EXECUTIVE SUMMARY

Demonstrating Enhanced Demand Response Program Participation for Naval District Washington

ESTCP Project EW-201343

JUNE 2019

Distribution Statement A
This document has been cleared for public release

Page Intentionally Left Blank

This report was prepared under contract to the Department of Defense Environmental Security Technology Certification Program (ESTCP). The publication of this report does not indicate endorsement by the Department of Defense, nor should the contents be construed as reflecting the official policy or position of the Department of Defense. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the Department of Defense.

Page Intentionally Left Blank

EXECUTIVE SUMMARY

Project: EW-201343

TABLE OF CONTENTS

Page

1.0 INTRODUCTION 1
2.0 OBJECTIVES 3
3.0 TECHNOLOGY DESCRIPTION 5
3.1 DEMAND RESPONSE PROCESS 5
3.2 NDW DEMAND RESPONSE/PEAK REDUCTION PILOT 5
3.3 DAILY ACTIONS PREPARATORY AND PLANNING FOR POWER REDUCTION EVENT. 7
3.4 DPR EVENT ACTIONS 8
3.5 DEMAND RESPONSE ACTIONS 9
4.0 PERFORMANCE ASSESSMENT 11
4.1 PERFORMANCE OBJECTIVES 11
4.2 OUTCOMES OF ANALYSIS USING AVAILABLE DATA 11
4.3 ESTIMATING DEMAND RESPONSE POTENTIALS 12
4.3.1 Modeling 12
4.3.2 Data Quality 12
5.0 COST ASSESSMENT COST ASSESSMENT 13
5.1 RESULTS 13
6.0 IMPLEMENTATION ISSUES 15

LIST OF FIGURES

Page

Figure 1. Demand Response Process 5
Figure 2. ESTCP Demand Response/Peak Reduction Pilot – NDW 7
Figure 3. Daily Actions Preparatory and Planning for Power Reduction Event 8
Figure 4. Daily Actions – Demand Peak Reduction (DPR) Event Response 9
Figure 5. Daily Actions – Demand Response (DR) Actions 10

ACRONYMS AND ABBREVIATIONS

AMI	Advanced Metering Infrastructure
ATO	Authority to Operate
BMS	Building Management System
COTS	Commercial Off the Shelf
DAH	Naval Support Facility Dahlgren
DDC	Direct Digital Control
DoD	Department of Defense
DPR	Demand Peak Reduction
DR	Demand Response
DRRC	Demand Response Research Center
HVAC	Heating, Ventilation, and Air-Conditioning
ICS	Industrial Control System
JBAB	Joint Base Anacostia-Bolling
kW	Kilowatt
kWh	Kilowatt hour
LBNL	Lawrence Berkeley National Laboratory
Navy	Department of the Navy
NDW	Naval District Washington
NMCI	Navy Marine Corps Internet
NOAA	National Oceanic and Atmospheric Administration
PIT	Platform Information Technology
PJM	Regional Transmission Organization that coordinates the movement of wholesale electricity in all or parts of 13 states and the District of Columbia
PLC	Programmable Logic Controller
PRA	PIT Risk Approval
RMF	Risk Management Framework
SCADA	Supervisory Control and Data Acquisition
SHoC	Shore Operations Center
SSSPN	Shore Sensor System Platform Network
WNY	Washington Navy Yard

Page Intentionally Left Blank

1.0 INTRODUCTION

The project objective was to demonstrate a mechanism that would easily, safely, and effectively allow a Department of Defense (DoD) installation to participate in a Demand Response (DR) program. Demand Response programs have proven very useful in the commercial sector and are part of many energy management programs. Although the electrical utility market has many varied 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. The ability for an installation to participate in DR brings significant economic benefits in terms of energy reduction, economic incentives, and resiliency. In addition, as the largest consumer of electricity on the electrical grid at many locations, DoD's inability to curtail load when requested increases grid fragility, the likelihood of power delivery failures, and potentially jeopardizes an installation's energy security and mission.

At the initiation of this project, the proposed system to be demonstrated was originally granted an Authority to Operate (ATO) by the Department of the Navy (Navy) U.S. Fleet Cyber Command. This Platform Information Technology (PIT) Risk Approval (PRA) for the Advanced Metering Infrastructure (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.

As the project progressed, it had to be halted upon the advent of new government-required cybersecurity processes that made it virtually impossible to collect data needed to meet the study objectives. The Risk Management Framework (RMF) process was first enacted in or about 2017 as a replacement to the original accreditation process. This essentially became an insurmountable hurdle to completing the demonstration.

The final report summarizes the approach and documents the work that was accomplished on the pilot study up to the point where the project was discontinued. It is hoped that the work initially accomplished in the development of this project may be useful at a later date to allow widespread DoD participation in DR programs.

Page Intentionally Left Blank

2.0 OBJECTIVES

The overall objective was to show that through the deliberate control of building energy-consuming assets, a predictable kilowatt (kW) capacity reduction can be achieved to support enrolling DoD installations in DR programs—thus achieving greater capacity. The ancillary benefits of the solution would allow an installation to use the same process to reduce its peak demand load, further offering additional energy reduction and economic benefits, as well as aiding in the stability of the local grid. Increased participation in DR program can not only benefit the installation but the overall economy as well. For example, over time, the Base Residual Auction price for capacity in the PJM grid (PJM is the Regional Transmission Organization that coordinates the movement of wholesale electricity in all or parts of 13 states and the District of Columbia) 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.

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. The project was to demonstrate how to use DR on up to 15 buildings, on three Naval District Washington (NDW) region bases (Washington Navy Yard [WNY], Naval Support Facility Dahlgren [DAH], and Joint Base Anacostia-Bolling [JBAB]). These sites represented for this demonstration the overall mix of DoD building end-use types, which includes office, mixed work use, and dormitories. The project data were to be gathered in the Shore Operations Center (SHoC), located at the 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 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.

By participating in a DR program, it is anticipated that peak saving 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.

Page Intentionally Left Blank

3.0 TECHNOLOGY DESCRIPTION

3.1 DEMAND RESPONSE PROCESS

The illustration in Figure 1 outlines the proposed DR process. Incoming signals from PJM requesting load curtailment direct operators at the 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 (DPR), except that the response action to initiate a response is determined by the predicted forecast load exceeding a predefined load target.

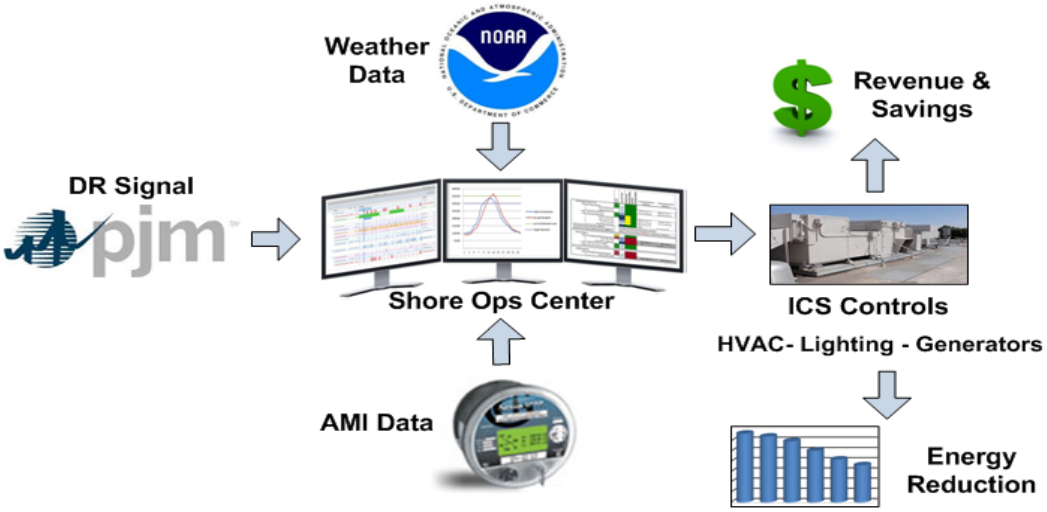

Figure 1. Demand Response Process

3.2 NDW DEMAND RESPONSE/PEAK REDUCTION PILOT

Depicted in Figure 2 is the system overview and connectivity for existing components of the demonstration system. The project required only enabling, configuring, and interconnecting the existing capabilities and functional controls between the systems.

The Navy and other military services have expended significant effort to improve their energy management systems and tools. NDW had invested in both an AMI including metering and metering data systems, and a uniform Industrial Control System (ICS) to monitor and control building systems. The AMI system deployed for NDW was a Commercial Off the Shelf (COTS) solution currently being used commercially for DR and DPR, energy monitoring, analysis, and commissioning applications. These investments provided NDW with an ideal opportunity to demonstrate the value of integrating and using these systems and tools. Ideally, a single solution could be implemented for DR and applied to DPR and other processes to assist in meeting the DoD energy reduction goals.

The integrated NDW energy management systems and tools (EnergyGuard for ICS and EIServer for AMI) were to be used to participate in the DR and DPR programs. Specifically, to improve energy security, load reduction options would be executed and monitored, and energy demand and costs would be identified and quantified.

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 would 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.

Prior to project initiation both the AMI and ICS had been granted a PRA for the operation of an AMI system for all Navy installations (Pre-RMF process). The use of accredited COTS solutions that conform to existing cyber and operational security requirements for both energy and building control solutions would have reduced the level of effort. The challenge remained to implement an acceptable solution for both the facility and building levels that did not compromise the day-to-day mission while achieving significant financial benefits.

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

Where a common ICS exists on a secure network, the ability to deploy a DR/DPR solution would probably be feasible/possible at most DoD locations. The processes developed and the understanding gained in operating a common 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 (Chosen by the Principal Investigator for this demonstration), 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 was to be evaluated.

To fully understand the proposed process, Figure 2 depicts the system overview and connectivity for existing components of the planned demonstration system.

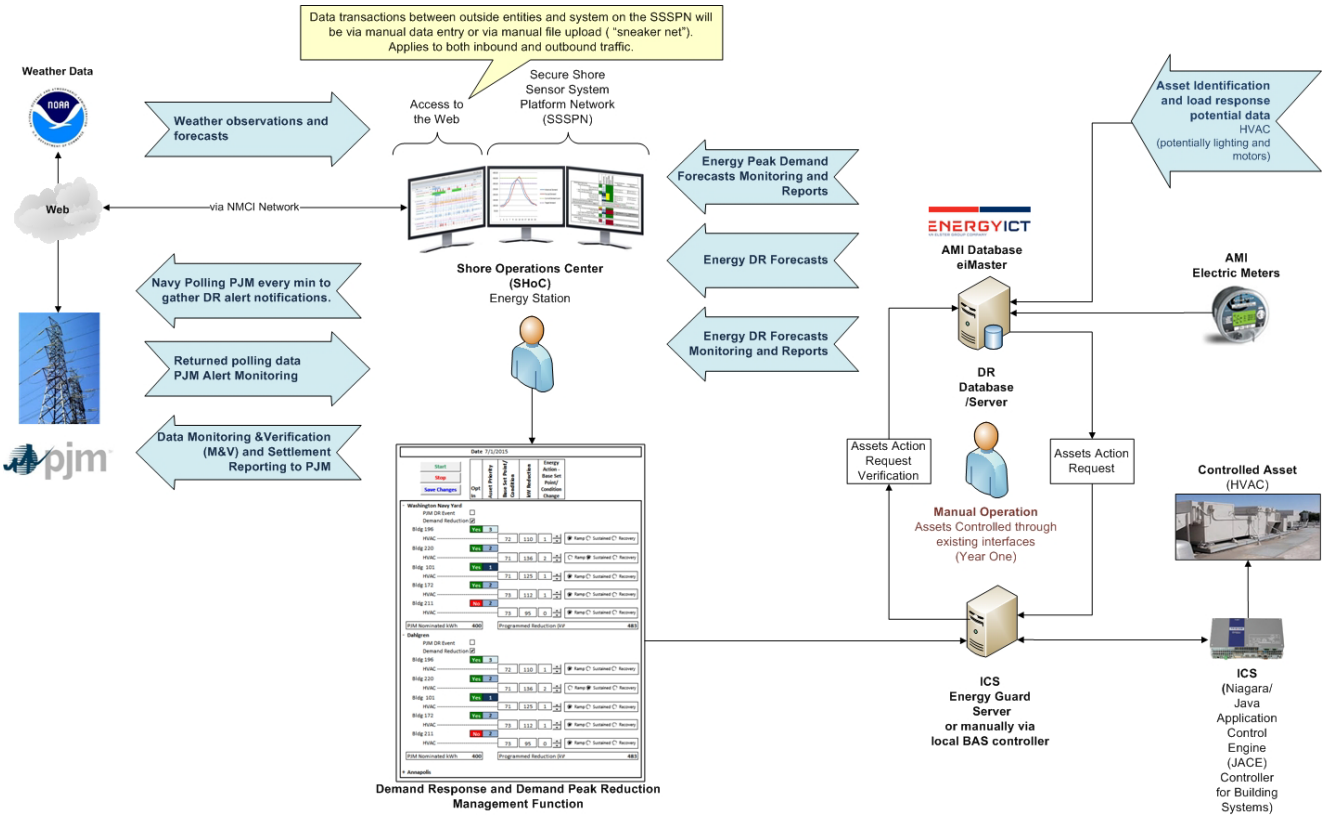

Figure 2. ESTCP Demand Response/Peak Reduction Pilot – NDW

In Figures 3 through 5 the connectivity and proposed operating process depicted in Fig 2 is expanded to show how the project planned to implement the DR/DPR actions for a DR event. That is, how it would be planned for and executed.

3.3 DAILY ACTIONS PREPARATORY AND PLANNING FOR POWER REDUCTION EVENT.

Daily actions are depicted in Figure 3 including the data inputs that would allow monitoring of projections of upcoming events and participation by the demonstration buildings. 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 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.

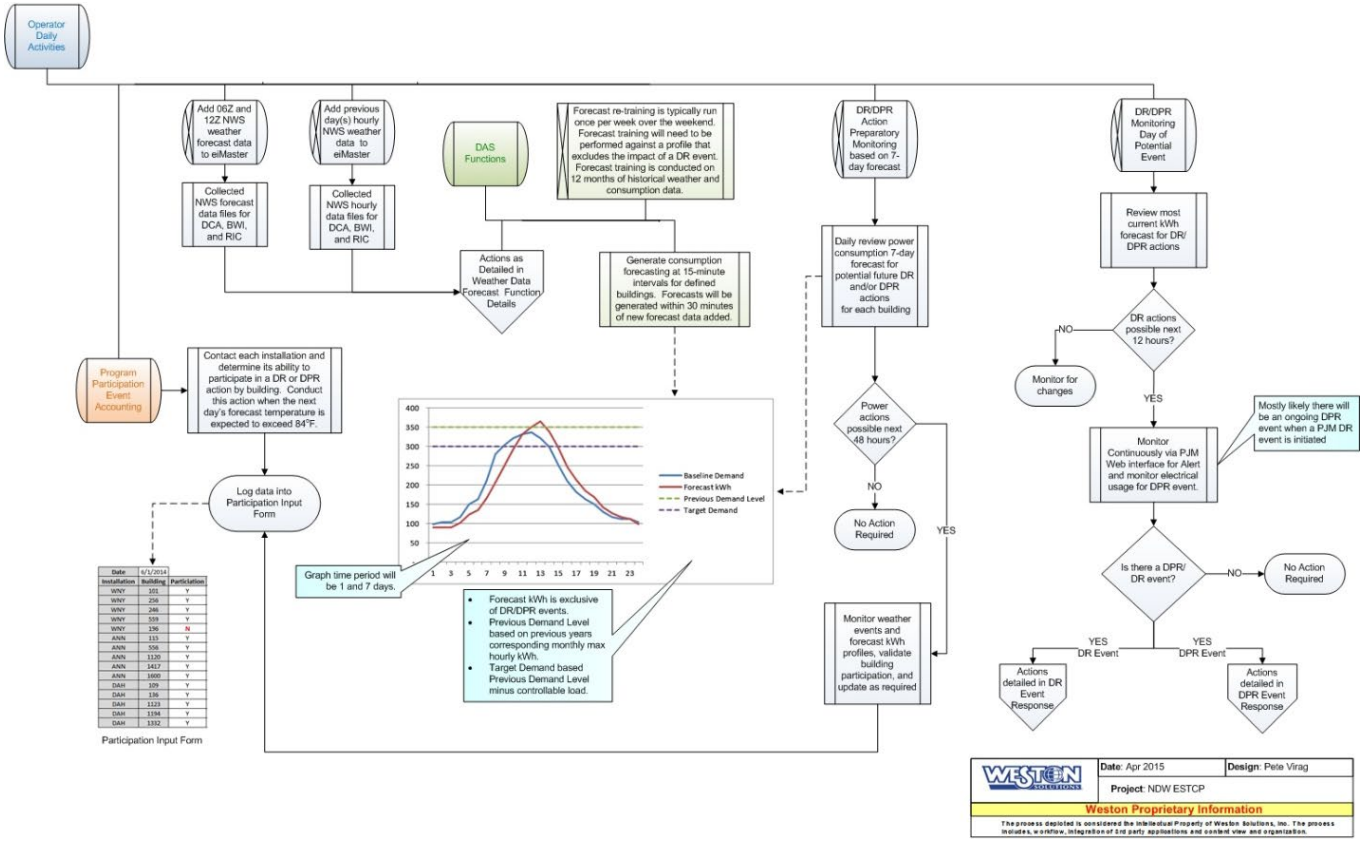

Figure 3. Daily Actions Preparatory and Planning for Power Reduction Event

3.4 DPR EVENT ACTIONS

Figure 4 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 the recovery phase when the Forecast Demand retreats below the Target Demand level. At the end of the event, the log file of event actions will be uploaded to eiMaster.

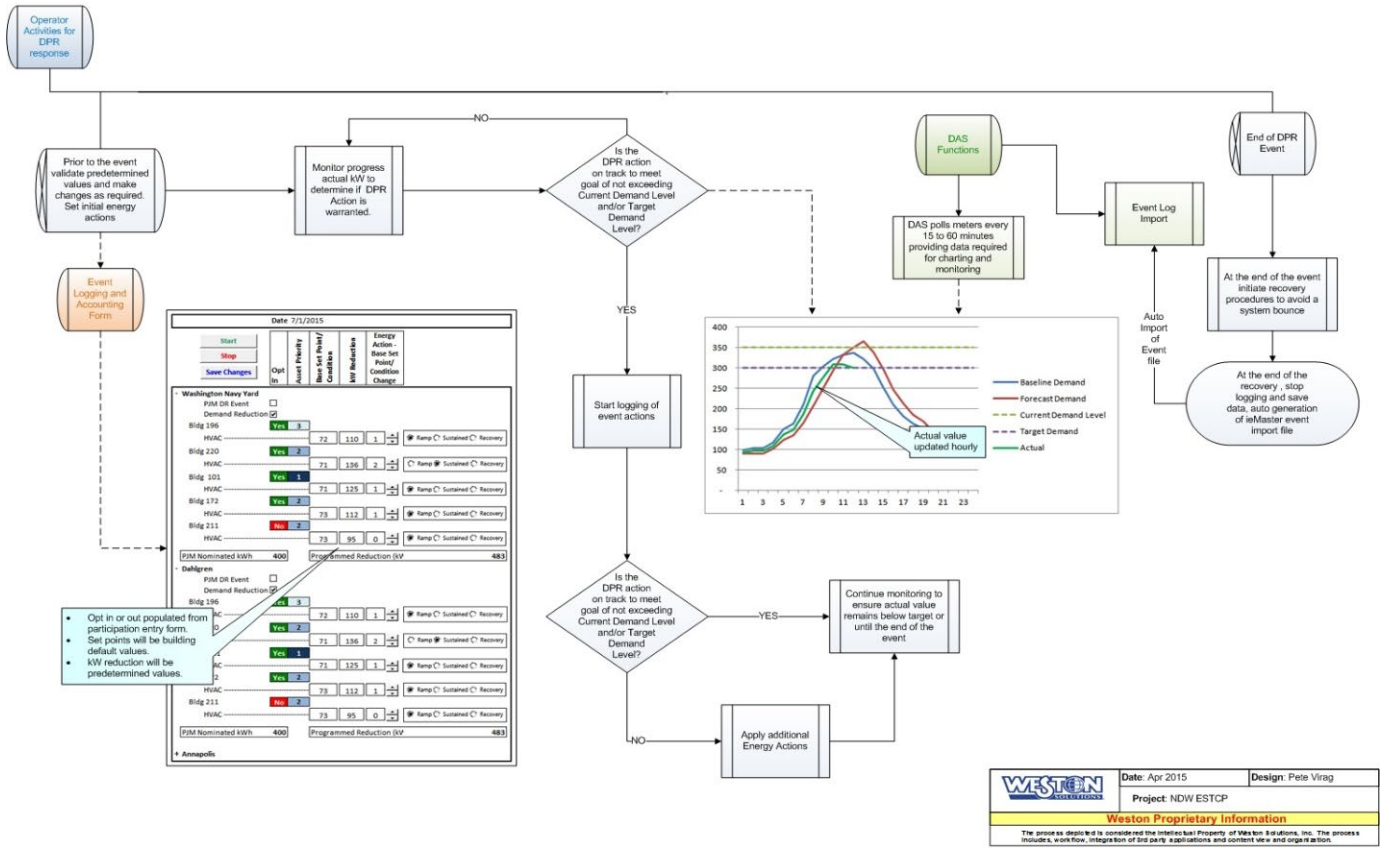

Figure 4. Daily Actions – Demand Peak Reduction (DPR) Event Response

3.5 DEMAND RESPONSE ACTIONS

The monitoring actions shown in Figure 3 are depicted in Figure 5. The DR actions (Figure 5) are the same as DPR actions, except for tracking against the desired 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 the recovery phase. At the end of the event, the log file of event actions will be uploaded to eiMaster.

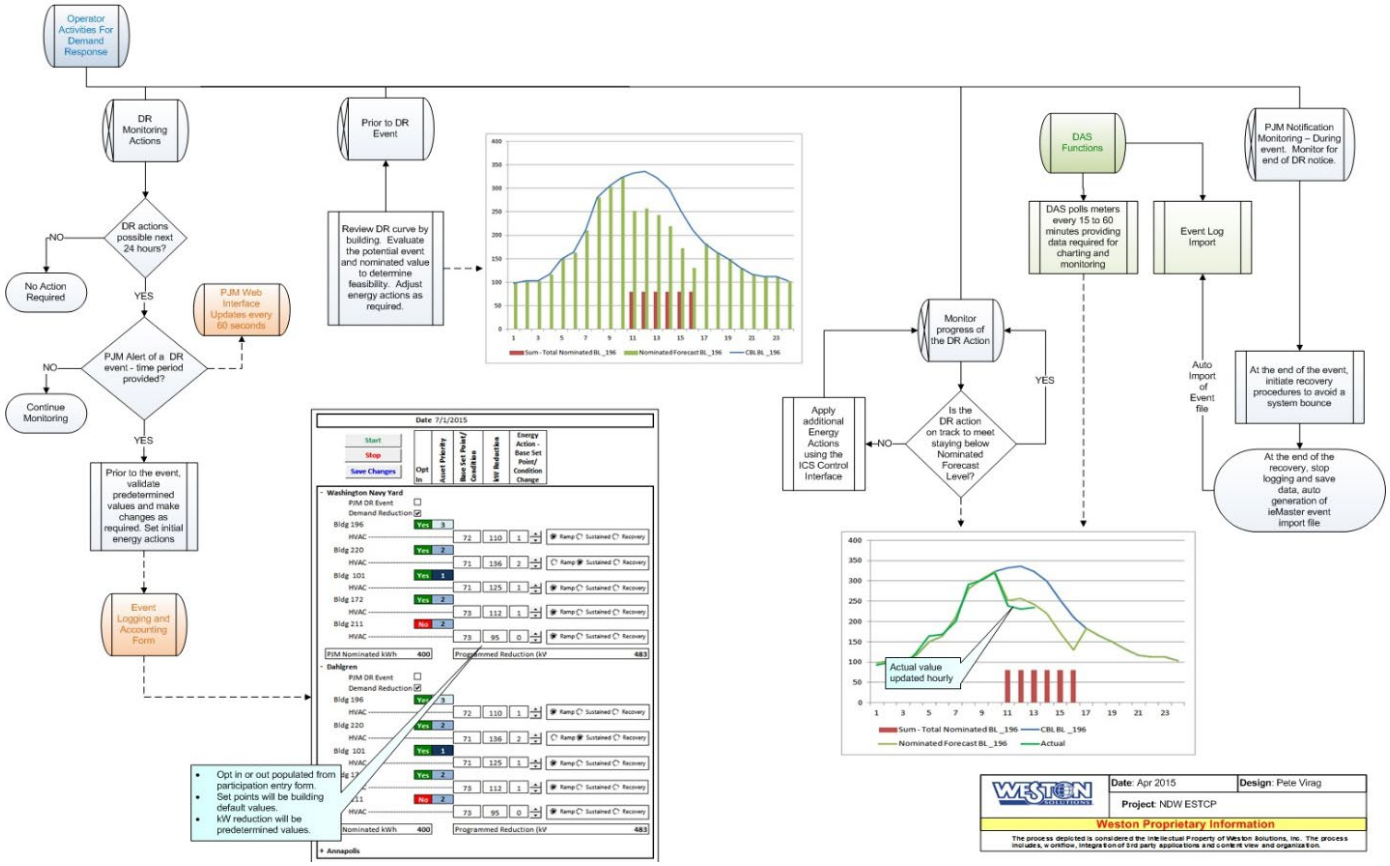

Figure 5. Daily Actions – Demand Response (DR) Actions

4.0 PERFORMANCE ASSESSMENT

4.1 PERFORMANCE OBJECTIVES

Two questions needed 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. Because of the need to discontinue the project the objectives could not be definitively met. However, some useful information was developed from the limited work accomplished and data gathered.

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 were in place at NDW—the electric metering solution, the building control integration solution, and the communications network— were 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 were to address whether employing a broad DR/DPR strategy can produce the expected net savings in energy and cost and the applicability at other locations.

Due to previously discussed circumstances, the project collected only limited data before collection and implementation were discontinued. 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. Numerous combinations of building types and infrastructure configurations contribute to parametric variability.

The 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. Lawrence Berkeley National Laboratory (LBNL) Demand Response Research Center (DRRC) provided methods and tools for the assessment of the data, methods, and results.

4.2 OUTCOMES OF ANALYSIS USING AVAILABLE DATA

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, summarized here, are graphically depicted in the final report (**Figures 6-1** and **6-2)** and showed mixed results. Temperature setpoint data from the building automation system were not available for duration of the event. Results seemed to indicate that during the test setpoint reductions were overridden by building staff. This could explain anomalies observed during initial testing. During the simulated DR event on September 8, 2015, however, a noticeable drop in actual kilowatt hours (kWh) consumption was observed and sustained for several hours with a 3°F increase in the building temperature setpoint.

Additional simulated DR events were planned for Building 182 with large setpoint reductions however for various logistical reasons these could not be carried out before the end of the DR seasons.

4.3 ESTIMATING DEMAND RESPONSE POTENTIALS

4.3.1 Modeling

The demonstration team also used regression modeling of the HVAC system 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. 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. In addition to the building modeling the customer baseline model used by the PJM was applied. The measurement and verification 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).

4.3.2 Data Quality

The assessment of each of the objectives is not a complex solution if limited to the scope of the buildings in the demonstration. In the final report 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. Procedural variability has the greatest potential effect on repeatability. Procedural influences are defined through the qualitative objectives and can affect the quantitative objectives. For the demonstration period, the defined boundaries are known, which will significantly limit procedural variability.

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. LBNL DRRC provided methods and tools for the assessment of the data, methods, and results.

Central to DR/DPR is the ability to reduce electrical demand. LBNL DRRC was to evaluate Weston's electrical demand reduction estimates using its DR assessment models and validate forecast and modeled energy curves produced by the EnergyICT solution.

The early termination of the project precluded robust analysis of DR Potentials on the planned scale originally proposed.

5.0 COST ASSESSMENT COST ASSESSMENT

One of the goals of the DR/DPR pilot was to establish the economic feasibility of entering into various markets. A theoretical economic model was going to be developed during the analysis of the data without the risk of entering into binding contracts with an Independent System Operator (ISO). The data presented in this 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.

5.1 RESULTS

The demonstration effort is centered on the participation (virtual/modeled) during the 2015/2016 and 2016/2017 delivery years of PJM Interconnection (the grid operator) and participation in the PJM June through October 2015 and 2016 Extended Summer DR Program. This demonstration project participation between PJM and the Department of the Navy was to be a pilot program within PJM that would not have actual fiscal results. The outcome would have been 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.

The final report presents a DR estimation framework to predict the load reduction possible (kW capacity) from building HVAC systems. Interestingly, 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.

However, it should be noted, 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.

Page Intentionally Left Blank

6.0 IMPLEMENTATION ISSUES

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 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 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.