FINAL REPORT

Demonstrating Enhanced Demand Response Program Participation for Naval District Washington (NDW)

ESTCP Project EW-201343

JUNE 2019

Gregory J. White P.E.
Weston Solutions, Inc.

ESTCP

Page Intentionally Left Blank

Page Intentionally Left Blank

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*
06/28/2019

2. REPORT TYPE
ESTCP Final Report

3. DATES COVERED *(From - To)*
9/27/2013 - 3/27/2019

4. TITLE AND SUBTITLE
Demonstrating Enhanced Demand Response Program Participation for Naval District Washington

5a. CONTRACT NUMBER
13-C-0036

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Gregory White

5d. PROJECT NUMBER
EW-201343

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Weston Solutions, Inc.
1400 Weston Way
West Chester, PA 19380

8. PERFORMING ORGANIZATION REPORT NUMBER
EW-201343

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Environmental Security Technology Certification Program
4800 Mark Center Drive, Suite 17D03
Alexandria, VA 22350-3605

10. SPONSOR/MONITOR'S ACRONYM(S)
ESTCP

11. SPONSOR/MONITOR'S REPORT NUMBER(S)
EW-201343

12. DISTRIBUTION/AVAILABILITY STATEMENT
Distribution A; Approved for public release: distribution unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT
This final report is submitted at the request of the ESTCP program to document the plan to conduct the demand response (DR) pilot study and summarize the work accomplished up to the point where the pilot was halted due to new government-required cybersecurity processes put in place. The Risk Management Framework (RMF) process was first enacted in or about 2017 as a replacement to the accreditation process that the Weston Solutions, Inc. (WESTON®) Advanced Metering Infrastructure (AMI) was originally granted an Authority to Operate (ATO) by the Department of the Navy (Navy) U.S. Fleet Cyber Command in 2012.

15. SUBJECT TERMS
Enhanced Demand Response, Naval District Washington

16. SECURITY CLASSIFICATION OF: a. REPORT	b. ABSTRACT	c. THIS PAGE	17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON / 19b. TELEPHONE NUMBER *(Include area code)*
UNCLASS	UNCLASS	UNCLASS	UNCLASS	101	Gregory White / 301-824-9050

Standard Form 298 (Rev. 8/98)
Prescribed by ANSI Std. Z39.18

Page Intentionally Left Blank

FINAL REPORT

Project: EW-201343

TABLE OF CONTENTS

Page

TABLE OF CONTENTS (Continued)

Page

LIST OF FIGURES

Page

LIST OF TABLES

Page

ACRONYMS AND ABBREVIATIONS

%	percent
%WBP	DR percentage of the whole building power
°F	degree Fahrenheit
AMI	Advanced Metering Infrastructure
ATO	Authority to Operate
BAS	Building Automation System
BMS	Building Management Systems
CBL	Customer Base Line
COTS	Commercial Off the Shelf
CSP	Curtailment Service Provider
CSV	Comma Separated Values
DAH	Naval Support Facility Dahlgren
DCA	Washington DC Reagan National Airport
DDC	direct digital control
DLAT	Demand-Limiting Assessment Tool
DoD	Department of Defense
DOE	Department of Energy
DPR	demand peak reduction
DR	demand response
DRQAT	Demand Response Quick Assessment Tool
DRRC	Demand Response Research Center
DST	Daylight Savings Time
DY	delivery year
EISA	Energy Independence and Security Act
EO	Executive Order
ES	electricity supply
GTA	global temperature adjustment
HVAC	heating, ventilation, and air conditioning
ICS	Industrial Control System
ISO	Independent System Operator
JBAB	Joint Base Anacostia-Bolling
kW	kilowatt
kWh	kilowatt hour

LBNL	Lawrence Berkeley National Laboratory
LMP	locational margin pricing
M&V	monitoring and verification
MA	morning adjustment
MW	megawatt
MWh	megawatt hour
N/A	not applicable
Navy	Department of the Navy
NCDC	National Climate Data Center
NDW	Naval District Washington
NMCI	Navy Marine Corps Internet
NOAA	National Oceanic and Atmospheric Administration
PIT	Platform Information Technology
PJM	PJM Interconnection
PLC	programmable logic controller
PRA	PIT Risk Approval
RMF	Risk Managements Framework
SAA	symmetric additive adjustment
SCADA	supervisory control and data acquisition
SHoC	Shore Operations Center
SSSPN	Shore Sensor System Platform Network
W/ft^2	DR per building square feet or meter
WESTON®	Weston Solutions, Inc.
WNY	Washington Navy Yard
WSA	Water Sensitive Adjustment factor

EXECUTIVE SUMMARY

This final report is submitted at the request of the ESTCP program to document the plan to conduct the demand response (DR) pilot study and summarize the work accomplished up to the point where the pilot was halted due to new government-required cybersecurity processes put in place. The Risk Management Framework (RMF) process was first enacted in or about 2017 as a replacement to the accreditation process that the Weston Solutions, Inc. (WESTON®) Advanced Metering Infrastructure (AMI) was originally granted an Authority to Operate (ATO) by the Department of the Navy (Navy) U.S. Fleet Cyber Command in 2012 (**Appendix A**).

This Platform Information Technology (PIT) Risk Approval (PRA) for the WESTON AMI was the basis whereby the pilot program would be able to collect and perform an analysis of data collected from the secure side of the network of various building usages when controlled temperature set points were changed to determine the effects of electrical usage and peak demand under a variety of environmental conditions.

Under the proposed concept detailed later in this report, the data were to be gathered in the Shore Operations Center (SHoC), located at the Washington Navy Yard (WNY), which was designed as the central control center and depository of data collections. Because of the difficulty of assimilating data gathered from a variety of legacy Building Management Systems (BMS) that were being updated at various Navy installations within the Naval District Washington (NDW), the available data were limited. The full use and advantage of the SHoC was never able to be utilized due to delays in connecting to the various installations before the advent of the RMF process halted all data collections.

The original plan was to analyze DR capabilities at the three installations in the WNY reporting footprint (WNY, Naval Support Facility Dahlgren [DAH], and Joint Base Anacostia-Bolling [JBAB]), but, due to delays and challenges, limited tests were able to be performed. Only a limited data set was able to be collected at the Navy's Dahlgren installation during some high temperature days. That data are presented at the conclusion of this report, along with some analysis that was able to be applied to the limited information gathered. Conclusions based on this analysis and other known industrial collected data are presented in the event the balance of the work proposed in this pilot are eventually funded and completed. The remainder of this document outlines the program plans and performance objectives for the original demonstration plan that would have been performed if the project had proceeded as planned.

Page Intentionally Left Blank

LESSONS LEARNED

One of the key lessons learned while preparing for the demonstration was establishing the true schedule to be able to enact the pilot efficiently within the constraints of working with the Department of Defense (DoD) processes. It became evident early in the process that there were limitations as to how much and when data could be made available for the purposes of generating the reports to verify the approach and integrate that data into the functional design development.

Although all the necessary security measures and ATO documents were in place, the actual information gathering and controls were not. Despite the best efforts of the Navy to be in a position to control and pass data to the pilot, the NDW region was still developing the ability to control the BMS at the various bases within the SHoC for the first few years after the contract was awarded. This delay in getting the information to the pilot program resulted in a gap in time, leading to the then new RMF cybersecurity process to supersede the security measures put in place when the pilot was initially kicked off.

The work required in the development of data gathering and analysis was prepared and readied for the time that data would be made available to integrate into the analysis and reports. Unfortunately, the data never became available.

Programs working with DoD agencies and alike should plan and verify that systems are in place and ready to be used when proposing research projects and pilot programs. Private industry can enact processes much more efficiently and quickly than federal programs.

SUMMARY OF COMMENTS ON FINAL REPORT

Comment #1

1. *Discuss the impact of the demand response system on the installation's facilities managers in terms of the time and skills needed to safely and effectively operate the system.*

Response – As envisioned in its final form, the DR system would only require the nomination of which assets on the facility would participate in the DR event. This “yes or no” selection would be based on the criticality of the building mission on the day of the event. As shown in Figure 2-1, the “Energy Operations Manager” would include or not include buildings in the event. Once included in the event, the building automation systems would control set points to achieve previously determined building performance to reduce power consumption during the DR event, as well as control power consumption during the “rebound” period after the DR event. Because contracts are entered into between the power supplier and the end user, a minimum number of available assets would need to be entered to realize the “credits” involved with the supplier. Therefore, the number of available assets would need to be greater than the minimum needed to meet the contracted energy reduction amounts.

Because the system is operating on the secure side of the network, the monitoring of unsecured weather data, as well as the DR event signaling system would need to bring the information into the secure side without jeopardizing the security of the secure side of the network. These data flows are shown as arrows pointing to the right.

In terms of skills and time needed to operate the system, once the system is automated, the operator would basically be needed to bring data cleared to be entered into the system, and the system would, through developed algorithms, conduct the operations and produce the data needed for verification back to the supplier.

2. *Explain the calculations underlying the economic analysis, particularly the payback associated with the system.*

Response – One of the goals of the DR/DPR pilot was to establish the economic feasibility of entering into various markets, as they vary from year to year. A theoretical economic model was going to be developed during the analysis of the data without the risk of entering into binding contracts with the ISO. The data presented in this demonstration plan/final report were added based on prior work completed by LBNL at various NDW bases to augment the limited data that were able to be taken.

3. *Discuss the minimum level of metering needed for military installations to participate in DR programs.*

Response – The rule of thumb, in the industry, is traditionally 20% of the buildings on a given base consume 80% of the power. If the government continues installation of metering at that level, it would provide the needed inventory to be used for a DR program. Specifically, NDW used the largest 20% of building square footages to fill out the inventory on which metering would be added.

4. *Color-code diagrams of the DR system to depict where actions involve human decisions or automated responses.*

Response – Figures 5-1, 5-2, and 5-3 and Appendix C have flow and decision matrix diagrams depicting where actions involve human decisions.

Comment #2

Discuss how under-maintained HVAC systems (if there are such systems on the buildings that are chosen) impact the ability to respond to Demand Response events.

Response – The process of choosing buildings to respond to DR applications and programs is predicated on the ability of the Building Automation System (BAS) to react and record events required for verification that needs to be submitted to the ISO as proof the savings in energy were in fact achieved. If systems are under maintained and not able to react and collect data, those buildings are not good candidates, and should be avoided. Likewise, it is very important that buildings that have recent BAS installations have preventative maintenance programs kept current, again to be able to provide reaction to and verification to DR/DPR events. Because contracts typically have penalties associated with them, if reductions are not achieved and documented, it is very important that building systems are well maintained.

1.0 INTRODUCTION

The Department of Defense (DoD) is under a directive to reduce energy usage, thereby reducing energy costs. The commercial sector has found that demand response (DR) programs are part of the energy solution. Although the electrical utility market has many DR programs, DoD is limited in its participation because of concerns about cyber and operational security, the lack of integrated energy management systems and tools, and the perceived impact to the DoD mission. Increased participation brings significant economic benefits in terms of energy reduction and economic incentives from participation in DR programs. In addition, as the largest consumer of electricity on the electrical grid at many locations, DoD's inability to curtail load when requested increases the likelihood of power delivery failures and potentially jeopardizes an installation's energy security and mission.

Controlling energy-consuming assets (i.e., heating, ventilation, and air-conditioning [HVAC], lighting, motors) based on signals from the grid allows on-demand electrical capacity reduction and, thus, frees up this capacity to be used elsewhere on the grid. To demonstrate this control, up to 15 demonstration sites, or buildings, on 3 Naval District Washington (NDW) region bases (Washington Navy Yard [WNY], Naval Support Facility Dahlgren [DAH], and Joint Base Anacostia-Bolling [JBAB]) have been selected to represent the overall mix of DoD building end-use types, which include office, mixed work use, and dormitories for this demonstration.

The demonstration effort is centered on the participation during the 2015/2016 and 2016/2017 delivery years (DYs) of PJM Interconnection (PJM) (the grid operator) and participation in the PJM June through October 2015 and 2016 Extended Summer DR Program. This demonstration project will be a pilot program within PJM. Participation between PJM and the Department of the Navy (Navy) is facilitated by Weston Solutions, Inc. (WESTON®) in the form of a "pilot program" that does not have actual fiscal results. The outcome will be a theoretical financial model to show economic benefits should DoD wish to sign contracts in the future, to enter the program and to receive actual financial rewards.

Prior to participation and operation, an assessment of the controllable energy assets at the demonstration sites will be performed, and systems integration between existing systems for building control and electrical metering systems will be conducted. When the Extended Summer DR Program data are available, a theoretical cost analysis will be conducted during the late 2016 and into the 2017 time period. Depending on the results of the 2016 program, participation in DR programs may continue into summer 2017, but efforts now are being focused to have the demonstration completed by the end of the 2016 cooling season.

By using the same process as DR, it is anticipated that peak shaving will mean that an installation can avoid exceeding its existing maximum annual demand level and be able to have sufficient control to set and sustain lower demand levels for the future. Because a significant portion, typically 20 to 30 percent (%), of an installation's electrical bill is a result of a peak demand charge, setting and sustaining lower peak demand levels can result in significantly lower electrical costs and save energy.

Figure 1-1 illustrates the demand response process. Incoming signals from PJM requesting load curtailment direct operators at the Shore Operations Center (SHoC) to affect building operations to curtail load. Electrical metering and weather data are used to forecast demand curves and baselines, to monitor the curtailment action, and to validate load reduction commitments where realized. The resulting actions yield revenue from PJM program participation and savings from avoided/reduced energy costs. The same response process is used for demand peak reduction except that the response action to initiate a response is determined by the predicted forecast load exceeding a predefined load target.

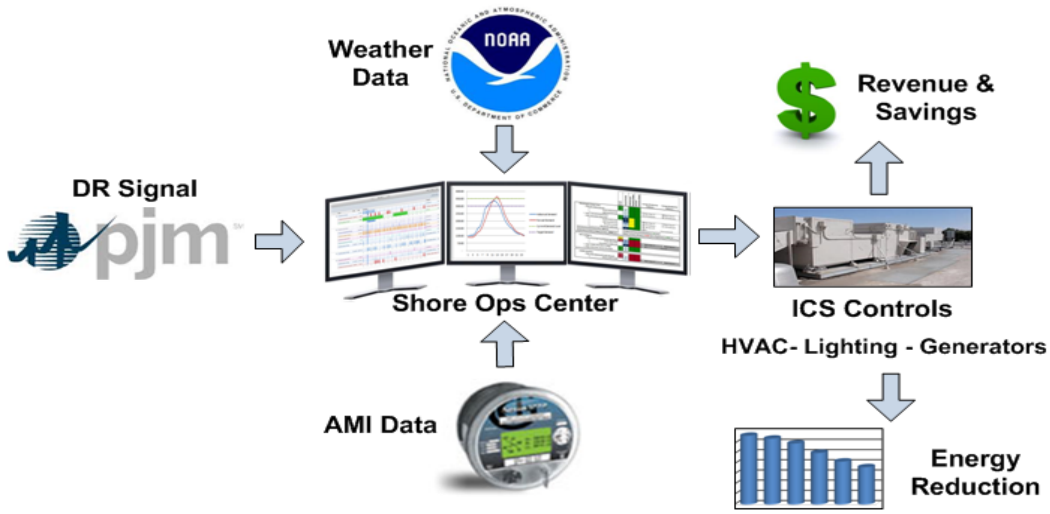


Figure 1-1. Demand Response Process

1.1 BACKGROUND

The Navy and other military services have expended significant effort to improve their energy management systems and tools. NDW has invested in both an Advanced Metering Infrastructure (AMI) that includes metering and metering data systems, and a uniform Industrial Control System (ICS) to monitor and control building systems. The AMI system deployed for NDW is a Commercial Off the Shelf (COTS) solution currently being used in the commercial marketplace for DR and demand peak reduction (DPR), and for other energy monitoring, analysis, and commissioning applications. These investments provide NDW with an ideal opportunity to demonstrate the value that can be achieved from the integration and effective use of these systems and tools by DoD. A single solution can be implemented that can be used for DR and applied to DPR and other processes to assist in meeting the energy reduction goals.

Both AMI and ICS have been granted a Platform Information Technology (PIT) Risk Approval (PRA) by the U.S. Fleet Navy Cyber Command for the operation of an AMI system for all Navy installations. The use of COTS solutions that are accredited and conform to existing cyber and operational security requirements for both energy and building control solutions reduces the level of effort. The challenge remains in implementing a solution that is acceptable at both the facility and building levels and that does not compromise the day-to-day mission. The goal of this demonstration project is to meet this challenge and build the required level of confidence for all involved while achieving significant financial benefits.

The ICS and AMI system are proven technologies. No technical restraints are anticipated that would prevent this demonstration phase of the ESTCP project from being replicated across NDW or other DoD services. The DR system is scalable across an entire region and customizable to allow for future interoperability. The layout of the system allows key data and algorithms to be installed and operated. The SHoC operator will follow set procedures and maintain the required data inputs for optimal DR monitoring and control. Education, training, and adoption of future sites would follow a procedure similar to the demonstration program. The primary areas for development relate to linking the technology to the screening, selection, business process, and evaluation of the technology and processes in the context of the market environment and the PJM administrative rules.

1.2 DRIVERS

Both legislative and Executive Orders (EOs) require a 3% energy reduction per year or 30% by 2015 (Energy Independence and Security Act [EISA] ’07 and EO 13423). A new EO 13693, Planning for Federal Sustainability in the Next Decade, issued March 19, 2015, requires the reduction of energy use in federal buildings by 2.5% per year between 2015 and 2025. The Navy goal is 50% reduction ashore by 2020 compared to the 2003 baseline. Initial energy reduction efforts have focused on readily implementable opportunities for energy efficiency and conservation. Now, other, more complex approaches need to be applied to meet energy reduction goals. Participation in DR programs and DPR will reduce energy consumption and provide cost savings through reduced demand costs and through revenue from DR program participation. These economic benefits are also a significant driver because DoD budgets are continually being reduced.

1.3 OBJECTIVES OF THE DEMONSTRATION

The overall objective of the demonstration project is to show that through the deliberate control of building energy-consuming assets, a predictable kilowatt (kW) capacity reduction can be achieved to support the enrollment of DoD for greater capacity in DR programs. The ancillary benefits of the solution will allow an installation to use the same process to reduce its peak demand load, further offering additional energy reduction and economic benefits. DoD installations may be the largest consumer of electricity on the electrical grid at many locations. DoD’s inability to curtail load when requested increases the likelihood of power delivery failures and potentially jeopardizes an installation’s energy security and mission. Increased participation in DR also benefits the economy. Over the last year, the Base Residual Auction price for capacity in the PJM grid has dropped significantly, and the increased DR capacity was cited as one of the factors in the price decline. This price decline has a direct impact on the consumer and results in stabilizing energy costs.

Unique within DoD, this project at NDW can be executed with a high degree of control, monitoring, and integration of systems because the necessary systems have a PRA and Authority to Operate (ATO). The existing AMI and ICS software and hardware functions will be used to perform DR/DPR actions. The solution involves the process of working within the closed cyber-secure network, performing DR/DPR actions without impacting the mission, and determining the kW capacity reduction available. Implementation and operational processes and guidelines will be developed for both operations and economic determination, allowing the transfer of the approach to other installations.

Ultimately, this demonstration project must show that establishing and maintaining a DR/DPR program has a net positive economic impact and must provide documentation of the processes that will result in energy reductions while not impacting an installation's mission.

2.0 TECHNOLOGY DESCRIPTION

The integrated NDW energy management systems and tools (EnergyGuard for ICS and EIServer for AMI) will be leveraged to safely and securely participate more fully in the DR programs and DPR. Specifically, load reduction options will be executed and monitored; identifying and quantifying reduced energy demand and reduced energy costs; improving energy security; and determining how to transfer the technology and processes to the other DoD services.

2.1 TECHNOLOGY OVERVIEW

The overall concept has been defined and proven in the commercial sector. The steps are as follows:

1. Notice is received from the utility to curtail load and/or to provide electricity back to the grid.
2. Building control systems are enabled for load response.
3. System provides notification and back-up documentation of load curtailment/electricity provided.
4. Facility receives payment for its participation.

The application of this technology is different in the DoD environment because of cybersecurity and because of the potential for an installation to deny load reductions due to overriding mission obligations. The internal cybersecurity concerns have been addressed by using accredited solutions that reside on an accredited network, the Shore Sensor System Platform Network (SSSPN). The actual impact to mission operations is one of the evaluation objectives of this demonstration project.

Elster's EnergyICT eiMaster software is the center of the DR/DPR solution. The eiMaster software provides real-time advanced energy algorithm analysis through its native regression modeling functionality, utility meter and data management, weather depository, ad hoc reports, benchmarking, and data validation, and manages access to information. The system can aggregate multiple facilities/sites, model results based on performance indicators, and present DR options to the SHoC operator.

The ICS incorporates supervisor monitoring, control and trending capability integrating legacy direct digital control (DDC), programmable logic controller (PLC), and supervisory control and data acquisition (SCADA) systems in support of NDW's Regional Energy Reduction Initiatives. ICS will receive signals from the DR ICS interface to put modified schedules and logic into action during the specified DR/DPR event. The ICS provides three layers of control for staging and implementing DR/DPR actions as commanded from the SHoC. An equipment layer at the facility is directly integrated by software protocols to different automation manufacturers, bringing data and control into one system. A second layer at the base level is for the local operator to make routine control changes, to navigate and maintain connected facility systems, and to implement authorized DR/DPR strategies. The last level is the regional level at the SHoC where centralized ICS data are collected and overall administration of control and system operations oversight and redundancy is provided.

Network connectivity is provided by the SSSPN. For DR/DPR actions, access to information is required through the web, from PJM sources, and from a National Oceanic and Atmospheric Administration (NOAA) weather data source. For the demonstration project, interfaces with external sources will be through the Navy Marine Corps Internet (NMCI), which has access connections to the web. All transactions between the web and the SSSPN will be manual, including the transfer of data files.

The center of operations in 2015 initially was located at DAH due to increased security measures and concerns at the desired location at NDW WNY in the SHoC. The energy station was manned by an operator performing the required actions during the PJM Extended Summer DR Program period from June through October 2015. For the period from June through October 2016, locating the center of operations at the NDW WNY at or close to the SHoC will be revisited because regional operations continue to be deployed at that location. The demonstration can still be run from DAH if plans at WNY do not come to fruition. Closer coordination of mechanical set point changes will be required from the DAH demonstration location.

Figure 2-1 provides an illustration of data flow and systems connectivity. The SHoC is the focus of the DR/DPR activities from monitoring for events to implementing actions and facilitating verification reporting. The energy SHoC operator is charged with implementing the process as defined by the following areas:

- **Asset Load Response** – For each asset type within a building, the asset will be evaluated for its potential load response for each energy action. For example, if the energy action is a global temperature adjustment to raise the temperature by 1 degree Fahrenheit (°F) in a building, what is the load response curve during the duration of each 1 °F increment adjustment? The kW of single and incremental 1 °F adjustments needs to be understood for the entire DR deployment period, from the deployment start through the reduction deadline (ramp period) and then through the release call (sustained response period). These responses are based on theoretical calculations, and SHoC will be responsible for monitoring actual load response throughout the demonstration period and making the necessary adjustments. Load response will also be monitored after the release call to determine the proper release strategy to avoid HVAC bounce and inadvertently setting a new peak demand. It should be noted that a 3 °F increment was needed based on the information gathered during summer 2015 work in order for any recognizable savings to be seen in the data. Closer examination of this finding will be conducted during the next part of the demonstration.
- **Daily Preparation** – Weather data (daily hourly observations and forecast data) are loaded into eiMaster. This action is done manually by copying data from one computer onto CD and then loading the data onto eiMaster. Because JBAB is in part an Air Force operation, use of weather data originating from that branch of DoD will be investigated for use in the DR program. Security concerns across the various DoD branches will still need to be addressed.
- **Daily Monitoring** – eiMaster uses historical building load baselines and creates a load forecast for up to 7 days. These forecast loads are compared to current and target peak loads and provide warning of the potential for DR alerts from PJM. Monitoring for PJM warnings also connects through the automated polling of the PJM notification system. If monitoring indicates the potential for an upcoming DR and/or DPR event, the operator queries the installation to determine whether the installation as a whole or an individual building needs to opt out of any energy action for mission-critical reasons.

- **Demand Response Actions –** Day-of-event monitoring of PJM is conducted for confirmation of a DR emergency action and the DR deployment period. The eiMaster software provides outputs indicating the kW reduction required based on the eiServer native regression modeling functionality to define the Customer Base Line (CBL) and the nominated load reduction to PJM. The operator programs the load reduction and the DR deployment period into the ICS interface, and the actions are sent to the ICS server for implementation. The interface and the reporting to conduct the monitoring of the DR event are provided by eiMaster, allowing the operator to make any adjustments to ensure the kW reduction is maintained below the nominated value.
- **Demand Peak Reduction Actions –** The day of the forecast for a DPR action, eiMaster outputs are reviewed, indicating the kW reduction required to avoid exceeding the previous peak and to obtain a target peak. The operator programs the load reduction and the time period into the DR/DPR management interface, and the actions are communicated to the designated ICS operators for implementation. The reporting to conduct the monitoring of the DR event is provided by eiMaster.
- **Post-Event Actions** – Settlement and measurement and verification (M&V) reporting must be provided to PJM as documentation that the Navy has met its obligation of load reduction for the DR deployment period. This action must be completed within 45 days of the DR event. These data reports are generated by eiMaster. For security reasons, submission of the reports will be through manual file copy from eiMaster to PJM. Other actions included in the post-event period are to ensure that all data are obtained for the performance assessment of the demonstration project.

Where a common ICS exists on a secure network, the ability to deploy a DR/DPR solution is possible at most DoD locations. The processes developed and the understanding gained in operation of the DR/DPR solution within the constraints of DoD are completely transferable. The specific energy informatics related to benchmarking, forecasting, and analysis are proprietary to EnergyICT, but similar functions exist on other energy software platforms. For optimal deployment within DoD, external data imports and required exports to the grid operator should be automated. As part of this demonstration, a process for implementing automated transactions in a cyber-secure manner will also be evaluated.

2.2 ADVANTAGES AND LIMITATIONS OF THE TECHNOLOGY

As stated in the preceding sections, the process for DR and DPR has been proven in the commercial market sector; however, at NDW, the components needed to implement a DR/DPR solution are also accredited by the Navy as cybersecure. This facilitates further implementation at NDW and within the Navy with minimal effort. The application within DoD provides for larger scale implementation within a boundary consistent with a large campus or small city. For the grid operator, it may be preferable to have such a large installation, a point on the grid, that can achieve a large kW reduction on a particular constrained node on the grid rather than reductions spread across a region.

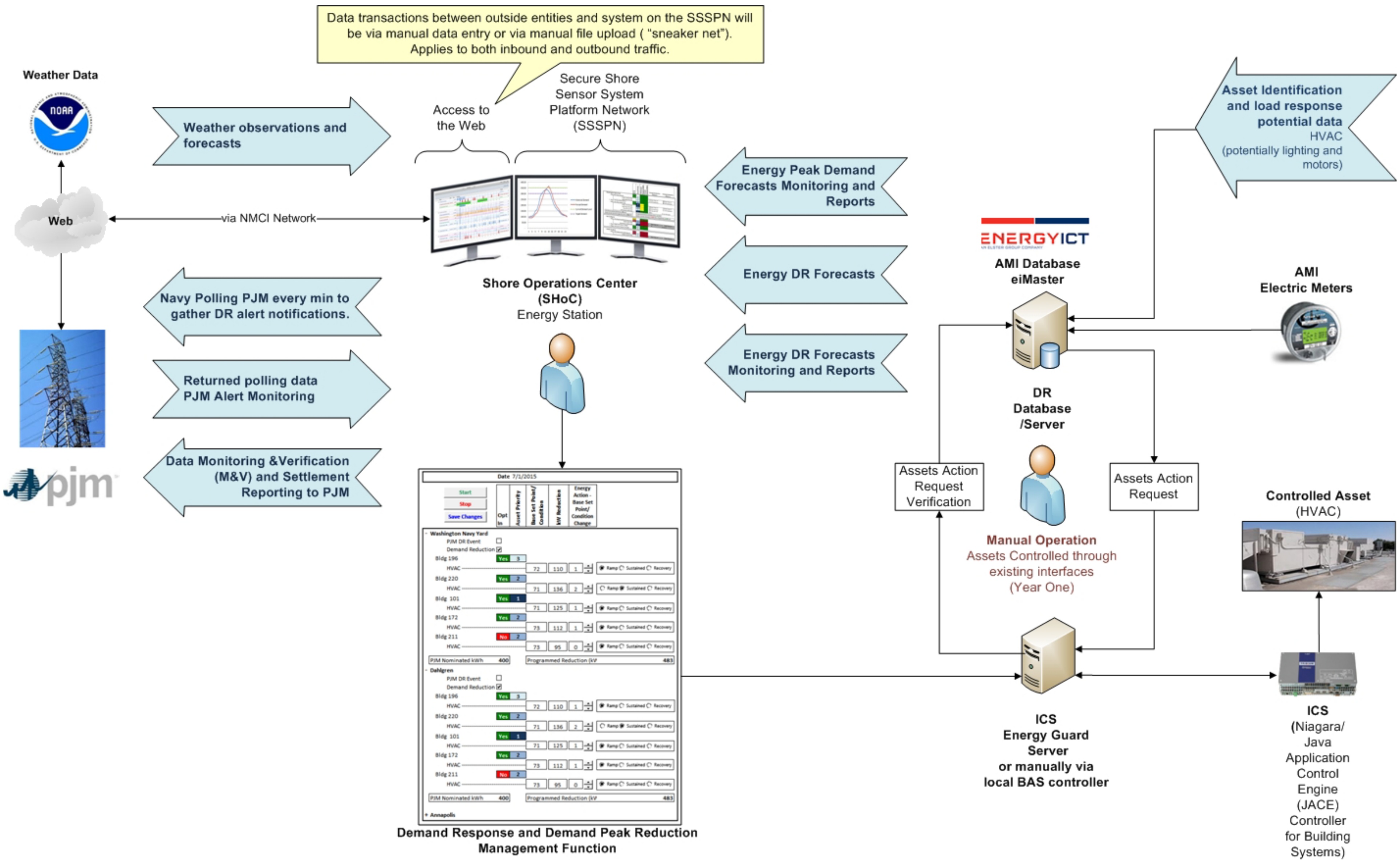


Figure 2-1. ESTCP Demand Response/Peak Reduction Pilot – NDW

The security of the solution is of the utmost importance. There are frequent reports of unauthorized access to government computer networks by individuals and foreign governments. Hackers have paid increased attention to machine-to-machine interfaces such as those involved in this technology. The limitation at DoD is the ability to expand a secure controls network for building and energy automation solution, not only within the installation, but also by connecting through the web to the regional Independent System Operator (ISO). At NDW, the demonstration system is already secure, and the focus will be on determining the process to implement secure connection to other entities through the web.

Another limitation is not related to the technology, but related to concerns that implementing the process might have either an actual or a perceived impact on an installation's mission. If a number of installations or buildings on an installation opt out of participating, the cost reduction from energy savings and the reduced revenue may make expanding the program not financially feasible.

Figure 2-2 depicts the hypothetical DR revenue and savings versus the kW hours (kWh) delivered as part of the DR curtailment efforts to show the varying levels of kW available, controllable, and delivered. For a given installation, the assessment initially defines the 100% kW value of what is available for control. Based on outages or the unavailability of buildings to participate and with a safety factor, the amount that can be delivered to the grid may be 80% of the 100% kW value. There is a point at which the cost to implement and operate a DR strategy is outweighed by the reduced savings and revenue generated. The figure depicts that a hypothetical 50% is the break-even value at which the demonstration will provide a reasonable estimate of the actual value. The values will also be predicated on a range because costs for capacity and delivered energy can change significantly from year to year.

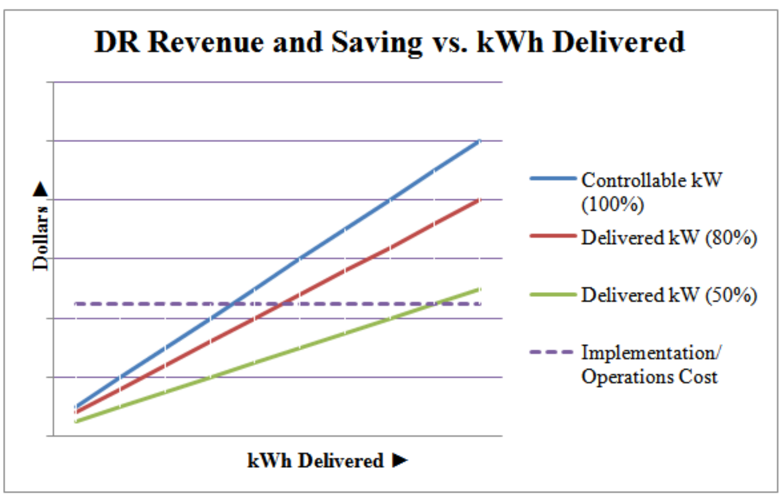


Figure 2-2. DR Revenue and Saving vs. kWh Delivered

Figure 2-3 highlights the dependence of demand peak reduction and savings versus kW controlled. Similar to the previous example for DR, the availability to deliver a kW reduction is central to achieving cost savings by being able to reduce the installation's peak demand level. Given a single line for comparison (orange circles) between varying levels of control, a hypothetical demand charge is applied. Starting at an existing demand charge for the installation, the charge can be adjusted downward by lowering the peak demand level to a lower level.

The more the available control, the lower the level of the demand charge. If sufficient control cannot be achieved, hypothetically only 50% of the available controllable kW, then there is not enough kW reduction to reach the lower demand charge level. At that level, the best-case assumption would be that there is enough control to avoid exceeding the current demand peak. The incremental saving gained by reducing the demand level is primarily a one-time occurrence unless additional kW can be made available. To maintain the demand level and the savings, the level of kW control must also be maintained.

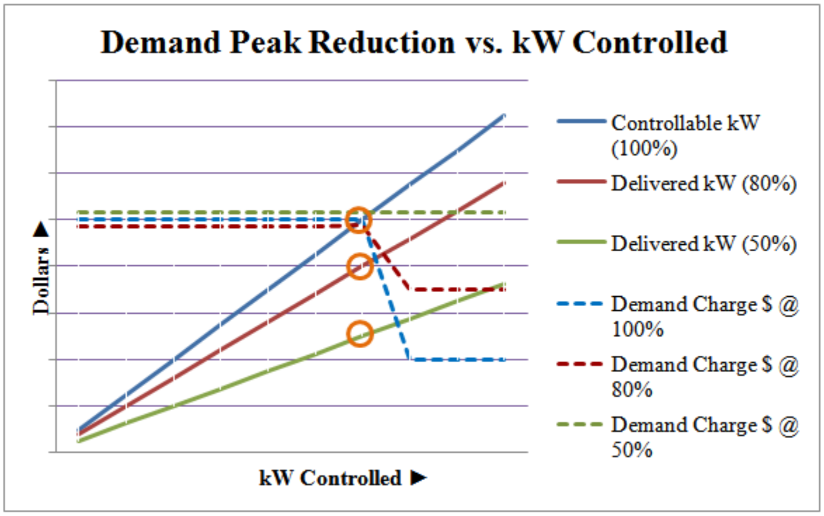


Figure 2-3. Demand Peak Reduction vs. kW Controlled

3.0 PERFORMANCE OBJECTIVES

In the demonstration project, a predefined demand response capability and protocol will be developed that is congruent with the facility and market drivers, including the PJM market rules. The project will also involve documenting the baseline and load reductions and the associated experiences and economic benefits as a result of the DR and DPR actions. The demonstration program will establish a baseline energy footprint and load profile of the studied NDW energy assets based on the selected general building types evaluated. For DR evaluation, a baseline estimate of electricity will follow a PJM-approved CBL. This task will involve establishing the major components of the baseline, a seasonal load profile, including time of use, coincident peak demand contributors, and a demonstration of the flexibility available to modify the load profile during coincident peak demand periods. Energy (kWh) saved and internal costs avoided, costs reduced, and revenue generated will be determined. Information from the evaluated buildings and baselines and the metered data from the remaining buildings on the installation will be used to scale the data to provide whole installation estimates for the evaluated installations.

In addition to these quantitative measurements, the issue of energy security is a performance objective that relates to the key benefit of identifying the primary power end-use and integrating the mission priority steps into the decision process. Loads that can be curtailed or generation devices that can be engaged will be determined to ensure that base functions can be maintained when reliable supplies of energy may not exist to meet the military installations' needs. A key component of the demonstration program is having the SHoC operator evaluate the possible vulnerability from power grid disruptions and ways to reduce energy demand (kW) consumption.

Finally, cost avoidance or reduction will be measured by using EnergyICT and Demand Response Research Center (DRRC) tools. The analytics are supplied time-measured AMI data and are updated with weather and price information to determine the trends and baselines. The measurement of energy, aligned with defining load information and associated baselines, primarily yields actionable information that will prevent operations at NDW facilities from being adversely impacted by price or supply volatility or disruption. The ability to integrate cost is a key performance indicator in the decision process. Cost reduction will also drive the determination of which programs were most cost effective compared to one another.

3.1 SUMMARY OF PERFORMANCE OBJECTIVES

The performance objectives and related metrics, data requirements, and success criteria are presented in **Table 3-1**. Supporting information for this task will be collected before and during system operation to evaluate the technical objectives of the project.

Table 3-1. Performance Objectives

Performance Objective	Metric	Data Requirements	Success Criteria
Quantitative Performance Objectives			
Building Load Control	Percent reduction from the coincident kW peak (%)	Equipment name plate capacity validated by building metering data	8 to 14% of coincident peak load is controllable for aggregate of buildings
Energy Cost Savings from DR	Dollars ($) and energy usage (kWh)	Validated DR participation through building metering data	4 to 6% energy cost reduction through DR rebates and reduced energy usage
Energy Cost Savings from DPR	Dollars ($) and energy usage (kWh)	DPR through building metering data	3 to 5% cost reduction through DPR and reduced energy usage
Peak Demand Reduction/Maintenance	Building demand maximum (max kW)	Building metering data	Building demand peak was not exceeded
Demand Response Program Participation	Percent participation (%)	Validated DR participation versus DR events	75% participation in available events
Energy Reduction	Energy (kWh)	Event type (DR, DPR, and load leveling) and building metering data	2 to 4% reduction of building energy consumption
Cybersecure Communications and Control Between DR and ICSs	Ability of timely control for DR actions (time)	Time delay delta from requested action to equipment response	A response time metric of 30, 60, and 120 minutes (manual process is implemented and visual DR/DPR response confirmed within 30, 60, or 120 minutes of initial control request)
Qualitative Performance Objectives			
Mission Impact	Effect on mission	Satisfaction survey	No impact on critical missions or services
Grid Operator DR Participation Requirements	Meeting PJM criteria for participation in various DR program types	PJM requirements versus Navy's participation when impacted by mission-critical events	DoD can enroll in DR programs beyond "Capacity DR"

3.2 PERFORMANCE OBJECTIVES DESCRIPTIONS

The following subsections describe each of the performance objectives in additional detail.

3.2.1 Building Load Control

- **Definition**: Building energy assets (either consuming or generating) will be controlled through the ICS.
- **Purpose**: Control of energy-consuming assets (i.e., raising the HVAC set point) will result in reduced kW demand for the building in its entirety for a designated period of time.
- **Metric**: Reduction will be measured by comparison of the building baseline to the usage achieved during a building control action.
- **Data**: The building baseline values are calculated by eiMaster using historical building metering data and actual metering data collected by eiMaster during an energy action. The required temperature setbacks will be programmed into the ICS to achieve the required kW reductions.
- **Analytical Methodology**: The building energy baseline is defined by eiMaster algorithms using historical data and similar conditions. The methodology involves simple subtraction of kW from the predicted baseline from actual observed conditions. The programmed kW reductions will be used to verify/test that the reduction actions are accurately represented in the measured kW reduction.
- **Success Criteria**: It is expected that the peak load can be reduced by 8 to 14% for the aggregate average of all the buildings.

3.2.2 Energy Cost Savings from Demand Response

- **Definition**: The cost savings resulting from avoided cost and from revenue generated through reduced demand and maintaining kW capacity for participation in DR programs.
- **Purpose**: During an energy emergency, the grid operator requests those enrolled in DR programs to curtail load. In return for participation, payments are provided.
- **Metric**: Total dollars from costs avoided and revenue generated versus the utility cost if DR participation and actions were not performed.
- **Data**: PJM method CBL determination is calculated by eiMaster, actual metering data and utility invoices, validation of PJM-nominated kW capability values versus delivered, and calculated payments/penalties from PJM.
- **Analytical Methodology**: Capability payments will follow the PJM schedule for DY 2016/2017. Capacity is determined by what can be delivered, the nominated capacity, which is less than the controllable kW. The CBL will be used as the baseline from which the comparison with kWh will be derived to yield cost/benefit and kWh avoided. Because only subsets of buildings are part of the demonstration, the results will be extrapolated to the other buildings on each installation on the basis of building type and size to estimate the values for the entire installation.
- **Success Criteria**: The cost of energy will be reduced by 4 to 6% annually.

3.2.3 Energy Cost Savings from Demand Peak Reduction

- **Definition** – The cost savings resulting from avoided energy consumption as a result of reducing demand peaks.

- **Purpose**: At a minimum, the goal is to prevent exceeding the current demand threshold, and optimally to establish and maintain a lower threshold.
- **Metric**: Current peak demand threshold and target threshold compared to measured kW.
- **Data**: Utility data will be required to define the peak load thresholds and cost and the measured kW.
- **Analytical Methodology**: Demonstrated kW reduction capability at the building level for the study building will be extrapolated to define peak reduction capability installation-wide and to define cost savings attainable.
- **Success Criteria**: The ability to reduce the annual installation utility invoice by 3 to 5%.

3.2.4 Peak Demand Reduction/Maintenance

- **Definition**: The sustained ability to control building kW loads to set new target peak thresholds and to be able to maintain peak loads at or below the threshold.
- **Purpose**: The ability to set new thresholds results in lower demand costs from the utility. Cost savings can be maintained only if the threshold is not exceeded in the future.
- **Metric:** Peak demand kW by building and as an aggregate by installation is not exceeded during the demonstration period.
- **Data**: Peak demand kW threshold and measured kW.
- **Analytical Methodology**: Simple comparison of threshold to measured kW.
- **Success Criteria**: Current demand threshold is not exceeded. New target demand threshold can be set and maintained.

3.2.5 Demand Response Program Participation

- **Definition**: The ability of the Navy to participate in the DR programs is contingent on participation not impacting mission. Prior to each anticipated DR event, the installation will be asked if the demonstration buildings will be allowed to participate.
- **Purpose**: Participation is requested prior to a DR action to avoid mission impact. Meaningful and consistent participation is also required to be fully involved in DR programs.
- **Metric**: Participation rate in DR events.
- **Data**: Total controllable kW, load DR events (including test events), and participation.
- **Analytical Methodology**: Simple data summaries.
- **Success Criteria**: Participation in 75% of the controllable load events.

3.2.6 Energy Reduction

- **Definition**: Energy reduction is defined in this demonstration as the kWh that is avoided as a result of reducing consumption as part of a DR/DPR action.
- **Purpose**: Energy reduction required to meet both legislative orders and EOs and Navy goals.

- **Metric**: Energy avoided as defined by the baselines for DR and DPR versus the metered values.
- **Data**: Baselines as calculated by eiMaster for DR and DPR and metered values for kWh.
- **Analytical Methodology**: From the performance objectives above for "Energy Cost Savings from Demand Response" and "Energy Cost Savings from Demand Peak Reduction," the same analytical approach will be used to define energy reduction. Energy reduction will be determined by the difference between the baseline and metered values calculated on daily and monthly totals, not just during events to ensure that energy savings realized during an event were not simply shifted to another usage period.
- **Success Criteria**: Achieve a 2 to 4% reduction in energy consumption for the demonstration period from June through October 2016.

3.2.7 Cybersecure Communications and Control Between DR Systems and ICSs

- **Definition**: Cybersecurity is a critical concern to DoD; therefore, the AMI and ICS reside on a closed SSSPN network. Access to PJM for alert notifications will be through the Navy's NMCI computer network.
- **Purpose**: Ideally, the automated DR response could be processed automatically from PJM to the ICS. The potential concern is that PJM, NMCI, or the connection between PJM and the Navy could be compromised. An outside entity would be able to affect the building systems and jeopardize the DoD mission. For the demonstration, the monitoring and response actions will be conducted manually to determine what portions of the process can be automated. The manual interface will add time from notification of the PJM request to the ability to deliver the sustained kW response.
- **Metric**: Time of request for a DR action to the delivery of a sustained kW response.
- **Data:** DR actions database, metered values, and the CBL as calculated by eiMaster.
- **Analytical Methodology**: Validating that the sustained response matches the DR action reduction deadline.
- **Success Criteria**: For each installation, the sustained response was achieved by the reduction deadline. Deadlines that will be evaluated are 30, 60, and 120 minutes from the notification to the reduction deadline.

3.2.8 Mission Impact

- **Definition**: When given approval to proceed with DR/DPR actions, was there a real or perceived impact on the mission?
- **Purpose**: After the DR/DPR action, the installations will be requested to provide input on the real or perceived impact on the mission. This information is critical in evaluating the ability to expand the program beyond the demonstration phase and to provide valuable input for improving the process and implementation of the DR/DPR actions.
- **Metric**: Building/installation satisfaction survey.
- **Data**: DR event database and post-event surveys.
- **Analytical Methodology**: Simple data summaries.

- **Success Criteria**: DR/DPR actions did not impact the mission.

3.2.9 Grid Operator DR Participation Requirements

- **Definition**: The grid operator expects the capacity to be delivered as nominated in order to fulfill the requirements of the DR program in which the DoD is enrolled, and to provide post-event settlement reports as required.
- **Purpose**: Not meeting the commitments of the program would degrade the contribution to grid stability. The economic advantage can be substantial, but there is also a financial penalty for not meeting the agreed-upon commitment.
- **Metric**: PJM will evaluate the Navy's ability to meet requirements, capacity, reliability, and settlement.
- **Data**: PJM settlement reports generated by eiMaster and the Tableau software suite.
- **Analytical Methodology**: As defined by the existing PJM process for settling DR actions.
- **Success Criteria**: DoD can enroll in DR programs beyond "Capacity DR."

4.0 FACILITY/SITE DESCRIPTION

The location and sites selected would rely on existing systems, software, and hardware that are currently in place, including leveraging the existing PRA. This situation limits the demonstration to NDW and bases that already have the necessary infrastructure.

4.1 FACILITY/SITE SELECTION CRITERIA

A sample group of up to 15 demonstration sites on 3 NDW bases will be selected using screening criteria. The criteria include AMI electrical meter instrumentation installed, connectivity to ICS, sub-system integration into ICS, and representativeness of the facility compared to the overall building sample based on square footage and end-use type. The three facility end-use types are office, mixed work use, and dormitories.

4.2 FACILITY/SITE LOCATION AND OPERATIONS

The installations selected at NDW are the WNY, DAH, and JBAB. The specific buildings that will be selected will be based on use type, AMI metering availability, and level of ICS control within the building. The selected building participation in the demonstration will be coordinated by NDW. After the buildings have been selected, on-site facility visits will be conducted to identify major service entrances, load metering, features of energy using assets, billing histories, energy management, and demand reduction actions. Subsequent steps will be identifying applicable equipment and evaluating reduction strategies. The reduction strategies at the demonstration facilities will focus on HVAC control logic modifications programmed to implement known and prescribed procedures. Other systems will be added to the demonstration on a limited scale if control is available through the ICS. The systems at this time will include only HVAC unless other load types can be identified during the course of the project, which can include lighting controls and pumps and motors.

4.3 SITE-RELATED PERMITS AND REGULATIONS

There is no conflict with any federal, state, or local regulations, and no permits will be required to conduct this demonstration.

The program will be conducted as a pilot project within PJM. The goal for this demonstration is to define the process and interaction with an ISO. The load reductions planned are minimal because the overall demonstration is limited in scale. The energy generation from emergency generators for DR events is currently being accounted for under NDW's existing Curtailment Service Provider (CSP) agreements.

Page Intentionally Left Blank

5.0 TEST DESIGN

The fundamental problem to be solved by the demonstration project is to show that through the deliberate control of building energy-consuming assets, a predictable kW capacity reduction can be achieved to support the enrollment of DoD for greater capacity in DR programs. The ancillary benefits of this solution will allow an installation to use the same process to reduce its peak demand load, further offering additional energy reduction and economic benefits.

Two questions need to be answered by this demonstration project: (1) whether establishing and maintaining a DR/DPR program has a net positive economic impact, and (2) whether doing so will provide energy reductions without adversely impacting an installation's mission.

The aggregate energy consumption of a building can be reduced through equipment control, and the timing of consumption reduction can result in a significant economic benefit beyond energy savings alone. The systems are in place at NDW—the electric metering solution, the building control integration solution, and the communications network—all under the umbrella of a PRA to realize these benefits. To more fully utilize the existing capabilities of these systems, the combination of defined calculations, reporting, and workflow processes should be configured to perform DR and DPR actions. The results of the demonstration will address whether employing a broad DR/DPR strategy can produce the expected net savings in energy and cost and the applicability at other locations.

5.1 CONCEPTUAL TEST DESIGN

The design is based on three sets of actions, building/assets assessment, system configuration, and operation. These actions are explained in a series of workflow and process figures, which depict actions; system outputs, inputs, and interfaces; and logical connections. Each of the variables, dependencies, and controls are defined within the system to validate the performance objectives of this demonstration.

5.1.1 Asset Evaluation

For the selected buildings, the major focus will be on the HVAC system and defining the load response curve based on the set of predefined actions. The response curves need to adequately define the ramp time to the point of a sustained response. The ramp time will define DR program participation and the level of economic benefit.

5.1.2 Daily Actions – Demand Response and Demand Peak Reduction

Figure 5-1 depicts the process of daily actions, including the data inputs that will allow monitoring of projections of upcoming events and participation by the demonstration buildings. Once the need for a DR and DPR action has been identified, the process is defined both for the operator and the functional requirements of eiMaster and the ICS interface.

5.1.3 Daily Actions – Demand Peak Reduction Event Response

The DPR response builds from the actions depicted in **Figure 5-1**. **Figure 5-2** details the actions for a DPR event. Based on the monitoring of forecast demand and actual usage, the operator enables energy actions targeting actual demand not to exceed the Target Demand and ultimately not to exceed the Current Demand Level. Once actual demand has been controlled, energy actions can be reversed and then enter into the recovery phase when the Forecast Demand retreats below the Target Demand level. During recovery, it is important to monitor actual demand to avoid system demand bounce. At the end of the event, the log file of event actions will be uploaded to eiMaster.

5.1.4 Daily Actions – Demand Response Actions

The DR monitoring actions build from the actions depicted in **Figure 5-1**. DR actions are depicted in **Figure 5-3**. DR actions are the same as DPR actions, with the exception of tracking against the desired demand target reduction, which is based on the PJM-nominated value. Actions are initiated based on the PJM notification with start and stop times for the requested DR action. Energy actions will start prior to the DR start time with the ramp period to ensure that a sustained response is reached prior to the start of the DR period. Monitoring is conducted during the DR actions to ensure the nominated value is maintained through the application of energy actions. Once PJM issues a release notice, energy actions will be reversed and enter into the recovery phase. During recovery, it is important to monitor actual demand to avoid system demand bounce. At the end of the event, the log file of event actions will be uploaded to eiMaster.

5.1.5 Daily Actions – DR/DPR After Actions

Following a DR/DPR action, a defined set of data is collected and reports are processed. A specific set of reports is required by PJM to verify compliance with the nominated energy guaranteed. The format and content of these settlement reports are defined by PJM. Other data are collected and reports are generated to validate the demonstration’s performance objectives. These data and reports are described in the Traceability Matrix detailed in Section 6.

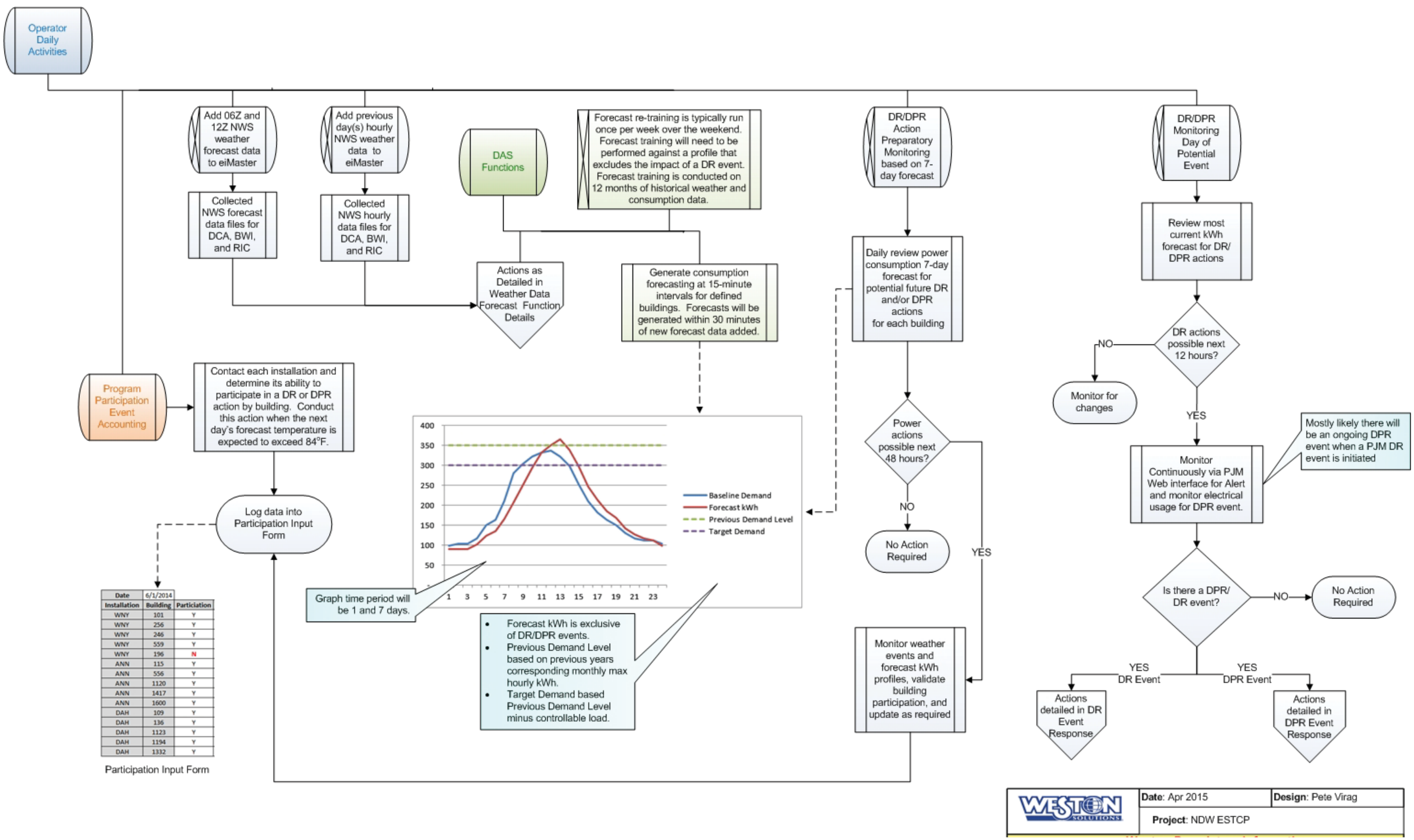


Figure 5-1. Daily Actions – Preparatory and Planning Action for Power Reduction Events

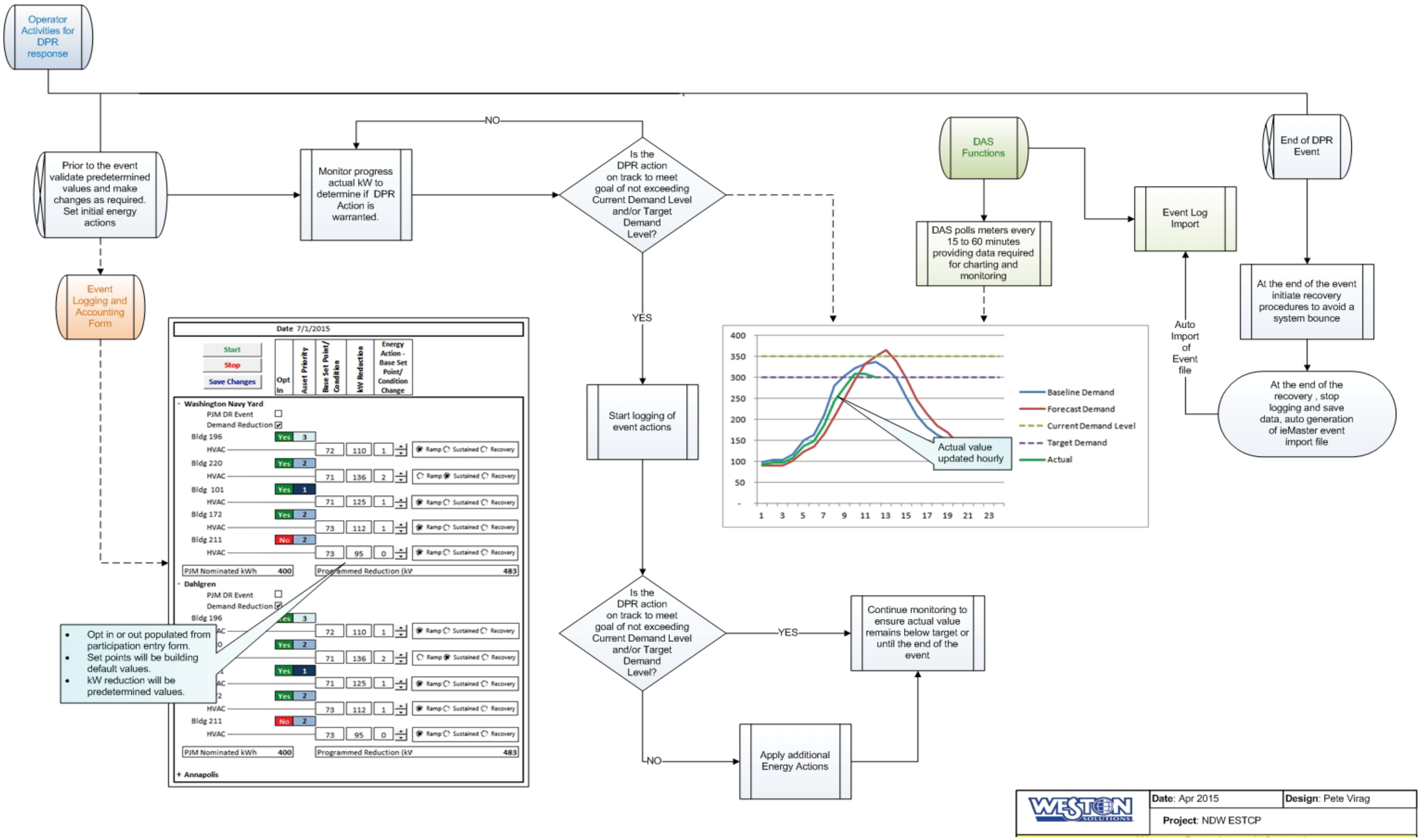


Figure 5-2. Daily Actions – Demand Peak Reduction Event Response

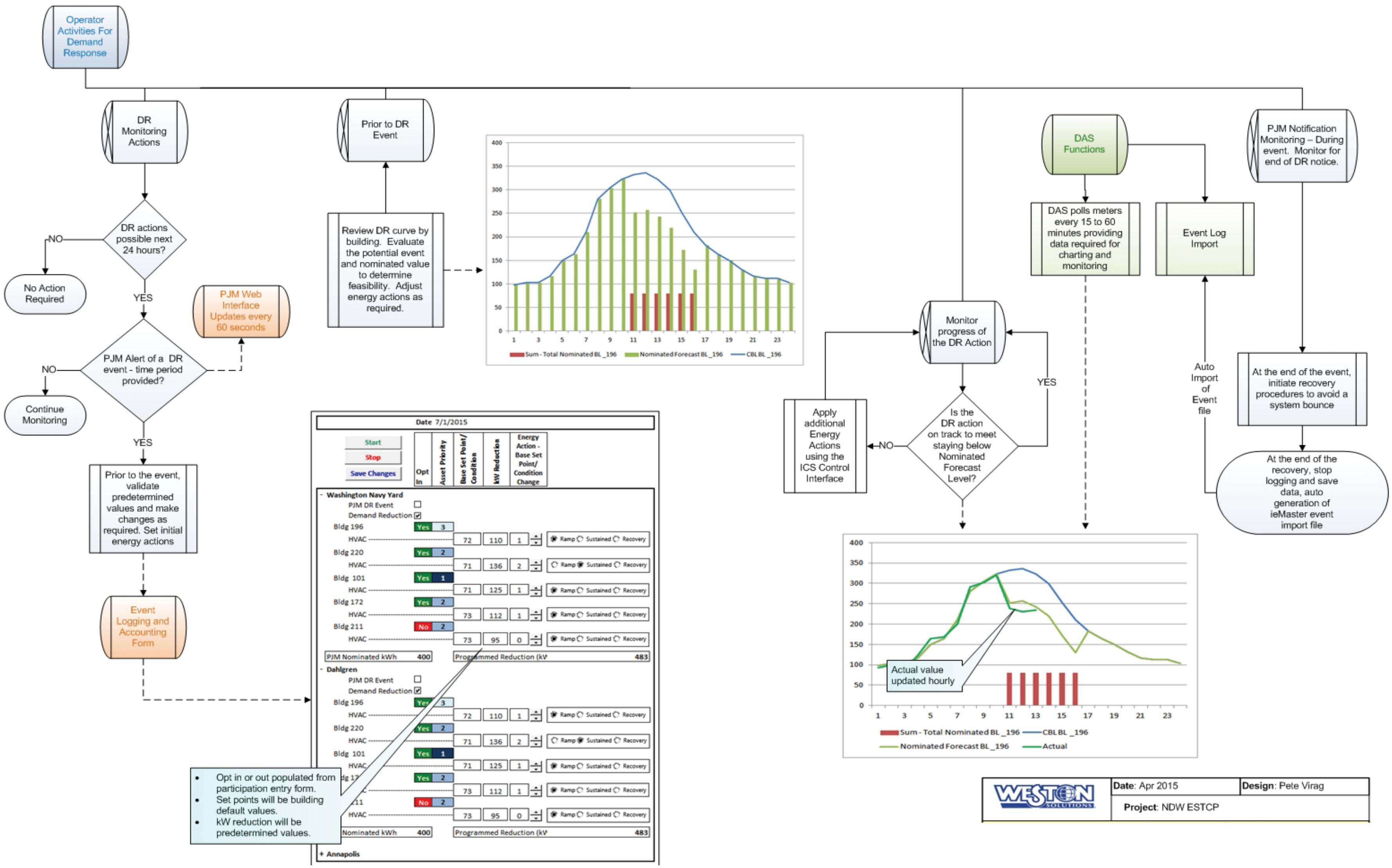


Figure 5-3. Daily Actions – Demand Response Actions

5.2 BASELINE CHARACTERIZATION

The data for baselines exist as AMI metering and utility invoicing data. How baselines are calculated is dependent on the application and requirement. For peak demand reduction, the baseline is the previous peak within the last 12 months, and monthly peaks and the next lower peak level are defined by the utility. For DR, the baseline calculation is defined by the eiServer native regression modeling functionality in lieu of the PJM CBL methods. Historical energy and cost data when used will be weather normalized for comparison with data from the demonstration.

5.3 DESIGN AND LAYOUT OF THE SYSTEM COMPONENTS

Figure 2-1 depicts the system overview and connectivity for existing components of the demonstration system. **Figures 5-1** through **5-3** provide the functional requirements for performance of the DR/DPR demonstration project. The demonstration project will require only enabling, configuring, and interconnecting the existing capabilities and functional controls between the systems. The following are the two major components of the system:

- EnergyICT eiMaster provides real-time advanced energy native regression modeling algorithm analysis, utility meter and data management, weather depository, ad hoc reports, benchmarking, and data validation, and manages access to information. The system aggregates across multiple facilities/sites, models results based on performance indicators, and presents indicators to the SHoC operator. It also provides storage for data for evaluation and verification. The eiMaster apps will be used to provide the load monitoring and verification (M&V) of facility load reductions by time of day, season, and weekday to comply with the PJM load verification requirements. EnergyICT's benchmarking and dashboard tools will be used to support the SHoC, the PJM and M&V reporting requirements, and pre- and post-evaluation reporting. Specific EnergyICT eiMaster configuration parameters specific to this project are defined in the Functional Design Version 1.4 presented in **Appendix B**.
- The ICS Data Guard solution provides real-time information and is scalable for Navy-wide deployment. It incorporates supervisor monitoring, control and trending capability integrating legacy DDC, PLC, and SCADA systems in support of NDW Region Energy Reduction Initiatives. ICS will receive manual inputs from ICS operators on direction from the Energy Station Operator. The ICS provides three layers of control for staging and implementing DR/DPR actions as commanded from an Energy SHoC. An equipment layer at the facility directly integrated via software protocols to different automation manufacturers brings data and control into one system. A second layer at the base level for the local operator makes routine controls changes and navigates and maintains connected facility systems and implements authorized DR/DPR strategies. The last level is the regional level where centralized ICS data are collected and overall administration of control and system operations oversight and redundancy is provided.

5.4 OPERATIONAL TESTING

The operational phase of the program will be from June 2015 through October 2015 and June 2016 through October 2016 to coincide with the PJM Extended Summer DR program. For DR, the daily program period during which interruptions can occur is from 1000 to 2200 hours.

DPR actions will also be conducted during the same period. During a typical summer, 5 to 10 DR events can occur, but a sample set of 5 would not be adequate to test the hypothesis in the performance objectives. To provide an adequate set of data, 15 to 20 DR events will be conducted, consisting of test, actual, and hypothetical events. DPR events will depend on the target baseline for peak reduction, and that level can be established to provide sufficient events.

After the completion of the Extended Summer DR program, the data will be evaluated to determine how effective the system was in meeting the performance objectives. At that time, the Navy will determine how to proceed with DR/DPR and whether to extend and/or expand the programming into 2017 and beyond. The system will be in place and functional, and can transition into continuous operation, but adjustments to the process and some functional changes will likely be necessary based on the lessons learned from the demonstration.

5.5 SAMPLING PROTOCOL

The systems currently deployed reside on an NDW server within a data center where all data are currently collected and stored. All systems are maintained, updated, and backed up in accordance with existing network operation procedures. The configuration of the existing software for this demonstration will include new data points, which will be managed and stored in the same manner as the existing AMI and ICS data. The functionality that will be integrated into the existing system is further detailed in **Tables 5-1** through **5-3**. The tables present the function matrices corresponding to **Figures 5-1** through **5-3**. The matrices detail the function, the action (human or automated), and the location of the data.

Table 5-1. Function Matrix – Daily Actions – Preparatory and Planning Action for Power Reduction Events

*(Corresponds to **Figure 5-1**)*

Item	Function	Action	Location
A1	Weather Forecast Data	Daily – gather data from NOAA and copy to eiMaster.	NOAA to eiMaster
A2	Daily Weather Observations	Daily – gather data from NOAA and copy to eiMaster.	NOAA to eiMaster
A3	Energy Forecasting	A 7-day energy consumption forecast by installation in comparison to baseline is created in eiMaster. This forecast is updated based on the most current forecast.	eiMaster
A4	DR/DPR Participation Input Form	Data for participation by building are loaded into the ICS Control Interface.	ICS Control Interface
A5	Day-of, DR/DPR Peak Forecast	By building, graphics will be generated in eiMaster displaying baseline and forecast demand by hour in relationship to both Current Demand Level and Target Demand Level.	eiMaster

NOTES:

- All data should be displayed at 15-minute intervals. Examples on table and graphs are shown as 1-hour intervals to reduce example sizes.
- Installation for the purposes of this demonstration will be considered at the four to six test buildings at each installation.
- Weather forecast and actual data from Air Force weather data sources will be investigated. If available, modifications to import interface for eiMaster would be needed. The Air Force data may also have the advantage of being on a secure network, eliminating the “open” side of the NOAA data along with allowing for a more automated import mechanism (NOAA data are moved manually from the “open” to secure network).

Table 5-2. Function Matrix – Demand Peak Reduction Event Response

*(Corresponds to **Figure 5-2**)*

Item	Function	Action	Location
B1	Monitoring of Demand Referencing Current and Target Demand Level	By building, monitor continually actual demand compared to baseline and forecaster demand.	eiMaster
B2	ICS Log for DPR	DR Energy Actions are entered, and kW reductions are tabulated in the interface. Actions are passed to ICS staff for implementation to start, modify, or end an energy action.	ICS Control Interface to Data Guard ICS
B3	Export/Import of Log Data	Export of energy actions data log from ICS Log in Comma Separated Values (CSV) format for import into eiMaster.	ICS Log and eiMaster

NOTES:

- All data should be displayed at 15-minute intervals. Examples on table and graphs are shown as 1-hour intervals to reduce example sizes.
- Installation for the purposes of this demonstration will be considered at the four to six test buildings at each installation.
- During the evaluation phase, interior humidity data captured by ICS will be correlated with DPR events to determine whether there is a risk of interior humidity rising above air quality standards. An override process will be incorporated into the design if needed.

Table 5-3. Function Matrix – Demand Response Actions

*(Corresponds to **Figure 5-3**)*

Item	Function	Action	Location
C1	Electronic Notification of DR Events from PJM	The PJM web interface will query via PJM's web service eLRS once every minute for DR event notification information.	PJM eLRS to Web Interface
C2	Reply of Acceptance of DR Event to PJM	This is a pilot project with PJM. The process is to-be-determined.	PJM eLRS to Web Interface
C3	ICS Log for DR	DR energy actions are entered, and kW reductions are tabulated in the ICS Log. Actions are pushed to data guard for implementation to start, modify, or end an energy action.	ICS Log for Data Guard ICS Actions
C4	CBL Calculation	The current CBL for each building will be calculated in eiMaster.	eiMaster
C5	DR Monitoring	Tabular and graphical reports for the operator will be generated in eiMaster to monitor the DR action in real time.	eiMaster
C6	Export/Import of Log Data	Export of energy actions data log from ICS Log in CSV format for import into eiMaster.	ICS Log and eiMaster

NOTES:

- All data should be displayed at 15-minute intervals. Examples on table and graphs are shown as 1-hour intervals to reduce example sizes.
- Installation for the purposes of this demonstration will be considered at the four to six test buildings at each installation.
- During the evaluation phase, interior humidity data captured by ICS will be correlated with DR events to determine whether there is a risk of interior humidity rising above air quality standards. An override process will be incorporated into the design if needed.

5.6 EQUIPMENT CALIBRATION AND DATA QUALITY ISSUES

All equipment and systems are currently being maintained by NDW and are routinely monitored as part of normal operations. The data are being monitored for consistency and accuracy and also as part of daily operations through existing defined reports and graphics. During the demonstration project, the SHoC energy operator will be an additional resource reviewing the data and providing a second review to identify any issues that require a correction by the NDW.

Page Intentionally Left Blank

6.0 PERFORMANCE ASSESSMENT

The performance assessment of each of the objectives is not a complex solution if limited to the scope of the buildings in the demonstration. **Table 6-1** expands the performance objectives table by adding data requirements, data source, and calculation methods for each of the performance objectives. Assessing the objective of reducing energy consumption to affect peak demand and to reduce the burden to the grid involves a simple calculation of utility rate components and consumption/consumption avoided values. These are quantitative values; the level of uncertainty rises, however, as the demonstration data set is interpolated to represent an entire facility. The parametric variability resulting from extending the results to represent all buildings at a facility provides the greatest level of uncertainty in the quantitative objectives. Numerous combinations of building types and infrastructure configurations contribute to parametric variability. Assigning a level of uncertainty is not feasible because the detail needed is not available. Procedural variability has the greatest potential effect on repeatability. Procedural influences are defined through the qualitative objectives and can have a negative, natural, or positive effect on the quantitative objectives. For the demonstration period, the defined boundaries are known, which will significantly limit procedural variability. The final results will be interpreted to highlight which objectives have the greatest potential of uncertainty.

The demonstration performance is directly influenced by the quality of the data and the system components used to make the decisions that ultimately result in the qualitative objectives. Although each of these items is not a specific performance objective, their assessment is critical to the overall outcome. Lawrence Berkeley National Laboratory (LBNL) Demand Response Research Center (DRRC) will provide methods and tools for the assessment of the data, methods, and results.

Central to DR/DPR is the ability to reduce electrical demand. DRRC will evaluate WESTON's electrical demand reduction estimates using its DR assessment models, as follows:

- Small Commercial Buildings Tool – The Demand-Limiting Assessment Tool (DLAT) is capable of evaluating the peak demand reduction, utility cost savings, and comfort impacts associated with the use of building thermal mass for precooling and demand limiting for a limited number of prototypical small commercial buildings. The program is able to perform hourly calculations with fairly detailed models of the buildings and equipment.
- Large Commercial Buildings Tool – The Demand Response Quick Assessment Tool (DRQAT) is able to predict the energy and demand saving, the economic saving, and the thermal comfort impact for various demand responsive strategies. It is based on the most popular feature and capabilities of the Department of Energy (DOE) EnergyPlus program. The assessment tool is then able to use the prototypical simulation models to calculate the energy and demand reduction potential under certain demand responsive strategies, such as precooling, zonal temperature setup, and chilled water loop and air loop set points adjustment.

The results of the DRRC assessment will also be used to validate forecast and modeled energy curves produced by the EnergyICT solution.

Table 6-1. Traceability Matrix

Performance Objective	Metric	Data Requirements	Data Source(s)	Calculation*	Success Criteria
Quantitative Performance Objectives					
Building Load Control	Percent reduction from the coincident kW peak (%)	Equipment name plate capacity validated by building metering data	eiMaster	Coincident peak of the "Forecast Demand" peak minus the corresponding recorded "Actual." The calculation will be performed for each installation.	8% to 14% of coincident peak load is controllable for aggregate of buildings
Energy Cost Savings from DR	Dollars ($) and energy usage (kWh)	Validated DR participation through building metering data	eiMaster, utility billing, and PJM payments	Cost savings are the aggregate of the following by each area: 1. **Energy costs avoided during DR actions** – Energy cost savings based on kWh avoided resulting from DR actions. Utility rates based on 2014 billing will be used. 2. **PJM payments for DR capacity** – Payments will be calculated at full value using the PJM schedule. The payments will be based on estimates of the future deployment of ICS and the demonstration results of "Controllable Load" and available DR emergency generation capability. Total DR capacity will be calculated by installation. 3. **PJM payments for DR event participation** – PJM payments will be based on total DR capacity using the 2014 payment schedule and DR events during the 2014 DY Extended Summer program.	4% to 6% energy cost reduction through DR rebates and reduced energy usage
Energy Cost Savings from DPR	Dollars ($) and energy usage (kWh)	DPR through building metering data	eiMaster and utility billing	Cost savings are the aggregate of the following by each area: 1. **Energy cost reduced through building load control –** kWh based on the "Forecast Demand" minus the "Actual" kWh during the DPR action, multiplied by the aggregated $/kWh from both distribution and energy billing. 2. **Cost reduction through decreasing the peak load demand charge of an installation** – Based on billing from 2014, a new calculated peak will be determined from demonstration data to determine an estimated peak. Cost savings will be determined by estimating the 2014 billing adjusted for the new peak.	3% to 5% cost reduction through DPR and reduced energy usage

Table 6-1. Traceability Matrix (Continued)

Performance Objective	Metric	Data Requirements	Data Source(s)	Calculation*	Success Criteria
Peak Demand Reduction/ Maintenance	Building demand maximum interval (max kW)	Building metering data	eiMaster	Comparison of the previous 12 months of 15-minute peak demand periods.	Previous demand interval peak was not exceeded, by building
DR Program Participation	Percent participation (%)	Validated DR participation vs. DR events	Event Log and eiMaster	Comparison of available DR events to those in which full participation could take place. Valid event participation is defined, by installation, as the ability to participate to the full extent of the DR action and the achievement of the installation load curtailment obligation.	75% participation of available events.
Energy Reduction	Energy (kWh)	Event type (DR, DPR and load leveling) and building metering data	eiMaster	Calculations will be performed, using weather normalized data, by monthly comparison between the demonstration period and the corresponding months in 2013.	2% to 4% reduction of building energy
Qualitative Performance Objectives					
Cybersecure Communications and Control Between DR System and ICS	Ability of timely control of DR actions (time)	Delta from requested action to equipment response	eiMaster, ICS Control Log	The calculation will include several elements: DR event notification time from PJM, notification receipt by PJM web interface, energy action sent to ICS, and action implemented by ICS. All variables will be used to assess successful participation.	A response time metric of 30, 60, and 120 minutes (manual process is implemented and visual DR/DPR response confirmed within 30, 60, or 120 minutes of initial control request)
Mission Impact	Effect on mission	Satisfaction survey	Event Log and building owners	Calculated by installation, the number of actions versus any mission impact relating to DR or DPR action. Post-event impacts will be assessed to determine the extent and nature of the impact.	No impact to critical missions or services
Grid Operator DR Participation Requirements	Meeting PJM criteria for participation in various DR program types	PJM requirements versus Navy participation when impacted by mission critical events	eiMaster, Event Log and PJM debriefs	Two elements will be used to define this performance objective: the availability of participation compared to the number of DR events during the demonstration period, and the ability to meet the load curtailment obligations.	DoD can enroll in DR programs beyond "Emergency Generation Capacity DR"

NOTES:

*Where applicable, the ratio of the values is calculated based on results from the demonstration to provide a whole installation estimate. Data interpolation will be based on building use type code and size

The DDRC will provide an independent analysis of DR/DPR strategies and events throughout the evolution of the program to allow mid-course adjustments and as a final assessment of the demonstration results. The principal elements of the DRRC analysis will be as follows:

1. **Baseline and DR Event Analysis** – The DRRC will use a set of tools and techniques to evaluate historical electric load shapes and estimate measurement of DR control strategies. These include methods and models examining weather sensitivity, day of week, hour of day, and electric load variability. A close examination of historical baselines will allow evaluation of the DR level of predictability. Next, the team will examine the DR event data to understand whether the change in electric loads is statistically significant and predictable.

   As an example of baseline analysis tools, the outside air baseline uses a least squares regression model that assumes that whole-building power is linearly correlated with outside air temperature. It estimates the whole building power demand during the event day using the 10/10 baseline data as shown in equation (1):

   Equation (1) $Li = ai + bi\ Ti$

   Li is the predicted 15-minute interval electricity demand for time i from the previous 10 non-DR event workdays. Ti is the 15-minute interval outside air temperature at time i, interpolated from the hourly National Climate Data Center (NCDC) data. The parameters ai and bi are generated from a linear regression of the input data for time i. Individual regression equations are developed for each 15-minute interval, resulting in 96 regressions for the entire day (24 hours/day, with four 15-minute periods per hour. Time i is from 0:00 to 23:45).

   Input data are hourly outside air temperature and 15-minute interval whole-building electricity demand for the 20 non-DR days prior to the DR event day. Historically, these have been non-weekend, non-holiday, Monday through Friday workdays.

2. **Trend Log Analysis** – The DRRC will use a set of methods to examine control system trend log data to understand whether the intended control strategy was successful. This analysis often requires understanding the state of commissioning, sensor calibration, location, and other HVAC or lighting control issues. The DRRC will explore how the trend log data sets from the individual Navy facilities compare to each other and to other building energy data sets.
3. **Economics** – The DRRC will review electricity cost data, DR program costs, and load shapes to understand current billing rates, opportunities for DR program participation, and ancillary services. These data will be used to evaluate the existing cost and potential cost savings of participating in current and emerging DR programs. The following variables will be examined:
   - Independent variables (values that can be changed by the investigator): e.g., capacity of a system to generate renewable energy or the setpoint in a thermal regulation (air or water) system. Weather is considered an independent variable because it influences the outcome of a test, although, strictly speaking, the investigator can only control it to the extent the location of a test can be chosen.

- Dependent variables (typically the changes in observable responses arising from changes in the independent variables): e.g., kW, market price.
- Controlled variables (those values that are held constant to avoid influencing the independent or dependent variables): e.g., square footage, end-use type, utility rate as negotiated per year by NDW.

6.1 LIMITED DATA GATHERED ANALYSIS

DR and DPR operations were limited due to the nature of the deployment of building controls. DAH Building 182 was the only building where temperature setbacks were initiated during simulated DR events. These results are graphically depicted in **Figures 6-1** and **6-2**.

The following events were initiated, as presented in **Table 6-2**.

Table 6-2. Dates and DR Control Strategies on the DR Event Days

Date	Time (Eastern)	Setback
September 2, 2015	12:00 – 18:00	3 degrees Fahrenheit (°F)
September 3, 2015	12:00 – 18:00	3°F
September 8, 2015	12:30 – 18:00	3°F

Access to building automation data to confirm the temperature setpoint was maintained for duration of the event was not available. It was suggested that setpoint reductions were overridden by building staff that were not aware that testing was being conducted. This could explain limited load impacts observed on September 2 and 3, 2015 during initial testing.

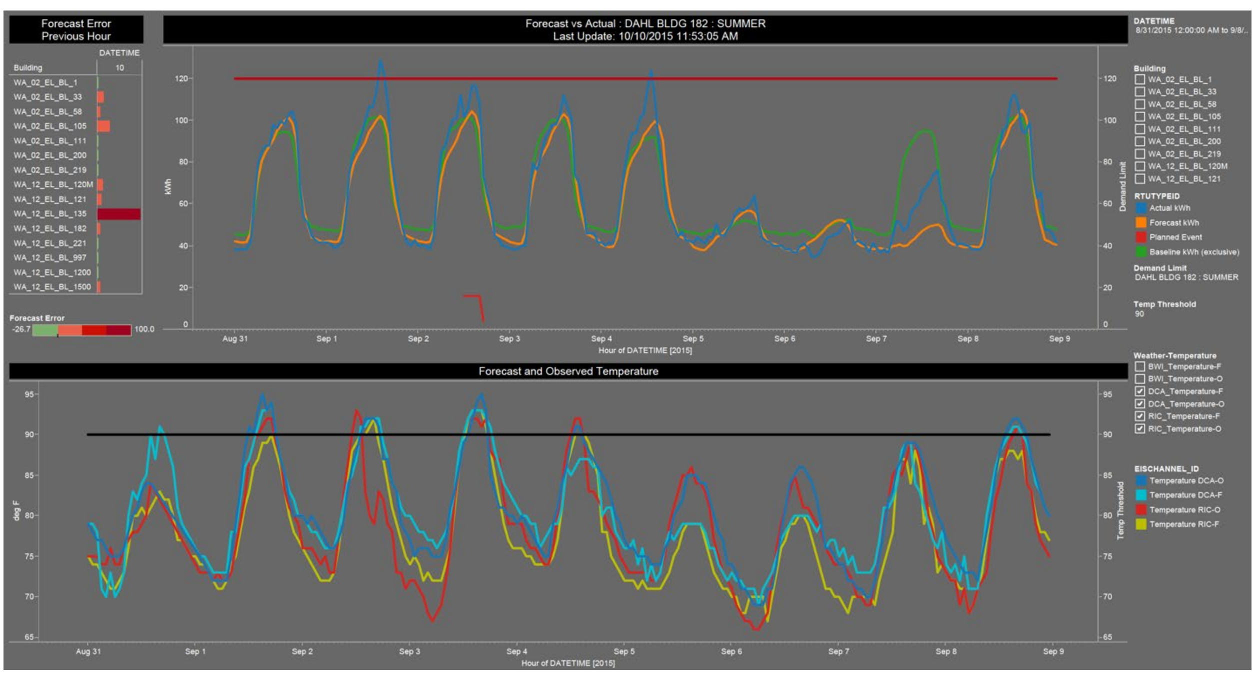


Figure 6-1. Forecast and Observed Power Usage in Dahlgren Building 182 (up) and Outside Air Temperature (down)

During the simulated DR event on September 8, 2015, a noticeable drop in actual kWh consumption is observed and sustained for several hours with a 3°F increase in the building temperature setpoint.

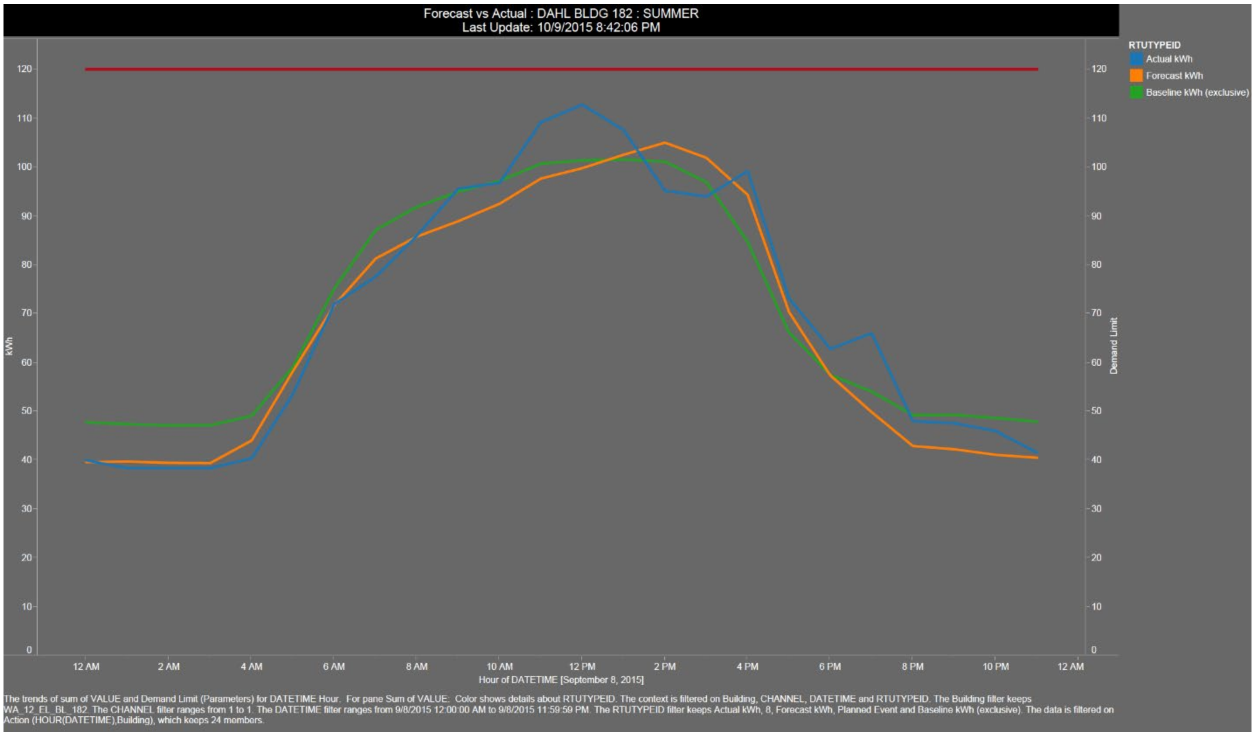


Figure 6-2. Forecast and Observed Power Usage in Dahlgren Building 182 (up) on a DR Event Day (9/8/2015)

Additional simulated DR events were planned for Building 182 with large setpoint reductions. These were not carried out before the end of the DR seasons. This was due to delays with regards to the negotiations with building tenants as to the notification and approval process for simulated events.

6.2 ESTIMATION OF DR POTENTIALS

6.2.1 Methodology

Among commercial end-uses, HVAC is one of the most promising and commonly used end-use for delivering peak capacity DR when needed. In this section, we introduce a DR estimation framework for quantifying the DR potential from HVAC systems. The framework proposed in this investigation utilizes a regression-based prediction strategy to estimate the DR potential as a function of a number of key inputs (e.g., the outside air temperature at a certain time of the day). These variables include changes to thermostat setpoints, time of the day, seasons of the year, weather condition, and building envelope and HVAC characteristics. This novel approach captures the building thermal response to these inputs with high accuracy by leveraging a collection of previously generated detailed simulation results from physical models. This eliminates the high computational time required by physical building models used to estimate the DR potential of a large heterogeneous load population. Each regression model is generated based on the following process:

1. Physical models or representative buildings are used to simulate HVAC and other thermostatically controlled load setpoint adjustments at various time steps.

2. The load differences due to setpoint changes are determined for the period of the setpoint adjustment.

3. Linear regression models are fit to the simulated load changes based on other input variables (e.g., outside air temperature) for each hour of the day.

As illustrated in **Figure 6-3**, we propose a data-driven regression model to estimate the DR potential resulted from the control strategies of "cycle on/off HVAC units". On the other hand, we deploy the physical model-based DR estimation method in the previous work to estimate the effect of "precooling with global temperature adjustment" in building HVAC systems (Yin et al., 2016), along with the data-driven approach. The goal is to achieve fast and accurate prediction of the kW capacity reduction using both data-driven model (i.e., meter interval data, weather data) and physical model (i.e., EnergyPlus model)

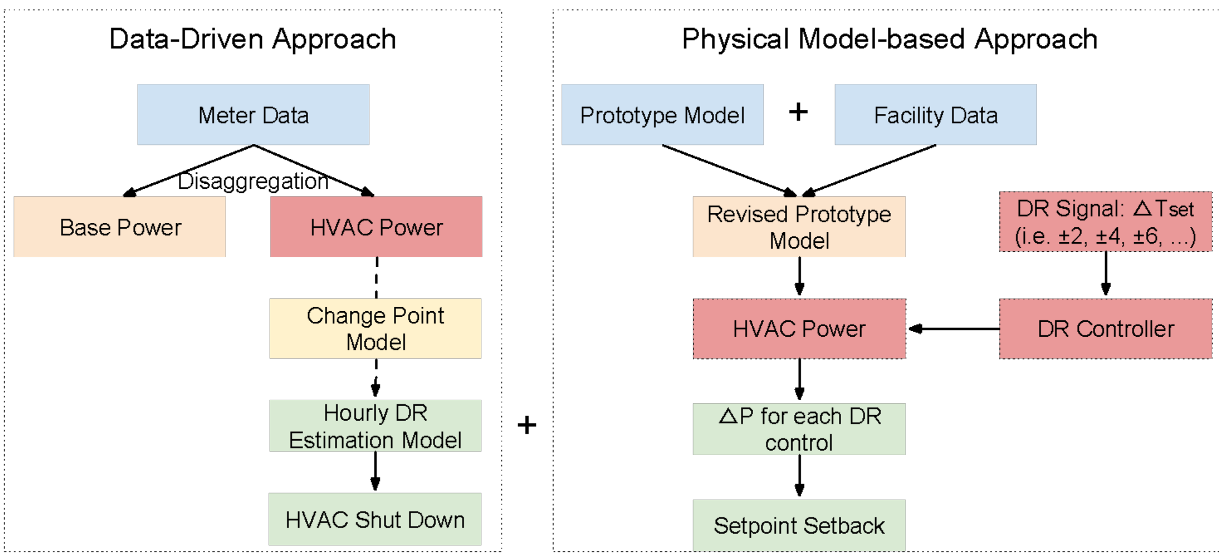


Figure 6-3. Overall DR Estimation Model Framework

The LBNL team applied this DR estimation framework to predict the load reduction possible (kW capacity) based on the predicted building load and weather forecast (either hour-ahead or day-ahead) for all the sites.

- **Data-driven** model for HVAC system tells when to turn off HVAC:

$$DR^{HVAC} = \alpha_1 + \beta_1 \times OAT, for\ OAT \leq T$$
$$DR^{HVAC} = \alpha_2 + \beta_2 \times OAT, for\ OAT \geq T$$

- **Hybrid model** for impact of global temperature adjustment:

$$DR^{GTA} = DR^{HVAC} \times (\alpha_1 + \beta_1 \times OAT, for\ OAT \leq T)$$
$$DR^{GTA} = DR^{HVAC} \times (\alpha_2 + \beta_2 \times OAT, for\ OAT \geq T)$$

It is noted that $\alpha$and βrepresent the intercept and slope of linear model coefficients, separately. Given the outside air temperature at a certain time of the day, DR potentials from the strategy of "HVAC cycle on/off" and "global temperature adjustment" can be easily calculated.

6.2.2 Baseline Models Used by PJM

The M&V of DR refers to quantification of the DR performance in terms of energy (kWh) and demand (kW) changes, which earn separate energy and demand credits during event hours. In particular for demand changes, previous LBNL studies have developed the following DR performance metrics: the total DR (kW), DR per building square feet or meter (W/ft^2), and the DR percentage of the whole building power (%WBP) (Piette et al., 2005; Motegi et al., 2004; Yin et al., 2008). The M&V methodologies for DR are the basis for the settlement of the DR achieved by a customer and the estimation of the impact of program-level demand reduction on the grid supply side. The M&V plays a key role in retail and wholesale DR market settlement, projection of the impact of large-scale DR market implementation, estimation of the impact of the DR program, and electric grid operations and planning.

Our primary focus is on the customer baseline (CBL) model used by the PJM, as presented in **Table 6-3**. We review other baselines as a reference point for future activities. In this study, each site had a smart meter to measure the energy use at 15-minute intervals. All AutoDR test events' baseline loads were calculated using the default CBL model: simple average over the highest 5 out of 5 recent good baseline days (5/5 baseline), with and without morning adjustment (MA) (Coughlin et al., 2008), which are described below:

PJM Economic CBL (5-in-5)

In the PJM market, common baseline models are a simple average over the past 3 or 5 baseline days, with and without the "day-of" event adjustment (PJM Manual 11):

- 5 out of 5 baseline model (5/5): The 5 days with the highest average load during the event period were selected from the previous 45 days of good data (excluding weekends, holidays, a DR event day, and any operation off day). The average of the load over these 4 days was calculated for each time interval.
- 5-day average baseline with "day-of" adjustment: The "day-of" adjustment is a ratio of (a) the average load of the first 3 of 4 hours before the DR event to (b) the average load of the same hours from the selected 5 baseline days. The adjustment factor is limited to ±25% of the CBL.

Table 6-3. Available Customer Baseline (CBL) Used by PJM (PJM Manual 11)

Parameter/CBLs	3 Day/Types		3 Day Types with SAA (Tariff Default)		3 Day Types with WSA	
Day Type	Weekdays	Sat, Sun/Holiday	Weekdays	Sat, Sun/Holiday	Weekdays	Sat, Sun/Holiday
Calculation	Average	Average	Average	Average	Average	Average
CBL Basis Window	5	3	5	3	5	3
CBL Basis Window Limit	45	45	45	45	45	45
Start Selection from Days Prior to Event	1	1	1	1	1	1
Exclude Previous Curtailment Days	Y	Y	Y	Y	Y	Y
Exclude Long/Short DST Days	N/A	N/A	N/A	N/A	N/A	N/A
Exclude Avg, Event Period Usage Less than Threshold	25%	25%	25%	25%	25%	25%
Exclude # of Low Usage Days	1	1	1	1	1	1
Use Previous Curtailment if CBL Basis Window Incomplete	Yes	Yes	Yes	Yes	Yes	Yes
Use Highest or Recent Previous Curtailment Day	Highest	Highest	Highest Symmetric Additive	Highest Symmetric Additive	Highest	Highest
Adjustments	None	None			Weather Sensitive	Weather Sensitive
Allow Negative Adjustments	N/A	N/A	Yes	Yes	Yes	Yes
Adjustments Start	N/A	N/A	4	4	0	0
Adjustment Basis Hours	N/A	N/A	3	3	Event Hours	Event Hours

NOTES:
DST – Daylight Savings Time
N/A – not applicable
SAA – symmetric additive adjustment
WSA – Water Sensitive Adjustment factor

In addition to the simple average baseline model, we also developed a weather regression model for weather-sensitive buildings. As we know, HVAC system energy use is often influenced by weather, dry bulb, and wet-bulb conditions. For the outside air temperature regression baseline model, an HVAC power baseline will be estimated first, using a regression model that assumes that HVAC power correlates linearly with outside air temperature. The regression model is computed, as follows:

$$P_i = a_i + b_i \times T_i$$

Where: P_i is the predicted 15-minute interval electricity demand from time i from the previous non-DR event weekdays. In this study, T_i is the 15-minute interval outside air temperature for time i. The parameters a_i and b_i are generated from a linear regression of the input data for time i. Individual regression models are developed for each 15-minute interval, resulting in 96 regressions for the entire day (24 hours/day, with four 15-minute periods per hour). Selected baseline days are non-weekend, non-holiday, and Monday through Friday workdays. The weather data source will be located at the testing facility. Meter data of 15-minute interval will be sub-metered for HVAC electricity demand.

6.3 DR PERFORMANCE IN BUILDING 182

6.3.1 Facility Descriptions and Load Analysis

Building 182

The building is of modern construction, concrete, and steel framed. It has 35,659 square feet with max peak demand of 130 kW in 2015. This building is in operation from 6:30 am to 4:00 pm, Monday through Friday. As shown in **Figure 6-4,** there are large variations of hourly whole building power on weekdays through the year, especially on summer hot days.

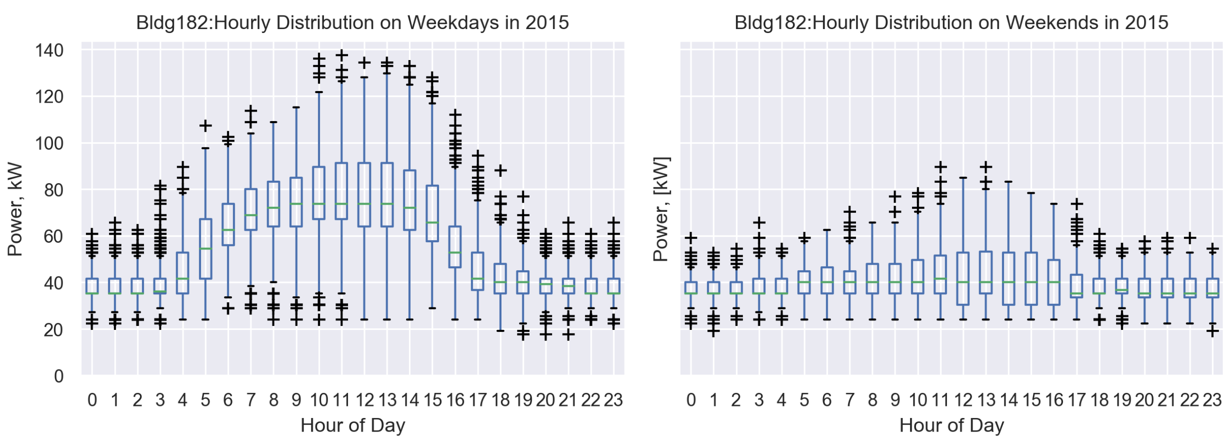


Figure 6-4. Distribution of the Hourly Whole Building Power on Weekdays (left) and Weekends (right) in 2015

Moreover, we analyzed the building load duration curve and the daily power usage on weekdays in 2015, as depicted in **Figure 6-5.** The load duration curve depicts every hour of the year arranged based on demand, from highest demand to lowest demand throughout the year. In 2015, the highest and the 100th highest building load values are 130 kW and 110 kW. These indicate that about 20 kW of HVAC power are consumed by only 100 hours per year, which can be used for reducing the generation and transmission and distribution capacity of the grid.

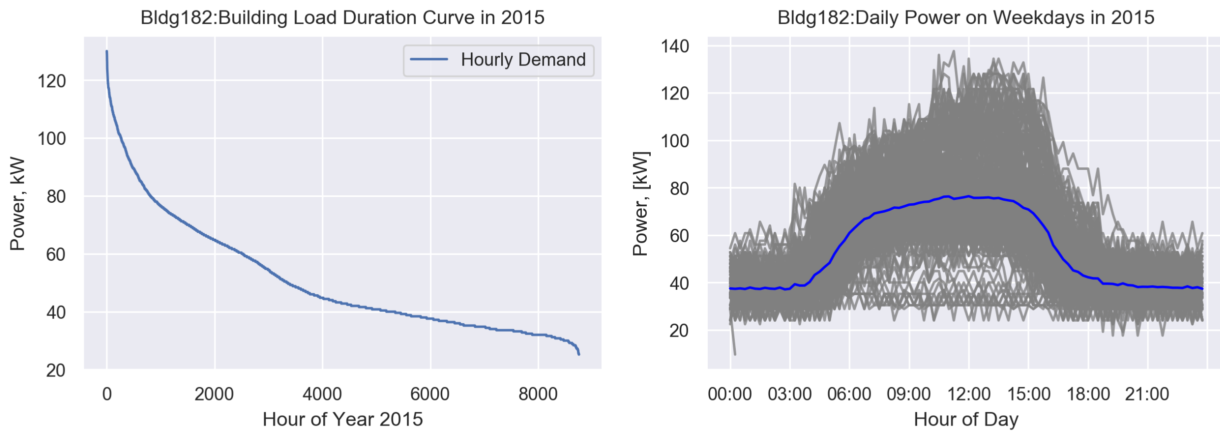


Figure 6-5. Building Load Duration Curve in 2015 (left) and Daily Power Usage on Weekdays (right) in 2015

As we know, the building HVAC power use comprises a significant portion of peak demand, though it varies with building vintages and locations. It is necessary to understand the building HVAC power use for quantifying the DR potential from it. **Figures 6-6** and **6-7** depict the HVAC power use along with the outside air temperature at each hour between 6:00 AM and 6:00 PM, which are calculated from the meter data using the data-driven model. It can be seen that the HVAC power use on the hot summer days accounts for nearly 50% of the peak demand.

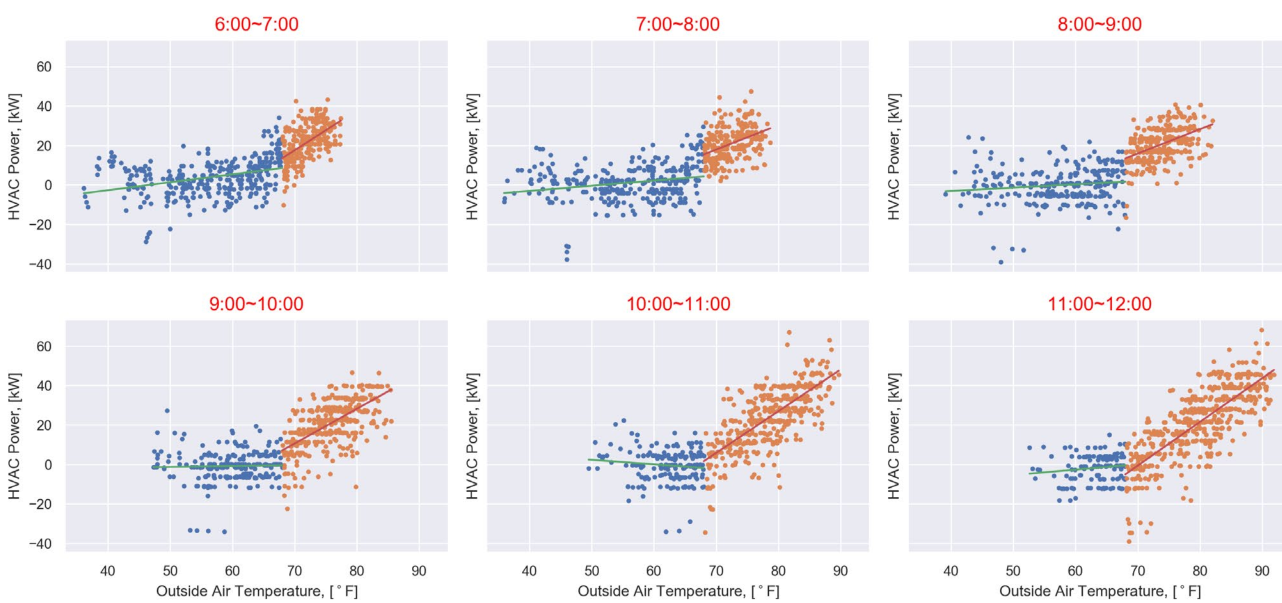


Figure 6-6. Estimated Power Usage of HVAC System in Bldg 182 between 6:00 AM and 12:00 PM

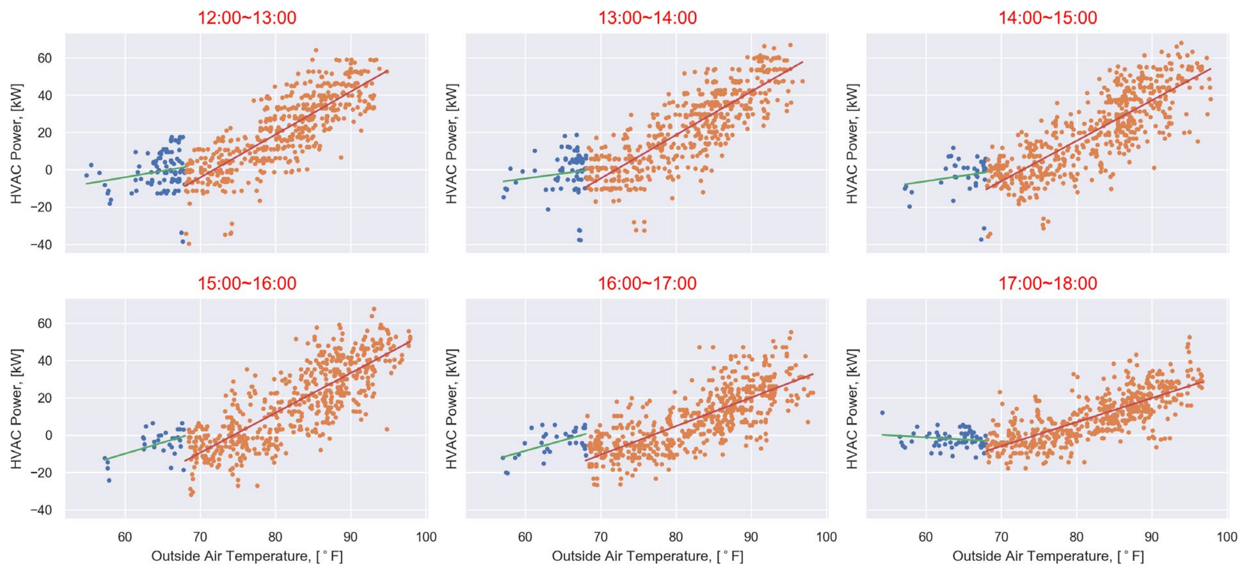


Figure 6-7. Estimated Power Usage of HVAC System in Bldg 182 between 12:00 PM and 6:00 PM

6.3.2 DR Control Strategy and Performance

As discussed in the ESTCP DR audit report, two types of DR control strategy were considered as follows:

- Global temperature adjustment (GTA)
- HVAC system cycle on/off

On September 8, 2015, a 6-hour DR event was conducted from 12:00 PM to 6:00 PM by raising 3°F of the global temperature setpoint. The following DR performance metrics were calculated from the meter data.

- kW, W/ft^2, %WBP
- Impact on indoor temperature (if trend logs are available)

Figure 6-8 shows the effects of the global temperature setpoint reset during the event hours. The demand reductions were much more obvious between 12:00 PM and 3:00 PM. A rebound was observed after 3:00 PM, which was caused by the restart of the HVAC cycle. It is mentioned that the building has very limited thermal mass in its aged style construction. Therefore, the zone temperature can raise to the new setpoint quickly for this reason.

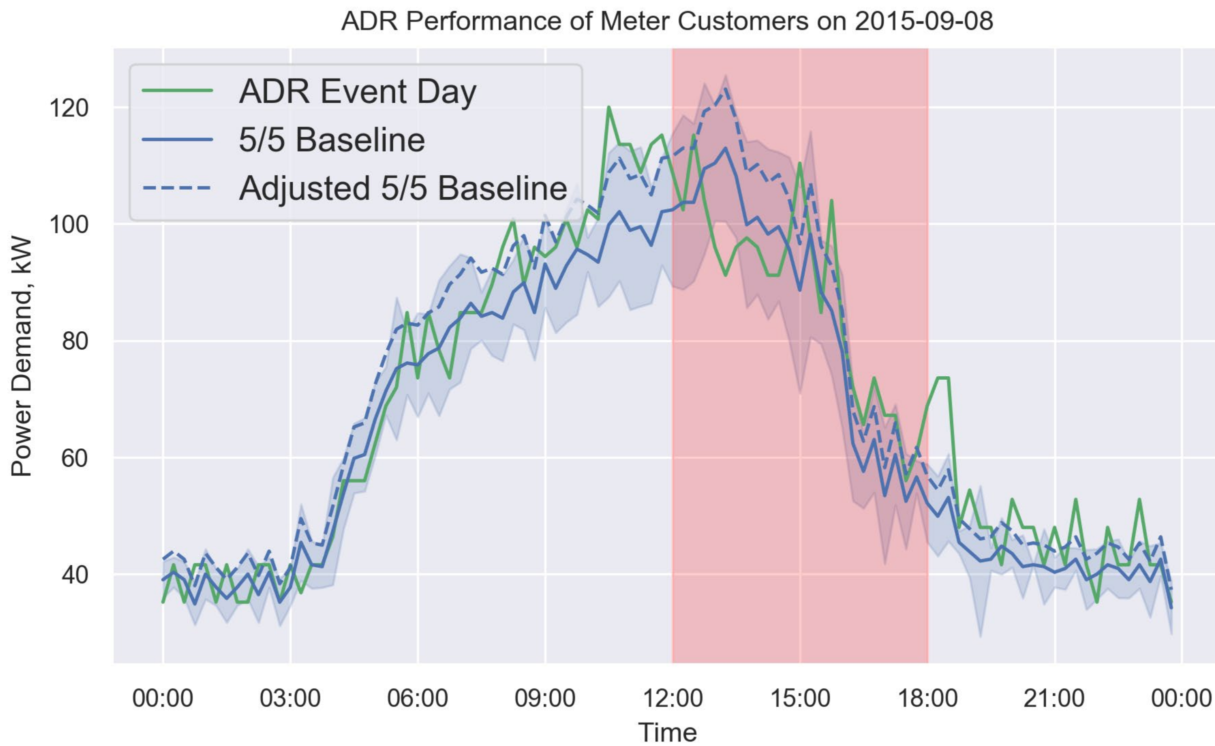


Figure 6-8. DR Performance on the DR Event Day - 9/8/2015

Table 6-4 summarizes the CBL and hourly DR performance metrics on September 8, 2015. The CBL is calculated based on the PJM Economic CBL (5-in-5) as described in **Table 6-3**. The hourly load shed reached to the maximum value of 27.3 kW at 1:00 PM, which accounted for 23% of the whole building power. The averaged load shed in kW, %WBP, and W/ft^2 are 11 kW, 10%, and 0.31 W/ft^2.

Table 6-4. DR Performance on the DR Event Day - 9/8/2015

DR Event Hours	CBL (kW)	Adjusted CBL (kW)	Event Day (kW)	Load Shed (kW)	Load Shed %	Load Shed (W/ft2)
12:00 PM - 1:00 PM	104.8	114.2	103.9	10.3	9%	0.29
1:00 PM - 2:00 PM	107.8	117.5	90.2	27.3	23%	0.77
2:00 PM - 3:00 PM	98.6	107.5	89.0	18.5	17%	0.52
3:00 PM - 4:00 PM	90.1	98.2	94.2	4.0	4%	0.11
4:00 PM - 5:00 PM	65.3	71.1	68.2	2.9	4%	0.08
5:00 PM - 6:00 PM	55.8	60.8	57.8	3.0	5%	0.08

6.3.3 Energy Cost Savings

6.3.3.1 Cost Savings from PJM's DR Participation

PJM pays the locational marginal pricing (LMP) to customers' participation of their DR resources in the wholesale market. Resource is made whole to its offer value, which includes: (1) offer price and (2) shutdown costs **(Figure 6-9).**

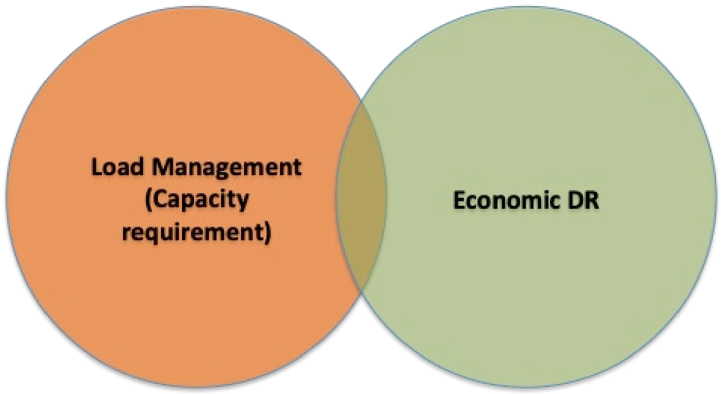


Figure 6-9. Demand Resource Participation in the PJM Energy Market (PJM Manual 11)

Resources will be paid Daily Load Response Emergency Credits + Emergency Load Response Make Whole Credit, as presented in **Table 6-5**. The following points need to be considered when calculating revenues:

- Load Reduction × LMP, adjusted for line losses.
- Make whole payment (based on lessor of offer volume and actual load reduction):
  - Load reductions must be within +/- 20% of dispatch amount.
  - Compensation is based on offer price.
  - Shutdown cost will not be paid if any hour in segment is outside 20% volume deviation.
  - Shutdown cost is paid once for all contiguous hours.
  - Segment make whole is sum of hourly make whole (i.e., negative make whole will offset positive make whole).

For an individual site (Building 182) with the DR capacity of 11 kW, the estimated total credit is $82 (it is assumed that the offer price is $1,100 per megawatt hour [MWh]). It is noted that the real-time LMP listed in the table is the price data of the pricing node where the site is located on September 8, 2015. The shutdown cost (e.g., $1,000) is not included for the individual site analysis because the requirement of the minimum load reduction is 0.1 megawatt (MW) for the emergency DR participation.

Table 6-5. Estimated Load Response Emergency Credits

	HE 13	HE 14	HE 15	HE 16	HE 17	HE 18	Total
Nominated kW	11	11	11	11	11	11	N/A
Actual Reduction kW	11	11	11	11	11	11	N/A
Real-Time LMP ($/MWh)	115	210	130	186	90	70	N/A
Strike Price	$1,100	$1,100	$1,100	$1,100	$1,100	$1,100	N/A
Load Response							
Emergency Credits	$1.3	$2.3	$1.4	$2.0	$1.0	$0.8	$9
Emergency Offer	$12.1	$12.1	$12.1	$12.1	$12.1	$12.1	$73

6.3.3.2 Additional Cost Savings from Retail Market

In addition to the credit received from the DR participation in the PJM energy market, there is cost savings from the retail market from the reduced power usage during the DR event hours. It is assumed that DAH has the same option as other Virginia customers to purchase both the supply (generation and transmission) and delivery (distribution) portions of their electric service from Dominion Energy Virginia. Based on the peak demand of the site, Building 182, as seen in **Table 6-6**, was selected to calculate additional energy cost savings by participating into the PJM's DR market programs (Emergency and Economic DR).

Table 6-6. Schedule GS-2 – Intermediate General Service (30-500 kW) [Schedule GS-2, effective on 4/1/2019]

Distribution Service Charges	Basic Customer Charge ($/billing month)		$19.89
	Distribution Demand Charge ($/kW)		$3.18
	Plus Distribution kWh Charges ($/kWh)		$0.0075
Electricity Supply (ES) Service Charges	Generation Demand Charge ($/kW)	June – September	$2.00
		October – May	$0.64
	Plus Generation kWh Charge ($/kWh)	First 150 kWh per kW	$0.043587
		Next 150 kWh per kW	$0.024432
		Next 150 kWh per kW	$0.010564
		Additional kWh	$0.002568
	Plus Transmission Demand Charge ($/kW)		$1.97

Table 6-7 presents the estimated energy and demand cost savings. It is noted that the demand charge is calculated based on the monthly peak demand in the billing period, as indicated in **Table 6-6**. Even though 11 kW of demand reduction in average was achieved during the DR event hours on 9/8/2015, the monthly peak demand was observed on other days in the same billing period. Energy cost savings were very little compared to DR credits received from the participation in the PJM energy market. In September, the total energy and demand charges are $1,801 and $961 separately. If the peak DR capacity of 27.2 kW is nominated for Building 182, a total credit of $201 can be awarded from the DR participation on 9/8/2015, which accounts for about 7.3% of the total monthly utility bill, and 20.9% of the demand charges, respectively.

Table 6-7. Estimated Energy and Demand Cost Savings

Site	DR Capacity (kW)	Energy Cost Saving ($) on the Event Day
Bldg 182	Ave: 11 and Max: 27.2	$3.40

6.4 DR PERFORMANCE IN BUILDING 121

6.4.1 Facility Descriptions and Load Analysis

The building (tech office) is of an older construction type, cinder block and concrete, 14,028 square feet with maximum peak demand of 96 kW in 2015. This building is in operation from 7:00 AM to 5:00 PM, Monday through Friday. **Figure 6-10** shows the distribution of hourly building load on weekdays and weekends in 2015. Large seasonal variations can be observed from the building HVAC power use. **Figure 6-11** shows the building load duration curve and the daily power usage on weekdays in 2015. The load duration curve of Building 121 is flatter than that in Building 182. One of the reasons is the concrete and steel-framed construction in Building 121 and Building 182, which are different due to the age and year of construction.

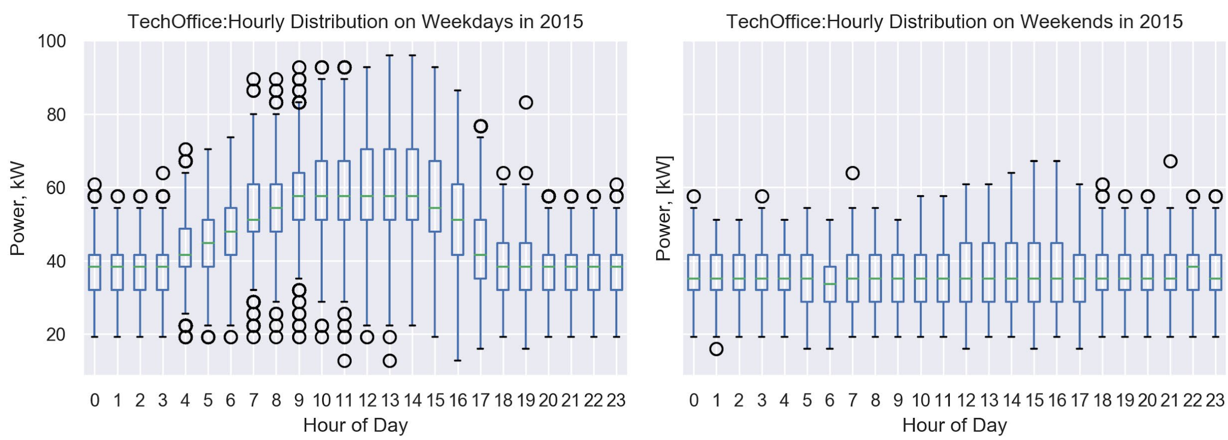


Figure 6-10. Distribution of the Hourly Whole Building Power on Weekdays (left) and Weekends (right) in 2015

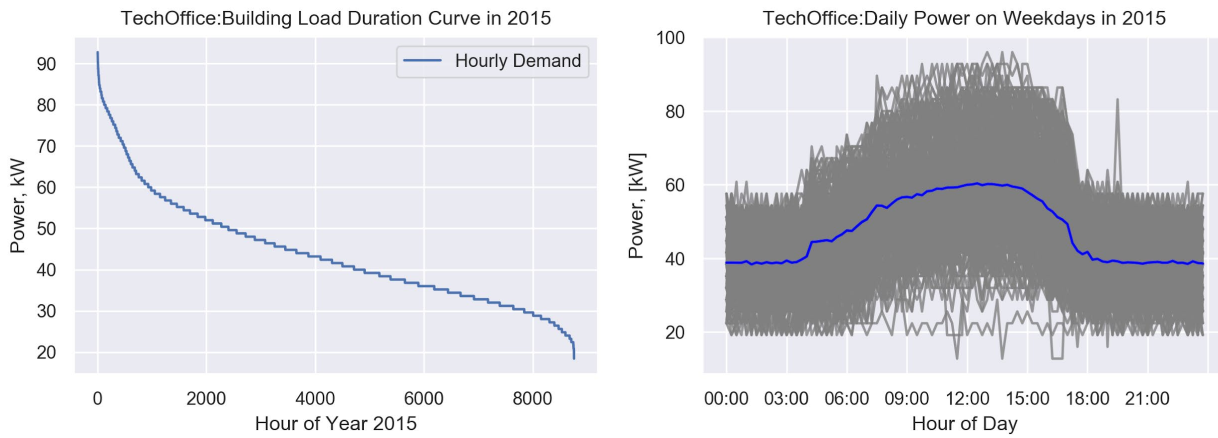


Figure 6-11. Tech Office Load Duration Curve in 2015 (left) and Daily Power Usage on Weekdays (right) in 2015

Same as Building 182, the HVAC system in Building 121 also shows a strong linear relationship along with the weather when the outside air temperature exceeds 68 to 70°F. As shown in **Figures 6-12** and **6-13**, the HVAC power use on hot summer days accounts for about 42% of the peak demand.

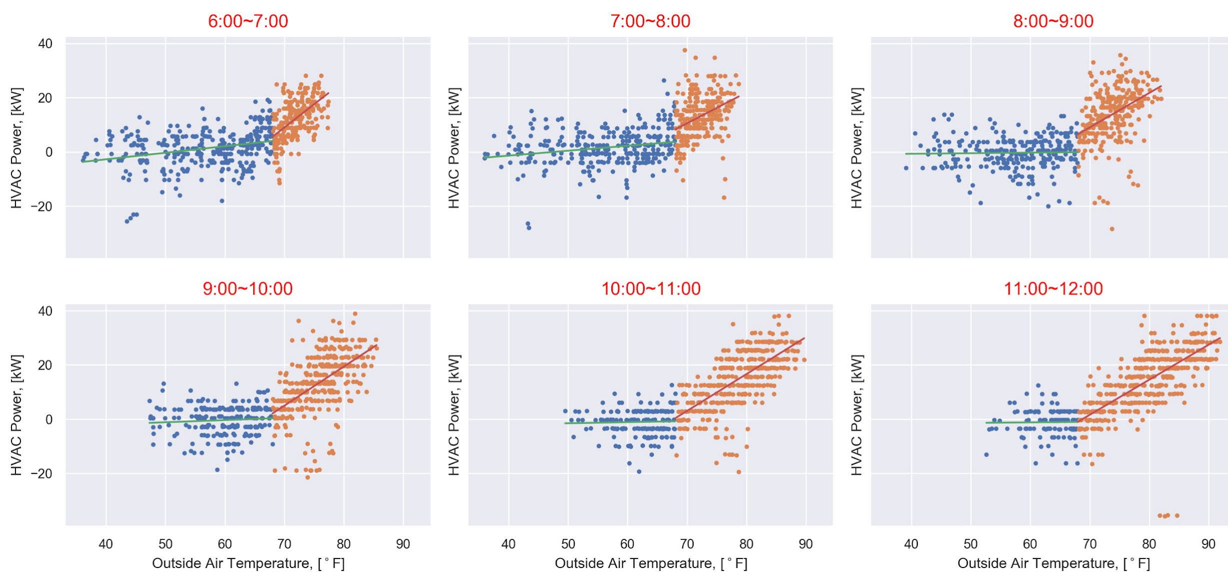


Figure 6-12. Estimated Power Usage of HVAC System in Tech Office between 6:00 AM and 12:00 PM

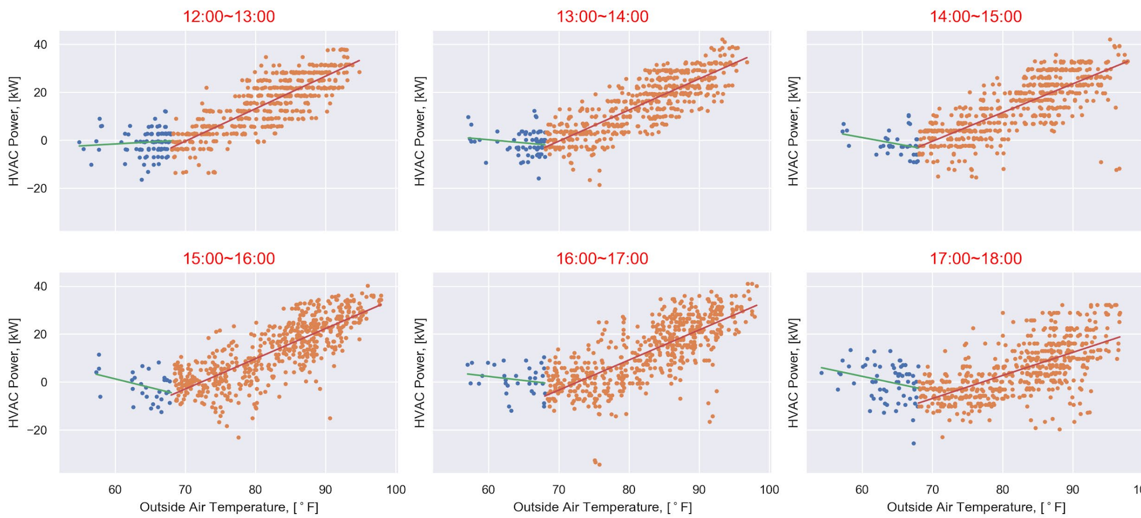


Figure 6-13. Estimated Power Usage of HVAC System in Tech Office between 12:00 PM and 6:00 PM

6.4.2 DR Control Strategy and Performance

Though there was no DR control strategy implemented in 2015, we also estimated the DR potential from the same control strategy of "raising the thermostat setpoint 3°F". **Figure 6-14** shows the estimation of DR potentials from the building HVAC system by raising the thermostat setpoint 3-4°F between 2:00 PM and 6:00 PM. When the outside air temperature reaches 95°F, the DR potential of the HVAC power use is about 40% in average. Together with the disaggregated HVAC power as presented in **Figures 6-14**, the DR capacity is estimated to be ~16 kW.

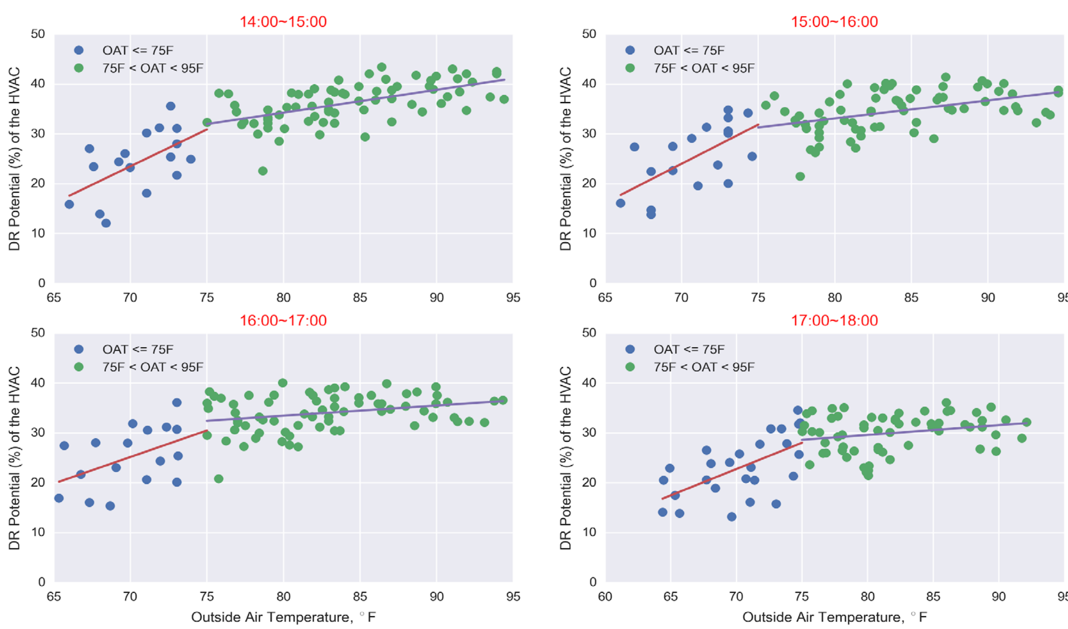


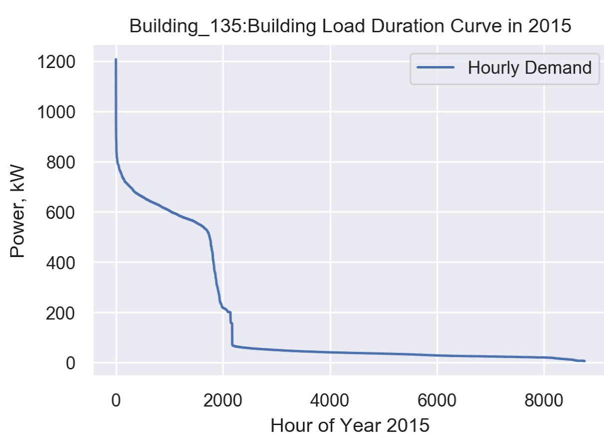
Figure 6-14. DR Potentials from the Building HVAC System by Raising the Thermostat Setpoint 3°F between 2:00 PM and 6:00 PM

6.5 SUMMARY OF ALL SITES

Based on the collected meter data, **Table 6-8** summarizes the estimated peak HVAC power, DR capacities of eight sites and credits from DR participation in the PJM energy market, except for Bowling Center and Computation-Analysis Building. The estimated total credit is $1,560 from the participation into a one-time DR event. Both of these two buildings are not weather sensitive at all. Bowling Center has a very large process load running at constant cycles, as shown in **Figures 6-15** and **6-16**. The Bowling Center Computation-Analysis Building is operated at a constant load of ~400 kW through the year, except for a day with the peak demand of over 6 MW.

Table 6-8. Estimated Peak DR Capacity of 8 Sites (Available Meter Data)

Building	Name	Peak HVAC Power (kW)	Peak DR Capacity (kW)	Credit ($) from DR Participation in the PJM Market
121	TECH OFFICE/PHOTO LAB	42	16.8	$124
135	BOWLING CENTER	N/A	N/A	N/A
182	PUBLIC WORKS DEPARTMENT HQ.	68	27.2	$201
221	WEAPONS EFFECT & LAUNCH BLDG	200	80	$592
997	RANGE CONTROL	35	14	$104
1200	COMPUTATION-ANALYSIS BLDG	N/A	N/A	N/A
1500	STARK BUILDING	150	60	$444
120M	PW MAINTENANCE SHOP	32	12.8	$95



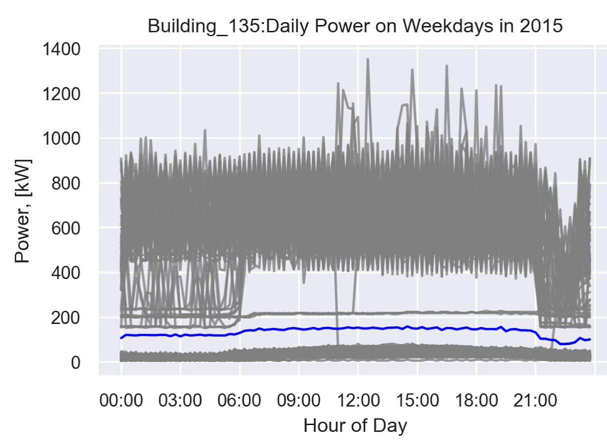


Figure 6-15. Building 135 Load Duration Curve in 2015 (left) and Daily Power Usage on Weekdays (right) in 2015

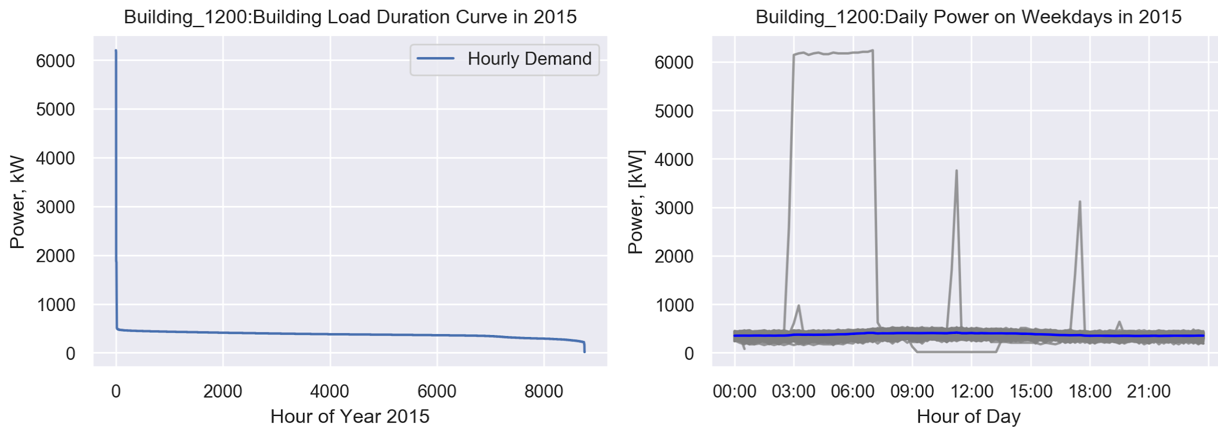


Figure 6-16. Building 1200 Load Duration Curve in 2015 (left) and Daily Power Usage on Weekdays (right) in 2015

Excluding Bowling Center and Computation-Analysis Building, the total estimated Peak DR Capacity is 210 kW. According to the calculation method of load response emergency credits offered by the PJM, **Table 6-9** presents the total emergency credits and offer for the emergency DR participation.

Table 6-9. Estimated Load Response Emergency Credits of the Aggregated DR Resources

	HE 13	HE 14	HE 15	HE 16	HE 17	HE 18	Total
Nominated kW	210	210	210	210	210	210	N/A
Actual Reduction kW	210	210	210	210	210	210	N/A
Real-Time LMP ($/MWh)	115	210	130	186	90	70	N/A
Strike Price	$1,100	$1,100	$1,100	$1,100	$1,100	$1,100	N/A
Load Response							
Emergency Credits	$24.2	$44.1	$27.3	$39.1	$18.9	$14.7	$168
Emergency Offer	$231.0	$231.0	$231.0	$231.0	$231.0	$231.0	$1,386

PJM notes in its most recent DR strategy document that "DR participation as an economic resource in the wholesale energy market has been low, even with the payment of full LMP."[1] As a result, that program has essentially been eliminated from the portfolio in favor of a Capacity Performance product in which resources are paid to be available and penalized if they do not respond when called. Historically, there have been few actual events called, but mandatory test events are called almost every month and lack of response to these test events is also penalized.

[1] PJM, Demand Response Strategy, June 28, 2017, https://www.pjm.com/~/media/library/reports-notices/demand-response/20170628-pjm-demand-response-strategy.ashx

Enrollment in a DR program within the PJM territory must be done via a CSP, with each CSP determining specific financial details for DR participation. There are over 60 CSPs serving the Washington, D.C. and Maryland areas (contact list attached below – can be moved to an appendix if needed). However, general PJM rules can be expected to apply. Although PJM offers a price-based economic DR program, the financial rewards from this program have been so limited that enrollment has declined to almost nil (see **Figure 6-17**):

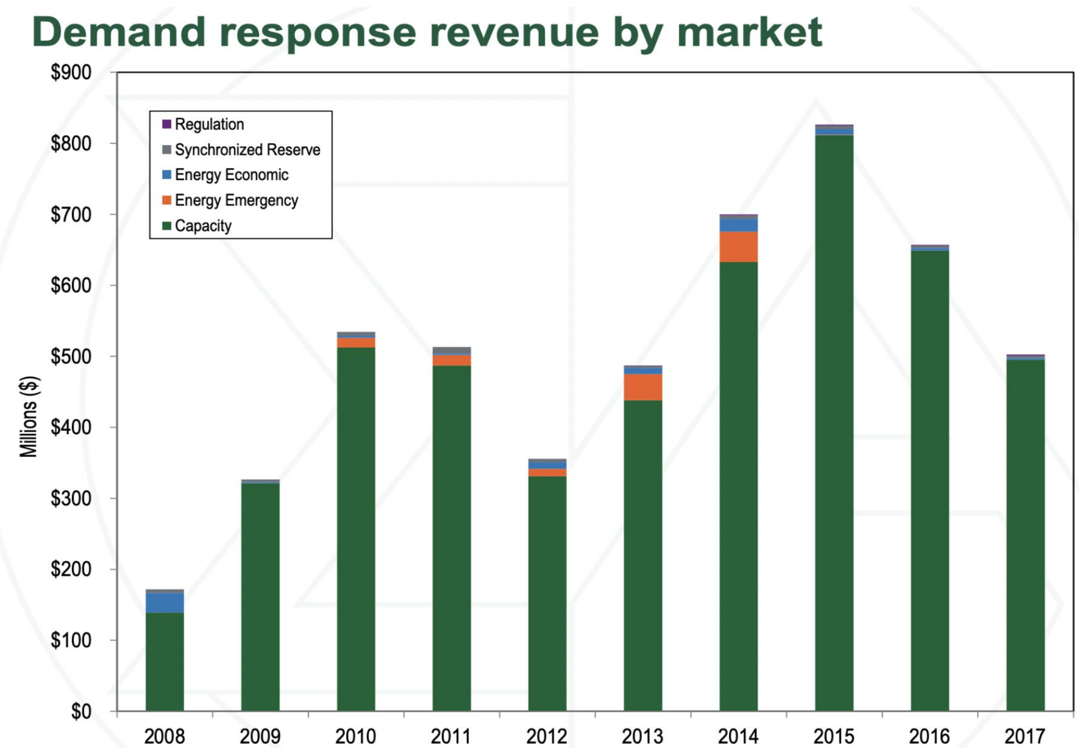


Figure 6-17. PJM Demand Response Revenue by Market (2008-2017)

Source: monitoringanalytics.com, retrieved 2/20/2019

Consequently, we focus on the PJM capacity market in the discussion below:

- Participation requires at least a 1-hour utility grade meter.
- Load reductions in the (lightly subscribed) economic DR program are measured against a (confirmed based on PJM developed tests) CBL representing the anticipated load during the time when a DR event is called. By contrast, load reductions in the capacity market are based on the amount of load the customer commits to being able to reduce (with significant penalties if that amount of load is not reduced when called).
- Minimum load reduction is 100 kW, which may represent an aggregated load over a given load zone.
- The program runs all year, not just during hot summer days. However, there is a limited possibility that, depending upon the CSP chosen, it might still be possible to enroll in a summer only DR program (Base Capacity) through summer 2020, after which the only program available will be Capacity Performance.

- Although there is no limit to the number of events that can be called, events can last up to 12 hours (10:00 AM to 10:00 PM) from June through October, and up to 15 hours (6:00 AM to 9:00 PM) from November through May of a given year.
- No mandatory events have been called since 2013.
- Payment is based on a capacity value in a given location determined via regular auctions to identify and commit resources three years in advance. The actual payment is based on auction results the rules applied by the particular CSP.
- In addition to this auction-based payment, the site may also accrue limited benefits from energy payments related to the amount of reduction used from a site during a called DR event.
- Underperformance is penalized by whichever is greater: loss of program revenue plus 20% or $7.30/kW or CSP specific rules.
- Underperformance penalties apply to both called events and test events.
- On-site emergency generators, energy storage, or power from renewable resources can be used to offset the power that otherwise would be used from PJM during a DR event or test event. However, if renewables are used to offset load requirements during normal business operations, then they would already be part of the baseline calculation for that site, and their operation could not provide demand response.
- Sites in other utility jurisdictions have used the funds from participating in a capacity DR program to pay for the costs of DR equipment installation.

6.6 FINDINGS AND RECOMMENDATIONS

In this chapter, we present a DR estimation framework to predict the load reduction possible (kW capacity) from building HVAC systems. Two types of DR control strategies are evaluated in the framework: (1) global temperature adjustment and (2) cycle on/off HVAC units. In the field testing, the control strategy of "raising thermostat setpoint 3°F" was implemented at one of the field sites. For a 35,659 square feet, steel-framed office building, 27.3 kW of the peak demand reduction were achieved, which accounted for 23% of the whole building power. In average, the load shed in kW, WBP % and W/ft^2 were 11 kW, 10%, and 0.31 W/ft^2. By contrast, the estimated DR capacity is 27.2 kW when the outside air temperature is around 95°F. These comparison results indicate the accuracy and value of the model to a certain extent, though the field testing data are limited.

Benefits in the retail and wholesale markets are evaluated with the following assumptions: (1) all the field sites have the same option as other Virginia customers to purchase both the supply (generation and transmission) and delivery (distribution) portions of their electric service; (2) participation in PJM's Capacity Performance DR Programs. Taking one of the field sites as an example, 27.2 kW of DR capacity in Building 182 can receive a total DR credit of $201 in the PJM's Capacity Performance DR Program on the test event day of 9/8/2015. If the entire site acts as an aggregator, a total DR capacity of 210 kW can be dispatched to the PJM's Capacity Performance DR Program. As a result, when an event is called, more than $1,500 of credit can be awarded if the nominated capacity is delivered.

Reported customer load reduction methods in 2015-2016 for PJM included HVAC (27%) and back-up, on-site generator (23%), both of which appear to be plausible mechanisms for the sites included in this study. Based on the ability to reduce HVAC load observed during a simulated demand response event, it is reasonable to assume that each of the three NDW region bases sites selected for study in this project (WNY, DAH, and JBAB) could participate in PJM's Capacity Performance demand response programs. These would provide payment based on the total amount of load that the site could agree to reduce from its overall demand if called and the auction clearing price for that demand. Because back-up generation can be used in place of the load reduced and it is reasonable to expect military bases to have extra generation, a substantial load reduction is likely, thereby providing a strong basis for participation. Although events are rarely called at the present time, should one occur, back-up generation and any renewable resources not currently being used can supplement the capability to participate in the Capacity Performance DR market. As noted above, DR participation as an economic resource (price-based DR) is extremely low with PJM because most customers can get greater, more consistent bill savings via dynamic retail rate contracts or index-based contracts to translate load reductions into cost savings. In addition, capacity market participation does not preclude additional compensation in the energy market for the actual energy reduced.

A list of CSPs serving Maryland and Washington, D.C. area (for DR participation in PJM Capacity Markets) is provided in **Appendix D**.

Page Intentionally Left Blank

APPENDIX A AUTHORITY TO OPERATE (PIT/PRA) DATED 22 JUNE 2012

DEPARTMENT OF THE NAVY
COMMANDER
U.S. FLEET CYBER COMMAND
9800 SAVAGE ROAD SUITE 6586
FORT GEORGE G MEADE MD 20755-6586

5239
Ser ODAA/0376
JUN 22 2012

From: Commander, U.S. Fleet Cyber Command
To: Commander, Naval Facilities Engineering Command

Subj: PLATFORM INFORMATION TECHNOLOGY (PIT) RISK APPROVAL (PRA) FOR THE WESTON ADVANCED METERING INFRASTRUCTURE (WESTON AMI) VERSION 1.0 (FY12P0100)

Ref: (a) OPNAVNOTE 5230 Ser N2N6F1/U151297 of 4 August 11 (Canc: August 12)
(b) DON CIO memo 02-10 of 26 April 10
(c) DoD Directive 8500.1 of 24 October 2002
(d) DoD Instruction 8500.2 of 6 February 2003
(e) CJCSI 6211.02D of 24 January 2012
(f) Information Assurance Tracking System (IATS) website https://iats.nmci.navy.mil, Reference # 19014

1. By authority granted in reference (a), a PRA is hereby granted for the operation of Weston AMI v1.0 at all Navy Installations. This PRA is granted in accordance with references (b) and (c), in compliance with references (d) and (e), and based on a review of the information contained in reference (f).

SYSTEM PROFILE	
Classification	Up to Unclassified
MAC	III
Confidentiality Level	Sensitive
Mode of Operation	System High
IATS	19014

2. Per reference (b), a scheduled periodic review of this PRA is required by the approving DAA within a four year period. Schedule a periodic review of the system's baseline and risk level with the approving DAA via the Echelon II at least 30 days prior to 2 May 2016. If there is a known change in the security posture or the system baseline, coordinate a periodic review at that time.

Subj: PLATFORM INFORMATION TECHNOLOGY (PIT) RISK APPROVAL (PRA) FOR THE WESTON ADVANCED METERING INFRASTRUCTURE (WESTON AMI) VERSION 1.0 (FY12P0100)

3. The overall residual risk of Weston AMI has been determined to be **Medium**.

4. All external connections must be identified. Platform IT Interconnections (PITI) are not exempt from the Certification & Accreditation (C&A) process and must be accredited prior to connecting the system in accordance with references (b) through (d).

5. The PM is required to notify the ODAA of changes which result in modification to the system architecture to include: additional components, changes to external connections, or any hardware or software changes that add new functionality.

6. Ensure Tracking Number **FY12P0100** is used in the subject line of all correspondence relating to this system.

7. Neither PIT designation nor subsequent PRA exempts any system from applicable Cross-Domain Solution (CDS) requirements. Any data streams traversing multiple security domains must comply with current DoD and DON requirements.

8. Consent to Monitor - In accordance with the requirements of reference (e), FLTCYBERCOM acknowledges that Defense Information Systems Agency (DISA) will conduct periodic monitoring of Navy networks. FLTCYBERCOM acknowledges and consents to DISA conducted assessments to include periodic, unannounced vulnerability assessments on connected host systems to determine effective security features and enhance IA posture.

9. POC: Mrs. Narinder Hancock, Action Officer/Mr. Terry Hartsell, Team Lead or Mr. Ron Velasquez, Operations Division Head, (757) 417-6719 ext. 0, Email: FCC_ODAA@navy.mil.

C. M. KIRIAKOU
By direction

Copy to:
IATS Ref # 19014
NAVFAC CIO Washington DC
CNIC CIO Washington DC

Page Intentionally Left Blank

APPENDIX B ELSTER FUNCTIONAL DESIGN FOR WESTON ESTCP

Functional Design

Functional Design for Weston - ESTCP

Date: Mar. 23, 2015
Version: 1.4

Version Control

Date	Author	Description	Version
2/9/15	Owen Jolly / James Fox	Initial draft	1.0
3/4/15	Pete Virag, Tarik Khan, Todd Davis, Owen Jolly, Jamie Murphy, James Fox	Revision prepared at day 1 of 2 day workshop in Raleigh	1.1
3/5/15	Pete Virag, Tarik Khan, Todd Davis, Owen Jolly, Jamie Murphy, James Fox	Revision prepared at day 2 of 2 day workshop in Raleigh	1.2
3/18/15	James Fox, Owen Jolly	Revise document to more clearly define deliverables.	1.3
3/23/15	James Fox, Todd Davis	Add detail to sections 4.3 and 4.8	1.4

Distribution List – Internal

Name	Title	Email
Jamie Murphy	Manager, Customer Solutions	jamie.murphy@elster.com
Todd D. Davis	Sales Director, National Accounts	todd.davis@elster.com
James Fox	Senior Integration Consultant, Customer Solutions	james.fox@elster.com
Tarik Khan	Application Consultant, Customer Solutions	tarik.khan@elster.com
Owen Jolly	Head of Managed Services and EM Solution Management	owen.jolly@elster.com

Distribution List – External

Name	Title	Email
Peter E. Virag	Sr. Technical Manager	Email: peter.virag@westonsolutions.com 610.733.3541
Gregory White		Email: gregory.white@westonsolutions.com
Kirk Fossum		Email: kirk.fossum@westonsolutions.com

Related Documents

Date	Author	Description	Version

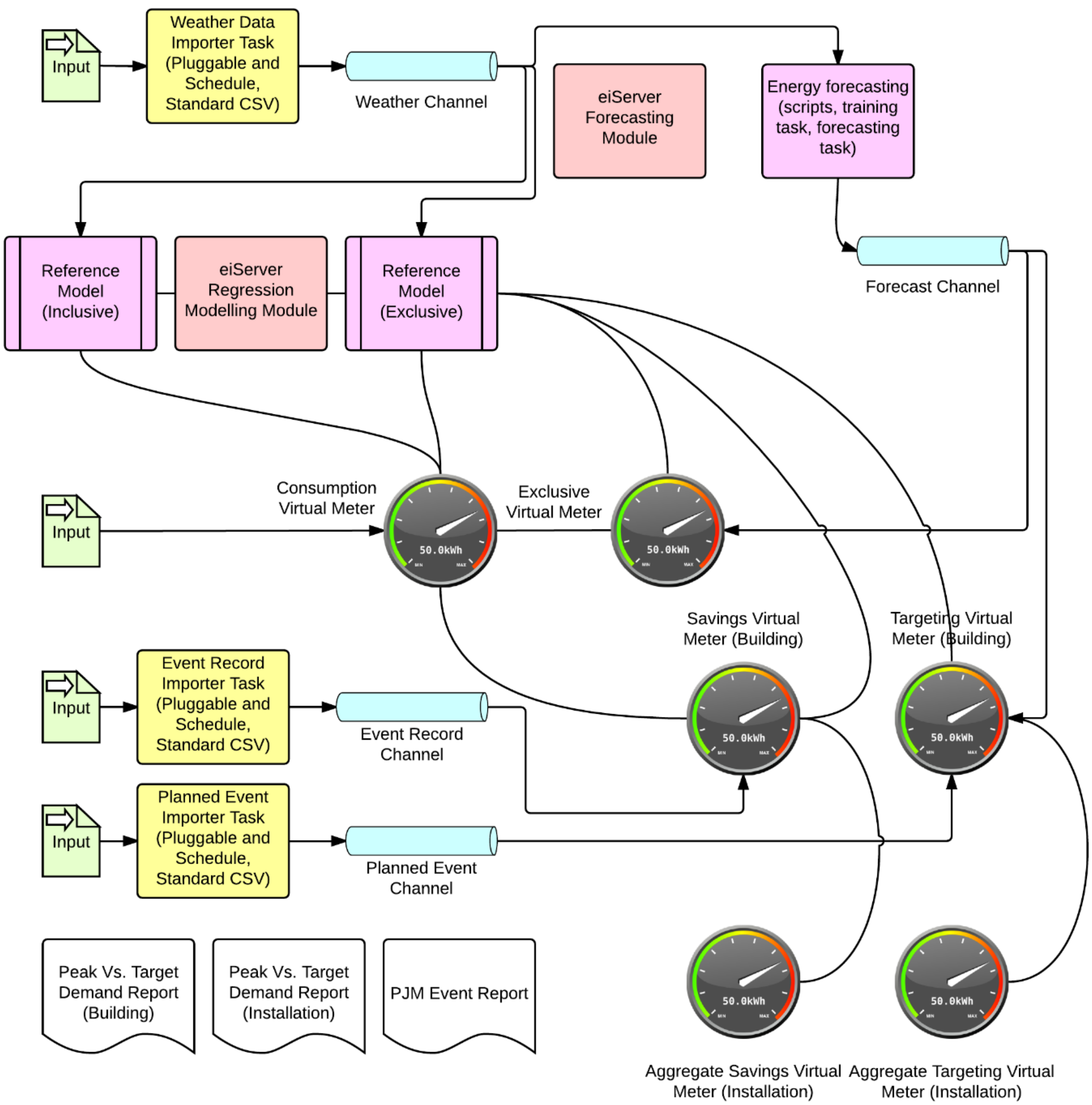
Table of Contents

1.0 Functional Overview

The requirements for the ESTCP Demand Response pilot program are addressed in this Functional Design Document (FDD).

There are two facets to the system design. Energy forecasting will be employed to allow system operators to predict peak consumptions and allow them to make decisions regarding DR, Peak Shaving or other types of intervention. Reporting on energy savings from DR and Peak Shaving will be determined by comparing a customer baseline against actual kWh consumption.

Virtual meters and reports will be employed to provide visual representation of the savings.



2.0 Assumptions

The scope of this project is to add extensions (modules/meters/reports) to existing EIServer functionality. This will be implemented on the existing U.S. Navy EIServer installation (operated by Weston) and hosted on-premises at Naval District Washington.

A data dump from the existing EIServer production installation will be made available to the development team in a timely fashion to allow development and testing to be performed.

Once development and testing have been completed on Elster's development environment, the new modules and configuration will be deployed to the existing live production environment.

This design assumes that there will be one meter per building in scope, representing the total consumption of the building OR the total consumption of relevance to Demand Response / Peak Shaving, i.e. the total controllable consumption. This will be determined on a building-by-building basis by Weston. These meters should follow a standard naming convention so that they can be readily identified for reporting purposes.

Similarly, installation-level meters will follow a standard naming convention.

3.0 Introduction

The functional design is based on requirements specific to Weston/ESTCP. The functions are a result of discussions between Elster and Weston Solutions.

The following table lists the set of requirements in scope

Requirement	Description
4.1	Week-ahead forecasting
4.2	Targeting
4.3	Customer baseline
4.4	Avoided consumption reporting
4.5	Peak kW reporting
4.6	PJM event reporting
4.7	Dashboards
4.8	API training

4.0 Functional Design

4.1 Week-Ahead Forecasting

4.1.1 Description

In order to support accurate prediction of peak shaving and DR events the forecasting module will be deployed to EIServer. This incorporates an input of week-ahead weather data that will be used to forecast energy consumption based on a rolling 12 months of historical observation of correlations between weather and energy usage.

4.1.2. Assumptions

- Weston will convert the weather data into the standard CSV format specified for EiMaster (refer to appendix B)

- CSV format includes a code 80/81 for actual/estimated respectively.

- There will be a channel per building to store events.

- Weston to provide 12 months of historical weather and metering data via dump from live installation (to be decided how sensitive information will be filtered out (IP addresses etc.))

4.1.3 Weather Importer

The weather importer will have a pluggable class that is capable of reading the standard CSV format. A schedule will be created which references the pluggable class and runs the importer on a periodic basis. There will be a standard directory structure with an "input" folder where the CSV files to be imported can be placed. The importer will read the CSV files on a periodic basis defined by the schedule and place the imported values into the correct weather channels.

There are two drops of weather data from Weston:

- 6z – this is 6am UTC, will be available following processing by about 4-5 am EST
- 12z – this is 12am UTC, will be available following processing by about 10 am EST

4.1.4 Forecasting

Forecast re-training will be run once per week, chained to successful completion of the weather import task. The forecasting will be implemented at 15-minute interval granularity on a per-building basis. Forecast consumption will be calculated for one week ahead.

The forecast training will be performed against a profile that excludes the impact of any DR or Peak Shaving events (described in the section "Avoided Consumption Reporting" below). To achieve this, a virtual meter will be created which replaces consumption data during any event with the forecast data for that period.

There will be no channel journaling applied to the forecast data channels.

There will be unique channels for forecast and observation weather data. If the observation data is late the virtual meter formula can be written to fall back to forecasted data to prevent calculation against null values.

Refer to Appendix C for details of the variables used as input to the forecasting calculations.

Energy ICT will investigate the possibility of correcting forecasts for holidays.

4.1.5 Deliverables

- Historical weather data importer pluggable class
- Historical weather data importer schedule
- Historical weather data importer directory structure
- Weather channels (Refer to Appendix A for channel naming conventions)
- Energy forecasting scripts
- Energy forecast training task
- Energy forecaster task, configured to deliver seven days forecast data on a daily basis
- An initial seven days of weather forecast data per weather station based on twelve months training

4.2 Targeting

4.2.1 Description

Baseline energy consumption will be calculated per building using the EIServer regression modeling module. This will allow comparison of baseline energy consumption to actual energy consumption to determine savings from DR and PS events for reporting purposes.

4.2.2 Assumptions

Baselines will be calculated on daily totals for dependent and independent variables. The resulting value will be distributed over the intervals of the day by means of synthetic load profiling.

The training period will be 12 months, in the absence of any specific reason to indicate otherwise.

Baseline retraining will occur on a quarterly basis or more frequently if required.

Reference baselines will not be corrected for holidays.

4.2.3 Reference Models

There will be two separate reference models. One will exclude the effect of the events and will use the profile from the forecast input meter as its dependent variable (Exclusive). The other will include the effect of the events and will use the actual kWh consumption data as its dependent variable (Inclusive).

The models will be identical in all other respects (i.e. they will use the same independent variables). The exclusive baseline is the primary baseline and this will determine the variables used for the inclusive baseline.

The reference models will use independent variables with the highest R^2 values as determined by the EIServer regression modeling module. Available independent variables will include day of week and the weather variables from forecasting as defined in Appendix C.

4.2.4 Targeting

The aim is to look ahead over a seven-day load forecast and determine potential events occurring on the next business day. Actions will be taken to reduce demand based on these events (DR events). We will also report on the impact of these events in terms of energy saving compared to baseline.

There will be versioned attributes for max demand (kW), target demand (kW) and demand reduction capacity (kW) per building

There will be versioned attributes for max demand (kW), target demand (kW) and demand reduction capacity (kW) per installation

4.2.5 Planned Events Channel

There will be a channel per building to store planned events.

Channel naming convention: <Building Name>/Planned_Event

The channel will contain an integer representing planned kW downturn. It will be populated for all intervals during a planned event time.

The planned events importer will have a pluggable class that is capable of reading the standard CSV format. A schedule will be created which references the pluggable class and runs the importer on a periodic basis. There will be a standard directory structure with an "input" folder where the CSV files to be imported can be placed. The importer will read the CSV files on a periodic basis defined by the schedule and place the imported values into the correct planned event channel.

4.2.6 Targeting Virtual Meter

There will be a Targeting Virtual Meter created per building to compare Actual kWh with Baseline, Forecast, Demand and downturn, fields as specified below.

Fields:

- Forecast kWh
- Actual kWh
- Baseline Exclusive kWh
- Contracted Demand Annual (kWh = demand kW (from attribute) / 4)
- Contracted Demand Monthly (kWh = demand kW (from attribute) / 4)
- Versioned Targeted Demand (kWh = demand kW (from attribute) / 4)
- Planned downturn

Meter views:

- Seven days ahead Forecast vs Baseline vs Targeted Demand Annual
- Seven days ahead Forecast vs Baseline vs Targeted Demand Monthly
- Seven days ahead Forecast vs Baseline vs Versioned Targeted Demand
- Seven days ahead Forecast vs Baseline vs Planned downturn

An additional instance of this virtual meter will be created per installation to sum all the building VMs to provide an aggregate view.

4.2.7 Deliverables

- Versioned attributes for max demand (kW), target demand (kW) and demand reduction capacity (kW) per building
- Versioned attributes for max demand (kW), target demand (kW) and demand reduction capacity (kW) per installation
- Targeting virtual meters (per building)
- Targeting virtual meters (per installation - aggregate of building-level VMs)
- Planned event importer pluggable, schedule and directory structure
- Planned event channels (per building)

4.3 Customer Baseline (CBL)

4.3.1 Description

The targeting methodology described In 4.2 will confirm to the methodologies outlined in the tables using WSA as defined below.

PJM Manual 11, Section 10.4.2, pages 123-130 presents the approved methodology for establishing a customer baseline. Over time, PJM has accepted additional methodologies being used. The CBL methodology is clearly explained in tables, thereby acknowledging that any modifications to the methodology will be subject to PJM review and that of the Load Serving Entity (LSE) or EDC. Strong preference exists to use one of the prescribed PJM CBL methodologies. Two of the methodologies involve the use of a Weather Sensitive Adjustment factor (WSA). On page 129 the PJM rules state:

The WSA Factor represents the kW change in load for each degree of temperature change within a specified temperature range. The WSA factor is the slope of the line that describes the load and temperature relationship at the customer site between two temperature set points. The WSA Factor or slope of the line is obtained by performing a linear or piecewise linear regression analysis on the load and temperature data from the customer site. There should be at least two years of data used in the linear regression analysis to indicate the normal operation of the facility. ***Exceptions may be granted by PJM to use less data in cases where the normal operations have changed significantly between years. The analysis data should only include the day types and hours where load reductions are expected.*** (Emphasis added). For example, if the customer is only expected to respond during the hours of 8am to 6pm from Monday through Friday during non-holidays, then such historic hours should be used in the regression model."

4.3.2 Assumptions

We will use the EIServer native regression modeling functionality in place of PJM methodologies for calculating the customer baseline. See definition earlier in this document.

4.3.3 Deliverables

- The targeting VM as described in section 4.2

4.4 Avoided Consumption Reporting

4.4.1 Description

Reports will be developed to demonstrate the avoided consumption as a result of DR and PS events, at both the building and installation level.

4.4.2 Assumptions

Weston to provide details of events in standard CSV format on a timely basis (before C.O.B. Friday).

4.4.3 Savings Virtual Meter

There will be a Savings Virtual Meter created per building to show various views of the energy savings arising from DR and PS events, fields as specified below.

Fields:

- Actual kWh
- DR Savings. Formula: decode the event code. if code=DR then exclusive baseline kWh – actual consumption kWh else 0
- Peak Shaving savings. Formula: If code=PS then exclusive baseline kWh – actual consumption kWh else 0
- Exclusive Baseline
- Target. Formula: max(Exclusive baseline over day) * versioned target param (for building)

There will also be a VM instance that aggregates these building-level VMs up to installation-level (utilizing installation target versioned parameter for saving calculation).

Meter views:

- DR savings as: CBL Exclusive kWh – Actual kWh Consumption during DR event
- PS savings as: CBL Exclusive kWh – Actual kWh Consumption during PS event.
- Summed DR and PS savings as: CBL Exclusive kWh – Actual kWh Consumption during any event
- Actual vs. Baseline vs. Target Peak with savings overlaid (kWh)
- CuSum of savings kWh over selected period (viewable as DR; PS and both aggregated)
- Savings expressed as % of baseline (query returning table of data – available as DR; PS and both aggregated)

4.4.4 Event Records

The event record importer will have a pluggable class that is capable of reading the standard CSV format. A schedule will be created which references the pluggable class and runs the importer on a periodic basis. There will be a standard directory structure with an “input” folder where the CSV files to be imported can be placed. The importer will read the CSV files on a periodic basis defined by the schedule and place the imported values into the correct event record channel.

Weston will provide a file that contains a row per interval (columns: Channel Name, Timestamp, Integer value). Weston will provide this data in standard CSV format. Forecast re-training will occur over the weekend, therefore this event data will need to be uploaded into EiMaster before C.O.B. Friday.

The code column will be populated in the CSV to indicate the type of intervention – i.e. 2=DR, 3=Peak-Shaving. This will be referred to from the virtual meter used to determine the savings per intervention event.

Event record channel naming convention: <Building Name>/Event_Record

The channel will contain a pre-defined integer (of meaning to Weston) – any non-zero value will indicate an event occurring in that interval.

A virtual meter will be created to serve as the forecast input meter containing the following formula:

If "Event Record" = 0 || null, kWh consumption ELSE kWh forecast

4.4.5 Deliverables

- Savings virtual meters (per building) with views
- Savings virtual meters (per installation) with views
- Event record channel
- Event importer pluggable task, schedule and directory structure
- Forecast input virtual meter (per building)

4.5 Peak kW Reporting

4.5.1 Description

Provision of group report definitions and summary reports to show the performance in terms of peak demand vs. target at both the building and installation level.

4.5.2 Assumptions

There will be group report definitions and summary reports to show the performance in terms of peak demand versus target.

The reports can be run for a selected period, and the peak values displayed will be the maximum value observed for that period.

4.5.3 Building Level Report

Columns:
Building name; Target kW (from building folder attribute); Peak kW register read; Peak kW (calculated)

Rows (members):
Building

4.5.4 Installation Level Report

This will report on the maximum demand versus target at installation level.

Supporting this report will be a Virtual Meter summing together the kWh consumption at interval level for the buildings in the installation – this will give a profile for the total installation. The maximum value from this meter over the period of the report will give the maximum demand (in kWh). This will be multiplied by 4 to give a max kW demand.

Columns:
Installation name; Target kW (from installation level parameter); Peak kW (calculated)

Rows (members):
Installation

4.5.5 Deliverables

- Building level report
- Installation-level report

4.6 PJM Event Reporting

4.6.1 Description

There will be a group report definition and summary report to quantify the impact of participation in DR events.

4.6.2 Assumptions

It is assumed that the PJM events channel will have been populated with all observed events prior to the execution of this report.

4.6.3 Report Definition

Columns:
Building Name; Interval; kWh consumption; Baseline (exclusive) kWh; Downturn kWh (baseline – consumption); Planned downturn for interval (as kWh = kW/4); Downturn achieved? (Boolean: if (Downturn kWh – Planned downturn >= 0) then True, else False.)

Rows: Building

4.6.4 Deliverables

- Group report definition and summary report

4.7 Dashboard

4.7.1 Description

There will be a dashboard that gives an overall view of the savings from and performance of the DR and PS activities.

4.7.2 Assumptions

Weston will implement this with support from EnergyICT in defining and building a dedicated data extract that will provide the required metrics to the dashboard.

4.7.3 Deliverables

- Dashboard metrics data extract.

4.8 API Consulting and Training

4.8.1 Description

Elster Energy ICT will provide support in the form of miscellaneous consulting and training

4.8.2 Assumptions

Each request for consulting support will be received by Elster EICT in writing and Elster will provide a labor estimate for this service and once approved by Weston the work will be scheduled. This will cover any item lasting more than five minutes of consulting support.

Time will be kept for all assistance offered and at the end of the month a bill will be provided for all assistance averaging over 15 minutes total during the monthly period.

4.8.3 Consulting

Upon request Elster EnergyICT will provide miscellaneous consulting support in the deployment of the API for developing dashboards related to EIServer as it is deployed at the bases associated with Naval District Washington for the ESTCP demand response project. This consulting information will cover an overview of the API, the coding, questions on its operation and maintenance.

4.8.4 Training

The training will be scheduled in advance with a written memo stating the topics, duration, and key results desired by Weston or its consultant. Likely topics include an overview of the API, key algorithms and code elements, frequently asked questions and issues and their resolution, and responses to specific questions and issues tied to producing the desired dashboards. Elster EnergyICT will schedule a formal training and overview into the API with the support of our Belgium software analytical support team. Both items above will be billed on a time and materials basis.

4.8.5 Deliverables

- Miscellaneous consulting support (as requested)
- Formal API training

Appendix A: Weather Importer Channel Naming Conventions

XXX/Temperature-Y
XXX/Dewpoint-Y
XXX/Surface_Wind-Y
XXX/Sky_Cover-Y
XXX/Relative_Humidity-Y

XXX = weather station prefix, possible values:

DCA – Washington
BWI – Baltimore (Annapolis)
RIC – Richmond (Dahlgren)

Y = Forecasted/Observed suffix (F/O)

Appendix B: Standard CSV Format

Refer to document Standard CSV Format.pdf

Appendix C: Inputs to Energy Forecast Training

Weston will provide a feed of weather data in standard CSV format for three weather stations (BWI, DCA, RIC). Variables included are Temperature, Dew Point, Surface Wind, Sky Cover and Relative Humidity.

xxxx/BWI_Temperature
xxxx/BWI_Dewpoint
xxxx/BWI_Surface_Wind
xxxx/BWI_Sky_Cover
xxxx/BWI_Relative_Humidity

yyyy/DCA_Temperature
yyyy/DCA_Dewpoint
yyyy/DCA_Surface_Wind
yyyy/DCA_Sky_Cover
yyyy/DCA_Relative_Humidity

zzzz/RIC_Temperature
zzzz/RIC_Dewpoint
zzzz/RIC_Surface_Wind
zzzz/RIC_Sky_Cover
zzzz/RIC_Relative_Humidity

Appendix D: Glossary

Term	Definition
RFP	Request For Proposal
SOW	Statement of Work
AMI	Automated Meter Information System
UI	User Interface
UIS	User Information System
CIS	Customer Information System
MDM/MDMS	Meter Data Management System
EIServer	Energy Information Server. EnergyICT's meter data management system. EIServer manages meter data, performs VEE, provides a workflow engine and is capable of direct meter interrogation via ComServerJ.
Installation	A collection of buildings forming a Navy Base
DR	Demand Response
PS	Peak Shaving

Page Intentionally Left Blank

APPENDIX C ADDITIONAL FLOW DIAGRAMS WHERE HUMAN DECISION ARE MADE

Weather Data Forecast Function Details

Forecast Weather parameters

Date	01/16			
Hour (EST)	18	19	20	21
Temperature (°F)	36	32	31	30
Dewpoint (°F)	20	20	18	17
Wind Chill (°F)	27	23	22	20
Surface Wind (mph)	13	11	11	11
Wind Dir	NW	NW	NW	NW
Gust	22	20		
Sky Cover (%)	16	14	11	8
Precipitation Potential (%)	3	3	3	2
Relative Humidity (%)	51	61	58	58
Rain	--	--	--	--
Thunder	--	--	--	--
Snow	--	--	--	--
Freezing Rain	--	--	--	--
Sleet	--	--	--	--

Forecast for BWI (Baltimore, MD for)
Web View http://forecast.weather.gov/MapClick.php?lat=39.1742&lon=-76.66965&lg=english&&FcstType=digital
XML http://forecast.weather.gov/MapClick.php?lat=39.1742&lon=-76.6697&FcstType=digitalDWML

Forecast for DCA (Washington DC)
Web View http://forecast.weather.gov/MapClick.php?lat=38.8514&lon=-77.03821&lg=english&&FcstType=digital
XML http://forecast.weather.gov/MapClick.php?lat=38.8514&lon=-77.0382&FcstType=digitalDWML

Forecast for RIC (Richmond, VA)
Web View http://forecast.weather.gov/MapClick.php?lat=37.5056&lon=-77.32075&lg=english&&FcstType=digital
XML http://forecast.weather.gov/MapClick.php?lat=37.5056&lon=-77.3208&FcstType=digitalDWML

Weather Observations

BWI - http://www.weather.gov/data/obhistory/KBWI.html
DCA - http://www.weather.gov/data/obhistory/KDCA.html
RIC - http://www.weather.gov/data/obhistory/KRIC.html

weather.gov
Weather observations for the past three days
Baltimore, Baltimore-Washington International Airport
Enter Your "City, ST" or zip code Go metric en español

Date	Time (est)	Wind (mph)	Vis. (mi.)	Weather	Sky Cond.	Temperature (°F)				Relative Humidity	Wind Chill (°F)	Heat Index (°F)	Pressure		Precipitation (in.)		
						Air	Dwpt	6 hour Max.	6 hour Min.				altimeter (in)	sea level (mb)	1 hr	3 hr	6 hr
16	16:54	W 12	10.00	Partly Cloudy	FEW050 SCT250	39	20			46%	32	NA	30.02	1016.8			
16	15:54	W 15 G 23	10.00	Mostly Cloudy	BKN055 BKN250	42	21			43%	34	NA	30.01	1016.4			
16	14:54	W 22 G 31	10.00	Partly Cloudy and Breezy	SCT048 SCT250	42	21			43%	33	NA	29.99	1015.6			
16	13:54	W 18 G 29	10.00	Partly Cloudy	SCT044 SCT250	42	22			45%	34	NA	29.97	1015.1			
16	12:54	NW 20 G 26	10.00	Partly Cloudy	SCT044	41	22	44	31	47%	32	NA	29.98	1015.3			
16	11:54	W 23 G 32	10.00	Partly Cloudy and Breezy	SCT041	43	24			47%	34	NA	29.98	1015.5			

Weather Data Source

Convert NOAA based outputs to Elster CSV format

Elster Weather Format (.csv)

Channel Name	Date/Time	GMT offset	Value	Code
xxx/Temperature-O	2011/12/31 21:00	4 or 5	68	80 or 81
xxx/Dewpoint-O	2011/12/31 21:00	4 or 5	45	80 or 81
xxx/Surface_Wind-O	2011/12/31 21:00	4 or 5	12	80 or 81
xxx/Sky_Cover-O	2011/12/31 21:00	4 or 5	1,2,3,4 or 5	80 or 81
xxx/Relative_Humidity-O	2011/12/31 21:00	4 or 5	72	80 or 81

Channel Name = xxx/condition-Y;
xxx = DCA – Washington; BWI – Baltimore (Annapolis); RIC – Richmond (Dahlgren)
Condition = Temperature; Dew point Surface_Wind; Sky Cover; Relative Humidity
Y = O for Observed; F for Forecast

Time – Forecast, note all times are current local time (EST or DST); Observations -note all times are current local time (EST or DST) and time needs to be rounded to the nearest hour…so 15:54 becomes 16:00, note the observation time can vary from 15:50 to the 16:05

GMT offset – 5 for EST and 4 during DST

Value – self explanatory except for clouds; In the observations, record only the predominant cloud condition when more than one code is presented for Sky Cond, in this order OVC, BKN, SCT. Convert cloud condition to the numeric value in the table below.

Code – 80 for Observation, 81 for Forecast

Definition	Code in Observation	% Sky Cover in Forecast	Value
Clear	CLR	less than 12	1
Few Clouds	FEW	13 to 31	2
Scattered	SCT	32 to 55	3
Broken	BKN	56 to 88	4
Overcast	OVC	greater than 88	5
No Ceiling, for observations treat as OVC	VV		5

Process runs automatically on host PC twice per day (06Z forecast and 12Z forecast) and loads file into designated directory. Weather observation data will be processed in the AM uploaded and uploaded to EiMaster.

There will be unique channels for forecast and observation weather data. If the observation data is late the virtual meter formula can be written to fall back to forecasted data to prevent calculation against null values

SHoC Energy Operator

Weather Data Daily Activities

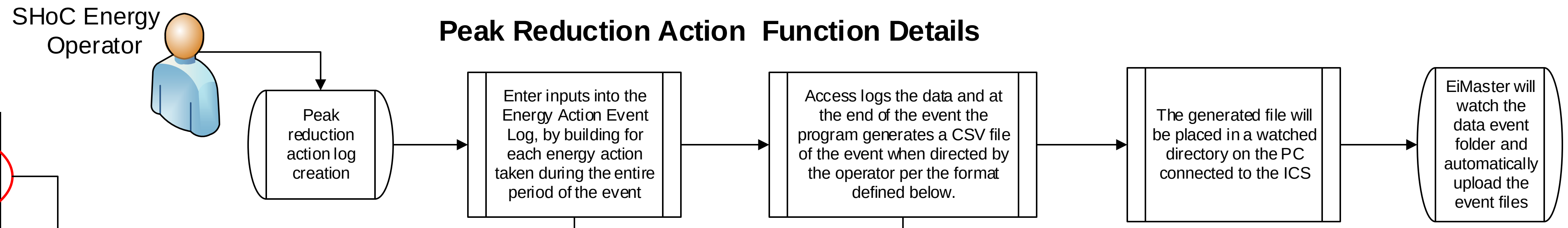
Add 06Z and 12Z NWS weather forecast and Observation data to eiMaster

Run Weather Forecast and Weather Observation data retrieval programs which downloads data from the NWS Web site and formats into Elster CSV format

Copy files onto CD for network computer and transfer to eiMaster folder

eiMaster overwrites observed data with forecast data.

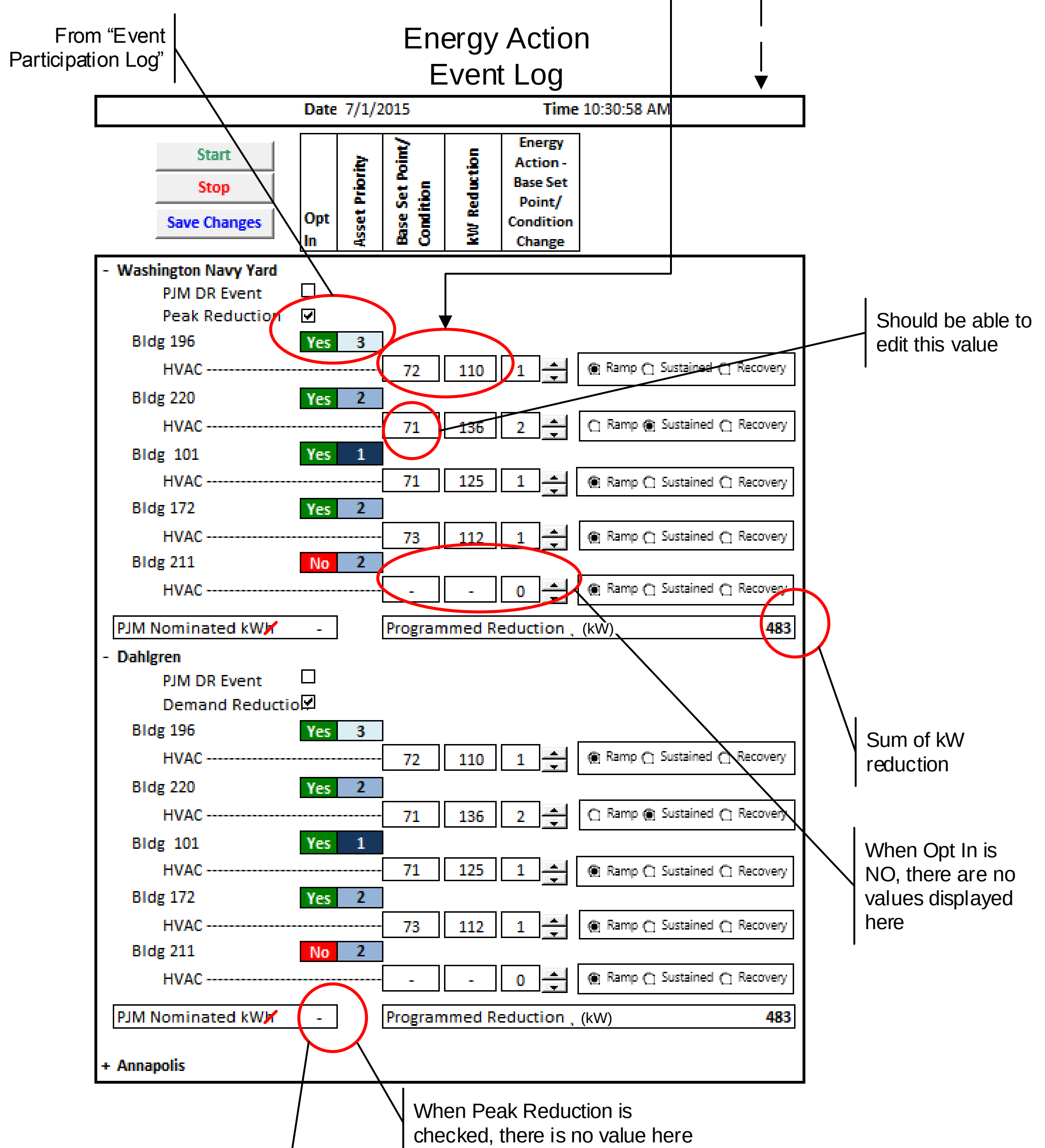
Peak Reduction Action Function Details



Building Asset Information Table

Location	Building	Resource Type	Base Set Point/ Condition	kW Reduction
WNY	101	HVAC	72	110
WNY	172	HVAC	72	111
WNY	211	HVAC	72	112
WNY	220	HVAC	71	113

Energy Action Event Log



Elster Peak Reduction Log Format (.csv)

Channel Name	Date/Time	GMT offset	Value (EBBBCCCWWW)				Code
Base/Building	Date/Time	Number	Equip - E	Base Set Point - Value (BBB)	Change Condition Value (CCC)	kW Reduction Value (WWW)	Number
WNY/B#/Event_Record ANN/B#/Event_Record DAH/B#/Event_Record		4 (DST) 5 (ST)	1= HVAC 2= Lighting 3=HVAC & Lighting 4=Other	Value	Value Negative Values begin with 9	Value	21= DR Ramp 22= DR Sustained 23= DR Recovery 31= DPR Ramp 32= DPR Sustained 33= DPR Recovery

Example	**WNY/B219**	**2015/7/20 21:00**	**4**	**1072001100**	**22**
As CSV	WNY/B219,2015/7/20 21:00,4,1072001100,22				
Description	Washington Navy Yard Building 219 on 20 July 2015 at 21:00 hours with a GMT offset of 5 where HVAC base set point is 72 degrees, temperature increase of 1 degree, 100 kW load reduction in a DR sustained state				

Elster Peak Reduction Log file example for a single building (.csv)

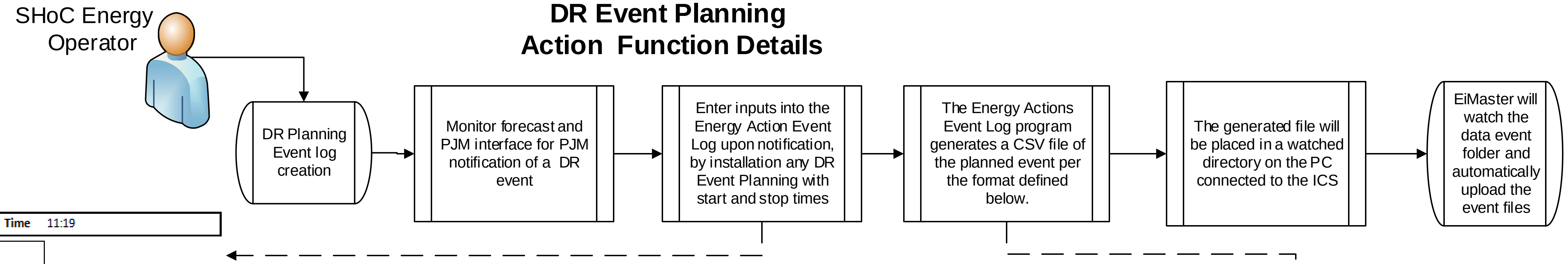
Channel Name	Date	Time	GMT offset	Equip - E	Base Set Point - Value (BBB)	Change Condition Value (CCC)	kW Reduction Value (WWW)	Code	Comments
WNY/B196/Event_Record	2015/7/20	11:00	4	1	72	001	110	31	Action started 11:08, temp rasie one degree. Created for the prevous 15 min interval. Frist record.
WNY/B196/Event_Record	2015/7/20	11:15	4	1	72	001	110	31	No Actions are taken, the prevous record is repeated
WNY/B196/Event_Record	2015/7/20	11:30	4	1	72	001	110	32	Status changed to sustained response at 11:20. Record is created for the next 15 min interval
WNY/B196/Event_Record	2015/7/20	11:45	4	1	72	001	110	32	No Actions are taken, the prevous record is repeated
WNY/B196/Event_Record	2015/7/20	12:00	4	1	72	001	110	32	No Actions are taken, the prevous record is repeated
WNY/B196/Event_Record	2015/7/20	12:15	4	1	72	002	110	32	Action taken to raise temp by another 1 dgree at 12:04. Record is created for the next 15 min interval
WNY/B196/Event_Record	2015/7/20	12:30	4	1	72	002	110	32	No Actions are taken, the prevous record is repeated
WNY/B196/Event_Record	2015/7/20	12:45	4	1	72	002	110	32	No Actions are taken, the prevous record is repeated
WNY/B196/Event_Record	2015/7/20	13:00	4	1	72	002	110	32	No Actions are taken, the prevous record is repeated
WNY/B196/Event_Record	2015/7/20	13:15	4	1	72	002	110	32	No Actions are taken, the prevous record is repeated
WNY/B196/Event_Record	2015/7/20	13:30	4	1	72	002	110	32	No Actions are taken, the prevous record is repeated
WNY/B196/Event_Record	2015/7/20	13:45	4	1	72	003	110	32	Action taken to raise temp by another 1 dgree at 13:44. Record is created for the next 15 min interval
WNY/B196/Event_Record	2015/7/20	14:00	4	1	72	003	110	32	No Actions are taken, the prevous record is repeated
WNY/B196/Event_Record	2015/7/20	14:15	4	1	72	003	110	32	No Actions are taken, the prevous record is repeated
WNY/B196/Event_Record	2015/7/20	14:30	4	1	72	003	110	32	No Actions are taken, the prevous record is repeated
WNY/B196/Event_Record	2015/7/20	14:45	4	1	72	003	110	32	No Actions are taken, the prevous record is repeated
WNY/B196/Event_Record	2015/7/20	15:00	4	1	72	002	110	32	Action taken to lower temp by 1 dgree at 14:50. Record is created for the next 15 min interval
WNY/B196/Event_Record	2015/7/20	15:15	4	1	72	002	110	32	No Actions are taken, the prevous record is repeated
WNY/B196/Event_Record	2015/7/20	15:30	4	1	72	002	110	32	No Actions are taken, the prevous record is repeated
WNY/B196/Event_Record	2015/7/20	15:45	4	1	72	001	110	32	Action taken to lower temp by 1 dgree at 15:41. Record is created for the next 15 min interval
WNY/B196/Event_Record	2015/7/20	16:00	4	1	72	001	110	32	No Actions are taken, the prevous record is repeated
WNY/B196/Event_Record	2015/7/20	16:15	4	1	72	001	110	33	Status changed to sustained response at 16:09. Record is created for the next 15 min interval
WNY/B196/Event_Record	2015/7/20	16:30	4	1	72	001	110	33	No Actions are taken, the prevous record is repeated
WNY/B196/Event_Record	2015/7/20	16:45	4	1	72	000	110	33	Action taken to lower temp by 1 dgree at 15:50. Record is created for the next 15 min interval
WNY/B196/Event_Record	2015/7/20	17:00	4	1	72	000	110	33	No Actions are taken, the prevous record is repeated
WNY/B196/Event_Record	2015/7/20	17:15	4	1	72	000	110	33	No Actions are taken, the prevous record is repeated
WNY/B196/Event_Record	2015/7/20	17:30	4	1	72	901	110	33	Action taken to lower temp by 1 dgree at 15:50. Record is created for the next 15 min interval
WNY/B196/Event_Record	2015/7/20	17:45	4	1	72	901	110	33	End of all actions for this building 17:39. Record is created for the next 15 min interval. Last record.

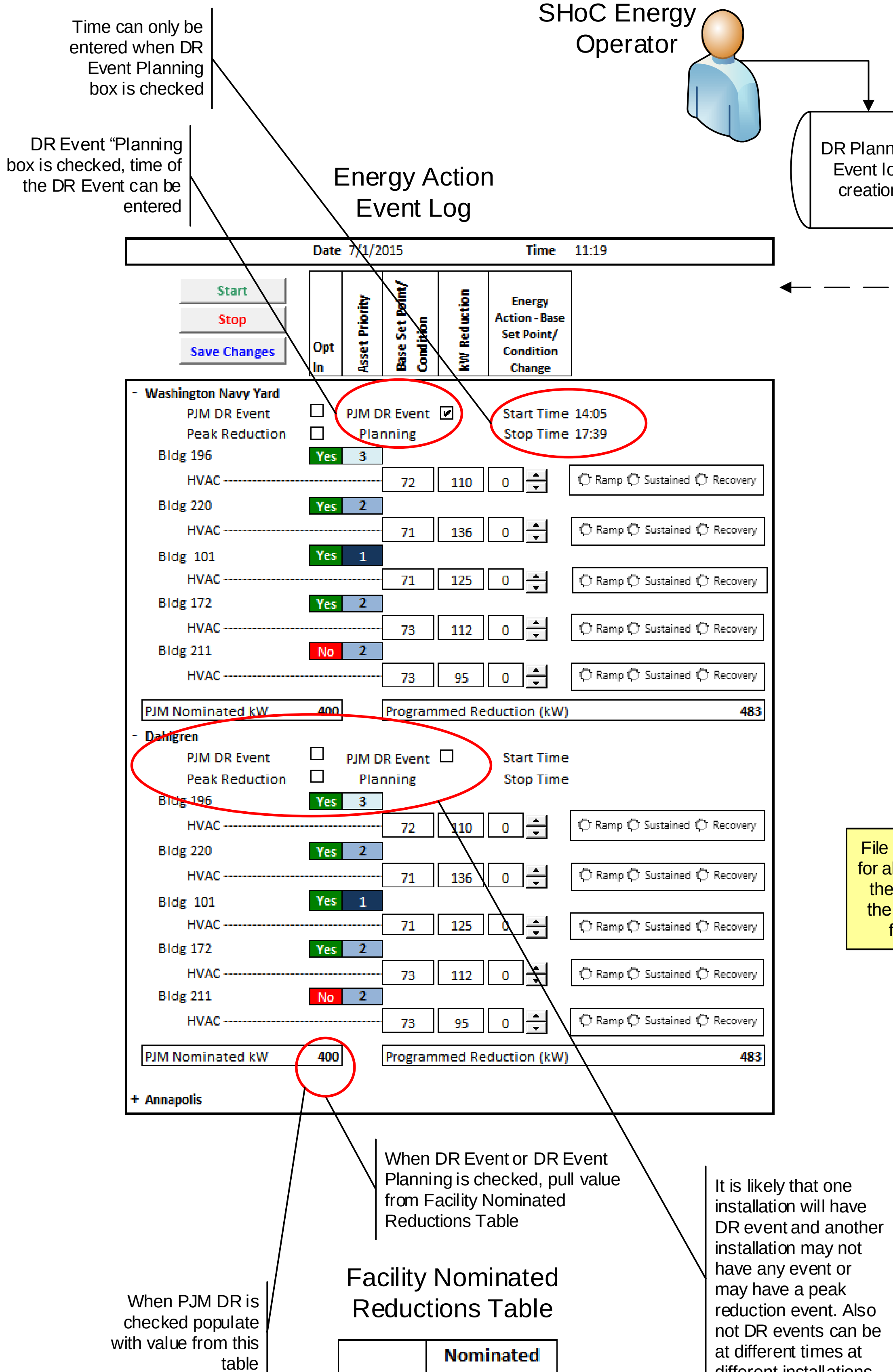
When PJM DR is checked populate with value from this table

Facility Nominated Reductions Table

Location	Nominated kW reduction
WNY	200
ANN	250
DAH	150

DR Event Planning Action Function Details





Facility Nominated Reductions Table

Location	Nominated kW reduction
WNY	200
ANN	250
DAH	150

Elster Demand Respond Planning Log Format (.csv)

Channel Name	Date/Time	GMT offset	Value (EBBBCCCWWW) - BBBCCC not used in planning and are replaced with 999999		Code
Base/Building	Time	Number	Equip - E	kWh Reduction- Value (WWW)	Number
WNY/B#/Planned_Event ANN/B#/Planned_Event DAH/B#/Planned_Event		4 (DST) 5 (ST)	1= HVAC 2= Lighting 3=HVAC & Lighting 4=Other	Value	20= Planned

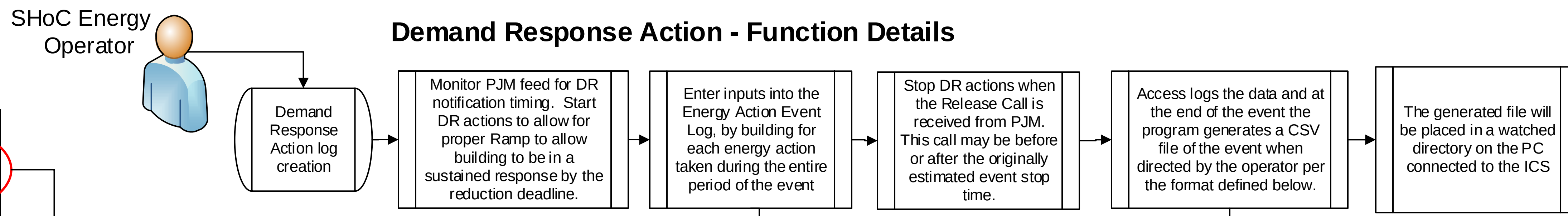
Example	WNY/B219	2015/7/20 21:00	4	1	100	20
As CSV	WNY/B219,2015/7/20 21:00,4,1999999100,20					
Description	Washington Navy Yard Building 219 on 20 July 2015 at 21:00 hours with a GMT offset of 5 where 100 kW load reduction is anticpated in a Planned DR event					

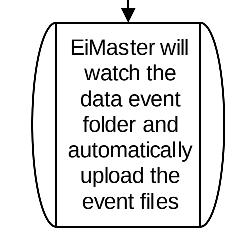
Elster DR Planning Event Log file example for a single building (.csv)

File is generated for all buildings at the installation the have 'YES' for Opt In

Channel Name	Date	Time	GMT offset	Equip - E	Base Set Point - Value (BBB)	Change Condition Value (CCC)	kW Reduction Value (WWW)	Code	Comments
WNY/B196/Planned_Event	2015/7/20	14:00	4	1	999	999	110	20	Demand response planned to started 14:05, record created for the previous 15 min interval. Frist record.
WNY/B196/Planned_Event	2015/7/20	14:15	4	1	999	999	110	20	Previous record is repeated.
WNY/B196/Planned_Event	2015/7/20	14:30	4	1	999	999	110	20	Previous record is repeated.
WNY/B196/Planned_Event	2015/7/20	14:45	4	1	999	999	110	20	Previous record is repeated.
WNY/B196/Planned_Event	2015/7/20	15:00	4	1	999	999	110	20	Previous record is repeated.
WNY/B196/Planned_Event	2015/7/20	15:15	4	1	999	999	110	20	Previous record is repeated.
WNY/B196/Planned_Event	2015/7/20	15:30	4	1	999	999	110	20	Previous record is repeated.
WNY/B196/Planned_Event	2015/7/20	15:45	4	1	999	999	110	20	Previous record is repeated.
WNY/B196/Planned_Event	2015/7/20	16:00	4	1	999	999	110	20	Previous record is repeated.
WNY/B196/Planned_Event	2015/7/20	16:15	4	1	999	999	110	20	Previous record is repeated.
WNY/B196/Planned_Event	2015/7/20	16:30	4	1	999	999	110	20	Previous record is repeated.
WNY/B196/Planned_Event	2015/7/20	16:45	4	1	999	999	110	20	Previous record is repeated.
WNY/B196/Planned_Event	2015/7/20	17:00	4	1	999	999	110	20	Previous record is repeated.
WNY/B196/Planned_Event	2015/7/20	17:15	4	1	999	999	110	20	Previous record is repeated.
WNY/B196/Planned_Event	2015/7/20	17:30	4	1	999	999	110	20	Previous record is repeated.
WNY/B196/Planned_Event	2015/7/20	17:45	4	1	999	999	110	20	Previous record is repeated.
WNY/B196/Planned_Event	2015/7/20	18:00	4	1	999	999	110	20	Previous record is repeated.
WNY/B196/Planned_Event	2015/7/20	15:15	4	1	999	999	110	20	Previous record is repeated.
WNY/B196/Planned_Event	2015/7/20	15:30	4	1	999	999	110	20	Previous record is repeated.
WNY/B196/Planned_Event	2015/7/20	15:45	4	1	999	999	110	20	Previous record is repeated.
WNY/B196/Planned_Event	2015/7/20	16:00	4	1	999	999	110	20	Previous record is repeated.
WNY/B196/Planned_Event	2015/7/20	16:15	4	1	999	999	110	20	Previous record is repeated.
WNY/B196/Planned_Event	2015/7/20	16:30	4	1	999	999	110	20	Previous record is repeated.
WNY/B196/Planned_Event	2015/7/20	16:45	4	1	999	999	110	20	Previous record is repeated.
WNY/B196/Planned_Event	2015/7/20	17:00	4	1	999	999	110	20	Previous record is repeated.
WNY/B196/Planned_Event	2015/7/20	17:15	4	1	999	999	110	20	Previous record is repeated.
WNY/B196/Planned_Event	2015/7/20	17:30	4	1	999	999	110	20	Previous record is repeated.
WNY/B196/Planned_Event	2015/7/20	17:45	4	1	999	999	110	20	Planned end of DR actions at 17:39. Record is created for the next 15 min interval. Last record.

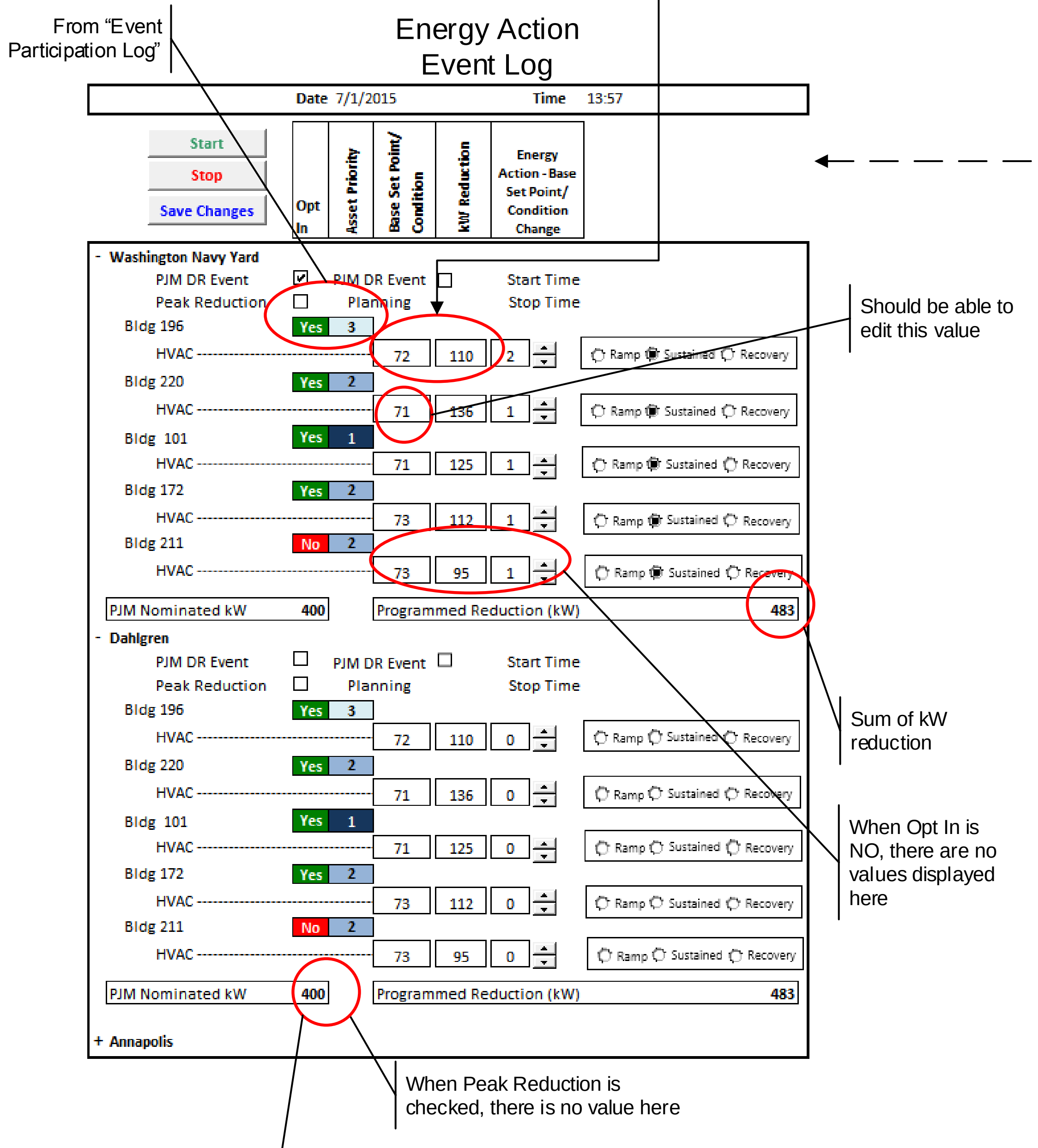
Demand Response Action - Function Details





Building Asset Information Table

Location	Building	Resource Type	Base Set Point/ Condition	kW Reduction
WNY	101	HVAC	72	110
WNY	172	HVAC	72	111
WNY	211	HVAC	72	112
WNY	220	HVAC	71	113



When PJM DR is checked populate with value from this table

Facility Nominated Reductions Table

Location	Nominated kW reduction
WNY	200
ANN	250
DAH	150

Elster Demand Response Log Format (.csv)

Channel Name	Date/Time	GMT offset	Value (EBBBCCCWWW)				Code
Base/Building	Date/Time	Number	Equip - E	Base Set Point - Value (BBB)	Change Condition Value (CCC)	kW Reduction Value (WWW)	Number
WNY/B#/Event_Record ANN/B#/Event_Record DAH/B#/Event_Record		4 (DST) 5 (ST)	1= HVAC 2= Lighting 3=HVAC & Lighting 4=Other	Value	Value Negative Values begin with 9	Value	21= DR Ramp 22= DR Sustained 23= DR Recovery 31= DPR Ramp 32= DPR Sustained 33= DPR Recovery

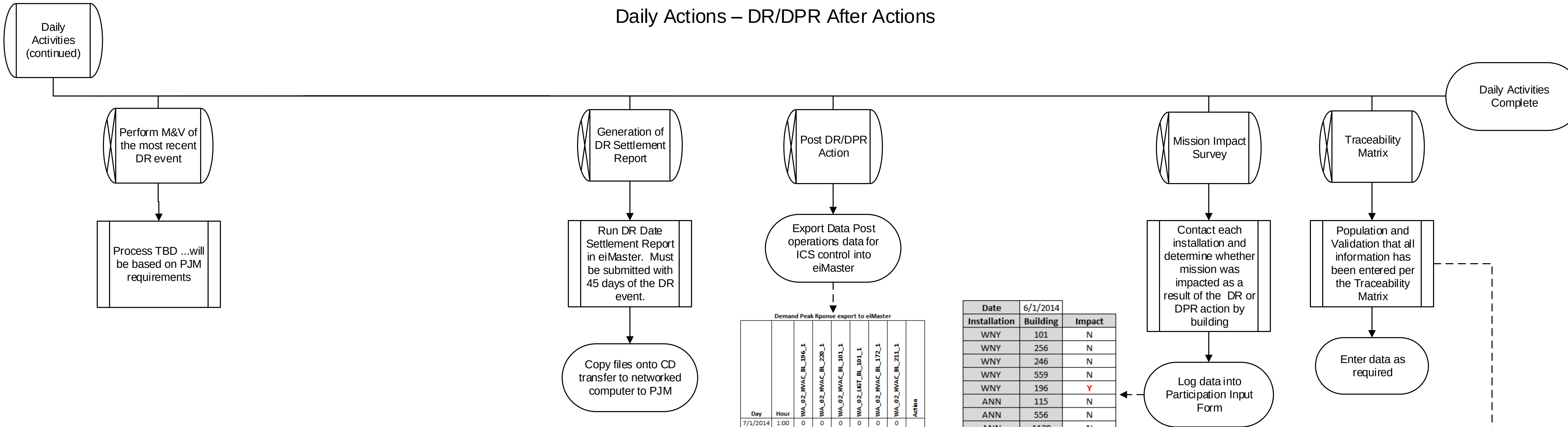
Example	**WNY/B219**	**2015/7/20 21:00**	**4**	**1072001100**	**22**
As CSV	WNY/B219,2015/7/20 21:00,4,1072001100,22				
Description	Washington Navy Yard Building 219 on 20 July 2015 at 21:00 hours with a GMT offset of 5 where HVAC base set point is 72 degrees, temperature increase of 1 degree, 100 kW load reduction in a DR sustained state				

Elster Demand Response Log file example for a single building (.csv)

For Demand Response the Code begins with "2".

Channel Name	Date	Time	GMT offset	Equip - E	Base Set Point - Value (BBB)	Change Condition Value (CCC)	kW Reduction Value (WWW)	Code	Comments
WNY/B196/Event_Record	2015/7/20	11:00	4	1	72	001	110	21	Action started 11:08, temp rasie one degree. Created for the prevous 15 min interval. Frist record.
WNY/B196/Event_Record	2015/7/20	11:15	4	1	72	001	110	21	No Actions are taken, the prevous record is repeated
WNY/B196/Event_Record	2015/7/20	11:30	4	1	72	001	110	22	Status changed to sustained response at 11:20. Record is created for the next 15 min interval
WNY/B[illegible]	2015/7/20	11:45	[illegible]	[illegible]	72	001	110	22	No Actions are taken, the prevous record is repeated
WNY/B[illegible]	[illegible]	[illegible]	4	1	72	001	110	22	No Actions are taken, the prevous record is repeated
WNY/B[illegible]	[illegible]/20	12:15	4	1	72	002	110	22	Action taken to raise temp by another 1 dgree at 12:04. Record is created for the next 15 min interval
WNY/B[illegible]	2015/7/20	12:30	4	1	72	002	110	22	No Actions are taken, the prevous record is repeated
WNY/B196/Event_Record	2015/7/20	12:45	4	1	72	002	110	22	No Actions are taken, the prevous record is repeated
WNY/B196/Event_Record	2015/7/20	13:00	4	1	72	002	110	22	No Actions are taken, the prevous record is repeated
WNY/B196/Event_Record	2015/7/20	13:15	4	1	72	002	110	22	No Actions are taken, the prevous record is repeated
WNY/B196/Event_Record	2015/7/20	13:30	4	1	72	002	110	22	No Actions are taken, the prevous record is repeated
WNY/B196/Event_Record	2015/7/20	13:45	4	1	72	003	110	22	Action taken to raise temp by another 1 dgree at 13:44. Record is created for the next 15 min interval
WNY/B196/Event_Record	2015/7/20	14:00	4	1	72	003	110	22	No Actions are taken, the prevous record is repeated
WNY/B196/Event_Record	2015/7/20	14:15	4	1	72	003	110	22	No Actions are taken, the prevous record is repeated
WNY/B196/Event_Record	2015/7/20	14:30	4	1	72	003	110	22	No Actions are taken, the prevous record is repeated
WNY/B196/Event_Record	2015/7/20	14:45	4	1	72	003	110	22	No Actions are taken, the prevous record is repeated
WNY/B196/Event_Record	2015/7/20	15:00	4	1	72	002	110	22	Action taken to lower temp by 1 dgree at 14:50. Record is created for the next 15 min interval
WNY/B196/Event_Record	2015/7/20	15:15	4	1	72	002	110	22	No Actions are taken, the prevous record is repeated
WNY/B196/Event_Record	2015/7/20	15:30	4	1	72	002	110	22	No Actions are taken, the prevous record is repeated
WNY/B196/Event_Record	2015/7/20	15:45	4	1	72	001	110	22	Action taken to lower temp by 1 dgree at 15:41. Record is created for the next 15 min interval
WNY/B196/Event_Record	2015/7/20	16:00	4	1	72	001	110	22	No Actions are taken, the prevous record is repeated
WNY/B196/Event_Record	2015/7/20	16:15	4	1	72	001	110	23	Status changed to sustained response at 16:09. Record is created for the next 15 min interval
WNY/B196/Event_Record	2015/7/20	16:30	4	1	72	001	110	23	No Actions are taken, the prevous record is repeated
WNY/B196/Event_Record	2015/7/20	16:45	4	1	72	000	110	23	Action taken to lower temp by 1 dgree at 15:50. Record is created for the next 15 min interval
WNY/B196/Event_Record	2015/7/20	17:00	4	1	72	000	110	23	No Actions are taken, the prevous record is repeated
WNY/B196/Event_Record	2015/7/20	17:15	4	1	72	000	110	23	No Actions are taken, the prevous record is repeated
WNY/B196/Event_Record	2015/7/20	17:30	4	1	72	901	110	23	Action taken to lower temp by 1 dgree at 15:50. Record is created for the next 15 min interval
WNY/B196/Event_Record	2015/7/20	17:45	4	1	72	901	110	23	End of all actions for this building 17:39. Record is created for the next 15 min interval. Last record.

Daily Actions – DR/DPR After Actions



Demand Peak Rponse export to eiMaster

Day	Hour	WA_02_HVAC_BL_196_1	WA_02_HVAC_BL_220_1	WA_02_HVAC_BL_101_1	WA_02_LIGT_BL_101_1	WA_02_HVAC_BL_172_1	WA_02_HVAC_BL_211_1	Action
7/1/2014	1:00	0	0	0	0	0	0	
7/1/2014	2:00	0	0	0	0	0	0	
7/1/2014	3:00	0	0	0	0	0	0	
7/1/2014	4:00	0	0	0	0	0	0	
7/1/2014	5:00	0	0	0	0	0	0	
7/1/2014	6:00	0	0	0	0	0	0	
7/1/2014	7:00	0	0	0	0	0	0	
7/1/2014	8:00	0	0	0	0	0	0	
7/1/2014	9:00	0	0	0	0	0	0	
7/1/2014	10:00	0	0	0	0	0	0	
7/1/2014	11:00	80	80	80	42	90	76	DPR
7/1/2014	12:00	80	80	80	42	90	76	DPR
7/1/2014	13:00	80	80	80	42	90	76	DPR
7/1/2014	14:00	80	80	80	42	90	76	DPR
7/1/2014	15:00	80	80	80	42	90	76	DPR
7/1/2014	16:00	80	80	80	42	90	76	DPR
7/1/2014	17:00	0	0	0	0	0	0	
7/1/2014	18:00	0	0	0	0	0	0	
7/1/2014	19:00	0	0	0	0	0	0	
7/1/2014	20:00	0	0	0	0	0	0	
7/1/2014	21:00	0	0	0	0	0	0	
7/1/2014	22:00	0	0	0	0	0	0	
7/1/2014	23:00	0	0	0	0	0	0	
7/1/2014	0:00	0	0	0	0	0	0	

Date	6/1/2014	
Installation	**Building**	**Impact**
WNY	101	N
WNY	256	N
WNY	246	N
WNY	559	N
WNY	196	Y
ANN	115	N
ANN	556	N
ANN	1120	N
ANN	1417	N
ANN	1600	N
DAH	109	N
DAH	136	N
DAH	1123	N
DAH	1194	N
DAH	1332	N

Traceability Matrix

Performance Objective	Metric	Data Requirements	Data Source(s)	Calculation (1)	Success Criteria
Quantitative Performance Objectives					
Building Load Control	Percent reduction from the coincident kW peak (%)	Equipment name plate capacity validated by building metering data	eiMaster	Coincident peak of the "Forecast Demand" peak minus the corresponding recorded "Actual". The calculation will be conducted for each installation.	8-14% of coincident peak load is controllable for aggregate of buildings
Energy Cost Savings	Dollars ($) and energy usage (kWh)	Validated Demand Response participation and Demand Peak Reduction though building metering data	eiMaster, utility billing and PJM payments	Cost saving are the aggregate of the following by each area. 1. *Energy cost reduced though building load control* – kWh based on "Forecast Demand" minus "Actual" kWh during the Demand Peak Reduction (DPR) action multiplied times aggregated $/kWh from both distribution and energy billing. 2. *Cost reduction though the reduction of a installations peak load demand charge* – Based on billing from 2014, a new calculated peak will be determined based on demonstration data to determine and estimated peak. Cost saving will be determined by estimating the 2014 billing adjusted for the new peak. 3. *Energy costs avoided during DR Actions* - Energy cost savings based in kWh avoided resulting from DR actions. Utility rates based on 2014 billing will be used. 4. *PJM payments for DR capacity*- Payments will be calculated at full valve using the PJM schedule. Based on estimates of the future deployment of ICS and the demonstration results of "Controllable Load" and available DR emergency generation capability. Total DR capacity will be calculated by installation. 5. *PJM payments for DR participation*- PJM payments will be based on total DR capacity using 2014 payment schedule and DR events during the 2014 DY Extended Summer program.	4-6% energy cost reduction though DR rebates, 3-5% cost reduction though demand peak reduction and reduced energy usage
Peak Demand Reduction/Maintaince	Buildings demand maximum interval (max kW)	Building metering data	eiMaster	Comparison of the previous 12 months of 15-minute peak demand.	Previous demand interval peak was not exceed, by building
Demand Response Program Participation	Percent participation (%)	Validated DR participation vs. DR events	Event Log and eiMaster	Comparison of available DR events to those that could be fully participated. Valid event participation is defined, by installation, as able to participate to the full extent of the DR action and meeting its load curtailment obligation.	75% participation of available events.
Energy reduction	Energy (kWh)	Event type (DR, DPR and load leveling) and building metering data	eiMaster	Calculations will be conducted using weather normalized data, by monthly comparison between the demonstration period and the corresponding months in 2013.	2-4% Reduction of building energy
Qualitative Performance Objectives					
Cyber secure communications and control between DR system and ICS systems	Ability of timely control for DR actions (time)	Delta from requested action to equipment response	eiMaster, ICS Control Interface and ICS	The calculation will include several elements, DR Event notification time from PJM, notification received by PJM Web interface, Energy Action sent to ICS and action implemented by ICS. All variable will be used to assess successful participation.	Successful participation in DR program.
Mission Impact	Effect to mission	Satisfaction survey	Event Log and building owners	Calculated by installation, number of actions verses any mission impact relating to DR or DRP action. Post event impacts will be assessed as to determine the extent and nature of the impact.	No impact of critical missions or services
Grid operator DR participation requirements	Meetings PJM criteria for participation of various DR program types	PJM requirements vs. Navy's participation when impacted by mission critical events	eiMaster, Event Log and PJM debriefs	Two elements will be used to define this performance objective: The availability of participation as compared to the number of DR events during the demonstration period; and the ability to meet the load curtailment obligations.	DoD can enroll into DR programs beyond "Emergency Generation Capacity DR"

1. Values where applicable, are ratioed based on results from the demonstration to provide a whole installation estimate.

WESTON SOLUTIONS	**Date**: 26 Feb 2014	**Design**: Pete Virag
	Project: NDW ESTCP	

Weston Proprietary Information

Page Intentionally Left Blank

APPENDIX D CURTAILMENT SERVICE PROVIDERS SERVING MARYLAND AND WASHINGTON, D.C. AREA

APPENDIX D CURTAILMENT SERVICE PROVIDERS SERVING MARYLAND AND WASHINGTON, D.C. AREA

CSPs Serving Maryland and Washington, D.C. Area 2019 (DR PJM Capacity Markets Participation)	Contact	Phone
AEP Energy Partners, Inc.	Ritesh Tipnis	(312) 488-5020
Allegheny Power	Gary Musgrave	(724) 838-6367
American PowerNet	David Butsack	(610) 372-8500
Boston Energy Trading and Marketing, LLC	Diane Janicki	(312) 583-6028
Buckeye Energy Brokers, Inc.	Thomas Bellish	(866) 302-2237
Calpine Energy Solutions, LLC	Greg Adams	(732) 596-6420
Chai Energy	Julie Castro	(310) 261-7289
Comperio Energy, LLC dba ClearChoice Energy	Carolyn Pengidore	(412) 833-4113
Conectric Networks, LLC	Phillip Kopp	(858) 240-8880
Constellation Energy Source	Ray Buckingham	(410) 470-2504
CPower Corp.	Dann Price Bruce Campbell	(610) 813-6376 (202) 360-4371
Dayton Power & Light Company (The)	John Hemmert	(937) 331-4172
Direct Energy Business Marketing, LLC.	Raymond Polakowski Marina Hod	(732) 750-6618 (732) 750-6098
Downes Associates, Inc.	George E. Owens	(410) 546-4422
Duquesne Light Company	Kerry E. Bauer	(412) 393-8007
EDF Trading North America, LLC	Chris Armitage	(281) 781-0346
EMC Development Company, Inc.	Tim Seelaus	(410) 531-2480
ENBALA Power Networks Inc.	Andy Gassner	(604) 998-8923
Energy Logic, Inc.	Carolyn Banks	(508) 398-0533
Energy Spectrum Inc.	Carrie Pasch	(718) 677-9077
EnerNOC, Inc.	Michael Desmarais Doug Matheson Steve Doremus	(617) 535-7382 (617) 692-2508 (617) 692-2443
Enerwise Global Technologies, Inc.	Bruce Campbell	(202) 360-4371
ENGIE Resources, LLC	Victor Wulc	(713) 636-1736

CSPs Serving Maryland and Washington, D.C. Area 2019 (DR PJM Capacity Markets Participation)	Contact	Phone
Galt Power	Jedidiah Trott	(267) 238-4790
Genbright, LLC	Jeffrey Ellis	(339) 203-0564
Glacial Energy of New Jersey, Inc.	Michael Giery	(340) 715-7053
Green Light Energy, LLC	Erik Wagner Jack Patrick	(610) 698-7036 (484) 818-1923
Icetec.com, Inc.	Michael Webster	(302) 477-1792
Independent Energy Consultants, Inc.	Mark Burns	(888) 862-6060
Innoventive Power LLC	Craig Gruber	(973) 762-5510
Integrys Energy Services, Inc.	Kirsten Young	(312) 681-1805
IntelliGen Resources LP	John Tate	(214) 727-7200
IPKeys Power Partners, LLC	Robert Nawy	(732) 389-8112
J3 Energy Group	Stephen Russial	(570) 449-3935
KeyTex Energy, LLC	Greg Cammerata	(724) 468-6500 ext. 201
KOREnergy, Ltd.	Robert Korandovich	(614) 496-3507
Kupper Engineering, Inc.	Craig Rosenberger	(215) 884-5970
LVI Power, LLC	Jerome L. Sanders Eliot Powell	(410) 989-1256 (410) 202-0652
Mid Atlantic Power Partners	Mike DeCarlo	(610) 358-3721
Mosaic Power	Greg Vaudreuil	(301) 401-8075
MP2 Energy, LLC	Robert Douglas	(832) 510-1042
Negawatt Business Solutions, Inc.	Michael McCormick	(412) 999-3826
NetPeak Energy Group LLC	Mike Verkuylen	(920) 636-8560
Noble Americas Energy Solutions, LLC	Greg Adams	(732) 596-6420
North America Power Partners, LLC	James Powick Laurie Wiegand-Jackson	(856) 439-0800 (856) 439-0800
NRG Curtailment Solutions, Inc.	James McKenna	(716) 906-5306
NuEnergen, LLC	Hamilton Sandy	(866) 977-0901
OhmConnect, Inc.	Matt Duesterberg	(844) 646-2664

CSPs Serving Maryland and Washington, D.C. Area 2019 (DR PJM Capacity Markets Participation)	Contact	Phone
Orion Asset Management, LLC	Dan Waibel	(920) 482-1918
Penncat Corporation	Michael L. Kane	(610) 272-0505
PEPCO	Steve Sunderhauf	(202) 872-3507
PEPCO Energy Services	Wayne Hudders	(703) 253-1641
Power Generation Services, Inc.	Stephen Knapp	(919) 659-3336
Power Supply Services, LLC	Alex Goodman	(212) 255-8050
PowerSecure, Inc.	Stanley Timblin	(336) 706-9746
Siemens Industry, Inc.	Rita Trevino	(512) 483-1519
Tangent Energy Solutions, Inc.	Brad Swalwell	(610) 444-2800 ext. 212
Tenaska Power Services Co.	Curry Aldridge	(817) 303-1876
THG Energy Solutions, LLC	Cory Kowal	(512) 583-1972
Trane Grid Services LLC	Chad Singer	(502) 214-9333
Verde Energy USA, Inc.	Thomas FitzGerald	(203) 663-5700
Verisae, Inc.	Paul Hepperla	(612) 455-2324
Viridity Energy, Inc.	Allen Freifeld Mike Pavo Craig Young Market Operations	(443) 878-7155 (267) 507-9041 (913) 558-0505 (484) 474-5350
Voltus, Inc.	Dana Guernsey	(718) 344-7655