LADWP Smart Grid Regional Demonstration Program

Technical Performance Report 1 (Preliminary)

Reporting Period – July 1, 2014 to December 31, 2014

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Contents

1 Change History

1.1 Authors

Author(s)	Organization and Role	Version	Date

1.2. Reviewers / Approvers

Reviewer(s)/Approver(s)	Organization and Role	Version	Date

2 Introduction

The Department of Energy (DoE) awarded the Los Angeles Department of Water and Power (LADWP) funding for a Smart Grid Regional Demonstration Program (SGRDP) in response to DoE Federal Opportunity Announcement DE-FOA-0000036. The LADWP is collaborating with its project partners to carry out this demonstration on the designated areas to include two university campuses – the University of California, Los Angeles (UCLA) and the University of Southern California (USC) – surrounding neighborhoods, City of Los Angeles facilities, and LADWP power system test labs, to:

- Develop and demonstrate innovative SG technologies;
- Identify sociological and behavioral factors essential for SG technology adoption by utility customers;
- Quantify costs and benefits of these technologies.

The last project partner, Jet Propulsion Laboratory (JPL), is responsible for the Cyber Security aspects of the project.

It is hoped that the SGRDP will help open the market for viable, commercially available SG solutions, representing the state of the industry such that similar large-scale SG infrastructure projects can be implemented across the nation.

This Report provides insight into the implementation, operation, and analytical progression of demonstrated technologies. Many of the observations in this Report are preliminary while LADWP continues to refine impact trends and conclusions. Since LADWP undertook numerous smart technologies simultaneously, data and interpretation adjustments are anticipated as the technologies evolve.

2.1 Glossary of Terms

Terms	Meaning

2.2 List of Acronyms

Acronyms	Definition
AAC	Authorization and Access Control
AMI	Advanced Metering Infrastructure
B2G	Building-to-Grid
BAN	Building Area Network
CB	Customer Behavior
CE	Collection Engine
CEI	Commercial Energy Information
CG-NMS	Cisco Grid-Network Management System

CGR	Cisco Connected Grid Router
CIS	Customer Information System
CS	Cyber Security
DDR	Detection, Diagnosis, and Remediation
DE-FOA	Department of Energy-Federal Opportunity Announcement
DMS	Distribution Management System
DoE	Department of Energy
DR	Remand Response
EV	Electric Vehicle
FCR	Fault Containment Region
FIPS	Federal Information Processing Standard
FOA	Federal Opportunity Announcement
G2B	Grid-to-Battery
G2V	Grid-to-Vehicle
GHG	Green House Gas
HAN	Home Area Network
HEI	Home Energy Information
HVAC	Heating Ventilating and Air Conditioning
ICS	
IRP	Integrated Resources Plan
IVR	Interactive Voice Response
JPL	Jet Propulsion Laboratory
LADWP	Los Angeles Department of Water and Power
MDM	Meter Data Management
NIST	National Institute of Standards and Technology
OMS	Outage Management System
OSB	Oracle Service Bus
PNNL	Pacific Northwest National Laboratory
POLA	Port of Los Angeles
PQ	Power Quality
PV	Photovoltaic
RF	Radio Frequency
RPS	Renewable Portfolio Standard
RRE	RF Range Extender
SG	Smart Grid
SGRDP	Smart Grid Regional Demonstration Program
SIEM	System Information and Event Management
SOPO	Statement of Program Objectives
TOU	Time of Use
UCLA	University of California, Los Angeles
USC	University of Southern California
V2G	Vehicle-to-Grid
WAN	Wide Area Network

2.3 References

No.	Documents	Date

2.4 Contacts

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3 LADWP SGRDP

3.1 Background

LADWP is the largest Municipal Utility in the United States. It was established in 1902 to deliver water to the City of Los Angeles. Electric distribution began in 1916. Its service territory covers 465 square miles and serves 3.8 million residents. LADWP employs more than 8,800 workers and has an annual budget of about $4.9 billion.

In 2010, LADWP produced its Power Integrated Resources Plan (IRP). This plan provides a 20-year framework to ensure LADWP will meet the future energy needs of its ratepayers. Through an IRP, utilities forecast the demand for energy and determine how that demand will be met. The 2010 IRP was guided by the following key objectives:

- Maintain a high level of electric service reliability
- Maintain competitive rates
- Exercise environmental stewardship.

For the IRP, LADWP's goal—and primary challenge—is to develop a long-term resource plan that is informative, sensitive to the local and regional economy, and adaptable to changes in state and federal regulations, fuel prices, and advances in power generation technologies. An important component in support of this plan will be leveraging opportunities offered by Smart Grid (SG) technology. Hence, LADWP has a keen interest in leveraging what functions existing SG technology can offer and shaping the next generation of SG technologies.

The SGRDP is comprised of a set of interrelated demonstration projects – Demand Response (DR), Electric Vehicle (EV), Customer Behavior (CB), Cyber Security (CS) and Advanced Metering Infrastructure (AMI).

The key to an effective implementation of the SGRDP is the creation of a secure, scalable, standards-based, and interoperable cyber-physical system architecture; specifically, creating one that allows relevant-time flow of information between customer and institutional facilities at the demonstration sites, LADWP's AMI communications network, and utility grid.

The goal of SGRDP is to demonstrate SG technologies that embody essential and salient characteristics and present a suite of use cases for national implementation and replication. These use cases will collect and provide the optimal amount of information necessary for customers, distributors, and generators to change their behavior in a way that reduces system demands and costs, increases energy efficiency, optimally allocates and matches demand and resources to meet that demand, and increases the reliability of the grid.

3.2 Key Statistics

Workforce	8,800 employees
Area Served	465 square miles
Population Served	Over 3.8 million residents Power Customers: 1.4 million in Los Angeles; 5,000 in the Owens Valley
Power System Fiscal Year 2013-2014 Budget	Total: $3.9 billion $1 billion for operations and maintenance $1.5 billion for capital projects $1.4 billion for fuel and purchased power
Total Megawatts Capacity	Over 7,300 megawatts from a diverse mix of energy resources
All-Time Peak Demand	6,396 megawatts (September 16, 2014) (instantaneous peak)
Power Use for Fiscal Year ending June 2013	
Residential	8.4 million megawatt-hours
Commercial	12.8 million megawatt-hours
Industrial	1.9 million megawatt-hours
Other	0.4 million megawatt-hours
Overhead Transmission Circuits	3,507 miles (spanning five Western states)
Underground Transmission Circuits	124 miles
Overhead Distribution Lines	6,800 miles
Underground Distribution Cables	3,597 miles
Distributing Stations	162
Receiving Stations	21
Substructures	50,636
Distribution Utility Poles	321,516
Pole Mounted Capacity Banks	3,166
Utilitarian Streetlights	29,550
Distribution Transformers	126,000

Table 1: Facts & Figures on LADWP

3.3 System Overview

SGRDP will demonstrate innovations in key areas of SG technologies. It will use the USC and UCLA campuses and surrounding neighborhoods, City facilities, and LADWP labs as testing grounds to prove the technologies and architectures. Figure 1 shows the locations of the testing areas for the Program.

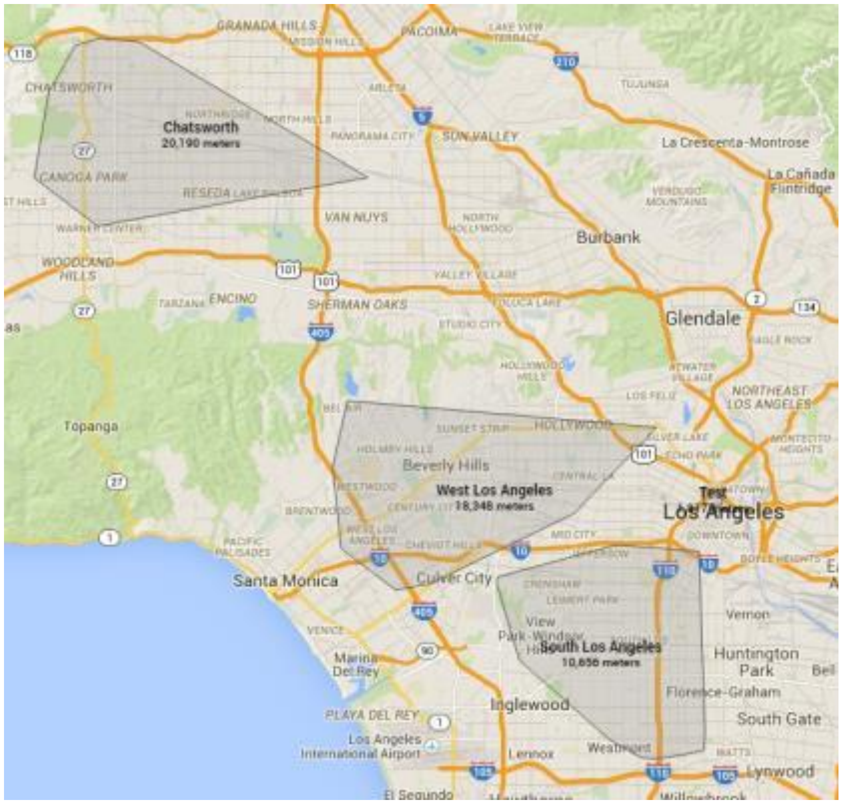


Figure 1: Demonstration Locations

Included will be five interrelated demonstration projects.

DR – An integrated demonstration of SG technology and operations for *DR* (e.g., to manage load in peak demand conditions). DR test bed sites and appropriate tools will be chosen to investigate a full range of user infrastructure environments, including residential, commercial, institutional, medical, retail, and light industrial. Forecasting power consumption of the system based on historical trends and the system's characteristics will be part of the DR's approach to monitor and manage the system's load.

EV – The integration of EVs into the LADWP-managed grid. This will include: smart charging; aggregated battery storage for vehicle fleets as a distributed storage option with a 'garage of the future' demonstration, a fully operational EV micro-grid with communications and grid management system; and EV sharing programs at USC and UCLA, two urban test beds representing different user demographics, driving patterns, and grid specifications for accommodation of EVs. A 'grid impact study' will also be performed in order to analyze the effect of connection of the EV chargers to the grid at different timings.

CB – A portfolio of *customer behavioral* studies to: a) study, monitor, and alter customer energy usage patterns by providing timely water and power usage data; b) yield energy savings from the implementation of approaches for DR, such as through Time of Use (TOU) rates and real-time price signals; and c) encourage customers to participate in the DR event programs and adopt EVs. A comprehensive set of focused surveys and studies of customer behavior will be conducted to assess these impacts and to educate customers regarding the use of messaging services and incentives to reduce energy consumption and peak demand.

CS – Demonstration of next-generation *CS* technologies to show: Grid resilience - how the SG can operate resiliently against physical and cyber attacks; Operational effectiveness - to demonstrate a complete CS testing approach for components and installed systems; and redefinition of the security perimeter – to demonstrate new CS measures that address the expansion of this perimeter by SG technologies to the meter in residential and commercial sites.

AMI – The AMI demonstration provides the *advanced metering infrastructure*, which includes smart metering, communications network, and the back office operations and applications that will enable, support and integrate all aspects of the SGRDP. The data provided by smart meters will be used by various components of the DR, CB, and EV projects. Revenue meters will be installed in a number of Microgrids within the LADWP service area. The location of these Microgrids will be selected to allow a diversity of demographics and environments that reflect almost all other utilities within the nation.

3.4 Project Areas

Demand Response Project

Demonstration	Demonstration Description	Functions To Be Demonstrated	Tangible Deliverable
AMI communications and Smart Meter deployment	While LADWP is already committed to installing AMI communications infrastructure and Smart Meters, the demonstration will test the viability of several Smart Meter technologies to meet customer and LADWP requirements. This will provide cost effective input to choose the best technology in deploying Smart Meters to all LADWP customers.	1. Demonstrate the initiation of a meter the first time it's installed 2. Demo the benefits of potential "automatic demand response" through AMI versus manual demand response 3. Demo how AMI supports customer rates/pricing options 4. Demo how AMI and data integration with LADWP systems facilitates a Distribution Management System (DMS) and Outage Management System (OMS)	1. Periodic reports documenting the results of the demonstration 2. Final specifications and reports 12/2015 3. Modeling and analysis for demand periods: Hourly, daily, seasonal, annual 4. Analysis of: shifting/shedding and grid reliability 5. Integration of customer surveys/market test data to help determine rate options/pricing incentives for full-scale AMI implementation 6. Integration of AMI and AMI meter data with other LADWP systems for DMS and OMS functionality
Demonstrate Demand Response events in LADWP's Smart Grid Demo Lab Control Center	The Control Center demonstration in the SG Demo Lab will provide LADWP with a real time perspective of the impact on the LADWP system when the campus test beds' micro grids respond to an LADWP initiated demand response event.	1. Demonstrate successful two-way communication with smart meters. 2. Demo control over voltage adjustment where it's needed to manage the demand. 3. Demo two way communications with smart appliances. 4. Demo customer interface, including updated DWP website to monitor and control demand. 5. Demo tools for data and power flow to correct the distribution system 6. Demo the impact of distributed generation, storage, and new demand technologies (as they become available) on building, sub-system, and grid level performance. 7. Demonstrate the power quality impacts of building-to-grid load management systems and optimization on "digitally-dependent" customer applications associated with high-performance computing, laboratory, and medical sub-systems.	1. Periodic reports documenting the results of the demonstration 2. Final specifications and reports 12/2015 3. Successful two-way communication with smart meters. 4. Control over voltage adjustment where it's needed to manage the demand. 5. Two way communication with smart appliances. 6. Customer interface to monitor and control their demand. 7. Update DWP website with new capabilities for interface. 8. Develop tools for data and power flow to correct distribution system 9. Test and validate the impact of distributed generation, storage, and new demand technologies (as they become available) on building, sub-system, and grid level performance. 10. Determine the power quality impacts of building-to-grid load management systems and optimization on "digitally-dependent" customer applications associated with high-performance computing, laboratory, and medical sub-systems.

Demand response systems in buildings - Building–to-Grid (B2G) technology integration	While this technology holds immense promise for building managers and utilities alike, much is untested. Connecting Building Automation Systems, and on-site renewables/other generation and storage devices to the grid, LADWP will use this information for grid optimization, market-based pricing, and improvements in efficiency, reliability, and power quality for commercial and industrial customers.	1. Demonstrate successful building-to-grid system integration 2. Demo integrated system optimization scenarios across the diverse building portfolio of the campus test bed including: loading and demand management interactions for building sub-spaces and infrastructure sub-systems (water, heating / cooling, etc.). 3. Demo the impact of measurement density (energy use, temperature, etc.) on system performance and optimization. 4. Demo the power quality impacts of building-to-grid load management systems and optimization on "digitally-dependent" customer applications associated with high-performance computing, laboratory, and medical sub-systems. 5. Demo the impact of distributed generation, storage, and new demand technologies (as they become available) on building, sub-system, and grid level performance.	1. Periodic reports documenting the results of the demonstration 2. Final specifications and reports 12/2015 3. Comprehensive suite of case studies on building-to-grid integration demonstrations including identified processes, barriers, and best practices. Studies will have evaluated the impact of building, infrastructure sub-system, and grid control and optimization technologies across a range of customer use environments (residential, commercial, etc.). 4. Deliver an integrated set of energy measurements including efficiency, power quality, and environmental performance (incorporating the USC GHG emissions management system).
Communications protocol and prototype Home Area Network (HAN) using WINSmartGrid Technology	Home Area Networks (HANs) will connect appliances, on-site renewables, and storage devices in homes to the grid for access to real-time energy usage and pricing information, and providing the ability to react to demand response events from LADWP. An open, standards-based, and flexible architecture for HANs is important to ensure longer life as the technology evolves. This demonstration involves protocols and prototypes for communications, and sense-and-control and	1. Demonstrate capabilities and interoperability of different automation sensing, monitoring and control technologies 2. Demo wired and wireless networking and communication technologies for HAN 3. Demo how the integrated automation network and AMI infrastructure support energy usage models, pricing models and demand-response events and messaging	1. Periodic reports documenting the results of the demonstration 2. Final system specifications and reports - 12/2015 3. Evaluation of technical capabilities and interoperability of different automation sensing, monitoring and control technologies 4. Evaluation of wired and wireless networking and communication technologies for HAN/BAN, NAN and WAN 5. Aggregate technology and system features and capabilities to assist open system development using UCLA-WINSmartGrid technology 6. Integration of automation network with AMI infrastructure, energy usage models, pricing models and demand-response events and messaging to support LADWP's service domain.

	information-based systems for HAN using UCLA WINSmartGrid technology.		
Campus test bed microgrid demonstration: React reliably and precisely to a demand response event from the utility by activating procedures to curtail demand.	The USC/UCLA facilities which include a full range of user infrastructures: Commercial, medical, retail, semi-industrial, and residential will be used for this demonstration. This will provide LADWP with outcomes and performance data for deploying fully-integrated DR Smart Grid operations and technologies for all customer types. The demonstration outcomes and data can then be used by LADWP for full scale deployment; for developing the business case and for selecting the best operational models and technologies.	1. Demonstrate a full campus-wide integrated Smart Grid infrastructure incorporating both existing and new energy and information systems. 2. Demo targeted load curtailment, using different types of load profiles and customer service requirements, different facility configurations, and different network technologies and strategies. 3. Demo demand response events and processes, highlighting seamless operation of services-based architecture, granularity of load control, cyber security controls, and compliance with customer's load profiles and service requirements.	1. Periodic reports documenting the results of the demonstration 2. Final system specifications and reports - 12/2015 3. Development and execution of test plans to demo targeted load curtailment, different types of load profiles and customer service requirements, different facility configurations, and different network technologies and strategies. 4. Design, development, and implementation of an advanced Smart Grid architecture, integrating operations, control, data management systems, and cyber-security. 5. Testing and validation of operational and demand response configurations and scenarios and detailed performance data and analysis to support LADWP full deployment objectives. 6. Integration of Customer Behavior research and demonstration programs, including incorporation of customer information and data access technologies. 7. Establish and manage internal and external community communications processes regarding the demonstration. 8. Establish and manage technology selection & testing programs for Smart Grid technology vendors.

Electric Vehicles Project

Demonstration	Demonstration Description	Functions To Be Demonstrated	Tangible Deliverable
Smart charging using WINSmartGrid for EV and existing charging stations and EV's in and around Los Angeles and the UCLA campus	The demonstration of automated smart charging using wireless communications will take into account cyber security concerns, reliability, and result in outcomes to help determine upgrades required to the LADWP electric distribution system (transformers/wires) with full scale implementation of EVs.	1. Demo monitoring of all Chargers. 2. Demo reading of power consumption for the vehicles. 3. Demo control of the chargers (time/usage). 4. Demo disconnect of the chargers. 5. Demo smart charging through mobile interfaces.	Report on smart charging infrastructure results (Data and Controls). Completed by 12/2015
Battery aggregation and backfill	Determine how to locally aggregate EV batteries to serve as backfill into the LADWP power grid. This provides local grid stability, and by ensuring that sub-sections of the grid maintain an available back-up power supply, can serve as a primary prevention against large-scale outages. Backfilling can also provide an effective means of load leveling power supply for customers in the event of a power outage to reduce LADWP costs and improve customer reliability and satisfaction.	1. Demo use of the batteries into the grid (1 way - charging only). 2. Demo use of the batteries into the grid (2 way - charging and discharge). 3. Demo distribution effects.	Report on integration and aggregation of EV batteries into the power grid Completed by 12/2015

Fully operational microgrid. The scalability of the wireless, sensing, monitoring and control within the WINSmartGrid EV framework will be studied during the research. Scalability will be studied in the context of the UCLA Microgrid.	Other demonstrations that have been performed in the EV Project will be included in this fully integrated demonstration. A key outcome for use by LADWP will be the demonstrated ability of the Microgrid to operate either off-grid or on-grid and the viability of the fully automated wireless sensing, monitoring and control to move between these two states depending on system conditions.	1. Demo inductive charging (remote charge, no wires). 2. Demo various vehicles charging. 3, Demo distribution effects. 4. Demo local grid balancing management.	Report on EV charger integration and the impact on the grid Completed by 12/2015
Renewables and battery integration	Demonstrate the viability of using charged EV batteries as an integrated set of storage devices to use for maintaining grid integrity as LADWP pursues its RPS and related IRP goals	1. Demo use of community storage on EV batteries and external storage. 2. Demo garage of the future. 3. Demo cycling of the batteries. 4. Demo aggregation of the batteries. 5. Demo integrated EV and solar.	Report on the usage of EVs as renewables Completed by 12/2015
Using car sharing programs at USC and UCLA	This provides the opportunity to use two distinct test-beds that include different user demographics, grid specifications, and driving patterns. UCLA and USC are in different areas of Los Angeles that result in different average distances traveled per car trip, a key factor in planning the rate and capacity of charge provided to a fleet of EVs. This	1. Demo monitoring of chargers, power usage, and car usage. 2. Demo distribution effects	Report on EV usage, consumption, and charging Completed by 12/2015

	information can be used by LADWP for full scale Smart Grid implementation planning.		
Grid Impact Stability/Power Study	Demonstrate the impact of EVs on the Electrical Grid	1. Demo generation, transmission, & distribution effects. 2. Demo various loading scenarios.	Report demonstrating the impact of EVs to the grid Completed by 12/2015

Next Generation Cyber Security Project

Demonstration	Demonstration Description	Functions To Be Demonstrated	Tangible Deliverable
Grid resilience against cyber attacks	This is a demonstration of the Grid's active defenses against cyber attacks. It will take into account the accuracy and timeliness of detection and response and the outcome will lay out the pros and cons that accompany the full-scale deployment of such active cyber defense.	1. Demonstrate the capability to detect attacks. 2. Demonstrate the capability to diagnose the provenance of attacks. 3. Demonstrate the capability to remediate or contain the consequences of cyber attacks.	1. Periodic reports documenting the results of the demonstration 2. Final reports – 12/2015
System Integrity	This is a demonstration of the ability of the SmartGrid to detect and recover from compromises of system integrity, including software and firmware modifications (possibly resulting from malware attacks), and the addition of unauthorized physical components to the system.	1. Demonstrate the detection of manual inserted changes to software on all classes of nodes. 2. Demonstrate the reconfiguration and/or recovery to legitimate software configuration on affected components.	1. Periodic reports documenting the results of the demonstration 2. Final reports – 12/2015
Secure Data Management	A demonstration of the ability of the Smart Grid infrastructure to limit the flow of customer, configuration, and audit data according to defined policies and to protect the integrity of the data.	1. Demonstrate the detection of modified billing, configuration and audit data, and behavior of system upon detection. 2. Demonstrate the denial of attempts to access or transmit data where such access or transmission is counter to defined information flow policies.	1. Periodic reports documenting the results of the demonstration 2. Final reports – 12/2015

Testing: Effectiveness	A demonstration, through emulation on the DETER cyber-security test bed, the effectiveness of the security measures within the Smart Grid architecture.	1. Demonstrate the systemic response to various threats such as malware penetration and physical threats that will affect parts of the Smart Grid.	1. The design of the security mechanisms for the Smart Grid demonstration project – this is a prerequisite to the deployed system, and to this demonstration 2. The model/architecture of the cyber-security infrastructure for the Smart Grid. 3. Periodic reports documenting the results of the demonstration 4. Final specifications and reports – 12/2015
Testing: Predictive capability	A demonstration of the effectiveness of the proposed security capabilities when extended to a full-scale implementation of the Grid.	1. Demonstrate the issues (limitations and possibilities) facing a full-scale deployment of the cyber-security approach.	1. The architecture of the cyber security infrastructure for the Smart Grid demonstration project – this is a prerequisite to the deployed system, and to this demonstration 2. The model/architecture of the cyber-security infrastructure for the Smart Grid. 3. Periodic reports documenting the results of the demonstration 4. Final specifications and reports – 12/2015

Customer Behavioral Studies Project

Demonstration	Demonstration Description	Functions To Be Demonstrated	Tangible Deliverable
Customer Behavior Studies using the USC campus test bed	The USC campus test bed will provide to the Demonstration a unique combination of facility types (offices, hospitals, residences, laboratories, and retail), integrated energy services operations, multi-disciplinary research capabilities, and an exceptionally diverse community of faculty, students, and staff. The lessons learned and best practices developed from Customer Behavior studies conducted within the test bed (USC campus and surrounding neighborhoods) will be utilized to support and optimize LADWP's large-scale Smart Grid deployment.	1. Demonstrate the impact of smart grid communication systems and processes on customer usage patterns. 2. Demo effective individual and group participation mechanisms for increasing energy awareness and improving usage patterns. 3. Demo the introduction and trial of new energy-related information and interface technologies to energy use data and information 4. Demo communication and media content on Smart Grid deployment, incorporating changes observed in awareness, attitudes, and energy use behaviors. 5. Demo multi-level educational products targeted to learning about Smart Grid technologies and their implementation. 6. Demo energy savings resulting from the use of smart grid enabled interfaces, pricing options and programs.	1. Identification of the effective individual and group participation mechanisms for increasing energy awareness and improving usage patterns. 2. Identification of the key socio-demographic and community structure variables in the Smart Grid adoption process. 3. Identification of the key decision factors in the adoption of Smart Grid related technologies. 4. Integration of behavioral and social factors into the design and implementation of Smart Grid information architecture, data management, and cyber-security systems. 5. Deliver comprehensive data, analysis, and models relating socio-demographic compositions and customer use types to Smart Grid technology acceptance and use patterns. 6. Develop and test applications for a broad array of customer interfaces to energy information including an understanding of the impacts of emerging social media (such as Face book, Twitter, etc.) 7. Periodic reports documenting the results of the demonstration. 8. Final specifications and reports – 12/2015
Measure and track, against the baseline, attitudes and behaviors relevant to EVs and the potential to buy in the future.	Conduct a survey at the household level for a random set of customers in the LADWP service area concerning what cars they own and what cars they may buy in the future.	1. Demonstrate differences and similarities in attitudes, values, and beliefs (between distinct target audiences) that predict intent to purchase Electric Vehicles, compared to traditionally powered alternatives. 2. Demo effective messaging strategies to educate different/distinct target customer types/groups about factors which predict purchase and usage of Electric Vehicles (instead of traditionally powered vehicles).	1. Enhanced customer communication materials (e.g., newsletter, website) to increase awareness and understanding of increasing availability of electric vehicles 2. Public outreach and educational forums (e.g., energy and behavior conference, EVWorld, SmartGrid News). 3. Trend reports as electric vehicles become more available and widespread, how do drivers (and potential drivers') attitudes, beliefs, and intentions change/adapt/evolve. 4. Periodic reports documenting the results of the demonstration 5. Final specifications and reports – 12/2015

Customer Communications and Education	LADWP will be able to use the outcomes from within the test bed and from surveys developed for the LADWP customer base as input to making changes to the communications and outreach plan for LADWP's 4 million customers, including: Changes to the CIS (Customer Information System), IVR (Interactive Voice Response) system, Web Portal redesign, Bill Redesign and Bill Print upgrade	1. Demonstrate differences and similarities between different target audiences by demographic, psychographic features, as well as by consumer type (e.g., household, commercial, retail). 2. Demo demographic and psychographic factors that predict customers (or end users) affective and behavioral responses to Smart Grid, Smart Meters, and related technologies. 3. Demo effective messaging strategies to educate different/distinct target customer types/groups. 4. Demo features and benefits (of Smart Grid, Smart Meters, and related technologies) that promote/predict increased acceptance and adoption, and those that promote/predict increased customer satisfaction. 5. Demo effective strategies for utilizing the influence of opinion leaders. 6. Demo effective target marketing (of Smart Grid, Smart Meters, and related technologies) to reduce blowback via customer website, newsletter, billing, and other communications. 7. Demo community outreach and education programs.	1. Enhanced customer bill to teach energy literacy and encourage energy efficiency. 2. Enhanced customer website to educate customers about the Smart Grid and energy efficiency. 3. Public outreach and educational forums (e.g., energy and behavior conference, forums, etc). 4. Integration of energy literacy curriculum into existing or new courses. 5. Periodic reports documenting the results of the demonstration. 6. Final specifications and reports – 12/2015

3.5 Impacts and Benefits

The following Table shows each projects' impacts and benefits throughout the duration of the Program.

Benefit Type	Categories	AMI	CB	CS	DR	EV
Energy and Cost Savings	Utility Bill Savings	X			X	X
	Peak Demand Reductions				X	X
	Energy Savings	X			X	X
	Reduced Utility Capital Expenditures	X		X	X	X
	Reduced Utility Maintenance Expenditures	X		X	X	
	Avoided Procurement Costs	X	X	X	X	X
Greater Reliability	Reduced Frequency of Service Interruptions	X			X	X
	Reduced Duration of Service Interruptions	X			X	X
	Improvement in Power Quality				X	X
Addressing Barriers	Grid Integration	X		X	X	X
Information Dissemination	Journal Articles Published	X	X	X	X	X
	Web-based surveys of people viewing materials or participating in program reviews		X			
Adoption of technology, strategy, and research data/results by others	Availability of a new technology for sale in the marketplace	X			X	X
	Customers using outcome		X			
Economic Development	Job Creation	X	X	X	X	X
	Economic Growth	X	X	X	X	X
Environmental Benefits	GHG Emission Reduction				X	X

Table 2: Impacts and Benefits

4 Customer Behavior

The overall goal of the CB Project is to demonstrate the impact of the adoption, use and penetration of Smart Grid and home automation integrated technologies on customer awareness, attitudes, and behaviors related to energy use and energy management. New developments in information technology on the customer and utility sides of the meter, such as AMI (Advanced Metering Infrastructure), Home Energy Management (HEM) systems, and Smart Grid applications offer the potential for the sophisticated integration of demand-side resources into utility operations to support improved grid reliability and cost containment. For this potential to be realized, residential utility customers will need to be better informed, motivated, and be able to manage their energy use and participate in Demand Response (DR).

To keep our residential utility customers better informed and responsible for their power consumption, we had several use demonstrations designed. These demonstrations would allow our customers to be more involved and provide data on what the grid consumption patterns would be like once consumers have more access to control their appliances and monitor their usage.

New developments in information technology on the customer and utility sides of the meter, such as an AMI and HEM systems, and Smart Grid applications offer the potential for the sophisticated integration of demand-side resources into utility operations to support improved grid reliability and cost containment. For this potential to be realized utility customers will need to be better informed, motivated and able to manage their energy use and participate in DR.

The CB demonstrations will seek to prove that targeted messaging and other communication approaches such as web and smart device enabled applications, billing and other multi-media approaches, directed to specific segments of the population at the appropriate time and in the appropriate format, will produce positive customer reaction.

4.1 Summary

Demonstration Areas	Use Cases
Customer Behavior Studies Using USC Campus Test Bed	*Impact of Smart Grid Communication Systems and Processes on Customer Usage Patterns*
	Effective Individual and Group Participation Mechanisms for Increasing Energy Awareness and Improving Usage Patterns
	Introduction and Trial of New Energy-Related Information and Interface Technologies to Energy Use Data and Information
	Communication and Media Content on Smart Grid Deployment
	Multi-Level Educational Products Targeted to Learning About Smart Grid Technologies and their Implementation
	Energy Savings Resulting from the Use of Smart Grid Enabled Interfaces, Pricing Options and Programs
Measuring and Tracking Attitudes and Behaviors Relevant to EVs and the Potential to Buy	*Differences and Similarities in Attitudes, Values, and Beliefs to Predict Intent to Purchase Electric Vehicles*
	Effective Messaging Strategies to Educate Target Customer Types/Groups about Factors which Predict EV Purchase and Usage

Customer Communications and Education	*Differences and Similarities Between Different Target Audiences by Demographic, Psychographic Features, and Consumer Type*
	Demographic and Psychographic Factors that Predict Customers/End Users Affective and Behavioral Responses to Smart Grid, Smart Meters, and Related Technologies
	Effective messaging Strategies to Educate Different/Distinct Target Customer Types/Groups
	Features and Benefits that Promote/Predict Increased Acceptance, Adoption, and Increased Customer Satisfaction
	Effective Strategies for Utilizing the Influence of Opinion Leaders
	Effective Target Marketing to Reduce Blowback Via Customer Website, Newsletter, Billing, and Other Communications
	Community Outreach and Education Programs

Table 2: Customer Behavior Demonstration Areas and Use Cases

4.2 Demonstration Areas

4.2.1 Customer Behavior Studies Using the USC Campus Test Bed

4.2.1.1 Methodology

The USC campus test bed will provide to the demonstration a unique combination of facility types (offices, hospitals, residences, laboratories, and retail), integrated energy services operations, multi-disciplinary research capabilities, and an exceptionally diverse community of faculty, students, and staff. The lessons learned and best practices developed from Customer Behavior studies conducted within the test bed (USC campus and surrounding neighborhoods) will be utilized to support and optimize LADWP's large-scale Smart Grid deployment.

To demonstrate the use case and meet the success criteria for this demonstration, the Customer Behavior team will use this use case which is an extension of Use Case DR-6, to show an integrated Smart Grid infrastructure that can accept DR control signals from LADWP and perform targeted load curtailment across campus, while considering the curtailment potential available in buildings across campus and occupant preferences.

4.2.1.2 Technologies Deployed

Equipment Overview	Total	Installed/ Acquired
Smart Meters on Participating Buildings at USC	41	41
Kiosk displaying Energy Data at USC	1	1

Table 3: Customer Behavior Studies Using the USC Campus Test Bed Equipment List

4.2.1.3 Success Criteria

The success criteria for the Customer Behavior Studies using the USC campus test bed include the successful completion of all use cases. Additionally, the CB Project team will deliver several reports and specifications on the following:

- Identification of effective individual and group participation mechanisms for increasing energy awareness and improving usage patterns
- Identification of key socio-demographic and community structure variables in the Smart Grid adoption process
- Identification of key decision factors in the adoption of Smart Grid related technologies
- Integration of behavioral and social factors into the design and implementation of Smart Grid information architecture, data management, and cyber security systems

Lastly, the team will develop and test applications for a broad array of customer interfaces to energy information and deliver comprehensive data, analysis, and models relating socio-demographic compositions and customer use types to Smart Grid technology acceptance and use patterns.

4.2.1.4 Observations and Results

Across the two DR events, 64-78% of survey respondents indicated that they participated in the DR event. On average, respondents participated in the event for 1-2 hours of the three-hour events. Across the samples, the mean level of participation was mid-range and did not vary significantly by condition, though the trend was in the expected direction, with highest ratings. Participants also reported the likelihood that they would participate in future DR events. Mean ratings were rather high, and varied across groups in the expected direction, though group differences were not statistically significant. When making a dichotomous comparison between both anthropomorphism conditions versus control, differences were marginally significant.

4.2.2 Customer Communications and Education

4.2.2.1 Methodology

LADWP will be able to use the outcomes from within the test bed and from surveys developed for the LADWP customer base as input to making changes to the communications and outreach plan for LADWP's 4 million customers, including: Changes to the Customer Information System (CIS), Interactive Voice Response (IVR) system, Web Portal redesign, Bill Redesign and Bill Print upgrade.

To demonstrate these use cases and meet the success criteria for this demonstration, the Customer Behavior team will provide LADWP customers with online access to a digital platform that will visualize their electricity usage with graphics. Several different tools for various customers such as small commercial customers, large commercial customers, and residential customers will be available through the LADWP web portal to allow customers to monitor and manage their energy consumption. Through their active participation, Customer Behavior will be able to educate consumers on the importance and impact of monitoring their load demand and also will have valuable data collected from how it is impacting our grid. Residential customers will have the Home Energy improvement – Service and Home Energy Management tool. Small commercial customers will have the CEI service and large commercial customers will be able to participate in the Building-to-Grid Technology Integration and DR Program. USC will also be a large commercial test bed since their facilities have similar energy consumptions. Along with these use case studies, the Customer Behavior team will also conduct various surveys including a baseline survey to assess baseline behavior patterns and other such reports.

4.2.2.2 Technologies Deployed

Equipment Overview	Total	Installed/ Acquired
Customer Behavior Web Portal	1	1*

*Web Portal developed, currently awaiting full functionality of MDM before deployment

Table 4: Customer Communications and Education Equipment List

4.2.2.3 Success Criteria

The success criteria for Customer Communications and Education include the successful completion of all use cases. Additionally, the CB Project team will submit reports on the integration of energy literacy curriculum into existing or new courses. The team will also develop an enhanced customer bill to teach energy literacy and encourage energy efficiency, an enhanced customer website to educate customers about the Smart Grid and energy efficiency, and hold educational forums.

4.2.2.4 Observations and Results

Due to configuration issues with the MDM System and delays in installation of Smart Appliances, some parts of the demonstration area cannot collect any data. However, based on the surveys the CB Project team sent out, they observed the following:

- Many SGRDP respondents were not aware they had a smart meter installed at their home: only 27% correctly identified having a meter installed. This suggests that the multiple direct mail materials regarding meter installation were not opened, attended to, or perhaps forgotten about by participants
- The sample also reported low levels of knowledge related to smart meters. Nonetheless, respondents reported neutral to favorable opinions related to smart meters.
- More than two-thirds of respondents were open to participating TOU pricing plans and Save Power Events
- In terms of preferences for monitoring home energy usage, no major differences were observed, but in-home displays were slightly preferred
- Participants tended to overestimate amount of energy they could save if they made an effort (36%). If participants set goals that cannot be achieved, they may become discouraged and stop trying. This finding suggests that energy awareness can be improved so participants are able to set realistic and achievable conservation goals
- Overall, respondents believed that less than half of their neighbors were conserving energy. This suggests an opportunity to convey social norms about the energy conservation efforts of others that can motivate participants to conserve in their own homes
- Based on perceived benefits of smart grid systems, the following benefits should be highlighted in SGRDP program messaging: environmental benefits, ability to control bill, efficiency of grid system

4.2.3 Measuring and Tracking Attitudes and Behaviors Relevant to EVs and the Potential to Buy in the Future

4.2.3.1 Methodology

This demonstration area will be responsible for researching the differences and similarities in attitudes, values, and beliefs between distinct target audiences that predict intent to purchase Electric Vehicles and to demonstrate effective messaging strategies to educate different and/or distinct target customer types or groups about factors which will predict purchase and usage of Electric Vehicles.

To demonstrate the use cases and meet the success criteria for this demonstration area, the CB Project team will conduct a survey at the household level for a random set of customers in the LADWP service area concerning what cars they own and what cars they may buy in the future.

4.2.3.2 Technologies Deployed

None acquired/installed.

4.2.3.3 Success Criteria

The success criteria for this demonstration area include the successful completion of all use cases. Additionally, the CB Project team will develop enhanced customer communication materials to increase awareness and understanding of increasing availability of Electric Vehicles, perform public outreach and hold educational forums, and submit a report on the change/adaptation/evolution of Electric Vehicle driver attitudes, beliefs, and intentions.

4.2.3.4 Observations and Results

The CB Project team acquired and entered the data collected from the surveys in December 2014. Analysis of the data will begin early 2015.

5 Demand Response

New developments in technology on the customer and utility sides of the meter offers the potential for the sophisticated integration of demand-side resources into utility operations to support improved grid reliability, cost containment, reduction of Green House Gas (GHG) emissions, and integration of renewable energy resources. These DR technologies are by definition smart grid (SG) technologies, purposed for active monitoring and dynamic control of electricity usage.

Analytics based on real-time and historic power system data provide utility control center operators with forecasting and visualization tools to increase the accuracy and reliability of load management decisions. Smart meters and advanced building and home automation systems provide customers with unprecedented levels of convenience and control to manage how and when energy is used.

Building and home automation, smart charging and discharging of electric vehicles, distributed generation, and Micro-grids all create new opportunities and new challenges for grid operations and optimization.

Using facilities at Los Angeles Department of Water and Power (LADWP) and our partners' campuses, project test beds, and customer premises, the DR Project will demonstrate how some of the most promising new and emerging DR technologies can be applied to best address these opportunities and challenges. Demonstrations will include:

- The use of integrated historical and real-time Advanced Metering Infrastructure (AMI) and system data with geospatial analytics software to provide power system control operators with real-time information and visualization tools for making outage and load management decisions, including initiating DR events, and analyzing the response to these events.
- A LADWP Web Portal powered by smart meter data, interactive energy use feedback tools, and customized messaging provides services for customers to become actively involved in changing and improving their energy use habits
- A program tested with residential customers who are interested in participating in Home Area Network (HAN) demonstrations that will help to define future state offerings for Home Energy Management (HEM) and automated DR.
- Building-to-Grid (B2G) energy management describes the interactions of the SG with commercial buildings. DR testing will be conducted to optimize load reduction and minimize building occupant negative impacts.
- A campus testbed Micro-grid demonstration will confirm an integrated SG infrastructure can accept DR control signals from LADWP and perform targeted load curtailment across campus, while considering the curtailment potential available in buildings and the preferences of the facility users.

During the course of the Smart Grid Regional Demonstration Project (SGRDP) Project, 52,000 smart meters and related AMI network technology will be deployed to customers in three geographic areas served by selected LADWP distribution substations. Customers receiving these meters will be offered certain services and programs that are enabled by smart meter technology. However, we will also offer new services, such as Web Portal energy information services, to the entire LADWP customer base.

The SGRDP includes a Customer Behavior (CB) Project that has several interdependencies with the DR Project. The SGRDP-CB will demonstrate the impact of the adoption, use and penetration of SG and home automation integrated technologies on customer awareness, attitudes, and behaviors related to energy use and energy management.

5.1 Summary

Demonstration Areas	**Use Cases**
AMI Communications and Smart Meter Deployment	*Initiation of a Meter at Initial Installation*
	Benefits of Potential "Automatic Demand Response" Through AMI Versus Manual Demand Response
	AMI Support of Customer Rates and/or Pricing Options
	Developing a Distribution Management System and Outage Management System in the LADWP system for AMI and data integration
Demonstration of Demand Response Events in LADWP's Smart Grid Demo Lab Control Center	*Successful Two-Way Communication with Smart Meters*
	Control Over Voltage Adjustments where Needed to Manage Demand
	Two –Way Communication with Smart Appliances
	Customer Interface with Updated LADWP Website to Monitor and Control Demand
	Data and Power Flow Tools to Correct Distribution System
	Impacts of Distributed Generation, Storage, and New Demand Response Technologies on Building, Sub-System, and Grid Level Performance
	Power Quality Impacts of Building-to-Grid Load Management Systems and Optimization of "Digitally-Dependent" Customer Applications
Demand Response Systems in Buildings – Building-to-Grid Technology Integration	*Successful Building-to-Grid System Integration*
	Integrated System Optimization Across Diverse Building Portfolio of Campus Test Bed
	Impacts of Measurement Density on System Performance and Optimization
	Power Quality Impacts of Building-to-Grid Load Management Systems and Optimization of "Digitally-Dependent" Customer Applications
	Impacts of Distributed Generation, Storage, and New Demand Response Technologies on Building, Sub-System, and Grid Level Performance
Communications Protocol and Prototype Home Area Network (HAN) using WINSmartGrid Technology	*Capabilities and Interoperability of Different Automation Sensing, Monitoring and Control Technologies*
	Wired and Wireless Networking and Communication Technologies for HAN
	Support of Energy Usage Models, Pricing Models, and Demand Response Events and Messaging using Integrated Automation Network and AMI Infrastructure
Campus Test Bed Microgrid Demonstration	*Full Campus-Wide Integrated Smart Grid Infrastructure Incorporating Both Existing and New Energy and Information Systems*
	Demonstration of Targeted Load Curtailment
	Demonstration of Demand Response Events and Processes

Table 5: Demand Response Demonstration Areas and Use Cases

5.2 Demonstration Areas

5.2.1 AMI Communications and Smart Meter Deployment

See Section 6 for all AMI and Smart Meter demonstrations.

5.2.2 Demonstration of Demand Response Events in LADWP's Smart Grid Demo Lab Control Center

5.2.2.1 Methodology

The Control Center demonstration in the SG Demo Lab will provide LADWP with a real time perspective of the impact on the LADWP system when the campus test beds' micro grids respond to an LADWP initiated demand response event.

To demonstrate these use cases and meet the success criteria for this demonstration, the Demand Response team will integrate historical and Real-time AMI and System Data for making outage and demand-side load management decisions. This demo will have ECC operators demonstrating control of voltage adjustments to manage load demand and integrate AMI data to verify energy savings and also have data integration, load forecast, and demand response optimization for demand-side load management. Additionally, it will also integrate AMI data for the purpose of coordinating voltage and reactive power optimization and control in improving distribution system performance.

5.2.2.2 Technologies Deployed

Equipment Overview	Total	Installed/ Acquired
MDM DEV 02	1	1
MDM INT 02	1	0
MDM Production	1	0

Table 6: Demonstration of Demand Response Events in LADWP's Smart Grid Demo Lab Control Center Equipment List

5.2.2.3 Success Criteria

The success criteria for the Demand Response team will include the successful completion of all use cases. The Demand Response team will be responsible in being able to demonstrate: successful two-way communication with smart meters; control over voltage adjustments where it's needed to manage the demand; two way communications with smart appliances; customer interface, including updated DWP website to monitor and control demand; the impact of distributed generation. Storage, and new demand technologies (as they become available) on building, sub-system, and grid level performance; the power quality impacts of building-to-grid load management systems and optimization on "digitally-dependent" customer applications associated with high-performance computing, laboratory, and medical sub-systems.

5.2.2.4 Observations and Results

Due to configuration issues with the MDMS, this demonstration area is not collecting data.

5.2.3 Demand Response systems in buildings – Building-to-Grid (B2G) technology integration

5.2.3.1 Methodology

While this technology holds immense promise for building managers and utilities alike, much is untested. Connecting Building Automation Systems, and on-site renewables/other generation and storage devices to the grid, LADWP will use this information for grid optimization, market-based pricing, and improvements in efficiency, reliability, and power quality for commercial and industrial customers.

To demonstrate these use cases and meet the success criteria for this demonstration, the LADWP Demand Response team will offer a DR program to selected large customers who have indicated an ability and willingness to provide load curtailment during a DR request. This is a volunteer group which will be used to test the initial program design prior to rollout to a larger subset of customers. In order to participate in the LADWP DR program to be offered during the demonstration, large commercial customers will implement at least some of the steps described in the B2G scenario, depending on applicable energy end-uses and technologies in their buildings. It's important to note that the campus testbed buildings are managed by an integrated facilities management system; this may not be the case for large commercial customers participating in the DR program scenario.

5.2.3.2 Technologies Deployed

None Installed/Acquired

5.2.3.3 Success Criteria

The success criteria for the Demand Response team will include the successful completion of all use cases. Additionally, installation of sub-metering in various buildings on USC campus to demonstrate the end-use load profiles for HVAC fans, HVAC cooling systems, lighting, emergency power and receptacle loading and also conduct a range of DR strategies to provide the greatest sustainable load curtailment with less than 15% of occupant complaints over a 2 year time period.

5.2.3.4 Observations and Results

Building to Grid (B2G) integration is used to identify the energy use of building functions (heating, cooling, lighting etc.), within a building and to identify the greatest opportunities for demand response and/or energy efficiency. To accomplish this, end-use metering was installed in 5 buildings as identified below:

Building	Building Code	Chilled Water System	HVAC Fans	Lighting	Receptable	Total
Leavy Library	LVL	X	X	X	(1)	X
Ralph and Goldy Lewis Building	RGL	(4)	X	X	X	X
Tutor Campus Center	TCC	X	X	(1)	(1)	X
Cinema Building B	SCB	(4)	X	X	X	X
Fluor Tower	FLT	(3)	(3)	X	(2)	X
(1)	Indirectly measured, used total less other end use loads					
(2)	Individual kitchen and space loads are measured					
(3)	Combined cooling and HVAC fans since packaged units					
(4)	Building is on campus wide chilled water loop					

Table 8: USC Buildings used for Building to Grid Operation

The end-use metered data was brought into the Energy Control Center front end to provide real time monitoring and display of the information. The amount of energy used by each building system varies over time based on the needs of the building. Presented below is a screen capture of the electrical data for one of the buildings on the UPC campus.

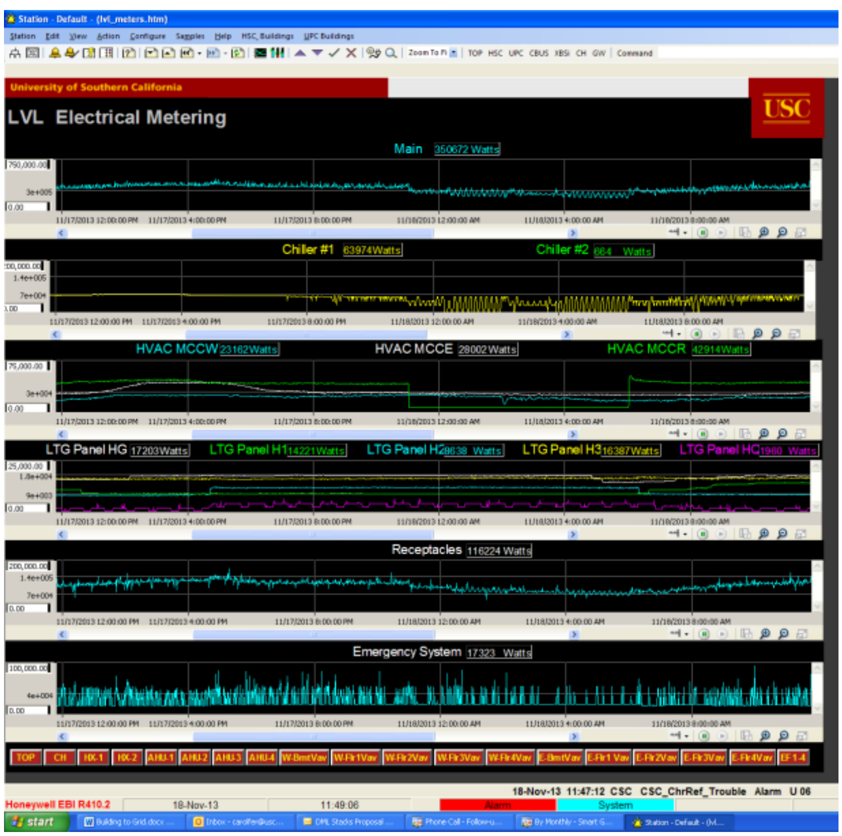


Figure 2: Screen Capture of Energy End Use for the Specific Buildings

Each function within a building has operating characteristics, which impact the energy usage of that building system. An example is lighting, which, in its simplest form is either on or off at a specific load (Watt). The operating characteristics of the building functions become much more complex when addressing heating and cooling systems and more elaborate lighting systems.

To demonstrate that the grid electrical usage data aligns with building functions, tests of operation were performed as well as graphic display pages which show the operating characteristics of the systems and the resulting end-use metering. For example, an air conditioning system includes a fan which blows hot or cold throughout the building. Most medium to large commercial buildings have a variable air volume system, which varies the amount of air into the building based on the load. The greater the need for cooling or heating the more air that is circulated in the building to keep the space cooled or heated. A signal is sent to the fan to speed up or slow down based on the load, and varies constantly throughout the day. So, by changing the fan speed, we change the power draw of the motor and hence energy use for this building function. The following screen capture illustrates fan speed, fan motor amps and the resulting end use metering for HVAC.

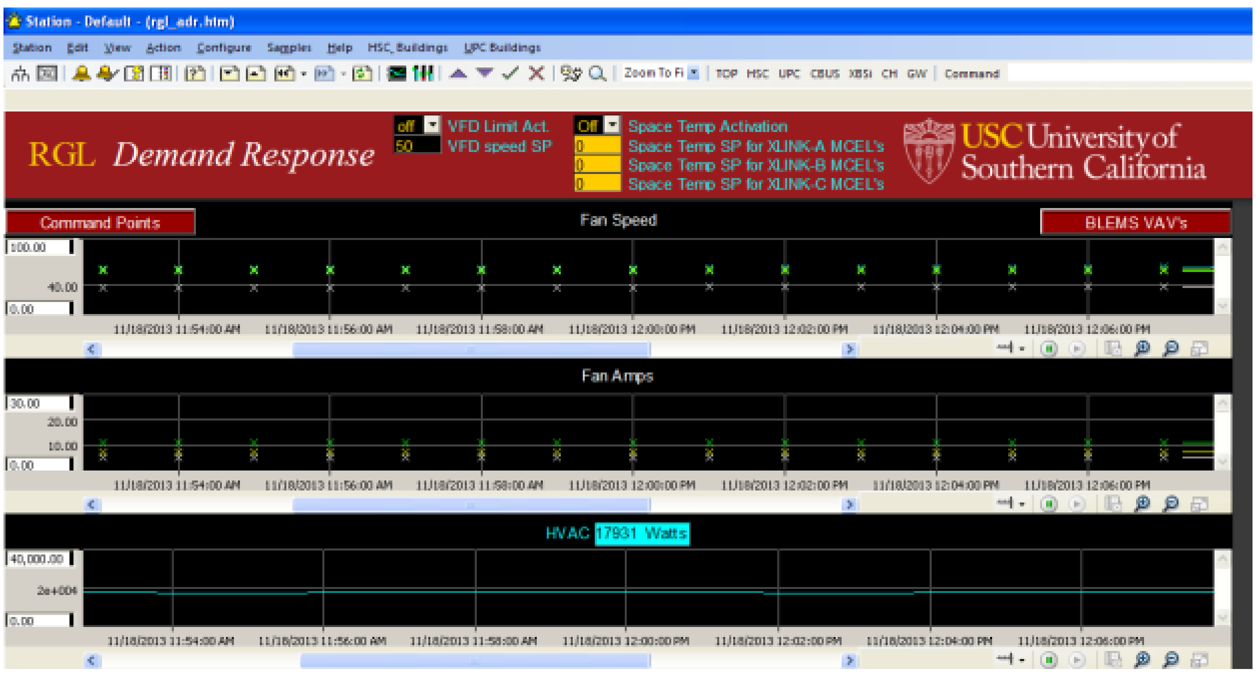


Figure 3: Screen Capture of Operating Characteristics and Energy End Use for the Building Systems

Additionally, in the month of July 2014, the DR Project team ran several DR events during this time for a number of buildings. For the Ralph and Goldy Lewis Building, the load curtailment graph and table were the following:

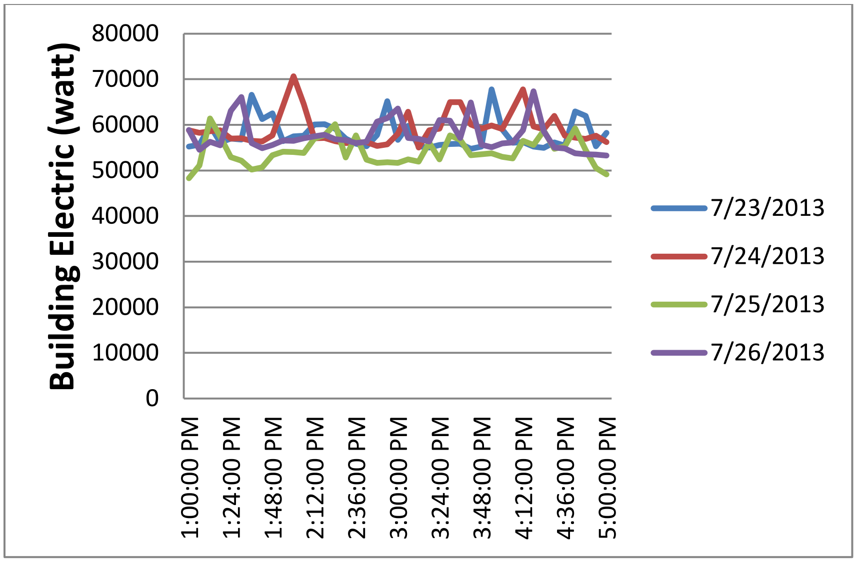


Figure 4: Load Curtailment Graph for DR Event on Ralph and Goldy Lewis Hall

DR Test			15:00-17:00	
Date	7/23/2013	7/24/2013	7/25/2013	7/26/2013
kw on DR	57.3	60.0	54.3	57.6
Load Curtailment			4.0	

Table 9: Load Curtailment for DR Event on Ralph and Goldy Lewis Hall

For Leavy Library, the load curtailment graph and table were the following:

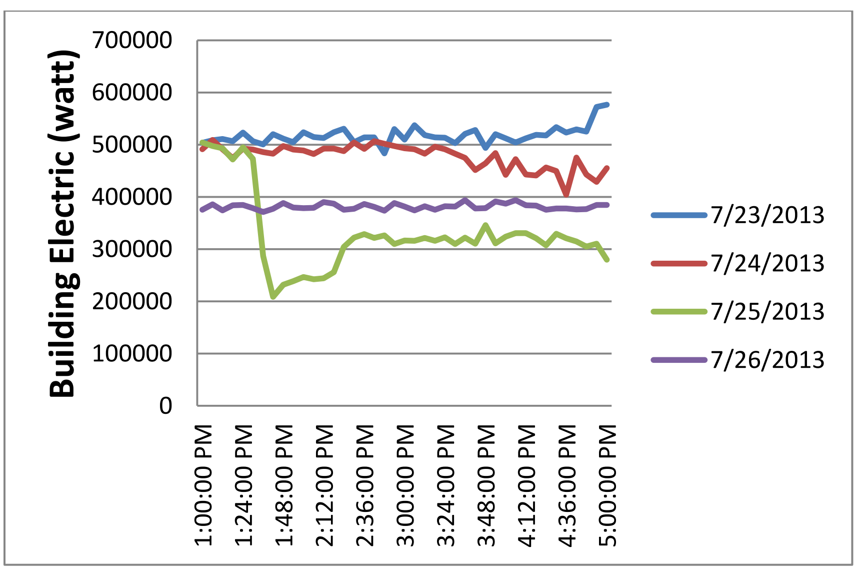


Figure 5: Load Curtailment Graph for DR Event on Leavy Library

DR Test			15:00-17:00	
Date	7/23/2013	7/24/2013	7/25/2013	7/26/2013
kw on DR	522.9	462.9	317.3	381.8
Load Curtailment			138.5	

Table 10: Load Curtailment for DR Event on Leavy Library

For the School of Cinematic Arts – Building B, the results were the following:

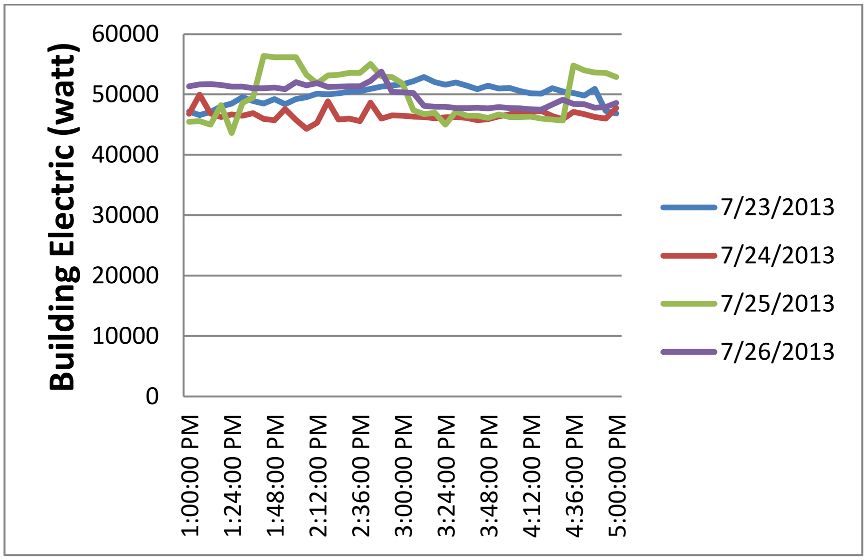


Figure 6: Load Curtailment Graph for DR Event on School of Cinematic Arts – Building B

DR Test			15:00-17:00	
Date	7/23/2013	7/24/2013	7/25/2013	7/26/2013
kw on DR	50.7	46.5	48.4	48.2
Load Curtailment			0.1	

Table 11: Load Curtailment for DR Event on School of Cinematic Arts – Building B

For the Ronald Tutor Campus Center, the results were the following:

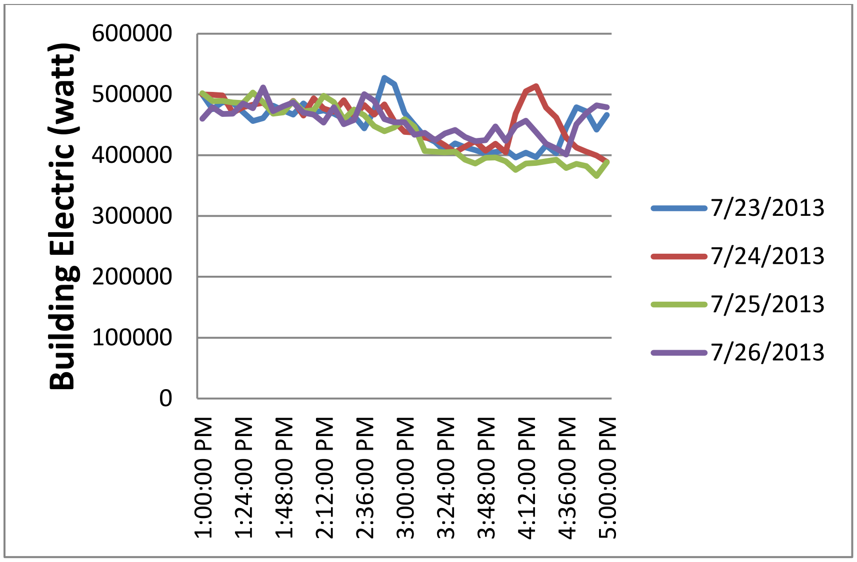


Figure 7: Load Curtailment Graph for DR Event on Ronald Tutor Campus Center

DR Test			15:00-17:00	
Date	7/23/2013	7/24/2013	7/25/2013	7/26/2013
kw on DR	426.5	432.6	396.4	439.5
Load Curtailment			36.5	

Table 12: Load Curtailment for DR Event on Ronald Tutor Campus Center

5.2.4 Communications protocol and prototype Home Area Network (HAN) using WINSmartGrid Technology

5.2.4.1 Methodology

Home Area Networks (HANs) will connect appliances, on-site renewables, and storage devices in homes to the grid for access to real-time energy usage and pricing information, and providing the ability to react to demand response events from LADWP. An open, standards-based, and flexible architecture for HANs is important to ensure longer life as the technology evolves. This demonstration involves protocols and prototypes for communications, and sense-and-control and information-based systems for HAN using UCLA WINSmartGrid technology.

To demonstrate these use cases and meet the success criteria for this demonstration, the Demand Response team will integrate the historical and real-time Ami and System data for making outage and demand-side load management decisions. Additionally, the LADWP Demand Response team will provide HAN and HEM services to customers to better educate customers about how interactive energy management applications work and will also be a means of providing customers with the ability to set preferences to control how and when their appliances and other equipment use energy. Also, a Home Energy Management program will be available to those interested in a HAN demonstration. This will be a source of data and implementing it for load forecasting and load curtailment.

5.2.4.2 Technologies Deployed

Equipment Overview	Total	Installed/ Acquired
Refrigerator	26	18
Direct Load Control Device	90	12
Lighting System	13	7
Smart Gateway	26	18
Smart Thermostat	1100	730

Table 13: Communication Protocol and Prototype Home Area Network using WINSmartGrid Technology Equipment List

5.2.4.3 Success Criteria

The success criteria for the Demand Response team will include the successful completion of all use cases. The demand response team will achieve demand-side load management by integrating data and implementing load forecasting and DR optimization. Small commercial customers with building control systems will participate in DR demonstrations and convince customers into opting in to DR programs and customer automated systems are able to communication with utility systems using automated DR.

5.2.4.4 Observations and Results

At the time of this report, the DR Project team collected the thermostat data only. However, UCLA is installing smart appliances at their dormitories and the DR team is collecting smart appliances data.

For the thermostat data, the following figures is a sample of five different thermostats undergoing twenty-four DR events on August 30, 2014:

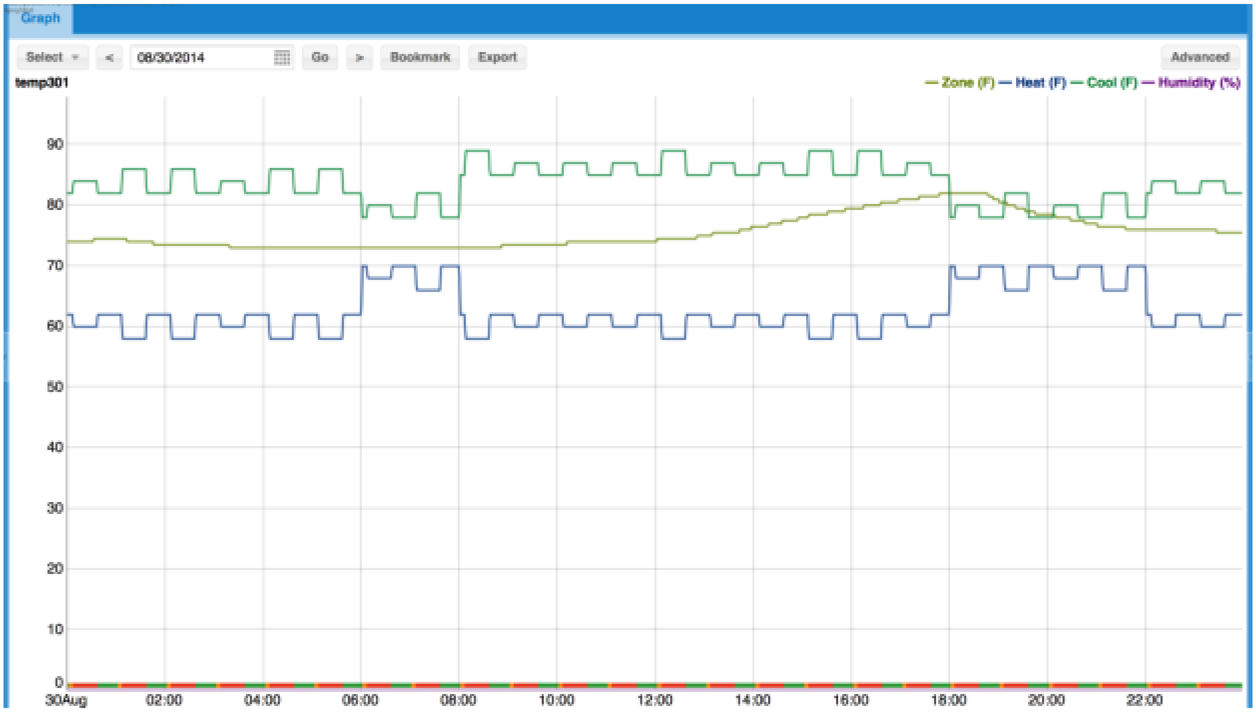


Figure 8: Thermostat “temp301” Temperature Graph for DR Event on 30 Aug 2014

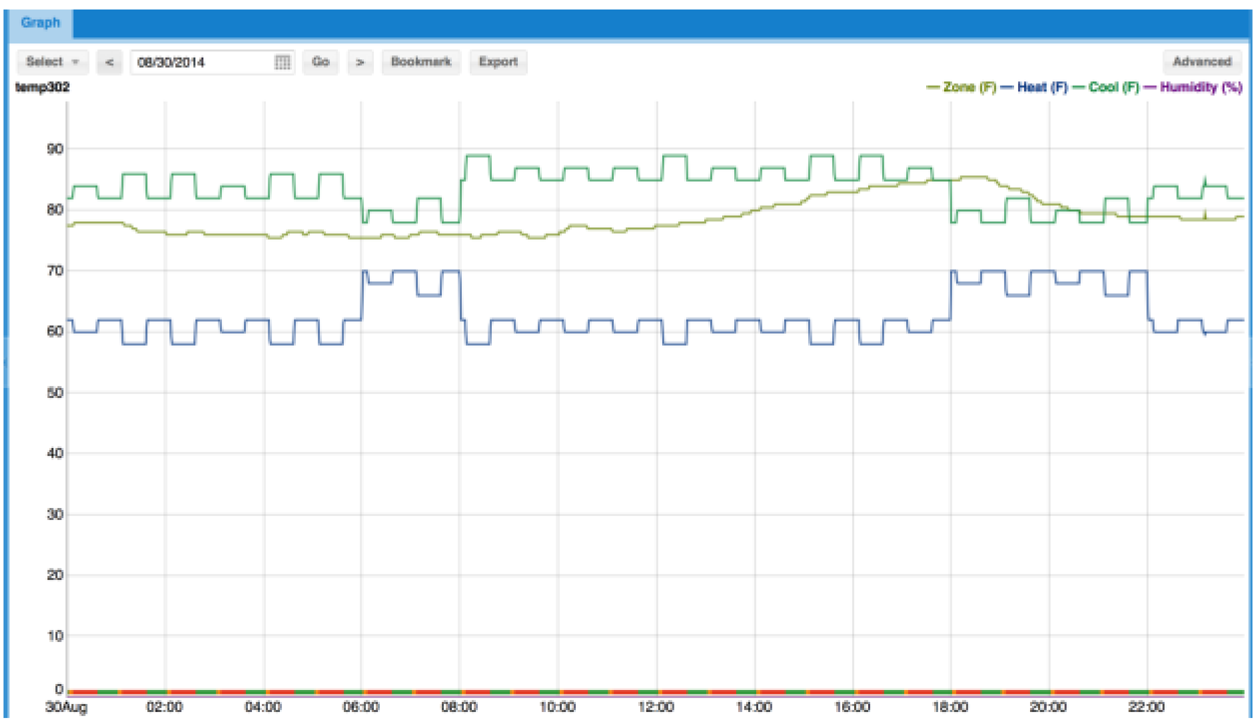


Figure 9: Thermostat “temp302” Temperature Graph for DR Event on 30 Aug 2014

Figure 10: Thermostat “temp303” Temperature Graph for DR Event on 30 Aug 2014

Figure 11: Thermostat “temp304” Temperature Graph for DR Event on 30 Aug 2014

Figure 12: Thermostat "temp305" Temperature Graph for DR Event on 30 Aug 2014

5.2.5 Campus Test Bed Microgrid Demonstration

5.2.5.1 Methodology

The USC/UCLA facilities which include a full range of user infrastructures: Commercial, medical, retail, semi-industrial, and residential will be used for this demonstration. This will provide LADWP with outcomes and performance data for deploying fully-integrated DR Smart Grid operations and technologies for all customer types. The demonstration outcomes and data can then be used by LADWP for full scale deployment; for developing the business case and for selecting the best operational models and technologies.

To demonstrate these use cases and meet the success criteria for this demonstration, the Demand Response team will integrate the historical and real-time AMI and System data for making outage and demand-side load management decisions with load forecasting and DR optimization. Additionally, the Demand Response team will implement DR optimization in the campus test bed micro-grid using service-based software architecture.

5.2.5.2 Technologies Deployed

None Installed/Acquired.

5.2.5.3 Success Criteria

The success criteria for the Demand Response team will include the successful completion of all use cases. The demand response team will achieve demand-side load management by integrating data and implementing load forecasting and DR optimization. Additionally, the LADWP Smart Grid Control Center will deliver reliable and precise responses to utility demand curtailment events and also provide load demand forecast and curtailment strategy selection using software architecture.

5.2.5.4 Observations and Results

The USC DR Project team ran several DR events during June and July using various strategies. The following figures are the load graphs for eleven different buildings undergoing the events:

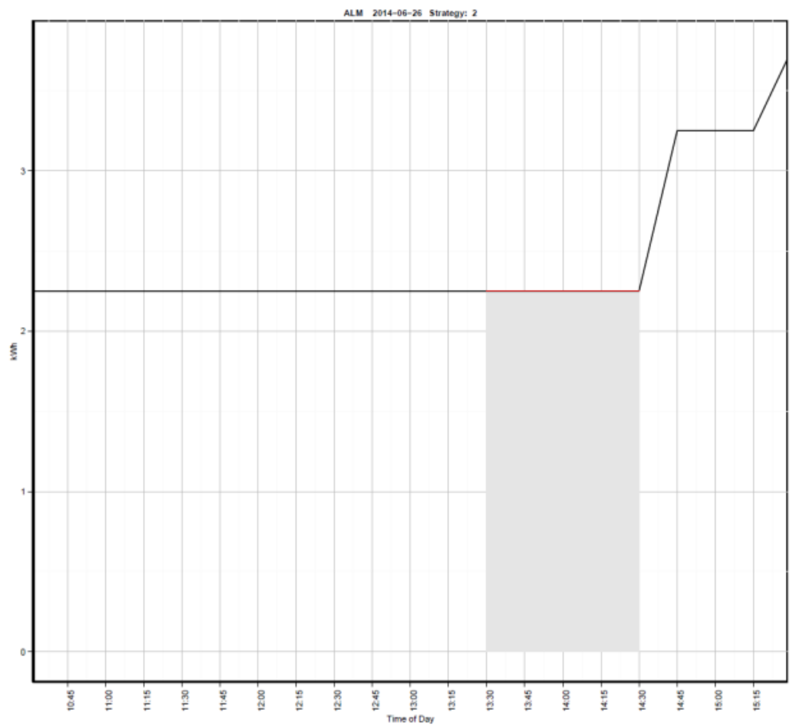


Figure 13: Load Curve for Widney Alumni House on June 26, 2014

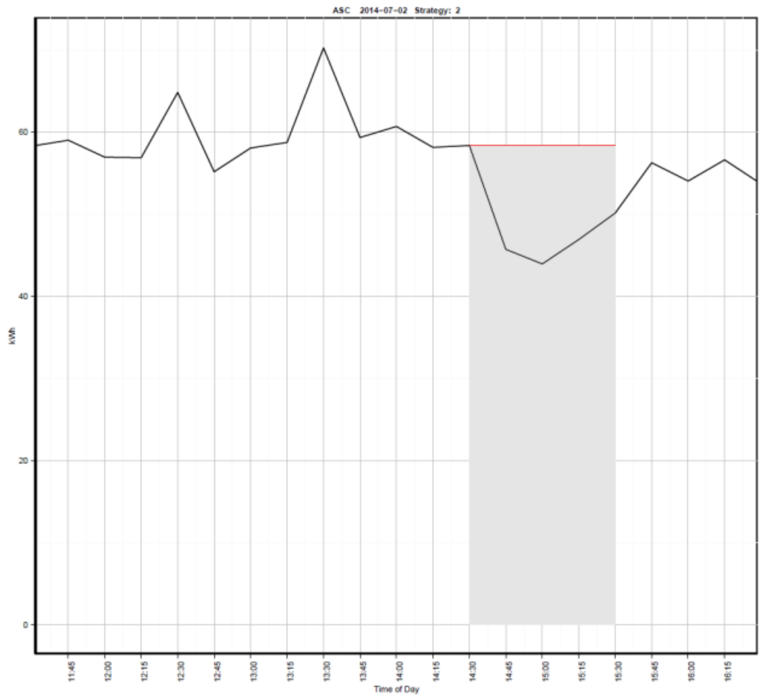


Figure 14: Load Curve for Annenberg School for Communication on July 02, 2014

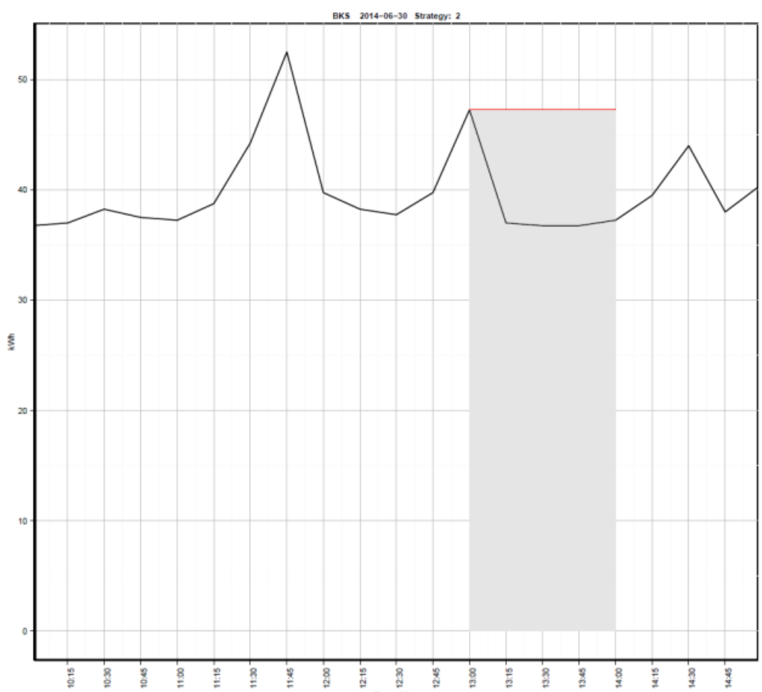


Figure 15: Load Curve for Pertusati University Bookstore on June 30, 2014

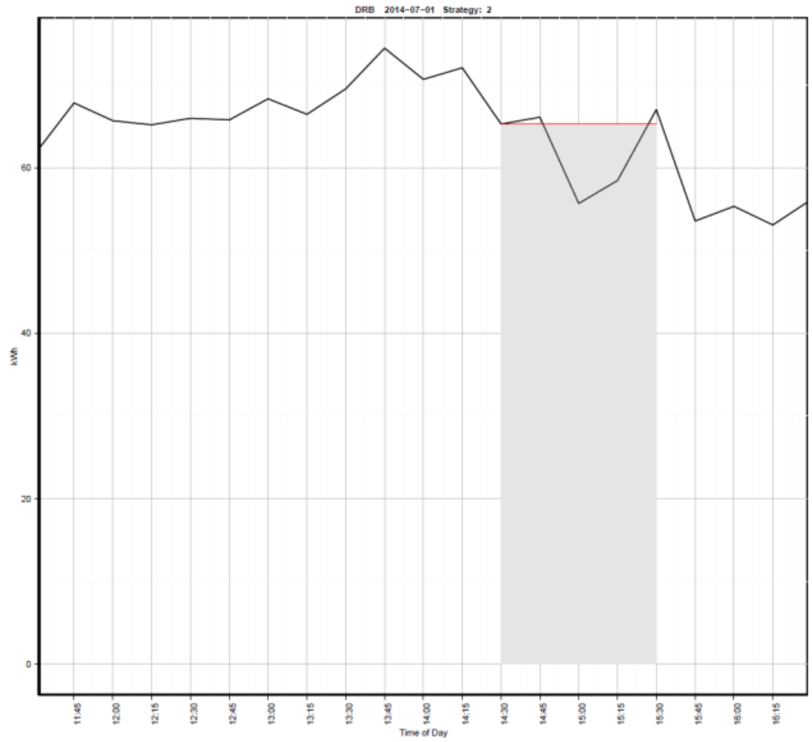


Figure 16: Load Curve for Corwin D. Denny Research Center on July 01, 2014

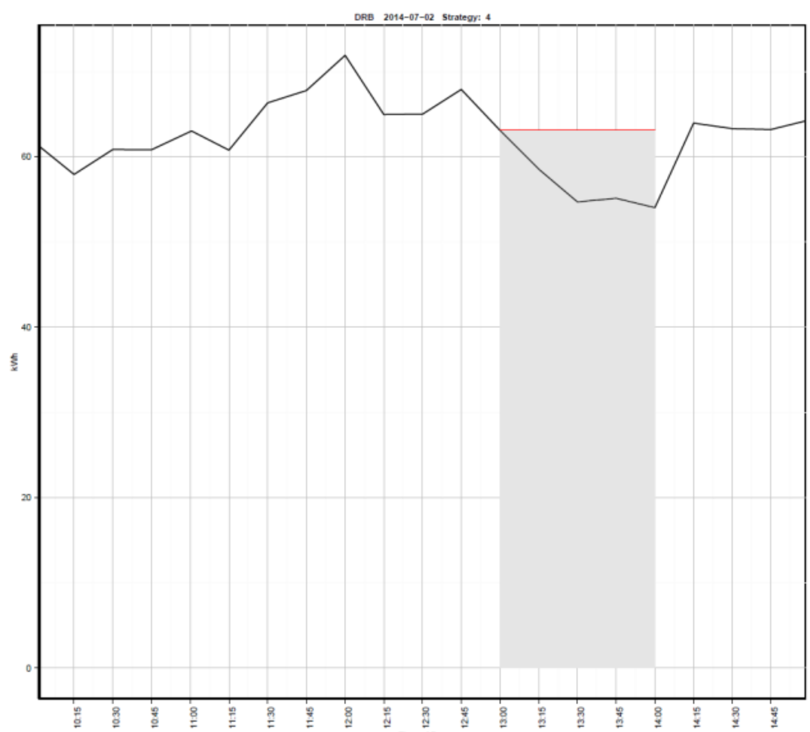


Figure 17: Load Curve for Corwin D. Denny Research Center on July 02, 2014

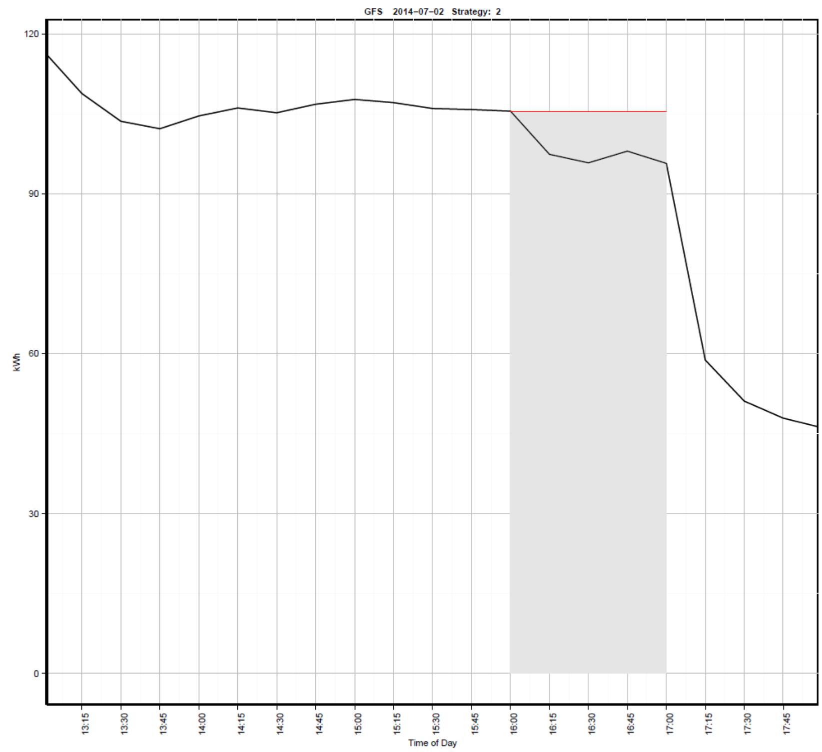


Figure 18: Load Curve for Grace Ford Salvatori Hall of Letters, Arts & Sciences on July 02, 2014

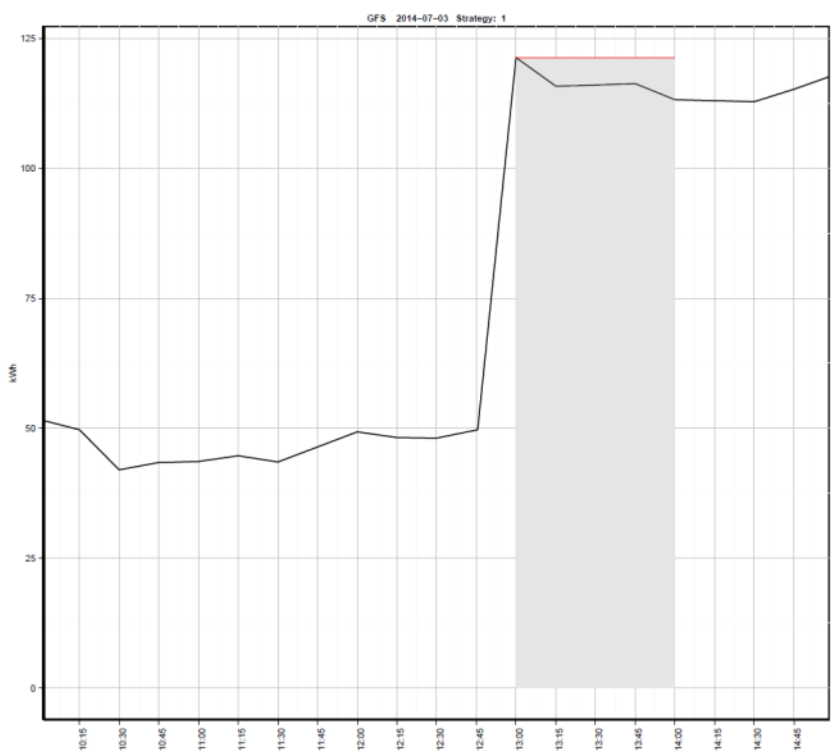


Figure 19: Load Curve for Grace Ford Salvatori Hall of Letters, Arts & Sciences on July 03, 2014

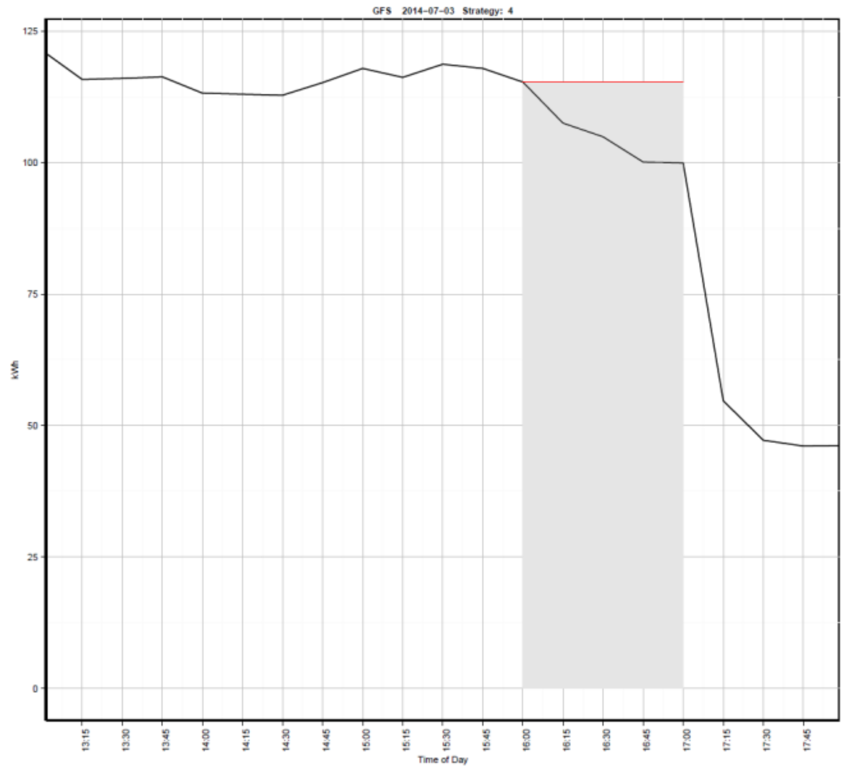


Figure 20: Load Curve for Grace Ford Salvatori Hall of Letters, Arts & Sciences on July 03, 2014

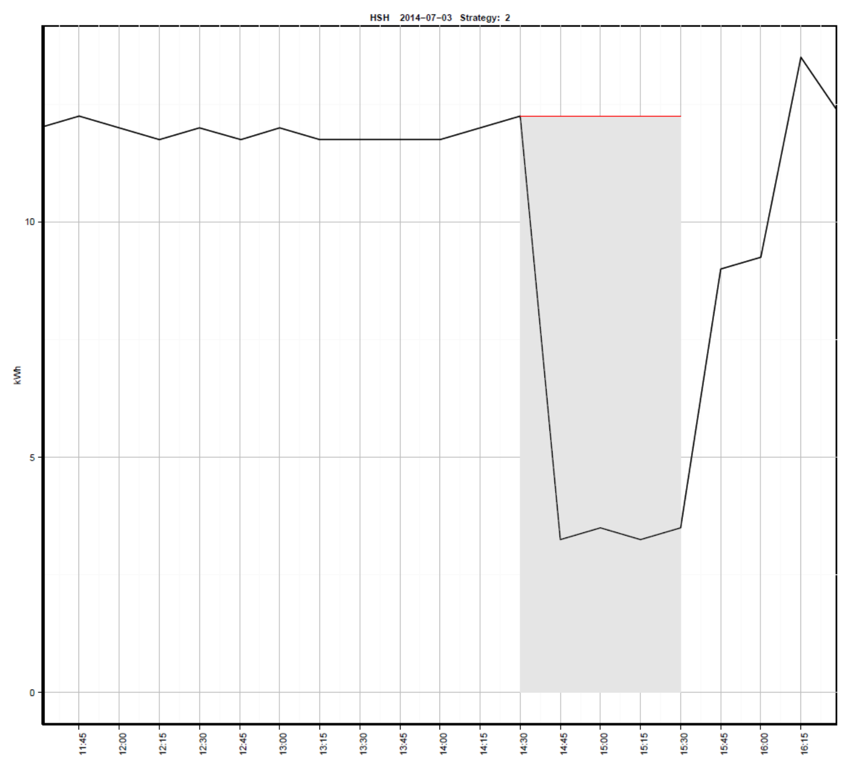


Figure 21: Load Curve for Hazel & Stanley Hall Financial on July 03, 2014

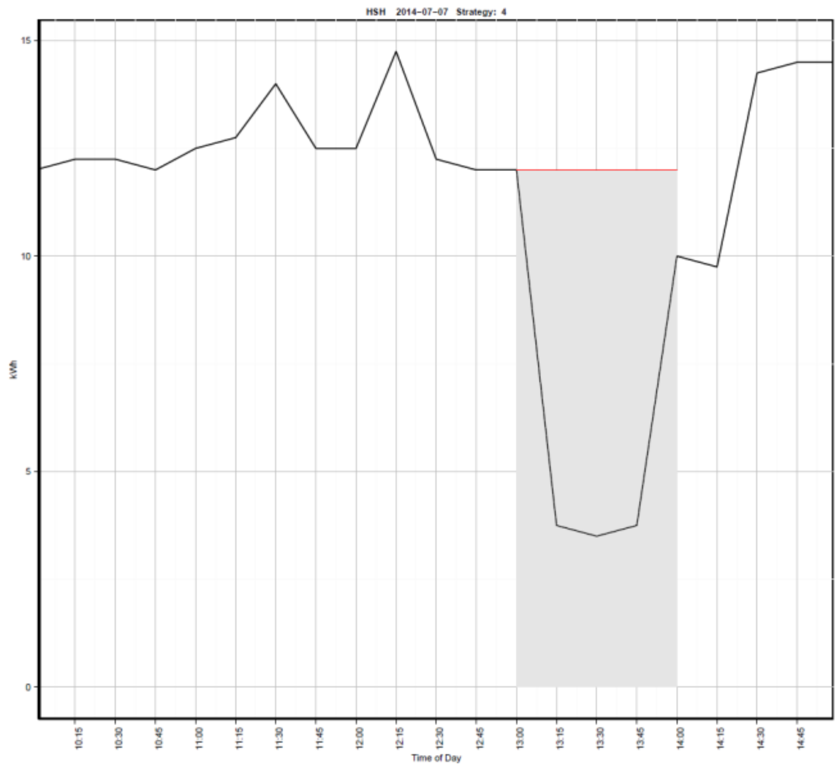


Figure 22: Load Curve for Hazel & Stanley Hall Financial on July 07, 2014

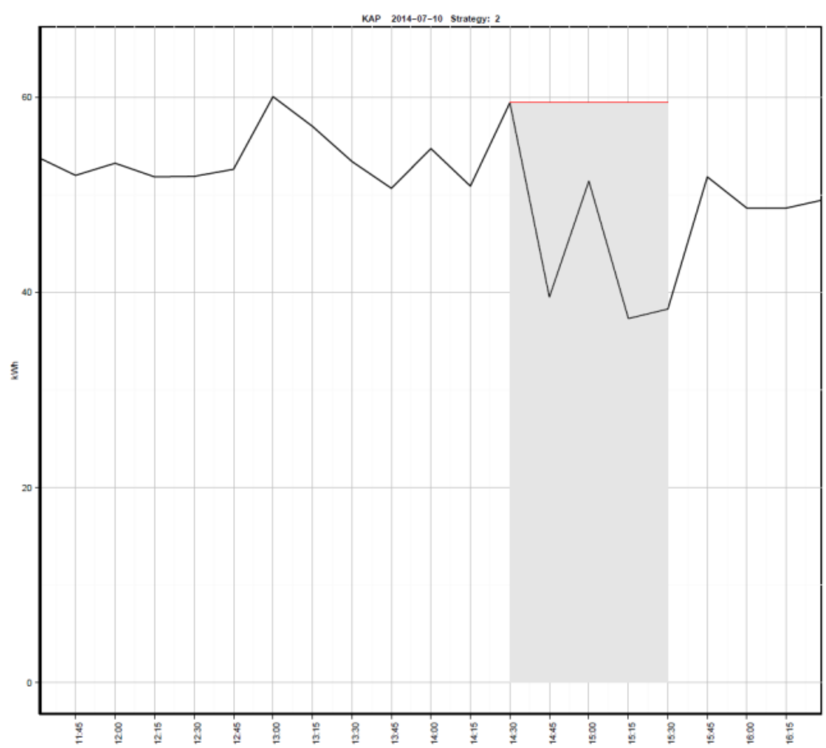


Figure 23: Load Curve for Kaprielian Hall on July 10, 2014

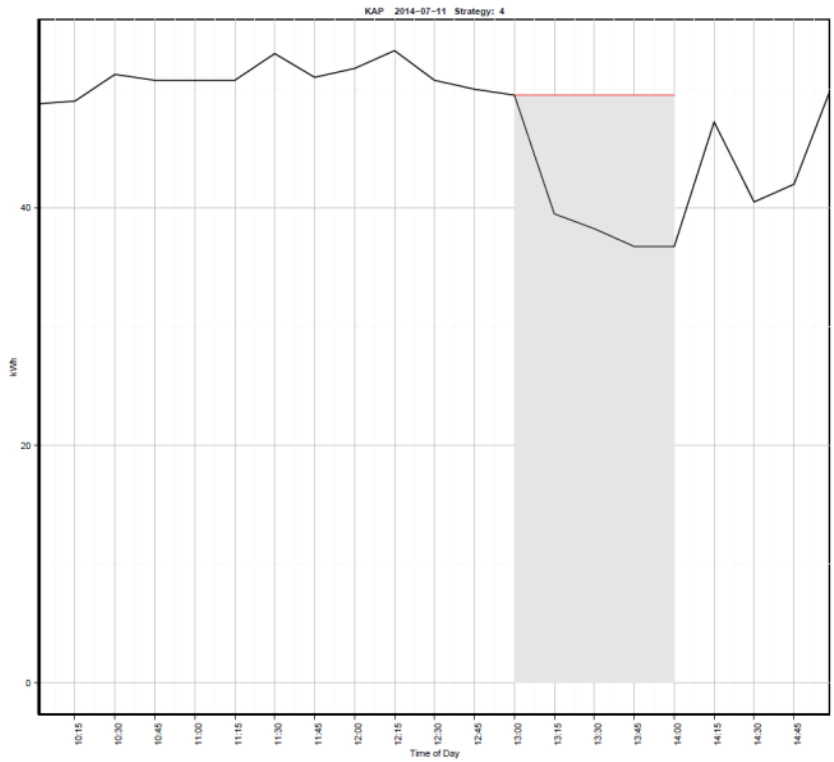


Figure 24: Load Curve for Kaprielian Hall on July 11, 2014

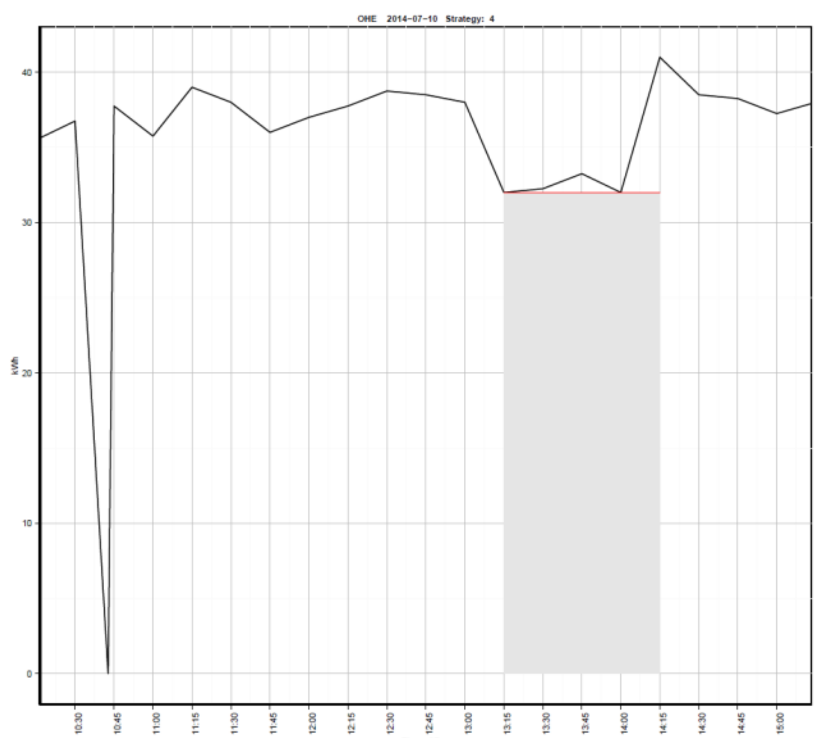


Figure 25: Load Curve for Olin Hall of Engineering on July 10, 2014

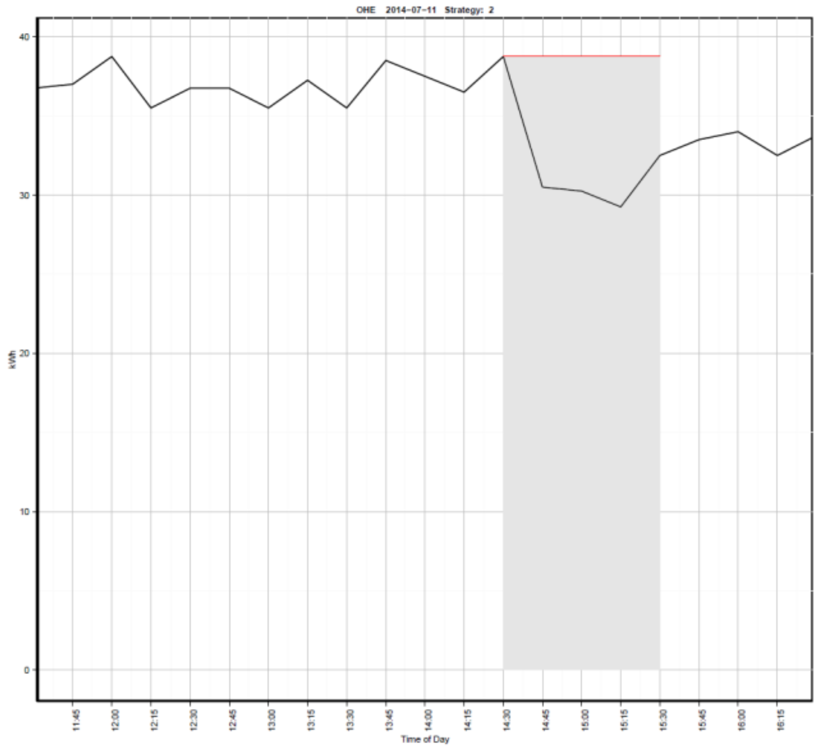


Figure 26: Load Curve for Olin Hall of Engineering on July 11, 2014

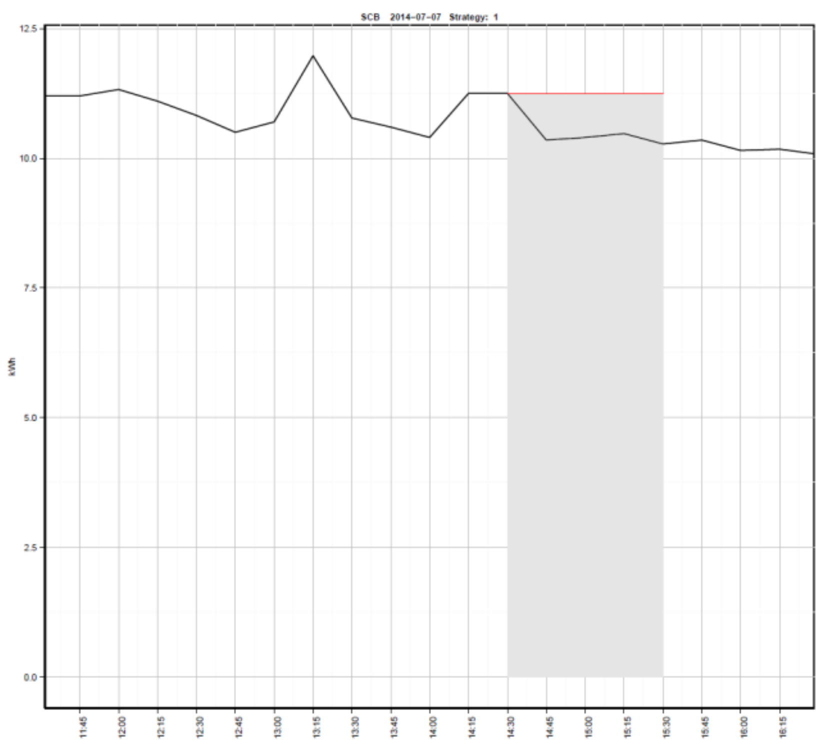


Figure 27: Load Curve for School of Cinematic Arts Building B on July 07, 2014

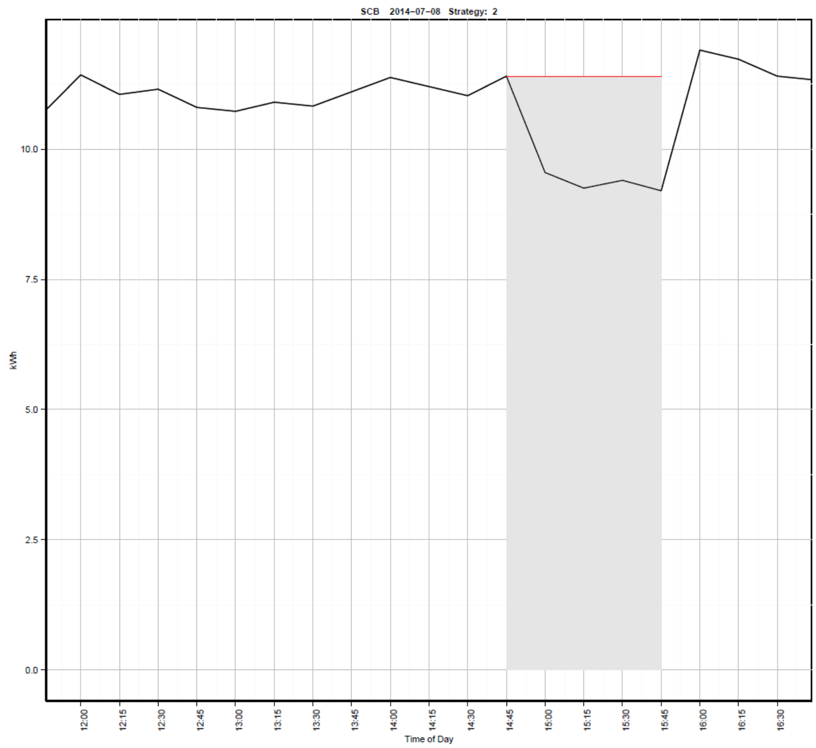


Figure 28: Load Curve for School of Cinematic Arts Building B on July 08, 2014

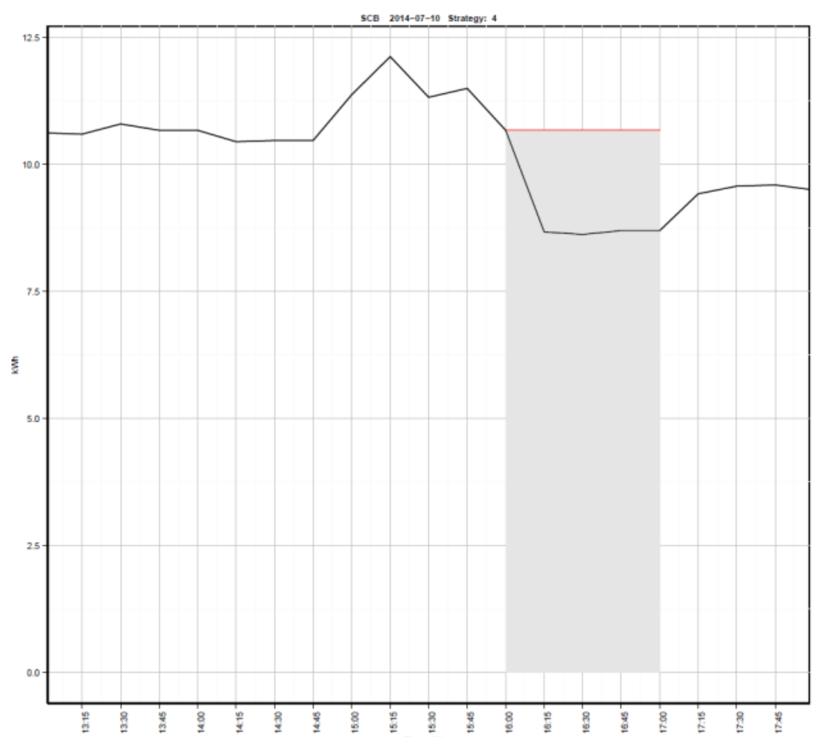


Figure 29: Load Curve for School of Cinematic Arts Building B on July 10, 2014

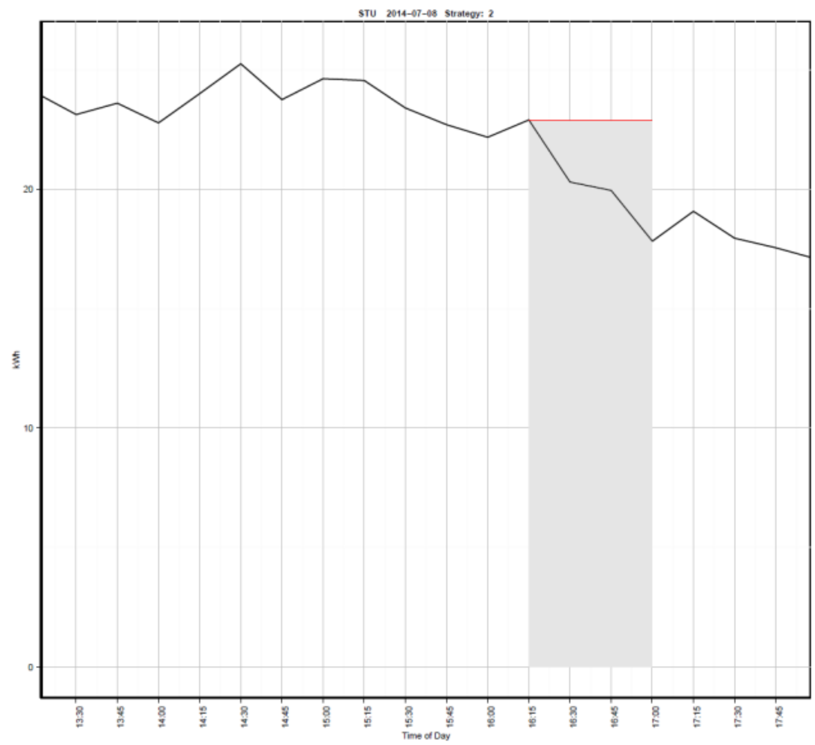


Figure 30: Load Curve for Gwynn Wilson Student Union on July 08, 2014

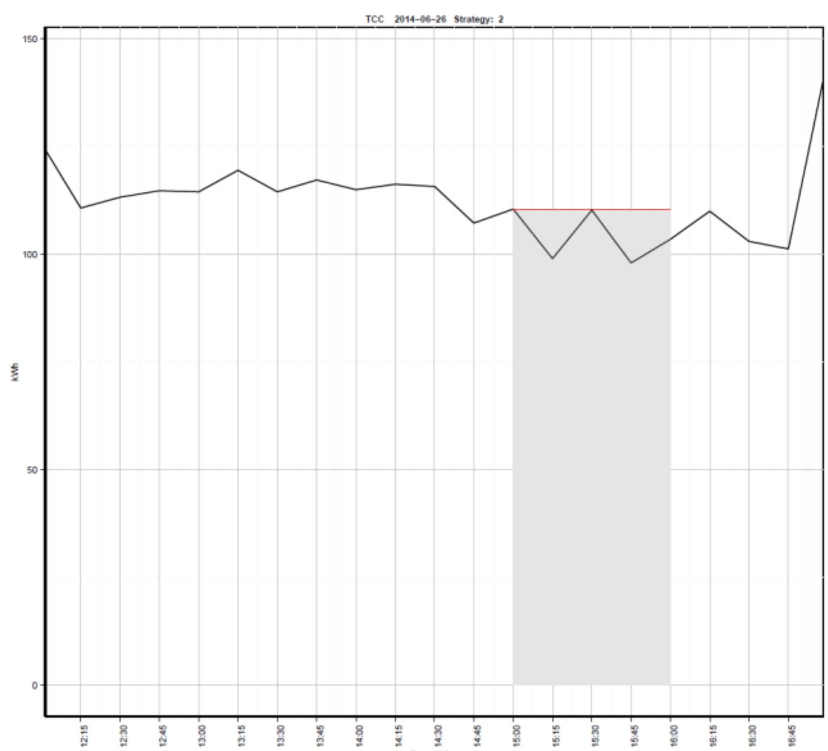


Figure 31: Load Curve for Ronald Tutor Campus Center on June 26, 2014

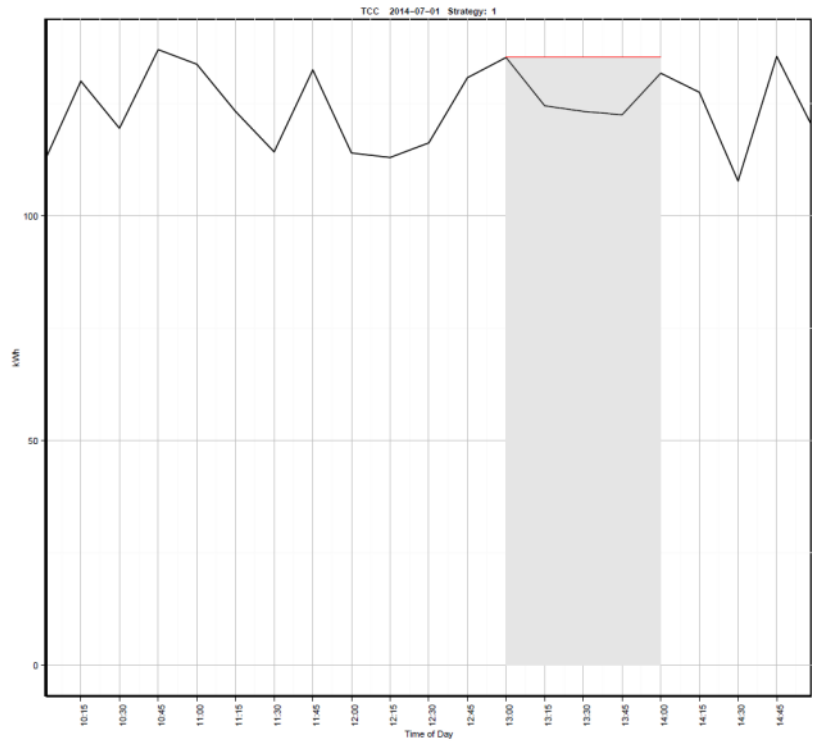


Figure 32: Load Curve for Ronald Tutor Campus Center on July 01, 2014

6 AMI

The scope of the SGRDP AMI project is to install approximately 52,000 AMI compatible meters, the supporting communication network and back office applications and operations. The AMI compatible meters will include power meters, Power Quality (PQ) meters and water meters. Given the DoE's interest in developing solutions that can be implemented across the nation by other utility companies, LADWP would like to develop an interoperable solution that supports electric, water and gas meters.

The SGRDP AMI project is needed to enable/accomplish the following objectives:

1. Provide a mechanism and strategy for carrying out DR actions (to provide load leveling and peak load shaving during critical peak load periods or whenever load reduction is deemed necessary).
2. Provide a mechanism for managing the integration of renewable energy resources, such as solar photovoltaic (PV) and wind power generators (to be able to balance the grid in response to the intermittencies inherent in solar PV and wind power generation).
3. Provide a mechanism for managing EV charging and customized EV electric power billing (to encourage earlier adoption of EVs and to provide grid load management associated with EV charging).
4. Provide metering of power (and water) usage at various service connections (to understand energy and water consumption patterns and load profiles).
5. Enable the capability to provide timely feedback to customers related to their electricity and water use profiles (to encourage reduced energy consumption and water conservation).
6. Enable the preparation of more timely billing of customers for power and water use (to encourage better energy management and water conservation, and to improve utility cash flow).
7. Enable improved power outage detection and management (for improved grid operations and reliability).
8. Enable scheduled/remote service connection and disconnection to manage move-outs, payment delinquencies, etc.

Additionally, in light of the partnerships with USC and UCLA in the SGRDP, LADWP has selected to install the AMI meters in three concentrated areas in and around the USC campus, in and around the UCLA campus, and meters contained in a circuit around the existing EV demonstration site.

6.1 Summary

Demonstration Areas	Use Cases
Metering System	*Step by Step Process of Procurement of Smart Meters*
	Preparation, Testing, and Installation Residential AMI Electric Meters
	Preparation, Testing, and Installation AMI Meter for Demand Applications

Metering System	*Preparation, Testing, and Installation AMI Time of Use (TOU) Meter for Electric Vehicle Applications*
	Preparation and Installation AMI Meter to Monitor Power Quality Meter on 4.8 kV Distribution Line as well as required Current Transformer and Potential Transformer
	Preparation and Installation Water Meter with RF Communication Module
	Step by Step Process to Build Configuration Programs for Various Metering Applications
	Performing "Accuracy Test" (Calibration Test) on Meter
	Performing Acceptance Test on a Shipment of Meters
	Developing an AMI Asset Management System to keep Track of Inventory and Installation of Meters
	Tracking Installation and Inventory of Meters, using an AMI Asset Management System
	Replacing A Defective Meter and Return Defective Device to Vendor Per Warranty
Communication Network	*Designing Communication Network and Select Sites for Installation of Cisco Connected Grid Routers (CGR)*
	Designing the Back Haul Communication Network
	Step by Step Process for Site Preparation for Communication Equipment: Data Collector (CGR), RF Range Extenders (RRE)
	Step by Step Process for Preparation of Communication Equipment: CGR, RRE
	Performing Communication Network "Tuning"
	Installation Network Management System (CG-NMS)
	Monitoring Communications between Meters and CGRs through CG-NMS
	Configuration and Installation of CGRs with Cellular Backhaul
	Installation of RRE to fill RF Mesh gaps
	Demonstration of effects of RRE on Improvement of Communication with RF Meters
	Creating Sample Maps of Communicating and Non-Communicating RF Meters for LADWP AMI System
	Configuration and Installation of CGRs with Corporate Network Ethernet backhaul
Back Office and Data Collection	*Step by Step Process to Install Head-End System*
	Preparation at least one Form of Reporting System
	Remote Two-Way Communication – Reading Meters and Writing into Meters with Installed AMI Meters, using Head-End
	Reading Events and Exceptions from Meter through Head-End
	Demonstration of taking Action based on a Received Event or Exception to Correct an Issue in AMI System
End-to-End	*Performing End-to-End AMI Acceptance Test*
	Real-Life Operation of the AMI System
	Providing Metering Data from Head-End to the MDM

Table 14: AMI Demonstration Areas and Use Cases

For the Advanced Metering Infrastructure Project, there are four different demonstration areas that are part of the Program Objectives. These areas include the metering system, communication network, back office and data collection, and end-to-end. Within each of these areas are use cases that will be executed in order to satisfy the Program Objectives. In all, there are a total thirty-one use cases to successfully demonstrate in order to satisfy the objectives.

6.2 Demonstration Areas

6.2.1 Metering System

6.2.1.1 Methodology

This demonstration area will be responsible for the step by step process of procuring Smart Meters and build configuration programs for various metering applications; the preparation, testing, and installation of residential AMI electric meters, AMI meters for demand applications, Time of Use meters, AMI meters monitoring Power Quality on a 4.8 kV Distribution Line and current and potential transformers, and water meters with an RF Communication Module; performing “accuracy tests” (calibration tests) and acceptance tests on meters; develop and use an AMI Asset Management System to track inventory and installation of meters; and replacing and returning defective meters to the vendor.

To demonstrate the use cases and meet the success criteria for this demonstration area, the AMI Project team will procure meters that meet the requirements for this project. Once procured, LADWP will test a sample of the meters in-house before installation. Next, the AMI team will map out location for the meters and will work with LADWP Meter Services division to install all of the meters.

6.2.1.2 Technologies Deployed

Equipment Overview	Total	Installed/ Acquired
7FM9 (Demand Meters)	903	893
EV Meters	600	57
7FY9 Meters (Residential with Neutral Wire)	1778	1778
POLA PQ Meters	19	0
7A9 Meters (Cellular Residential)	1960	1948
7F9 Meters (RF Residential)	47000	44940
Solar Meters	12	0

Table 15: Metering System Equipment List

6.2.1.3 Success Criteria

The success criteria for Metering System include the delivery and installation of all meters, the successful transmittal of data, and a fully functional Asset Management System along with documentation. Additionally, reports on all tests performed on the meters will also be generated as a part of the success criteria for the demonstration area.

6.2.1.4 Observations and Results

Please see Appendix A for the complete report on the AMI demonstrations.

6.2.2 Communication Network

6.2.2.1 Methodology

This demonstration area is responsible for designing the communication network and the back haul communication network, installation of the Cisco Connected Grid Routers and RF Range Extenders, performing communication network "tuning", installation of the Network Management System, monitoring communications between the meters and CGRs through the NMS, demonstrating the effect of the RF Range Extender to improve communication with meters, and creating sample maps of all RF meters for the LADWP AMI system.

To demonstrate the use cases and meet the success criteria for this demonstration area, the AMI Project team will implement two different communication networks: cellular and RF. After procuring devices, the team will work with LADWP Construction crews to install Cisco Connected Grid Routers and RF Range Extenders. Next, the AMI team will establish a two-way connection between all meters and the data collection engine. Concurrently, the AMI team will develop the Network Management System to monitor communications between the meters and Grid Routers.

6.2.2.2 Technologies Deployed

Equipment Overview	Total	Installed/ Acquired
CGRs - Cisco-Connected Grid Routers	59	59

Table 16: Communication Network Equipment List

6.2.2.3 Success Criteria

The success criteria for the Communication Network include the successful completion of all use cases. Additionally, the complete installation of all CGRs and RREs in addition to installation and procedural documentation, the installation of the Network Management System, and the completion of all required testing on all equipment are required as a part of the success criteria.

6.2.2.4 Observations and Results

Please see Appendix A for the complete report on the AMI demonstrations.

6.2.3 Back Office and Data Collection

6.2.3.1 Methodology

This demonstration area will be responsible for the step by step process to install the head-end system, preparation of at least one form of reporting system, utilizing remote two-way communication using the head-end system, reading events and exceptions from a meter through the head-end system, and taking action based on a received event or exception to correct an issue in the AMI system.

To demonstrate the use cases and meet the success criteria for this demonstration area, the AMI Project team will install, configure, test, and integrate a back-office system, the Meter Data Management (MDM) System and Customer Information System (CIS). The team will utilize an outside vendor's help (Oracle) when developing the system. Additionally, the AMI team will install, configure, test, and implement Itron's OpenWay head-end system to utilize.

6.2.3.2 Technologies Deployed

Equipment Overview	Total	Installed/ Acquired
MDM	1	0
CIS	1	1
OpenWay	1	1

Table 16: Back Office and Data Collection Equipment List

6.2.3.3 Success Criteria

The success criteria for Back Office and Data Collection include the successful completion of all use cases. Additionally, the head-end system must be in the LADWP's production environment and LADWP AMI Operators must be trained to maintain the head-end system.

6.2.3.4 Observations and Results

Please see Appendix A for the complete report on the AMI demonstrations.

6.2.4 End-to-End

6.2.4.1 Methodology

This demonstration area will be responsible for performing the end-to-end AMI acceptance test, a real-life operation of the AMI system, and metering data from the head-end system to the Meter Data Management System.

To demonstrate the use cases and meet the success criteria for this demonstration area, the AMI Project team will perform the AMI acceptance test and demonstrate sample activities that will result from operation and maintenance of the system. Additionally, the AMI team will demonstrate that metering data is able to travel from the head-end system to the MDM system.

6.2.4.2 Technologies Deployed

None installed/acquired.

6.2.4.3 Success Criteria

The success criterion for End-to-End is the successful completion of all use cases.

6.2.4.4 Observations and Results

Please see Appendix A for the complete report on the AMI demonstrations.

7 Electric Vehicles

The EV Project Team's vision is to satisfy the SGRDP goals by demonstrating EV technology and its role with regard to Smart Charging, Battery Aggregation, Microgrids, Renewables, Car/Ride Share, and Grid Impact Analysis.

The EV Project will document the above EV demonstrations, which test the aggregation and integration of EVs with transmission and distribution systems, and assess the impact of EV integration on such systems, accounting for:

- Multiple user demographics, grid specifications, and driving patterns
- A variety of EV types
- A variety of charging equipment types

The project will also document experiences with the communications and control systems associated with EV integration; noting the scalability of wireless, sensing, monitoring and control within the project.

Such monitoring and control systems will include the linkage between charging stations and grid management systems. The EV Project will also incorporate the necessary requirements to ensure cyber security.

Overall, the project will demonstrate:

- The monitoring of chargers, power usage, and EV usage
- The viability of applying charged EVs for maintaining grid integrity related to renewable portfolio and resource planning goals
- The integration of EVs with the LADWP grid, including Smart charging, battery aggregation and backfill, renewables and EV battery integration
- The Smart-charging of EVs and charging stations in the LADWP Service Territory
- The ability of the SG infrastructure to protect the integrity of customer, configuration, and audit data

The scope of this project is to demonstrate SG and Energy Storage technologies in the LADWP service territory (specifically, LADWP SG Power Lab, UCLA Research Labs, Chatsworth substations, and EV chargers at a several different locations) and develop a suite of use cases applicable not only to the study area, but also transferable for national implementation and replication. From these use cases, the goal is to collect and provide the information necessary for customers, distributors, and generators to modify existing usage and behavior patterns to reduce system demands and costs, increase energy efficiency, increase the reliability of the grid, and optimally allocate and match resources with demand.

The anticipated social benefits of EV and energy storage utilizing SG technologies are reduced emissions, lower costs, increased reliability, greater security and flexibility to accommodate new energy technologies; including renewable, intermittent and distributed resources.

7.1 Summary

Demonstration Areas	Use Cases
Smart Charging using WINSmartGrid for EV and Existing Charging Stations and EVs in and around Los Angeles and the UCLA Campus	*Monitoring of All Chargers*
	Reading Power Consumption for Vehicles connected to Chargers
	Control of Chargers
	Disconnection of a Vehicle that is Charging
	Smart Charging through Mobile Interface
Battery Aggregation and Backfill	*Use of Batteries in Grid (G2V)*
	Use of Batteries in Grid (G2V & V2G)
	Distribution Effects of Battery Aggregation and Backfill (G2B)
	Distribution Effects of Battery Aggregation and Backfill (B2V)
	Distribution Effects of Battery Aggregation and Backfill (B2G)
Fully Functional Microgrid	*Inductive Charging*
	Various Vehicle Charging
	Distribution Effects of EVs on the Grid
	Local Grid Balancing and Management
Renewables and Battery Integration	*Community Storage of EV Batteries and External Storage*
	Garage of the Future
	Cycling of the Batteries
	Aggregation of the Batteries
	Integration of EV and Solar
Using Car Sharing Programs at USC and UCLA	*Monitoring of Chargers, Power Usage, and Car Usage*
	Distribution Effects of Car / Ride Share Program
Grid Impact Stability / Power Study	*Generation, Transmission, and Distribution Effects*
	Various Loading Scenarios

Table 17: EV Demonstration Areas and Use Cases

For the Electric Vehicle Project, there are six different demonstration areas that are part of the Program Objectives. These areas include smart charging, battery aggregation and backfill, a fully functional microgrid, renewables and battery integration, the use of car sharing programs at USC and UCLA and a grid impact stability/power study. Within each of these areas are use cases that will be executed in order to satisfy the Program Objectives. In all, there are a total twenty-three use cases to successfully demonstrate in order to satisfy the objectives.

7.2 Demonstration Areas

7.2.1 Smart Charging using WINSmartGrid for EV and existing charging stations and EV's in and around Los Angeles and the UCLA campus

7.2.1.1 Methodology

This demonstration area will be responsible for the monitoring of all chargers, the ability to read power consumption for vehicles connected to chargers, the control of chargers, the ability to disconnect vehicles that are charging, and the utilization of a mobile interface. The demonstration of automated smart charging using wireless communications will take into account cyber security concerns, reliability, and result in outcomes to help determine upgrades required to the electric distribution system with fully scale implementation of EVs.

To demonstrate the use cases and meet the success criteria for this demonstration area, the EV Project team will install Level 1, Level 2, and Level 3 charging stations from various vendors at UCLA and LADWP parking structures. Additionally, in order to circumvent proprietary communication protocols which inhibit the EV team from collecting detailed user data and fully controlling the charging operations, the EV team will develop an open-architecture charging station that supports the data collection and circuit control of this project. With the use of the open-architecture, the EV team will be able to monitor and control (including disconnect) chargers and collect charger data. Lastly, the EV team will develop and implement a web interface and API interface to allow Smart Charging through mobile interfaces.

7.2.1.2 Technologies Deployed

Equipment Overview	Total	Installed/ Acquired
Level 2 EV Charger (DWP)	131	124
Level 3 EV Charger (DWP)	16	13
Level 2 EV Charger (Rebate Program)	898	898
Electric Vehicles	67	67

Table 18: Smart Charging Equipment List

7.2.1.3 Success Criteria

The success criteria for Smart Charging include the successful completion of all use cases. Additionally, a report on smart charging infrastructure results will also be generated as a part of the success criteria for the demonstration area.

The majority of the chargers for this demonstration area has been installed and is collecting data. Additionally, the UCLA Smart Grid Energy Research Center (SMERC) developed the mobile interface and can be utilized. The report on smart charging infrastructure results will be generated at the end of the project in 2016.

7.2.1.4 Observations and Results

The UCLA Smart Grid Energy Research Center (SMERC) has dedicated its efforts on large-scale testing of its smart charging network WINSmartEV™ using UCLA parking structures as the test bed. SMERC tested various communication networks and designed an optimal communication architecture based on the specific characteristics of the parking structures.

The WINSmartEV™ EV charging network utilizes a centralized control system to monitor and regulate the network for real-time smart charging services. This smart charging infrastructure uses standard networking technologies to create a network that facilitates charging services for the end user and monitoring and control tasks for maintainers/operators. The charging services are completely adaptable by way of local or remote charging algorithms. In addition, the architecture incorporates multiplexing capabilities with a unique safety system that integrates safety on all levels of control. Figure X shows the topology of the EV network's architecture.

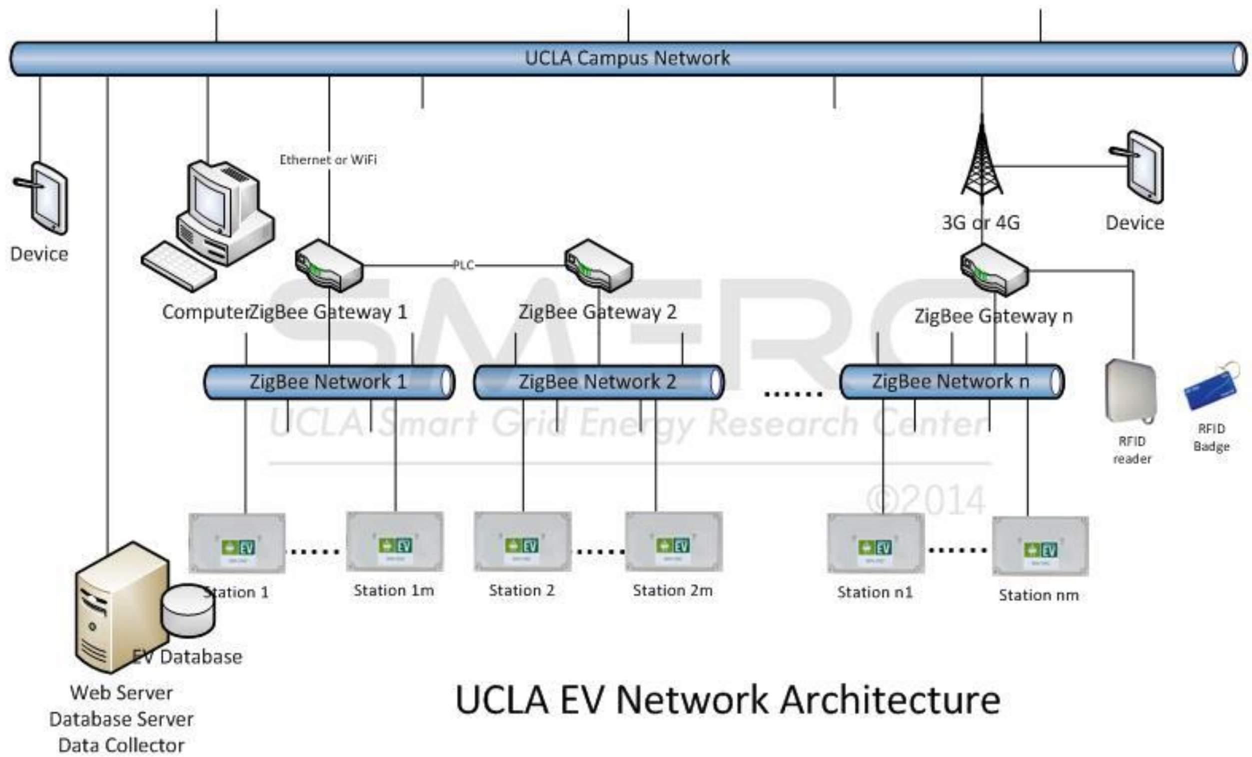


Figure 33: Topology of WINSmartEV™

Current commercial EV charging stations provide basic stations without any network features or they use proprietary technologies to connect charging stations to networks. For instance, while Coulomb provides a ChargePoint application programming interface (API) and an OpenCharge protocol for developers, the current application uses the company's own network to locate available charging stations for users. It is possible to build a smart charging system over a closed network with API and protocols; however, it is difficult to determine if such commercial implementations have an integrated safety design. SMERC implemented safety designs in basic, non-networked commercial charging stations, like those provided by Leviton and ClipperCreek. Nevertheless, these stations simply provide basic charging services without power information monitoring and network control features. In addition, the user must take extra steps in order to authorize charging sessions when using a closed system. Finally, commercial implementations like that of Coulomb may use smart charging algorithms in their charging stations, but these stations only have one or two outlets, which are not suitable for sharing electric current.

7.2.1.4.1 Monitoring All Chargers

UCLA SMERC control center monitoring and control interface shows current status of EV chargers.

Figure 34: Control Center – EV Status Monitoring

In Figure 34, the control center shows charging status as “standby” or “charging”. “Standby” means there is currently no EV connected or the charger is not charging. “Charging” means the station is currently charging a vehicle. The corresponding user and latest meter data are displayed.

Under “Station Status”, it shows “online” or “offline”. Online means the control was able to receive data from the EV charger in the past data collection loop. “Offline” means the data retrievals was not successful in the past data collection loop.

“Plugged-in” shows “yes” if a charging cable is connected to a vehicle. This option is only available for level 2 chargers.

The following picture shows current data collection of DC Fast Charger (DCFC).

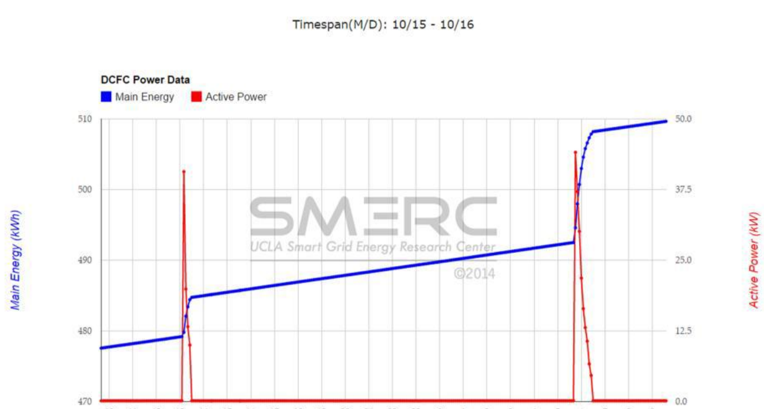


Figure 35: Data Collection on DCFC

For data collection, the following table, Table A, shows a sample of collected data:

Station ID	Timestamp	Voltage	Current	Frequency	Power Factory	Active Power	Apparent Power	Main Energy
000D6F000072BB56	7/1/2014 0:13	208.09	0	60.09	1	0.83	0.83	3130.526
000D6F000072BB56	7/1/2014 0:29	208.46	0	59.98	1	0.79	0.79	3130.526
000D6F000072BB56	7/1/2014 0:46	208.23	0	59.98	1	0.79	0.79	3130.527
000D6F000072BB56	7/1/2014 1:02	208.58	0	59.98	1	0.83	0.83	3130.527
000D6F000072BB56	7/1/2014 1:19	208.53	0	59.98	1	0.87	0.87	3130.527
000D6F000072BB56	7/1/2014 1:35	207.29	0	59.98	1	0.79	0.79	3130.527
000D6F000072BB56	7/1/2014 1:52	206.91	0	59.98	1	0.83	0.83	3130.528
000D6F000072BB56	7/1/2014 2:08	206.75	0	59.98	1	0.79	0.79	3130.528
000D6F000072BB56	7/1/2014 2:25	206.79	0	59.98	1	0.83	0.83	3130.528
000D6F000072BB56	7/1/2014 2:41	207.8	0	59.98	1	0.83	0.83	3130.528
000D6F000072BB56	7/1/2014 2:58	207.85	0	59.98	1	0.79	0.79	3130.528
000D6F000072BB56	7/1/2014 3:14	207.55	0	60.1	1	0.84	0.84	3130.529

Table 19: Sample Station Data Record for July 2014

As show in the sample, data are collected in 15 min intervals. The two sets of data that are required for this use case are as follows:

EV Status:
Timestamp – collected as indicated in Table 1.
EV charger operating status – collected in Table 1. Offline if voltage field is 0, online otherwise.
Charging state – collected in Table 1. Charging if current field is greater than 1, standby otherwise.

Accumulative Charging Data:
Timestamp – collected as indicated in Table 1.
kWh – collected as indicated in Table 1. “Main Energy” field.
kW – collected as indicated in Table 1. “Active Power field.
kvarh and kvar can be obtained by currently Power factor, kW, and kWh

7.2.1.4.2 Reading Power Consumption for Vehicles Connected to Chargers

When an EV is plugged into an EV charger, the user can activate a charging session through a smart phone or any Internet-connected device. Once activated, power consumption information is obtained through the EV network mentioned in Use Case EV.1. If a vehicle is equipped with the Status of Charge (SOC) box, the SOC information is also obtained. These operations can be illustrated by the screen shots taken from the mobile app/interface in the figures below.

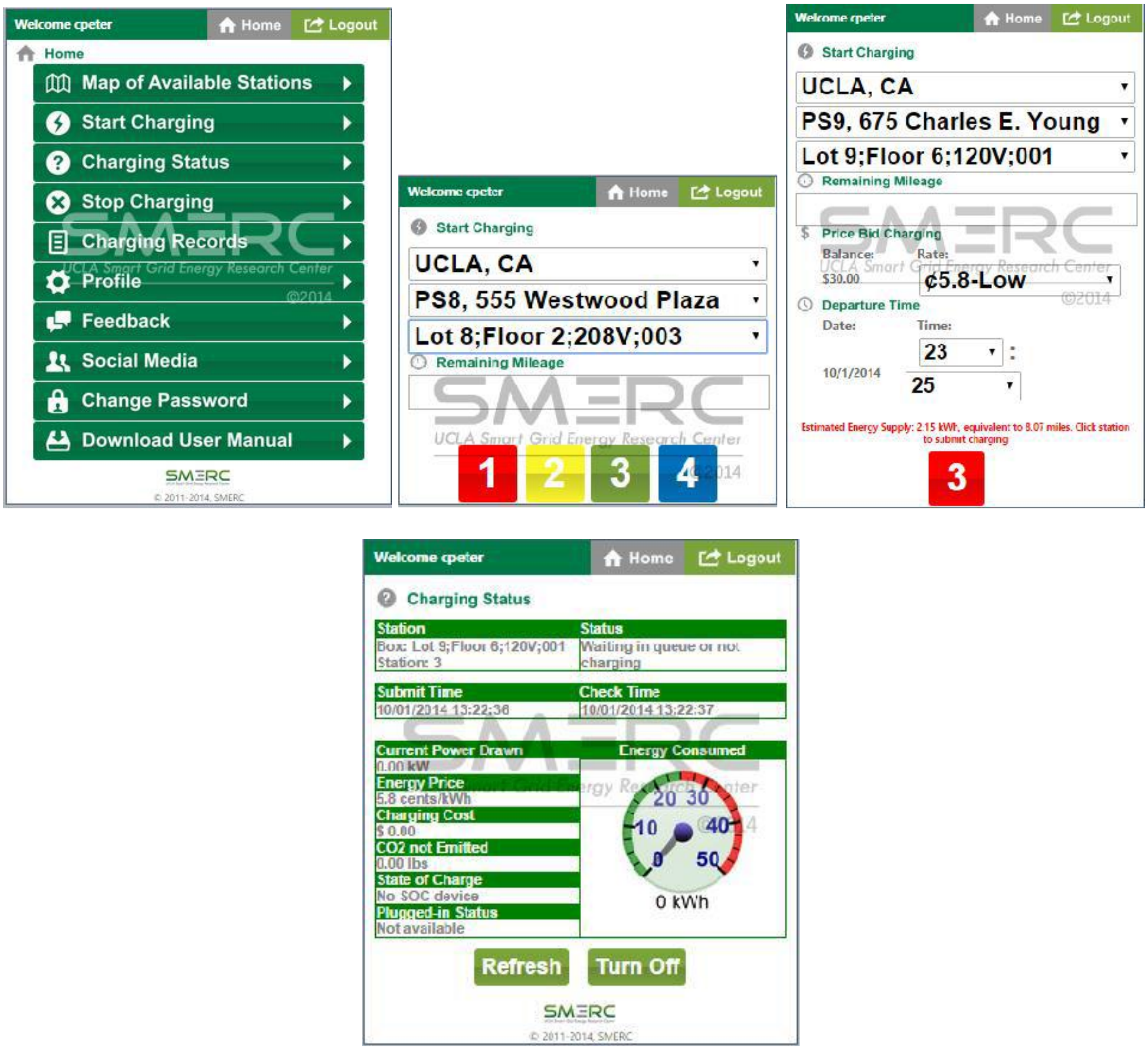
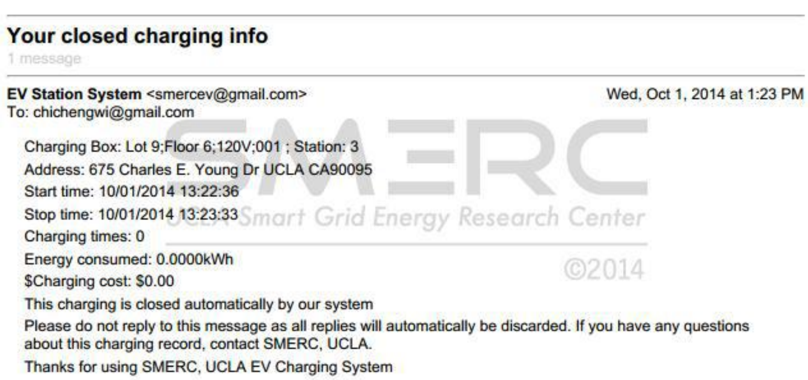


Figure 36: Screenshots from Mobile App Web Interface



Your closed charging info

1 message

EV Station System <smercev@gmail.com> Wed, Oct 1, 2014 at 1:23 PM
To: chichengwi@gmail.com

Charging Box: Lot 9;Floor 6;120V;001 ; Station: 3
Address: 675 Charles E. Young Dr UCLA CA90095
Start time: 10/01/2014 13:22:36
Stop time: 10/01/2014 13:23:33
Charging times: 0
Energy consumed: 0.0000kWh
$Charging cost: $0.00
This charging is closed automatically by our system
Please do not reply to this message as all replies will automatically be discarded. If you have any questions about this charging record, contact SMERC, UCLA.
Thanks for using SMERC, UCLA EV Charging System

Figure 37: Sample Sent Email when a Charging Session is Closed

Table B shows a sample of collected Charging Record:

ID	UserID	StationID	StartTime	StartVolta	StartCurre	StartPF	StartActiv	StartAppa	StartMain	EndTime	EndVoltag	EndCurrer	EndPF	EndActive	EndAppar	EndMainP	EVInfo	remaining
B65CC119-	248D0C20-	000D6F00	2014-10-01 00:12:59	119.46	0.18	1	7.48	7.48	11.926	2014-10-01 06:06:39	119.2	0	1	0	0	17.905	Other Oth	NULL
F8AD23F5-	D101BB93-	000D6F00	2014-10-01 04:28:29	204.29	2.53	0.1	7.48	72.4	253.401	2014-10-01 10:26:17	204.02	0	1	0	0	265.179	Chevrolet	0
F31B4539-	05B1FB52-	000D6F00	2014-10-01 06:41:55	211.89	0.53	1	112.3	112.3	2165.366	2014-10-01 21:30:22	212.01	0	1	0	0	2180.666	Nissan Lea	36
5F95ECB1-	0A6BB4ED	000D6F00	2014-10-01 07:15:27	205.19	0	1	0.24	0.24	807.345	2014-10-01 07:25:19	199.86	0	1	0.2	0.2	807.8	Nissan Lea	25
AFD84FD5	0A6BB4ED	000D6F00	2014-10-01 07:27:15	204.94	0	1	0.36	0.36	807.8	2014-10-01 07:28:28	199.62	0	1	0	0	807.838	Nissan Lea	25
AB578D81	0A6BB4ED	000D6F00	2014-10-01 07:29:28	204.34	0	1	0.2	0.2	807.838	2014-10-01 15:33:27	210.65	0	1	0.28	0.28	823.534	Nissan Lea	25
A91D1814-	F16545B7-	000D6F00	2014-10-01 07:43:38	194.38	0	1	0	0	628.838	2014-10-01 14:05:13	204.54	0	1	0	0	638.661	Chevrolet	11
650CE3AB-	56BE2C5E-	000D6F00	2014-10-01 07:54:59	118.66	0.2	1	7.64	7.64	545.704	2014-10-01 15:47:03	118.8	0	1	0	0	548.668	Nissan Lea	38
BCA0A625	B42BB610-	000D6F00	2014-10-01 07:57:37	205.83	0	1	0	0	792.728	2014-10-01 11:23:34	199.07	0	1	0	0	799.379	Ford Fusic	0
B3058352-	5565465A-	000D6F00	2014-10-01 08:12:41	118.15	0	1	0	0	2660.719	2014-10-01 18:22:39	119.62	0	1	0	0	2669.144	Nissan Lea	31
EDC3A209	9728FC26-	000D6F00	2014-10-01 08:18:49	110.96	0	1	0	0	548.328	2014-10-01 12:49:53	117.97	0	1	0	0	549.378	Toyota Pri	0
BC477F03-	9432996D-	000D6F00	2014-10-01 08:28:27	110.95	0	1	0	0	327.264	2014-10-01 16:15:10	118.69	0	1	0	0	330.079	Toyota Pri	0
1F0DEA73-	5559335F-	000D6F00	2014-10-01 08:31:36	115.82	0	1	0	0	381.418	2014-10-01 08:47:15	118.73	0	1	0	0	381.418	Chevrolet	20
39DDE48B	00D38F47-	000D6F00	2014-10-01 08:36:24	110.17	0	1	0	0	691.027	2014-10-01 14:29:00	118.51	0	1	0	0	692.978	Ford Fusic	2
1E2E6E1F-	90468DDE-	000D6F00	2014-10-01 08:40:39	196.18	0	1	0	0	360.961	2014-10-01 11:34:03	204.25	0	1	0	0	363.55	Chevrolet	11
79CD9105-	9A929C4D	000D6F00	2014-10-01 09:12:44	196.15	0	1	0	0	270.251	2014-10-01 09:37:18	203.31	0	1	0	0	270.251	Nissan Lea	50
CE8388D2-	9A929C4D	000D6F00	2014-10-01 11:15:47	195.71	0	1	0	0	265.179	2014-10-01 11:16:10	196.06	0	1	0	0	265.179	Nissan Lea	30
3FE32896-	48A8D898	000D6F00	2014-10-01 11:40:20	121.77	0	1	0	0	187.894	2014-10-01 11:40:56	121.68	0	1	0	0	187.894	Other Oth	22

Table 20: Sample Data from Charging Record

Figure D shows the screen shot of SOC data collection samples:

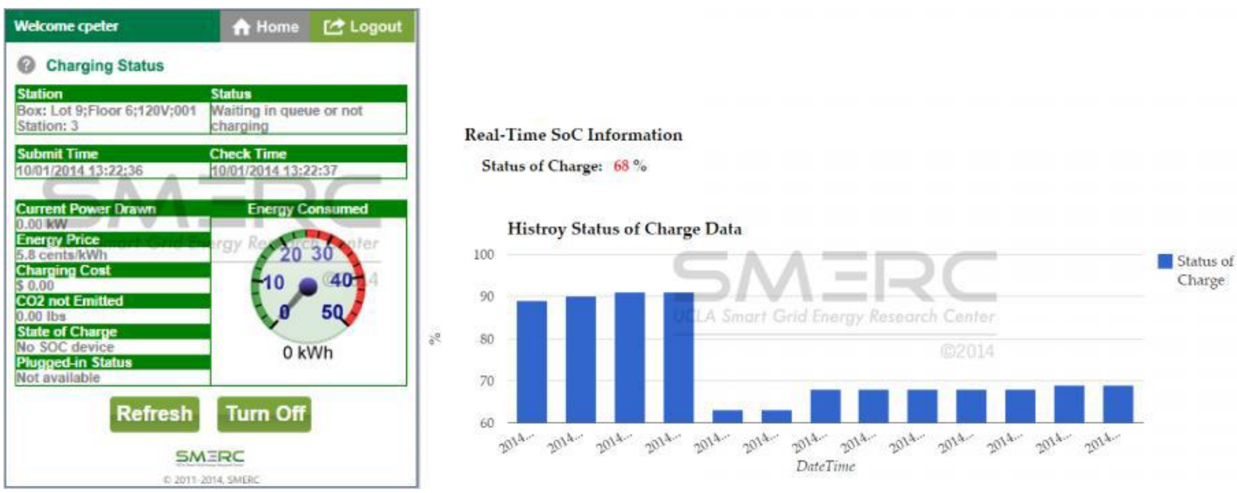


Figure 38: SOC Data Collection Samples

Figure E and Figure F show the Ambient Temperature Data Collection:

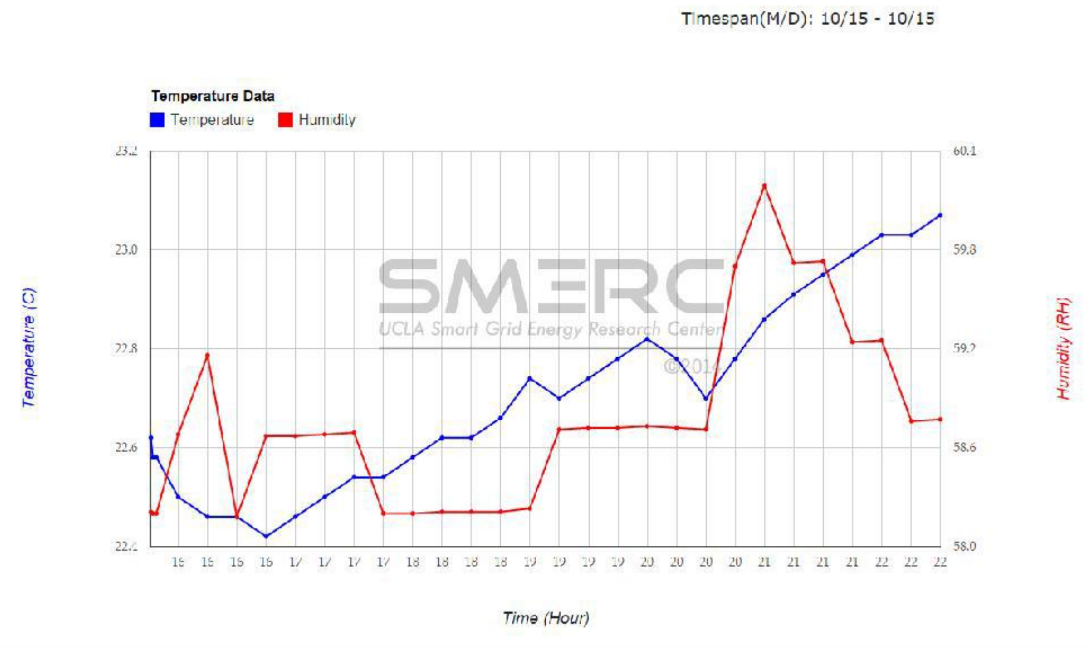


Figure 39: Ambient Temperature Data Collection

Epoch Time	timestamp	Temperature (C)	Humidity (%)
1413413158	10/15/2014 15:45	22.62	58.21
1413413217	10/15/2014 15:46	22.58	58.2
1413413331	10/15/2014 15:48	22.58	58.2
1413414001	10/15/2014 16:00	22.5	58.68
1413414901	10/15/2014 16:15	22.46	59.16
1413415800	10/15/2014 16:30	22.46	58.18
1413416702	10/15/2014 16:45	22.42	58.67
1413417601	10/15/2014 17:00	22.46	58.67
1413418501	10/15/2014 17:15	22.5	58.68
1413419401	10/15/2014 17:30	22.54	58.69
1413420301	10/15/2014 17:45	22.54	58.2
1413421201	10/15/2014 18:00	22.58	58.2

Figure 40: Ambient Temperature Data Spreadsheet

7.2.1.4.3 Control of Chargers

In addition to the implementation results presented in Use Case EV.1 and EV.2, Figure G and Figure H show the result of controlling the charging current and on/off state:

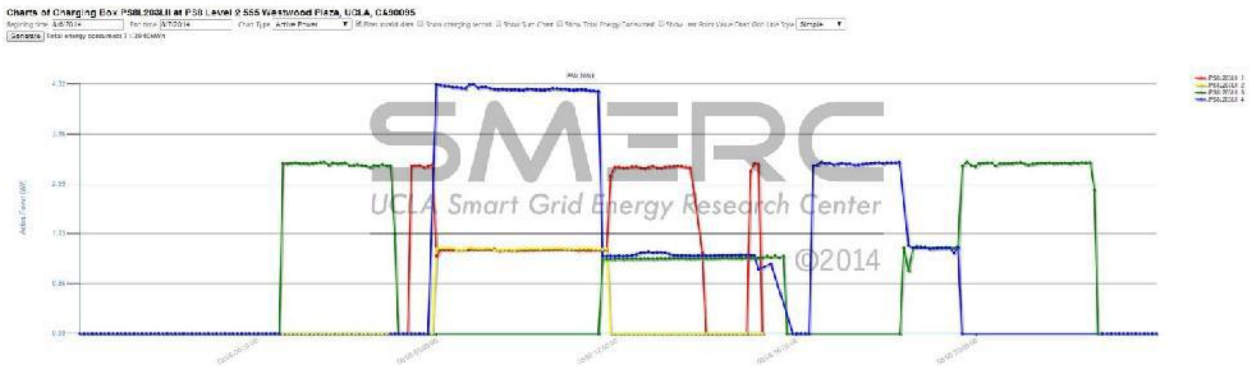


Figure 41: Charging Current Control

Figure G shows the active power consumptions from 4 different EV charging plugs that shares two power circuits. The power consumption of each individual plug is represented by the colored curves in the chart – one color corresponding to one individual plug. While charging stations represented by Red and Yellow curves share one power circuit; charging stations represented by and Green and Blue curves share one power circuit. As shown in Figure G, with the second EV plugged into the charging stations, the power (charging current) is reduced to accommodate the maximum capacity of the circuit. Similar current reduction control was also implemented on the power sharing among 4 EV charging stations.

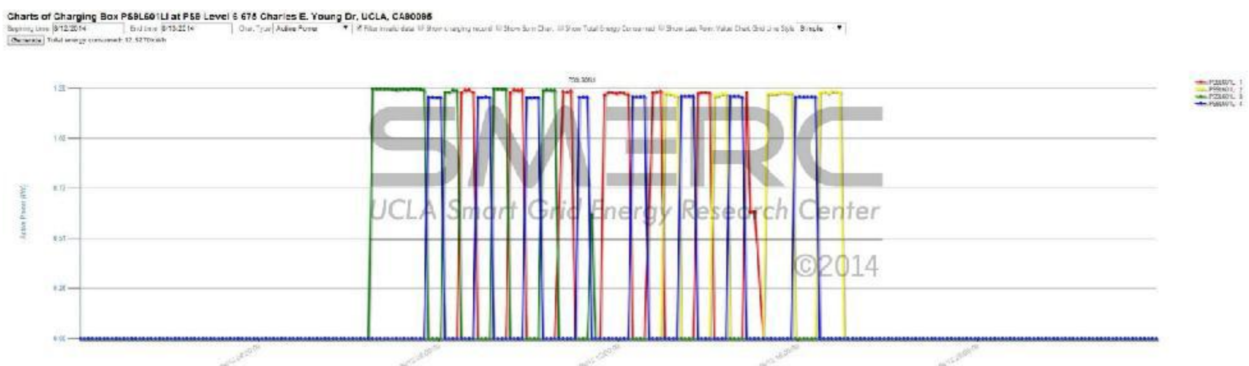


Figure 42: Control of On/Off State in a Level 1 Round Robin Algorithm

Similarly, Figure H shows the on/off control of four level 1 (120 VAC) EV charging stations in the control center. The control center alternatively turns the charging station on and off using round robin algorithm.

7.2.1.4.4 Disconnection of a Vehicle that is Charging

The function of suspending or reducing charging current can be done through control center's web interface as shown in Figure I:

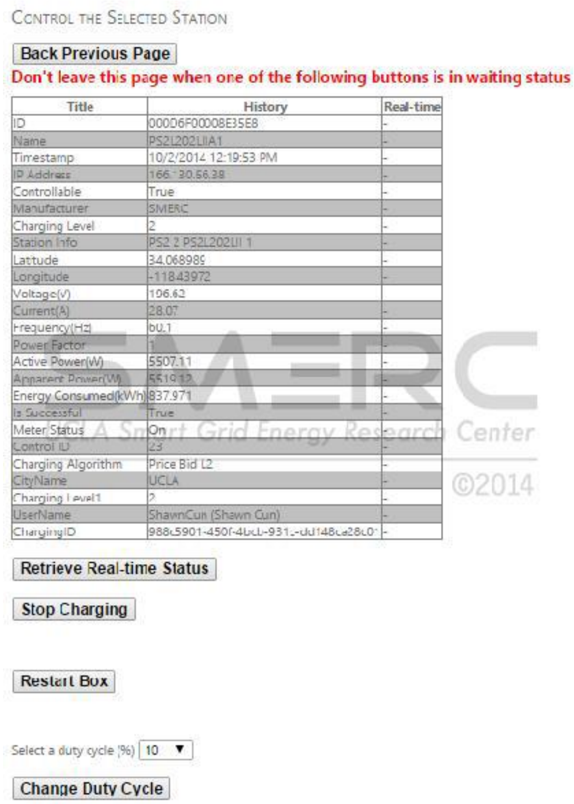


Figure 43: Suspend or Reduce Charging Current of an EV Charging Station

As shown in Figure 43, UCLA SMERC control center allows for “Stop Charging” and “Change Duty Cycle” to suspend or reduce charging current of an EV charging station.

7.2.1.4.5 Smart Charging through Mobile Interface

EV owners can control the charging sessions of their vehicles through a mobile app or any other device with internet capability. The following are the basic features available in the current mobile app:

1. Check charging station Availability
2. View a map of stations
3. Start and stop charging sessions
4. Check charging status and records
5. Schedule a charging session
6. Check or cancel a scheduled charge
7. Change password or settings under setup

SMERC integrated an updated API 2.0 into the web-based App and are currently working on integrating the 3rd generation GUI into the EVUser Mobile app. SMERC also modified the interface to support the new algorithms in development. The following figures show the new features available through the web-based app:

Figure 44: Mobile App/Web Interface Menu

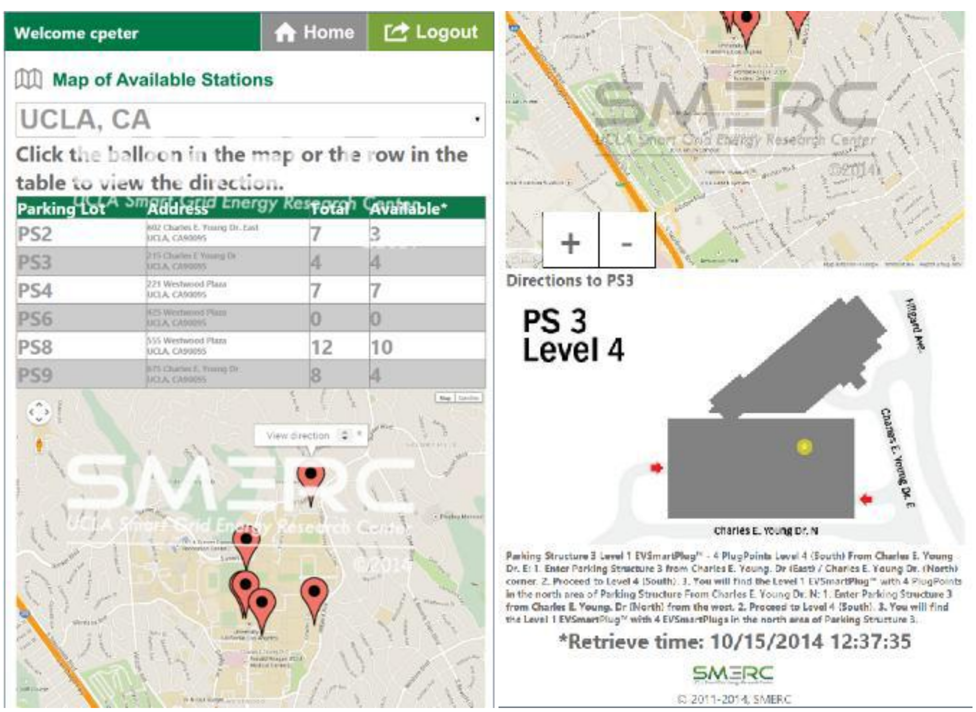


Figure 45: Map of Available Stations and Direction

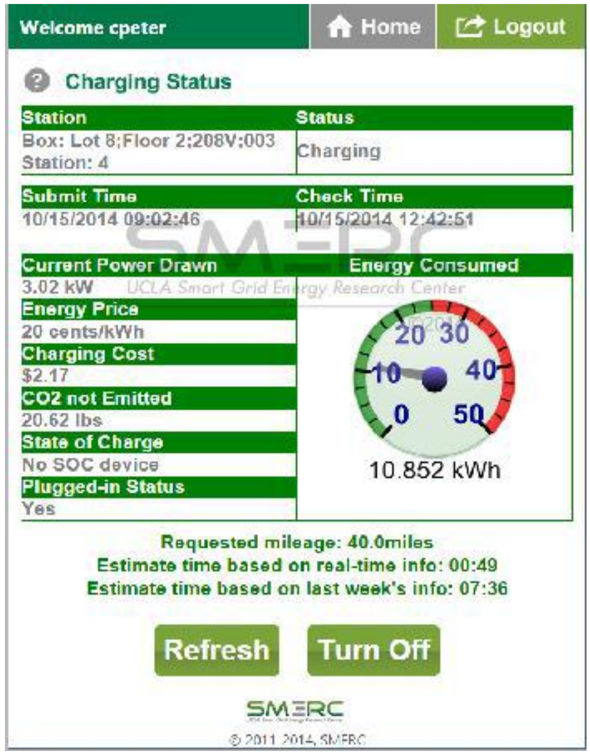


Figure 46: Information and User Preference Displayed on Charging Status

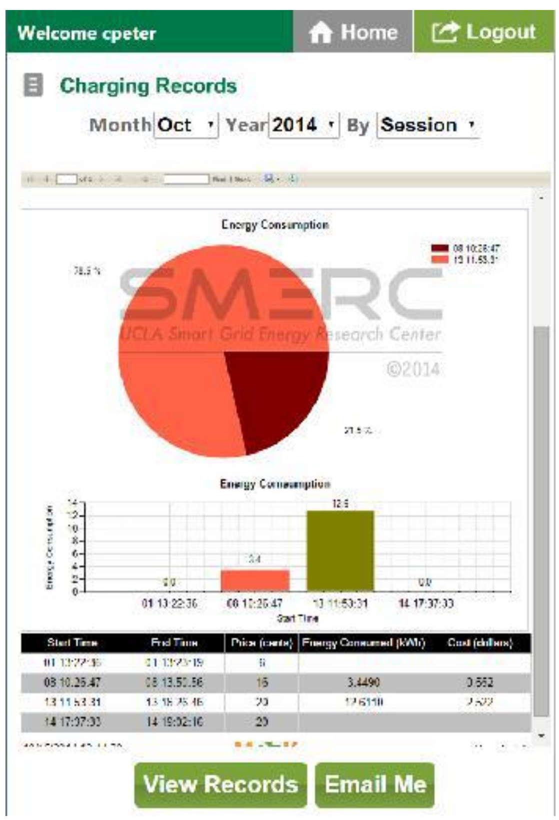


Figure 47: Information Display on Charging Record

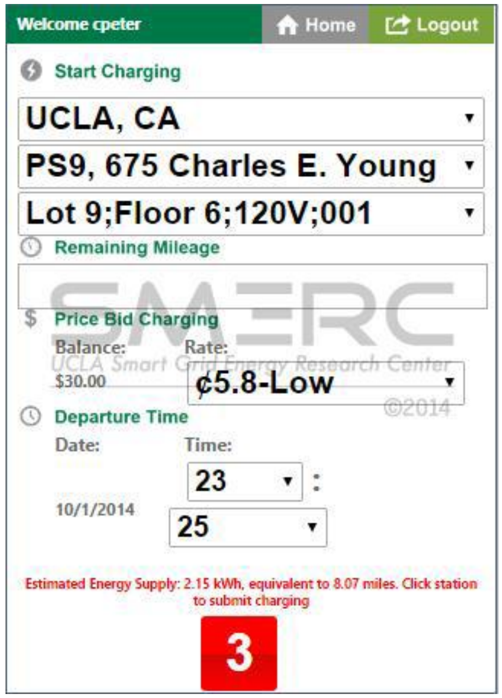


Figure 48: User Specify Preference when Starting Charging

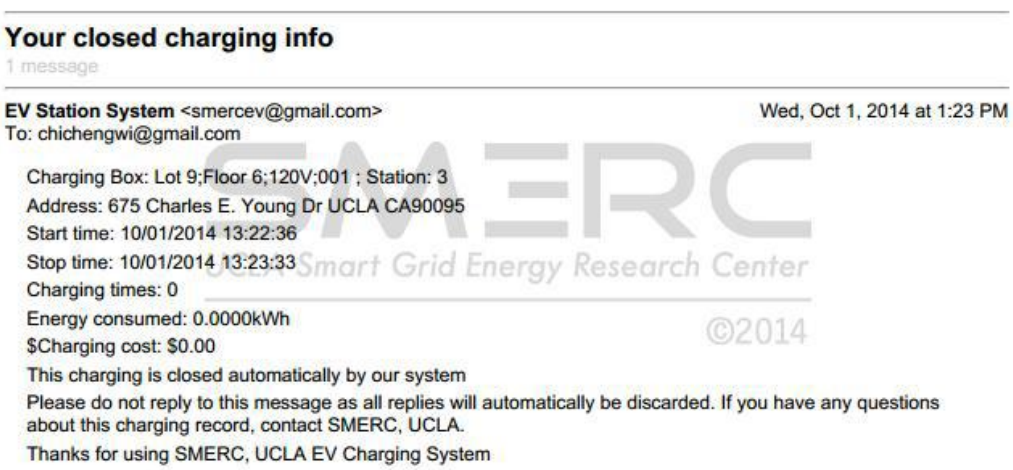


Figure 49: Example of Notification Messages

SMERC added web controls in the Start Charging page to support price-based charging algorithms. The charging profile consists of two main components: 1) price preference, i.e. maximum accepted electricity price, and 2) estimated departure time. The system remembers the input from the previous charging session and selects it as a default profile, which saves time for the user. Once the user completes the profile, a prediction algorithm on the control center will automatically compute the predicted energy consumption and equivalent miles according to the user's profile. The user can start the charging session based on the predicted schedule by clicking a charging station icon.

7.2.2 Battery Aggregation and Backfill

7.2.2.1 Methodology

This demonstration area will be responsible for the use of batteries in the Grid (one way, Grid-to-vehicle), the use of batteries in the Grid (two way, Grid-to-vehicle and vehicle-to-Grid) and the effects of battery aggregation and backfill on distribution (Grid-to-battery, battery-to-vehicle, and battery-to-Grid). This will determine how to locally aggregate EV batteries to serve as backfill into the power grid. This will provide local grid stability, and by ensuring that sub-sections of the grid maintain an available back-up power supply, will serve as a primary prevention against large-scale outages. Backfilling also will provide an effective means of load leveling power supply for customers in the event of a power outage to reduce costs and will improve customer reliability and satisfaction.

To demonstrate the use cases and meet the success criteria for this demonstration area, the EV Project team will design and implement a control system process to schedule EV charging and discharging in a manner that is beneficial for the vehicle and the grid. Additionally, the EV team will install appropriate grid-tie inverters and bi-directional AMI Smart Meters to demonstrate V2G and G2V operations. Lastly, the EV team will collect battery data at fifteen-minute intervals to study the effects of battery aggregation and backfill on distribution.

7.2.2.2 Technologies Deployed

Equipment Overview	Total	Installed/ Acquired
Electric Vehicle (G2V/V2G Capability)	2	2

Table 21: Battery Aggregation and Backfill Equipment List

7.2.2.3 Success Criteria

The success criteria for Battery Aggregation and Backfill include the successful completion of all use cases. Additionally, a report on the integration and aggregation of EV batteries into the power grid will also be generated as a part of the success criteria for the demonstration area.

UCLA SMERC is collecting data regarding the use of batteries in the Grid. The EV Project team will do research regarding the distribution effects of battery aggregation and backfill. The report on the integration and aggregation of EV batteries into the power grid will be generated at the end of the project in 2016.

7.2.2.4 Observations and Results

Figure Q shows a sample of the collected data in CVS format. Important information such as time, voltage, current, frequency, active power, apparent power, power factor and energy are stored in the database as well as the CVS file. The sensor retrieve data passively every 3 min.

ID	Time	Voltage(V	Current(A	Frequency	Active Po	Apparent	Power fac	Energy(kWh)
1	2014-11-24 15:24	123.58	6.1	59.98	717.79	753.84	0.95	14.529
2	2014-11-24 15:27	123.29	5.76	59.98	659.58	710.15	0.93	14.564
3	2014-11-24 15:30	122.97	5.52	59.98	678.79	678.79	1	14.596
4	2014-11-24 15:33	123	5.92	59.98	709.19	728.16	0.97	14.629
5	2014-11-24 15:36	123.13	6.3	59.98	691.48	775.72	0.89	14.661
6	2014-11-24 15:39	122.96	5.2	59.98	639.39	639.39	1	14.694
7	2014-11-24 15:41	123.03	5.12	59.98	597.92	714.73	0.84	14.714
8	2014-11-24 15:41	123.22	5.33	59.98	603.51	719.25	0.84	14.719
9	2014-11-24 15:44	123.79	6.33	59.98	725.4	783.59	0.93	14.746
10	2014-11-24 15:47	123.26	6.04	59.98	685.29	744.49	0.92	14.779
11	2014-11-24 15:49	123.37	5.87	59.98	667.43	724.18	0.92	14.803
12	2014-11-24 15:50	123.61	6.59	59.98	757.99	814.59	0.93	14.813
13	2014-11-24 15:53	123.25	5.76	59.98	608.27	622.33	0.98	14.847
14	2014-11-24 15:56	123.11	5.11	59.98	599.46	731.29	0.82	14.88
15	2014-11-24 15:59	123.62	6.64	60.1	700.61	820.84	0.85	14.912
16	2014-11-24 16:02	123.86	5.39	60.1	620.22	667.61	0.93	14.945
17	2014-11-24 16:05	124.53	6.48	60.1	717.1	717.1	1	14.98
18	2014-11-24 16:08	123.79	5.27	59.98	652.37	652.37	1	15.014

Figure 50: Sample of Collected Data of G2V/V2G

Figure 51 and Figure 52 show the measured power quality information over 2 days. From the figures, it can be observed that voltage magnitude fluctuates with the discharge of EV. It can be clearly seen that with the support of V2G, the voltage rises from 121V to 124V.

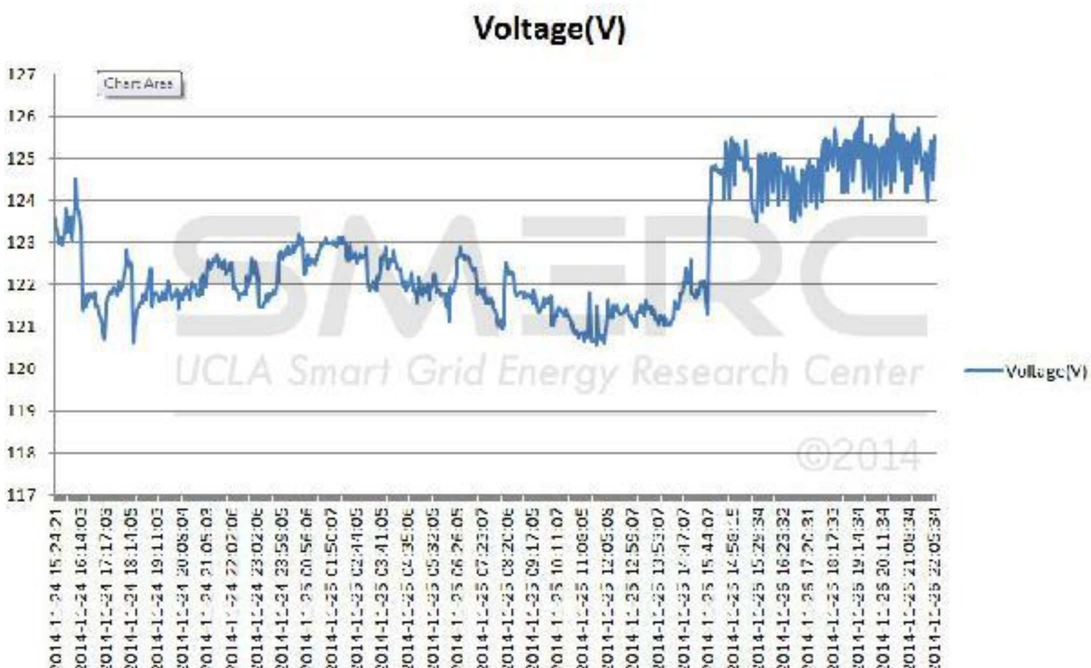


Figure 51: Measured Voltage

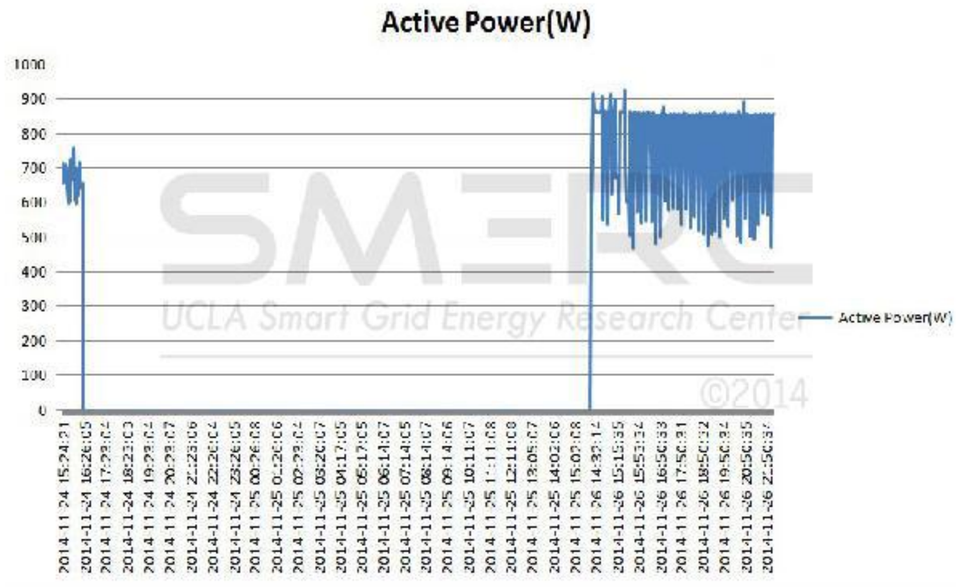


Figure 52: Measured Power Flow

Figure 53 and Figure 54 further show frequency variation and accumulated energy. It can be observed that V2G at an individual level cannot affect the frequency of the power grid. The frequency variation still comes from the generation and load side. However, if V2G is performed in a large scale - for example, 1000 EVs perform V2G at the same time - there is a possibility that observable frequency change can on the grid side.

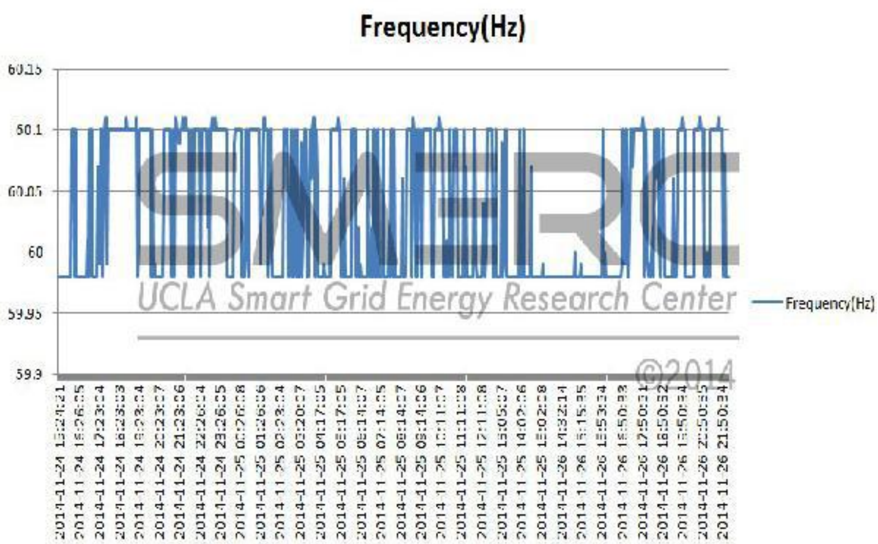


Figure 53: Measured Frequency Variation

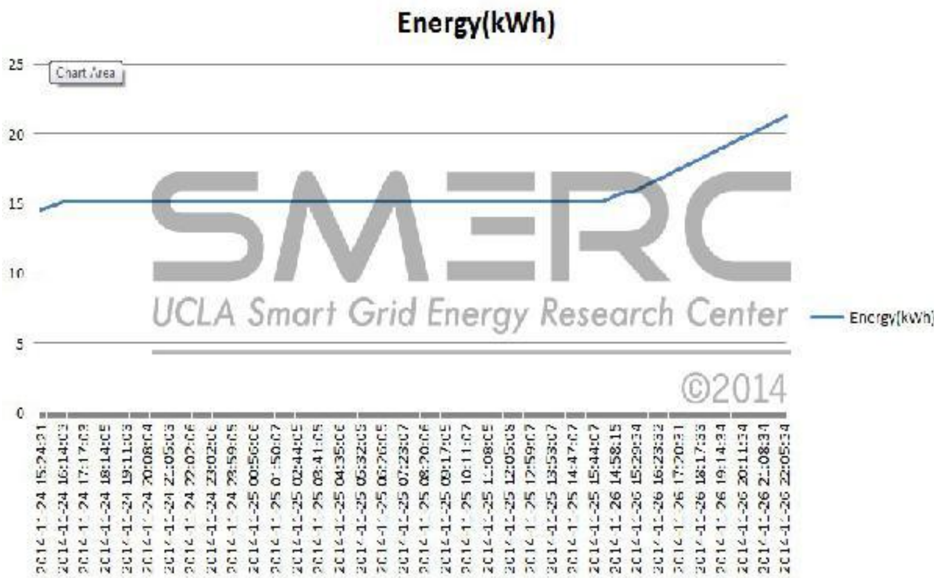


Figure 54: Energy Accumulation

7.2.3 Fully Functional Microgrid

7.2.3.1 Methodology

This demonstration area will be responsible for inductive charging, the ability to charge various vehicles, a study on distribution effects and a demonstration of the local grid balancing management. Other demonstrations that have been performed in the EV Project will be included in this fully integrated demonstration. A key outcome will be the demonstrated ability of the Microgrid to operate either off-grid or on-grid and the viability of the fully automated wireless sensing, monitoring and control to move between these two states depending on system conditions.

To demonstrate the use cases and meet the success criteria for this demonstration area, the EV Project team will retrofit selected electric vehicles to support inductive charging. Additionally, the EV team will install inductive charging stations to monitor power consumption and usage patterns. The EV team will also purchase various electric vehicles to compare the performance of various battery types and sizes. The EV team will study various positive and negative effects of electric vehicles on the microgrid to demonstrate how customers can lower their demand chargers and/or limit daily electric loads with EV chargers and battery storage.

7.2.3.2 Technologies Deployed

Equipment Overview	Total	Installed/ Acquired
Capacitor Bank Controllers w/cellular Modems	6	6
34.5KV Motorized Switch Operator (MSO)	1	1

MSO Single Phase Current Transformers	3	3
MSO Single Phase Potential Transformers	3	3
MSO Single Phase Faulted Circuit Indicators	3	3
MSO Controller/ Cabinet with Cellular Modem	1	1
Distribution Transformer Monitors (DTM)	74	74

Table 22: Fully Function Microgrid Equipment List

7.2.3.3 Success Criteria

The success criteria for the Fully Functional Microgrid include the successful completion of all use cases. Additionally, a report on EV charger integration and its impact on the grid will also be generated as a part of the success criteria for the demonstration area.

The report on EV charger integration and its impact on the grid will be generated at the end of the project in 2016.

7.2.3.4 Observations and Results

The EV Project team installed six capacitor controllers at Distribution Station (DS) 88 in the LADWP grid. Each capacitor controller is equipped with a Remote Terminal Unit (RTU) and a cellular modem. These controllers are connected to the LADWP OSI SCADA network and are observable and controllable. Below is a sample screenshot depicting the performance of two capacitor controllers at DS-88 and shows the corresponding KVAR flow.

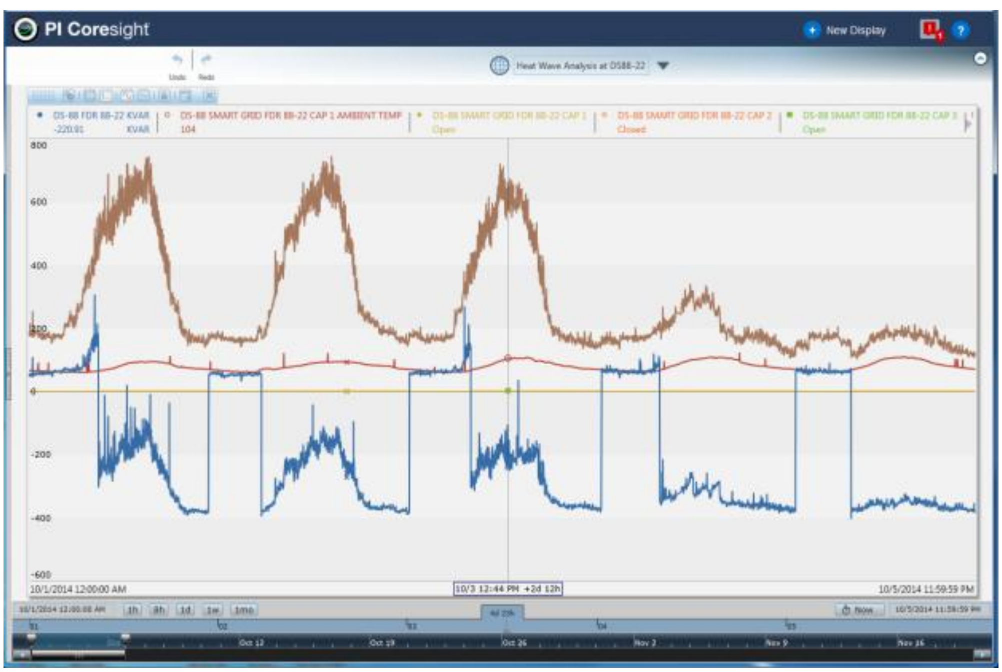


Figure 55: KVAR flow on a Capacitor Controller at DS 88

Additionally, the EV Project team deployed 65 overhead transformer monitors in circuits fed by DS-88. These devices log the following 11 characteristics with corresponding timestamps:

- DTMID – Distribution Transformer Monitor Identification
- KWH – Total Accumulated KWH for the device
- KVAH – Total accumulated KVAH for the device
- VRMS, VMAX, VMIN – The RMS voltage at time of reading and the max and min voltage recorded since last reading
- IRMS, IMAX, IMIN – The RMS current at time of reading and the max and min current recorded since last reading
- TEMPC, TEMPF – Recorded temperature in °C and °F

The Figure below is a screenshot of a sample data on a transformer monitor. The EV Project team delivers to USC on a monthly basis for analytical purposes.

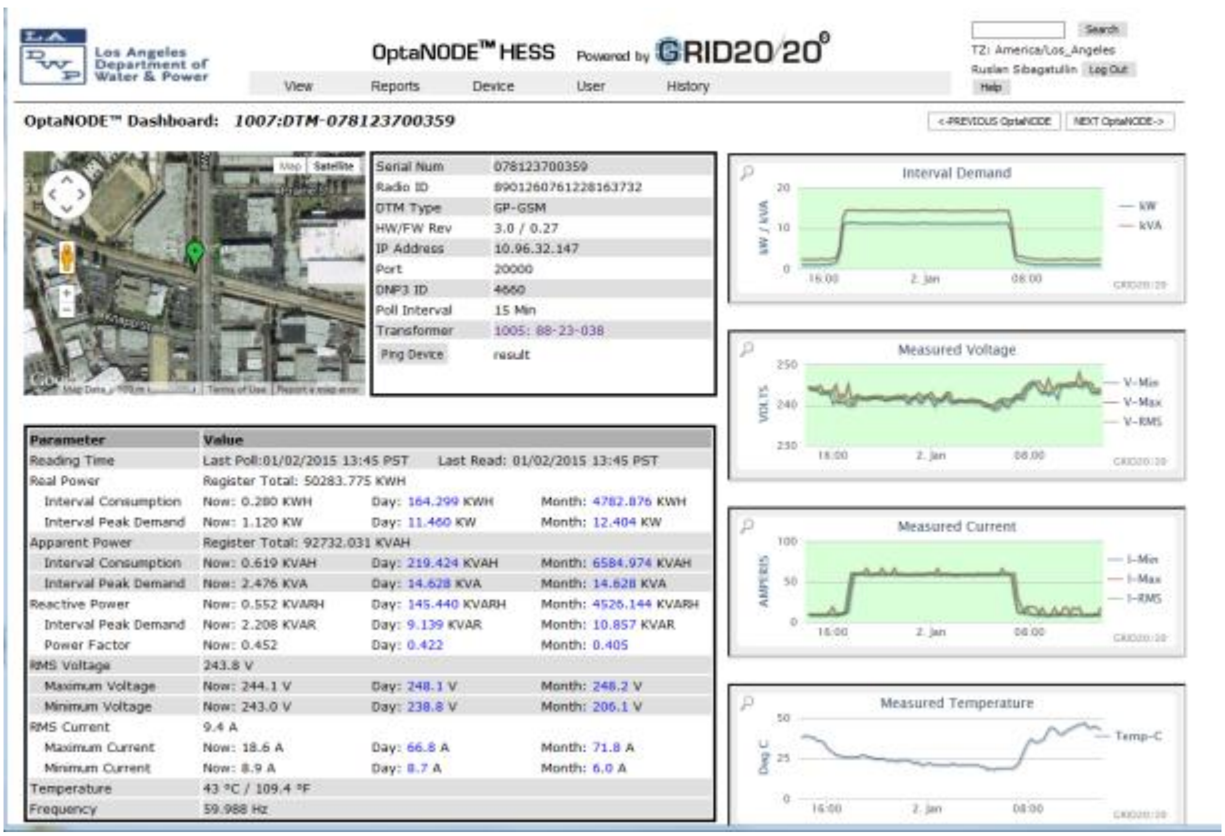


Figure 56: Transformer Monitoring Data Screenshot

7.2.4 Renewables and Battery Integration

7.2.4.1 Methodology

This demonstration area will be responsible for the use of community storage on Electric Vehicle batteries and external storage, the Garage of the Future, the cycling of batteries, the aggregation of batteries, and integrating Electric Vehicles and solar. This will demonstrate the viability of using charged EV batteries as an integrated set of storage devices to use for maintaining grid integrity.

To demonstrate the use cases and meet the success criteria for this demonstration area, the EV Project team will install lithium-ion battery modules in a parking structure to store/release energy. The EV team will also build the Garage of the Future to demonstrate EV charging through various renewable resources. Additionally, the EV team will replicate normal electric vehicle driving conditions by charging and discharging an EV battery in a lab environment. Lastly, various scenarios to explore the feasibility of load-shedding using a group of EV chargers will be performed in order to find the optimal aggregation, control methods, and potential benefits.

7.2.4.2 Technologies Deployed

Equipment Overview	Total	Installed/ Acquired
Garage of the Future	1	1*

*Installed but not energized

Table 23: Renewables and Battery Integration Equipment List

7.2.4.3 Success Criteria

The success criteria for Renewables and Battery Integration include the successful completion of all use cases. Additionally, a report on the usage of EVs as renewables will also be generated as a part of the success criteria for the demonstration area.

The report on the usage of EVs as renewables will be generated at the end of the project in 2016.

7.2.4.4 Observations and Results

UCLA SMERC is running practical experiments using the integrated battery storage system in the lab to research how to best decrease the power fluctuations of solar generation. These experiments will provide a solution for the fluctuation of PV output, which can negatively affect the performance of the greater electric network, especially where there are high levels of PV penetration. These fluctuations also complicate the prediction of the PV's output power, which makes PV generation difficult to consider for scheduling on the power network. Figure 57 and Figure 58 show the fluctuations of the solar panels on Ackerman Union.

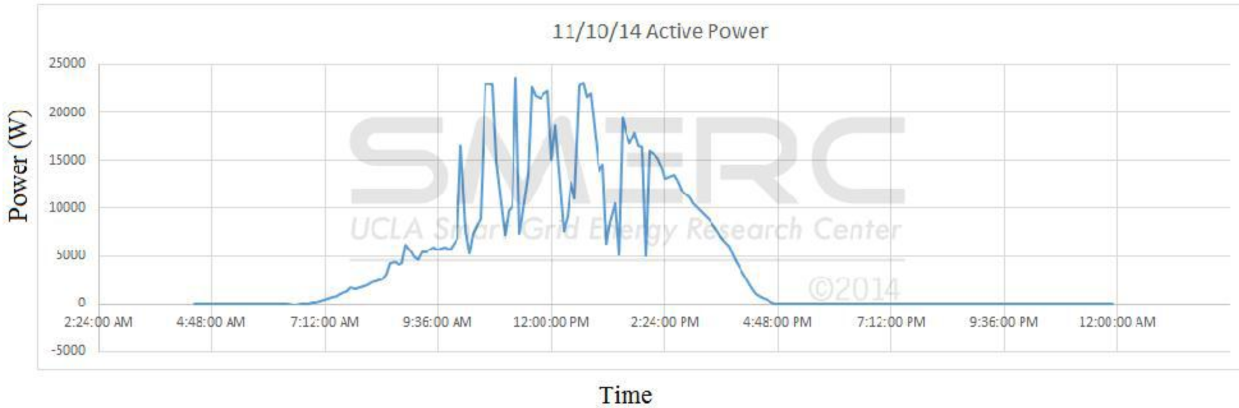


Figure 57: Power Fluctuation of PV over One Day

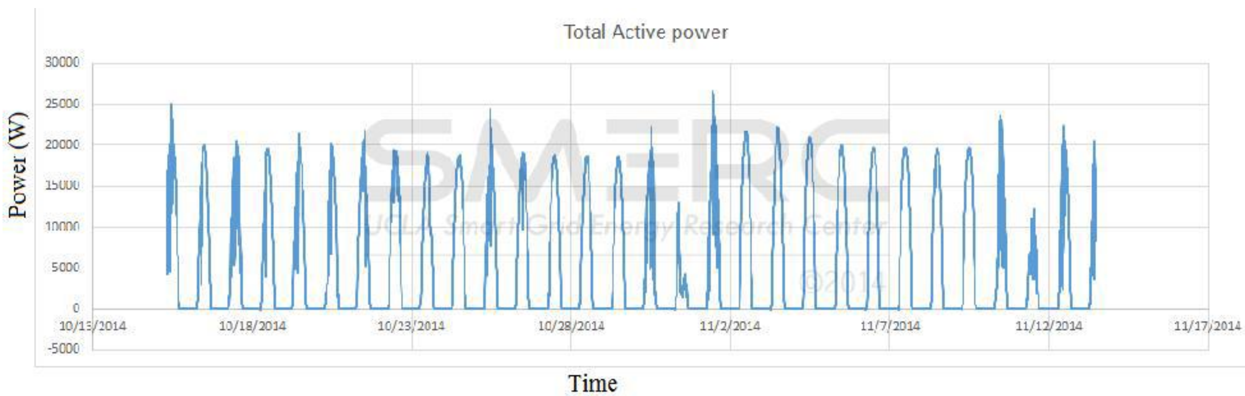


Figure 58: PV Power Fluctuation over One Month

For our experiments, we have developed a real-time control algorithm for the control center that processes data from solar power to generate an appropriate compensation command. The control center sends the generated command to the local controller via Ethernet and http, and the local controller communicates with the BMS and grid-tie inverter through the Modbus TCP/IP and serial port to execute the command. Figure 59 shows the battery storage system's energy compensation for solar power fluctuations on a typical day, using data obtained from the solar panels on Ackerman Union.

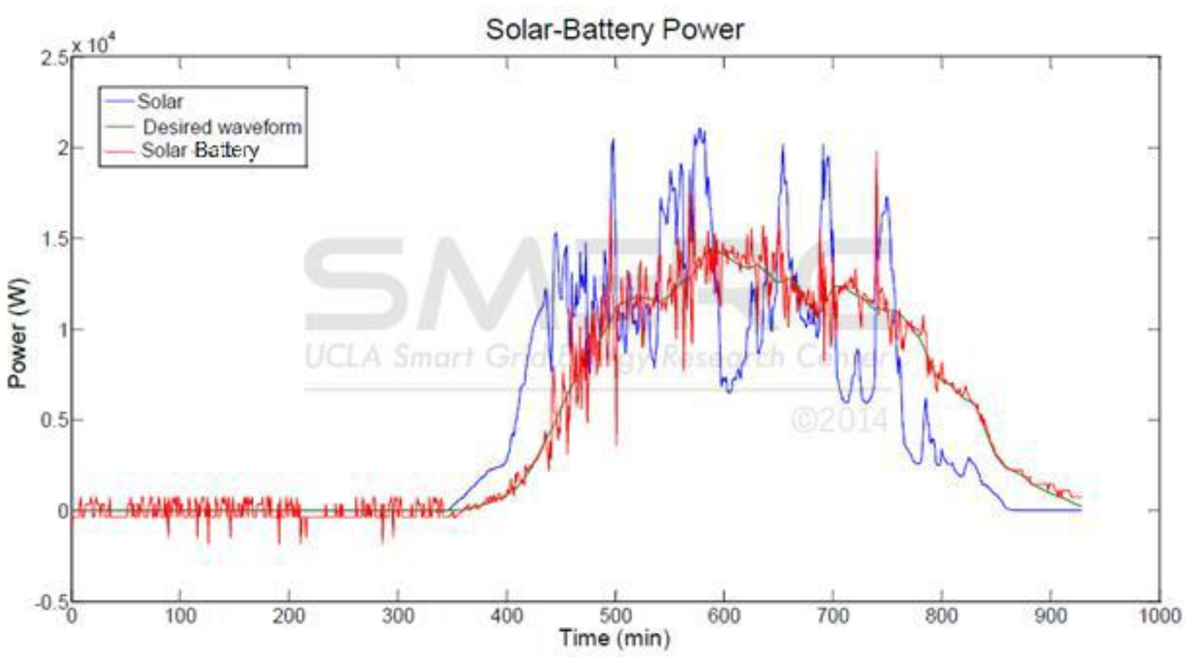


Figure 59: Output Power of Solar and Battery

From the chart, we still see some fluctuations in the output power, due to the computational and execution delays of the controller and devices, but the root-mean-square deviation (RMSD) or root-mean-square error (RMSE) show a 70% improvement in damping the fluctuation by employing the battery storage system. Moreover, the remaining fluctuations fall in a higher frequency range that we can ignore, as utilities are more concerned about results that last for several minutes. Despite these results, we continue research on how to decrease solar power fluctuations. We should note that, theoretically, we do not expect to dampen completely these fluctuations due to the existing delay in the control center; thus, we cannot expect a 100% success rate in a future physical system. Figure Y shows the battery storage system's execution time for a command signal sent by the control center. Although the battery system follows the command perfectly, a delay still exists between the sent command and its execution by the battery system.

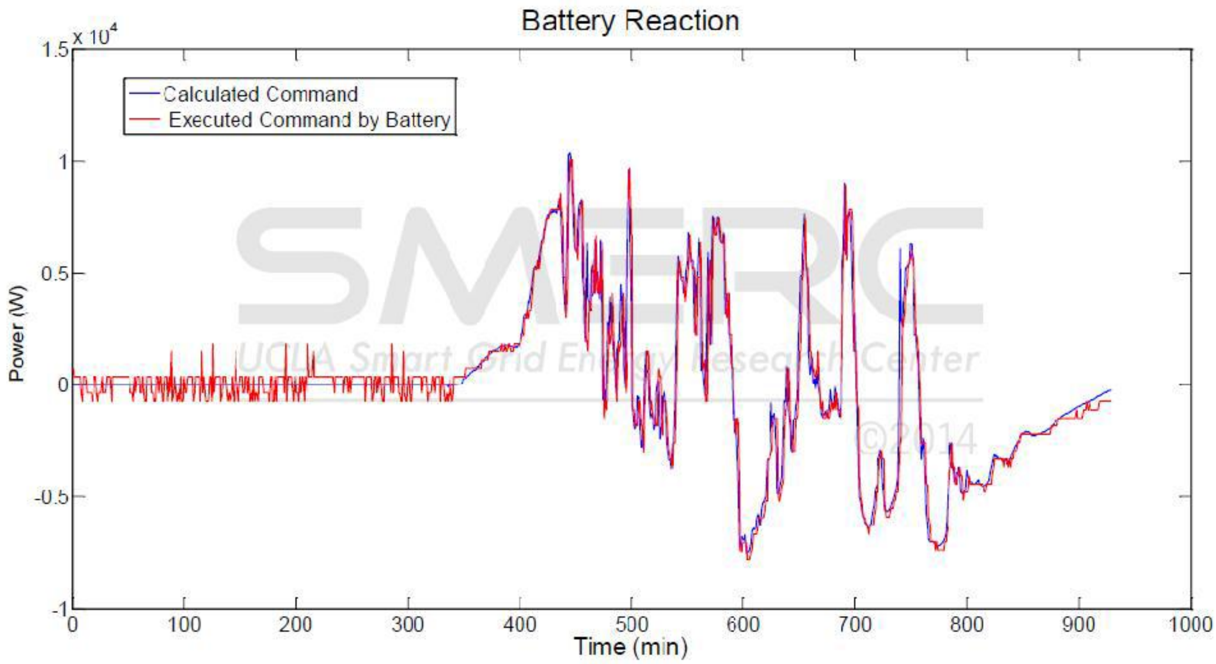


Figure 60: Battery Reaction to Command Sent by Control Center

Additionally, UCLA SMERC team successfully integrated the data collection for the existing Solar panel at Ackerman roof top – a 38 kW solar panel system.

Figure 61: Ackerman Roof Top Solar Panel

Another Solar Panel system (50 kW) is being installed in UCLA and will be used for the demonstration's 2nd phase data collection and demonstration with EV charger and ESS during the operation phase of the project.

Systematic data collection started on 10/15/2014. The following figure shows current data captures.

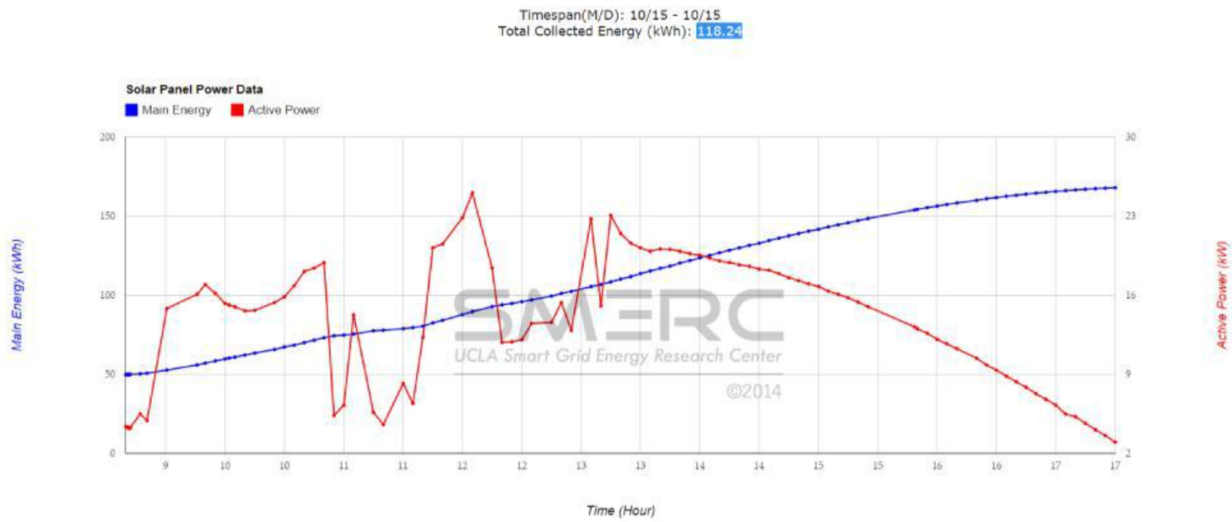


Figure 62: Solar Panel Data of 10/15/2014

7.2.5 Using Car Sharing Programs at USC and UCLA

7.2.5.1 Methodology

This demonstration area will be responsible for the monitoring of charges, power usage and car usage and the distribution effects of the car/ride sharing programs. This will provide the opportunity to use two distinct test-beds that include different user demographics, grid specifications, and driving patterns. UCLA and USC are in different areas of Los Angeles that result in different average distances traveled per car trip, a key factor in planning the rate and capacity of charge provided to a fleet of EVs. This information can be used for full scale Smart Grid implementation planning.

To demonstrate the use cases and meet the success criteria for this demonstration area, the EV Project team will collect data from electric vehicles to perform statistical analysis and driving characterization. Additionally, the EV team will study customer charging habits and will create models to study the impacts of large-scale deployment of EV chargers.

7.2.5.2 Technologies Deployed

Equipment Overview	Total	Installed/ Acquired
Electric Vehicle	67	67

Table 24: Using Car Sharing Programs at USC and UCLA Equipment List

7.2.5.3 Success Criteria

The success criteria for the Car Sharing Programs include the successful completion of all use cases. Additionally, a report on EV usage, consumption, and charging will also be generated as a part of the success criteria for the demonstration area.

7.2.5.4 Observations and Results

The EV Project team has been utilizing LADWP's fleet in order to collect data for this demonstration. The table below is a sample of the data collected:

Electric Vehicle Usage														
Required Basic Information			Trip Start						Trip Stop					
EV ID	Driver Name	Extension	Date	Time	EV Charger ID	Odometer Mileage	Battery Mileage	Battery Percent	Date	Time	EV Charger ID	Odometer Mileage	Battery Mileage	Battery Percent
P44658	Aram Chavdarian	x75292	6/19/2014	2:00 PM	PL3EV3	1785	63		6/19/2014	2:30 PM	PL3EV3	1790	57	
P44658	Aram Chavdarian	x75292	6/20/2014	10:45 AM	PL3EV3	1790	63		6/20/2014		PL3EV3	1796	57	
P44658	Emil Abdelshehid	x74841	6/23/2014	7:52 AM		1795.8	64		6/23/2014	8:15 AM				
P44658	Emil Abdelshehid	x74841	6/23/2014	8:49 AM					6/23/2014	9:06 AM		1808.7	53	
P44658	Aram Chavdarian	x75292	6/25/2014	2:30 PM	PL3EV3	1808	63		6/25/2014		PL3EV3	1814	57	
P44658	Emil Abdelshehid	x74841	6/26/2014	11:53 AM		1814.2	68		6/26/2014	1:15 PM		1823	58	
P44658	Aram Chavdarian	x75292	6/27/2014	8:15 AM	PL3EV3	1823	63		6/27/2014	9:45 AM	PL3EV3	1831	57	
P44658	Aram Chavdarian	x75292	6/30/2014	1:30 PM	PL3EV3	1836	63		6/30/2014		PL3EV3	1842	57	
P44658	Surendra Vohra	x74705	7/9/2014	7:30 AM		1847.3	70		7/9/2014	9:30 AM		1851.7	60	
P44658	Aram Chavdarian	x75292	7/9/2014	2:15 PM	PL3EV3	1850	67		7/9/2014	2:50 PM	PL3EV3	1856	63	
P44658	Aram Chavdarian	x75292	7/10/2014	1:38 PM	PL3EV3	1856	65		7/10/2014	2:10 PM	PL3EV3	1862	59	
P44658	Aram Chavdarian	x75292	7/11/2014	7:20 AM	PL3EV3	1862	66		7/11/2014	8:55 AM	PL3EV3	1867	65	
P44658	Aram Chavdarian	x75292	7/14/2014	2:22 PM	PL3EV3	1867	63		7/14/2014	3:05 AM	PL3EV3	1873	58	
P44658	Aram Chavdarian	x75292	7/15/2014	9:48 AM	PL3EV3	1871	63		7/15/2014	11:07 AM	PL3EV3	1877	56	
P44658	Emil Abdelshehid	x74841	7/17/2014	8:00 AM		1877.7	65		7/17/2014	8:40 AM		1879.4	59	
P44658	Aram Chavdarian	x75292	7/17/2014	2:10 PM	PL3EV3	1879	62		7/17/2014	3:01 PM	PL3EV3	1884	57	
P44658	Aram Chavdarian	x75292	7/18/2014	9:35 AM	EV3PL3	1884	63		7/18/2014	12:04 PM	EV3PL3	1891	61	
P44658	Aram Chavdarian	x75292	7/22/2014	10:10 AM	PL3EV3	1891	63		7/22/2014	11:47 AM	PL3EV3	1897	61	
P44658	Emil Abdelshehid	x74841	7/24/2014	7:37 AM		1901.3	69		7/24/2014	7:44 AM		1902.3	67	
P44658	Emil Abdelshehid	x74841	7/24/2014	8:07 AM		1902.3	67		7/24/2014	8:12 AM		1903	63	

Table 25: Electric Vehicle Usage Sample Data

Additionally, the EV team is submitting this data to USC for further analysis.

7.2.6 Grid Impact Stability / Power Study

7.2.6.1 Methodology

This demonstration area will be responsible for the generation, transmission, and distribution effects and various loading scenarios of the Electric Vehicle on the Grid. This will demonstrate the impact of EVs on the Electrical Grid.

To demonstrate the use cases and meet the success criteria for this demonstration area, the EV Project team will collect data from the chargers to study the impacts to generation, transmission, and distribution and also perform various loading scenarios. The EV team will create computer models to analyze existing LADWP infrastructure and will gather information from various substations, distribution automation equipment, and various AMI meters.

7.2.6.2 Technologies Deployed

None available.

7.2.6.3 Success Criteria

The success criteria for the Grid Impact Stability and Power Study include the successful completion of all use cases. Additionally, a report demonstrating the impact of EVs to the grid will also be generated as a part of the success criteria for the demonstration area.

The report demonstrating the impact of EVs to the grid will be generated at the end of the project in 2016.

7.2.6.4 Observations and Results

This demonstration area is underway with the data collection occurring with the other demonstration areas. A final report will be delivered at the end of the project at 2016.

8 Cyber Security

Effective implementation of a Smart Grid requires the design and development of a cybernetic system architecture that is secure, scalable and practical, while simultaneously meeting concerns of both LADWP and its customers. The rapidly changing customer environment is now characterized by introduction of Home-Area Networks (HANs), co-generation capabilities, plugin EVs, smart appliances and smart Heating, Ventilating and Air Conditioning (HVAC) systems. Grid applications in such a fluid environment require an open-access to many capabilities that in the past have been more tightly controlled.

To support these needs, the SG requires the timely exchange of information between the utility operators and its customers. Those exchanges will necessarily use both private and commercial computer networks which raising additional serious security issues. The CS project within the SGRDP is responsible for addressing such issues and creating the security strategy for the entire SGRDP system.

The recognition that new approaches are required to address such risks is also resonant with the Department of Energy's "*Smart Grid Cyber Mission*". To achieve needed security the CS project adopts a *defense-in-depth* strategy that integrates two complementary design approaches. The first approach draws upon standard or 'classic' security techniques, such as role-based authentication, authorization and application design guidelines, which provide needed security features, while preserving usability. The second approach will develop 'next generation' CB techniques, tailored to the SG, that improve its resilience to attacks and faults. The CS project will also implement a risk assessment process, patterned on federal guidelines FIPS 199 and NIST SP 800-30, and a rigorous test and validation process to comply with testing requirements described in DE-FOA 0000036.

The generated list of threats is used as input for a variety of tasks, namely: (a) overall risk analysis and mitigation (Risk Assessment Section) (b) attack analysis for understanding the flow of threats through the system from an attacker's perspective, (c) fault analysis for understanding threats from a system failure perspective (Fault/Failure Tree Analysis Section), (d) as inputs for the design of the detection, diagnosis and response component and (d) as inputs to generation of test cases for the CS design.

The CS component is driven by a number of requirements in the nominal system definition, and has its own decomposition of requirements from the top level. After a thorough assessment of these requirements, CS project has identified multiple areas where CS services can be provided to the SG project's core functionalities (AMI, DR, CB, and EV). These operations broadly fall under the following categories:

- Routine Operations
- Security Event Response– Detection, Diagnosis, Response
- Maintenance– Risk Assessment and Security Updates

During routine operations, features like encryption, authentication, and access control will be tightly integrated with the normal operation of the SG. At the same time, detection services will monitor the system for unusual events that may signal a cyber-attack, and if a security event is detected, security functions will respond to maintain system security. In some cases these responses will be automated, and in others, guided by the operator.

CS operations span the whole entire system, and will include:

- Day-to-day operation of CS components under nominal conditions
- Updates and routine maintenance of CS components, to ensure all knowledge bases are up-to-date, and that all components continue to operate within reasonable constraints.
- Real-time behavior of automated monitoring and response functions when detecting and responding to an incident.
- Operator responses to detected incidents, and interactions with CS components to secure the system and maintain critical grid functions.
- Forensics, updates, and maintenance of CS components after anomaly operations have completed, intended to correct the consequences of an incident and resume full system operation in a timely manner.
- CS support for business continuity operations.

8.1 Summary

Demonstration Areas	Use Cases
Grid Resilience against Cyber Attacks	*Capability to Detect Attacks*
	Capability to Diagnose the Provenance of Attacks
	Capability to Remediate or Contain the Consequences of Cyber Attacks
System Integrity	*Detection of Manual Inserted Changes to Software on All Classes of Nodes*
	Reconfiguration and/or Recovery to Legitimate Software Configuration on Affected Components
	Protection of Audit and Configuration Data
Secure Data Management	*Detection of Modified Billing, Configuration and Audit Data, and Behavior of System upon Detection*
	Denial of Attempts to Access or Transmit Data where such Access or Transmission is Counter to Defined Information Flow Policies
Testing: Effectiveness	*Systemic Response to Various Threats such as Malware Penetration and Physical Threats that will Affect Parts of the Smart Grid*
Testing: Predictive Capability	*Issues (Limitations and Possibilities) Facing a Full-Scale Deployment of the Cyber-Security Approach*

Table 26: Cyber Security Demonstration Areas and Use Cases

For the Cyber Security Project, there are five different demonstration areas that are part of the Program Objectives. These areas include grid resilience against cyber attacks, system integrity, secure data management, effectiveness testing and predictive capability testing. Within each of these areas are use cases that will be executed in order to satisfy the Program Objectives. In all, there are a total of nine use cases to successfully demonstrate in order to satisfy the objectives.

8.2 Demonstration Areas

8.2.1 Methodology

8.2.1.1 Grid resilience against cyber attacks

This demonstration area will be responsible for the Grid's capability to detect attacks, its capability to diagnose the provenance of attacks, and its capability to remediate or contain the consequences of cyber attacks. This will demonstrate the Grid's active defenses against cyber attacks. It will take into account the accuracy and timeliness of detection and response and the outcome will lay out the pros and cons that accompany the full-scale deployment of such active cyber defense.

To demonstrate the use cases and meet the success criteria for this demonstration area, the CS Project team will develop a system that will be able to detect, diagnose, and respond to threats to the Smart Grid. The CS team will develop a DDR instance to consist of a monitor or monitors, a detector or detectors, a diagnosis engine, a response engine, and a controller. Additionally, the team will program each DDR instance will take five inputs (goals, domain info, policies, command and control, and monitored data) and produce three outputs (response plan(s), reports, and DDR-to-DDR communication). Lastly, the team will develop the optimal DDR architecture for the Smart Grid.

8.2.1.2 System Integrity

This demonstration area will be responsible for the detection of manual inserted changes to software on all classes of nodes, the reconfiguration and/or recovery to legitimate software configuration on affected components, and the protection of audit and configuration data. This will demonstrate the ability of the Smart Grid to detect and recover from compromises of system integrity, including software and firmware modifications (possibly resulting from malware attacks), and the addition of unauthorized physical components to the system.

To demonstrate the use cases and meet the success criteria for this demonstration area, the CS Project team will implement numerous security technologies in order to maintain system integrity. These include end-to-end encryption, virtual private networks, asymmetric cryptography, key management, identity management, access control, policy management, firewalls, privacy enforcement, audit record generation, intrusion detection/prevention system, and firmware download integrity checks.

8.2.1.3 Secure Data Management

This demonstration area will be responsible for the detection of modified billing, configuration and audit data, and behavior of the system upon detection and the denial of attempts to access or transmit data where such access or transmission is counter to defined information flow policies. This will demonstrate the ability of the Smart Grid infrastructure to limit the flow of customer, configuration, and audit data according to defined policies and to protect the integrity of the data.

To demonstrate the use cases and meet the success criteria for this demonstration area, the CS Project team will implement security services to different parts of the Smart Grid in order to manage secure data. The security services are the following:
Identity Management Service; Security Key Management Service; AAS/AAC; Information Integrity Service; Confidentiality Service; Privacy Service; Non-repudiation Service; Audit Service; Security Policy Service; Electronic Security Perimeter Protection Service; AMI, EV, DR, and CB Monitoring Service; AMI, EV, DR and CB Intrusion Detection Service; Diagnosis Service; Reporting, Response and Recovery Service; and Intrusion Detection Knowledge Base Service.

8.2.1.4 Testing: Effectiveness

This demonstration area will be responsible for the systemic response to various threats such as malware penetration and physical threats that will affect parts of the Smart Grid. This will demonstrate, through emulation on the DETER cyber-security test bed, the effectiveness of the security measures within the Smart Grid architecture.

To demonstrate the use cases and meet the success criteria for this demonstration area, the CS Project team will run a series of simulated attacks on a cyber model of the Smart Grid control and data transmission plane. This model will be implemented on a DETER test bed at USC, where the CS team will have complete control over the testing. This will allow the team to simulate cyber attacks on the Smart Grid model and demonstrate the cyber response. In order to test the physical response of the system, the model will simulate responses on the DETER test bed using modules derived from power system simulation packages such as GRIDLAB from PNNL.

8.2.1.5 Testing: Predictive Capability

This demonstration area will be responsible for the issues facing a full-scale deployment of the cyber-security approach. This will demonstrate the effectiveness of the proposed security capabilities when extended to a full-scale implementation of the Grid.

To demonstrate the use cases and meet the success criteria for this demonstration area, the CS Project team will put the Smart Grid system through additional testing phases. First, the system will be inserted into a high fidelity, fully operational domain, such as the microgrid. A selection of appropriate test runs will be executed from the subsystem and system testing and additional testing may be performed as required. During these tests, evaluations will be performed in order to complete the risk assessment and evaluate the performance of the system at a high-level. Lastly, once the system is placed into the operational environment, a suite of smoke tests and core functionality tests will be performed as updates are delivered to the system.

8.2.2 Technologies Deployed

- CS DDR (Mongo) Database

- Collectors for AMI Data
- Collectors for CG-NMS
- Generation of Syslog to SIEM
- Demonstration Detectors in Detector Bank
    - Detects and responds to packet signatures, runaway processes, and Denial of Service attacks
- CS Firewall with
    - Monitors that write to CS Database
    - Firewall reads remediation actions from database and enforces
    - Rate Limitation
    - Blocking flows
    - Resetting priority on process

8.2.3 Success Criteria

The success criteria for the Cyber Security Project have been slightly modified due an integration of identity management and policy component dependency on system integration activities. The CS Project team is assessing the application of the technologies

8.2.3.1 Grid resilience against cyber attacks

The success criteria for Grid Resilience against Cyber Attacks include the successful completion of all use cases. Additionally, periodic reports documenting the results of this demonstration along with a final report will be generated as a part of the success criteria for the demonstration area.

8.2.3.2 System Integrity

The success criteria for System Integrity include the successful completion of all use cases. Additionally, periodic reports documenting the results of this demonstration along with a final report will be generated as a part of the success criteria for the demonstration area.

8.2.3.3 Secure Data Management

The success criteria for Secure Data Management include the successful completion of all use cases. Additionally, periodic reports documenting the results of this demonstration along with a final report will be generated as a part of the success criteria for the demonstration area.

8.2.3.4 Testing: Effectiveness

The success criteria for Effectiveness Testing include the successful completion of all use cases. Periodic reports documenting the results of this demonstration along with a final report will also be generated as a part of the success criteria for the demonstration area. Additionally, the design of the security mechanisms for the Smart Grid demonstration project and the model/architecture of the cyber-security infrastructure for the Smart Grid will be provided as a part of the success criteria.

8.2.3.5 Testing: Predictive Capability

The success criteria for Predictive Capability Testing include the successful completion of all use cases. Periodic reports documenting the results of this demonstration along with a final report will also be generated as a part of the success criteria for the demonstration area. Additionally, the design of the security mechanisms for the Smart Grid demonstration project and the model/architecture of the cyber-security infrastructure for the Smart Grid will be provided as a part of the success criteria.

8.2.4 Observations and Results

Most attack traffic is blocked by existing DWP infrastructure, before reaching the SGRDP, and the traffic is not visible directly to the SGRDP security components. We are establishing feeds of this observational data through the SIEM so that this data is available for analysis.

We have not observed specific attacks within the demonstration infrastructure. Emulated attack traffic has been used to validate the functioning of the components. There have been few detected events other than those based on the emulated attack traffic, and those additional events have been false positive detections.

We expect to see greater actual attacks once the visibility of the infrastructure to potential adversaries increases. This will occur as the system remains in operation for a longer period of time, and as publicity around the capabilities increases.

A unit test script "run_detector" ran MDAD repeatedly on exported production data hosted on separate environments (developer laptop, JPL Integration Environment, CS-LADWP Integration Environment) and produced identical output each time. Metrics were also captured on RAM consumed during each run, and total running times. With approximately 3 months' of data, the Detector took about 4 hours to complete, so with 2 years' of data a detection cycle (if not modified) will complete in ~32 hours. This execution time is sufficient to detect anomalies with a large data set, within the applicable response time for energy theft detection. Similar execution times may or may not be acceptable for other classes of anomalies and failures.

A small test set was derived from operational meter data, with a bias applied after an injected fault (especially low power reading of 10 Wh), as shown in Figure 63.

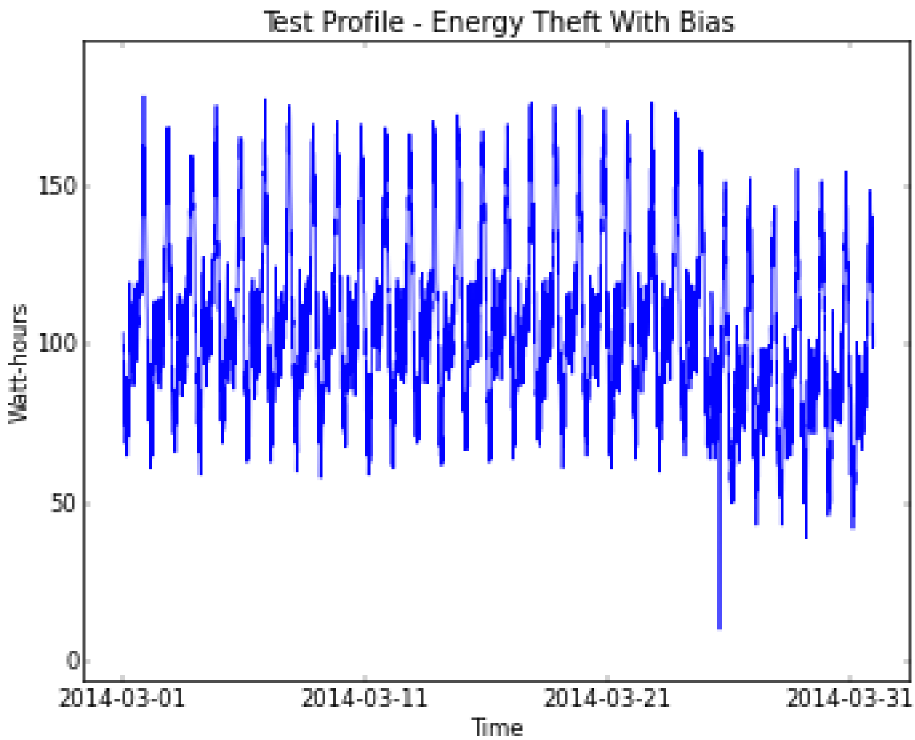


Figure 63: Test Profile

Command-line options are provided to modify the selected defaults for key parameters (such as threshold setting or running-average window size) so that hit rates and false alarm rates can be tuned with experience. Below are shown several different values for each such parameter used in unit testing to demonstrate their effects on hit and false alarm rates.

Parameter thresh_stdev_factor (default 2.5)	# Alarms	False alarm rate (1 - (1/Alarms))	Closest Alarm to Injected Fault time 2014-03-25T15:00:00
2	183	0.995	2014-03-25T15:00:00
2.5	23	0.96	2014-03-25T15:00:00
3	1	0	2014-03-25T15:00:00
4	0	--	--

Table 27: Detector – Statistical Outlier

Parameter Window_size (default 96)	Parameter Slope (default 1.5)	# Alarms	False alarm rate (1 – (1/Alarms))	Closest Alarm to Injected Fault time 2014-03-25:15:00:00
96	1.5	0	--	--
30	1.5	45	0.98	2014-03-25T07:45
40	1.5	1	0	2014-03-25T05:15

50	1.5	0	--	--
96	0.4	5	0.80	2014-03-24T15:15
96	0.5	2	0.50	2014-03-24T15:15
96	0.56	1	0	2014-03-24T15:15
96	0.6	0	--	--

Table 28: Detector: Running Average

A Appendix

AMI Technical Performance Report

Scope: This report indicates the status of the Technical Performance of the Advanced Metering Infrastructure (AMI) of the LADWP's Smart Grid Regional Demonstration Program (SGRDP), per the Demo Matrix and SOPO documents.

Note: Most of the following actions/demonstrations have been performed many times due to the nature of the operation of a metering system. The occasions described below have been recorded for the purpose of reporting.

Part 1: Metering Data Collection

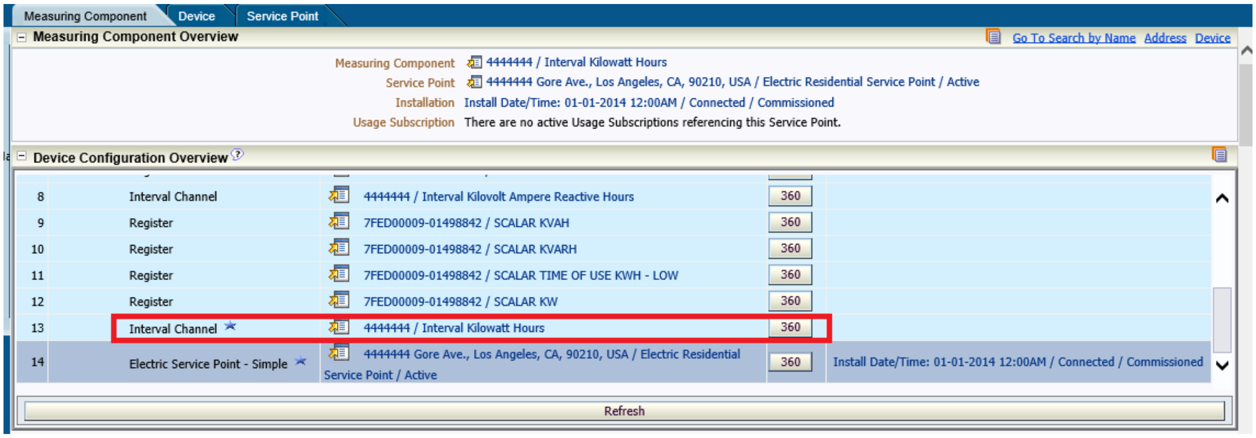
1. **Collect 15-minute KWH load profile data, as well as all the configured registers, such as KWH (Display 39) and KW Demand (Display 41), and events/alarms, such as high voltage and Last Gasp.**

   Action: 2 EV meters were selected for this test and included as part of the Acceptance Test Group
   1) 2.16.840.1.114416.1.24.1498842
      Badge: 7FED00009-01498842
   2) 2.16.840.1.114416.1.24.1498892
      Badge: 73FED00009-01498892

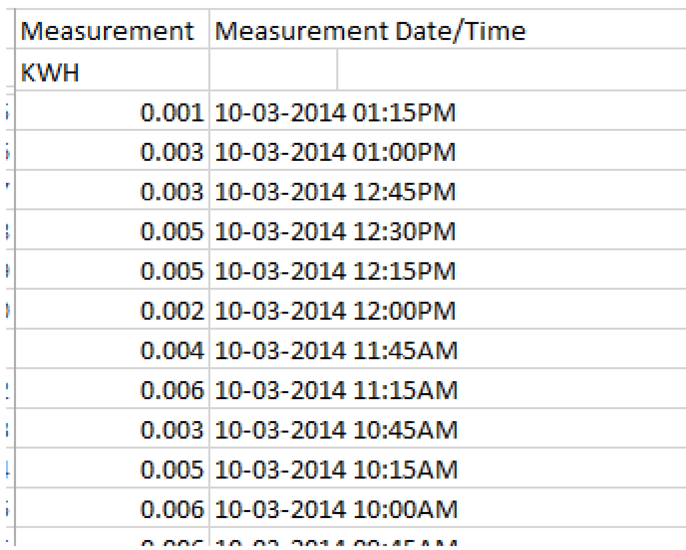
   Acceptance Criteria: Metering data to be collected successfully from at least 95% of tested meters. A 'read' is considered 'successful' when all load profile data, register data, and events/alarms are collected successfully
   Date: 9/10/2014 & 10/3/2014
   Results: Passed, per the following outcomes:

4 EV Meters that were part of Acceptance Test

1) 2.16.840.1.114416.1.24.1498842
   Badge: 7FED00009-01498842
   Itron SN: NXF312197831

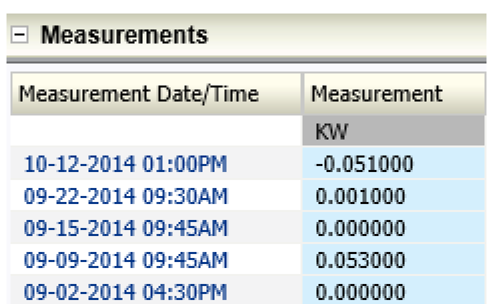


Attached sample data showing the reads with excel export



Measurement KWH	Measurement Date/Time
0.001	10-03-2014 01:15PM
0.003	10-03-2014 01:00PM
0.003	10-03-2014 12:45PM
0.005	10-03-2014 12:30PM
0.005	10-03-2014 12:15PM
0.002	10-03-2014 12:00PM
0.004	10-03-2014 11:45AM
0.006	10-03-2014 11:15AM
0.003	10-03-2014 10:45AM
0.005	10-03-2014 10:15AM
0.006	10-03-2014 10:00AM

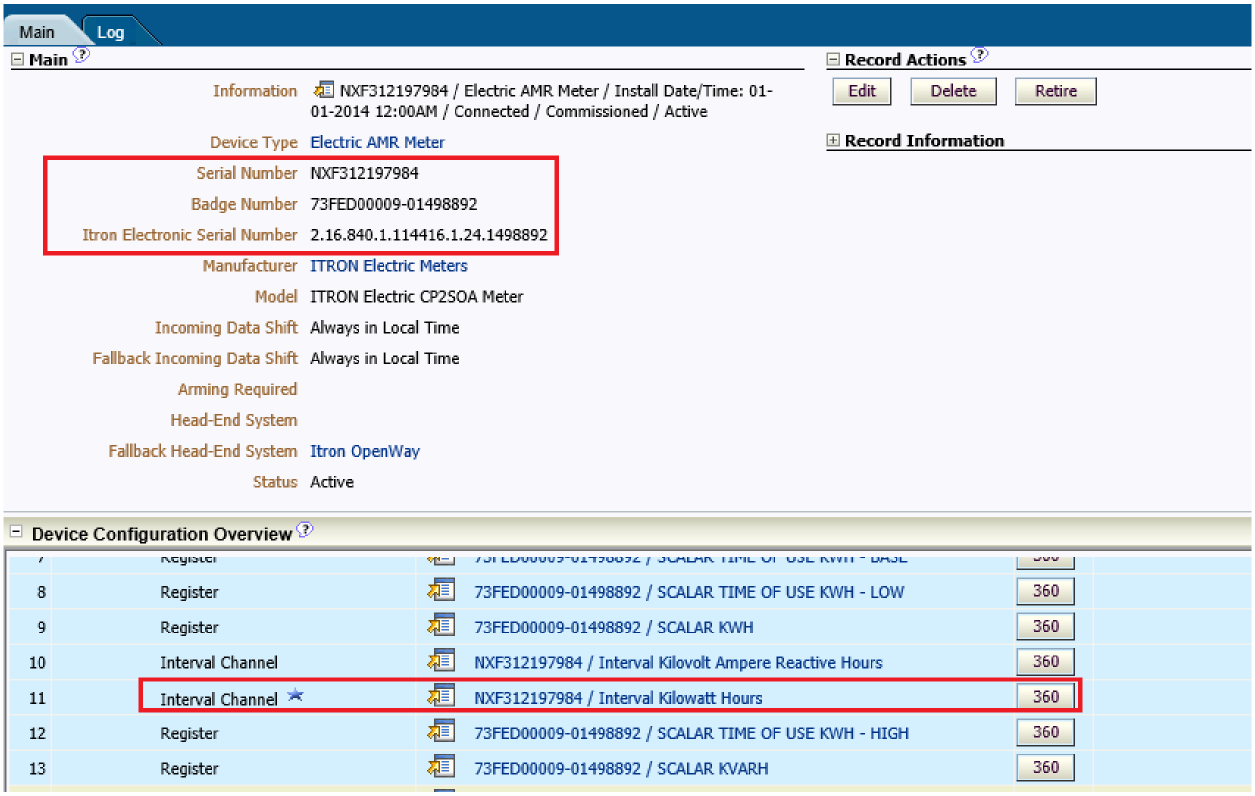
Results for Scalar KW



Measurements

Measurement Date/Time	Measurement KW
10-12-2014 01:00PM	-0.051000
09-22-2014 09:30AM	0.001000
09-15-2014 09:45AM	0.000000
09-09-2014 09:45AM	0.053000
09-02-2014 04:30PM	0.000000

2) 2.16.840.1.114416.1.24.1498892
Badge: 73FED00009-01498892 - Itron SN: NXF312197984



Main | Log

Main

Information	NXF312197984 / Electric AMR Meter / Install Date/Time: 01-01-2014 12:00AM / Connected / Commissioned / Active
Device Type	Electric AMR Meter
Serial Number	NXF312197984
Badge Number	73FED00009-01498892
Itron Electronic Serial Number	2.16.840.1.114416.1.24.1498892
Manufacturer	ITRON Electric Meters
Model	ITRON Electric CP2SOA Meter
Incoming Data Shift	Always in Local Time
Fallback Incoming Data Shift	Always in Local Time
Arming Required	
Head-End System	
Fallback Head-End System	Itron OpenWay
Status	Active

Record Actions

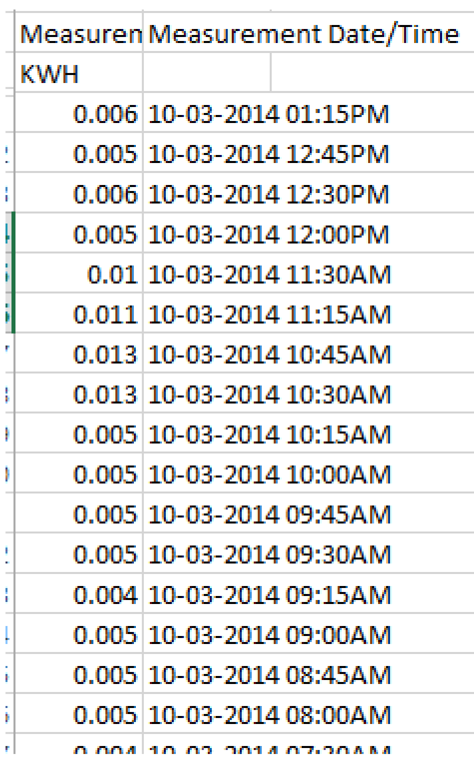
Edit | Delete | Retire

Record Information

Device Configuration Overview

8	Register	73FED00009-01498892 / SCALAR TIME OF USE KWH - LOW	360
9	Register	73FED00009-01498892 / SCALAR KWH	360
10	Interval Channel	NXF312197984 / Interval Kilovolt Ampere Reactive Hours	360
11	Interval Channel	NXF312197984 / Interval Kilowatt Hours	360
12	Register	73FED00009-01498892 / SCALAR TIME OF USE KWH - HIGH	360
13	Register	73FED00009-01498892 / SCALAR KVARH	360

Attached sample data showing the reads for 9/30 & 10/3 with excel export



Measuren	Measurement Date/Time
KWH	
0.006	10-03-2014 01:15PM
0.005	10-03-2014 12:45PM
0.006	10-03-2014 12:30PM
0.005	10-03-2014 12:00PM
0.01	10-03-2014 11:30AM
0.011	10-03-2014 11:15AM
0.013	10-03-2014 10:45AM
0.013	10-03-2014 10:30AM
0.005	10-03-2014 10:15AM
0.005	10-03-2014 10:00AM
0.005	10-03-2014 09:45AM
0.005	10-03-2014 09:30AM
0.004	10-03-2014 09:15AM
0.005	10-03-2014 09:00AM
0.005	10-03-2014 08:45AM
0.005	10-03-2014 08:00AM

Results for Scalar KW

Measurement Date/Time	Measurement
	KW
10-11-2014 09:30AM	0.337000
09-08-2014 10:45AM	0.000000

Note:

The product that was selected as our agnostic MDM has not performed as expected. Due to various product issues with the MDM, failure in the SOA or caching data, the data reported by the CE was missed at the MDM during the data collection period. The issues are logged in the LADWP's system, known as Rational to be followed up and fixed by the Oracle's technical team. The SGRDP team depends on the Oracle's technical team for such issues to be fixed. Following are a few issues, listed as example:

Defect 9969: MDM Modifications Required for Smart Grid EV Meters
Defect 9553: OSB Update needed to filter out UOM's
Defect 9675: OSB Code Changes to allow and convert new required UOM of EV meters and filter out the non-required UOM

2. **Issue the "read" command once every 15 minutes and record the observation.**

Action: 2 EV meters were selected for this test and included as part of the Acceptance Test Group
1) 2.16.840.1.114416.1.24.1498842
Badge: 7FED00009-01498842
2) 2.16.840.1.114416.1.24.1498892
Badge: 73FED00009-01498892

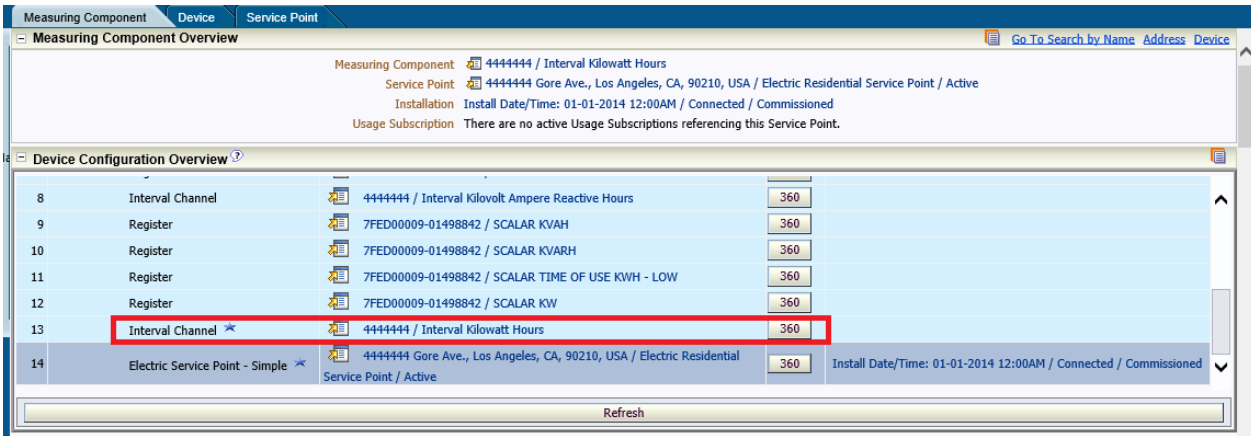
Acceptance Criteria: Metering data to be collected successfully from at least 95% of tested meters. A 'read' is considered 'successful' when all load profile data, register data, and events/alarms are collected successfully

Date: 9/10/2014 & 10/3/2014

Results: Passed, based on following outcomes

4 EV Meters that were part of Acceptance Test

1) 2.16.840.1.114416.1.24.1498842
   Badge: 7FED00009-01498842
   Itron SN: NXF312197831



Attached sample data showing the reads with excel export

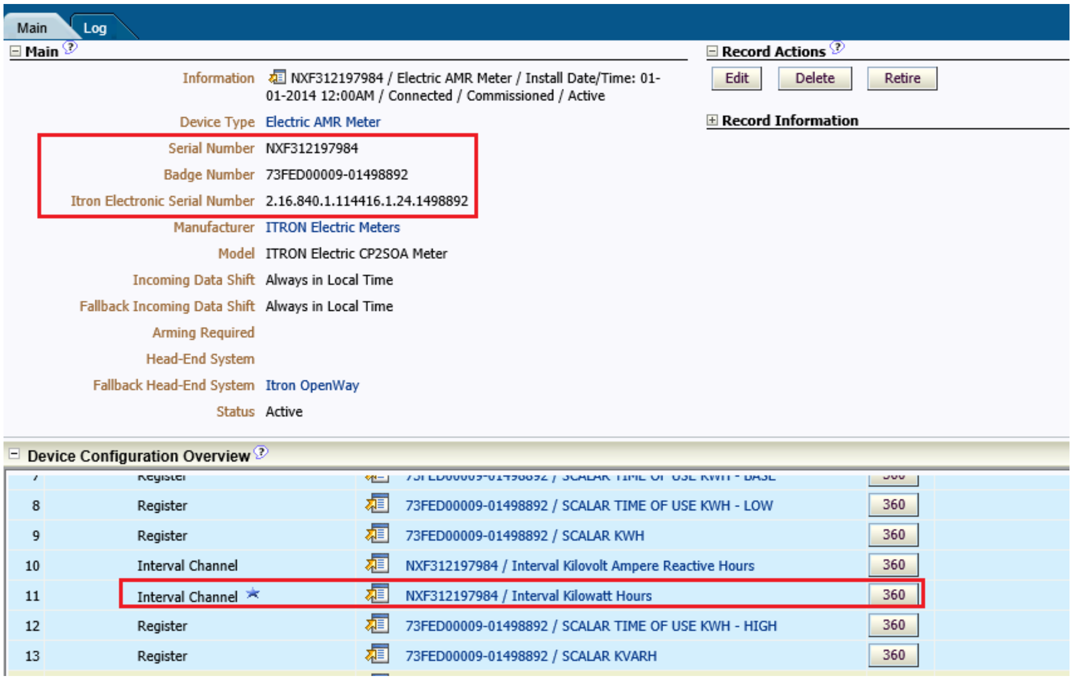
Measurement	Measurement Date/Time
KWH	
0.001	10-03-2014 01:15PM
0.003	10-03-2014 01:00PM
0.003	10-03-2014 12:45PM
0.005	10-03-2014 12:30PM
0.005	10-03-2014 12:15PM
0.002	10-03-2014 12:00PM
0.004	10-03-2014 11:45AM
0.006	10-03-2014 11:15AM
0.003	10-03-2014 10:45AM
0.005	10-03-2014 10:15AM
0.006	10-03-2014 10:00AM

Results for Scalar KW

Measurements

Measurement Date/Time	Measurement
	KW
10-12-2014 01:00PM	-0.051000
09-22-2014 09:30AM	0.001000
09-15-2014 09:45AM	0.000000
09-09-2014 09:45AM	0.053000
09-02-2014 04:30PM	0.000000

2) 2.16.840.1.114416.1.24.1498892
Badge: 73FED00009-01498892 - Itron SN: NXF312197984



Attached sample data showing the reads for 9/30 & 10/3 with excel export

Measuren	Measurement Date/Time
KWH	
0.006	10-03-2014 01:15PM
0.005	10-03-2014 12:45PM
0.006	10-03-2014 12:30PM
0.005	10-03-2014 12:00PM
0.01	10-03-2014 11:30AM
0.011	10-03-2014 11:15AM
0.013	10-03-2014 10:45AM
0.013	10-03-2014 10:30AM
0.005	10-03-2014 10:15AM
0.005	10-03-2014 10:00AM
0.005	10-03-2014 09:45AM
0.005	10-03-2014 09:30AM
0.004	10-03-2014 09:15AM
0.005	10-03-2014 09:00AM
0.005	10-03-2014 08:45AM
0.005	10-03-2014 08:00AM

Results for Scalar KW

Measurement Date/Time	Measurement
	KW
10-11-2014 09:30AM	0.337000
09-08-2014 10:45AM	0.000000

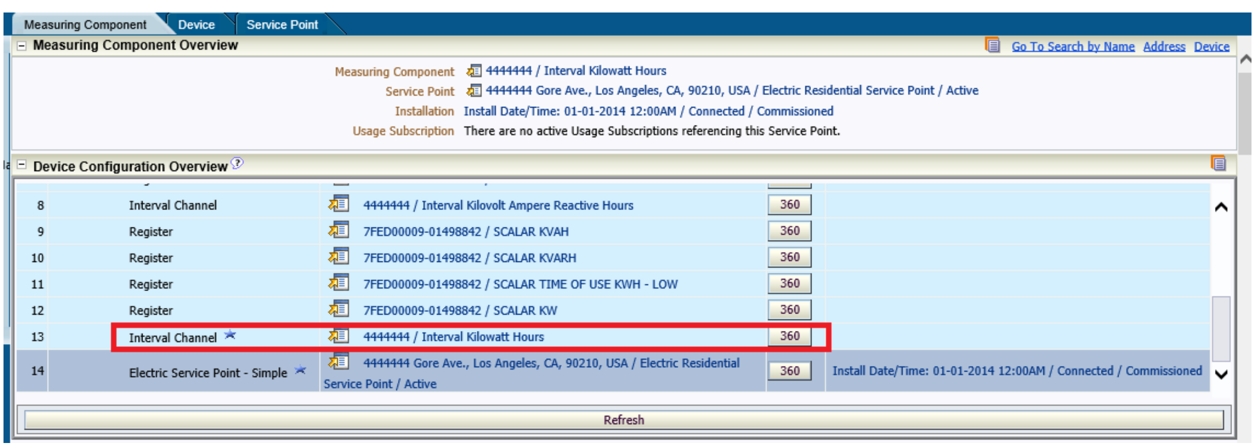
3. **Collect load profile and register data by issuing on-demand read, for each GROUP separately, at least once during Acceptance Test.**

   Action: 4 EV meters were selected for this test and included as part of the Acceptance Test Group
   1) 2.16.840.1.114416.1.24.1498842
   Badge: 7FED00009-01498842
   2) 2.16.840.1.114416.1.24.1498892
   Badge: 73FED00009-01498892

   Acceptance Criteria: Metering data to be collected successfully from at least 95% of tested meters. A 'read' is considered 'successful' when all load profile data, register data, and events/alarms are collected successfully
   Date: 10/3/2014
   Result: Passed, based on the following outcomes

4 EV Meters that were part of Acceptance Test

1) 2.16.840.1.114416.1.24.1498842
   Badge: 7FED00009-01498842 Itron SN: NXF312197831



Attached sample data showing the reads with excel export

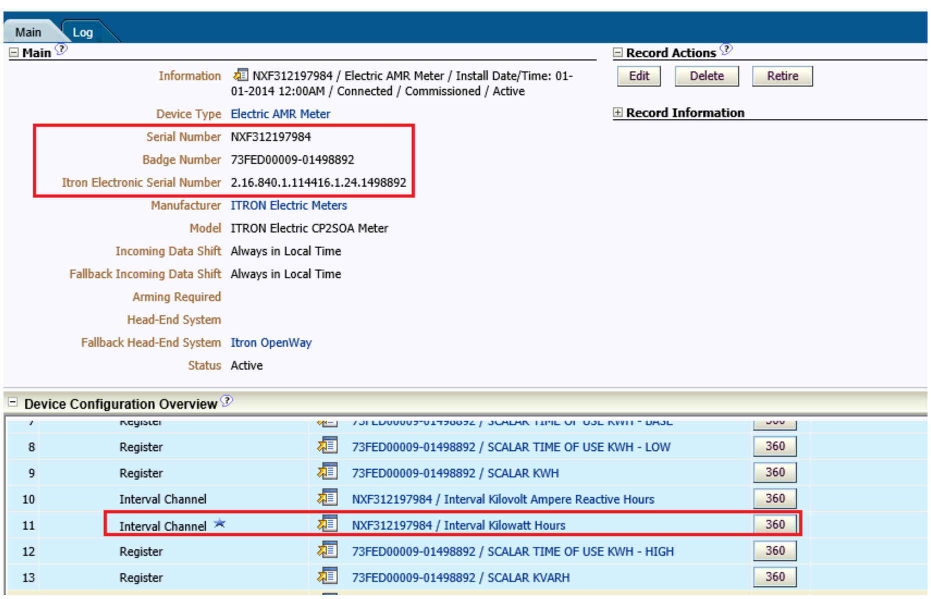
Measurement	Measurement Date/Time
KWH	
0.001	10-03-2014 01:15PM
0.003	10-03-2014 01:00PM
0.003	10-03-2014 12:45PM
0.005	10-03-2014 12:30PM
0.005	10-03-2014 12:15PM
0.002	10-03-2014 12:00PM
0.004	10-03-2014 11:45AM
0.006	10-03-2014 11:15AM
0.003	10-03-2014 10:45AM
0.005	10-03-2014 10:15AM
0.006	10-03-2014 10:00AM

Results for Scalar KW

Measurements

Measurement Date/Time	Measurement
	KW
10-12-2014 01:00PM	-0.051000
09-22-2014 09:30AM	0.001000
09-15-2014 09:45AM	0.000000
09-09-2014 09:45AM	0.053000
09-02-2014 04:30PM	0.000000

2) 2.16.840.1.114416.1.24.1498892
Badge: 73FED00009-01498892 - Itron SN: NXF312197984



Attached sample data showing the reads for 9/30 & 10/3 with excel export

Measuren	Measurement Date/Time
KWH	
0.006	10-03-2014 01:15PM
0.005	10-03-2014 12:45PM
0.006	10-03-2014 12:30PM
0.005	10-03-2014 12:00PM
0.01	10-03-2014 11:30AM
0.011	10-03-2014 11:15AM
0.013	10-03-2014 10:45AM
0.013	10-03-2014 10:30AM
0.005	10-03-2014 10:15AM
0.005	10-03-2014 10:00AM
0.005	10-03-2014 09:45AM
0.005	10-03-2014 09:30AM
0.004	10-03-2014 09:15AM
0.005	10-03-2014 09:00AM
0.005	10-03-2014 08:45AM
0.005	10-03-2014 08:00AM

Results for Scalar KW

Measurement Date/Time	Measurement
	KW
10-11-2014 09:30AM	0.337000
09-08-2014 10:45AM	0.000000

Part 2: Metering Events and Exceptions

Events and Exceptions indicate the 'abnormal' or 'unwanted' condition from the meter or the service, reported by the meter.

4. **Conditions for a few 'event' shall be created to ensure appropriate alarms are being generated.**

Action: Following meter was selected 7AED00009-01499052
ESN 2.16.840.1.114416.1.24.1499052

Action: Events/exceptions are appropriately generated by the meter and collected successfully

Date: 10/15/2014, 10/16/2014

Result: Passed, based on following outcomes

Test Results for Generating Events/Exceptions for an EV Meter as part of the Itron Acceptance Testing

Test Meter: 7AED00009-01499052 (Josh's desk)

ESN - 2.16.840.1.114416.1.24.1499052

Date & Time: 10/16/2014 @ 3:46 pm

1) Trigger a Power Off on the meter by turning off the switch and confirmed that the meter was completedly turned off
2) Waited 45 seconds and then Power the meter back on and confirmed the meter came back on
3) Confirmed in CE that the meter generated the needed event and exceptions

Events

Time	Event	User ID	Data
10/8/2014 8:12:10 AM	Device Reprogrammed	101	
10/8/2014 8:12:11 AM	Billing Data Cleared	0	
10/8/2014 8:12:15 AM	Table Configuration	0	
10/8/2014 8:12:20 AM	Time Adjustment Failed	0	Time Difference: Out of Range
10/15/2014 2:16:29 PM	Primary Power Down	0	
10/15/2014 2:17:35 PM	Primary Power Up	0	
10/15/2014 4:04:35 PM	Table Written	0	Table: 2090
10/15/2014 4:04:35 PM	Table Written	0	Table: 2090
10/15/2014 4:04:36 PM	Device Reprogrammed	65535	
10/15/2014 4:04:36 PM	Billing Data Cleared	0	
10/15/2014 4:57:51 PM	Table Written	0	Table: 2090
10/15/2014 4:57:51 PM	Table Written	0	Table: 2090
10/15/2014 4:57:52 PM	Device Reprogrammed	65535	
10/15/2014 4:57:52 PM	Billing Data Cleared	0	
10/16/2014 3:46:48 PM	Primary Power Down	0	
10/16/2014 3:47:18 PM	Primary Power Up	0	

4) Also, on 10/15, we completed a meter reprogram of the same meter as part of another Itron Acceptance Test
   - Meter Reprogram from Config 64 kWH TOU Single ICS to Config 60 kwh Only Single ICS (Date: 10/15 @ 4:04 pm)
   - Reprogram meter back to its original Configuration Group (50 back to 60) (Date: 10/15 @ 4:57 pm)

Confirmed that the Meter produced the expected event related to these meters

Events

Time	Event	User ID	Data
10/8/2014 8:12:10 AM	Device Reprogrammed	101	
10/8/2014 8:12:11 AM	Billing Data Cleared	0	
10/8/2014 8:12:15 AM	Table Configuration	0	
10/8/2014 8:12:20 AM	Time Adjustment Failed	0	Time Difference: Out of Range
10/15/2014 2:16:29 PM	Primary Power Down	0	
10/15/2014 2:17:35 PM	Primary Power Up	0	
10/15/2014 4:04:35 PM	Table Written	0	Table: 2090
10/15/2014 4:04:35 PM	Table Written	0	Table: 2090
10/15/2014 4:04:36 PM	Device Reprogrammed	65535	
10/15/2014 4:04:36 PM	Billing Data Cleared	0	
10/15/2014 4:57:51 PM	Table Written	0	Table: 2090
10/15/2014 4:57:51 PM	Table Written	0	Table: 2090
10/15/2014 4:57:52 PM	Device Reprogrammed	65535	
10/15/2014 4:57:52 PM	Billing Data Cleared	0	
10/16/2014 3:46:48 PM	Primary Power Down	0	
10/16/2014 3:47:18 PM	Primary Power Up	0	

Note: We could not capture these events in MDM, PI-Historian or K-Grid because these are the new EV meters and they have not been configured in these respective systems. As such, the only way to validate is to utilize the data results from the CE.

Part 3: Metering Configuration Program

Configuration Programs determine the functaion of the meters in terms of the type of data to be measured and reported by the meter as well as the displays to be shown.

5. **Prepare configuration programs for each GROUP, other than the configuration programs that meters are programmed with, and re-program every GROUP over-the-air at least once during Acceptance Test. Both communication methods (Cellular, RF). Meters shall be read afterward to ensure re-programming took place successfully**

   Action: Following meter was selected 7AED00009-01499052
   ESN 2.16.840.1.114416.1.24.1499052

   Acceptance Criteria: Remote meter programming to be successfully performed on tested meters.

   Date: 10/15/2014

   Result: Passed, based on following outcomes

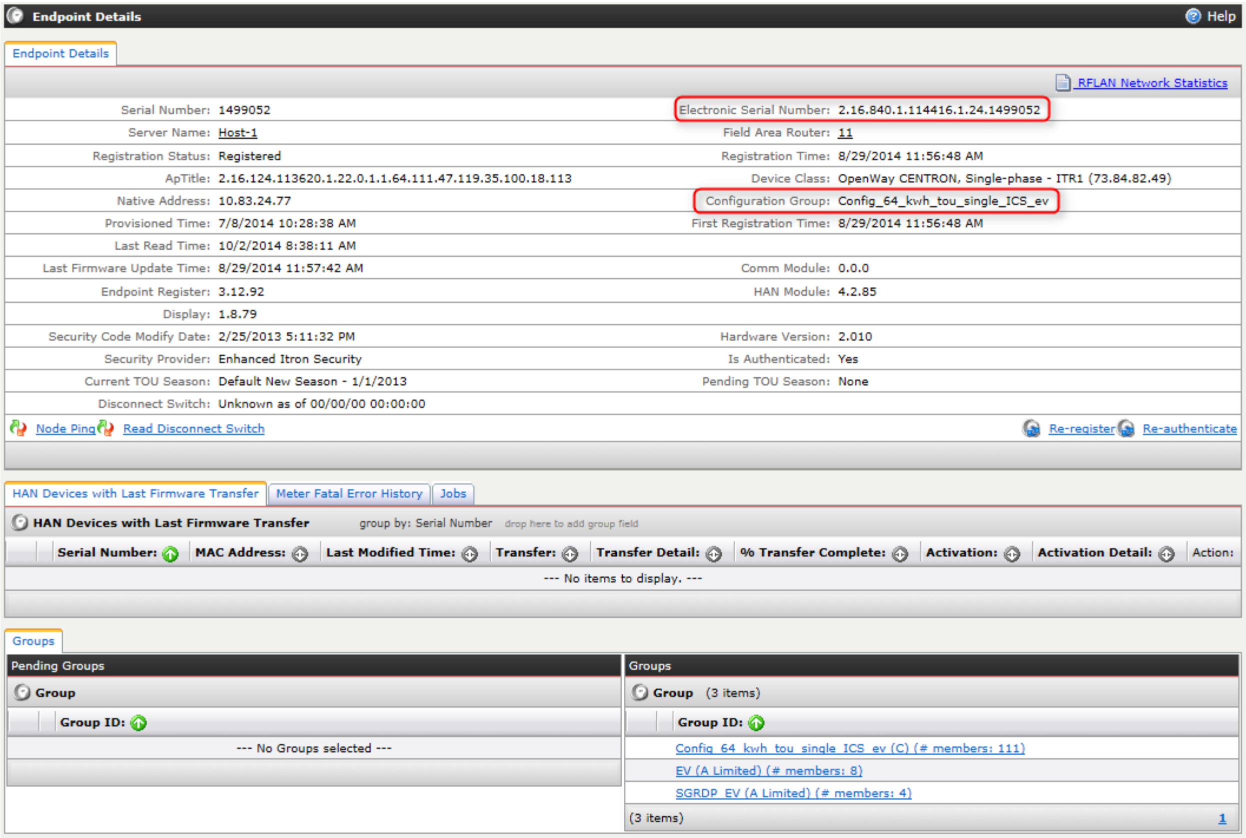
10/15/2014 @ 2-4:30 pm Conducted Two Tests

1) Meter Reprogram from Config_64_kwh_ tou_single_ ICS_ev to Config_60 _single_ICS_Solar
2) Reprogram meter back from Config_60 _single_ICS_Solar to its original Config_64_kwh_ tou_single_ ICS_ev

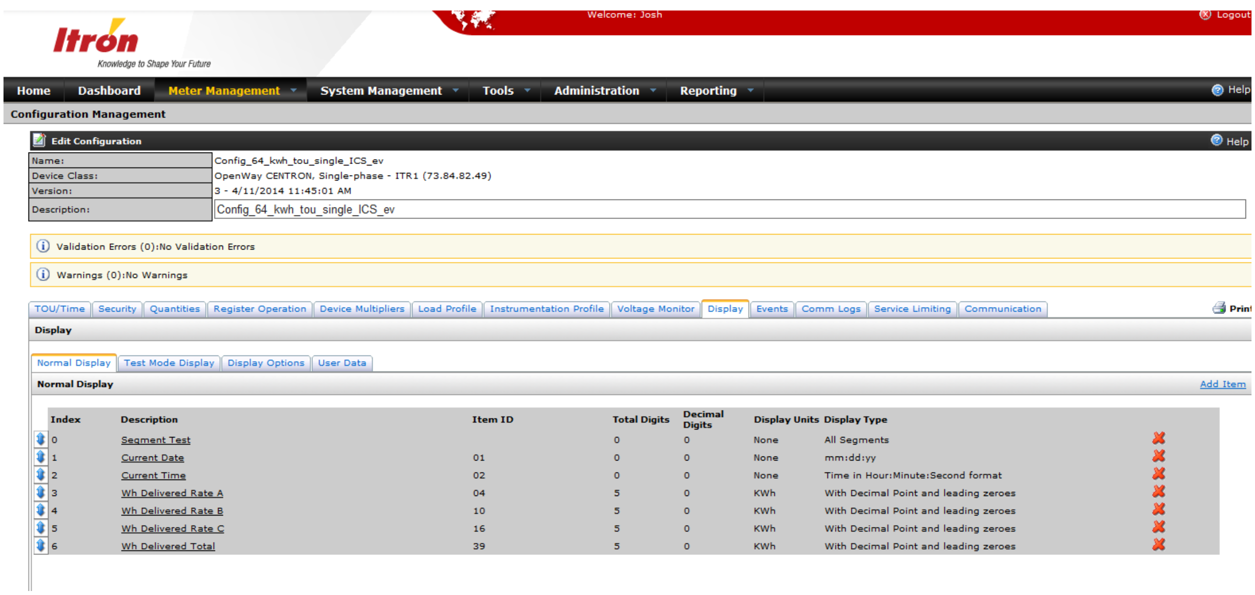
Test using meter with batch number: 7AED00009-01499052 with ESN 2.16.840.1.114416.1.24.1499052

1) Confirmed Meter is in Config_64_kwh_ tou_single_ ICS_ev and showing display 01, 02, 04, 10, 16 and 39

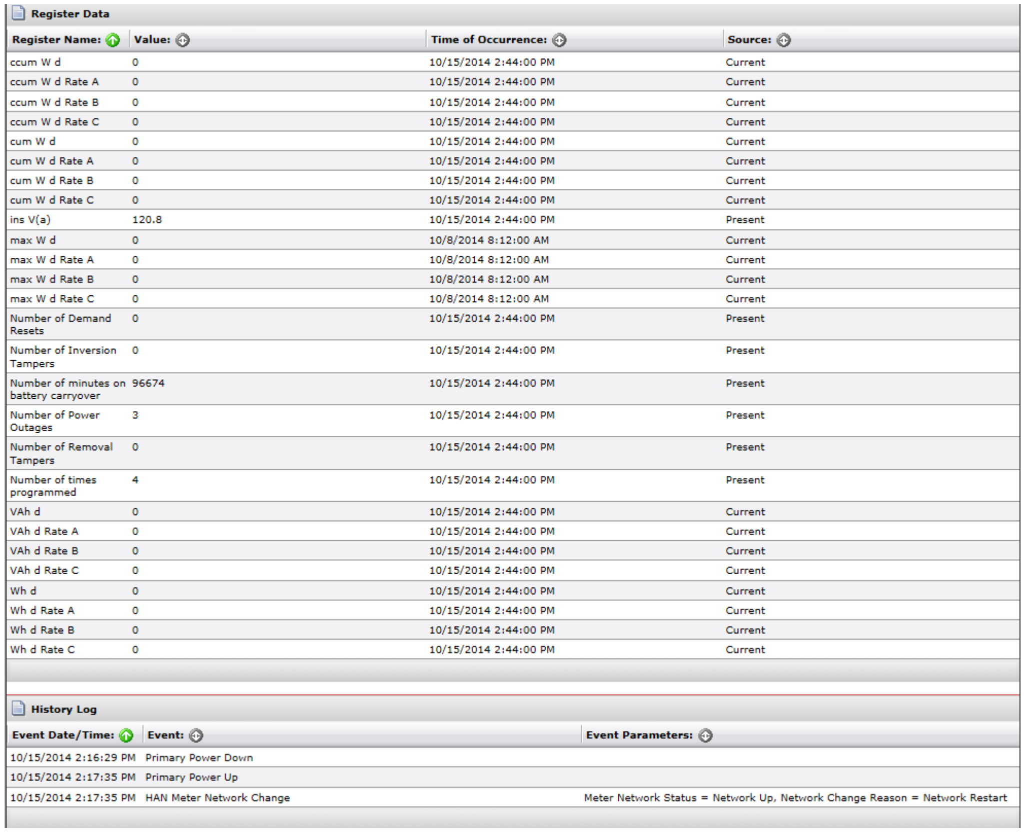
Confirmed in CE that ESN for this meter matches and that it is currenctly in Config_64_kwh_ tou_single_ ICS_ev



Specs for Config_60 _single_ICS_Solar confirming it has display 01, 02, 04, 10, 16 and 39



2) Before moving configuration group - completed an interrogation read through the CE to ensure that meter is communicating



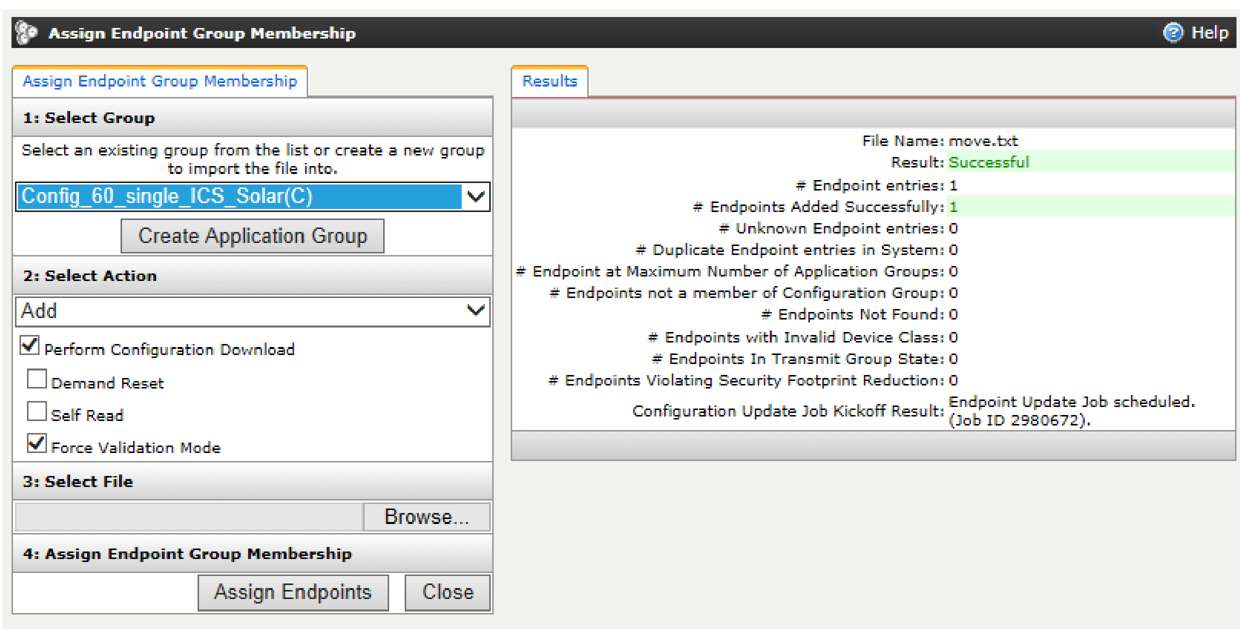
Register Data

Register Name:	Value:	Time of Occurrence:	Source:
ccum W d	0	10/15/2014 2:44:00 PM	Current
ccum W d Rate A	0	10/15/2014 2:44:00 PM	Current
ccum W d Rate B	0	10/15/2014 2:44:00 PM	Current
ccum W d Rate C	0	10/15/2014 2:44:00 PM	Current
cum W d	0	10/15/2014 2:44:00 PM	Current
cum W d Rate A	0	10/15/2014 2:44:00 PM	Current
cum W d Rate B	0	10/15/2014 2:44:00 PM	Current
cum W d Rate C	0	10/15/2014 2:44:00 PM	Current
ins V(a)	120.8	10/15/2014 2:44:00 PM	Present
max W d	0	10/8/2014 8:12:00 AM	Current
max W d Rate A	0	10/8/2014 8:12:00 AM	Current
max W d Rate B	0	10/8/2014 8:12:00 AM	Current
max W d Rate C	0	10/8/2014 8:12:00 AM	Current
Number of Demand Resets	0	10/15/2014 2:44:00 PM	Present
Number of Inversion Tampers	0	10/15/2014 2:44:00 PM	Present
Number of minutes on battery carryover	96674	10/15/2014 2:44:00 PM	Present
Number of Power Outages	3	10/15/2014 2:44:00 PM	Present
Number of Removal Tampers	0	10/15/2014 2:44:00 PM	Present
Number of times programmed	4	10/15/2014 2:44:00 PM	Present
VAh d	0	10/15/2014 2:44:00 PM	Current
VAh d Rate A	0	10/15/2014 2:44:00 PM	Current
VAh d Rate B	0	10/15/2014 2:44:00 PM	Current
VAh d Rate C	0	10/15/2014 2:44:00 PM	Current
Wh d	0	10/15/2014 2:44:00 PM	Current
Wh d Rate A	0	10/15/2014 2:44:00 PM	Current
Wh d Rate B	0	10/15/2014 2:44:00 PM	Current
Wh d Rate C	0	10/15/2014 2:44:00 PM	Current

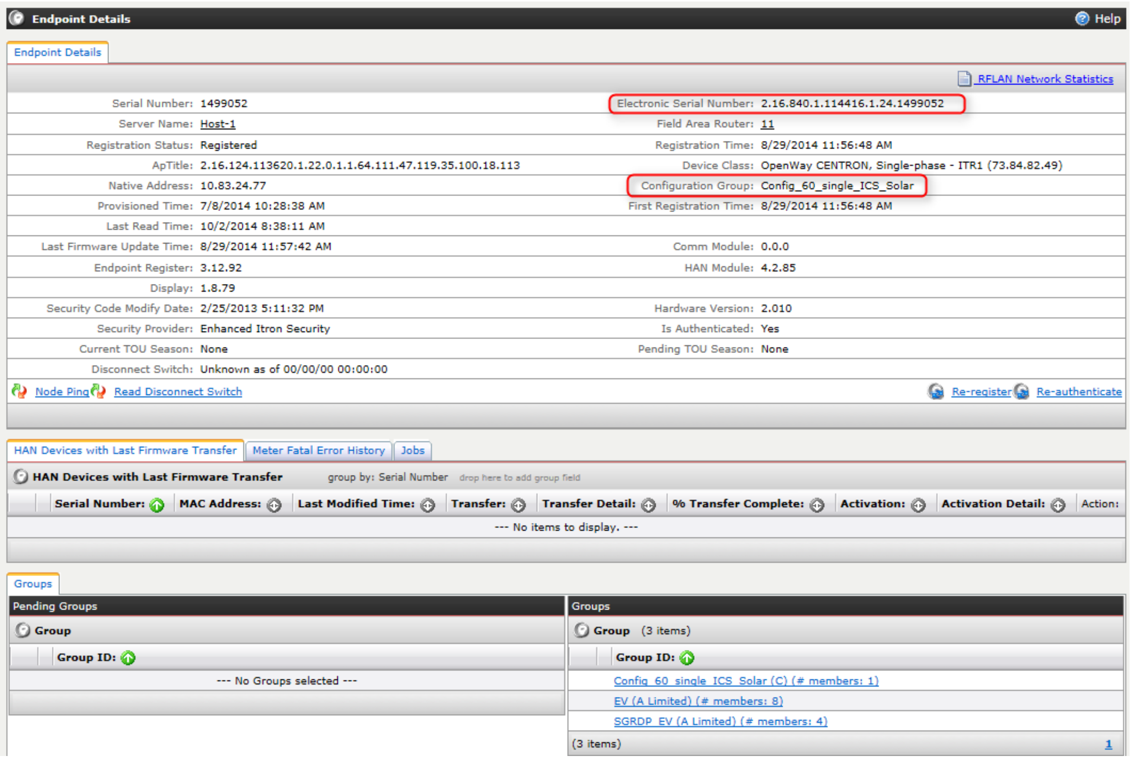
History Log

Event Date/Time:	Event:	Event Parameters:
10/15/2014 2:16:29 PM	Primary Power Down	
10/15/2014 2:17:35 PM	Primary Power Up	
10/15/2014 2:17:35 PM	HAN Meter Network Change	Meter Network Status = Network Up, Network Change Reason = Network Restart

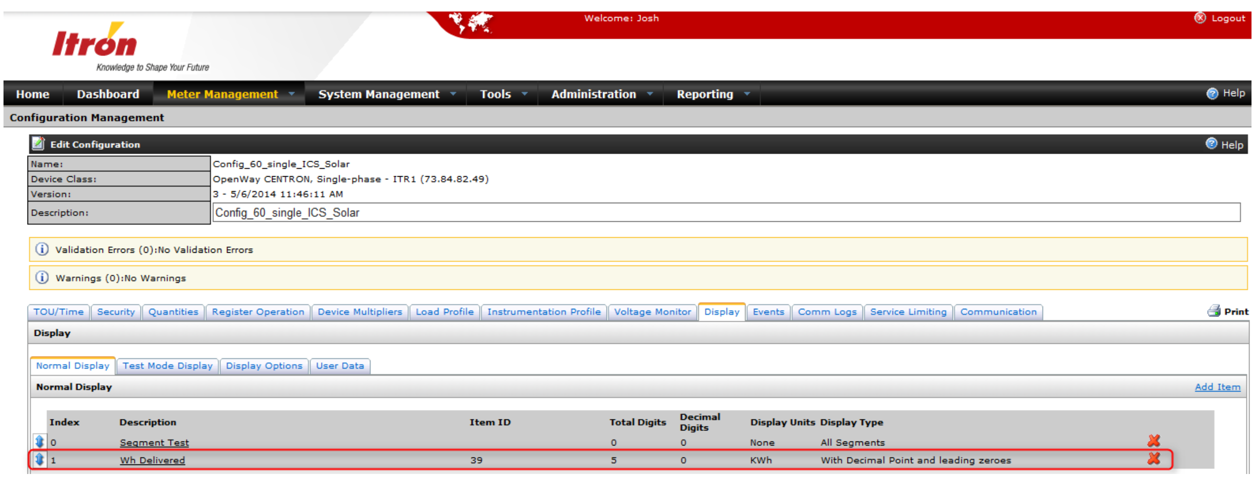
3) Move meter from Config 64 kWH TOU single ICS to Config_60 _single_ICS_Solar



4) Request a meter interrogation of the meter through CE and confirmed that the meter moved to Config_60 _single_ICS_Solar



5) Confirmed specs for Config_60 _single_ICS_Solar confirm that it has both Display 39 only



6) Confirmed that on display of the meter, it is showing only Display 39 (kWh) after the meter reprogrammed
First validated display 39 – see image attached

7) Re-programmed the meter back from Config_60 _single_ICS_Solar back to Config_64_kwh_ tou_single_ ICS_ev

Endpoint Details Help

Endpoint Details

RFLAN Network Statistics

Serial Number:	1499052	Electronic Serial Number:	2.16.840.1.114416.1.24.1499052
Server Name:	Host-1	Field Area Router:	11
Registration Status:	Registered	Registration Time:	8/29/2014 11:56:48 AM
ApTitle:	2.16.124.113620.1.22.0.1.1.64.111.47.119.35.100.18.113	Device Class:	OpenWay CENTRON, Single-phase - ITR1 (73.84.82.49)
Native Address:	10.83.24.77	Configuration Group:	Config_64_kwh_tou_single_ICS_ev
Provisioned Time:	7/8/2014 10:28:38 AM	First Registration Time:	8/29/2014 11:56:48 AM
Last Read Time:	10/2/2014 8:38:11 AM		
Last Firmware Update Time:	8/29/2014 11:57:42 AM	Comm Module:	0.0.0
Endpoint Register:	3.12.92	HAN Module:	4.2.85
Display:	1.8.79		
Security Code Modify Date:	2/25/2013 5:11:32 PM	Hardware Version:	2.010
Security Provider:	Enhanced Itron Security	Is Authenticated:	Yes
Current TOU Season:	Default New Season - 1/1/2013	Pending TOU Season:	None
Disconnect Switch:	Unknown as of 00/00/00 00:00:00		

Node Ping Read Disconnect Switch Re-register Re-authenticate

HAN Devices with Last Firmware Transfer | Meter Fatal Error History | Jobs

HAN Devices with Last Firmware Transfer group by: Serial Number drop here to add group field

Serial Number:	MAC Address:	Last Modified Time:	Transfer:	Transfer Detail:	% Transfer Complete:	Activation:	Activation Detail:	Action:
--- No items to display. ---								

Groups

Pending Groups
Group
Group ID:
--- No Groups selected ---

Groups
Group (3 items)
Group ID:
Config_64_kwh_tou_single_ICS_ev (C) (# members: 110)
EV (A Limited) (# members: 7)
SGRDP_EV (A Limited) (# members: 3)
(3 items) 1

8) Completed an interactive read from CE to confirm registers in Config_60_kwh_only.

Serial Number	1499052
Electronic Serial Number	2.16.840.1.114416.1.24.1499052
Interactive Read Time	10/15/2014 5:00:20 PM
Time Zone	(GMT-08:00) Pacific Time (US & Canada); Tijuana
Requested Time Span	10/15/2014 4:00:20 PM - 10/15/2014 5:00:20 PM
Job Status	Successful
Job Duration	00:00:53

Register Data

Register Name:	Value:	Time of Occurrence:	Source:
ccum W d	0	10/15/2014 5:00:29 PM	Current
ccum W d Rate A	0	10/15/2014 5:00:29 PM	Current
ccum W d Rate B	0	10/15/2014 5:00:29 PM	Current
ccum W d Rate C	0	10/15/2014 5:00:29 PM	Current
cum W d	0	10/15/2014 5:00:29 PM	Current
cum W d Rate A	0	10/15/2014 5:00:29 PM	Current
cum W d Rate B	0	10/15/2014 5:00:29 PM	Current
cum W d Rate C	0	10/15/2014 5:00:29 PM	Current
ins V(a)	121.9	10/15/2014 5:00:29 PM	Present
max W d	0	10/15/2014 4:57:00 PM	Current
max W d Rate A	0	10/15/2014 4:57:00 PM	Current
max W d Rate B	0	10/15/2014 4:57:00 PM	Current
max W d Rate C	0	10/15/2014 4:57:00 PM	Current
Number of Demand Resets	0	10/15/2014 5:00:29 PM	Present
Number of Inversion Tampers	0	10/15/2014 5:00:29 PM	Present
Number of minutes on battery carryover	96674	10/15/2014 5:00:29 PM	Present
Number of Power Outages	3	10/15/2014 5:00:29 PM	Present
Number of Removal Tampers	0	10/15/2014 5:00:29 PM	Present
Number of times programmed	6	10/15/2014 5:00:29 PM	Present
VAh d	0	10/15/2014 5:00:29 PM	Current
VAh d Rate A	0	10/15/2014 5:00:29 PM	Current
VAh d Rate B	0	10/15/2014 5:00:29 PM	Current
VAh d Rate C	0	10/15/2014 5:00:29 PM	Current
Wh d	0	10/15/2014 5:00:29 PM	Current
Wh d Rate A	0	10/15/2014 5:00:29 PM	Current
Wh d Rate B	0	10/15/2014 5:00:29 PM	Current
Wh d Rate C	0	10/15/2014 5:00:29 PM	Current

9) Check meter and confirm that meter is showing all display of Config_64_kwh_ tou_single_ ICS_ev (01, 02, 04, 10, 16 and 39)

See image attached.

6. **Re-program all the programmed meters back to their original configuration programs over-the-air. Meters shall be read afterward to ensure re-programming took place successfully.**

   Action: Following meter was selected 7AED00009-01499052
   ESN 2.16.840.1.114416.1.24.1499052

   Acceptance Criteria: Remote meter programming to be successfully performed on at tested meters.

   Date: 10/15/2014

   Result: Passed, based on the following outcomes

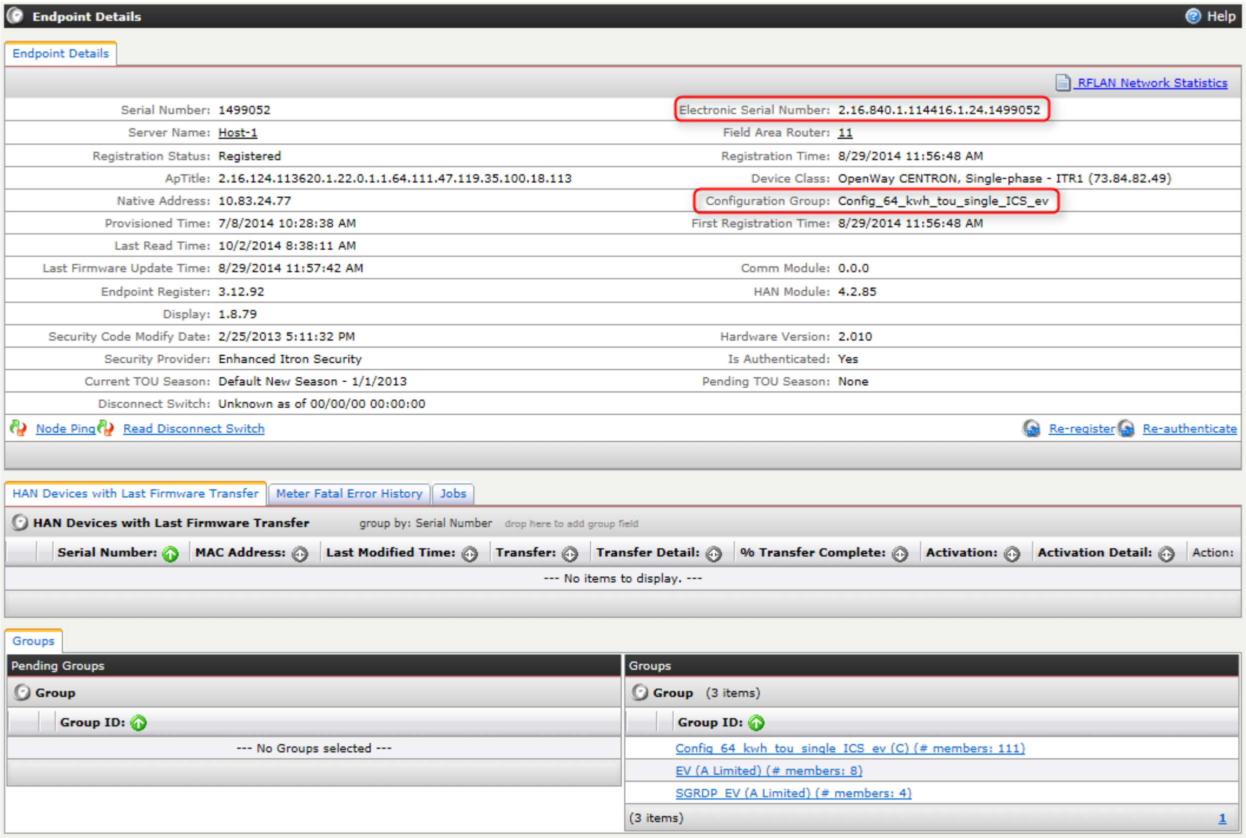
- Meter Reprogram from Config_64_kwh_ tou_single_ ICS_ev to Config_60 _single_ICS_Solar (Date & Time: 10/15/2014 @ 4:04 pm)

- Reprogram meter back from Config_60 _single_ICS_Solar to its original Config_64_kwh_ tou_single_ ICS_ev (Date & Time: 10/15/2014 @ 4:57 pm)

Test using meter with batch number: 7AED00009-01499052 with ESN 2.16.840.1.114416.1.24.1499052

Confirmed Meter is in Config_64_kwh_ tou_single_ ICS_ev and showing display 01, 02, 04, 10, 16 and 39

Confirmed in CE that ESN for this meter matches and that it is currenctly in Config_64_kwh_ tou_single_ ICS_ev



Endpoint Details

Serial Number:	1499052	Electronic Serial Number:	2.16.840.1.114416.1.24.1499052
Server Name:	Host-1	Field Area Router:	11
Registration Status:	Registered	Registration Time:	8/29/2014 11:56:48 AM
ApTitle:	2.16.124.113620.1.22.0.1.1.64.111.47.119.35.100.18.113	Device Class:	OpenWay CENTRON, Single-phase - ITR1 (73.84.82.49)
Native Address:	10.83.24.77	Configuration Group:	Config_64_kwh_tou_single_ICS_ev
Provisioned Time:	7/8/2014 10:28:38 AM	First Registration Time:	8/29/2014 11:56:48 AM
Last Read Time:	10/2/2014 8:38:11 AM		
Last Firmware Update Time:	8/29/2014 11:57:42 AM	Comm Module:	0.0.0
Endpoint Register:	3.12.92	HAN Module:	4.2.85
Display:	1.8.79		
Security Code Modify Date:	2/25/2013 5:11:32 PM	Hardware Version:	2.010
Security Provider:	Enhanced Itron Security	Is Authenticated:	Yes
Current TOU Season:	Default New Season - 1/1/2013	Pending TOU Season:	None
Disconnect Switch:	Unknown as of 00/00/00 00:00:00		

Node Ping Read Disconnect Switch Re-register Re-authenticate

HAN Devices with Last Firmware Transfer | Meter Fatal Error History | Jobs

HAN Devices with Last Firmware Transfer group by: Serial Number

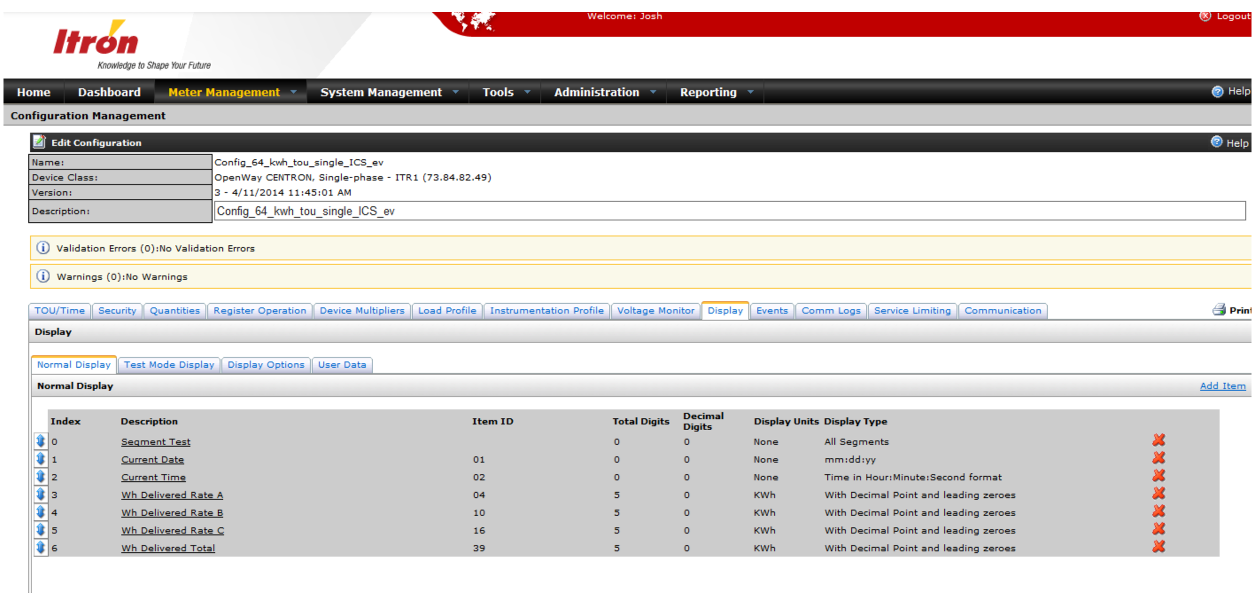
Serial Number:	MAC Address:	Last Modified Time:	Transfer:	Transfer Detail:	% Transfer Complete:	Activation:	Activation Detail:	Action:
--- No items to display. ---								

Groups

Pending Groups
Group ID:
--- No Groups selected ---

Groups (3 items)
Group ID:
Config_64_kwh_tou_single_ICS_ev (C) (# members: 111)
EV (A Limited) (# members: 8)
SGRDP_EV (A Limited) (# members: 4)
(3 items)

Specs for Config_60 _single_ICS_Solar confirming it has display 01, 02, 04, 10, 16 and 39



Welcome: Josh Logout

Home | Dashboard | Meter Management | System Management | Tools | Administration | Reporting | Help

Configuration Management

Edit Configuration

Name:	Config_64_kwh_tou_single_ICS_ev
Device Class:	OpenWay CENTRON, Single-phase - ITR1 (73.84.82.49)
Version:	3 - 4/11/2014 11:45:01 AM
Description:	Config_64_kwh_tou_single_ICS_ev

Validation Errors (0):No Validation Errors

Warnings (0):No Warnings

TOU/Time | Security | Quantities | Register Operation | Device Multipliers | Load Profile | Instrumentation Profile | Voltage Monitor | Display | Events | Comm Logs | Service Limiting | Communication

Display

Normal Display | Test Mode Display | Display Options | User Data

Normal Display Add Item

Index	Description	Item ID	Total Digits	Decimal Digits	Display Units	Display Type
0	Segment Test		0	0	None	All Segments
1	Current Date	01	0	0	None	mm:dd:yy
2	Current Time	02	0	0	None	Time in Hour:Minute:Second format
3	Wh Delivered Rate A	04	5	0	KWh	With Decimal Point and leading zeroes
4	Wh Delivered Rate B	10	5	0	KWh	With Decimal Point and leading zeroes
5	Wh Delivered Rate C	16	5	0	KWh	With Decimal Point and leading zeroes
6	Wh Delivered Total	39	5	0	KWh	With Decimal Point and leading zeroes

10) Before moving configuration group - completed an interrogation read through the CE to ensure that meter is communicating

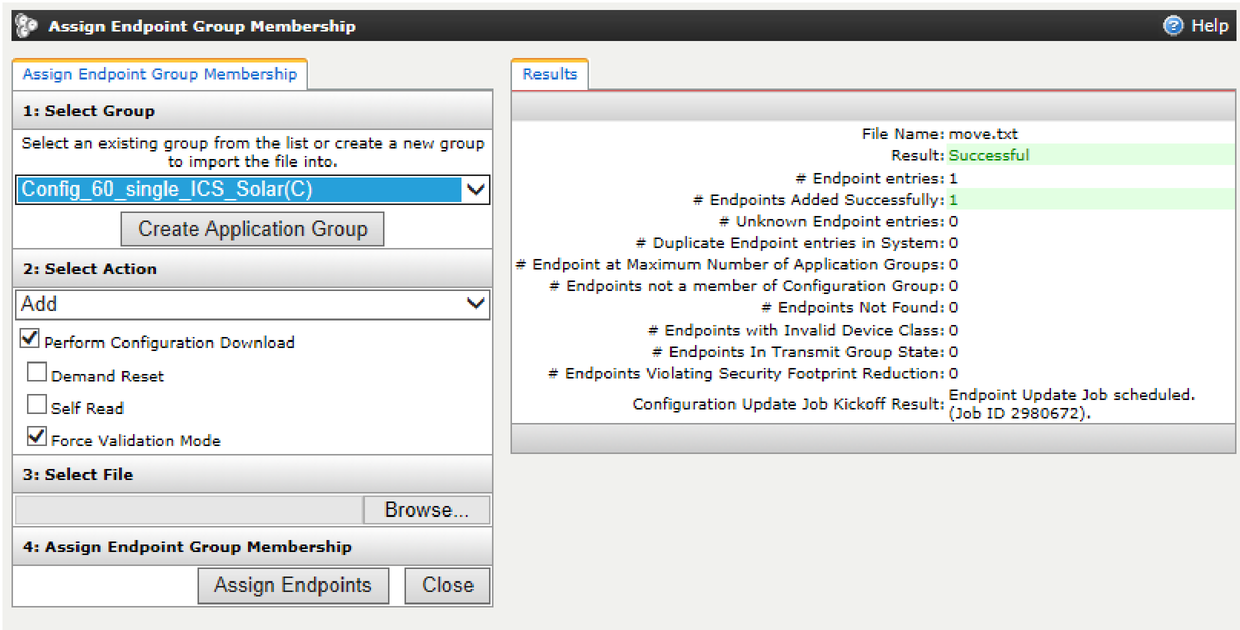
Register Data

Register Name:	Value:	Time of Occurrence:	Source:
ccum W d	0	10/15/2014 2:44:00 PM	Current
ccum W d Rate A	0	10/15/2014 2:44:00 PM	Current
ccum W d Rate B	0	10/15/2014 2:44:00 PM	Current
ccum W d Rate C	0	10/15/2014 2:44:00 PM	Current
cum W d	0	10/15/2014 2:44:00 PM	Current
cum W d Rate A	0	10/15/2014 2:44:00 PM	Current
cum W d Rate B	0	10/15/2014 2:44:00 PM	Current
cum W d Rate C	0	10/15/2014 2:44:00 PM	Current
ins V(a)	120.8	10/15/2014 2:44:00 PM	Present
max W d	0	10/8/2014 8:12:00 AM	Current
max W d Rate A	0	10/8/2014 8:12:00 AM	Current
max W d Rate B	0	10/8/2014 8:12:00 AM	Current
max W d Rate C	0	10/8/2014 8:12:00 AM	Current
Number of Demand Resets	0	10/15/2014 2:44:00 PM	Present
Number of Inversion Tampers	0	10/15/2014 2:44:00 PM	Present
Number of minutes on battery carryover	96674	10/15/2014 2:44:00 PM	Present
Number of Power Outages	3	10/15/2014 2:44:00 PM	Present
Number of Removal Tampers	0	10/15/2014 2:44:00 PM	Present
Number of times programmed	4	10/15/2014 2:44:00 PM	Present
VAh d	0	10/15/2014 2:44:00 PM	Current
VAh d Rate A	0	10/15/2014 2:44:00 PM	Current
VAh d Rate B	0	10/15/2014 2:44:00 PM	Current
VAh d Rate C	0	10/15/2014 2:44:00 PM	Current
Wh d	0	10/15/2014 2:44:00 PM	Current
Wh d Rate A	0	10/15/2014 2:44:00 PM	Current
Wh d Rate B	0	10/15/2014 2:44:00 PM	Current
Wh d Rate C	0	10/15/2014 2:44:00 PM	Current

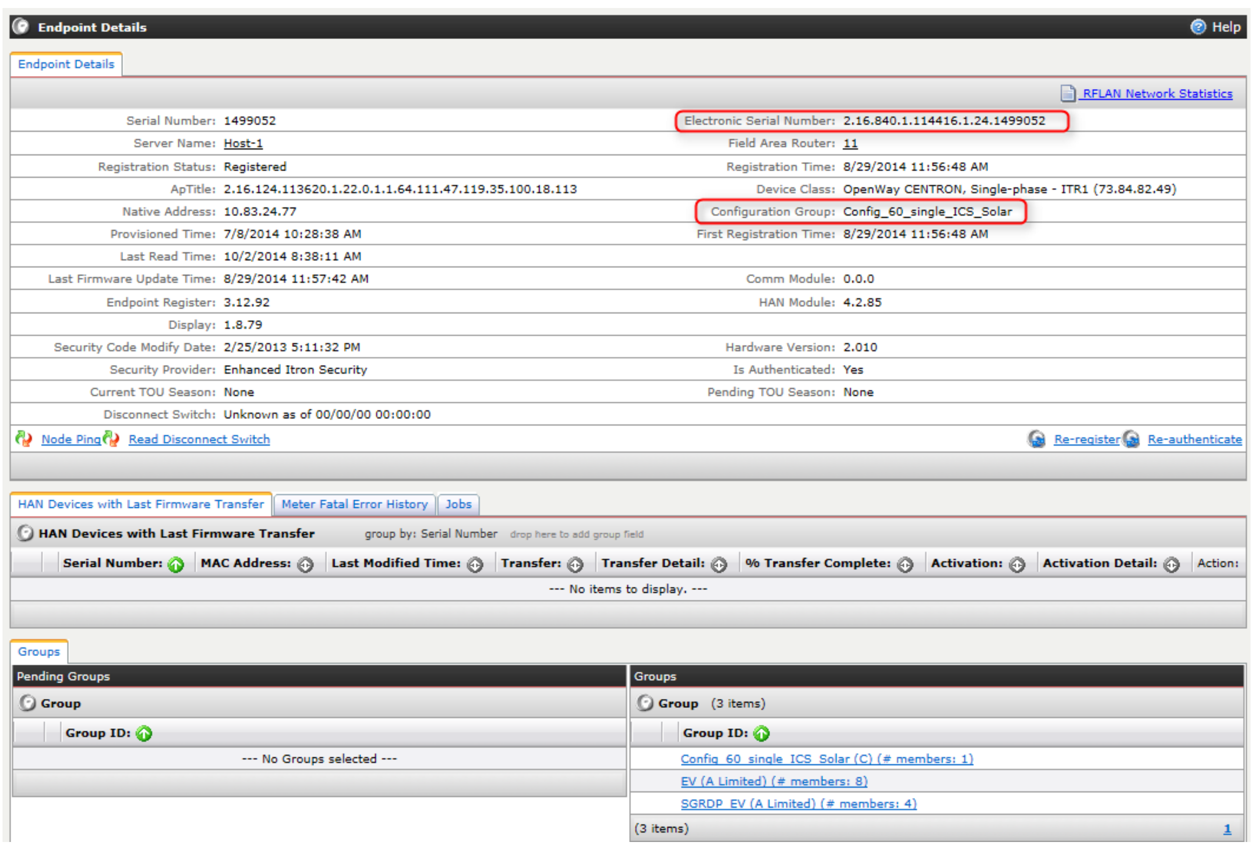
History Log

Event Date/Time:	Event:	Event Parameters:
10/15/2014 2:16:29 PM	Primary Power Down	
10/15/2014 2:17:35 PM	Primary Power Up	
10/15/2014 2:17:35 PM	HAN Meter Network Change	Meter Network Status = Network Up, Network Change Reason = Network Restart

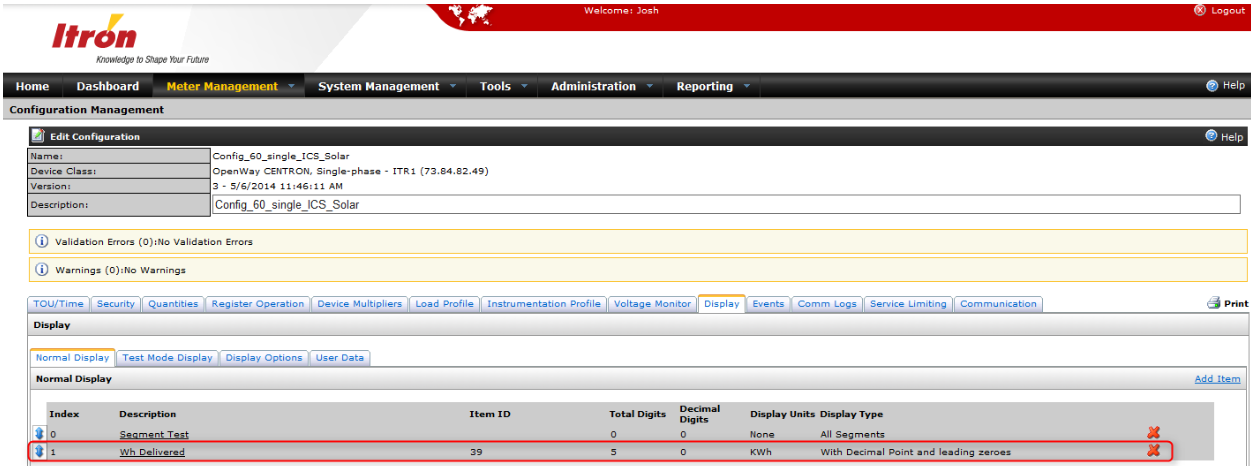
11) Move meter from Config 64 kWH TOU single ICS to Config_60 _single_ICS_Solar



12) Request a meter interrogation of the meter through CE and confirmed that the meter moved to Config_60 _single_ICS_Solar

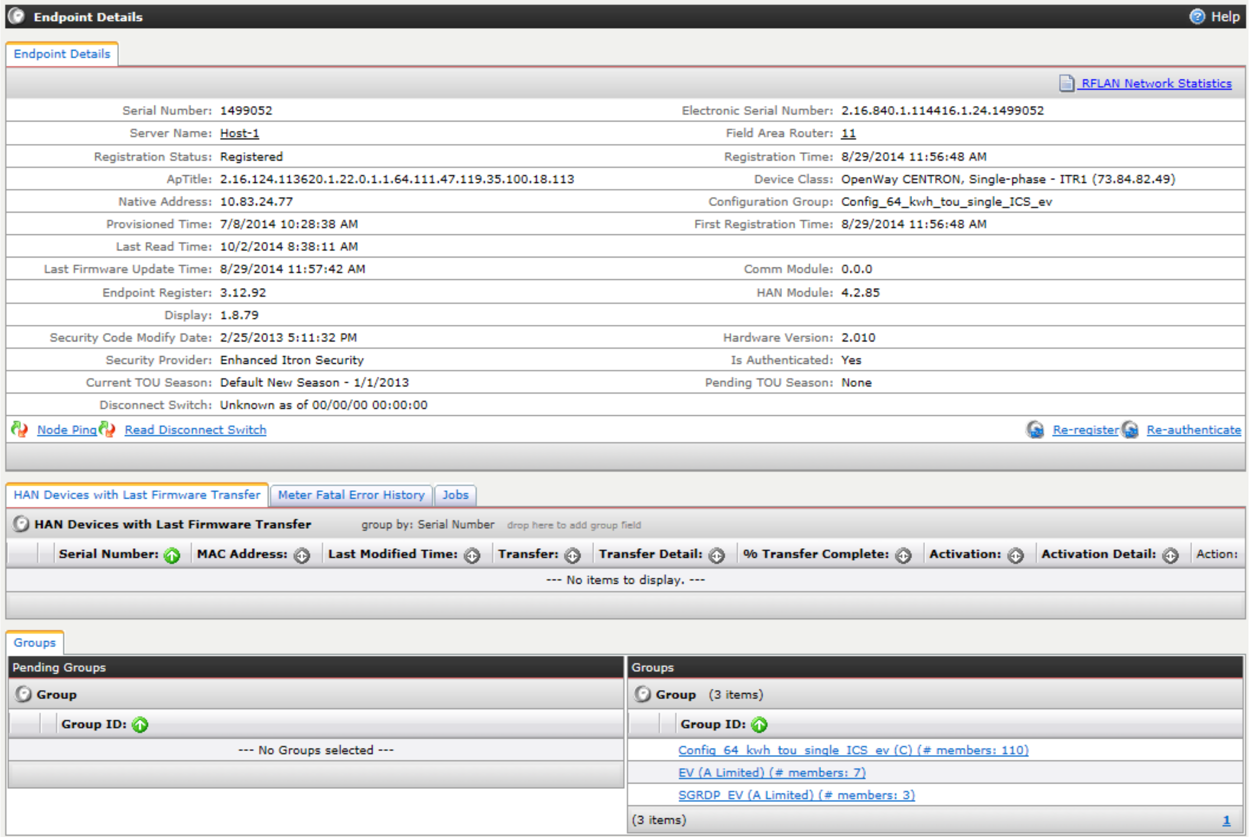


13) Confirmed specs for Config_60 _single_ICS_Solar confirm that it has both Display 39 only



14) Confirmed that on display of the meter, it is showing only Display 39 (kWh) after the meter reprogrammed
First validated display 39 – see image attached

15) Re-programmed the meter back from Config_60 _single_ICS_Solar back to Config_64_kwh_ tou_single_ ICS_ev



16) Completed an interactive read from CE to confirm registers in Config_60_kwh_only.

Serial Number	1499052
Electronic Serial Number	2.16.840.1.114416.1.24.1499052
Interactive Read Time	10/15/2014 5:00:20 PM
Time Zone	(GMT-08:00) Pacific Time (US & Canada); Tijuana
Requested Time Span	10/15/2014 4:00:20 PM - 10/15/2014 5:00:20 PM
Job Status	Successful
Job Duration	00:00:53

Register Data

Register Name:	**Value:**	**Time of Occurrence:**	**Source:**
ccum W d	0	10/15/2014 5:00:29 PM	Current
ccum W d Rate A	0	10/15/2014 5:00:29 PM	Current
ccum W d Rate B	0	10/15/2014 5:00:29 PM	Current
ccum W d Rate C	0	10/15/2014 5:00:29 PM	Current
cum W d	0	10/15/2014 5:00:29 PM	Current
cum W d Rate A	0	10/15/2014 5:00:29 PM	Current
cum W d Rate B	0	10/15/2014 5:00:29 PM	Current
cum W d Rate C	0	10/15/2014 5:00:29 PM	Current
ins V(a)	121.9	10/15/2014 5:00:29 PM	Present
max W d	0	10/15/2014 4:57:00 PM	Current
max W d Rate A	0	10/15/2014 4:57:00 PM	Current
max W d Rate B	0	10/15/2014 4:57:00 PM	Current
max W d Rate C	0	10/15/2014 4:57:00 PM	Current
Number of Demand Resets	0	10/15/2014 5:00:29 PM	Present
Number of Inversion Tampers	0	10/15/2014 5:00:29 PM	Present
Number of minutes on battery carryover	96674	10/15/2014 5:00:29 PM	Present
Number of Power Outages	3	10/15/2014 5:00:29 PM	Present
Number of Removal Tampers	0	10/15/2014 5:00:29 PM	Present
Number of times programmed	6	10/15/2014 5:00:29 PM	Present
VAh d	0	10/15/2014 5:00:29 PM	Current
VAh d Rate A	0	10/15/2014 5:00:29 PM	Current
VAh d Rate B	0	10/15/2014 5:00:29 PM	Current
VAh d Rate C	0	10/15/2014 5:00:29 PM	Current
Wh d	0	10/15/2014 5:00:29 PM	Current
Wh d Rate A	0	10/15/2014 5:00:29 PM	Current
Wh d Rate B	0	10/15/2014 5:00:29 PM	Current
Wh d Rate C	0	10/15/2014 5:00:29 PM	Current

17) Check meter and confirm that meter is showing all display of Config_64_kwh_ tou_single_ ICS_ev (01, 02, 04, 10, 16 and 39)

    See image attached.

Part 4: Remote Connect and Disconnect

The smart meters’ capability for remote connect and remote disconnect provides the utilities with the ability to perform the service connect and service disconnect from a remote control center in a safe and secure way. An every-day case for these functions is customer’s move-out from a house and move-in to a house.

The following demos are performed on residential and C&I meters:

- Residential (Form 2S, programmed with configuration programs 50 or 60) meters with both RFLAN and Direct-Connect communication shall be among the selected endpoints.
- Commercial & Industrial (Form 9S or 5S or 16S, programmed with any configuration program other than 60) with RFLAN and Direct-Connect communication shall be among the selected endpoints

7. **Select at least 2 meters at LADWP lab environment. Coordinate with LADWP, and issue Remote Disconnect command to meters at least once**

Action: Following meters were selected:
1) UCLA Meter: 7FY00009-00133315
ESN - 2.16.840.1.114416.1.24. 133315
2) Test Meter: 7F00009-1452194

ESN - 2.16.840.1.114416.1.24.1452194

Acceptance Criteria: Remote Connect to be performed successfully.

Date: 9/9/2014 and 10/16/2014

Result: Passed, based on the following outcomes

9/9/2014: Remote Connect Testing

Tester: Thuy-An, Michael

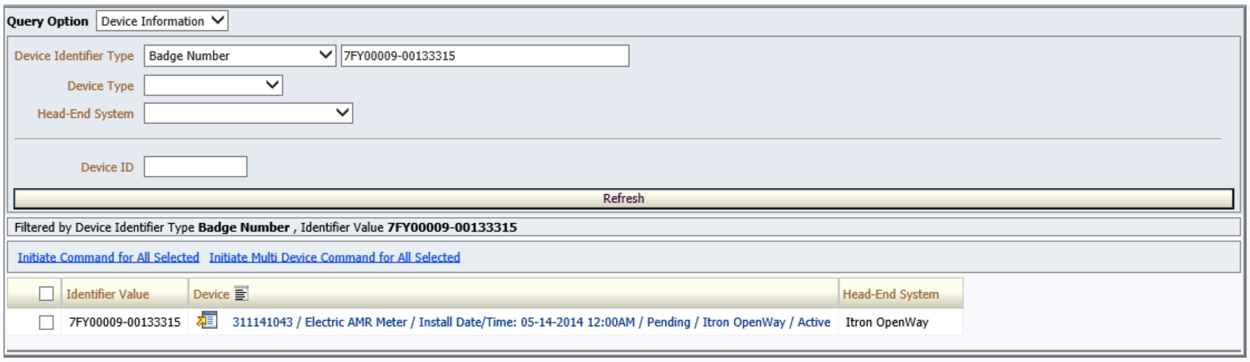
Witnesses: Emil, Afshin, Shawn and Josh

Test using meter with batch number: 7FY00009-00133315 with ESN**2.16.840.1.114416.1.24. 133315**

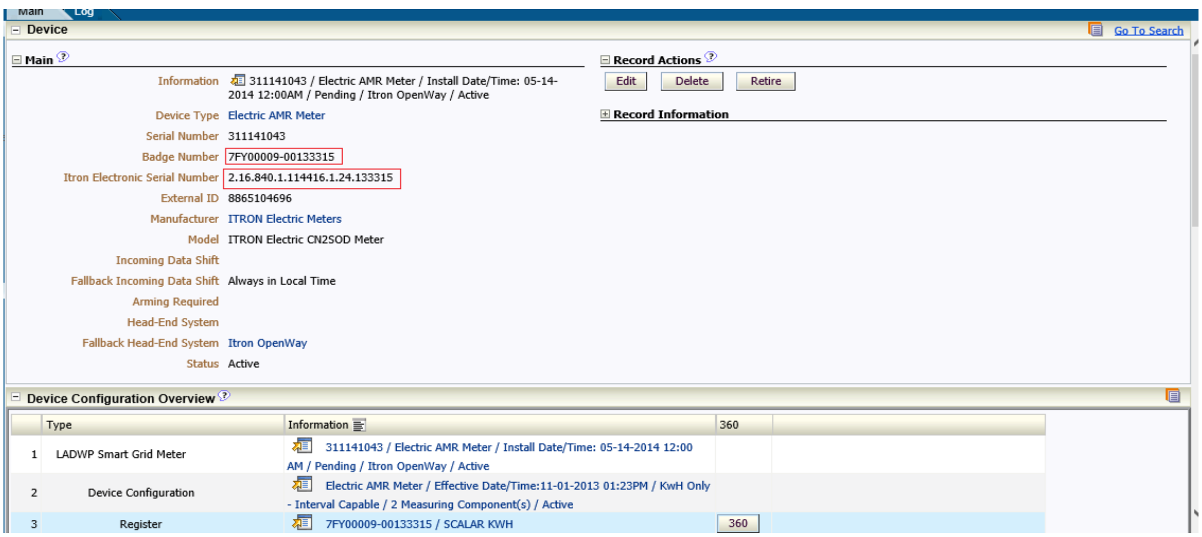
Account	WR No	Premise ID	Type	Classification	Address	New Meter Prefix	New Meter Size	New Meter Number	New Meter Serial Number	Old Meter Prefix	Old Meter Size	Old Meter Number	Date Completed	FI-39 RMVD KWH READ	FQ-41 RMVD KWD READ
	1360493	2068271458	NBRAC	SG-AMI-D	3300 SAWTELLE BL UNIT: 201 LOS ANGELES	7FY	9	133315	311141043	Y	9	53489	5/14/2014	40921	

Test Steps for Remote Connect

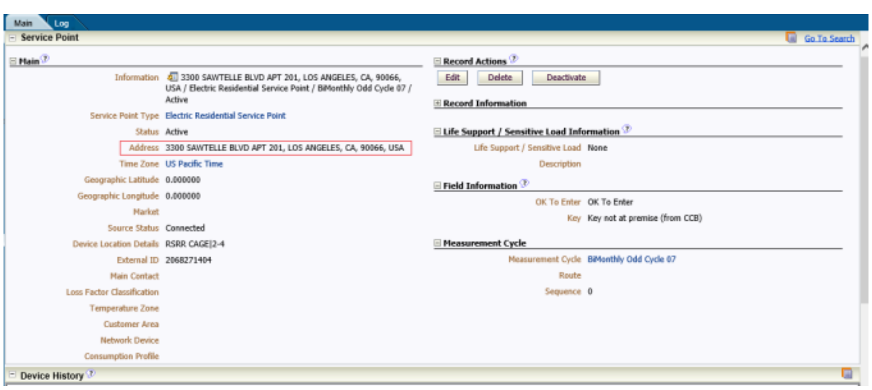
1) Navigate to Menu, click on Main Menu, drop down to Device and click on +Device
2) Select Device Identifier Type and choose Badge number and enter in 7FY00009-00133315 and click refresh



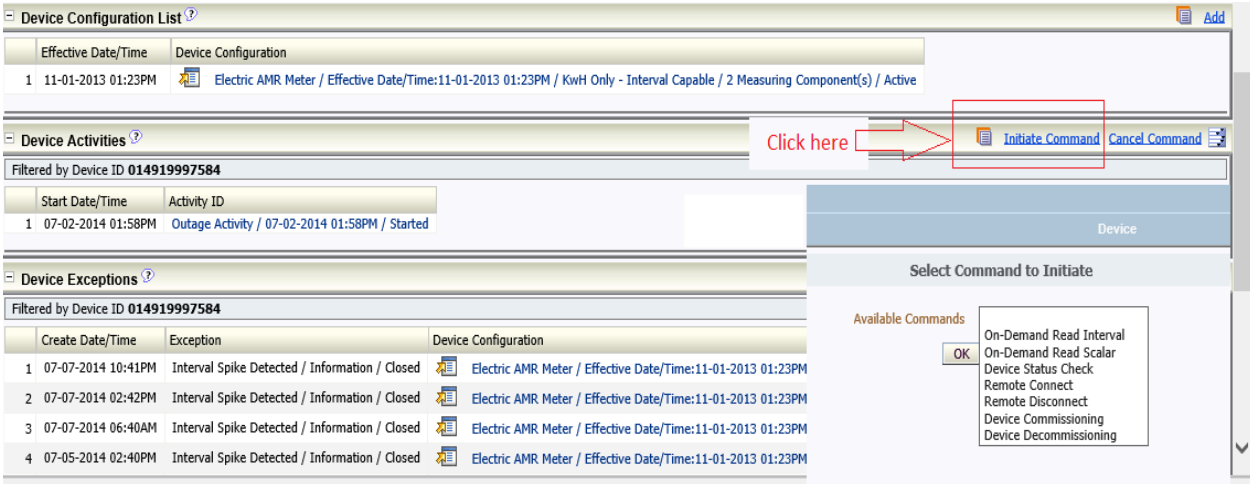
3) Click on meter below and confirm badge number and ESN for meter



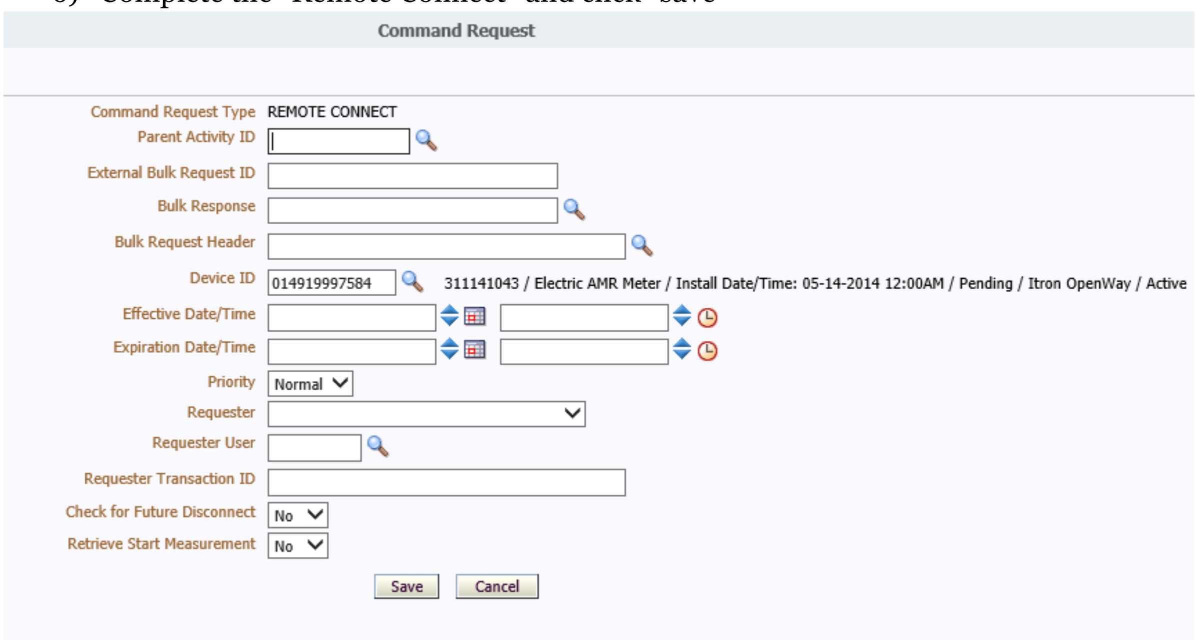
4) Click on Service Point and confirm the meter address location matches that of 3300 SAWTELLE BL UNIT: 201



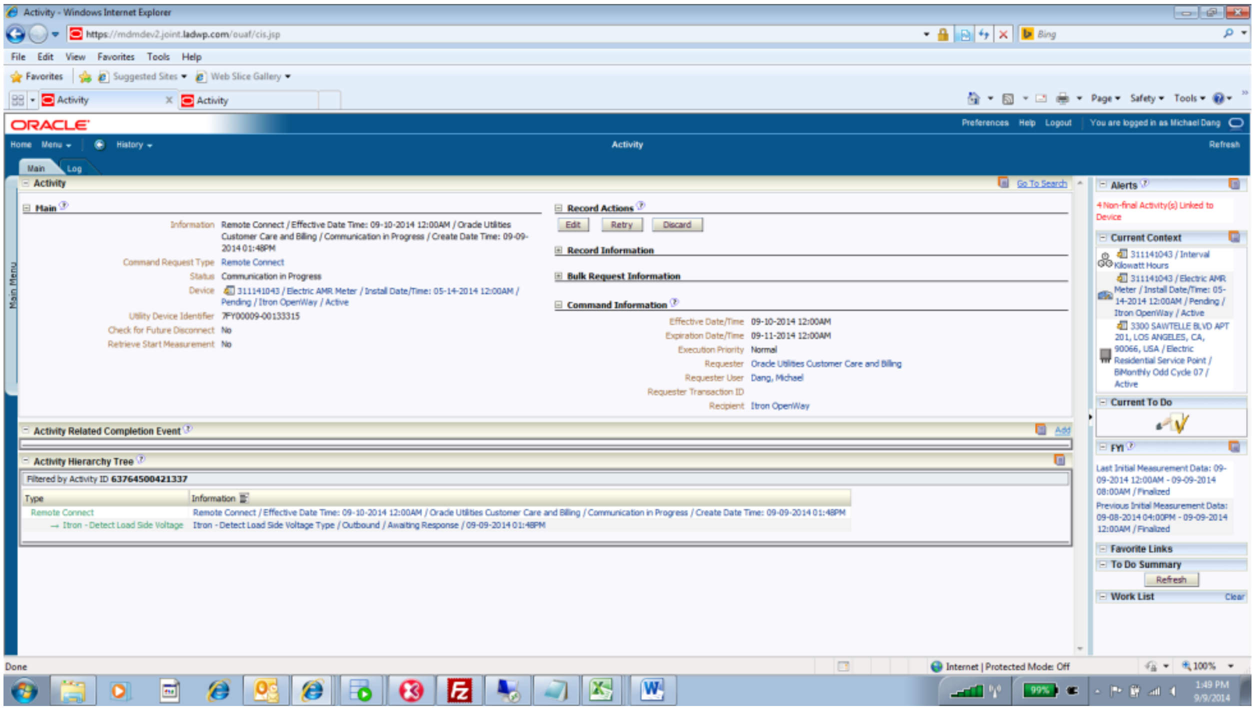
5) From Device, scroll down to Device Activities and click on “Initiate Command” and then from drop down select Remote Connect and click “ok”



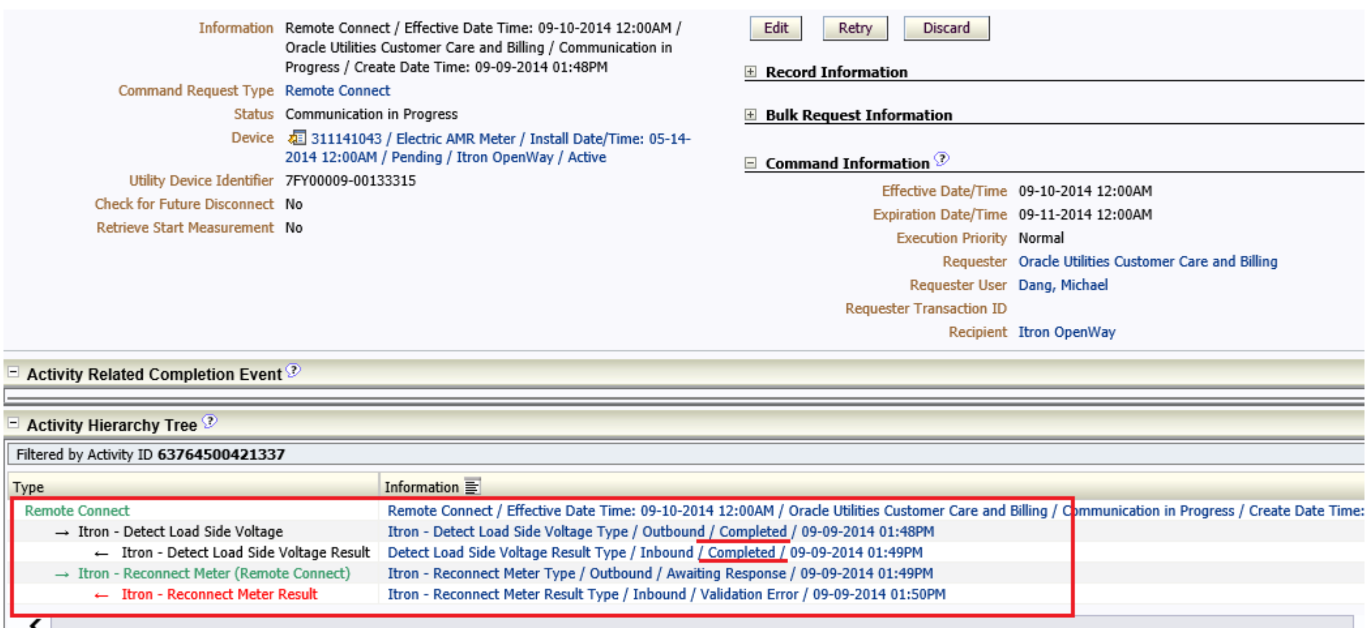
6) Complete the “Remote Connect” and click “save”



7) Confirm “Remote Connect” job kicked off



8) Confirmed "Remote Connect" job completed successfully



9) Offsite team, Emil, Afshin, Shawn & Josh was onsite at UCLA and confirmed that the meter was Re-connected

Results from Itron CE confirmed the Remote Connect was successful and processed in 41 seconds.

9/9/2014 1:49 PM request received by the OpenWay Collection Engine, command sent to meter
9/9/2014 1:49 PM meter received the command and executes remote reconnect, event is logged in meter:

History Log

Event Date/Time:	Event:
9/9/2014 1:32:29 PM	Remote disconnect success
9/9/2014 1:49:53 PM	Remote connect success

9/9/2014 1:49 PM response from meter received by OpenWay Collection Engine, status sent to MDM

Job Details Report

powered by Itron

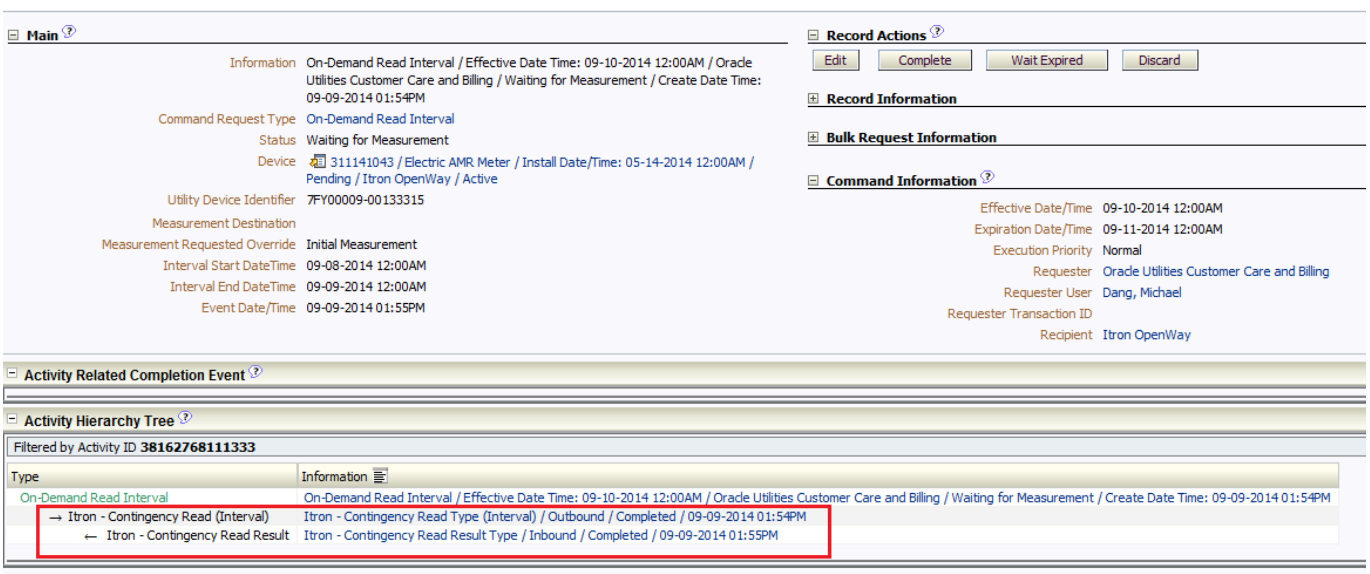
Job Details			
Job ID:	1334296	Action:	Connect Endpoint
Request Token:	7bd1bb57-7220-4f0b-a541-6fb4910afefa		
User:	OpenWaySystem	Client IP Address:	10.11.45.51
Group ID:	N/A	# Endpoints:	1
Status:	Successful	Job Duration:	00:00:41
% Complete:	100.0% (1)	Submit Time:	9/9/2014 1:49:18 PM
Start Time:	9/9/2014 1:49:18 PM	Completion Time:	9/9/2014 1:49:59 PM

Job Parameters	
RequireUserIntervention:	False

Job Endpoints

Serial Number	Field Area Router	Job Status	Final Result
	Job Status: Successful (1)		
133315	14555728	Successful	17019 - Job endpoint succeeded.

10) Requested an on-demand interval read on the meter after a “Remote Connect”. Confirmed contingency read was successful.



11) Confirmed in Itron that on demand contingency read was successful

Jobs

Jobs (3 of 24857 items) group by: Status drop here to add group field

Job ID:	Request Token:	Description:	Status:	Group:	Submit Time:	% Complete:
Status: Successful (3)						
1334286	ef64de1b-335f-4427-87ff-080c773acf3e	Contingency Read	Successful	None	9/9/2014 1:36:09 PM	100.0%
1334294	3543cf31-7b7c-40b8-9807-5669db2d462b	Contingency Read	Successful	None	9/9/2014 1:43:59 PM	100.0%
1334300	95bfb675-eee3-4f4b-898f-4795bfa1bced	Contingency Read	Successful	None	9/9/2014 1:54:30 PM	100.0%

(3 of 24857 items)

12) Also obtained meter register data from Itron CE following the remote connect/disconnect test to confirm no issues with the meter


```
<?xml version="1.0" encoding="US-ASCII"?>
- <edl xmlns="http://www.nema.org/tdl/NEMA.73.84.82.68/EDLSchema" version="2.5" deviceClass="73.84.82.68">
  - <data>
    - <GEN_CONFIG_TBL>
      - <FORMAT_CONTROL_1>
          <DATA_ORDER>0</DATA_ORDER>
          <CHAR_FORMAT>1</CHAR_FORMAT>
          <MODEL_SELECT>0</MODEL_SELECT>
          <FILLER>0</FILLER>
        </FORMAT_CONTROL_1>
      - <FORMAT_CONTROL_2>
          <TM_FORMAT>3</TM_FORMAT>
          <DATA_ACCESS_METHOD>1</DATA_ACCESS_METHOD>
          <ID_FORM>0</ID_FORM>
          <INT_FORMAT>0</INT_FORMAT>
        </FORMAT_CONTROL_2>
      - <FORMAT_CONTROL_3>
          <NI_FORMAT1>0</NI_FORMAT1>
          <NI_FORMAT2>1</NI_FORMAT2>
        </FORMAT_CONTROL_3>
        <DEVICE_CLASS binary="49545244"/>
        <NAMEPLATE_TYPE>2</NAMEPLATE_TYPE>
        <DEFAULT_SET_USED>0</DEFAULT_SET_USED>
        <MAX_PROC_PARM_LENGTH>44</MAX_PROC_PARM_LENGTH>
        <MAX_RESP_DATA_LEN>42</MAX_RESP_DATA_LEN>
        <STD_VERSION_NO>2</STD_VERSION_NO>
        <STD_REVISION_NO>0</STD_REVISION_NO>
        <DIM_STD_TBLS_USED>16</DIM_STD_TBLS_USED>
        <DIM_MFG_TBLS_USED>48</DIM_MFG_TBLS_USED>
        <DIM_STD_PROC_USED>4</DIM_STD_PROC_USED>
        <DIM_MFG_PROC_USED>21</DIM_MFG_PROC_USED>
        <DIM_MFG_STATUS_USED>5</DIM_MFG_STATUS_USED>
        <NBR_PENDING>8</NBR_PENDING>
      - <STD_TBLS_USED>
          <entry index="0-8,11-16,21-28,31-34,41-44,46,51-55,61-64,71-76,120-123,125-127">true</entry>
          <entry index="9-10,17-20,29-30,35-40,45,47-50,56-60,65-70,77-119,124">false</entry>
        </STD_TBLS_USED>
      - <MFG_TBLS_USED>
          <entry index="0-3,5-9,13-22,26-36,40-42,50-62,64-88,90-95,100-116,120,127,130-133,142-147,150-156,158-160,171-172,180-189,191-195,200
            -201,212-218,220-224,230-249,312,320-322,331,334-335,341-346,361-363,365,369-371,373-375">true</entry>
```


Test results for Remote Connect - Pass

8. **Select at least 2 meters at LADWP lab environment. Coordinate with LADWP, and issue Remote-Reconnect commands to meters at least once during the Test.**

   Action: Following meters were selected

   1) UCLA Meter: 7FY00009-00133315 ESN2.16.840.1.114416.1.24. 133315

   2) Test Meter: 7F00009-1452194

   ESN - 2.16.840.1.114416.1.24.1452194

   Acceptance Criteria: Remote Connect to be performed successfully.

   Date: 9/9/2014 and 10/16/2014

   Result: Passed, based on following outcomes

9/9/2014: Remote Connect Testing

Tester: Thuy-An, Michael

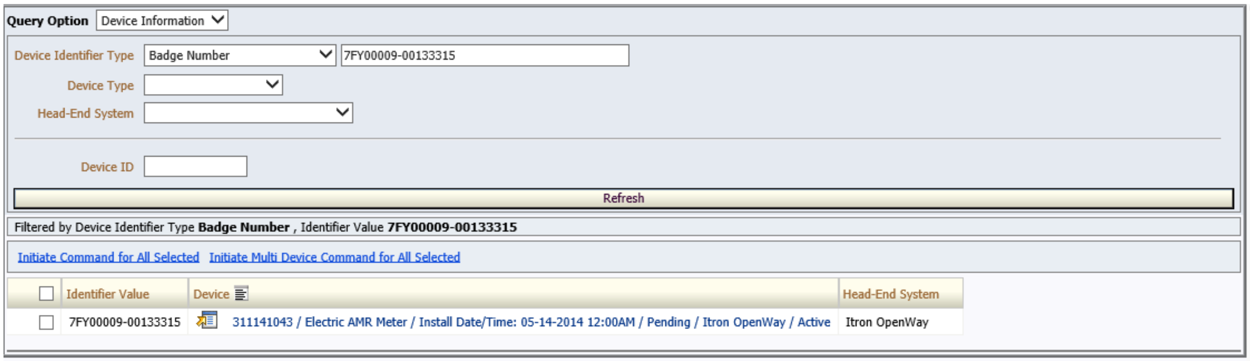
Witnesses: Emil, Afshin, Shawn and Josh

Test using meter with batch number: 7FY00009-00133315 with ESN**2.16.840.1.114416.1.24.133315**

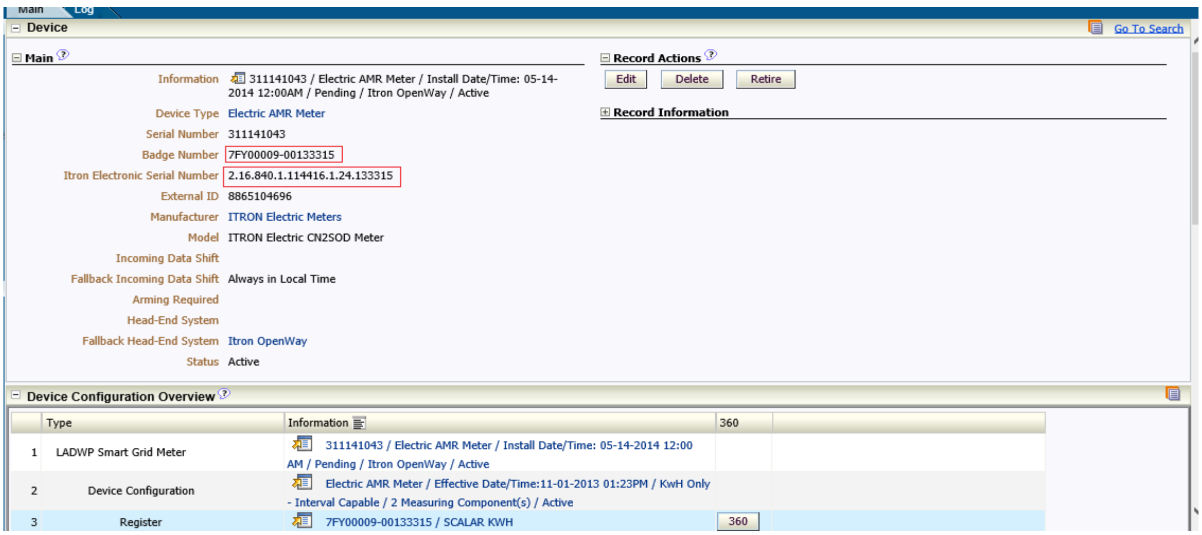
Account	WR No	Premise ID	Type	Classification	Address	New Meter Prefix	New Meter Size	New Meter Number	New Meter Serial Number	Old Meter Prefix	Old Meter Size	Old Meter Number	Date Completed	FI-39 RMVD KWH READ	FQ-41 RMVD KWD READ
	1360493	2068271458	NBRAC	SG-AMI-D	3300 SAWTELLE BL UNIT: 201 LOS ANGELES	7FY	9	133315	311141043	Y	9	53489	5/14/2014	40921	

Test Steps for Remote Connect

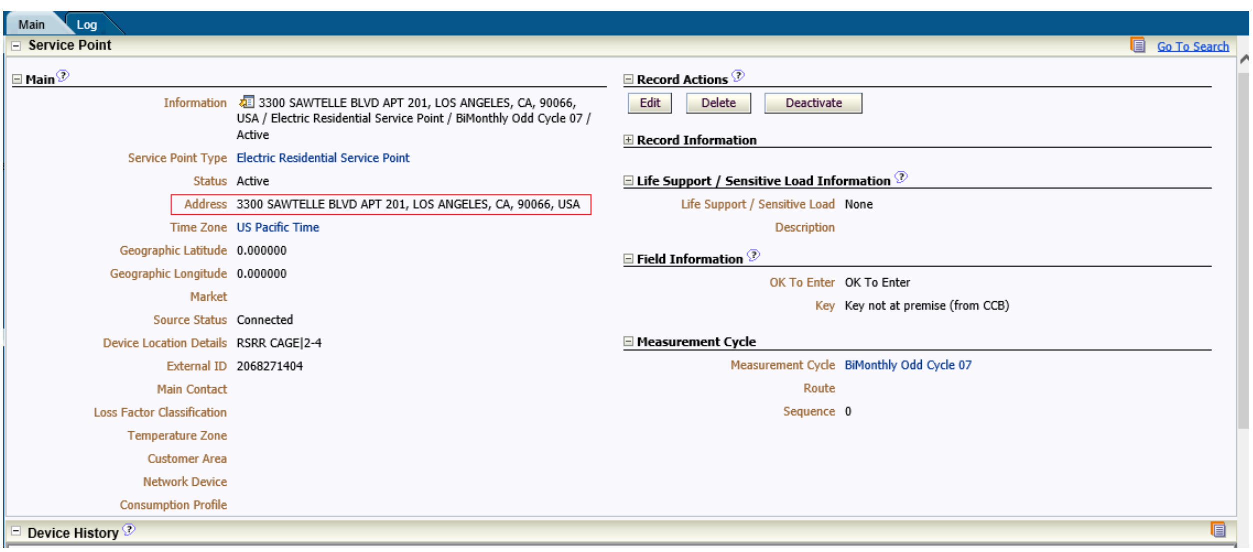
1) Navigate to Menu, click on Main Menu, drop down to Device and click on +Device
2) Select Device Identifier Type and choose Badge number and enter in 7FY00009-00133315 and click refresh



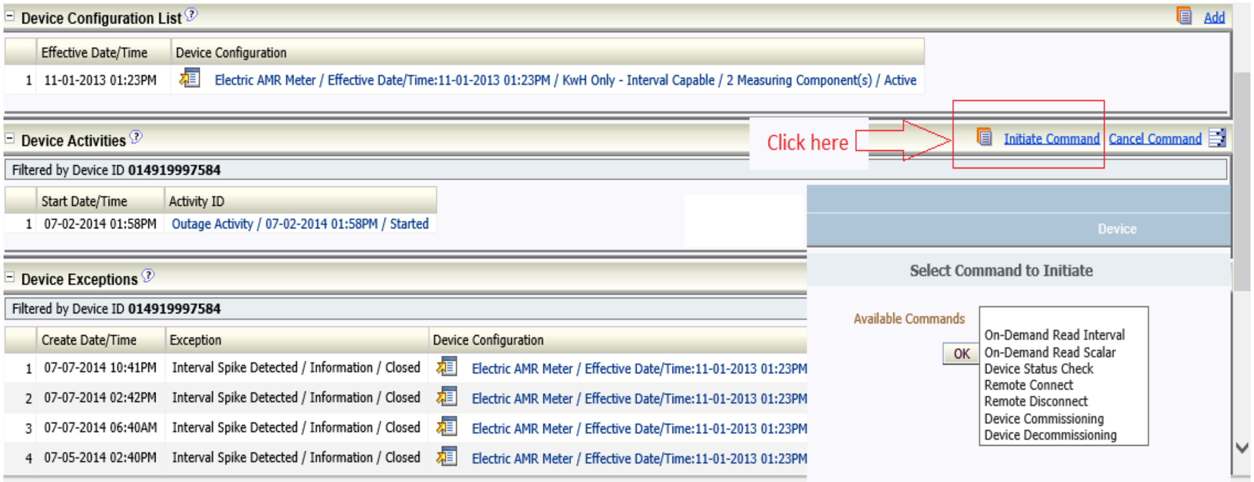
3) Click on meter below and confirm badge number and ESN for meter



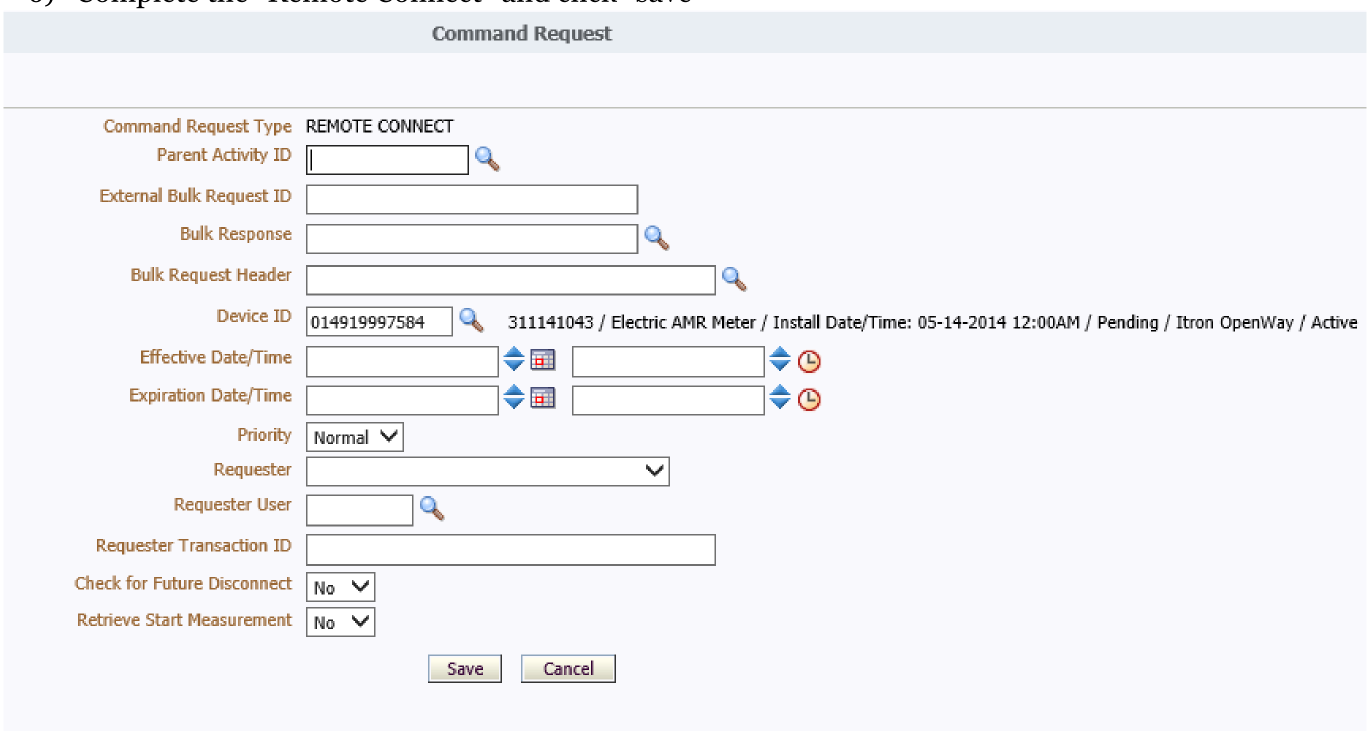
4) Click on Service Point and confirm the meter address location matches that of 3300 SAWTELLE BL UNIT: 201



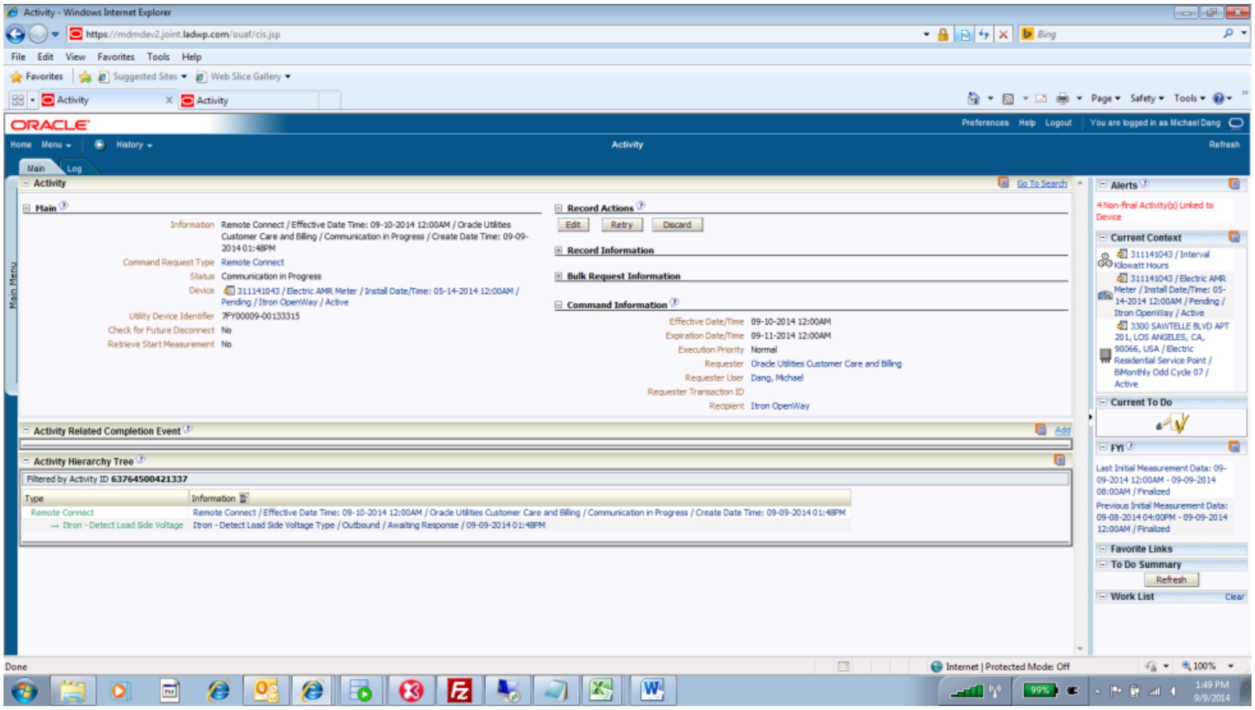
5) From Device, scroll down to Device Activities and click on “Initiate Command” and then from drop down select Remote Connect and click “ok”



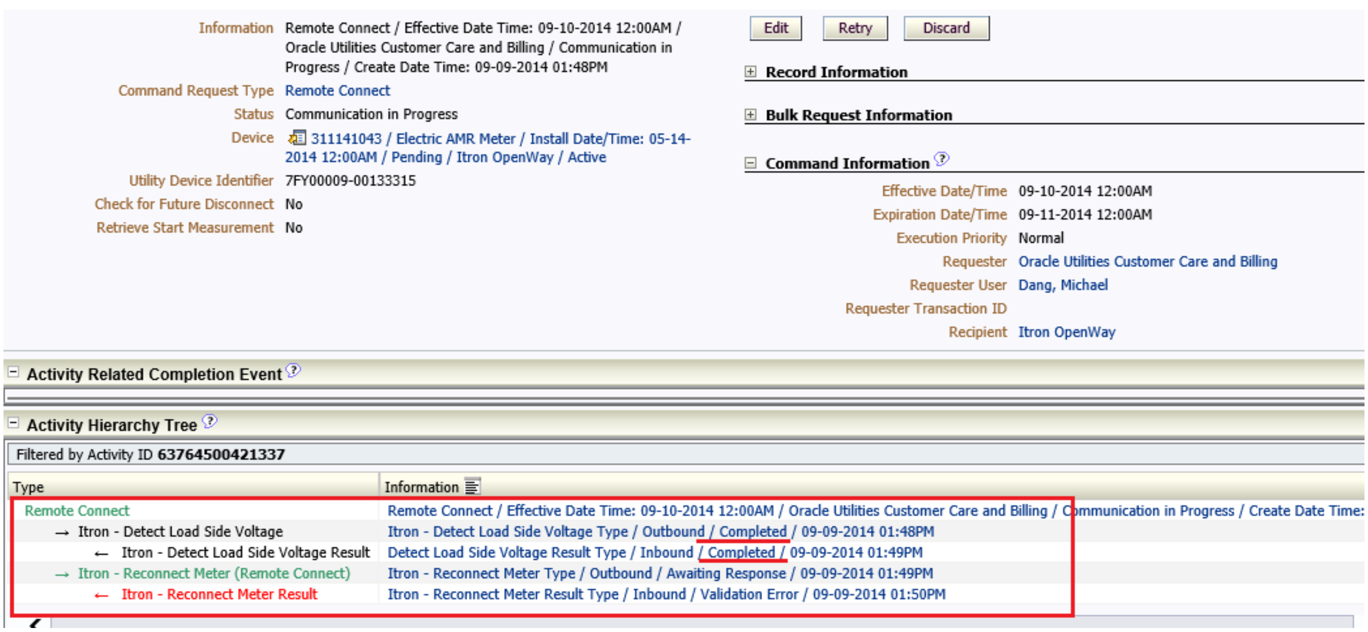
6) Complete the “Remote Connect” and click “save”



7) Confirm “Remote Connect” job kicked off



8) Confirmed “Remote Connect” job completed successfully



9) Offsite team, Emil, Afshin, Shawn & Josh was onsite at UCLA and confirmed that the meter was Re-connected

Results from Itron CE confirmed the Remote Connect was successful and processed in 41 seconds.

9/9/2014 1:49 PM request received by the OpenWay Collection Engine, command sent to meter
9/9/2014 1:49 PM meter received the command and executes remote reconnect, event is logged in meter:

History Log

Event Date/Time:	Event:
9/9/2014 1:32:29 PM	Remote disconnect success
9/9/2014 1:49:53 PM	Remote connect success

9/9/2014 1:49 PM response from meter received by OpenWay Collection Engine, status sent to MDM

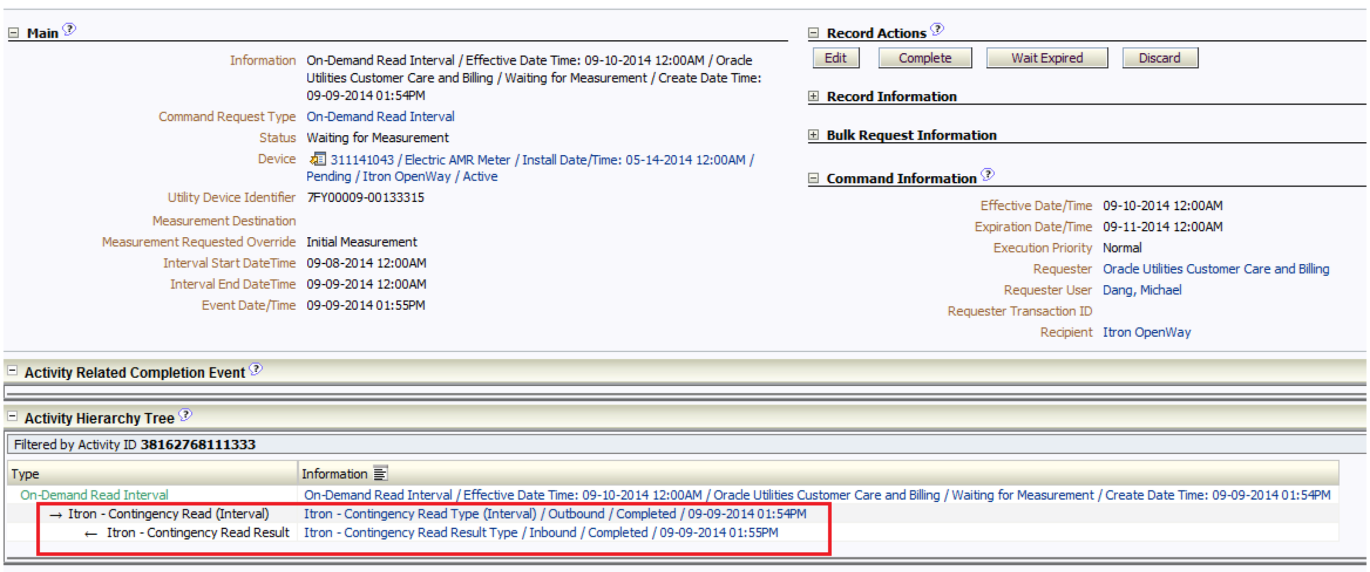
Job Details Report

Job Details			
Job ID:	1334296	Action:	Connect Endpoint
Request Token:	7bd1bb57-7220-4f0b-a541-6fb4910afefa		
User:	OpenWaySystem	Client IP Address:	10.11.45.51
Group ID:	N/A	# Endpoints:	1
Status:	Successful	Job Duration:	00:00:41
% Complete:	100.0% (1)	Submit Time:	9/9/2014 1:49:18 PM
Start Time:	9/9/2014 1:49:18 PM	Completion Time:	9/9/2014 1:49:59 PM

Job Parameters	
RequireUserIntervention:	False

Job Endpoints			
Serial Number	Field Area Router	Job Status	Final Result
	Job Status: Successful (1)		
133315	14555728	Successful	17019 - Job endpoint succeeded.

10) Requested an on-demand interval read on the meter after a “Remote Connect”. Confirmed contingency read was successful.



11) Confirmed in Itron that on demand contingency read was successful

Jobs

Jobs (3 of 24857 items) group by: Status drop here to add group field

Job ID:	Request Token:	Description:	Status:	Group:	Submit Time:	% Complete:
Status: Successful (3)						
1334286	ef64de1b-335f-4427-87ff-080c773acf3e	Contingency Read	Successful	None	9/9/2014 1:36:09 PM	100.0%
1334294	3543cf31-7b7c-40b8-9807-5669db2d462b	Contingency Read	Successful	None	9/9/2014 1:43:59 PM	100.0%
1334300	95bfb675-eee3-4f4b-898f-4795bfa1bced	Contingency Read	Successful	None	9/9/2014 1:54:30 PM	100.0%

(3 of 24857 items)

12) Also obtained meter register data from Itron CE following the remote connect/disconnect test to confirm no issues with the meter


```
<?xml version="1.0" encoding="US-ASCII"?>
- <edl xmlns="http://www.nema.org/tdl/NEMA.73.84.82.68/EDLSchema" version="2.5" deviceClass="73.84.82.68">
  - <data>
    - <GEN_CONFIG_TBL>
      - <FORMAT_CONTROL_1>
          <DATA_ORDER>0</DATA_ORDER>
          <CHAR_FORMAT>1</CHAR_FORMAT>
          <MODEL_SELECT>0</MODEL_SELECT>
          <FILLER>0</FILLER>
        </FORMAT_CONTROL_1>
      - <FORMAT_CONTROL_2>
          <TM_FORMAT>3</TM_FORMAT>
          <DATA_ACCESS_METHOD>1</DATA_ACCESS_METHOD>
          <ID_FORM>0</ID_FORM>
          <INT_FORMAT>0</INT_FORMAT>
        </FORMAT_CONTROL_2>
      - <FORMAT_CONTROL_3>
          <NI_FORMAT1>0</NI_FORMAT1>
          <NI_FORMAT2>1</NI_FORMAT2>
        </FORMAT_CONTROL_3>
        <DEVICE_CLASS binary="49545244"/>
        <NAMEPLATE_TYPE>2</NAMEPLATE_TYPE>
        <DEFAULT_SET_USED>0</DEFAULT_SET_USED>
        <MAX_PROC_PARM_LENGTH>44</MAX_PROC_PARM_LENGTH>
        <MAX_RESP_DATA_LEN>42</MAX_RESP_DATA_LEN>
        <STD_VERSION_NO>2</STD_VERSION_NO>
        <STD_REVISION_NO>0</STD_REVISION_NO>
        <DIM_STD_TBLS_USED>16</DIM_STD_TBLS_USED>
        <DIM_MFG_TBLS_USED>48</DIM_MFG_TBLS_USED>
        <DIM_STD_PROC_USED>4</DIM_STD_PROC_USED>
        <DIM_MFG_PROC_USED>21</DIM_MFG_PROC_USED>
        <DIM_MFG_STATUS_USED>5</DIM_MFG_STATUS_USED>
        <NBR_PENDING>8</NBR_PENDING>
      - <STD_TBLS_USED>
          <entry index="0-8,11-16,21-28,31-34,41-44,46,51-55,61-64,71-76,120-123,125-127">true</entry>
          <entry index="9-10,17-20,29-30,35-40,45,47-50,56-60,65-70,77-119,124">false</entry>
        </STD_TBLS_USED>
      - <MFG_TBLS_USED>
          <entry index="0-3,5-9,13-22,26-36,40-42,50-62,64-88,90-95,100-116,120,127,130-133,142-147,150-156,158-160,171-172,180-189,191-195,200
            -201,212-218,220-224,230-249,312,320-322,331,334-335,341-346,361-363,365,369-371,373-375">true</entry>
          <entry index="4,10-12,23-25,37-39,43-49,63,89,96-99,117-119,121-126,128-129,134-141,148-149,157,161-170,173-179,190,196-199,202-
```


Test results for Remote Connect - Pass

9/16/2014: Remote Re-Connect Testing

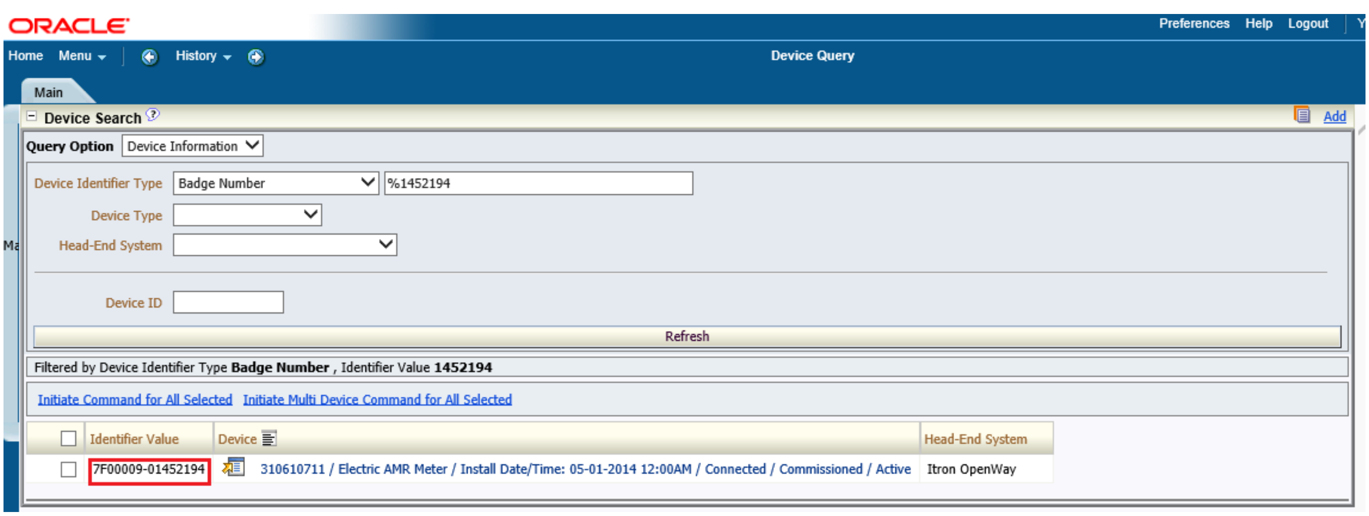
Tester: Thuy-An & Josh

Witnesses: Thuy-An & Josh

Test using meter with batch number: 7F00009-1452194 with ESN 2.16.840.1.114416.1.24.1452194 and confirmed that meter was Disconnected

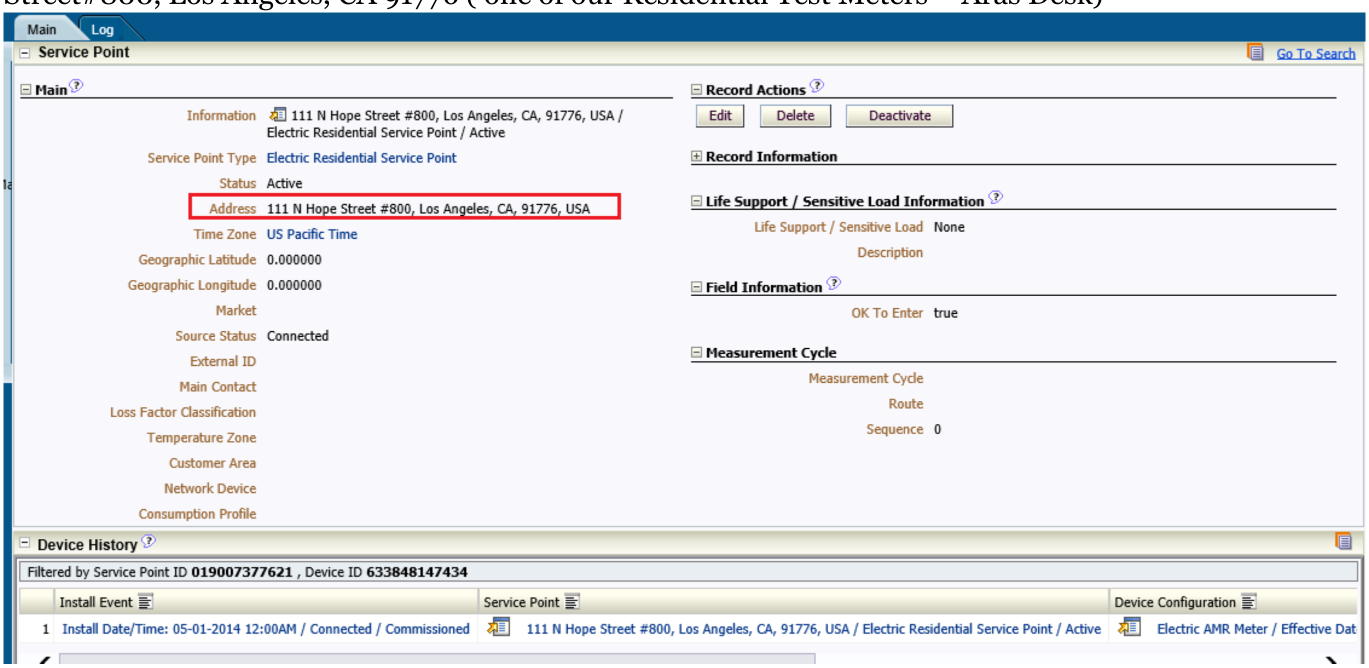
Test Steps for Remote Connect

1) Navigate to Menu, click on Main Menu, drop down to Device and click on +Device
2) Select Device Identifier Type and choose Badge number and enter in %1452194 and click refresh
3) Confirm full badge number 7F00009-1452194 matches with that on meter

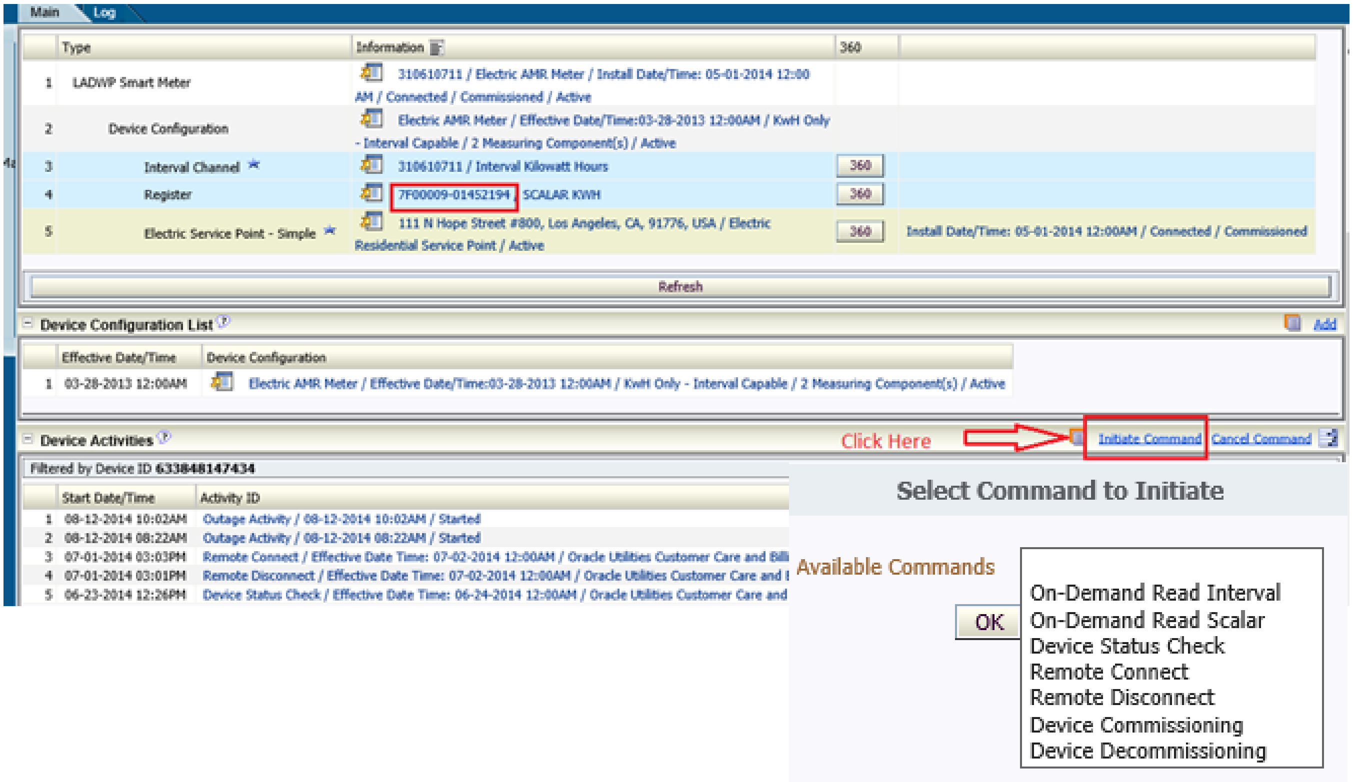


4) Click on meter below and confirm badge number and ESN for meter

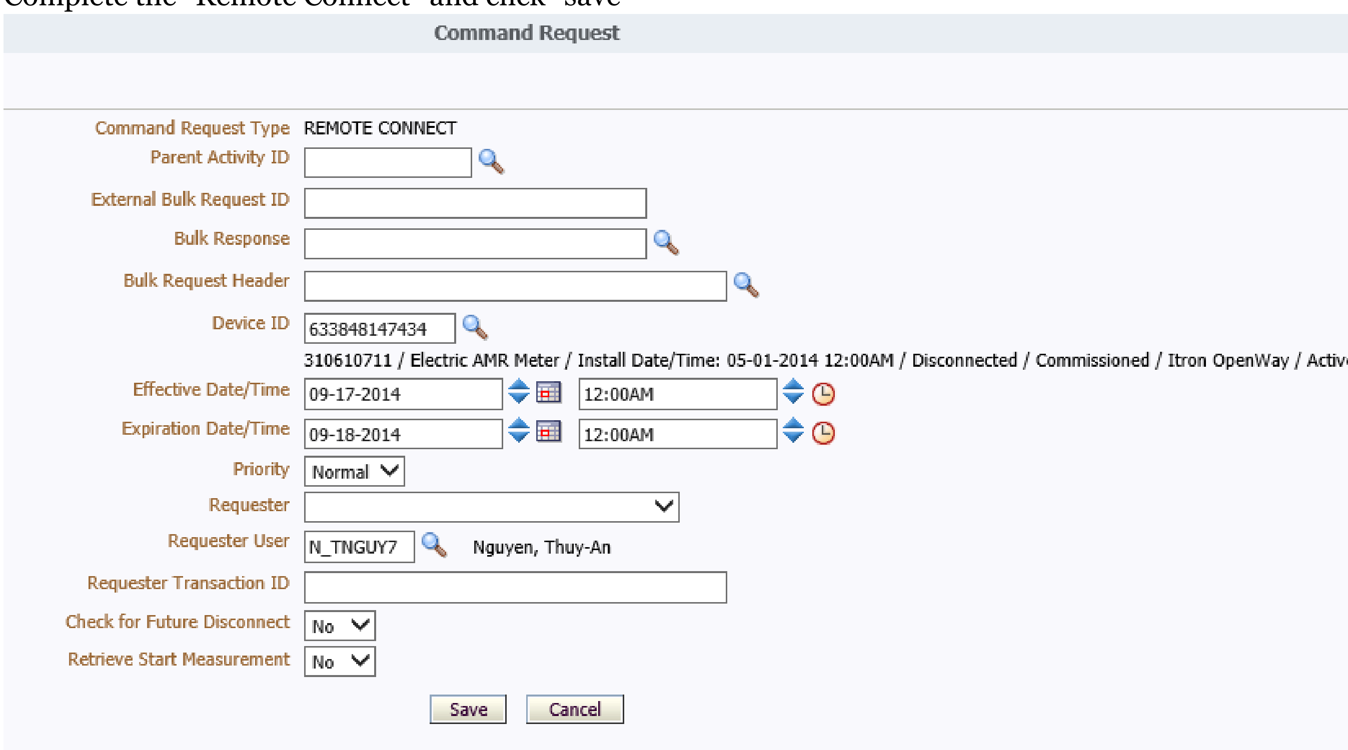
5) Click on Service Point and confirm the meter address location matches that of 111 N Hope Street#800, Los Angeles, CA 91776 (one of our Residential Test Meters – Aras Desk)



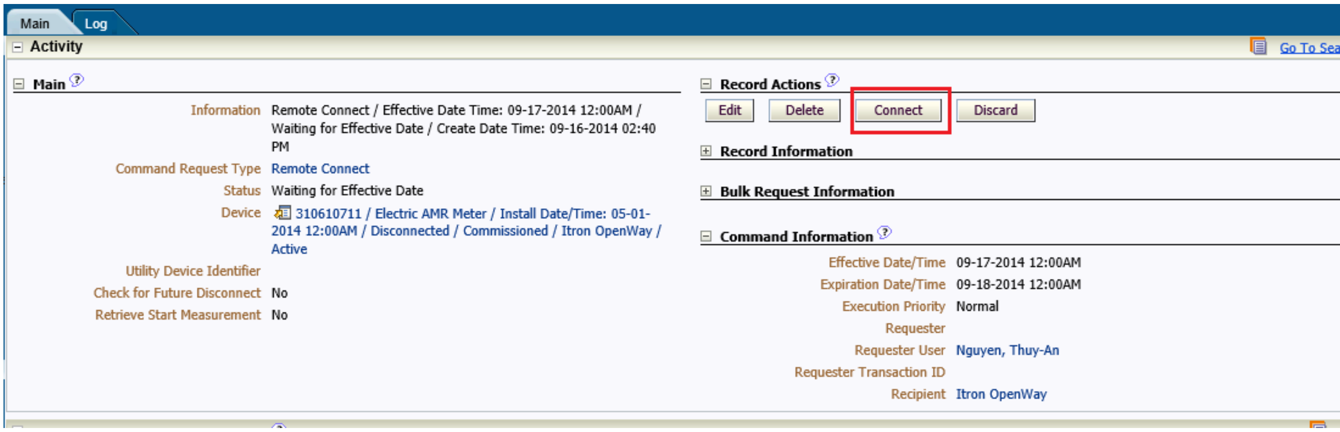
6) From Device, scroll down to Device Activities and click on “Initiate Command” and then from drop down select Remote Connect and click “ok”



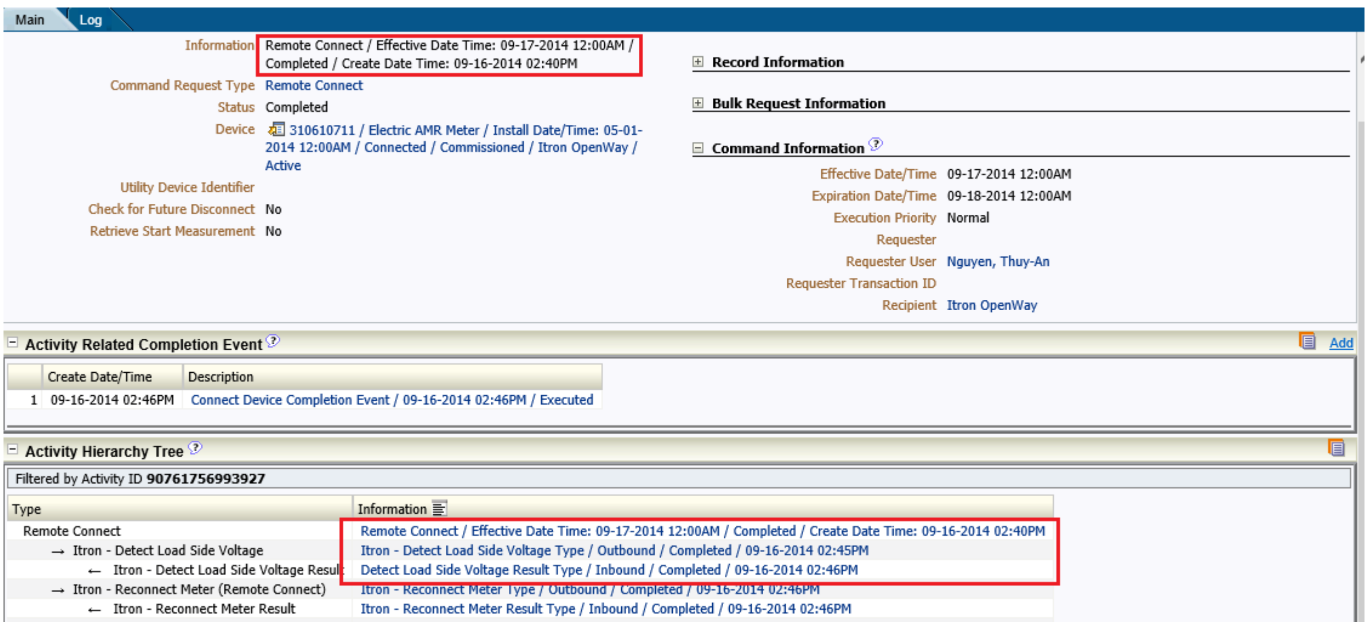
7) Complete the "Remote Connect" and click "save"



8) Click on “Connect”



9) Confirm that Re-Connect job completed in MDM



10) Josh and Thuy-An confirmed that the meter display is now power

Results from Itron CE confirmed the Remote Connect was successful and processed in 21 seconds.

> 9/16/2014 2:46:04 PM request received by the OpenWay Collection Engine, command sent to meter
> 9/16/2014 2:46:16 PM meter received the command and executes remote disconnect, event is logged in meter:

History Log

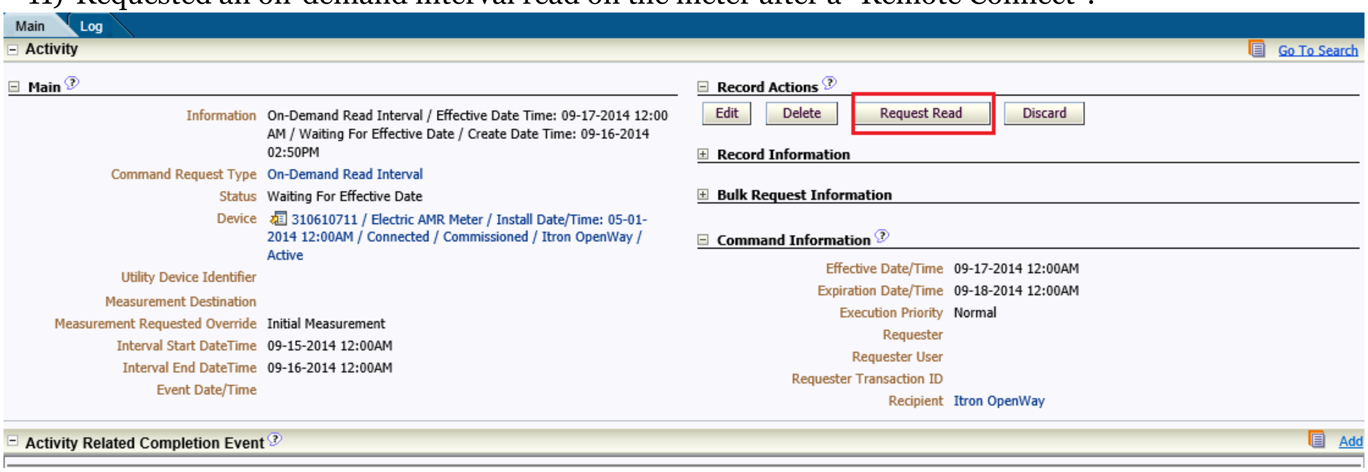
Event Date/Time:	Event:	Event Parameters:
9/16/2014 2:17:48 PM	Remote disconnect success	
9/16/2014 2:46:16 PM	Remote connect success	

Job Details			
Job ID:	1341064	Action:	Connect Endpoint
Request Token:	07dc3ca2-a3eb-40d7-bca1-cbc036dd93fa		
User:	OpenWaySystem	Client IP Address:	10.11.45.51
Group ID:	N/A	# Endpoints:	1
Status:	Successful	Job Duration:	00:00:12
% Complete:	100.0% (1)	Submit Time:	9/16/2014 2:46:04 PM
Start Time:	9/16/2014 2:46:04 PM	Completion Time:	9/16/2014 2:46:16 PM

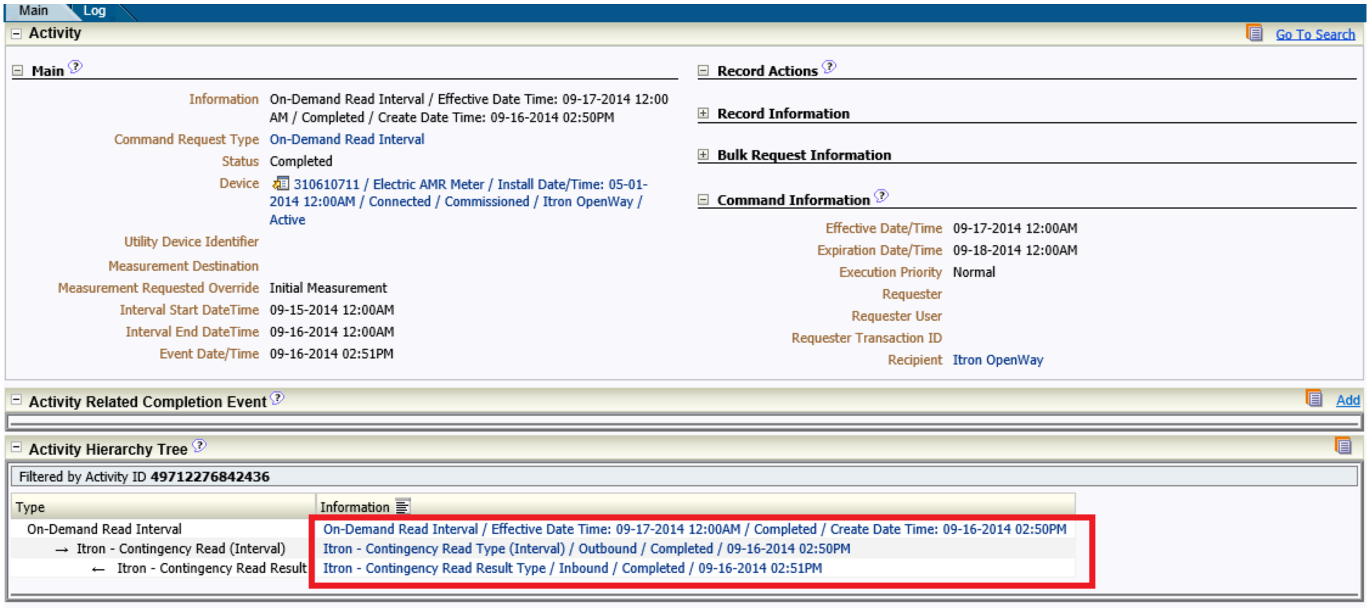
Job Parameters	
RequireUserIntervention:	False

Job Endpoints			
Serial Number	**Field Area Router**	**Job Status**	**Final Result**
	Job Status: Successful (1)		
1452194	14555232	Successful	17019 - Job endpoint succeeded.

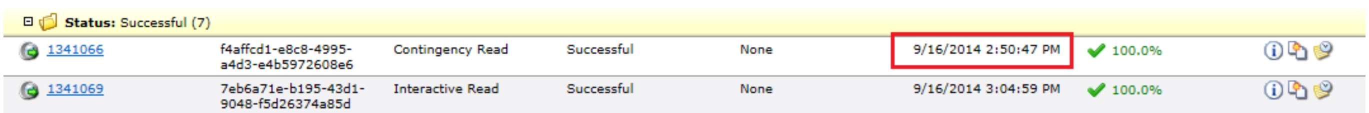
11) Requested an on-demand interval read on the meter after a “Remote Connect”.

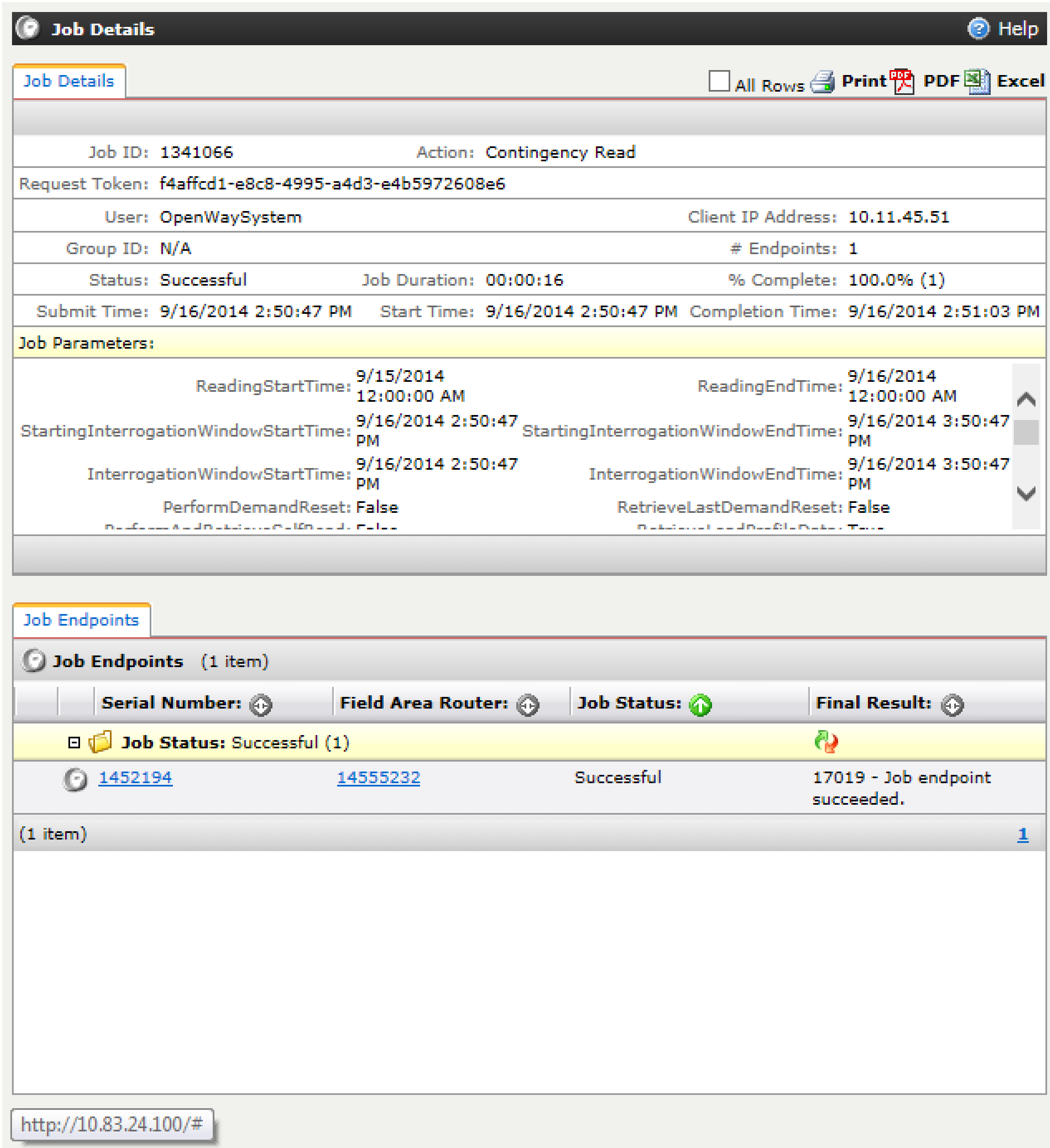


12) Confirmed contingency read was successful.



13) Confirmed in Itron that on demand contingency read was successful





Test results for Remote Disconnect - Pass