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Update on Solar PV and Other DG in New England

Planning Advisory Committee

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Executive Summary

- Approximately 2,000 MW of distributed generation (DG) – mostly solar photovoltaic (PV) resources– are anticipated in the region by the end of 2021
- ISO already accounts for many existing DG resources in long-term planning in a number of ways
- ISO continues to investigate the complex issues that must be addressed to efficiently and reliably integrate higher penetrations of DG from the perspective of planning and operating the regional power system
- In order to address the operational, planning, and market implications of high penetrations of DG, significant collaboration among ISO, state policymakers, DG/PV program administrators, distribution companies and others possessing needed expertise, will be needed
- In the Fall of 2013, ISO will kick-off a Distributed Generation Forecast Working Group (DGFWG)

Objective and Outline

- Objective: To update stakeholders on ISO's existing and future DG efforts. This presentation is intended to provide foundational information for the DG Forecast Working Group.
- Outline:
  1. Brief update on the growth of DG resources anticipated in the region
  2. ISO's treatment of existing DG resources in long-term planning and comparison with NEPOOL GIS data
  3. Summary of DG integration challenges and corresponding ISO initiatives and efforts
  4. 2012 historical analysis of the contribution of solar PV during peak load periods
  5. Distributed Generation Forecast Working Group

Region Experiencing Growth of PV and Other DG

- Regionally: More than 2,000 MW of DG anticipated by 2021
  - PV will be the dominant DG technology
    - 250 MW installed by end of 2012; approx. 125 MW in 2012 alone
- Massachusetts: reached its 250 MW PV goal three years early
  - May 2013: Announced expanded goal of 1,600 MW of PV by 2020[1]
- Connecticut: Public Act 11-80 is stimulating growth in DG
  - Could result in more than 300 MW of DG by 2022, mostly PV
- Vermont: State goal of 127.5 MW of DG by 2022
  - Approximately 26 MW of PV installed in VT by end of 2012
- Rhode Island: DG Standard Contract program aimed at stimulating 40 MW of DG by 2014
  - RI is considering expanding program to 120 MW by 2018
  - Program awarded contracts to 14.67 MW of PV through the end of 2012
- New Hampshire: Class II RPS will require about 25 MW of PV by 2015

[1] Note that the MA goal is based on total DC nameplate ratings. As a result of numerous DC-to-AC derate factors, AC power rating is typically in the range of 75%-85% of the DC nameplate rating. A description of the various derate factors can be found at: http://www.nrel.gov/rredc/pvwatts/changing_parameters.html

ISO’S CURRENT TREATMENT OF EXISTING DG RESOURCES IN LONG-TERM PLANNING AND A COMPARISON OF ISO DATA AND NEPOOL GIS DATA

DG and Long-Term System Planning

- Existing DG resources are already considered in long-term planning in the following ways:
  - Capacity Supply Obligations (CSOs) associated with DG projects that clear in the Forward Capacity Market (FCM) can satisfy the Installed Capacity Requirement (ICR)
  - Energy production and/or load reductions from existing non-FCM DG is:
    - Registered as a generating load asset (i.e., Settlement Only Generator, or SOG) that is explicitly counted as generation in determining Net Energy for Load
    - Embedded in the historic loads used to develop ISO's 10-year load forecast used in the ICR calculation on the load side
- At historical amounts of DG, this approach was sufficient. However, given the anticipated growth of DG, additional steps may be necessary

Distributed Generation – Tariff Definition

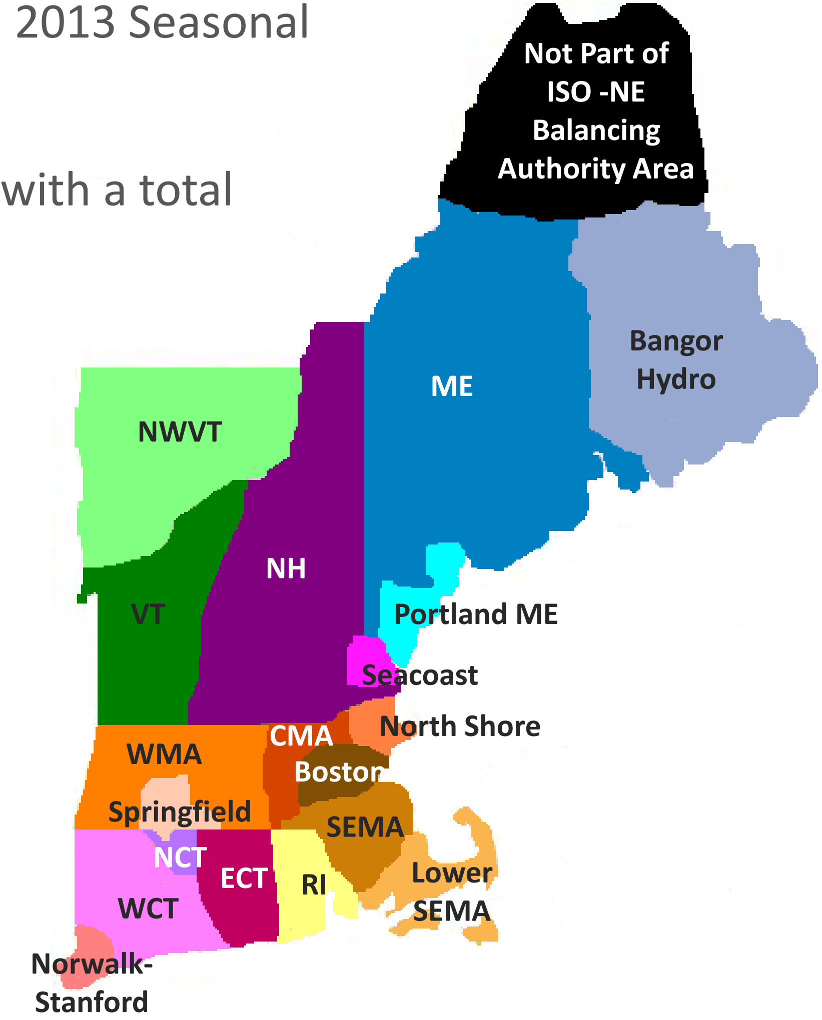
- Distributed Generation is a defined term in Sect. I of ISO-NE's Transmission, Markets & Services Tariff:
    - ***Distributed Generation*** *means generation resources directly connected to end-use customer load and located behind the end-use customer's Retail Delivery Point for the end-use customer, which reduce the amount of energy that would otherwise have been produced by other capacity resources on the electricity network in the New England Control Area during Demand Resource On-Peak Hours, Demand Resource Seasonal Peak Hours, Demand Resource Critical Peak Hours, Real-Time Demand Response Event Hours, or Real-Time Emergency Generation Event Hours, provided that the aggregate nameplate capacity of the generation resource does not exceed 5 MW, or does not exceed the most recent annual non-coincident peak demand of the end-use metered customer at the location where the generation resource is directly connected, whichever is greater.*
- For the purposes of this presentation, the term "DG" is used to refer to generator resources that are less than 5 MW

PV Settlement Only Generators (SOGs)

- A total of 232 PV SOGs are listed in the June 2013 Seasonal Claimed Capability (SCC) report[1]
  - No PV SOG projects located in VT or CT
- A total of 11 PV SOG units cleared in FCA#7 with a total summer capacity of 5.529 MW

PV SOG unit locations

Dispatch Zone	# projects	Total Summer SCC (MW)
Boston	19	2.687
North Shore	25	5.528
New Hampshire (NH)	1	0.046
Seacoast	1	0.018
Lower SEMA	18	6.204
SEMA	49	8.406
Central MA (CMA)	53	5.841
Springfield MA	9	2.774
Western MA (WMA)	52	6.421
Rhode Island (RI)	5	0.006
Totals	232	37.931



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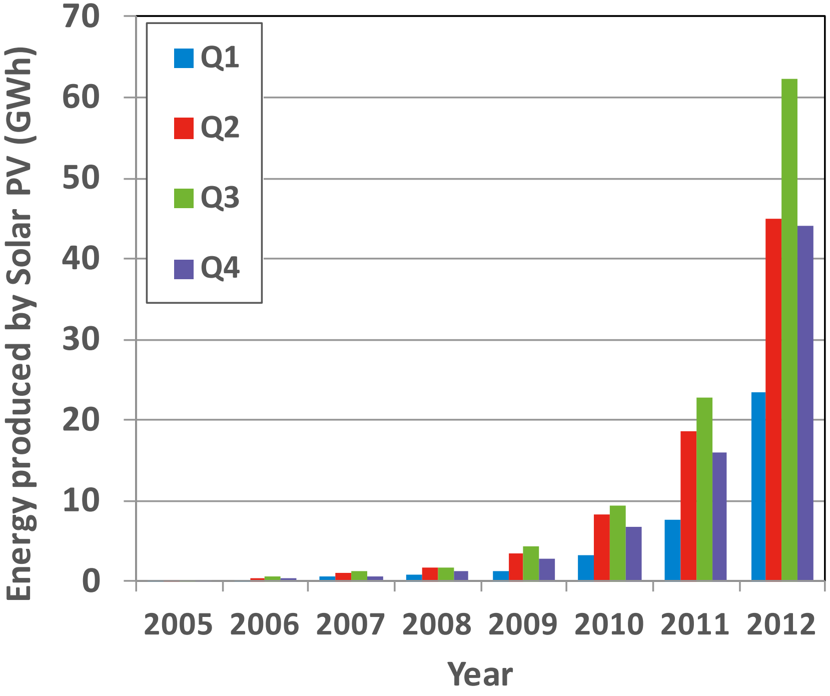
[1] Source: http://www.iso-ne.com/genrtion_resrcs/snl_clmd_cap/2013/scc_june_2013.xls

Regional PV Energy Generated in 2012

*ISO Settlement Market System/NEPOOL GIS**

NEPOOL GIS Data*

Quarterly Generated PV Energy by Quarter (GWh), 2005-2012



Source: NEPOOL GIS data, available at: http://www.nepoolgis.com/

*Comparison of 2012 Quarterly PV Generation ISO Settlement Market System/NEPOOL GIS**

Quarter	NEPOOL GIS Data (GWh)*	ISO Settlement Market System Data (GWh)[1]	% of NEPOOL GIS Data in ISO SMS
1	23.4	3.6	15.4%
2	45.0	7.4	16.4%
3	62.3	14.6	23.5%
4	44.1	10.9	24.7%
2012 Total	174.7	36.5	20.9%

[1] Refer to 2012 Energy and Peak by Source detail, available at: http://www.iso-ne.com/markets/hstdata/rpts/net_eng_peak_load_sorc/energy_peak_source.xls

Note: *Note that some of the excess generation that has been exported to the local distribution system from net metered, behind-the-meter DG may be double-counted within the NEPOOL GIS system. See: http://www.iso-ne.com/committees/comm_wkgrps/mrkts_comm/geninfo_sys/mtrls/day_pitney_memo_03_05_13.doc

Non-PV SOGs and Other DG in FCA#7

- A total of 322 non-PV SOG units are in ISO Settlements
- Of these, 242 units cleared in FCA#7
  - Approx. total summer capacity is 138 MW

Non-PV SOG units by Fuel Type, SSCC, and WSCC

Fuel Type	# Units	Sum of SSCC (MW)	Sum of WSSC (MW)
DIESEL OIL	11	22.484	22.596
GAS	4	5.221	6.293
HYDRO: PONDAGE	9	14.532	16.174
HYDRO: RUN OF RIVER	210	39.706	105.253
LANDFILL GAS	26	33.89	37.054
METHANE/REFUSE	9	4.19	4.347
REFUSE	3	2.403	2.561
STEAM	1	0	0
STEAM/REFUSE	2	3.928	3.848
WIND	44	7.985	7.688
WOOD/REFUSE	3	0	0.223
Total	**322**	**134.339**	**206.037**

- Additionally, 90 MW of Passive and 120 MW of Active DR identified as DG cleared as Existing Capacity in FCA#7

http://www.iso-ne.com/committees/comm_wkgrps/mrkts_comm/dr_wkgrp/mtrls/2013/apr32013/fca7_results_measure_type_v2.ppt

Using Non-NEPOOL Generation in NEPOOL GIS As Indicator of DG Unknown to ISO

This information accompanies the table on the next slide

- Non-NEPOOL units are behind-the-meter generator units that establish an account and an asset identification as a Non-NEPOOL Generator in NEPOOL GIS
  - Energy produced from these units is identified as ‘NON ID’
  - Energy produced from these units should not be associated with assets registered in ISO markets, and is distinct from energy imported into the ISO-NE service territory.
- ISO is presenting this data since it is believed to be associated with generators that are not registered in ISO markets
- However, some of the energy listed was generated by resources that are larger than what are typically considered DG resources
  - Fossil fuel-derived energy (i.e., from coal, NG, oil, diesel) could either be associated with CHP units that are RPS-eligible, or multi-fuel assets that burn at least one RPS-eligible fuel, and are larger than 5 MW

2012 Non-NEPOOL Generation*

The table below lists generation identified as 'NON ID' (Non-NEPOOL) in the NEPOOL GIS system. Note that not all of this energy is from DG resources!*

Fuel Type	Non-NEPOOL Generation (MWh)				Growth, 2009-2012 (MWh)
	2009	2010	2011	2012	
Biodiesel1			138	148	148
Biomass	144,193	196,764	277,112	495,220	351,027
Coal	4,799	16,160	12,146	10,915	6,116
Diesel	2,344	754	294	643	-1,701
Digester gas	29,569	26,886	33,768	39,796	10,227
Efficient Resource (Maine)			117,647	412,003	412,003
Energy Storage	1,003	2,030	303	17	-986
Fuel cell	17,604	15,666	16,686	38,204	20,600
Hydroelectric/Hydropower	45,410	81,321	183,579	178,904	133,494
Landfill gas	77,371	112,835	133,397	133,973	56,602
Methanol		265			-
Natural Gas	559,259	767,229	1,053,052	1,454,120	894,861
Oil	409	9,417	6,640	4,594	4,185
Solar Photovoltaic	11,245	26,487	57,678	156,606	145,361
Trash-to-energy				630	630
Wind	13,011	26,627	32,896	49,916	36,905
Wood	5,713	5,487	6,184	7,684	1,971
Totals	911,930	1,287,928	1,931,520	2,983,373	2,071,443

Source: NEPOOL GIS data, available at: http://www.nepoolgis.com/

Note: *Note that some of the excess generation that has been exported to the local distribution system from net metered, behind-the-meter DG may be double-counted within the NEPOOL GIS system. See: http://www.iso-ne.com/committees/comm_wkgrps/mrkts_comm/geninfo_sys/mtrls/day_pitney_memo_03_05_13.doc

SUMMARY OF DG INTEGRATION CHALLENGES AND CORRESPONDING ISO INITIATIVES

Key Challenges of Large-Scale Adoption of DG

(Challenges – 1 of 4)

- Increased awareness of DG development and planning is needed
  - ISO has limited data concerning DG resources and will need increased knowledge about DG developments as they are planned and built
    - E.g., location, size, technology types
- A lack of real-time observability/controllability
  - The variability and uncertainty of intermittent DG (i.e., PV) output will eventually impact reserve/regulation operational requirements
  - ISO will need real-time data to support both a solar "nowcast" and solar forecast to enhance situational awareness and enable the efficient commitment and dispatch of resources
- Growing penetrations of DG could impact grid reliability, both in terms of system operations and system planning
  - Efforts are needed to harmonize state-jurisdictional interconnection standards with FERC-jurisdictional standards and other relevant NPCC and NERC standards

PV Impacts on System Operation

(Challenges – 2 of 4)

- Existing amounts of PV have not produced noticeable effects on system operations
  - At what penetration(s) will this no longer be the case?
- PV increases uncertainty in net load (i.e., load minus PV)
  - This is the case for both the day-ahead and intra-day operational load forecasts
- PV changes patterns of and increases overall net load variability
  - Studies of high penetration solar PV scenarios have demonstrated that PV dominates net load variability extreme events; however, much of this variability is predictable
  - Two sources of PV variability
    1. Clear-sky variability is the result of the sun’s diurnal cycle, irrespective of cloud cover
       - This variability is **largely predictable**
    2. Cloud-driven variability is the result of cloud density and movement
       - This variability is only partially predictable
  - Will we need increased ramping requirements during hours leading up to winter peak load?
- What will be the incremental impact of increased PV penetrations on reserve/regulation requirements?

Potential System Reliability Impacts of PV Interconnections* *(Challenges – 3 of 4)*

- State jurisdictional interconnection standards for DG are often modeled consistent with IEEE Standard 1547™
  - IEEE 1547™ originally developed with the assumption that DG would not reach significant levels with regards to the regional power system
- Unlike FERC Order 661A, IEEE 1547™ is a "don't ride through" requirement
  - Will likely lose DG during low frequency and low voltage conditions (if interconnected according to current IEEE standards)
- IEEE 1547™ prohibits DG from regulating feeder voltage
  - May change voltage response of system during disturbances
- The effectiveness of existing schemes for underfrequency and undervoltage load shedding may be impacted
- At large enough penetrations, decreased system inertia and impacts on system protection requirements may need to be evaluated
- At what penetrations do impacts begin?

Source: *NERC's Integration of Variable Generation Task Force (IVGTF) Task 1-8 Report, *Potential Bulk System Reliability Impacts of Distributed Resources*, August 2011.

DG Interconnection and Regional Power System Reliability *(Challenges – 4 of 4)*

- The IEEE Standards Coordinating Committee 21 (SCC21) is actively working on amending IEEE 1547-2003 to address the following three topics:
    1. Voltage regulation
    2. Voltage ride-through (VRT)
    3. Frequency ride-through (FRT)
  - Based on most recent draft,[1] the resulting amendments will not mandate VRT/FRT, but will permit these capabilities "as mutually agreed to by the area Electric Power System and Distributed Resource operators"
- NERC's IVGTF (Task 1-7) is conducting a technical review of the IEEE 1547 standards from the perspective of bulk system reliability
  - The Task 1-7 draft report is still forthcoming

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[1] Draft IEEE 1547a amendment document dated March 8, 2013, is available at: http://grouper.ieee.org/groups/scc21/1547a/docs/P1547a-Amendment1-20130308.docx

ISO Initiatives to Address Challenges

- ISO will be initiating a review of state interconnection standards with the New England states with the goal of harmonizing state-jurisdictional interconnection standards with FERC-jurisdictional standards and other relevant NPCC and NERC standards
  - FERC NOPR on Small Generator Interconnection Agreement (SGIA)/Small Generator Interconnection Procedures (SGIP)
    - ISO filed comments on June 3, 2013:

  http://www.iso-ne.com/regulatory/ferc/filings/2013/jun/rm13-2-000_6-3-13_iso_comments_sgia_procedures.pdf

  - ISO is participating in a NREL study aimed at examining the possible operational and reliability concerns associated with large amounts of distribution-connected generators
    - A primary study goal is the determination of the stability impacts of these resources on the transmission system resulting from state-jurisdictional interconnection standards modeled after IEEE 1547

ISO Initiatives to Address Challenges (cont'd)

- ISO is working with collaborative team led by IBM on a DOE-funded project to improve the state of the science of solar forecasting (DOE Award No DE-EE0006017)

- ISO is conducting research and will engage stakeholders to develop a long-term forecast of PV development in the region
  - Forecast will affect system studies of resource adequacy, transmission planning, economic studies
  - Will require re-evaluation of existing models and techniques and potentially the development of new models
  - The formation of the DG Forecast Working Group will enable ISO to work with other stakeholders to gather information needed to address all challenges

2012 HISTORICAL ANALYSIS: THE CONTRIBUTION OF SOLAR PV DURING PEAK LOAD PERIODS

What is the Capacity Value of PV?

- ISO uses PV's Seasonal Claimed Capability (SCC) as a measure of its capacity contribution towards system peak load
  - As an Intermittent Power Resource generator, SCC is determined using the median of net output from the most recently completed Summer Capability and Winter Capability Periods across the Summer (HE 14 - 18) and Winter (HE 18 - 19) Intermittent Reliability Hours, respectively.
    - Net-metered facilities will have their SCC determined this way regardless of their Intermittent/Non-Intermittent status
  - PV's Summer SCC is most often in the range of 35%-40% of its AC nameplate rating, and its Winter SCC is most often zero.
- In consideration of its unique generation profile, does historical PV generation data support the Reliability Hours estimation method as a reasonable approximation of PV's contribution to actual system peak loads?
  - What does the historical data reveal about the correlation of the weather driving the load and the weather driving solar output?

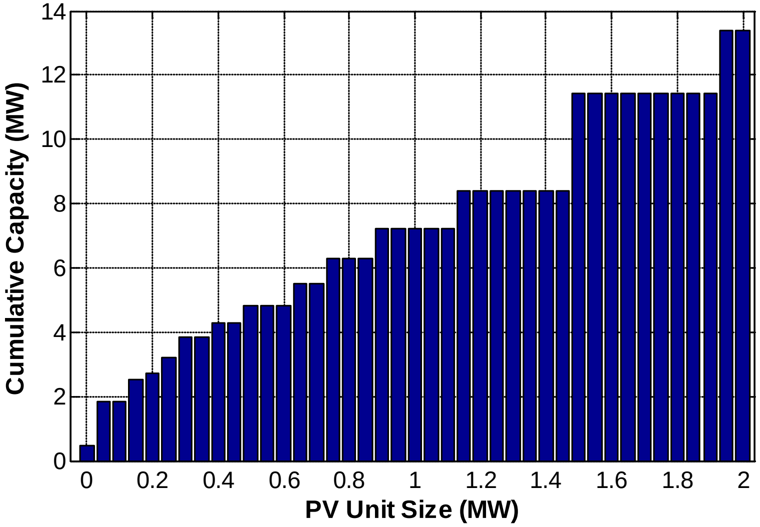
2012 Solar PV Settlements Data Analysis

- **Objective:** Conduct preliminary analysis to develop PV production characteristics to highlight the extent of PV generation’s correlation with system peak loads
- Of the 232 PV assets listed in June SCC Report, a total of 51 PV sites were operational for the entirety of 2012 and were used for analysis
- Assuming each PV unit’s max hourly output is its nameplate (AC), total AC nameplate capacity of 51 units is 13.4 MW
  - Maximum same-hour output of all 51 units is 12.87 MW (96% of total AC nameplate

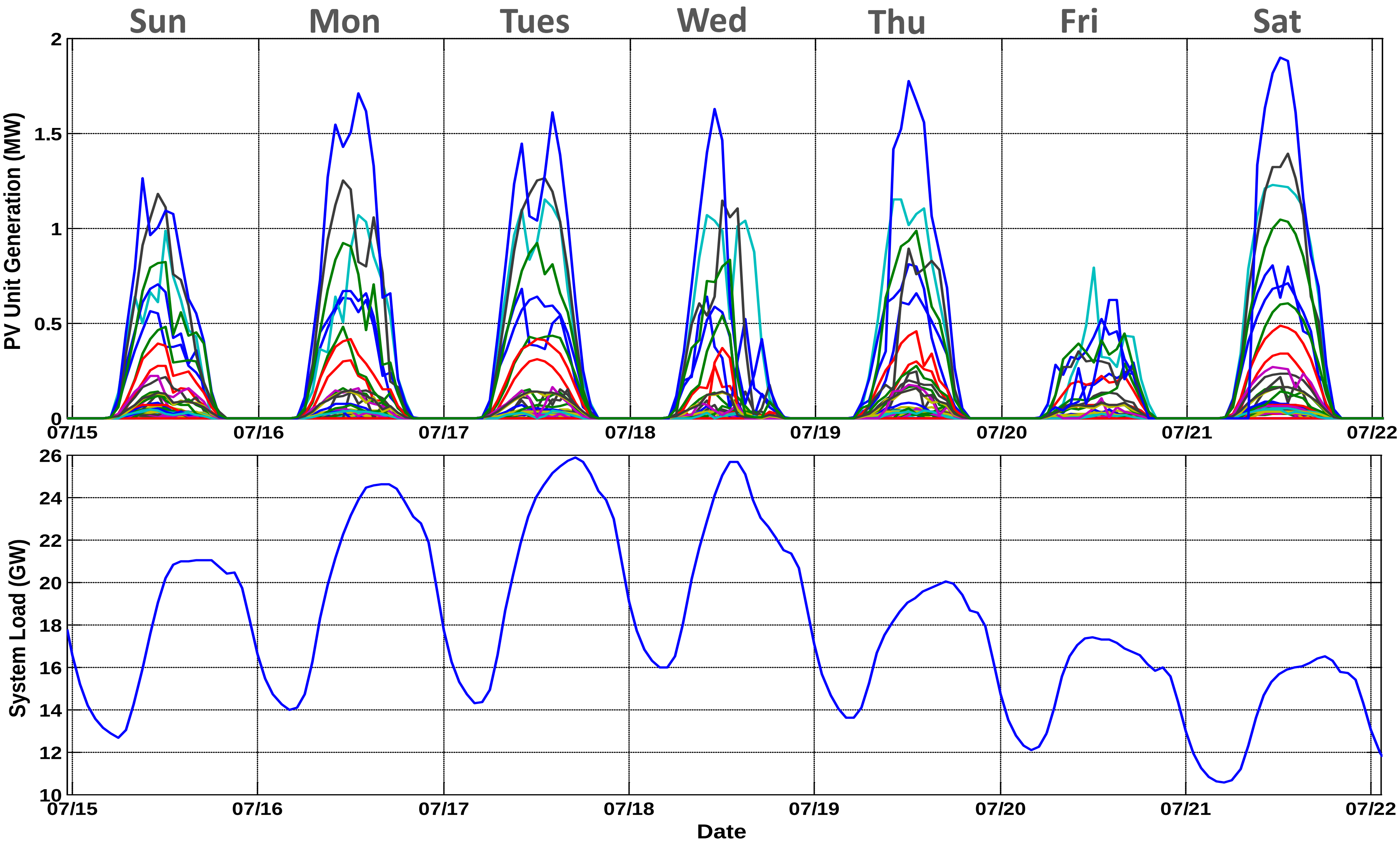
Dispatch Zone Distribution and Summer SCC

Dispatch Zone	# projects	Total Summer SCC (MW)
Boston	5	1.247
Central MA	10	0.231
Lower SEMA	3	0.793
North Shore	6	0.484
Rhode Island	3	0.006
SEMA	9	0.594
Springfield MA	2	0.9
Western MA	13	0.896
Totals	**51**	**5.151**

Cumulative Unit Size Distribution



July 15-21, 2012 PV Output and System Load

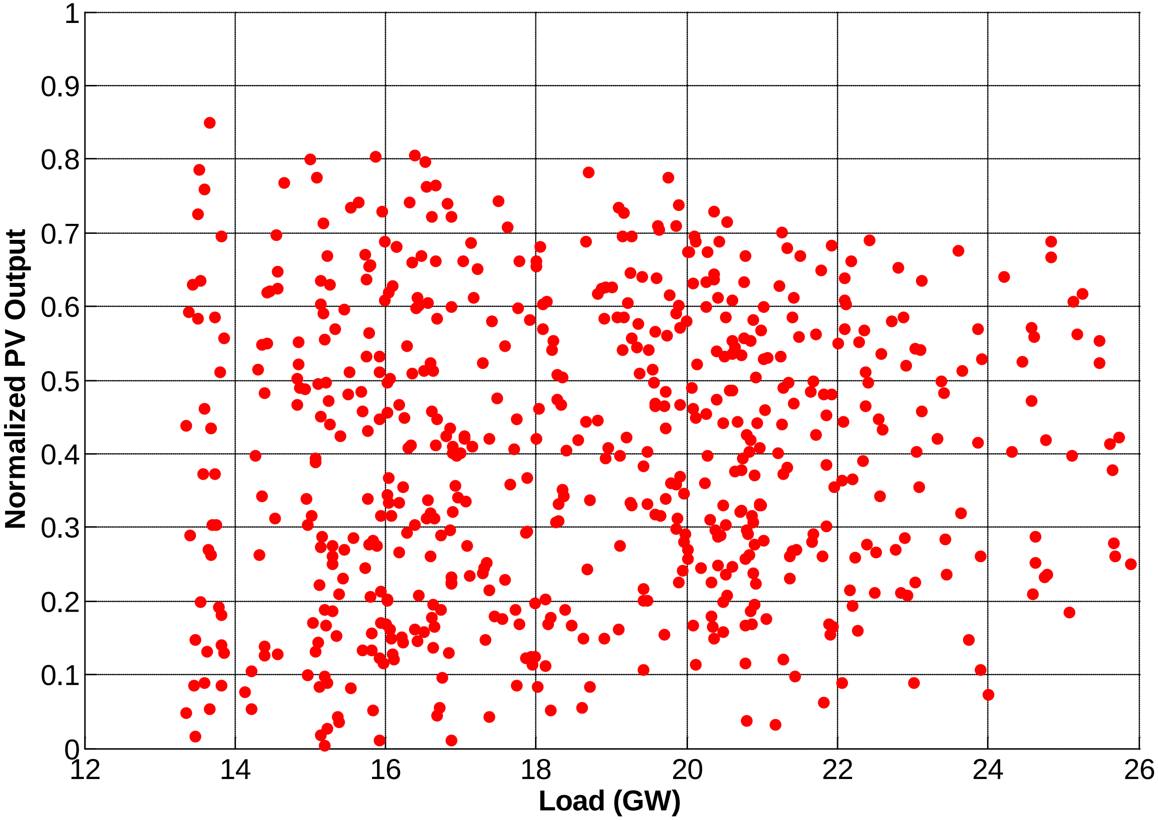


2012 Summer Reliability Hours

Normalized Aggregate PV Generation from 51 PV Units

- Not all reliability hours are peak load hours
- Summer SCC of aggregate PV profile = 40.4% nameplate (AC)
- Many peak loads occur later in afternoon when sun is lower in sky → lower PV output
- Weather conditions causing peak loads (high temperatures and humidity) also tend to reduce solar output
  - High temperatures reduce PV cell conversion efficiencies
  - High humidity cause lower clearness index
  - Low wind speeds→ less cooling of PV cells and power electronics

Normalized Aggregate PV Output vs. System Load
Summer Reliability Hours

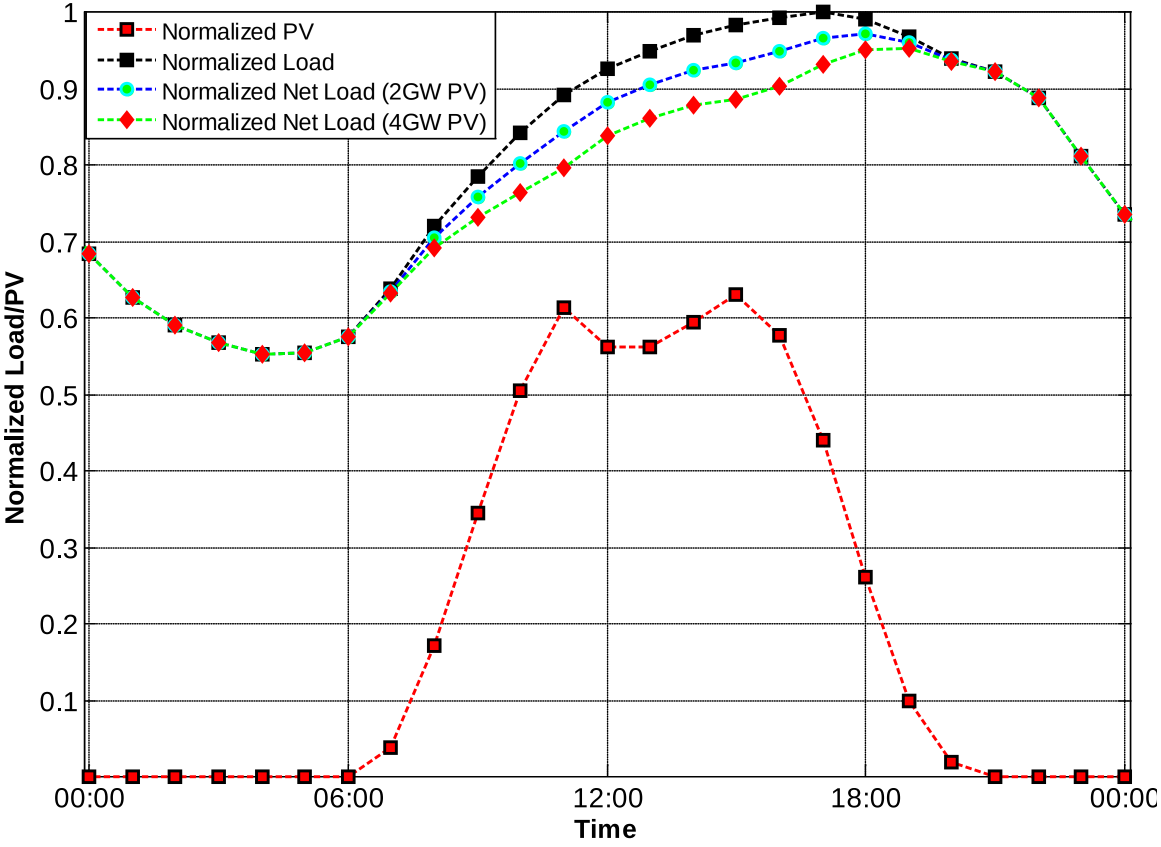


Summer Peak Load Analysis – July 17, 2012

Peak Load During Hour 17

- 2012 summer peak load day
  - 25,880MW at 5:00pm
- Load normalized to summer peak
- Simulated 2 GW and 4 GW of PV
  - Multiples of normalized PV used to determine “net load”
  - Net load normalized to original peak to observe effect of increased PV
- Peak net load with 2 GW PV
  - 25,144 MW at 6:00pm
  - 736 MW reduction, or 36.8% of nameplate (AC)
- Peak net load with 4 GW PV
  - 24,677 MW at 7:00pm
  - 1,203 MW reduction, or 30.1% of nameplate (AC)

July 17, 2012
Normalized Aggregate PV Output vs. System Load

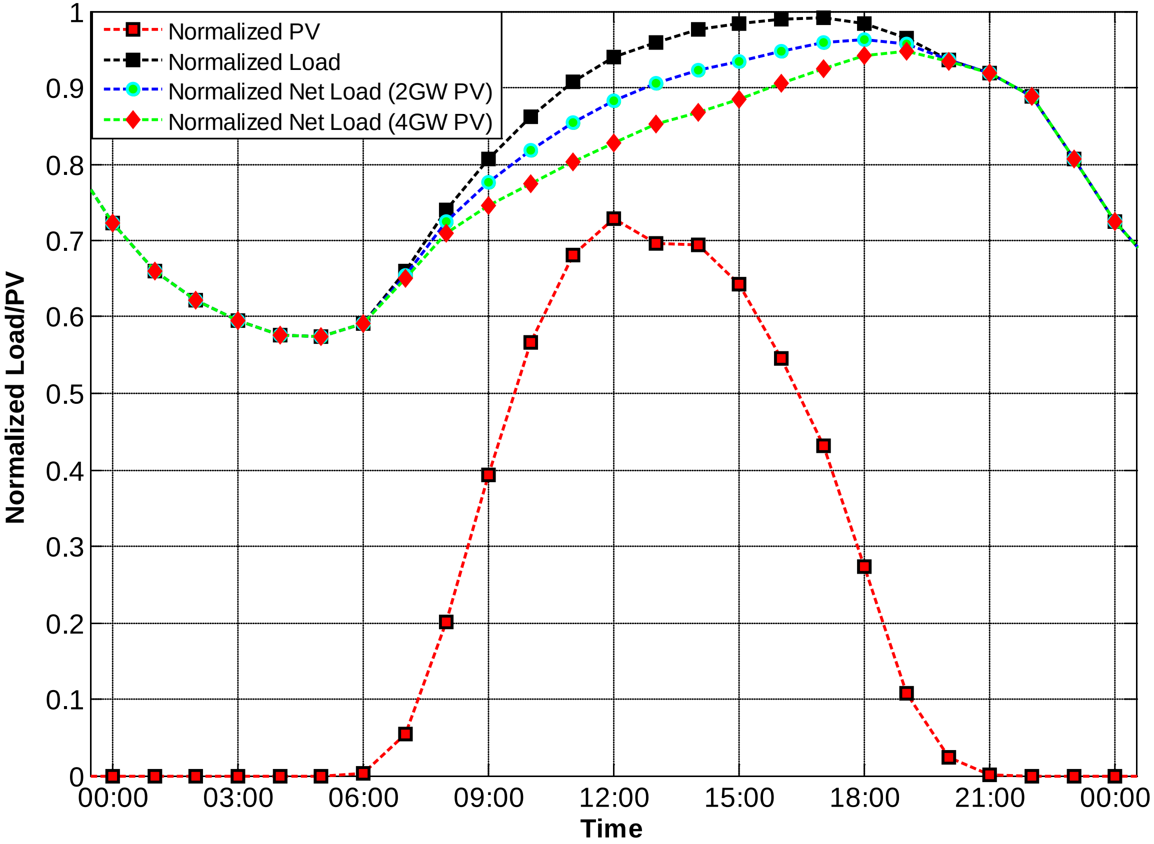


Summer Peak Load Analysis – June 21, 2012

Peak Load During Hour 17

- June 21, 2012 (2nd highest peak in 2012)
  - 25,678MW at 5:00pm
- Load normalized to summer peak
- Simulated 2 GW and 4 GW of PV
  - Multiples of normalized PV used to determine "net load"
  - Net load normalized to original peak to observe effect of increased PV
- Peak net load with 2 GW PV
  - 24,922 MW at 6:00pm
  - 756 MW reduction, or 37.8% of nameplate (AC)
- Peak net load with 4 GW PV
  - 24,548 MW at 7:00pm
  - 1,130 MW reduction, or 28.3% of nameplate (AC)

June 21, 2012
Normalized Aggregate PV Output vs. System Load

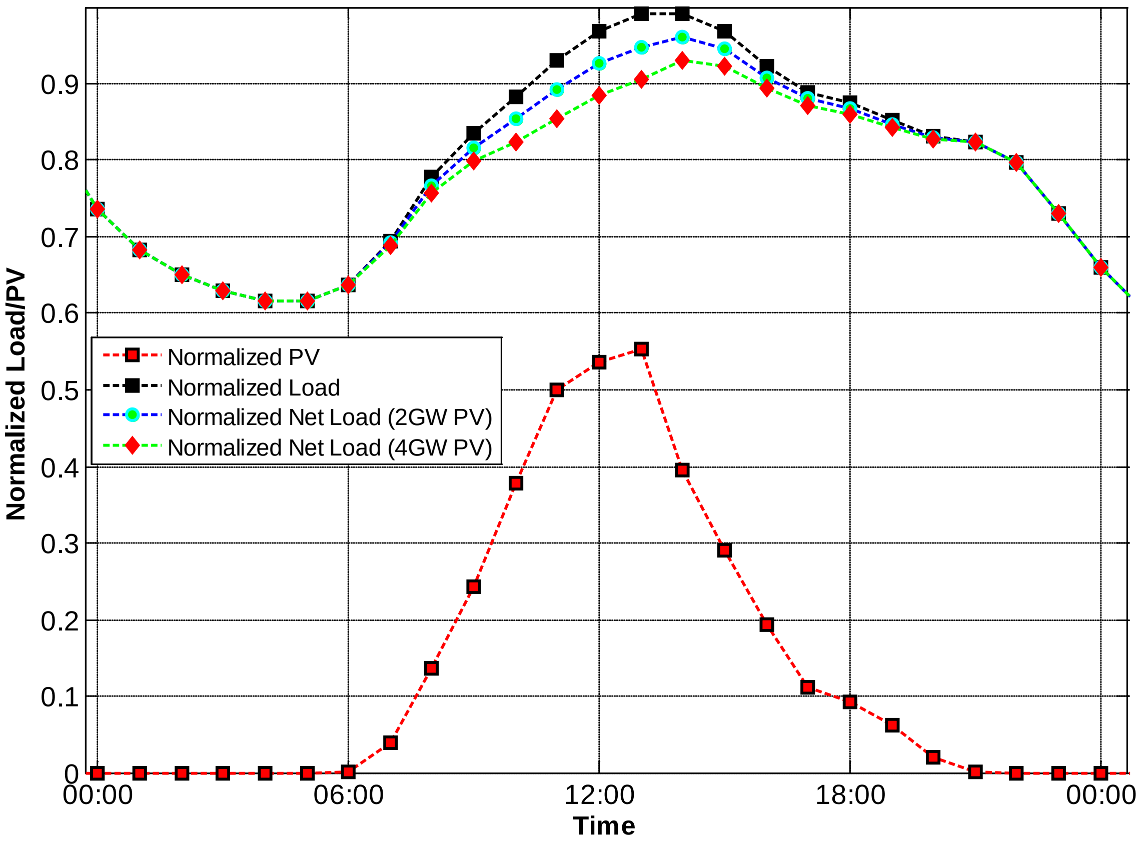


Summer Peak Load Analysis – July 18, 2012

Peak Load During Hour 14

- July 18, 2012 (3rd highest peak in 2012)
  - 25,667MW at 2:00pm
- Load normalized to summer peak
- Simulated 2 GW and 4 GW of PV
  - Multiples of normalized PV used to determine "net load"
  - Net load normalized to original peak to observe effect of increased PV
- Peak net load with 2 GW PV
  - 24,877MW at 2:00pm
  - 790MW reduction, or 39.5% of nameplate (AC)
- Peak net load with 4 GW PV
  - 24,087 MW at 2:00pm
  - 1,580 MW reduction, or 39.5% of nameplate (AC)

July 18, 2012
Normalized Aggregate PV Output vs. System Load

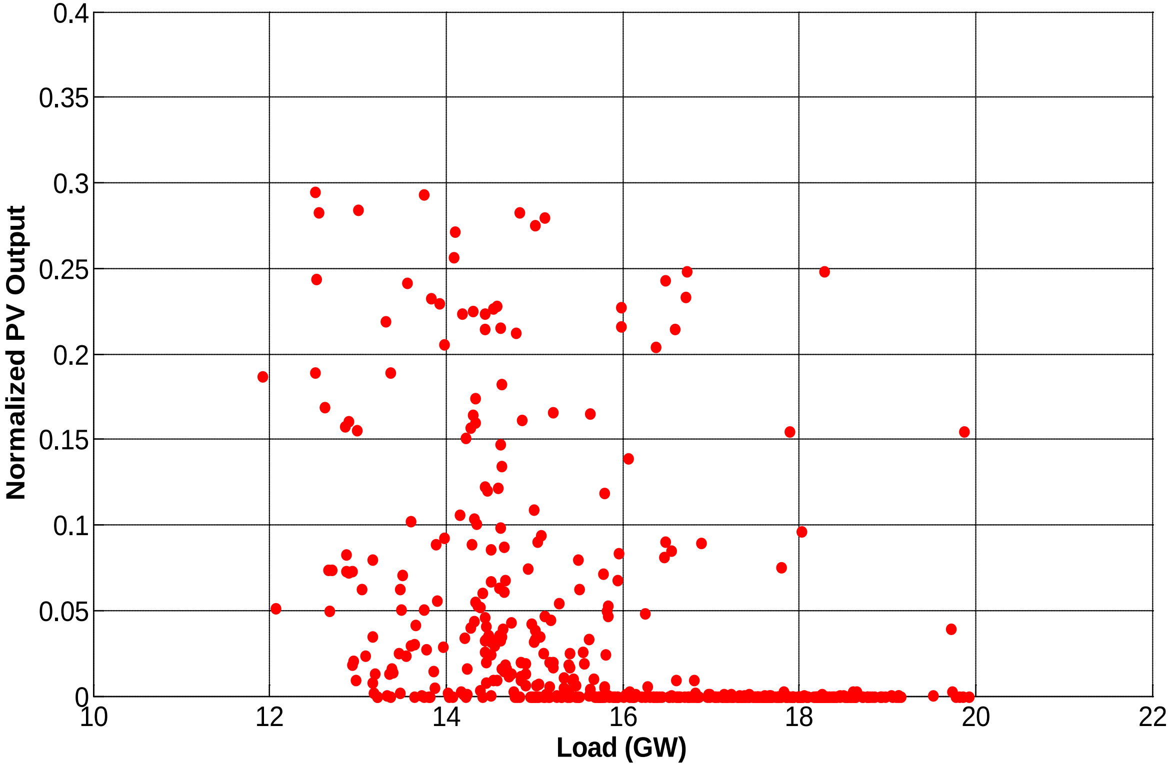


2012 Winter Reliability Hours

Normalized Aggregate PV Generation from 51 PV Units

- Not all reliability hours are peak load hours
- Winter SCC of aggregate PV profile = 0.7% nameplate (AC)
- During winter, sun is lower in sky → lower PV output
- Winter peaks occur in the evening, when sun is very low or it is already dark

Normalized Aggregate PV Output vs. System Load
Winter Reliability Hours

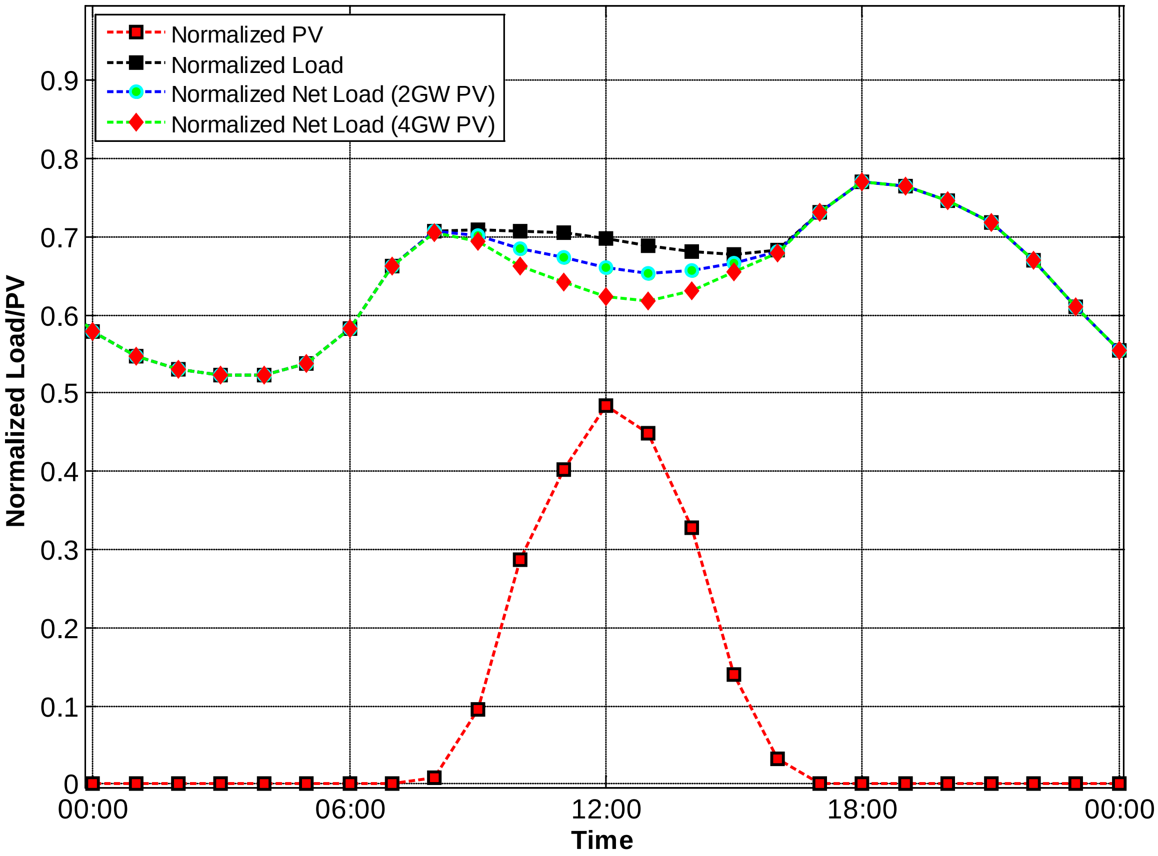


Winter Peak Load – January 4, 2012

Peak Load During Hour 18

- 2012 winter peak load day
- Load still normalized to summer peak
- Simulated 2 GW and 4 GW of PV
  - Multiples of normalized PV used to determine “net load”
  - Net load normalized to original peak to observe effect of increased PV
- Original peak load
  - Occurs at 6:00pm
  - 19,926 MW
- Peak load unaffected by PV
- Net load exhibits increased ramping leading into winter peak

January 4, 2012
Normalized Aggregate PV Output vs. System Load



Key Findings of 2012 Analysis and Conclusions

- The results of the 2012 analysis suggest that Summer SCC values may slightly over-state PV's contribution to summer peak load, but that they serve as a reasonable estimate at low penetrations
  - The timing of summer peak load is critical – in general, PV contributes more to earlier peak loads, and less to those occurring later in the afternoon
  - Increased amounts of PV will shift peak net loads later in the afternoon
    - This causes the incremental contribution of PV generation to peak loads to decrease as penetrations grow, and the Reliability Hours methodology to more significantly over-state its contribution
- Given that the long-term load forecast is based on many seasons of peak loads, additional analysis is needed to further evaluate PV's actual contribution to summer peak loads
  - ISO will periodically update this analysis as time passes and more historical data becomes available
  - Due to weather variability from year-to-year, there is a need to incorporate multiple years of data
- As PV penetrations increase, other methods of calculating PV's capacity value may be determined to be more suitable
  - Other potential methods were reviewed as part of NERC IVGTF's Task 1-2 efforts[1]
    - Method recommended by IVGTF – Effective Load Carrying Capability (ELCC)

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[1] Refer to NERC IVGTF's final report, *Methods to Model and Calculate Capacity Contributions of Variable Generation for Resource Adequacy Planning*, March 2011.

DISTRIBUTED GENERATION FORECAST WORKING GROUP

DG Forecast Working Group

- Will require an open collaborative effort between ISO and stakeholders, including:
  - State policy makers
  - DG/PV program administrators
  - Distribution companies
- Will require coordination of multiple simultaneous efforts
  - Need to address all of identified key challenges to the integration of large amounts of DG resources (refer to slide 14)
    - E.g., harmonization of state-jurisdictional interconnection standards and FERC-jurisdictional standards and other relevant NPCC and NERC standards
  - Data/information-sharing:
    - Obtain data and other information needed, including (but not limited to) amounts, locations, and time-series power production of DG resources
    - Need information concerning policy outlook to support DG resource projections
    - Data to support operational PV forecast
  - Conduct analysis of data to support forecast
- ISO will initiate group activities in the Fall of 2013

Challenges to Developing a DG Forecast

- Developing a forecast methodology
- Avoiding the double-counting of DG resources
  - Need to consider the ways in which existing DG are already treated in long-term planning (i.e., in FCA, as SOGs or historical loads used for CELT)
    - E.g., To what extent is the recent growth of DG resources already embedded in the long-term load forecast?
  - May need to reconstitute a portion of load that is served by DG resources
- Projecting the future growth of resources that have uncertain economics and product reliability
- How to determine resource capacity credit?
  - Will vary by resource type
- What geographic distribution should be applied to future DG resource projections?
  - DG resources will likely be unevenly distributed across region, and also across individual states
- Developing realistic timing of projected DG development

More Data is Needed

- Based on recent aggregate PV energy output, approximately 1/4 of PV energy produced in New England is registered in wholesale energy market
- More data will be needed for ISO's PV-related integration activities (e.g., solar forecast development)
  - ISO will likely need time series production and other related data associated with many additional projects, especially from parts of the region currently underrepresented in energy market data
- Data associated with other DG resources will also be needed

Summary of Issues/Needs That Must Be Addressed

- Potential reliability impacts due to DG interconnection standards
- Lack of data concerning DG project development and operation
- Potential operational issues due to the lack of DG visibility/control
- Meeting all of the challenges of developing a quality long-term DG forecast

Questions