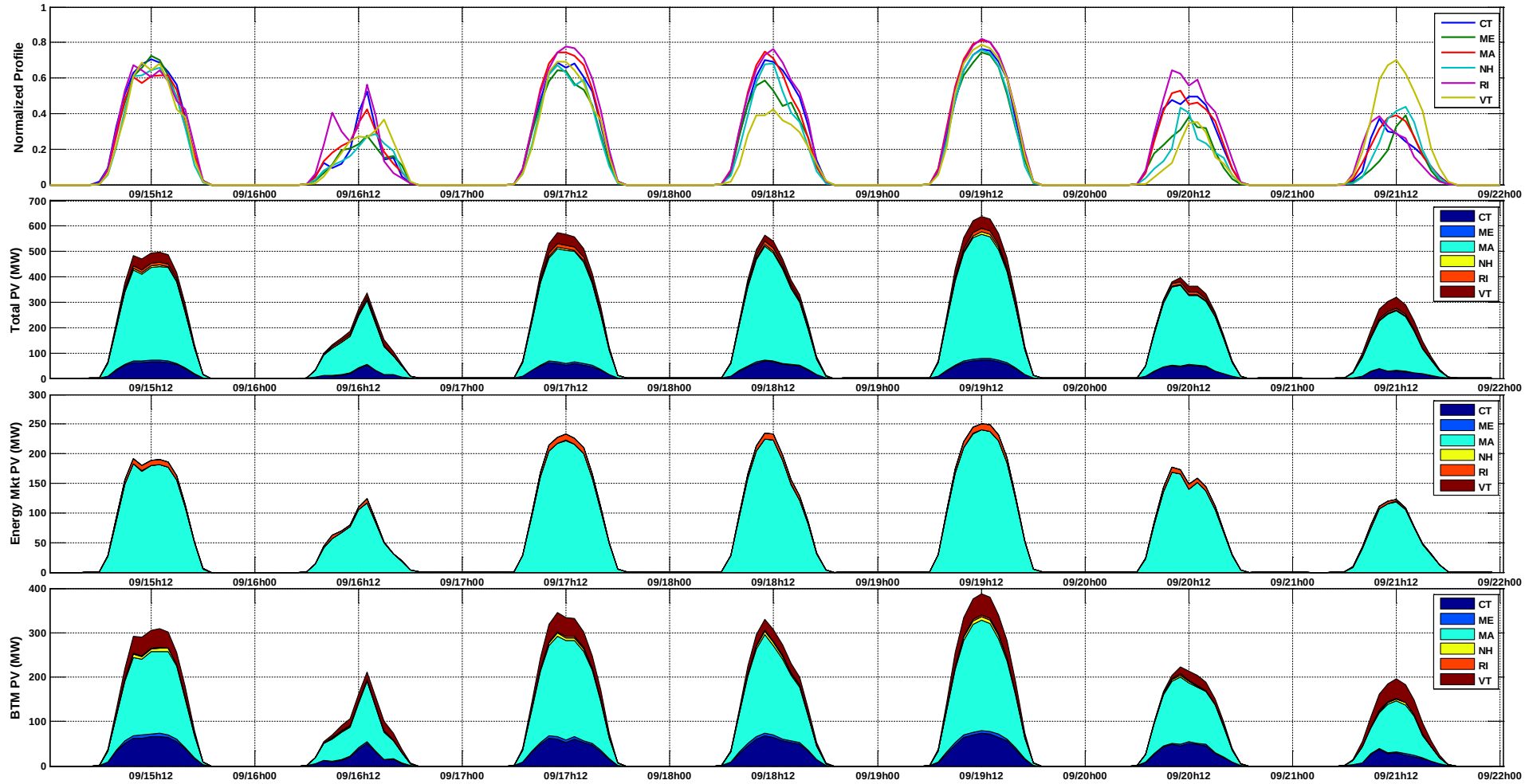
(82 MW_{ac} total)



Example Hourly Results

- The figure on the next slide contains 4 contemporaneous plots representing the hourly results of the previously described methods for the week of September 15-21, 2014:
  1. The top plot shows the normalized PV profiles resulting for each state
  2. The second plot shows each state's estimated total production resulting from multiplying the normalized profiles by the total PV installed over time
  3. The third plot is the total hourly PV production that settled in the energy market in each state
  4. The fourth plot shows the difference between the each state's estimated total PV and the PV in the energy market, and thus represents the estimated hourly BTM PV for each state
- Note the y-axis scale differences appearing on each plot

Example Hourly Results: September 15-21, 2014

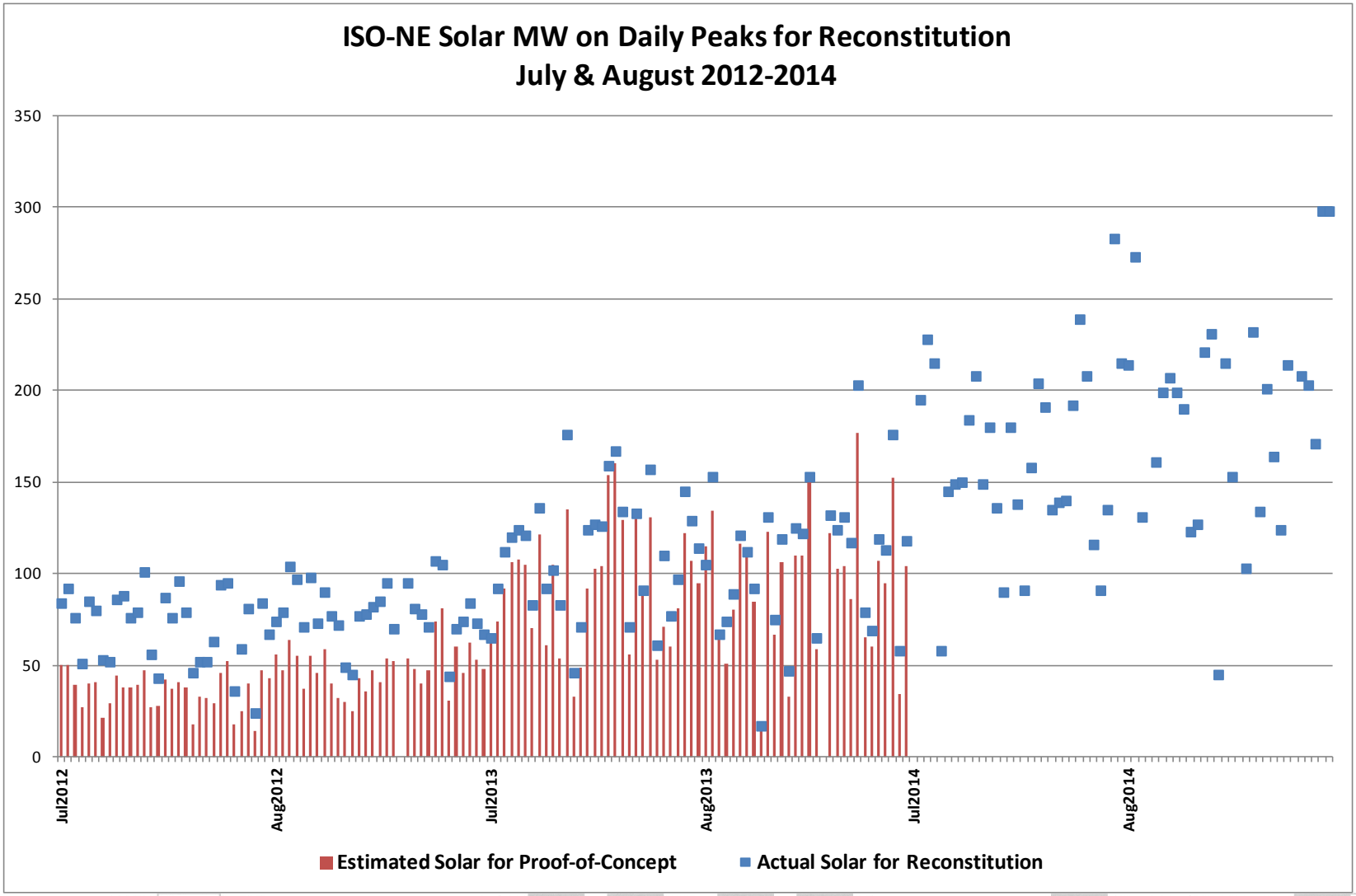


PV RECONSTITUTION & QUANTIFYING BTMEL

Overview

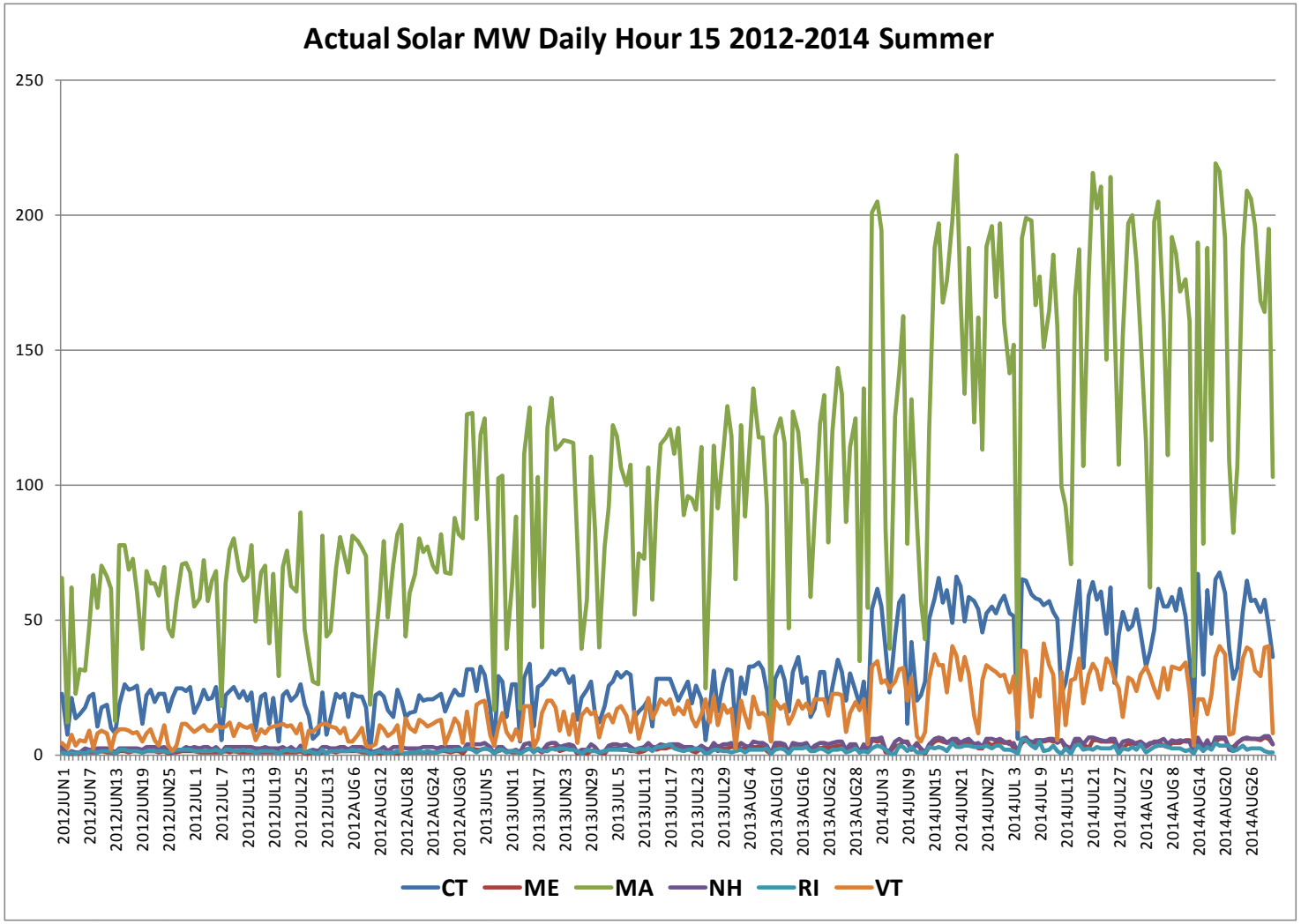
- A substantial amount of the ISO-NE BTM PV forecast is in service and producing MWs that have reduced the historical hourly loads that ISO-NE uses to estimate the peak and energy models and develop energy and peak load forecasts
  - The presence of this already in service BTM PV will have an impact on the models and forecasts
- In order to avoid double counting PV – that is, to identify and account for its impact on the forecast – we will on a regional and state basis:
  - Reconstitute the hourly historical load data with the actual PV production of the BTM PV
  - Re-estimate the energy and peak models, and re-forecast energy and peaks
  - Subtract the original forecast from the "reconstituted" forecast to identify the MW impact of the in service PV on the forecast
  - This MW impact is "embedded" in the energy and peak forecasts, and will have to be subtracted from the BTM PV
- ISO presented a simplified, preliminary proof-of-concept application of this process to the regional 2014 load forecast to the DGFWG on 9/15/14:
  - See: http://www.iso-ne.com/static-assets/documents/2014/09/preliminary_reconstitution_behind_meter_pv_09152014.pdf
- A simple linear trend analysis on the historical data, with and without the solar reconstitution, will serve as an example of what we are trying to do

2015 PV Reconstitution vs. 2014 Proof-of-Concept



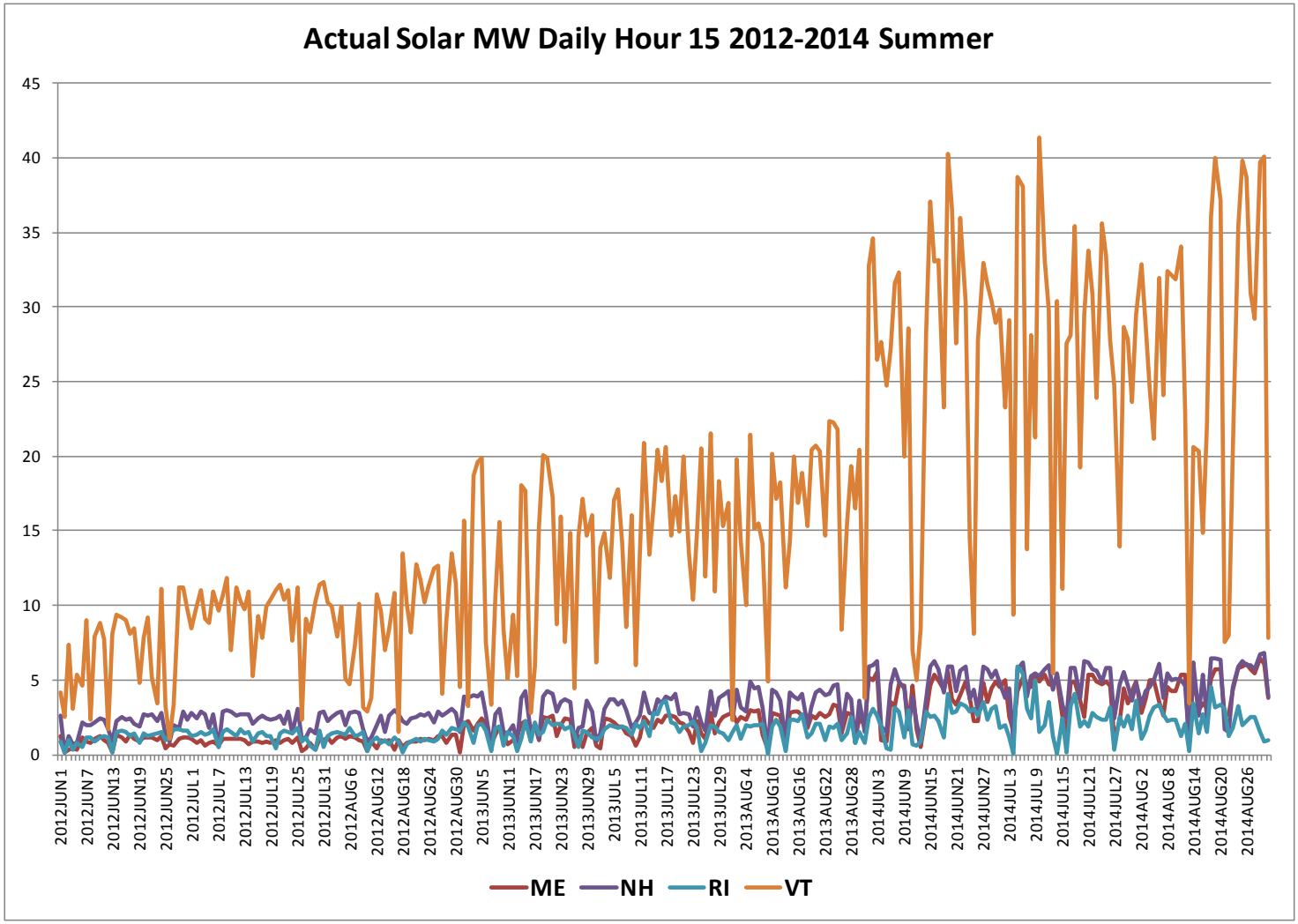
BTM PV, Hour 15: 2012-2014

All States

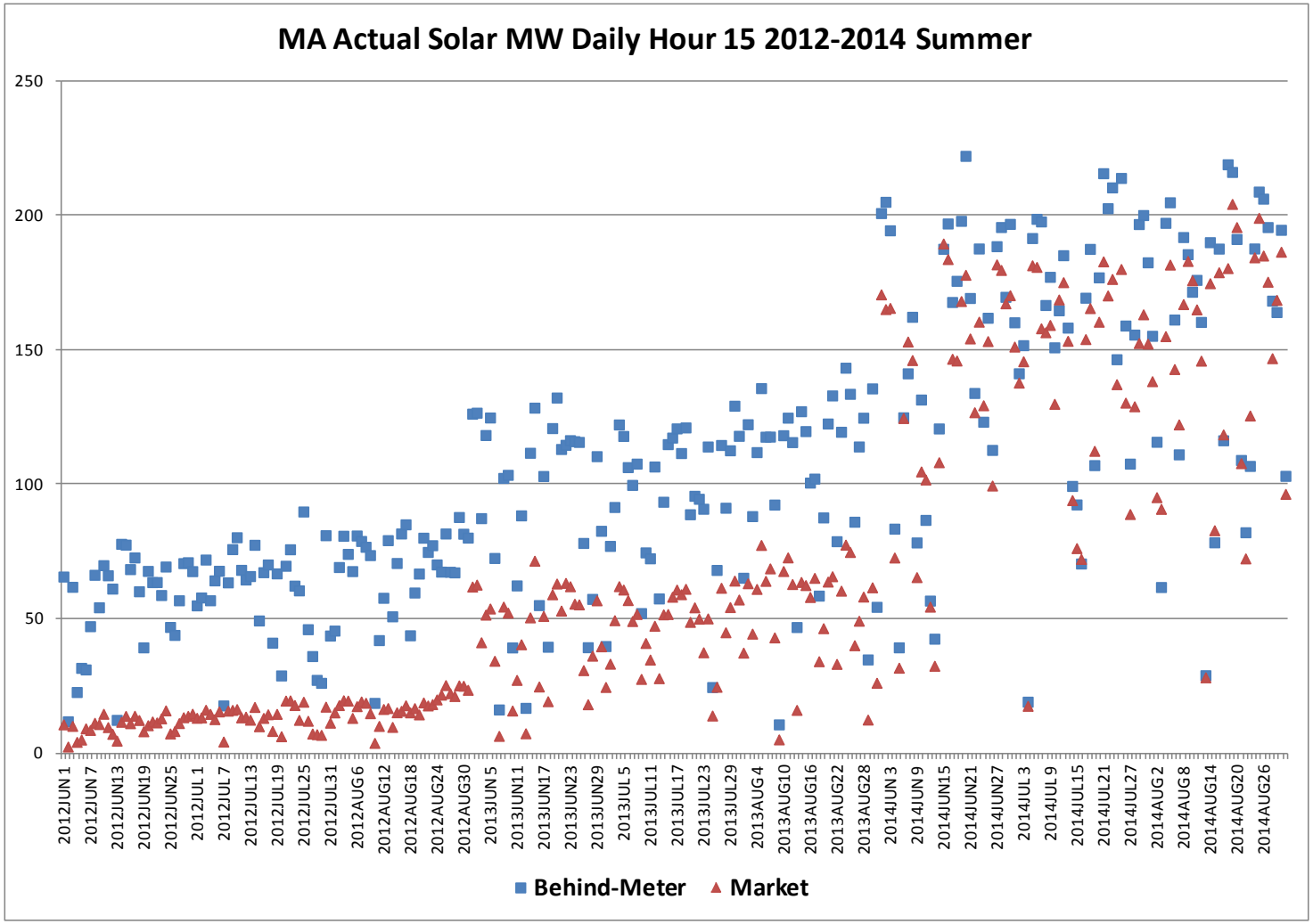


BTM PV, Hour 15: 2012-2014

Without MA & CT (To better illustrate ME/NH/RI/VT profiles)

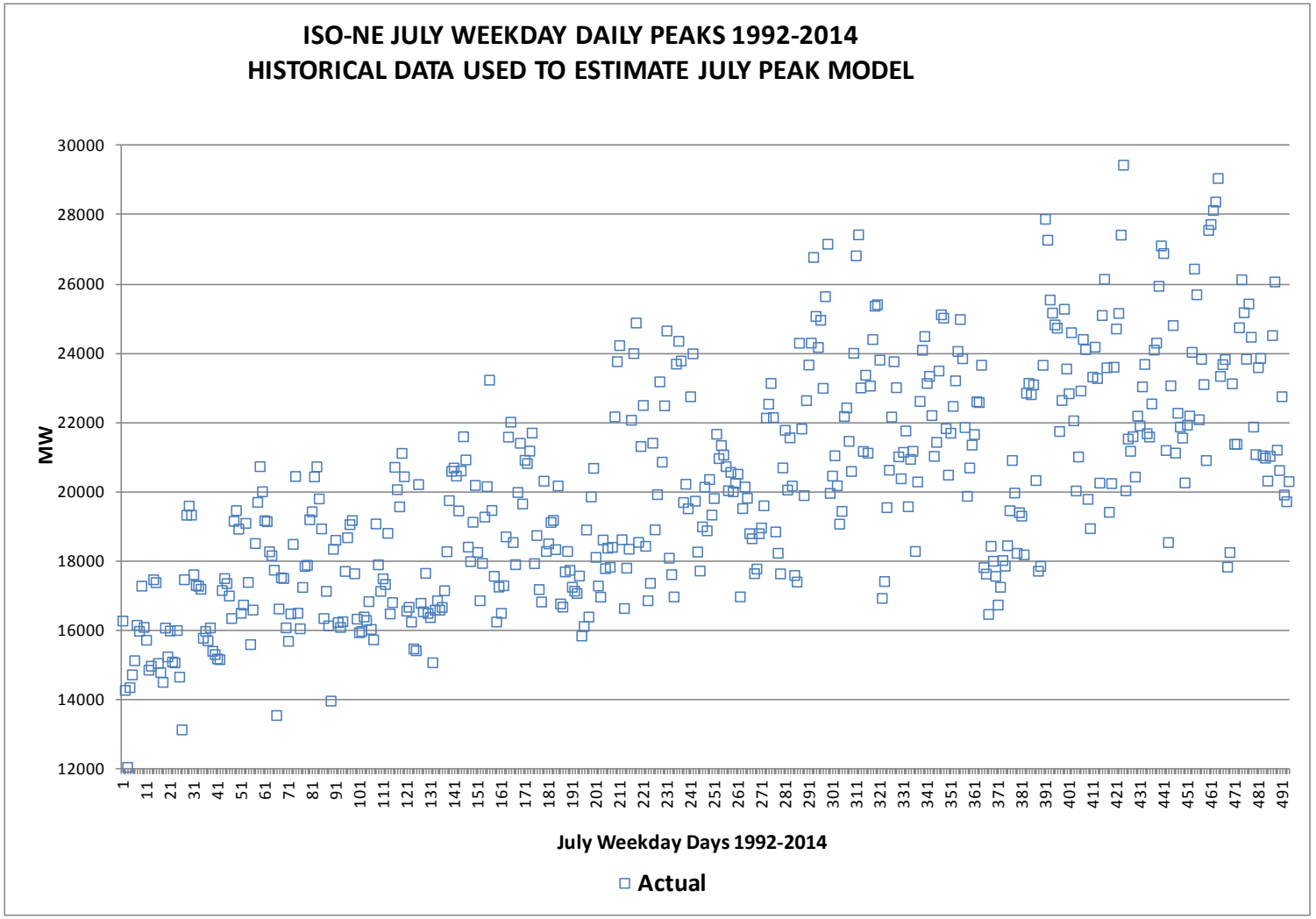


BTM and Market PV in MA: Summer Hr 15, 2012-2014



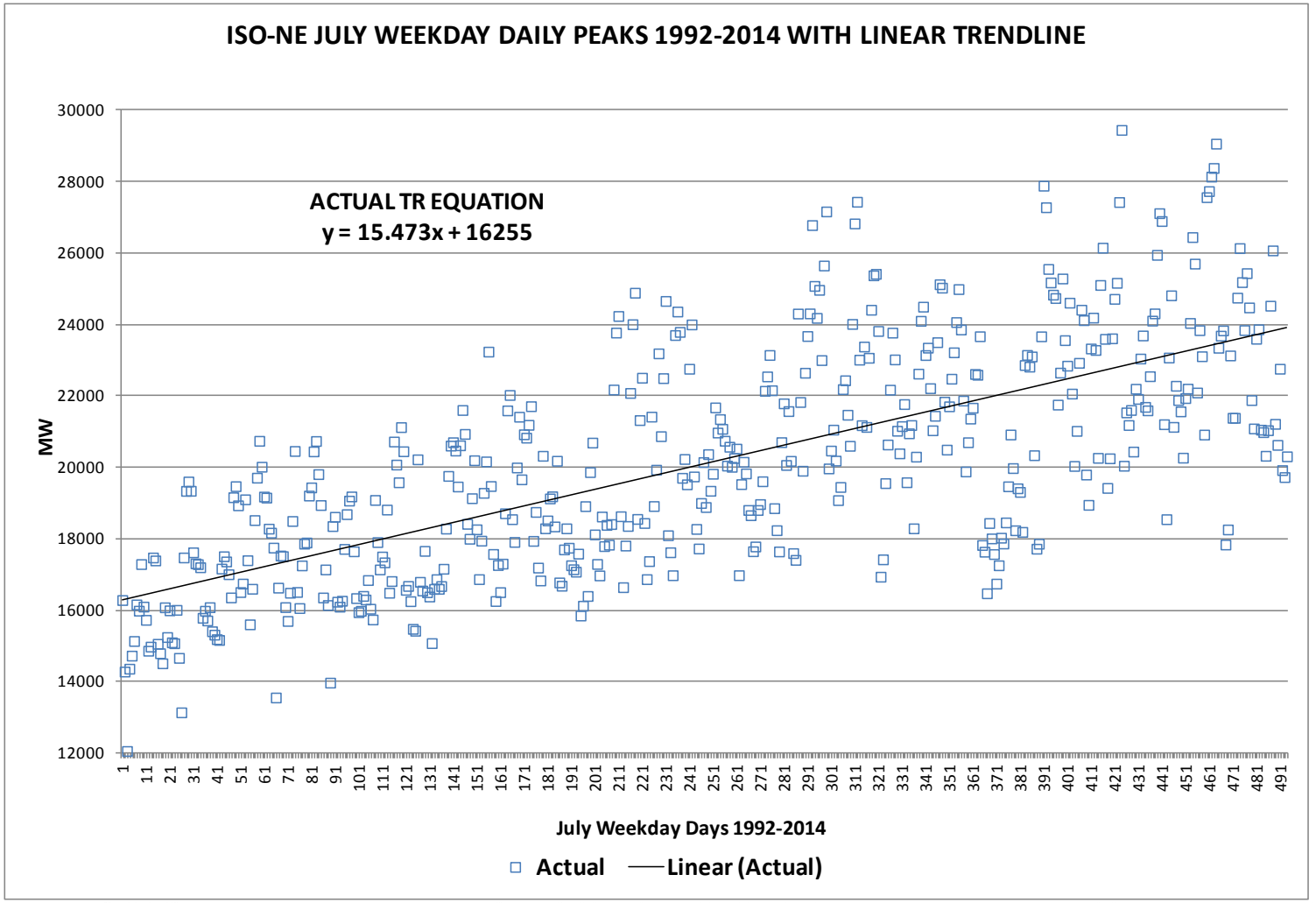
ISO-NE July Weekday Daily Peaks, 1992-2014

Before PV Reconstitution



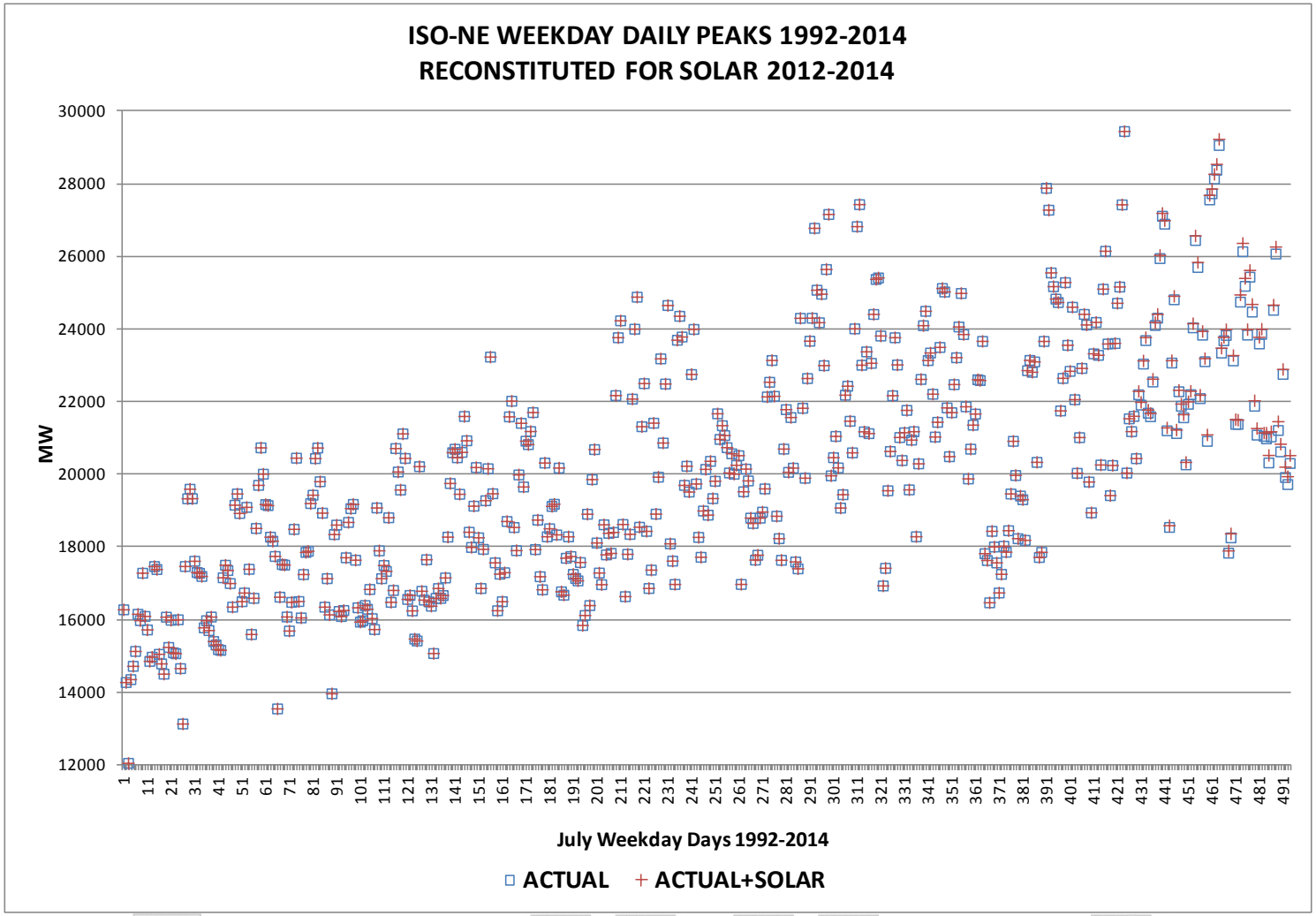
ISO-NE July Weekday Daily Peaks, 1992-2014

Before PV Reconstitution – Linear Trendline Included



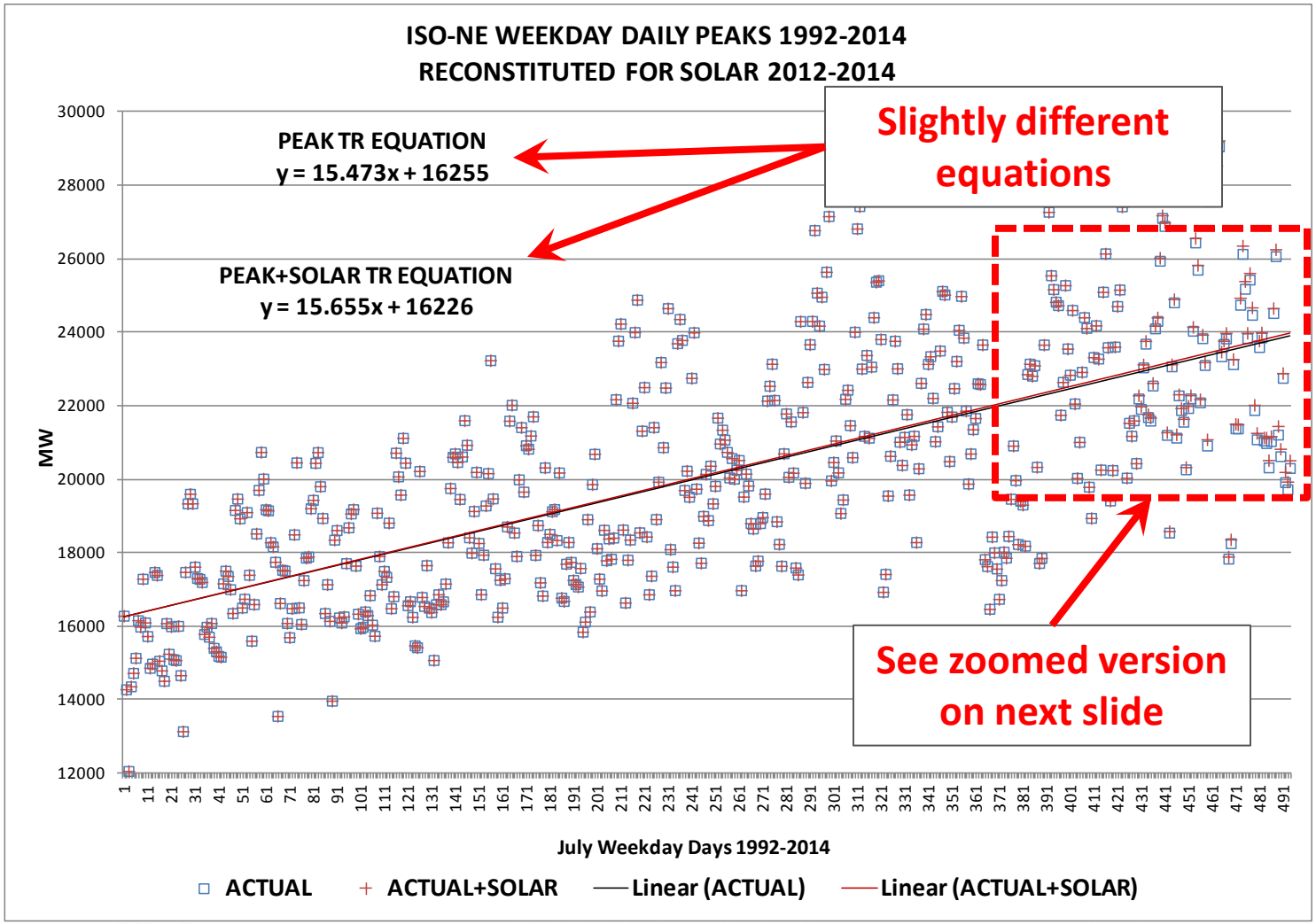
ISO-NE July Weekday Daily Peaks, 1992-2014

Before vs. After PV Reconstitution



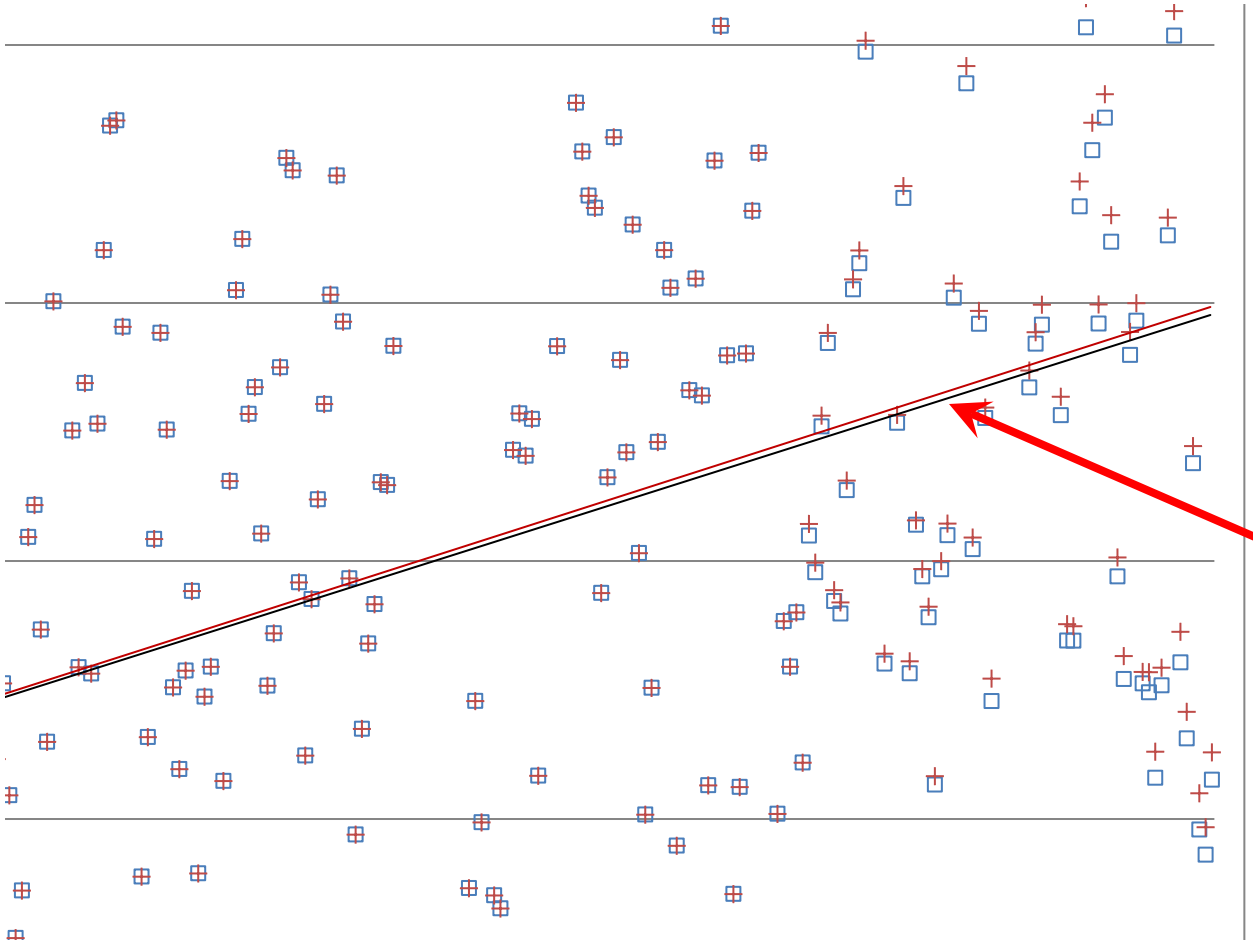
ISO-NE July Weekday Daily Peaks, 1992-2014

Before vs. After PV Reconstitution – Linear Trendlines Included



ISO-NE July Weekday Daily Peaks, 1992-2014

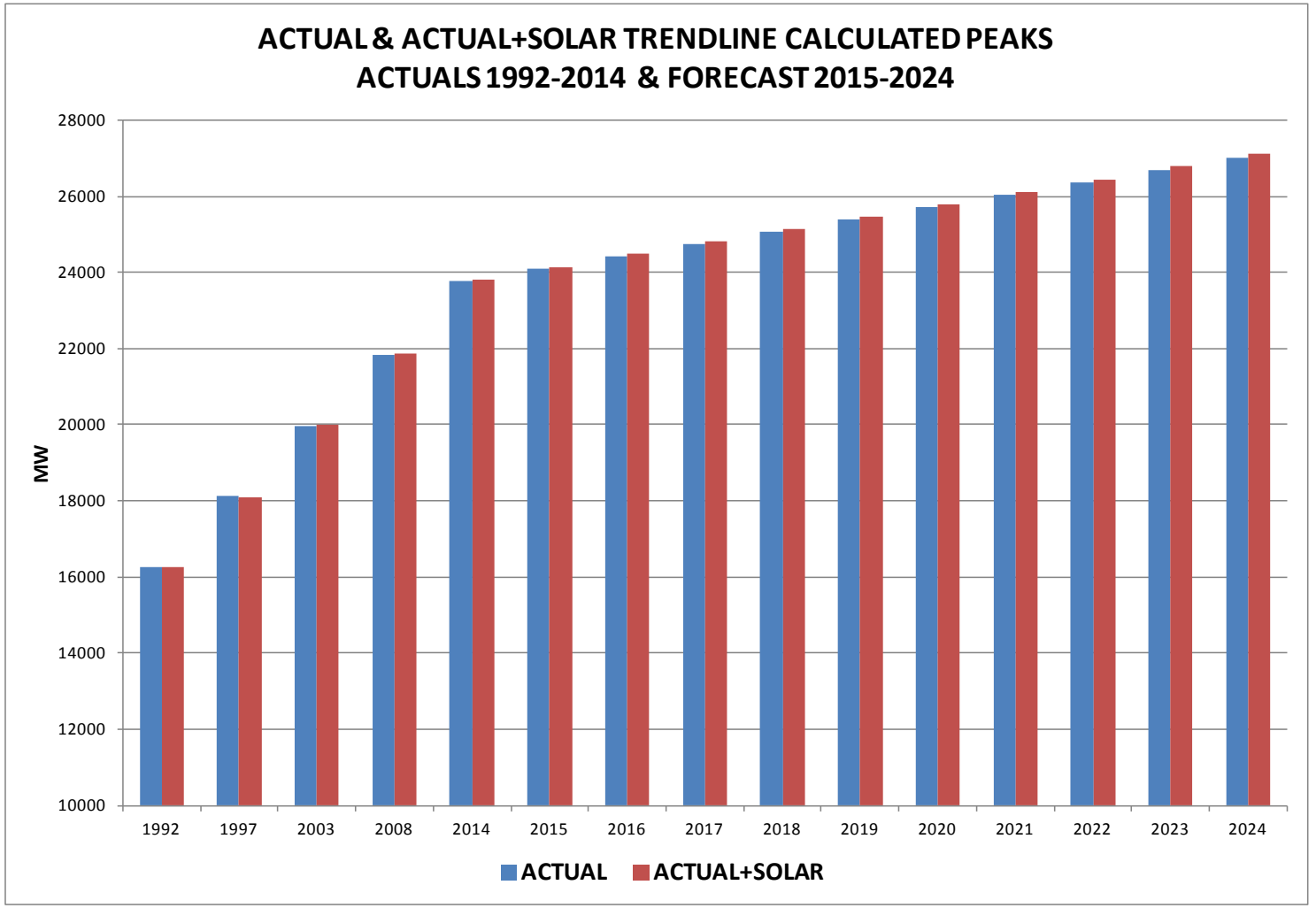
Before vs. After PV Reconstitution –Trendline Shifts Slightly



Trendlines before and after PV reconstitution are slightly different

Peaks Calculated Using Two Different Trendlines

1992-2024



PV Reconstitution Results

Load Forecast Reductions Due to BTM PV (top) and BTMEL (bottom)

- Top table: Cumulative reductions in the load forecast due to BTM PV, representing the change (increase) in the load forecasts after PV reconstitution, and includes transmission and distribution (T&D) losses (8%)
- Bottom table: Cumulative BTMEL, which is the behind-the-meter PV that is embedded in the load forecasts, after removing the assumed 8% T&D losses

States	Cumulative Load Forecast Reductions Due to BTM PV (MW)										
	Thru 2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
CT	30.0	31.0	32.0	34.0	36.0	38.0	40.0	42.0	44.0	46.0	48.0
MA	86.0	91.0	97.0	104.0	111.0	118.0	125.0	132.0	139.0	146.0	153.0
ME	4.0	4.0	4.0	5.0	5.0	5.0	6.0	6.0	6.0	6.0	7.0
NH	3.0	3.0	3.0	3.0	4.0	4.0	4.0	4.0	4.0	5.0	5.0
RI	1.0	1.0	2.0	3.0	4.0	5.0	5.0	5.0	5.0	6.0	6.0
VT	11.0	11.0	12.0	13.0	13.0	14.0	15.0	16.0	17.0	18.0	18.0
Regional - Embedded PV (MW)	**135.0**	**141.0**	**150.0**	**162.0**	**173.0**	**184.0**	**195.0**	**205.0**	**215.0**	**227.0**	**237.0**

States	Cumulative BTMEL (MW) - T & D losses removed										
	Thru 2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
CT	27.8	28.7	29.6	31.5	33.3	35.2	37.0	38.9	40.7	42.6	44.4
MA	79.6	84.3	89.8	96.3	102.8	109.3	115.7	122.2	128.7	135.2	141.7
ME	3.7	3.7	3.7	4.6	4.6	4.6	5.6	5.6	5.6	5.6	6.5
NH	2.8	2.8	2.8	2.8	3.7	3.7	3.7	3.7	3.7	4.6	4.6
RI	0.9	0.9	1.9	2.8	3.7	4.6	4.6	4.6	4.6	5.6	5.6
VT	10.2	10.2	11.1	12.0	12.0	13.0	13.9	14.8	15.7	16.7	16.7
Regional - BTMEL (MW)	**125.0**	**130.6**	**138.9**	**150.0**	**160.2**	**170.4**	**180.6**	**189.8**	**199.1**	**210.2**	**219.4**

FINAL 2015 PV FORECAST BY TYPE

Final 2015 PV Forecast

Cumulative Nameplate (MW_{ac})

States	Cumulative Total MW (AC nameplate rating)										
	Thru 2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
CT	118.8	189.7	279.5	325.3	368.3	408.7	449.1	476.0	502.9	529.8	556.8
MA	666.8	863.8	1093.6	1145.0	1193.4	1238.8	1284.1	1314.4	1344.6	1374.8	1405.1
ME	10.4	12.6	14.8	16.7	18.5	20.3	22.0	23.7	25.4	27.2	28.9
NH	12.7	17.0	21.3	25.1	28.7	32.1	35.4	37.7	39.9	42.2	44.4
RI	18.2	27.9	48.3	75.4	106.4	135.4	156.0	163.1	168.5	173.9	179.3
VT	81.9	122.2	162.6	184.9	198.7	205.1	211.4	217.7	224.1	230.4	234.7
Regional - Cumulative (MW)	**908.8**	**1233.1**	**1620.0**	**1772.4**	**1914.1**	**2040.3**	**2158.1**	**2232.6**	**2305.5**	**2378.4**	**2449.1**

Notes:

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

(2) The forecast reflects discount factors described on slides 4

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

(4) ISO is working with stakeholders to determine the appropriate use of the forecast

Final 2015 PV Forecast

Cumulative Estimated Summer Seasonal Claimed Capability

Based on 40% of Forecasted AC Nameplate Capacity

States	Cumulative Estimated Summer SCC (MW)										
	Thru 2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
CT	47.5	75.9	111.8	130.1	147.3	163.5	179.6	190.4	201.2	211.9	222.7
MA	266.7	345.5	437.5	458.0	477.4	495.5	513.7	525.7	537.8	549.9	562.0
ME	4.2	5.0	5.9	6.7	7.4	8.1	8.8	9.5	10.2	10.9	11.6
NH	5.1	6.8	8.5	10.0	11.5	12.8	14.2	15.1	16.0	16.9	17.8
RI	7.3	11.2	19.3	30.2	42.6	54.2	62.4	65.2	67.4	69.6	71.7
VT	32.7	48.9	65.0	73.9	79.5	82.0	84.6	87.1	89.6	92.2	93.9
Regional - Cumulative Summer SCC (MW)	**363.5**	**493.3**	**648.0**	**709.0**	**765.6**	**816.1**	**863.2**	**893.0**	**922.2**	**951.3**	**979.6**

Notes:

(1) ISO's methodology for determining SCC for Intermittent Resources is defined in Market Rule 1, Section III.13.1.2.2.2.1(c)

(2) Estimated SCC values include FCM Resources, non-FCM Energy Only Generators, and behind-the-meter PV resources

(3) Summer SCC values are based on the assumption that all end-of-year resources are in operation during the summer period

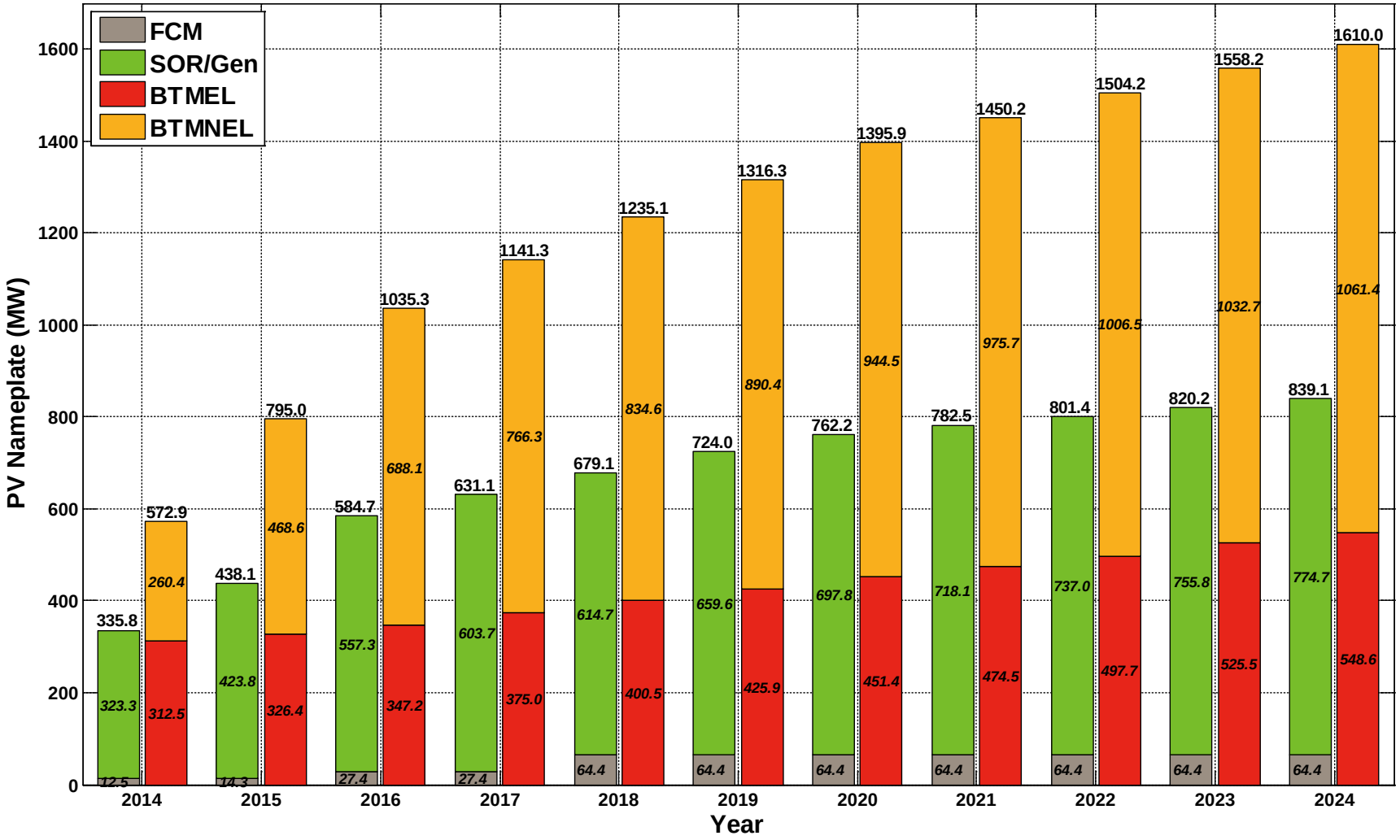
(4) PV's winter SCC is assumed to be zero

(5) Different planning studies may use values different from the estimated SCC based on the intent of the study

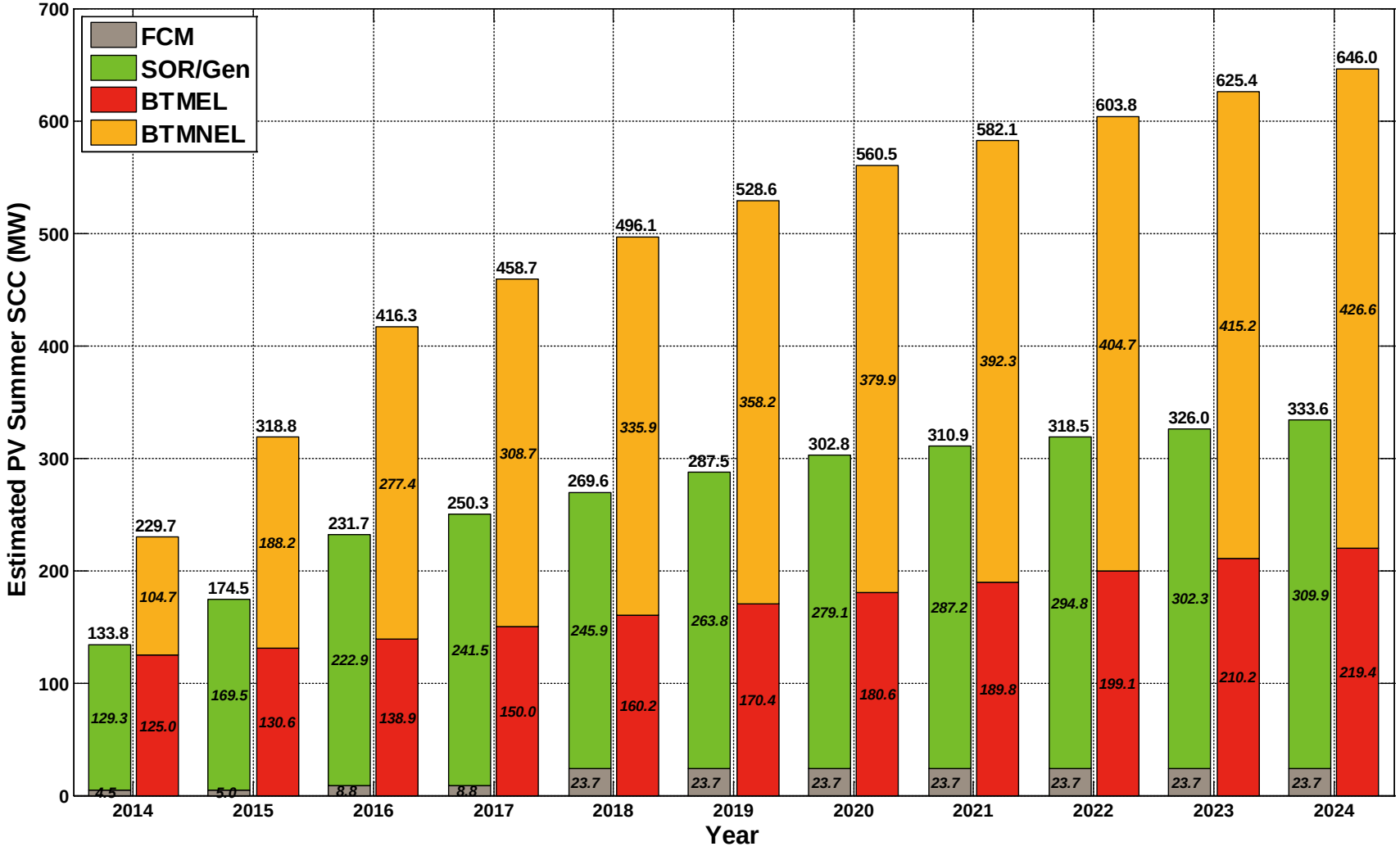
Final 2015 PV Forecast

Cumulative Regional PV by Market Participation Type

AC Nameplate



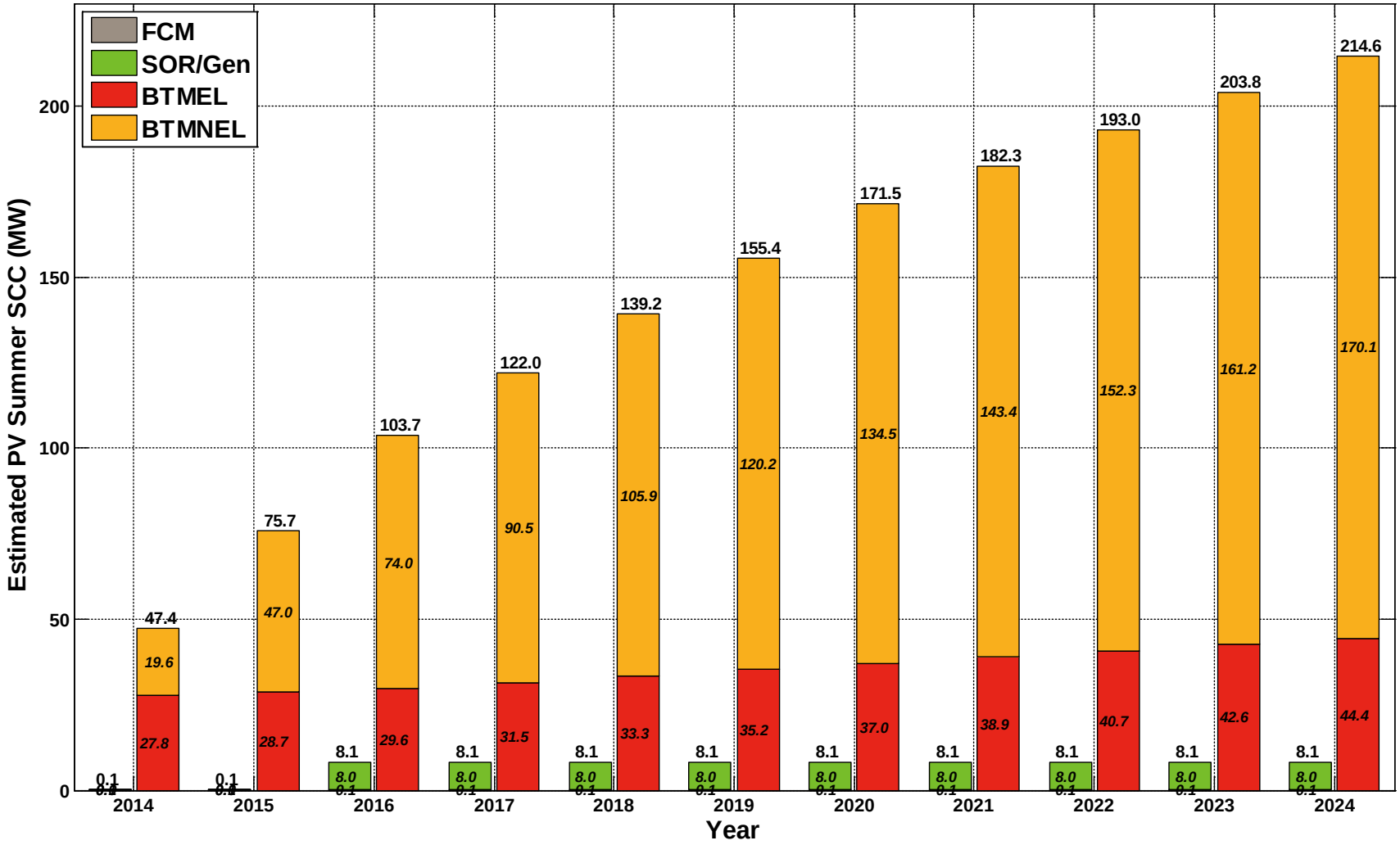
Final 2015 PV Forecast
Cumulative Regional PV by Market Participation Type
Estimated Summer Seasonal Claimed Capability



STATE CUMULATIVE ESTIMATED SCC PLOTS BY MARKET TYPE

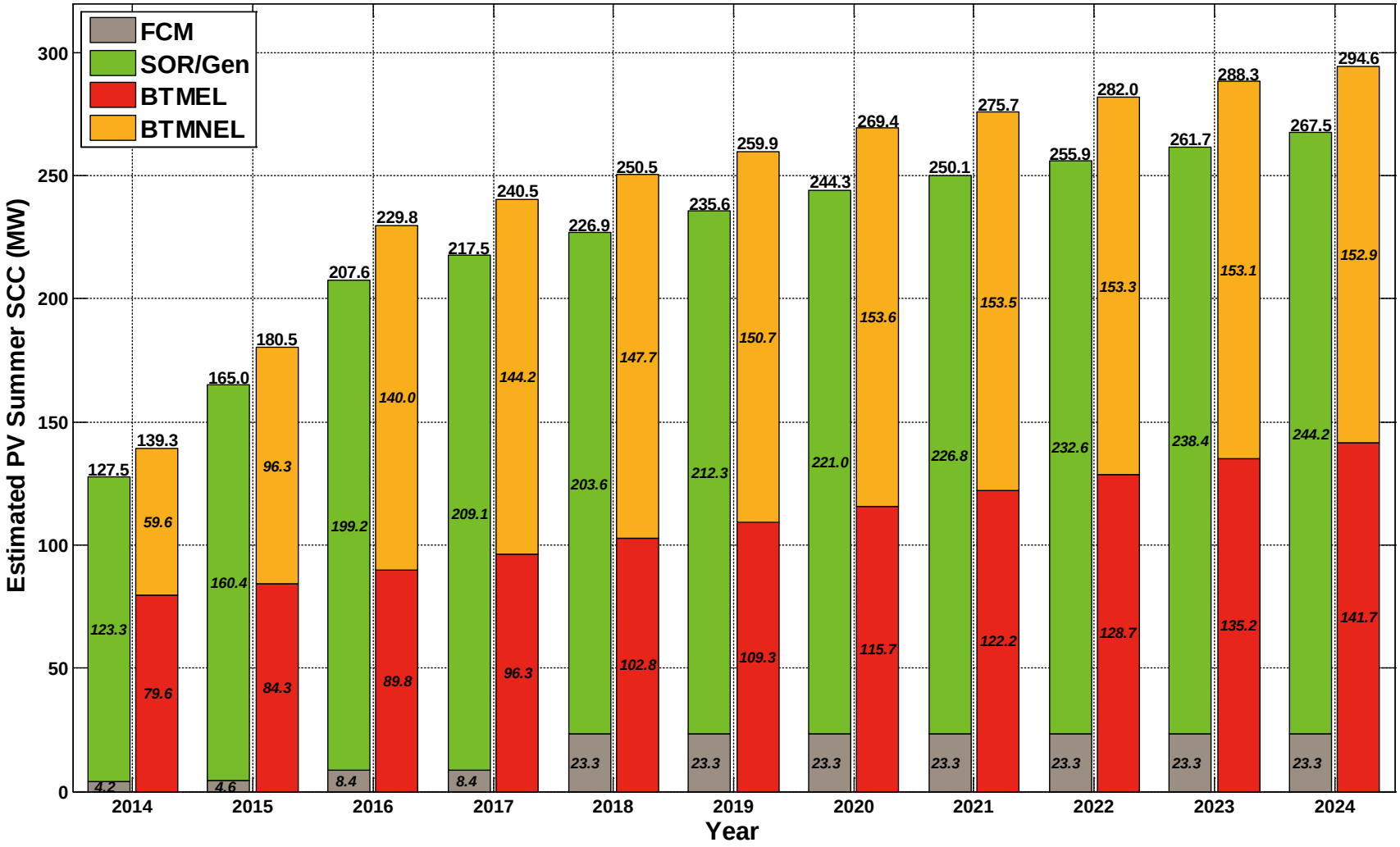
Cumulative SCC by Market Type

Connecticut



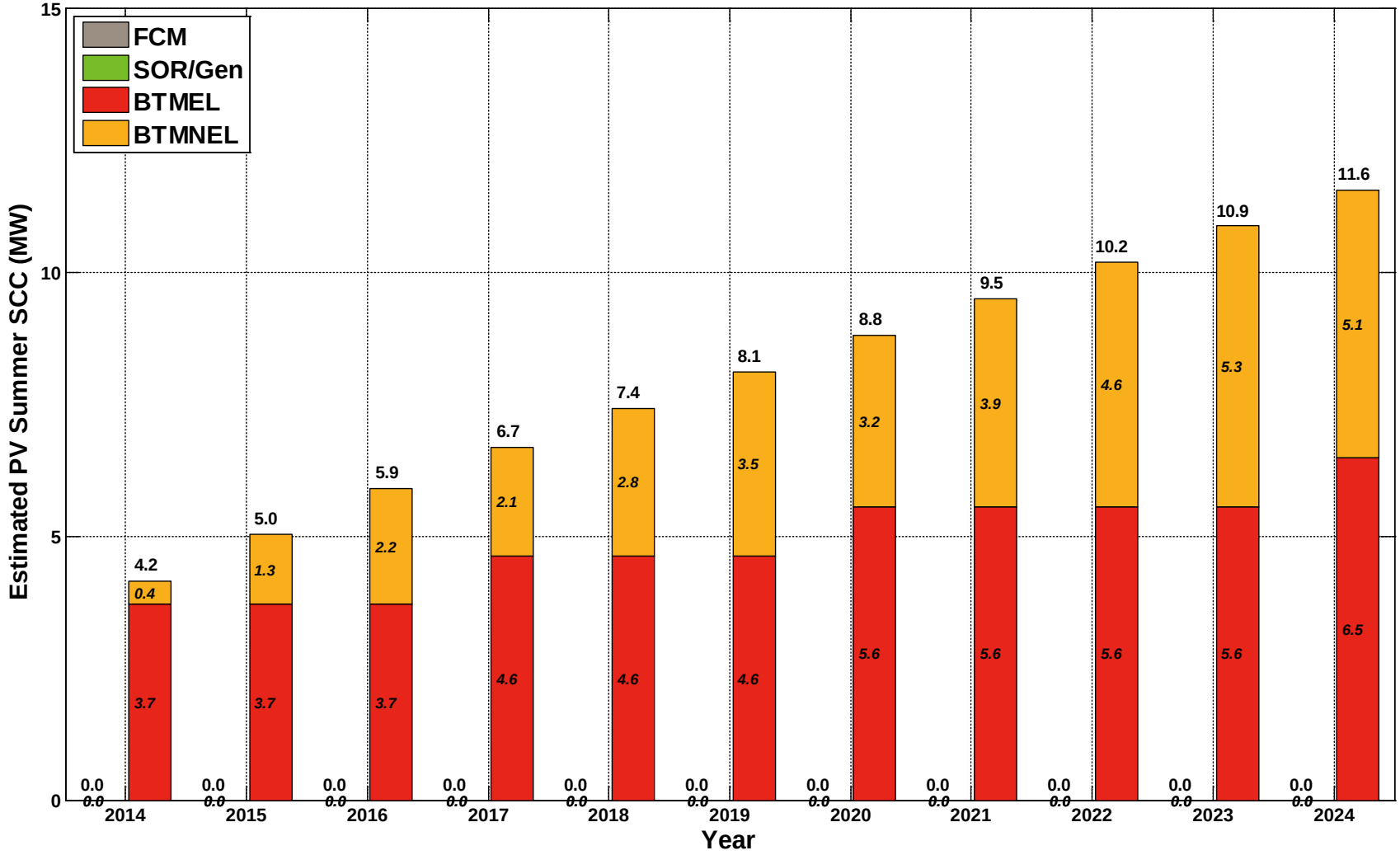
Cumulative SCC by Market Type

Massachusetts



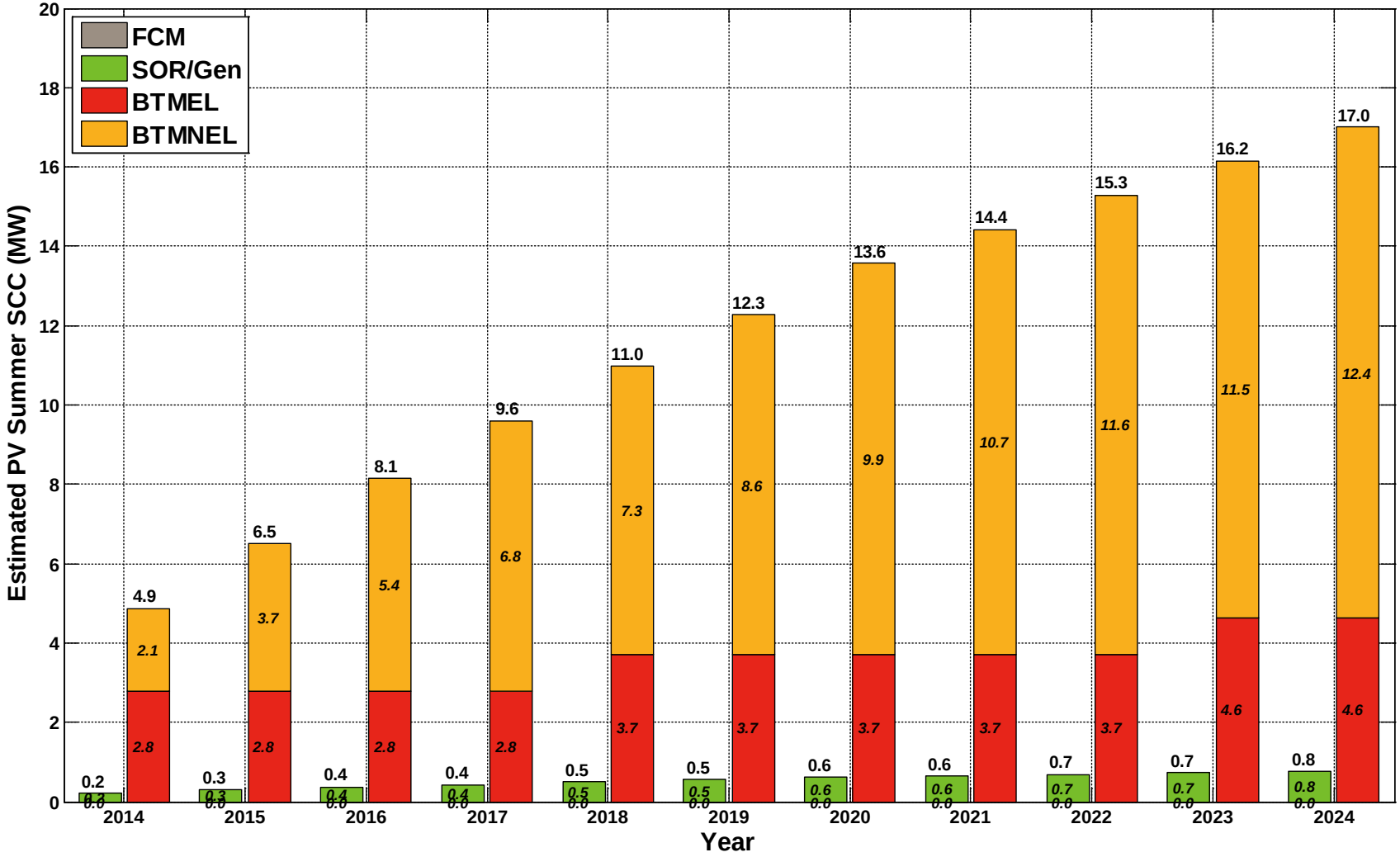
Cumulative SCC by Market Type

Maine



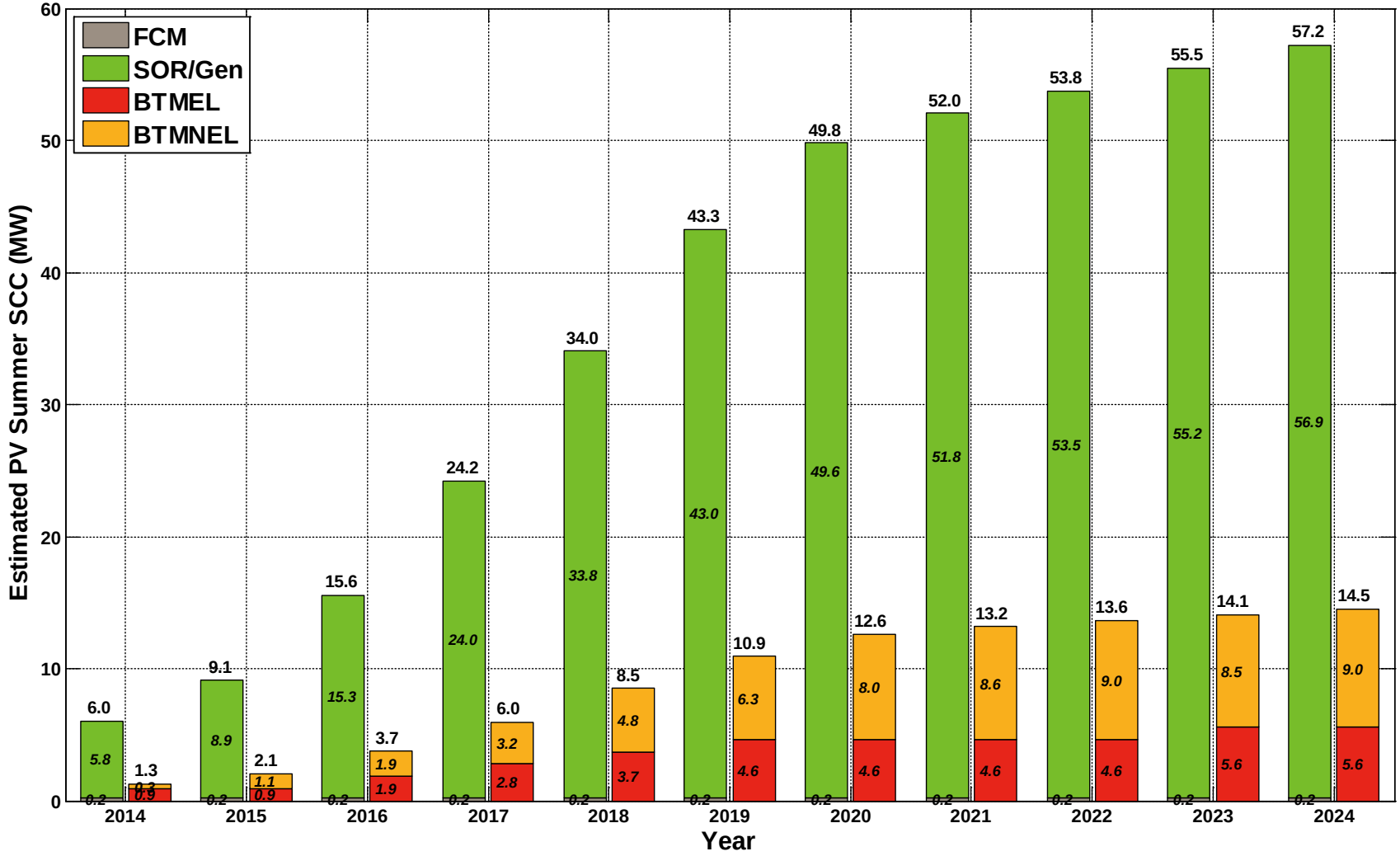
Cumulative SCC by Market Type

New Hampshire



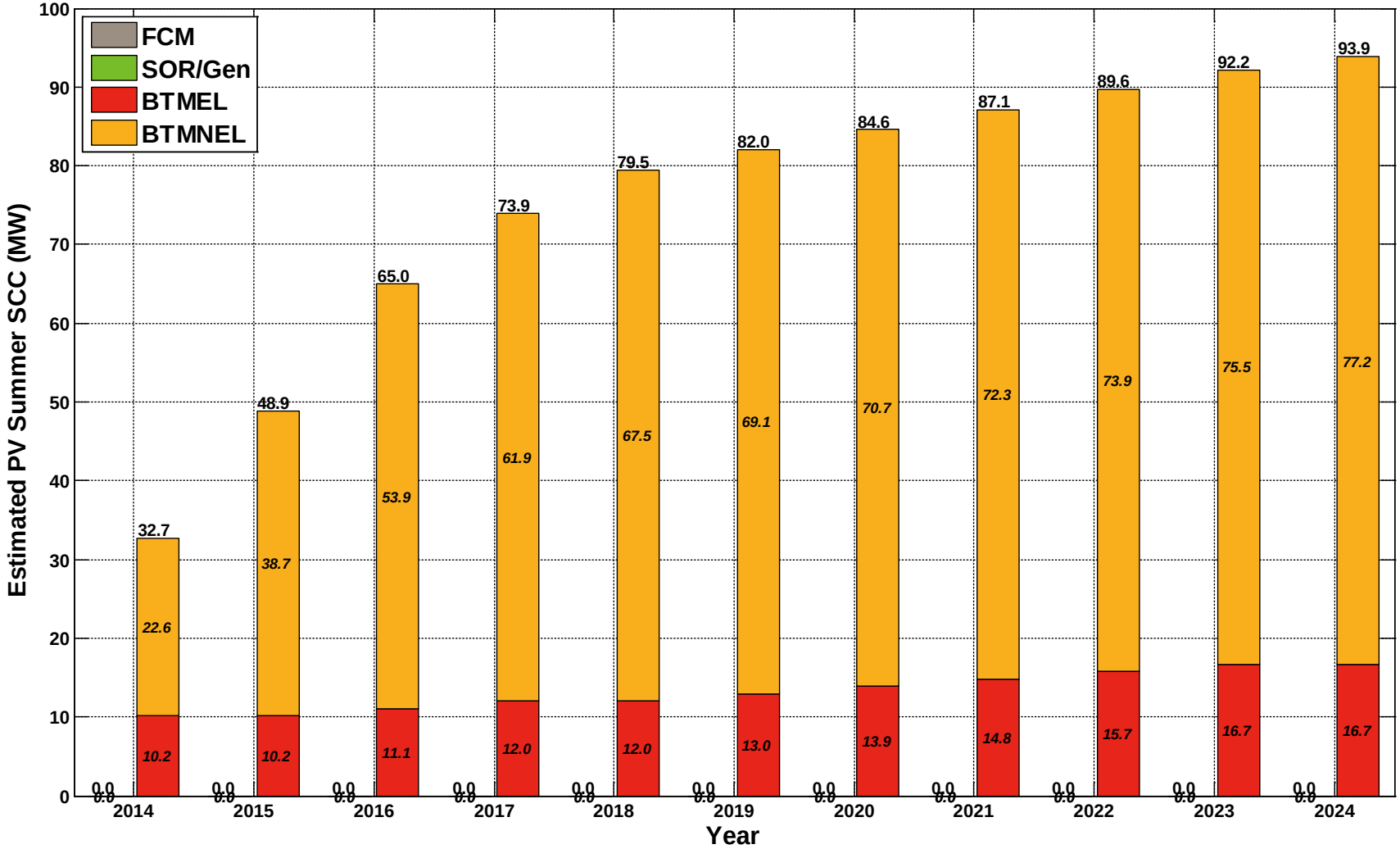
Cumulative SCC by Market Type

Rhode Island



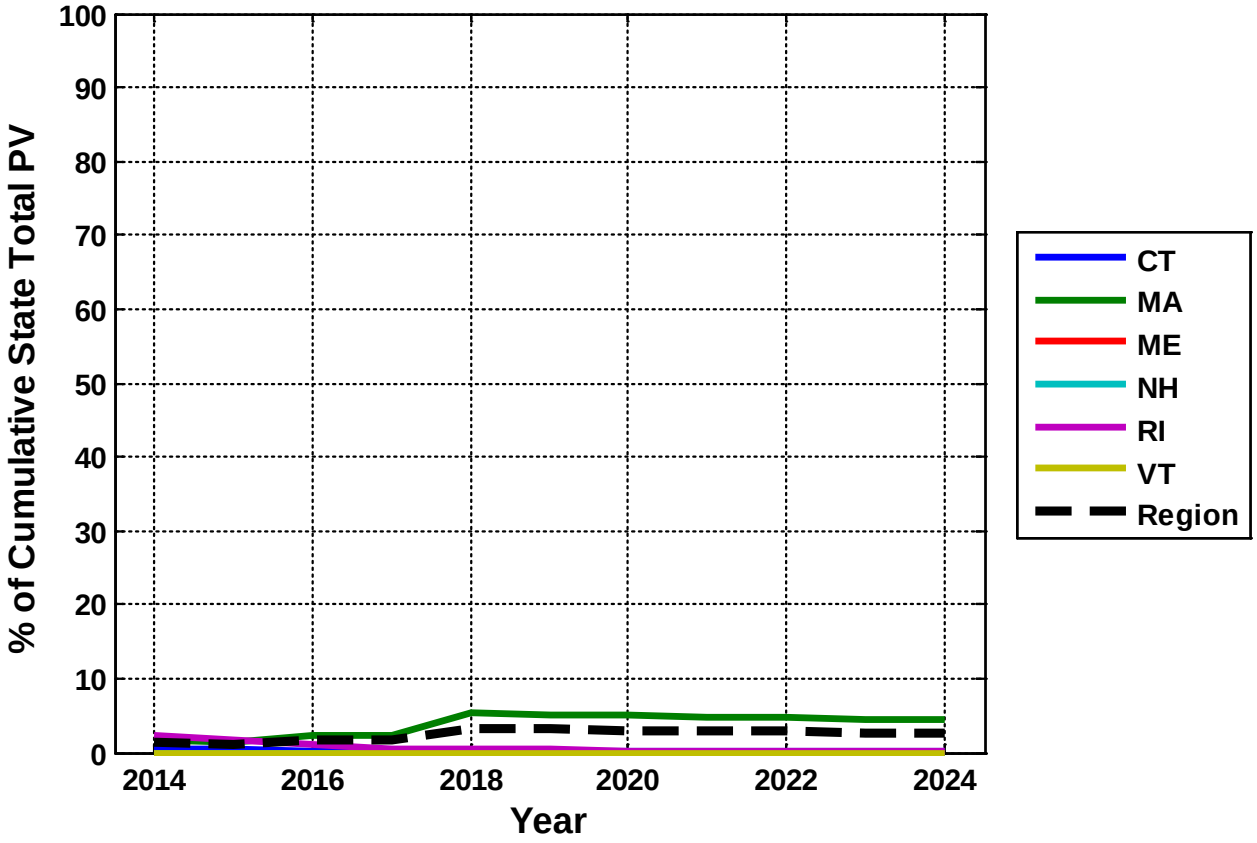
Cumulative SCC by Market Type

Vermont

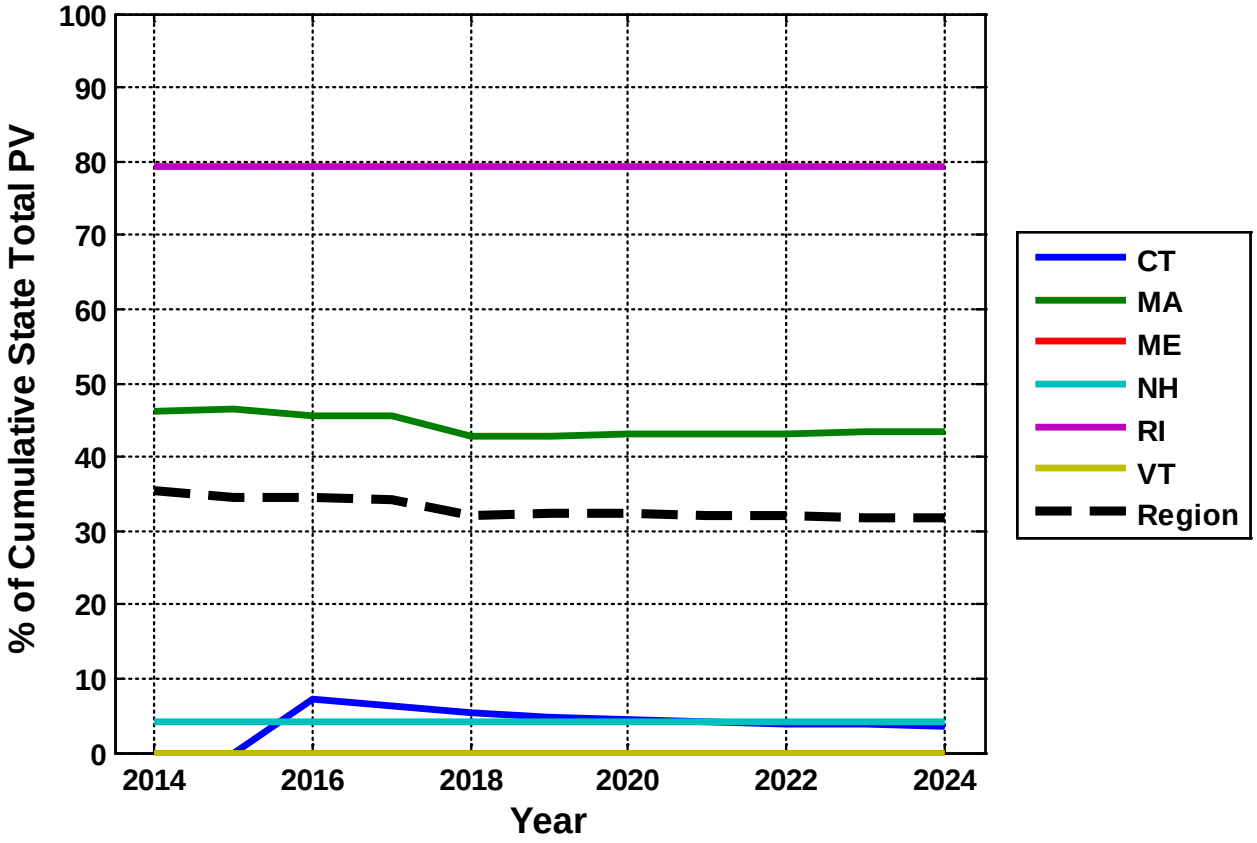


STATE AND REGIONAL CUMULATIVE PV FORECAST % SHARE BY MARKET TYPE

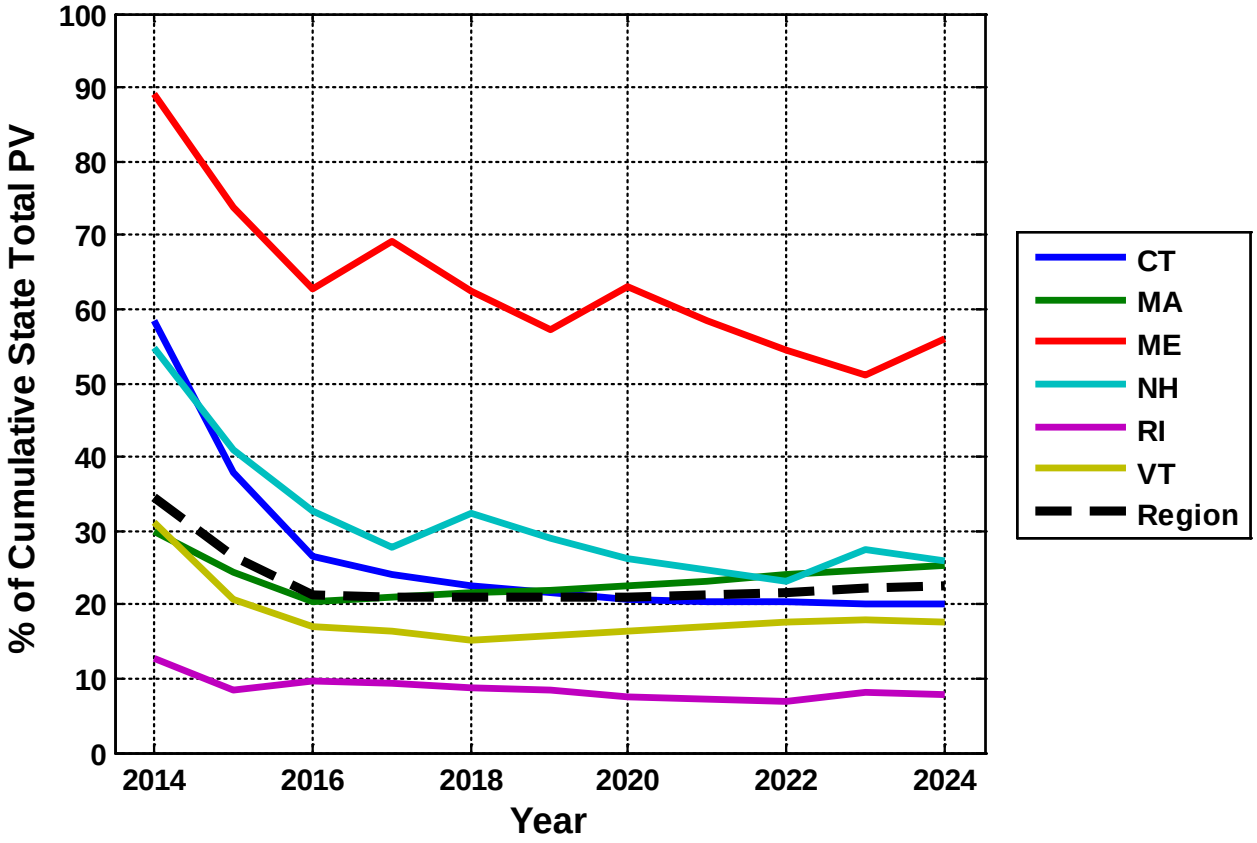
% Share of Cumulative, State and Regional FCM



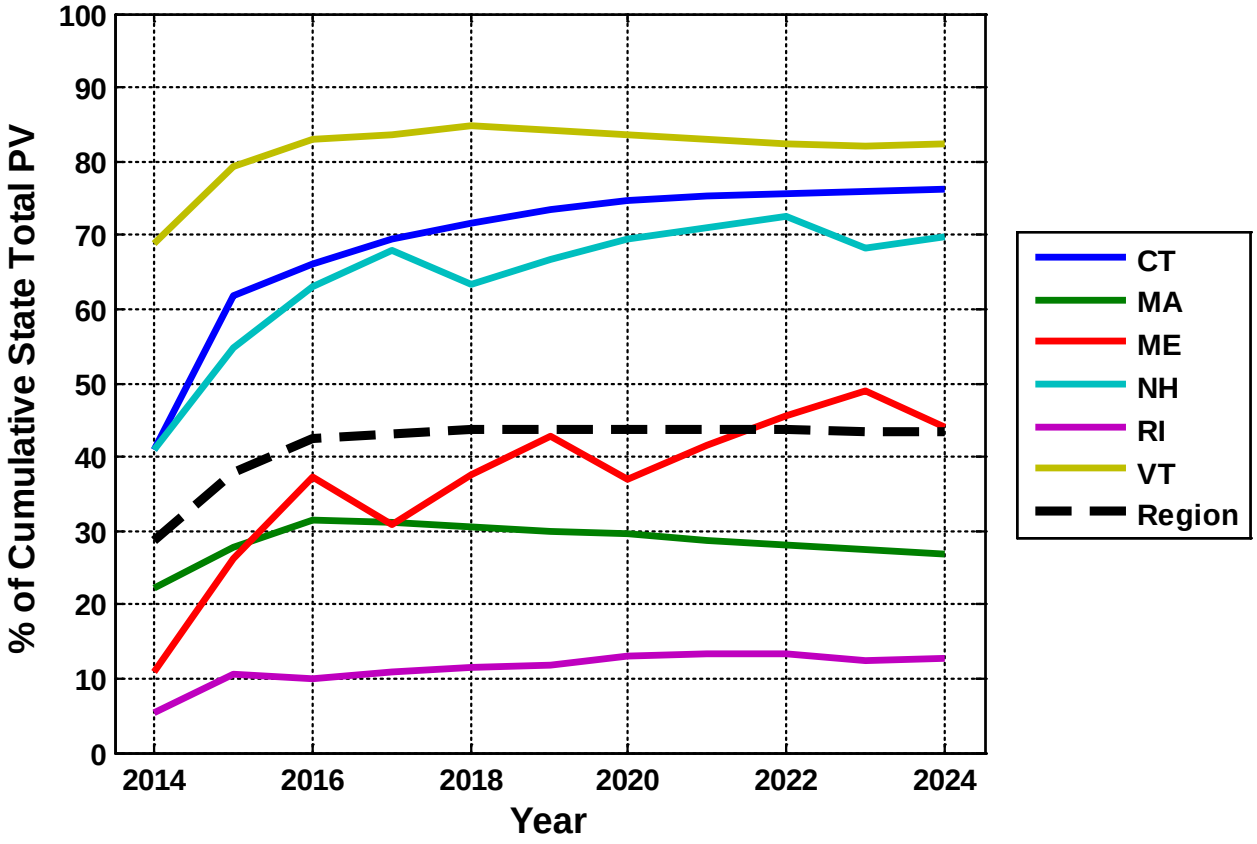
% Share of Cumulative, State and Regional
Non-FCM SOR/Gen



% Share of Cumulative, State and Regional
BTM, Embedded in Load Forecast (BTMEL)



% Share of Cumulative, State and Regional
BTM, Not Embedded in Load Forecast (BTMNEL)



Summary

- ISO has classified the 2015 state and regional PV forecasts according to the four market participation categories
- This information will appear in the 2015 CELT

APPENDIX

PV Profile Validation

Comparison to Quarterly NEPOOL GIS Data

- The most recent quarterly data available within NEPOOL GIS is Q3 2014, and represents all PV energy reported to GIS in the region
- Table on left calculates the difference between total estimated quarterly PV energy and NEPOOL GIS reported PV energy in Q3 2014
- Table on right calculates the difference between total PV nameplate in-service according to 12/31/14 distribution utility data and PV capacity registered in NEPOOL GIS
- Difference in estimated Q3 2014 energy (+12.3%) appears to be mostly attributable to a significant amount (almost 13%) of existing PV that did not report to NEPOOL GIS

PV Energy , Estimated vs. Reported

State	Estimated PV Energy
'CT'	40,944
'ME'	3,405
'MA'	249,962
'NH'	3,772
'RI'	7,895
'VT'	21,745
Total Estimated	327,723
NEPOOL GIS reported	291,908
% Difference: (GIS - Est)/GIS	12.3%

Installed PV, Utility vs. NEPOOL GIS

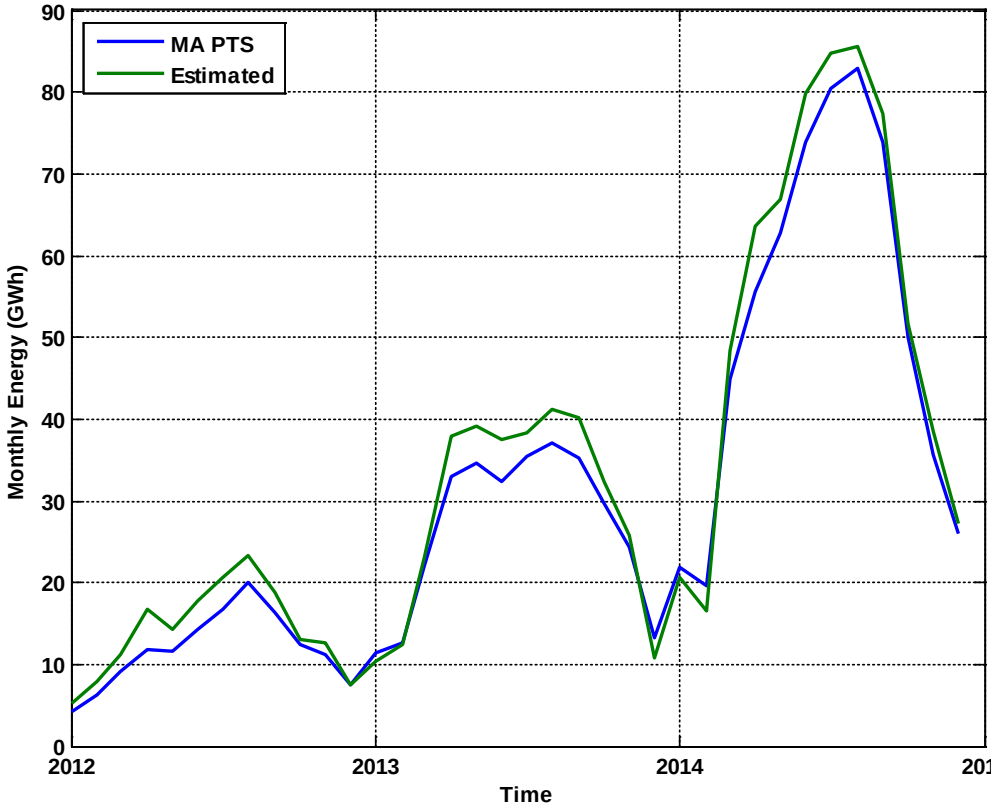
State	Installed MWs		
	12/31/14 Utility Data	NEPOOL GIS	Estimated "Missing" from NEPOOL GIS
'CT'	118.8	72	46.8
'ME'	10.4	1.7	8.7
'MA'	666.8	Unknown*	
'NH'	12.7	5	7.7
'RI'	18.2	17.7	0.5
'VT'	81.9	28	53.9
Non-MA Totals	242	124.4	117.6
% Difference (Utility-GIS)/Utility			12.9%

* Frequent misreporting of MA PV project capacity in GIS precludes calculation

PV Profile Validation

Comparison to Monthly MA SREC Data

- The overall energy estimated using the MA profile and distribution utility data closely matches the monthly SREC energy production data (MA PTS) provided by MA DOER
  - General convergence over time
- Total estimated energy is approximately 8% higher than reported energy
- The general trend of slight overestimated energy likely mostly attributable to the non-SREC PV installed in MA
  - Approximately 30-35 MW



Questions