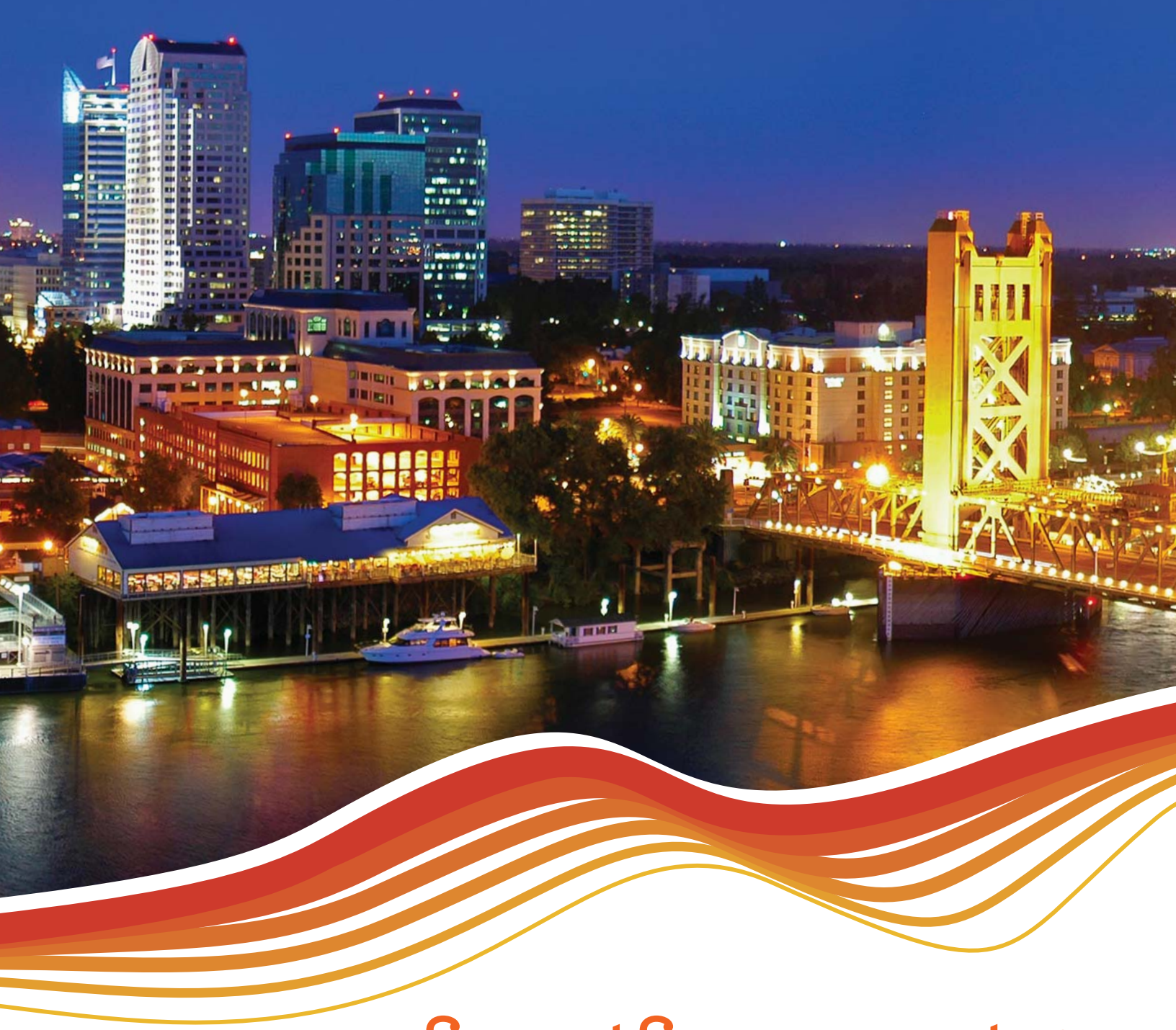

SmartSacramento®

2009 - 2014

August 2013

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Acknowledgement: "This material is based upon work supported by the Department of Energy under Award Number OE0000214."

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Cyber Security

Research and Development

SmartSacramento® Overview

In October 2009, The Department of Energy awarded SMUD a $127.5 million Smart Grid Investment Grant to implement a $308 million project. Additional grants were received for smart grid research and development projects, bringing the smart grid project total to almost $360 million. This series of grants kicked off an aggressive and comprehensive smart grid project for the Sacramento Municipal Utility District (SMUD), titled SmartSacramento. The project eventually included over 50 subprojects divided over eight project areas:

1. Advanced Metering Infrastructure (Smart Meters)
2. Distribution Automation
3. SmartPricing Options (Consumer Behavior Study)
4. Demand Response
5. Customer Applications
6. Technology Infrastructure
7. Cyber Security
8. Research and Development

This document contains individual fact sheets on 43 SmartSacramento projects. The fact sheets provide descriptions of the individual projects, including project features, expected benefits, and project manager contact information. Most of the projects are complete and the fact sheets accurately represent project details. A few projects are not complete. The associated fact sheets represent the current project status and may change over time.

Smart Grid

Smart Meters

Project Overview

The SmartSacramento® initiative started with smart meters, which laid the foundation for a wide range of customer benefits and utility-scale advances. SMUD replaced more than 620,000 old meters with new smart meters capable of two-way wireless communication. During the installation process, customer satisfaction was a resounding 93 percent, and installation refusals were less than 0.4 percent, which was much lower than the 1 to 1.5 percent refusal rates for similar installations by other utilities.

Smart meters allow customers to see their daily and hourly energy usage on the Web. The meters also enable SMUD to remotely read usage and sets the stage for customers to use smarter thermostats, home energy management systems and smart appliances that maximize energy efficiency. Smart meters also provide the opportunity for variable pricing so customers can use electricity when prices are lower.

Project Features

Goals & Objectives

The objectives of the project were to implement a smart meter system for all residential and commercial customers that would:

- Significantly reduce ongoing operational costs
- Enable SMUD to improve service to our customers
- Provide customers with new energy efficiency, demand response, and pricing programs
- Enable SMUD and our customers to reduce our impact on the environment
- Create a foundation on which we can build future smart grid functionality

Design & Features

- Landis+Gyr meters
- Silver Spring Networks two-way mesh network
- Acceptance testing of 78,000 meters, September 2011–December 2011

Continued on back

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- Smart Meters Communication Plan
- Full Deployment
- Transition to Operations

Benefits

- Reduces ongoing operations costs by approximately $14M per year
- Provides customers with hourly energy usage information via the Web
- Enables remote connection and disconnection of electricity
- Provides a platform to offer customers a choice of standard or time-of-use rates
- Integrates with customer-facing devices such as in-home displays, programmable controllable thermostats, and energy management systems that help customers better manage their energy usage
- Provides updated outage and restoration alarms that make it easier to respond to and resolve outages

At-a-Glance Facts

Project Components:

- Meters: 620,000
- Access Points: 174
- Relays: 201

Technology:

- Meters: Focus AX (single-phase) and S4e (poly-phase) – Landis+Gyr
- 802.15.4 radios in all single-phase meters for home area networks
- Network & head end software: Access points & relays, utility IQ software – Silver Spring Networks
- Meter data management system: Itron's IEE
- Backhaul: AT&T wireless data

"The foundation for a smart grid begins with a communications network and smart meters!"

— Erik Krause, Senior Project Manager

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Smart Grid

Substation SCADA Installation

Project Overview

Supervisory control and data acquisition (SCADA) enables real-time monitoring and control of the distribution substation transformers. SMUD's oldest distribution substations were installed prior to the availability of SCADA technology. Each year, SMUD budgets for the upgrade of a few of these older substations. The Substation SCADA Installation Project accelerated the upgrade plan, retrofitting 40 distribution substation transformers with SCADA. At the start of this project, there were 232 distribution substation transformers; 120 (52 percent) had SCADA. At the end of this project, 69 percent were SCADA-enabled.

Project Features

Goals and Objectives

- Remote monitoring and control of the substation equipment.
- Real-time equipment and system status.
- Support of the Advanced Operating System Project, which will develop and implement three automated strategies to improve efficiency and increase reliability of electricity provided to customers:
  - Conservation voltage reduction, which slightly reduces the voltage output of a substation without affecting electrical system performance, resulting in energy savings for SMUD and its customers.
  - Volt/VAR optimization, which reduces system losses, increasing system efficiency.
  - Automatic sectionalizing and restoration, which detects faults on the distribution system and automatically switches the electrical lines in use to minimize the number of customers impacted by an outage.

Project Features

Key elements of the Substation SCADA Project:

- Design and modify existing electrical and communication systems
- Install SCADA system
- Install intelligent electronic devices for remote monitoring and control of substation equipment
- Install 48-volt DC power supply and communication systems

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Benefits

- Improved reliability and quality of service
- Improved efficiency and response time
- Improved asset management
- Reduction in lost revenue due to outages

At-a-Glance Facts

Start date: April 2010

End date: December 2012

Number of substation transformers to be upgraded: 40

Budget: $16 million

Milestones

Planning: April 2010 – September 2010

Procurement: October 2010 – September 2012

Phase 1 – civil and telecommunications construction: May 2010 – June 2012

Phase 2 – electrical construction: November 2010 – December 2012

"This project enables system operators to have hands on the pulse and heartbeat of the distribution system."

– Manjit Sekhon, Project Manager

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Line Automation

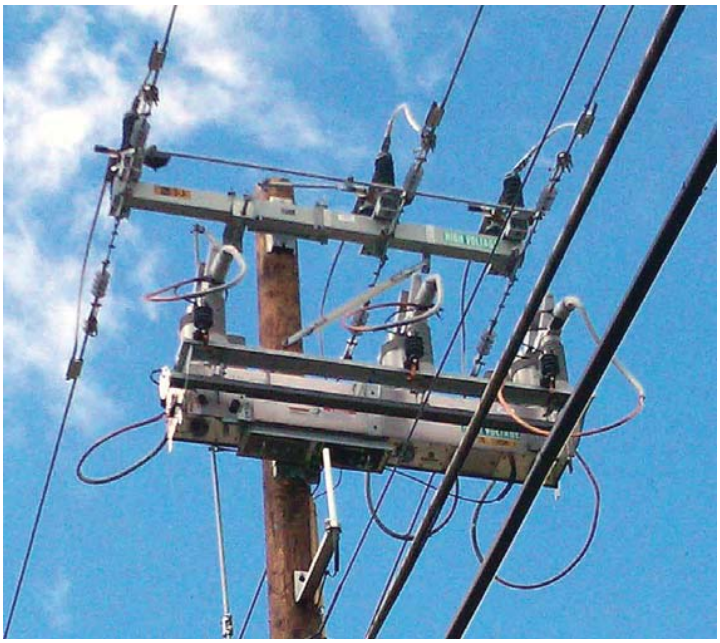
Project Overview

This project will enable and support smart grid, computer-based energy-efficiency initiatives through the installation of a communication network and automated line devices on more than 160 of SMUD's circuits.

Project Features

Goals & Objectives

- Remote monitoring and control of the electrical distribution system
- Real-time equipment and system status
- Support of the Advanced Operating System Project, which will develop and implement three automated strategies to improve efficiency and increase reliability of electricity supplied to customers:
  - Conservation voltage reduction, which slightly reduces the voltage output of a substation without affecting electrical system performance, resulting in energy savings for SMUD and its customers.
  - Volt/VAR optimization, which reduces system losses, increasing system efficiency.
  - Automatic sectionalizing and restoration, which detects faults on the distribution system and automatically switches the electrical lines in use to minimize the number of customers impacted by an outage.



Design and Features

Key elements of the Line Automation Project include design and installation of:

- A communication network for two-way communication with automated line devices
- On 118 12-kilovolt circuits: Capacitor banks, pad-mount, motor-operated switches, and reclosers all enabled with two-way communication
- On 18 21-kilovolt circuits: Reclosers enabled with two-way communication
- 44 motor operators on 25 69-kilovolt circuits (subtransmission)

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Benefits

- Improved reliability and quality of service
- Improved efficiency and response time
- Improved asset management
- Reduction in lost revenue from outages

"Distribution automation is what makes the smart grid 'smart.' "

— Joseph McGuire, Project Manager

At-a-Glance Facts

Start date: April 2010

End date: July 2013

Automation of 118 12-kilovolt circuits (18 percent of the distribution system)

Automated switches on 25 69-kilovolt circuits (44 percent of subtransmission)

Automated switches on all feasible 21-kilovolt circuits (100 percent of the 21 kv service area).

NOTE: The Network is very different from the 21 kv system.

Budget: $28 million

Milestones

Standards development and equipment procurement: April 2010 – January 2012

Installation of equipment: April 2013

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Conservation Voltage Reduction and Volt/Var Optimization

Project Overview

The CVR/VVO project implements a model-based conservation voltage reduction (CVR) and a volt/var optimization (VVO) strategy to reduce line losses and boost the efficiency of the distribution system.

Project Features

This project uses automated line capacitor banks and the communication network installed under the line automation project and the updated substation equipment in the Supervisory Control and Data Acquisition (SCADA) retrofit project.

SMUD modifies and leverages its existing capacitor control software for VVO and develops and implements CVR control capability within the existing Siemens SCADA system. The VVO software and line capacitor banks monitor and correct power factor on the distribution grid, decreasing line losses. Minimizing line losses enables system operations to initiate CVR, which lowers the voltage output at the substations while maintaining minimum voltage requirements. The lower voltage levels result in lower energy output at the substation and can mean lower energy consumption for SMUD customers.

We worked with the Electric Power Research Institute (EPRI) to develop the 2013 test plan. The project evaluates both summer and winter energy savings. These results are used to recommend how to best leverage the control strategies in the future.

Goals & Objectives

- Use CVR to reduce the voltage output at the substation, resulting in energy savings for SMUD and our customers
  - Test 2 percent voltage reduction at the substation
- Use VVO to reduce system losses, increase system efficiency, and provide voltage support
- Maintain the power factor as close to unity as possible

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Benefits

- Improved system efficiency
- Increased energy savings
- Reduced customer energy bills

At-a-Glance Facts

- Implemented on 18 percent of the distribution system
- **Total budget:** $2.8 million [includes cost for both CVR/VVO and Automatic Sectionalizing and Restoration (ASR)]

Key Milestones

- Implementation from April 2010 to June 2013
- Completed summer testing to validate control strategy: Summer 2011
- Evaluation through December 2014

"The advanced operating system is the brain that centrally controls substation and line devices to help SMUD operate its system more efficiently and reliably."

— Malissa Ellis, Project Manager

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Automatic Sectionalizing and Restoration

Project Overview

The automatic sectionalizing and restoration (ASR) project will detect faults on the distribution system and control automated switching devices to isolate the fault.

Project Features

This project uses automated switching devices and the communication network installed under the line automation project, and the updated substation equipment in the Supervisory Control and Data Acquisition (SCADA) Retrofit project.

SMUD will develop and implement the ASR control strategy to centralize control of automated switching devices and enable the system to "self-correct."

We'll develop a test plan to evaluate the ASR control logic and quantify the reliability impact. The test plan has three components:

- ASR lab simulation test: Simulation and validation of the ASR control logic under various scenarios for three basic feeder pair configurations, end-to-end, in a laboratory setting.
- Theoretical reliability improvement analysis: Review five years of historical outages and determine improvement in the System Average Interruption Duration Index (SAIDI, a measure of reliability) if the remotely controlled, automatic line devices and ASR had been implemented.
- Real-time performance evaluation: Documentation of SAIDI improvement based on actual performance of feeders equipped with remotely controlled automatic line devices and ASR.

Goals & Objectives

- Utilize ASR on upgraded circuits to detect faults on the distribution system and perform automated switching to minimize the number of customers impacted by an outage
  - Isolate the fault and restore power to most customers in less than a minute
  - Improve SAIDI on upgraded circuits

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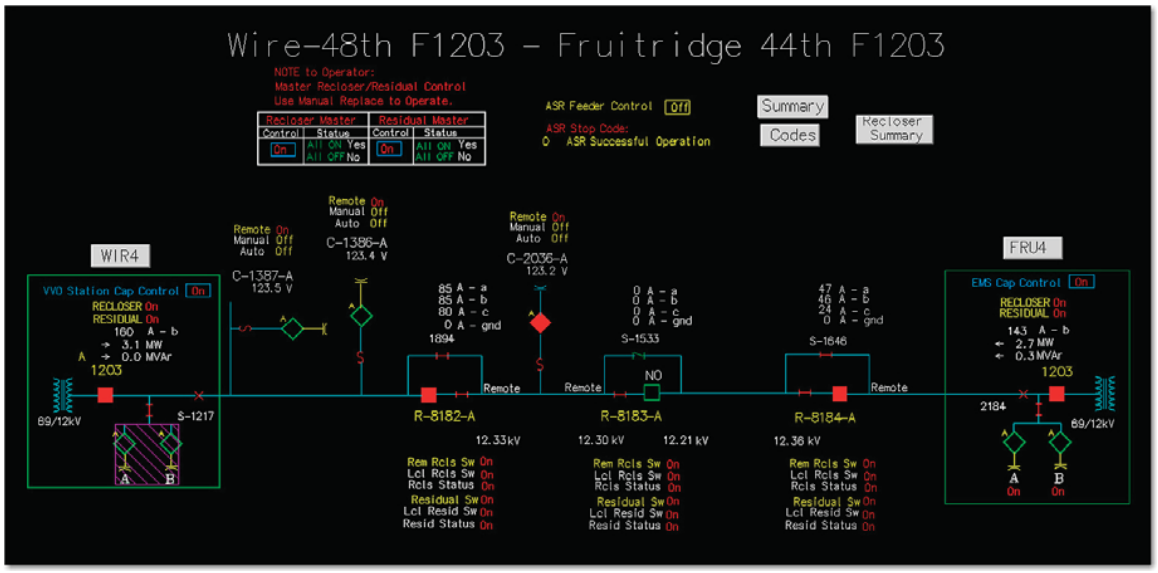

ASR Feeder Pair EMS One-Line screen

Benefits

- Improved restoration process efficiency
- Improved system reliability

At-a-Glance Facts

- Implemented on 18% of the distribution system
- Total budget: $2.8 million (includes cost for both CVR/VVO and ASR)

Key Milestones

- Implementation runs from April 2010 to December 2013
- Evaluation through December 2014

"The advanced operating system is the brain that centrally controls substation and line devices to help SMUD operate its system more efficiently and reliably."

— Malissa Ellis, Project Manager

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Situational Awareness and Visual Intelligence (SAVI)

Project Overview

Situational Awareness and Visual Intelligence, or SAVI, will give an in-depth view of the distribution system by overlaying information from many sources. It will help operators get hands-on experience with an array of scenarios. The project also includes procurement of the audio/visual equipment that will display Smart Grid technologies at the new East Campus-Operations Center.

Project Features

- Procuring and installing software.
- Integration with –
  - Geographic Information System (GIS) Oracle, Pi, Lightweight Directory Access Protocol (LADAP)/Active Directory;
  - Third party services like the National Oceanic and Atmospheric Administration (NOAA), Oracle Locator;
  - Enterprise Service Bus (ESB), Structured Query Language (SQL) Server, SAP, and Excel spreadsheets.
- New equipment includes –
  - a 30-foot by 9-foot LED heads-up display,
  - 55-inch monitors to view the SAVI dashboard,
  - 30-inch monitor to view the Outage Management System (OMS),
  - four 24-inch monitors to view and control Distribution Automation (DA) equipment in EMS,
  - new Redhat Linux Workstations and corporate desktops, and
  - a 70-inch touch table

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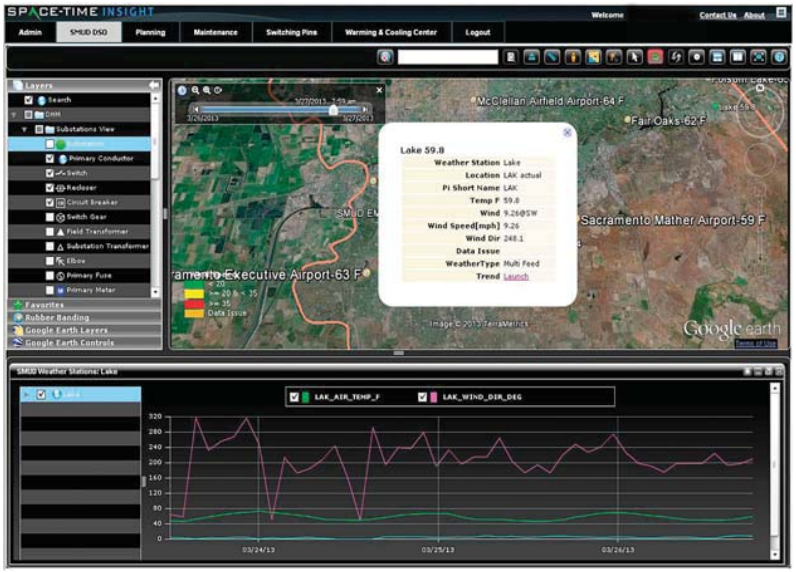
Goals & Objectives

The goal is to provide SMUD's Distribution System Operations greater ability to synthesize information and visualize data in a timely manner.

Benefits

The system offers a single platform from which to see and analyze information from several sources and observe trends over time. It applies the data to existing distribution network situations and gives operators better insight and more details.



At-a-Glance Facts

The project ran from March 1, 2012 to April 22, 2013

Total budget: $3.2 million

Information displayed to the operators will include:

- Current and historical substation loads
- Outages
- Feed-in tariff photovoltaic locations and generation
- Forecasted photovoltaic generation potential
- Emergency visualization
- Historical, current and forecasted weather

Planning: March to August 2012

Procurement: August 2012

Integration: March 2013

Project End: April 2013

"The Smart Grid enables us to do what some customers thought utilities always could do."

— Michael Greenhalgh, Project Manager

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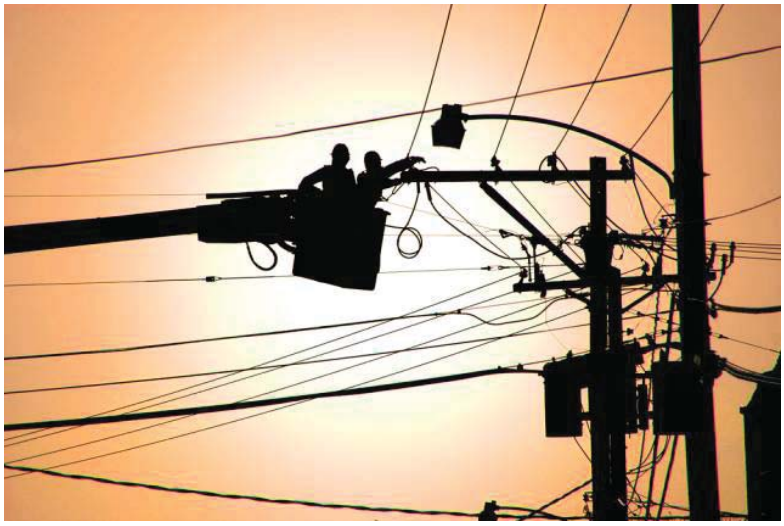
Outage Management System Upgrade

Project Overview

The Outage Management System Upgrade project updates the core technology for all computer-based remote control and automation technologies used to make electrical delivery systems more efficient. The project allows distribution system operators to view supervisory control and data acquisition information collected through automated line devices and upgraded substations within the outage management system. The upgrade also enables more efficient integration with other SMUD systems through Web services.



Project Features

- Upgraded the outage management system to Intergraph's InService 8.2
- Upgraded the mobile application used by distribution field forces
- Integrated SCADA through an inter-control center communications protocol gateway
- Developed an electronic wall map

Goals & Objectives

- Upgrade to a newer version of the outage management system and iMobile application
- Enable distribution system operators to view supervisory control and data acquisition (SCADA) information within the outage management system
- Enable the development of an electronic wall map to replace the paper wall map

Benefits

- Improved system functionality
- Integration with SCADA
- Improved system accuracy as a result of removal of the paper wall map (reducing to one system of record)

At-a-Glance Facts

Start date: April 2010

End date: April 2013

Budget: $3 million

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Procurement: April 2010 – September 2011
Upgrade development system: November 2010
Upgrade quality assurance: August 2011
User training: September 2012
Outage management system upgrade: September 2012
Development of electronic wall map: April 2013
SCADA/outage management system integration: April 2013

"This critical project upgrades the core technology for all smart grid applications."
— Teresa Klostermann, Project Manager

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Enterprise Data Historian (PI)

Project Overview

The Enterprise Data Historian project upgrades the OSIsoft LLC PI System, which allows real-time management and organization of meter data. The project supports SMUD's smart-grid capabilities, which use computer-based remote control and automation to make electrical delivery systems more efficient.

Project Features

Goals & Objectives

Provide our Grid Planning and Operations group greater insight into load demands at the meter.

Design and Features

The Project upgrades SMUD's license with OSIsoft LLC to an enterprise agreement in support of the SmartSacramento® Distribution Automation Project. The upgrade includes software updates, 24/7 technical support, bug fixes, and replacement of software to upgrade the current PI System (data management solution). As part of the agreement, SMUD will implement new infrastructure to host PI 2012, Asset Framework 2012, and Smart Connector in order to retrieve and store meter data.

Key elements of the project are:

- Contract execution.
- Procurement and installation of hardware and software.
- Integration with Silver Spring Networks UtilityIQ (smart grid application) for capturing and retaining meter kilowatt hours and kilovolt-amperes reactive.

Benefits

The system will analyze load at the meter for better power quality management and create a foundation for faster adjustments and decision-making for conservation voltage reduction/volt-VAR optimization (electricity-use reduction strategies).

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At-a-Glance Facts

Start date: May 1, 2012

End date: April 22, 2013

New infrastructure includes 14 virtual servers and two blade servers running Windows 2008 R2 Service Pack 1 to host PI System, Asset Framework, and an interface node

Information captured from UtilityIQ:

- Kilowatt hours
- Kilovolt-amperes reactive
- Voltage

Frequency: hourly

Budget: $2 million

"The smart grid enables SMUD to do what customers thought we always could."

— Michael Greenhalgh, Project Manager

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Outage Communication Project

Project Overview

The goal of the project is to use phone notifications to alert and update customers about power outages, including when power is estimated to be restored and confirmation that electric service has resumed.

The pilot targets customers during outages lasting for long periods of time. It will test the performance of call messaging, the timing of the calls, the accuracy of the estimated restoration time, the overall customer experience, and any impacts on the volume of calls to the Contact Center.

Project Features

The system will use automated phone voice messages to alert customers of a power outage, following up with a call indicating the estimated time of power restoration, and finally, a call to confirm that service has been restored.

Goals & Objectives

This program will allow SMUD to try out and refine performance and accuracy of phone messaging technology and time estimation models, and proactively inform customers of outages and updates on restoration.

Benefits

Streamlining up-to-date notification of outages, expected restoration and resumption of power will improve customer service and could reduce calls to the Contact Center.

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At-a-Glance Facts

- Project duration: September 2011 to May 2013.
- Total budget: $600,000.
- Calls made from May 2012 to December 2012:
  Initial outage calls: 14,772
  Estimated restoration calls: 801
  Restoration confirmation calls: 71,522
  Total calls: 87,095
- January 2012: Obtained cyber security approval.
- February 2012: Amended automated phone service contract.
- March 2012: Finalized outage messages, with approvals, and finalized business requirements.
- May 2012: Pilot program launched.
- May 2013: Moved application onto the enterprise service bus.

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Integrated T&D Modeling Tool

Project Overview

This project launches software for modeling the transmission and distribution of electricity, allowing SMUD to track all the benefits of the SmartSacramento® portfolio of projects. The software gives SMUD system planners a high-fidelity tool for designing and placing distributed generation systems, simulating demand response, conservation measures, energy storage and automated controls, so the overall electricity system can perform more effectively.

Project Features

Goals & Objectives

The goal is to create an integrated computerized model of transmission and distribution systems for evaluating the siting, sizing, dispatch and placement of distributed energy resources. Installing new software will allow SMUD to simulate impacts on the grid of electric vehicle charging loads and from different distributed generation and demand response scenarios throughout SMUD's service area. The software will reflect the most updated and accurate view of SMUD's current loads and power delivery system. It will dovetail with SMUD's existing modeling legacy software, making the models and simulations more accurate.

Design and Features

Modules of the modeling software

- Distributed energy resource (DER) optimization, for evaluating the best placement and sizing of DER systems
- Distributed generation impact evaluation
- Photovoltaic impact evaluation
- Electric vehicle impact evaluation
- Demand response application
- Employee training

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Benefits

The tool allows SMUD to plug in variables from many different systems and predict the outcomes of distributed generation, energy storage and projects aimed at reducing electrical loads throughout our service area. It also allows planners to compare different technologies to find the most economically effective and highest performing, optimizing SMUD's investment dollars.

At-a-Glance Facts

- Project runs from October 2012 to April 2013
- Project budget: $690,014

"To assess the value of advanced distributed energy resources, utilities will need software tools such as the integrated T&D Modeling tool. This type of tool will enable system engineers and capacity planners to simulate the potential impacts and benefits from various levels of distributed generation, energy storage, demand response, and electric vehicle deployments."

— Jeff Berkheimer, Project Manager

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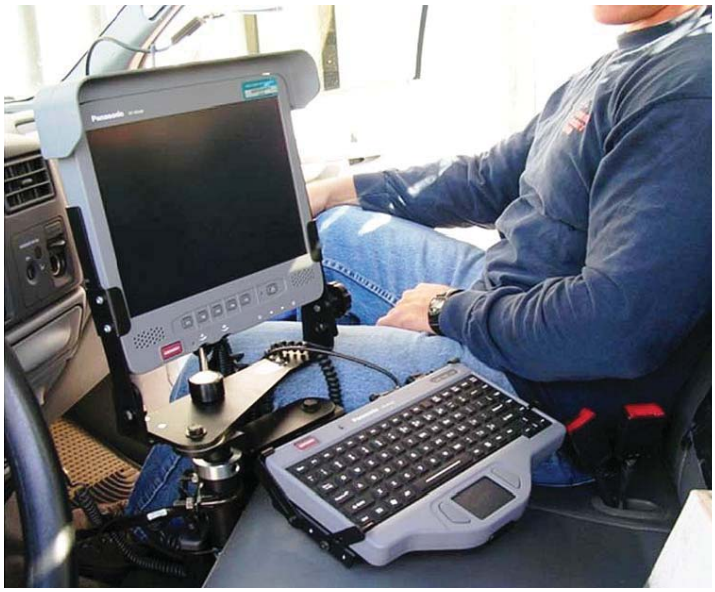
Mobile Data Terminal Replacement

Project Overview

Field forces use specially made rugged laptop computers mounted in their vehicles. These computers are used to display our entire distribution network electronically, receive work, update outage information and provide updates on job
progress, along with other functions that improve field force productivity and availability. This project includes replacement, retrofit and installation of new mobile data terminal laptops used by our distribution field forces.



Project Features

The project involved the evaluation, purchase and installation of rugged laptops. Appropriate software, including the upgraded mobile outage management system, was installed on the laptops prior to installation. Laptops were installed and the conversion to the upgraded system was tightly coordinated with the Outage Management System (OMS) upgrade project.

Goals & Objectives

- Provide the hardware needed to run the current Mobile Outage Management software
- Provide tools and equipment for increased reliability of the MDT and related systems
- Enable better support and customer service to crews
- Establish a multi-year support contract for MDT mounting hardware

Benefits

- Increased reliability of hardware and software
- Increased efficiency leading to faster event resolution and less down time
- Increased utilization of the Mobile Outage Management software
- Lower cost for support and maintenance

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At-a-Glance Facts

Start date: November 2010
Planning: August 2011
Laptop Evaluation: December 2011
Laptop Purchase: March 2012
Installation: May 2012 - August 2012
Conversion to new Mobile OMS: September 2012
End date: December 2012
Laptops Purchased: 112
Laptops Deployed: 103 (9 spares)
Vehicles Retrofitted: 82
Total budget: $1.2 million

"Having the right tools for the job is vital to our safety and providing our customers - both internal and external - the best customer service."

— Ariel Cumigad, Project Manager

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SmartPricing Options

Project Overview

SMUD's SmartSacramento® project includes a consumer behavior study evaluating the impacts of time-based rates, enabling technologies, and recruitment methods on energy consumption and peak demand.

Project Features

Goals & Objectives

SMUD's goal was to assess customer response to and seek customer acceptance of varying combinations of enabling technologies, recruitment methods, and time-based rates. SMUD is focused on the impact of customer response during peak hours and critical peak events.

Design and Features

With a study sample of approximately 100,000 residential customers and a test period from June 2012 through September 2013, we used three experimental designs to study customer response to pricing options:

- Randomized control trial (RCT) with delayed enrollment (i.e., "Recruit and Delay")
- Randomized encouragement design (RED) and
- Within-subjects design

In the RCT "Recruit and Delay" study design, a randomly selected group of customers from the study sample were recruited into a specific treatment (opt-in), but only half of those who are invited to participate were eligible to be exposed to that treatment for the test period, while the remainder served as a control group on the existing inclining block rate in years one and two; however, they were permitted to enroll in the offered rates after the study period ended after the second year.

In the RED study design, a group of randomly assigned customers from the study sample served as the control group and remained on SMUD's standard inclining-block (tiered) rates without any form of technology offered by SMUD. We then offered a randomly selected second group of customers from the study sample a specific treatment, "encouraging" them all to accept the offer on the opt-in basis or allowing them to reject the offer on an opt-out basis, depending upon the treatment. All of these

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"encouraged" customers were considered in the study for evaluation purposes whether they accept or reject the treatment.

The within-subjects design used no explicit control group; instead it estimated the effects of the treatment for each participant individually, using observed electricity consumption behavior both before and after becoming a participant in the study as well as on critical peak events and non-event days.

The control group selected for the RED design were used to control for exogenous effects in the within-subjects design.

Benefits

- Potential bill savings from dynamic pricing
- Customers own the devices during and after the pilot

"The SmartPricing Options pilot offers time-based pricing to customers and encourages them to shift their load to off-peak hours. Combined with educational information through a variety of customer-facing applications, customers can have more control over their energy bills and help SMUD reduce peak energy demand. SMUD has been able to gain valuable information on customer perceptions and behaviors for each of the pricing plans, which will help inform rate designs and future program planning."

— Jennie Potter, Project Manager

At-a-Glance Facts

Pilot Population: Residential

Number of Treatments: 7

Sample: 100,000

Pilot Type: Experimental Research Design

Treatment Groups:

- Default TOU with IHD Offer
- Opt-in TOU with IHD Offer
- Opt-in TOU without IHD Offer
- Default CPP with IHD Offer
- Opt-in CPP with IHD Offer
- Opt-in CPP without IHD Offer
- Default TOU-CPP with IHD Offer

Technology Summary:

- In-home displays
- Web portal

Rate Summary:

TOU:	SmartPricing Options "Summer Weekday Value Plan"
CPP:	SmartPricing Options "Off-Peak Discount Plan"
TOU-CPP:	SmartPricing Options "Optimum Off-Peak Plan"

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Demand Response Management System

Project Overview

The Demand Response Management System Project (DRMS) involved installing a software platform that supported SMUD's short- and long-term need to give customers price-based and incentive-based programs to manage peak electrical loads. Key aspects of the project include:

- Procuring and installing new DRMS software on SMUD-procured servers.
- Integrating the DRMS solution into existing SMUD systems.
- Planning, developing scripts for, and executing testing of the new system.
- Supporting the deployment of the solution into a production environment.
- Training SMUD project team members and technical staff.
- Enabling commercial automated demand-response (Auto DR) functionality with SMUD's six SmartSacramento® partners: the California Department of General Services, California State University Sacramento, Elk Grove Unified School District, Los Rios Community College District, Sacramento City Unified School District, and Sacramento County.
- Enabling direct load control of residential and small-commercial air conditioners and electric vehicle chargers.

Project Features

Goals & Objectives

- Build a new, highly secure system platform through which all of SMUD's demand-response activities can be managed.
- Use existing open standards to build the system.

Design & Features

The DRMS enables SMUD to provide demand-response functionality to customers enrolled in either price-based or incentive-based programs.

The DRMS features include:

- Wizards to create new demand-response programs that conform to a set of business rules.

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- Robust load-reduction forecasting with adaptive learning.
- Support of text message, phone, and email communication channels for program participants to receive messages.
- Support of ZigBee Smart Energy Profile v 1.1 Home Area Network devices, Open Automated Demand Response v 1.0 client devices, and broadband access via a customer gateway.
- Ability to tailor demand response events by program and by grid topology (system, substation, transformer).
- Support of the following programs: direct load control, load reduction commitment, battery storage, and critical peak pricing.
- High security.
- Capability for participants to opt out of demand-response events via devices, SMUD's Contact Center, or the Internet.
- Automated billing settlement.

Benefits for the Customer

- Customers can take advantage of new incentive-based and price-based demand response programs to manage energy use.
- Customers with Landis+Gyr ZigBee-enabled meters or broadband capability will have connectivity with SMUD to use new programs to manage their energy use.
- Through the Internet or Contact Center, customers can enroll, dis-enroll, and opt-out.

Contact Information

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Benefits for SMUD

- One platform will manage all of SMUD's demand response activities.
- The system is built within SMUD's secure environment.
- The system is built around open industry standards, so it is not dependent upon vendor-specific protocols.
- Robust load-reduction forecasting tools can predict load reduction at all levels of the distribution system.
- The Peak Corps air conditioning load management system can eventually be retired.

At-a-Glance Facts

Cost: $4.4 million

DRMS Vendor: Lockheed Martin

Open Standards Supported: Smart Energy Profile v 1.1, Open Automated Demand Response v 1.0

Project Start: March 2010

Project End: April 2013

"The DRMS will enable SMUD to manage all its demand response in one place."

— Craig Sherman, Senior Project Manager

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PowerStat Pilot — 2012 (Direct Load Control)

Project Overview

The 2012 PowerStat Pilot program evaluated the effects of three separate utility controlled strategies to reduce residential air conditioning use during times of high air conditioning usage. Each strategy had a different duration and degree of pre-cooling before the air conditioning system temperature was increased for the PowerStat-day event. A third-party load-management system triggered the testing events, and a paging communication service signaled the pre-cooling and temperature values to the customers' thermostats.

Project Features

Goals & Objectives

The 2012 PowerStat Pilot program focused on evaluating the effects on customer comfort and electricity use (load) of different levels and durations of pre-cooling. Additionally, the capabilities of the technology involved were assessed for use in future projects and programs.

Design and Features

The design called for a random sample of 180 participants, divided into three groups. Each group experienced a particular pre-cooling strategy twice before being moved to another strategy during eight PowerStat-day events in August and September, 2012. All customers experienced all strategies to reduce any potential bias they might have against any one approach, which allowed for better evaluation of the effects.

One key feature that customers appreciated was a website they could use to program their thermostat temperatures and schedules or to opt out of a PowerStat-day event. Customers were allowed an unlimited number of event opt-outs during the study.

Benefits for the Customer

- Increased awareness, satisfaction, and engagement with direct load control programs.
- Information on how to better control their energy usage through thermostat schedules.
- Potential bill savings based on energy efficiency education.

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- Installation of a free programmable thermostat.
- An online option to control temperature settings and thermostat schedules.
- Ability to override a PowerStat-day event via the Internet.

Benefits for SMUD

- Increased customer awareness, satisfaction, and engagement with direct load control programs.
- Experience with and documentation of pre-cooling and temperature offset recommendations for customers.
- Ability to provide customers with potential cost savings based on energy efficiency.
- Promotion of energy efficiency and peak-load reduction.

At-a-Glance Facts

Pilot population: Residential
Number of strategies: Three
Total invitations: 14,750
Total participants: 175
Field study timeline: August through Sept. 2012

Strategies:

- Six-hour pre-cool of 2 degrees with 3 degree offset.
- Two-hour pre-cool of 4 degrees with 3 degree offset.
- No pre-cool with 3 degree offset.

Technology summary:

- Honeywell UtilityPRO one-way programmable communicating thermostat.
- Cooper Power Systems Yukon load management system and customer portal to manage thermostat temperatures, schedules, and overrides.
- American Messaging Paging Communication Service.

Rate summary: Residential standard rate.

"The 2012 direct load control study results show that mild pre-cooling coupled with good insulation can significantly reduce not only peak demand but energy use throughout the day."

— Michael Daniels, Project Manager

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PowerStat Pilot — 2013 (Direct Load Control)

Project Overview

During the summer of 2013, the program will test three demand-response strategies using a customer-choice model. Customers will choose between incentive-based and price-based offerings. With the price-based offering, customers will also choose between having SMUD control the temperature offset or controlling the temperature offsets themselves.

The field study will create 12 conservation days in the summer during which thermostat settings will be increased by a few degrees. Participants will provide feedback on their experience via surveys throughout the year. A demand-response management system will trigger conservation days using the smart meter network and two-way programmable communicating thermostats.

Project Features

Goals & Objectives

The 2013 PowerStat Pilot Program will offer residential and small-commercial customers a choice between incentive-based and price-based demand response programs. This customer-choice model will give SMUD valuable information on future program benefits and costs and will capture customer preferences. Specifically, the pilot program will seek to:

- Assess energy savings potential.
- Assess customer preferences regarding program offerings.
- Assess effectiveness of applied technology to electricity use (direct load control).
- Assess the peak-period electricity savings derived from various temperature differential (offset) values.
- Evaluate customer satisfaction with and acceptance of the program design and applied technology.

Design and Features

The project design calls for a random sample of up to 1,000 participants: 600 residential customers and 400 small-commercial customers with demand of 20 kilowatts or less. Since customers choose which offering they will use, there is no predetermined number of participants required for any one offering.

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Over twelve conservation days from June through September 2013, the demand response management system will signal customers' thermostats through the smart meter network. Participants will receive notice before each conservation day, and they will be allowed an unlimited number of opt-outs during the field study.

Benefits for the Customer

- Increased customer awareness of, satisfaction with, and engagement in demand response programs.
- Information on how to better control energy usage.
- Potential bill savings either through an incentive in the form of a bill credit or through a time-of-use or critical-peak pricing rate.
- Installation of a free programmable, communicating thermostat.
- Ability to manage participation in conservation days through an unlimited number of opt-outs.

Benefits for SMUD

- Increased customer awareness of, satisfaction with, and engagement in direct load-control programs.
- Knowledge about the types of programs customers prefer (incentive-based or price-based).
- Information on the effect of opt-outs and overrides on the load reduction potential.
- Promotion of energy efficiency and peak-load reduction.
- Testing of new load-reduction forecasting models and gaining experience to refine models to better match actual load reductions.

At-a-Glance Facts

Pilot population: Residential and small-commercial

Number of program offerings: Three

Total participants: up to 1,000
Residential: up to 600
Small commercial: up to 400

Technology summary:

- Energate Pioneer Z100 two-way programmable communicating thermostat
- Lockheed Martin SEEload demand response management system
- Silver Spring Networks UtilityIQ and Home Area Network Communications Manager
- Landis+Gyr ZigBee-enabled smart meters
- SAP Customer Care and Services
- Intergraph Geographic Information System software
- Software AG Enterprise Service Bus
- Itron Enterprise Edition Meter Data Management System
- SMUD's My Account website feature
- TeleVox software

Rate summary:

- Residential standard rate
- Residential TOU-CPP (smart-pricing options rate)
- Small-commercial GSN_T (non-demand metered rate)
- Small-commercial GSN_TCPP (smart-pricing options rate)

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Automated Demand Response (Auto DR)

Project Overview

Automated demand response is an energy management strategy that uses Internet-based technology to signal customer equipment and facilities to make the most efficient use of energy resources and reduce overall energy use during peak periods.

SMUD is using a U.S. Department of Energy Smart Grid Investment Grant to coordinate feasibility studies and installation of automated demand response technologies at six key SMUD commercial customers, called the SmartSacramento® Partners. SMUD implemented PowerDirect℠, an Automated Demand Response Pilot Program in 2013 that included additional commercial participants.

Project Features

Goals & Objectives

Program Design Goals

- Deliver a program with participation and performance parameters that
  - Offers ease of compliance
  - Encourages maximum performance
  - Gives the customer a manageable, cost-effective, high-quality settlement
  - Provides reliable and predictable energy use (load) reduction
- Integrate demand response, energy efficiency, and energy information
- Create a program platform that allows for integrating new technology and approaches into demand response
- Deliver demand response products that provide value to participants, SMUD, and potentially to the Balancing Authority of Northern California, which is responsible for reliable electrical grid operation in Northern California

Overall Goals for 2011 Through 2013

- Build infrastructure
- Engage and educate both customers and SMUD in demand response
- Learn how to develop and apply the technology to benefit both SMUD and its customers
- Determine customer load reductions from the technologies and program operating scenarios
- Implement automated demand response strategies
- Operate the program as a limited-scope pilot in 2013

Design & Features

Primary Market

The primary market consists of customers with greater than 300 kilowatts of electrical demand. Customers with smaller loads may be included to test other Smart Grid technologies.

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Features

- Four program options for customers
  - Firm Load Reduction
  - Minimum Dependable Load Reduction
  - Demand Response Pricing (critical peak pricing)
  - Voluntary Load Reduction
- Automated notification, dispatch, and settlement
- Voluntary customer participation
- Payment based on capacity and performance
- Technology incentives up to $125 per kilowatt of enabled demand response
- Enrollment in Energy Profiler Online, an Internet resource customers can use to monitor energy use and control costs

Benefits

Customers benefit from technology and automation that enables them to operate more efficiently and better control their energy costs.

SMUD benefits from a reliable and sustainable demand response resource that can meet energy needs for both economic and reliability requirements.

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At-a-Glance Facts

Duration: September 2010 through December 2013

Pilot project operation: June through September 2013

Total budget: $3,400,000

Customer incentives: Technical assistance provided at no charge; technical incentives of up to $125 per kilowatt of enabled automated demand response capability.

Planned participants: Six SmartSacramento® Partners and five to 15 additional commercial customers

Planned automated demand response load reduction for 2013: five megawatts

"Automated demand response represents the future of demand response where technology provides the means to integrate demand response and energy efficiency, delivering a reliable and sustainable resource with high value for customers and SMUD."

— Harlan Coomes, Principal Engineer

Smart Grid

Partner Projects

Project Overview

This SmartSacramento® Partner project extends a portion of SMUD's Department of Energy Smart Grid Investment Grant to SMUD's commercial customer base. The project focuses on the replacement or major refurbishment of energy management control systems in more than 100 large government and college buildings, as well as 33 secondary schools. All buildings are within multi-building campus settings. In addition, as part of their energy control projects the six partners have developed strategies for allowing automated reductions of energy consumption during peak demand periods (automated demand response).

Project Features

Goals & Objectives

SMUD's vision for this project is to provide tangible benefits for commercial customers through the installation of "smart grid" control technologies. Common to each of the six partners is the design and installation of advanced energy management control systems for multiple buildings. The projects will allow partners to optimally control energy-consuming systems within their buildings. In addition, facility managers will be able to consolidate energy consumption information and alter control point settings from centralized locations for multiple buildings due to the development or enhancement of a network that links all facilities.

An important element of this project is developing and testing automated demand response control strategies for each partner. The strategies have been designed and are being tested in cooperation with SMUD. Automated demand response will allow SMUD to send a signal over the Internet to partners' energy management control systems to reduce energy use during peak use periods, when energy costs are highest, without compromising occupant comfort.

To achieve these goals, SMUD, acting as the prime agency under the Department of Energy, has partnered with some of the region's largest organizations:

- California State University, Sacramento
- California Department of General Services

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- Sacramento County
- Los Rios Community College District
- Sacramento City Unified School District
- Elk Grove Unified School District

Benefits

- Implemented applications for large commercial and industrial customers that can be replicated by others
- Incorporated interoperability improvements among multiple-building campus settings
- Increased understanding of energy patterns in individual buildings
- Enhanced ability to set or modify control point settings at the zone level
- Improved ability to preprogram independent equipment schedules hourly
- Ability to tie an entire population of buildings into a centralized control system with a graphical user interface
- Added new controls that optimize economizer functions and limit outside air entry and supply fan airflow during periods of limited or non-occupancy
- Installed advanced metering infrastructure as well as British thermal unit meters for chilled water flow to capture energy consumption profiles in existing buildings
- Developed an invoicing and billing system that works with a networked advanced metering infrastructure to allow one partner to bill private enterprises that manage facilities on campus and help them manage their electricity costs
- Use of direct digital controls, replacing pneumatic controls in some buildings
- Installed electric vehicle smart-charging equipment with an automated demand response capability for two partners
- Installed automated switching equipment with a supervisory control and data acquisition (SCADA) at one partner location for several key buildings

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At-a-Glance Facts

- Affects more than 100 large buildings and 33 secondary schools and 3 million square feet
- Gives tangible maintenance, operation, and energy savings to six large government / institutional customers
- Brings energy savings in excess of five percent of the current energy consumption for the participating buildings annually
- Provides SMUD more than two megawatts of potential summer afternoon load reduction
- Creates $36.6 million of overall project activity

"Demonstrates the latest in control and communication technologies for a large population of buildings in our service area. Facility management can easily change set-points from anywhere using the Web and can view near real-time energy profiles. The bottom line is significant energy, operational, and maintenance cost savings for our partners." — Jeff Molander, Project Manager

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Smart Charging Pilot

Project Overview

This pilot will evaluate EV charging patterns at various times throughout the day. We will monitor pattern shifts impacted by time-of-use pricing from periods of high energy demand to periods when demand is not at its peak. SMUD has teamed with Clipper Creek to develop the first ZigBee-enabled, level-two charging station to give participating customers load management capabilities.

The project looked at two pricing plans: One that draws a charge from the home and is lumped into the monthly utility bill, and another that uses dedicated meters installed at the home by SMUD. Both are geared to encourage drivers to charge their vehicles at times when energy demand is lower, so they can get electricity priced in reduced, off-peak periods and lessen the strain on the electrical grid all the way to the transformer level.

The program also conducted market research to assess driver attitudes about vehicle charging hardware and strategies, different pricing options, and how effectively SMUD is educating the public and delivering information about electric vehicles.

Project Features

Goals & Objectives

The goal of the project is to learn the preferences of electric vehicle drivers, get feedback on two new pricing plans, and measure the impact of the new ZigBee-enabled EVSEs. The pilot also aims to make drivers more aware of off-peak charging and its benefits, both to the customer and to the utility. The pilot will be a foundation for future program designs and equipment procurements.

Design and Features

The study places customers in one of three pricing plans featuring time-based pricing with low-cost, off-peak pricing:

- **Whole House Pricing Plan:** This is for electric vehicles charging at 120 volts. The vehicle charges are combined with the customer's residential electric bill, with reduced pricing during off-peak periods.
- **Dedicated Meter Pricing Plan with a self-managed option:** This is for customers who charge at up to 240 volts. Customers will be notified one day before a Conservation Day. The customer is expected to manage the charging of their electric vehicles by avoiding charging

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during periods when prices are much higher.

- **Dedicated Meter Pricing Plan with a SMUD-managed option:** This is for customers who charge at up to 240 volts. Charging loads for plugged-in vehicles will automatically be reduced to 1.4 kW during Conservation Day periods to reduce strain on the grid. SMUD will control the load reduction by sending a signal through the meter to a "smart" charging station. The customer will receive a notice one day before the Conservation Day.

SMUD will evaluate up to 20 Data-Only customers who charge at 120 volts on a dedicated circuit. In this group 120-volt charging patterns will be evaluated.

Benefits

- Lower off-peak charging prices
  - 7.4 cents (winter) and 8.3 cents (summer) per kWh for the Whole House option
  - 6 cents per kWh year-round for Self-Managed and SMUD-Managed options
- Electric vehicle charge will show separately on monthly bill for the Self- and SMUD-managed plans
- Two electric vehicle specialists will provide customer support by answering questions and analyzing and discussing usage data
- Reduced load on local transformers and the grid in general
- Reduced carbon emissions
- Promoting clean-air transportation

At-a-Glance Facts

Pilot population: Residential

Number of study groups: 3

Total participants: Up to 180 electric vehicle drivers

Pilot Type: Research and evaluation

Groups:

- Up to 60 residential whole-house participants
- Up to 60 residential self-managed meters
- Up to 60 residential SMUD-managed meters

"What will SMUD and Sacramento be like when most of the vehicles on the road are electric vehicles?"

— Dwight MacCurdy, Electric Vehicles projects coordinator

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Smart Thermostats

Project Overview

The Smart Thermostat pilot evaluates how self-optimizing thermostats impact energy efficiency, peak load, and customer bills. These thermostats automatically learn a customer's energy usage preferences over time and optimize performance. The thermostats will be combined with dynamic pricing and offered to customers at no cost. In addition to the field study, a laboratory study will see which features and interfaces are the most appealing and intuitive to customers.

Project Features

Goals & Objectives

The Smart Thermostat pilot's goals and objectives center on evaluating customer acceptance of self-optimizing thermostats and the additional effect of dynamic pricing where rates vary due to factors such as time of use. This pilot focuses on the energy efficiency impacts of smart automation and customer behavior, as well as the impact on peak demand. The other key objectives of the study are customer satisfaction and enhanced engagement in energy literacy. This pilot seeks to learn about customer preferences related to overall thermostat design, functionality, and interface. Findings will be incorporated into future program designs.

Benefits

- A self-optimizing thermostat for energy efficiency that requires little customer effort
- Potential bill savings from automation and dynamic pricing
- Ownership of the self-optimizing thermostat
- Results that provide input into future program design and products that will enable the use of this new technology
- No cost to the customers

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At-a-Glance Facts

Pilot population: Residential

Number of program offers: Five

- 200 Nest
- 200 EcoFactor
- Up to 10: Allure
- 200 Nest + TOU-CPP
- 200 EcoFacto + TOU-CPP

Total invitations: 24,000

Technology summary:

- Nest thermostat
- EcoFactor software + Computime thermostat + Digi gateway
- Allure app + Computime thermostat + Sheeva Plug

Rate summary: TOU-CPP: SmartPricing Options "Optimum Off-Peak Plan"

Design and Features

The pilot design invites customers to participate in a specific offer that includes a self-optimizing thermostat, with approximately half of the offers including a dynamic rate designed to reward peak demand reduction. SMUD's third party installer will install the thermostats and leave the original thermostat with the customer. Property owners will own the new thermostats upon installation. SMUD and the manufacturer will maintain the devices during the study period.

The evaluation will measure customer satisfaction with the thermostats, service and rate, ease of use, energy efficiency, peak load, and bill impacts.

The rate design includes the TOU-CPP rate that was designed for SmartPricing Options. The rate is in effect from June 1 to Sept 30, 2013, with a weekday peak period from 4 p.m. to 7 p.m. and 12 critical peak events during the same hours. Customers will get a discount during the off-peak hours and charged higher prices during the peak and critical peak periods. Peak events will be called the day before, driven primarily by temperature. The rate is designed to reduce the system peak demand daily and on particularly high demand days.

The control, automation, and information technologies include three thermostats that optimize energy efficiency by learning from customer behavior. The products and services automate temperature and allow additional customer control via web portals and smart phone access.

- ***Nest*** is a self-contained thermostat with an occupancy sensor. Customers manually adjust temperatures during the short learning period while the thermostat learns preferences. High and low thresholds are programmed during set up. When the thermostat detects no occupancy, it resets to "away" mode. Nest is continually learning behavior and updating the schedule. Customers with Internet access can choose to activate an online account which includes enhanced controls and information, but this is not required.
- ***EcoFactor*** is a software product that can be used with a wide array of thermostats. Similar to Nest, it optimizes performance based on a customer-set schedule and learning period. Unlike Nest, there is no occupancy sensor, and EcoFactor performs the optimization in the cloud, incorporating weather data. EcoFactor requires internet access and a gateway.
- ***Allure*** uses proximity control technology to optimize energy savings. Using an iPhone or iPad Allure Mobile App, the temperature automatically adjusts when the customer is leaving and begins cooling (or heating) when the customer is returning home. Customers can customize their temperatures and proximity threshold, optimizing comfort.

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Low-income Weatherization

Project Overview

Customers with limited incomes can be particularly affected by spikes in their electric bills. We are piloting a program aimed at maximizing smart meter technology to interact with these customers so they can reduce their energy use. The program takes advantage of existing weatherization audits and includes educating customers on how to view and evaluate their usage. Tips on lowering bills by using self-optimizing thermostats and in-home displays (IHDs) that show real-time electricity use are provided. We'll evaluate the effectiveness of the program by looking at factors such as energy efficiency impacts, bill impacts, behavioral change and satisfaction.

Project Features

Goals & Objectives

Goals and objectives center on enhancing the existing weatherization audit program by adding new energy management tools. Two of the groups use technology and systems from other pilots: Smart Thermostat and In-Home Display (IHD) Check-Out. Additionally, some customers will receive training on how to read our online energy graphs that show hourly, weekly and monthly usage and costs. SMUD is focused on the energy efficiency impact of smart automation and customer behavior resulting from energy education. Customer satisfaction and enhanced engagement in energy literacy are key objectives.

Design & Features

This pilot project calls for using the weatherization audits already in SMUD's portfolio and smart grid technology to augment the help we give to limited-income customers. All customers in the project will be invited to receive a weatherization audit, while three of the groups will receive one of the additional measures described above.

Customers who receive the Nest thermostat will participate in the program for one year. Those receiving training on SMUD's online usage graphs will complete their participation obligation by installing any of the recommended energy assessment measures. Those who receive an in-home display will return it after two months via mail

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when their check-out period has ended, concluding their participation in the pilot. All participants will be asked to participate in market research efforts during the year.

SMUD's contractor will install the thermostats, leaving the original thermostat with the customer. Property owners will own the new thermostats upon installation. SMUD and the manufacturers will maintain the devices during the study period. The audit, equipment, service, and installation are provided at no cost to the customer. We will measure: customer satisfaction with the devices, tools, and service; ease of use; energy efficiency; and bill impacts.

Control, automation, and information technologies include thermostats, CDs and online videos, and in-home displays.

The in-home displays and online energy graphs facilitate customer education on consumption (real-time and day-delayed) and enable customers to better manage their electricity bills through improved understanding of electricity consumption patterns of the home, appliances and equipment. Specific devices include Power Tab™ in-home displays produced by Energy Aware.

Some customers will receive a Nest thermostat that optimizes energy efficiency by learning from customer behavior. Nest is a self-contained thermostat with an occupancy sensor. Customers manually adjust temperatures during the short learning period. High and low thresholds are programmed during set up. The thermostat resets to "away" mode when it detects no occupancy in the home. Nest is continually learning behavior and updating the schedule. Customers with Internet access can choose to activate an online account which includes enhanced controls and information, but this is not required.

Benefits

- Bill savings from education, automation and weatherization measures
- Self-optimizing thermostat ownership
- Weatherization measures installed in the home
- Energy efficiency education that helps customers manage their energy usage
- No cost to customers

At-a-Glance Facts

Pilot population: Residential

Total invitations: 6,000

Target participants: 628

Pilot type: Research and evaluation

Technology:

- Online usage training video
- Nest thermostat
- Energy Aware Power Tab™ in-home display

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In-Home Display Checkout

Project Overview

SMUD's In-Home Display Checkout pilot will offer residential and small business customers the chance to borrow technology to learn about their whole-house electricity consumption and its impact on their SMUD bills. In-home displays will be available for a two-month loan from public libraries or directly from SMUD via the U.S. Postal Service.

The pilot will evaluate the following:

- Customer interest in and satisfaction with in-home displays,
- SMUD's ability to provide and enable installation of third-party home area network equipment, and
- The subsequent impact on customer bills.

Pilot Features

Goals & Objectives

Goals and objectives center on customer acceptance of and response to whole-house electricity consumption and cost information provided in near real-time. SMUD is focused on the energy-efficiency impact of customer behavior in response to readily accessible cost and electricity-usage information.

Additional objectives are customer satisfaction and enhanced energy literacy.

This pilot also seeks to explore options for enabling third-party distribution of home-area-network equipment that works with SMUD's smart grid network and to understand the challenges and options for future programs and partnerships.

Design and Features

The design allows customers to borrow an in-home display for two months. Customers can borrow it from SMUD directly or borrow one from a public library. If the display is checked out directly from SMUD, we will prepare it for use and ship it to the customer, sending prepaid return packaging. Customers who check out the display from the library will contact SMUD to prepare the display for use (done over the phone) and will return the device directly to the library. The customer's data will be deleted from the display

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upon its return.

For small commercial customers, energy specialists will deliver the device during scheduled energy audits, or the customer can borrow one from a public library.

There is no cost to customers, and SMUD's Residential Services staff will support their needs. The evaluation will measure customer satisfaction with the pilot, ease of use, and resulting energy efficiency.

Benefits

- No cost to the customer
- Real-time consumption and cost information
- Potential bill savings from behavior change
- Increased energy literacy

At-a-Glance Facts

Pilot population: Residential and small commercial customers

Number of test group types: Four

Total invitations: Open to all residential and small commercial customers

Pilot type: Proof of concept

Groups:

- 300 units through direct checkout via U.S. Postal Service
- 25 units (150 for second phase) for checkout via Sacramento Public Libraries
- 150 units through the Energy Insights Weatherization Pilot Program
- 50 units for distribution during small commercial energy audits

Technology summary:

- Energy Aware Power Tab In-Home Display
- Digi XBee ZB Smart Energy Range Extender

Rate summary:

- No new rates are offered in this pilot
- Rates displayed will not be customer-specific. The most common rates will be used for educational purposes and customer tiers will not change

"Most people in the industry have given up on in-home displays, believing customers quickly grow bored with them. Who wants to spend over $100 on a device that will end up in the junk drawer after a month? This pilot program gives customers the opportunity to try out the technology with no cost and no strings attached."

— Bryan Serinese, Project Manager

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Commercial Energy Management and Control Systems

Project Overview

The Energy Management and Control System (EMCS) project was intended to leverage the lessons learned from the Smart Grid Investment Grant (SGIG) partner EMCS design and construction projects to benefit the general population of SMUD's medium to large commercial customers. The intent was to improve interoperability between energy systems, utilizing smart grid qualifying technologies.

It is typically difficult to develop electric utility rebate programs for EMCS due to the difficulty of verifying energy savings and high project costs. Further, rebate programs do not typically consider all of the interoperability benefits facilitated by smart grid technologies, such as a better and more streamlined building control capability, and in the case of this project, the requirement that replaced systems be AutoDR capable.

Project Features

Goals & Objectives

The program was offered as a pilot in tandem with a similar pilot incentive program overseen by SMUD's Customer Solutions area. Using both programs, the goal is to offer a higher level of customer incentives than could otherwise be offered to stimulate the market for controls vendors and building owners. The primary target audience was owners of office or retail building stock in excess of 50,000 square feet with obsolete or non-working control systems that were installed in the 1980's or earlier. As a condition of participation, verifiable AutoDR capability was required. Through SGIG, SMUD provides an incentive (much like a rebate) in the amount of 30 percent of the construction cost, not to exceed $100,000 per project. This is specific to smart grid qualifying componentry and associated labor. An additional goal is to use these projects as candidates for an elective AutoDR program, which was first made available for our commercial retail customers during the first quarter, 2013.

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Benefits

- Development of Automated Demand Response (AutoDR) capability for commercial buildings in SMUD's service area
- Improved interoperability between systems/equipment in commercial buildings, through the following improvements and new functions:
  - Scheduling
  - Economizer optimization
  - Reset strategies
  - Variable flow optimization
- Energy efficiency and greenhouse savings:
  - Seeking a minimum of five percent energy savings, annually
  - Greenhouse gas reduction
- Additional benefits for program participants:
  - Maintenance and operational savings
  - More precise control of building systems for occupant comfort

At-a-Glance Facts

- Program Start: January 2012
- Program End: March 2013

Application:

- Commercial buildings of 50,000 square feet or more
- Customer Incentive Budget: $800,000

Participation Criteria:

- Completed projects must yield a minimum of a five percent electrical energy savings for associated building energy systems.
- Not intended for new construction

Incentive

- $100,000 or 30 percent of the project cost, whichever is less

"Advanced energy management and control systems for commercial buildings will be a valuable tool for building operators, as well as helping both the customer and SMUD to achieve our energy efficiency and climate action goals."

— Jeff Molander, Project Manager

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Residential Smart Community Project

Project Overview

Together with Pacific Housing and Sunverge Energy, SMUD is testing the ability of the Sunverge Solar Integration System to monitor and control energy storage, intermittent solar generation, smart thermostats, and smart lighting controls in a new construction project of 34 single-family houses. The homes—constructed as part of the Residential Smart Community Project—will be designed to generate solar energy and store it for use during periods of peak energy consumption.

Project Features

Goals & Objectives

This project will determine whether energy storage, intermittent generation of electricity from solar, and other smart technologies within the home can be controlled and aggregated to help manage electrical grid resources. In addition, the project will test whether customers can use these resources to manage electricity use and minimize costs in addition to SMUD using them to support needs of the electrical grid.

The value of distributed energy resources such as solar has not been fully proven within the utility industry, and many logistical and operational questions remain unanswered. This project will allow SMUD to implement, evaluate, and advance these technologies as part of its broader SmartSacramento® initiative.

Design & Features

Thirty-four houses in midtown Sacramento will be designed and built to accommodate photovoltaic (solar energy) generation, residential energy storage systems, and innovative energy-management systems.

The houses are expected to use 40 percent less energy than the average new house. The energy-efficiency upgrades will be noted and included in the baseline for each house but will not be part of the proposed evaluation. Each house will have a rooftop solar system and its own lithium-ion battery system for storing solar power when the

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arrays produce more electricity than the household needs. The solar systems are expected to generate as much power as the houses use on an annual basis. Thus the development is called a "zero-net-energy community." The houses are designed to use no power during the hours of peak demand, relying instead on the solar energy stored by the batteries.

Use Cases

The measurement and verification effort will address the following use cases:

- Demand response: SMUD simulates a demand response (energy reduction) signal to the storage and home-area network systems and measures performance and characteristics under different scenarios.
- Peak load shifting: Demonstrate the potential for peak-load shifting without a time-of-use rate.
- Photovoltaic firming: Demonstrate the ability to automatically even out the supply of energy generated from photovoltaics, increasing their value.
- Regulation: Demonstrate the use of energy storage to provide ancillary benefits to SMUD or to the Balancing Authority of Northern California (e.g., fast frequency regulation).
- "Spinning reserves": Demonstrate the ability and value of spinning reserves (extra generating capacity).
- Uninterruptible power supply: Demonstrate reliability value and back-up power value.
- Power quality: Demonstrate high power quality for the customer.

Benefits

- Understanding the value of zero-net-energy homes to SMUD and its customers
- Determining the value of this technology for multiple purposes:
  - Peak demand management
  - Spinning reserve
  - VAR compensation/voltage support
  - Frequency regulation
  - Intermittent resource support
- Improving system reliability
- Gaining experience installing and interconnecting this new technology
- Quantifying utility, customer, and system benefits
- Understanding the impacts of multiple residential energy storage systems on the distribution system.

"It's one of the first residential projects in the nation to integrate solar, electricity storage, home energy management, smart lighting, energy efficiency and LEED certification – resulting in the complete smart home. In addition, this smart community of 34 homes will allow SMUD to explore the future of zero-net-energy homes and the benefits they may provide for the utility and our customers."

— Rachel Radell, Project Manager

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Advanced Controllable Lighting Rebates

Project Overview

Several recent SMUD research projects have shown that commercial customers can save 50 percent to 90 percent on energy costs by using advanced lighting controls in their facilities. To encourage adoption of these systems within our service area, SMUD put into place a pilot rebate program using funds from a U.S. Department of Energy Smart Grid Investment Grant and SMUD. Incorporating lessons learned from prior research, the advanced lighting control project gave economic benefits to customers and key insights to SMUD. Also, since an automated demand response (energy control) component was a condition of participation, this project will link customers to the smart grid network and enable participation in future demand-response programs to ensure reliability of the electrical grid.

Project Features

- Performance-based incentives (30 cents per kilowatt hour) paid to the customer, up to a maximum of $300,000 per project and not exceeding 80 percent of project cost.
- Development of a list of qualified advanced lighting control products.
- Use of advanced lighting control capabilities to validate energy savings calculations.
- Technical support from SMUD's energy-efficiency and research-program staff.
- Energy education and training classes through SMUD's Energy and Technology Center.

Goals and Objectives

- Encourage customers to install state-of-the-art lighting systems.
- Understand the challenges, requirements, and benefits of implementing advanced lighting controls, as well as the key elements for success.
- Determine the energy savings potential and customer acceptance of advanced lighting control technologies.
- Encourage local electrical contractors to participate.

Design and Features

The advanced lighting controls that qualified for

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this project will enable SMUD customers to control their lighting systems via user-friendly software that will:

- Display the real-time status of lighting fixtures (on, off, dimmed) overlaid onto a floor plan of the space.
- Modify operating schedules for the lighting fixtures for each control zone via a desktop computer, Internet connection, smart phone, etc.
- Track and generate reports for energy consumption, costs, and savings.
- Adjust the amount of light to suit the needs and preferences of the customer.
- Notify customers when a light fixture fails.

Benefits

- Customers achieved energy savings of 50 percent to 90 percent. The 12 companies that participated in the advanced lighting control project in 2012 expect to save from $5,000 to $100,000 per year.
- The project offered rebates and incentives to help commercial customers switch to technologies they might not otherwise be able to afford, while allowing manufacturers of advanced lighting control products to enter a market that might otherwise not be available for years.
- Information gained from the 2012 project helped SMUD develop its own self-funded program, which we launched in 2013.
- Businesses can track energy costs and savings while monitoring facility usage in real time on-site or remotely via web-based interfaces, including smart phones.
- The automated demand response capability will help ensure the reliability of SMUD's electrical grid on hot summer days.

At-a-Glance Facts

Start date: February 2012
End date: February 2013
Number of participants: 12 customers, 14 projects
Total incentives: $1.2 million
Range of energy savings: 50 percent to 90 percent
Average simple payback: 2.4 years
Evaluation: June 2012 through December 2015

"Advanced lighting controls can help our customers save energy, track their energy consumption, and reduce their maintenance costs. The automated demand response capability will also help ensure the reliability of our distribution system on hot summer afternoons."

– Dave Bisbee, Project Manager

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Commercial Energy Information and Tools

Project Overview

SMUD implemented an on-line tool to provide energy information and tools to commercial customers. The selected tool was developed by Schneider Electric and is called Electric Profiler Online or EPO. In order to enhance the usage of this tool and to provide near real-time data to customers, SMUD partnered with the California Department of General Services (DGS). Our aim is to provide complete and timely energy consumption information to the state Central Plant. The Central Plant serves 21 state buildings in downtown Sacramento with chilled and hot water for their heating and cooling systems. The Central Plant is not able to "see" several of the buildings on this loop, which make up about 25 percent of the total load, making its operation less accurate than it could be. Through this pilot project, DGS will acquire "visibility" of these buildings' heating and cooling needs, and SMUD will demonstrate the capability to provide real-time energy data with our Energy Profiler Online (EPO) tool.

Project Features

Goals & Objectives

1. Demonstrate the ability to provide near Real-time Data Acquisition utilizing smart grid technology and the EPO tool, with the intent of offering this service to other interested EPO customers
2. Demonstrate that SMUD meters are capable of feeding consumption data into a customer's building management system (BMS)
3. Ongoing reporting will evaluate:
   a. Usefulness of data
   b. Accuracy of data
   c. Added functionalities resulting from this data
   d. The value of EPO with near real-time data being delivered
   e. Security concerns recognized and/or addressed
   f. The value of this pilot in cost savings and ease of operation

Project Design & Features

This project is going to use a SMUD meter with a pulse output whose signal will be split and sent to the state's central plant's BMS and to the SMUD EPO tool. The data will be provided in near real-time (five minute intervals) and will be accessible anywhere with an Internet connection through the SMUD EPO website.

Using a series of firewalls to secure the signal, the central plant BMS will be fed via the DGS intranet system back to the central plant. To be able to communicate with the BMS, the DGS IT team will convert the pulse signal into BACnet protocol, which can then directly feed the consumption data into the BMS. This data will be used to optimize how the central plant operates: to run more efficiently and to minimize peak demand (kW) in the summer.

The EPO signal will be transmitted through the proprietary Schneider Electric protocol called MeterM@il, which is the standard protocol that EPO already uses. The difference will be the increase in the number of signals sent – rather than once a day on the day after the energy is used, the signal will be sent every five minutes.

Benefits

Currently, DGS is not able to monitor the loads on several of its downtown buildings and this pilot provides them with that capability. This will help them control their chillers and boilers more efficiently and responsively. The net result will be cost savings from more efficient operation of their equipment and from being able to avoid resetting their peak electric demand (kW) to a higher level. Each time the peak demand is reset to a higher level, a higher peak charge is generated for the next 12 months.

The benefit to SMUD is that we will successfully demonstrate the provision of (near) real-time data monitoring, which in turn demonstrates another way in which smart meters can benefit our customers.

At-A-Glance Facts

Project Start:	April 2012
Project End:	December 2014
Overall Budget:	$20,000
Meters Installed:	Three
Customers Affected:	DGS & State of California
Technology Involved:	Smart meters, EPO, Alerton BMS, IT security

"Real-time energy consumption data can be invaluable to the building managers and engineers who are charged with operating their equipment as cost-effectively as possible while still maintaining a comfortable environment for their tenants. Its value includes more efficient operations, adding longevity to the life of equipment, troubleshooting building systems, identifying opportunities for improvement, communicating red flags easily and quickly when systems go offline, and through all of these, saving money and energy for our customers."

— Mark Jagodzinski, Project Manager

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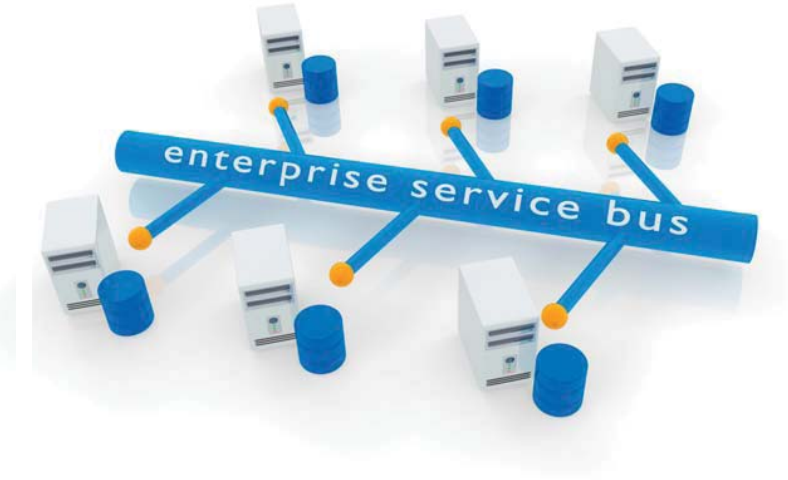
Enterprise Service Bus

Project Overview

In this project, we installed a software infrastructure that enhances interaction and communication among a business's integrated applications and services. An enterprise service bus boosts efficiency and reduces maintenance and support costs.



Project Features

Goals & Objectives

The enterprise service bus will reduce the number, size, and complexity of interfaces among existing organization-wide systems and new smart grid systems. Initially, this project provides the common platform to support interoperability between systems. On an ongoing basis, it will be used to simplify the integration of several additional smart grid systems into SMUD's operations.

Design & Features

The scope of this project was procurement and implementation of an enterprise service bus. Integration and interoperability needs within SMUD's smart grid were identified and documented.

With the enterprise service bus infrastructure in place, it can be used to enable the integration of SMUD's other smart grid applications, such as:

- Advanced meter infrastructure data
- SAP customer information
- Meter data management system billing interval usage data
- Demand response management system notifications and time-of-use/critical peak pricing
- Distribution System Operations dashboard
- Outage communication management
- Residential customer Web portal, called "My Energy Tools," with energy information and tools
- Near real-time meter voltage

Benefits

The project is expected to provide the following business benefits:

- Standardize the integration of selected SMUD systems
- Reduce the complexity of integration interfaces among systems
- Reduce operating costs

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- Improve application management processes
- Minimize the need to synchronize between versions of applications with point-to-point interfaces
- Improve issue-resolution and service-restoration times
- Provide a platform for interoperability and secure data communication among customer, distribution, and technology systems

At-a-Glance Facts

Project start: August 2009
Project end: July 2011
Overall budget: $1,470,000
Technology: Software AG WebMethods
Functional/technical requirements complete: December 2009
Procurement: November 2010
Construction complete: June 2011
Project and training complete: July 2011

"Implementation of the enterprise service bus is a best practice among the leading smart grid utilities in the United States."

— Steve Zeigler, Project Manager

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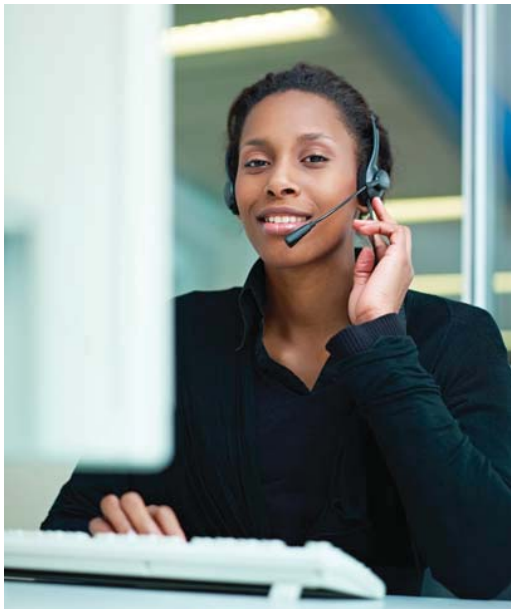
Customer Relationship Management



Project Overview

The Customer Relationship Management (CRM) project involved the installation and deployment of the SAP CRM module to replace earlier-generation software used to process customer requests such as move-in/out and program enrollment. The new software allows SMUD to separately track programs specific to the customer from those specific to property/building(s) on the account. This customer information, along with the premise-based program information, allows SMUD a more comprehensive view of our customer's needs, which will improve our customer service.

SMUD has used the SAP Customer Care and Service application for its Contact Center customer service processes since 2000. The CRM Project migrated these processes to the SAP CRM software. With CRM, SMUD can begin to capture and analyze more detailed customer information. This information can then be used to offer segments of customer information on smart grid capabilities and to share new offerings.

With CRM, SMUD can track equipment customers have in their homes, such as photovoltaic equipment and home area networks that are connected to SMUD. In addition, the software will allow SMUD to begin incorporating nonutility customers with whom we do business (such as out-of-area architects) into our database. Capturing this greater variety of information will give us a better understanding of our customer's needs.

Project Features

Goals & Objectives

The goal was to implement the CRM Interaction Center web client (Web-IC) as a technical foundation for integrating smart meter data into the Contact Center while maintaining or improving the JD Power Customer Service rating for the organization. Specific goals:

Incorporate 350 existing business processes into CRM and deploy the browser-based Web-IC.
Roll out CRM to more than 350 users, including Contact Center customer service representatives.

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Design and Features

- Designed, installed, configured, and integrated SAP CRM for Utilities 7.1 software to integrate with our SAP ECC 6.0 (EHP5) landscape. This meant setting up the CRM and CRM Business Warehouse systems and designing and configuring the middleware to allow for synchronization between the two systems.
- Configured and customized Web-IC to migrate all relevant ECC L-Shape CIC users and their business processes to Web-IC. Implement ease-of-use features.
- Ensured all interfaces, remote-function calls, workflows, previous Customer Care and Service reports, and customizations were operational and free of errors, and were modified to eliminate any reworking of existing systems.
- Ensured all current CCS Business Warehouse extracts and reports were operational and free of errors.
- Ensured new CRM Business Warehouse extracts and reports were enabled to support business processes.

Benefits

This project was expected to deliver the following business benefits:

- Improve integration between the Contact Center and back-office billing functions and systems.
- Support the integration of the customer business unit processes with the SAP Advanced Metering solution.
- Provide a single solution with workflows that can be audited and traced across all AMI processes.
- Support a data model that separates programs for customers from those for premises.
- Improve the customer experience to build customer loyalty in preparation for a more competitive landscape.

At-a-Glance Facts

Project start: April 2011
Project end: March 2013
Overall budget: $13,871,000
Technology: SAP CRM 7.1 software
System integrator procurement: May 2011
Solution construction complete: January 2012
Initial Go-live: May 2012
Optimization – enhancement release 1: October 2012
Optimization – enhancement release 2: March 2013

"CRM is the foundation for managing new service offerings for our customers and integrating smart grid data into the Contact Center."

— Paul Nelson, Program Manager

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Revenue Protection Detection Software

Project Overview

This project implements a solution that identifies and prioritizes probable theft cases by pulling data from SMUD's existing systems and outside sources, such as the county assessor, business listings, and weather reports. The software then applies proven algorithms to detect patterns that indicate meter tampering, bypass, and malfunction. This project draws on the wealth of data now available through smart meters and fills the gap left by the loss of monthly visual meter inspections, which were the primary source of tips about theft. Industry sources estimate that power theft totals 0.5 percent to 1 percent of revenues per year.

Project Features

Goals & Objectives

- Move theft investigations from reactive to proactive using meter information and other data sources.
- Focus on theft in the commercial sector, which has a greater impact on revenue loss and a higher probability of collection.
- Implement an overall analytics platform that can leverage the initial investment for future applications in planning, forecasting, billing, customer segmentation, rate analysis, and data-based decision-making.

Design and Features

The revenue protection detection software from Detectent consists of the Customer Intelligence Platform, a base analytics platform, and RevEnhance, a revenue protection application. The package includes more than 20 preconfigured score-based algorithms that have been proven to help identify tampering, bypass, and meter malfunction. The software uses third-party data from SAP, AMI, IEE, and GIS to:

- Understand external forces affecting usage trends
- Enhance utility data for display

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- Empower utility data for analytics

The outside data include county assessor's information, business listings, weather, and demographic information.

The software also has comprehensive tracking from the beginning of a suspected theft case to the close, with the ability to save field notes, letters, and photos as evidence. It also tracks estimated billed theft amounts and the amount collected on each account. It includes a number of standard reports that can be easily configured.

Benefits for the Customer

- Improves neighborhood and personal safety by better identifying tampering that could lead to shock, fire, property damage, and even death
- Reduces revenue loss, which could affect future rates

Benefits for SMUD

- Increased ability to identify and stop commercial theft from meter bypass or tampering.
- Catching theft earlier to limit revenue loss.
- More efficient use of resources.
- Increased visibility of meter tampering and malfunction.

At-a-Glance Facts

- Project timeline: January 2012 through May 2013.
- Budget: $1.27 million.
- Base analytics platform available to other applications for planning, pricing, segmentation.
- Directs resources to most likely and most costly theft cases.

"This project will fundamentally change the way SMUD identifies theft from a reactive mode using tips to a proactive mode using near real-time consumption patterns and anomalies."

— Michelle Giles, Project Manager

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Cyber Security

Project Overview

In support of the SmartSacramento® projects, SMUD sought to expand its information security capabilities and toolset. The Cyber Security Project focused on intrusion detection, vulnerability management, security information and event management, and security assessments.

Project Features

Key elements of the project are:

- Expanding SMUD's intrusion detection systems.
- Procuring and installing vulnerability management systems.
- Expanding SMUD's security information and event management system.
- Performing security assessments of SmartSacramento® systems.

Goals and Objectives

The key elements have subprojects and tasks but also contribute to the program goals and objectives:

- Monitor traffic and activity on new networks and systems built for SmartSacramento® projects.
- Enhance SMUD's ability to prevent, detect, and respond to cyber security events.
- Ensure SmartSacramento® systems are securely built and configured.

Design and Features

The project brings increased security for SMUD's SmartSacramento® projects individually and collectively. Along with other security controls already deployed, the project brings a defense-in-depth approach to securing the SmartSacramento® systems.

Some of the high-level features are:

- Traditional network and wireless mesh network intrusion detection systems.

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- Ability to correlate security events in disparate systems.
- Vulnerability management solutions that focus on network devices, servers, applications, and databases.
- In-house and independent third-party security assessment testing.

Benefits

- With intrusion detection capabilities in place, SMUD can detect and respond to anomalous and malicious traffic on its networks.
- Gathering and then correlating security event information into one system allows SMUD to see the big picture of what's happening with its information systems.
- By finding vulnerabilities in its systems, SMUD can proactively protect itself from threats.
- Testing allows SMUD to validate system security features and controls.

At-a-Glance Facts

Start:	September 2009
Complete:	April 2013

"The systems that have been implemented and enhanced as a result of this program enable SMUD to more effectively protect its systems."

— David Bitter, Project Manager

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Smart Grid R&D

High-Penetration Photovoltaics

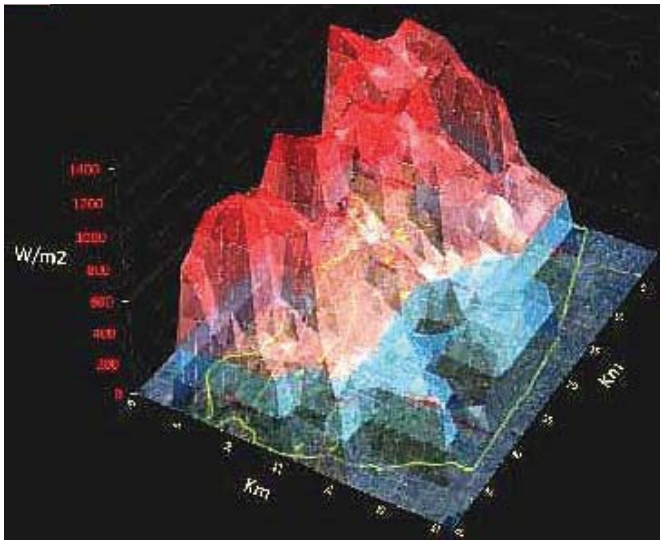
Project Overview

In partnership with the Hawaiian Electric Company, SMUD is testing and developing tools to ensure the reliability of our electrical grid as the amount of photovoltaic (solar) energy grows in our service area. We'll investigate key barriers to larger-scale adoption of photovoltaics into mainstream operations and the distribution grid. As utilities managing the introduction of photovoltaics into their systems, SMUD and the Hawaiian Electric Company worked together to align California and Hawaii case studies, solar assessment and forecasting needs, and photovoltaic grid integration goals.

Project Features

Key elements of the high-penetration photovoltaic project:

- Baseline modeling of several SMUD and Hawaiian Electric Company cases.
- A validated method to account for the impact of solar-generated energy on SMUD and the Hawaiian Electric Company.
- Development of a device that will connect and allow communication between a solar-energy inverter and a home area network.
- Demonstration of visualization tools that will help grid planners and operators in considering the impacts of high penetration of photovoltaic systems.
- Deployment of a network of irradiance sensors that monitors and collects solar data within the service area for use in forecasting solar power generation.



The effect of cloud cover on solar electricity generation.

Goals and Objectives

- Enabling the capability to reliably plan and operate a grid with high penetrations of variable renewable-energy resources, especially during high-impact conditions such as variable weather, peak loads and minimum loads.
- Informing and piloting the development of visual tracking, field measurement, and validated analytical (modeling) capabilities, including the hardware and software integration needed to evaluate the impact of high penetrations of photovoltaic systems on SMUD's and Hawaiian Electric's grid.
- Collaborating with other utilities and sharing the lessons learned.

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Benefits

This project provides tools and insight that will help ensure the reliability of SMUD's electrical grid as the number of photovoltaic systems in SMUD's service area grows. SMUD and HECO's lessons learned will also be shared with other utilities.

At-a-Glance Facts

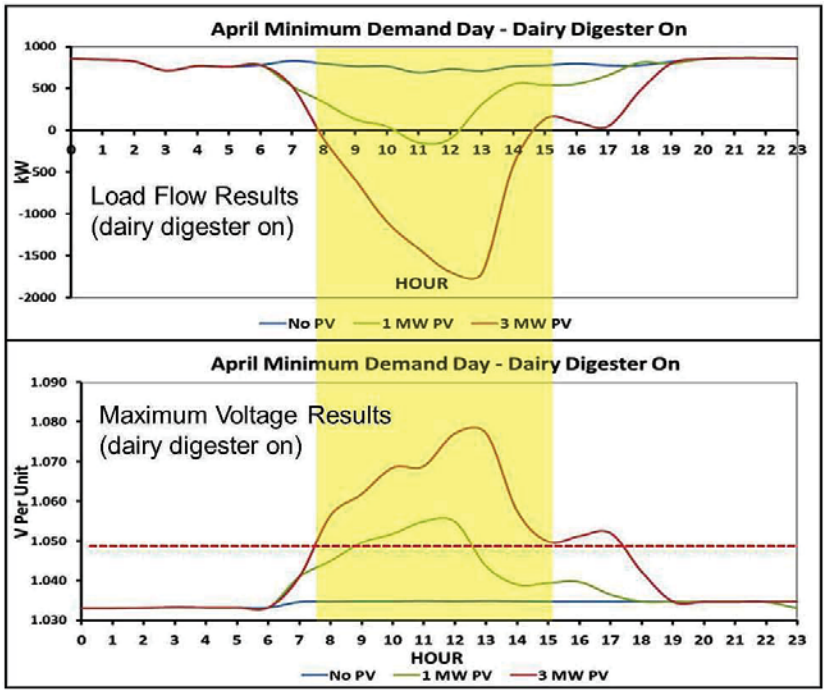
Start date: June 2010

End date: June 2013

Funding: $2.07 million grant from the California Public Utility Commission's California Solar Initiative Research, Development, Demonstration and Deployment Program

Key Partners: Hawaiian Electric Company, BEW Engineering (a subsidiary of DNV KEMA Energy & Sustainability), NEO Virtus Engineering, and the Electric Power Research Institute

Project Implementation: June 2010 through June 2013



The effect on the grid of a feeder (a power line transferring power from a substation to transformers) with photovoltaics and a dairy (manure) digester. The dairy digester creates energy from cow manure. The chart shows the overvoltage and backflow on the feeder due to the energy generated.

"We are seeing higher penetrations of photovoltaic systems on SMUD's grid, and this can have detrimental impacts. We need to have tools to plan and operate our grid safely and reliably."

— Elaine Sison-Lebrilla, Senior Project Manager

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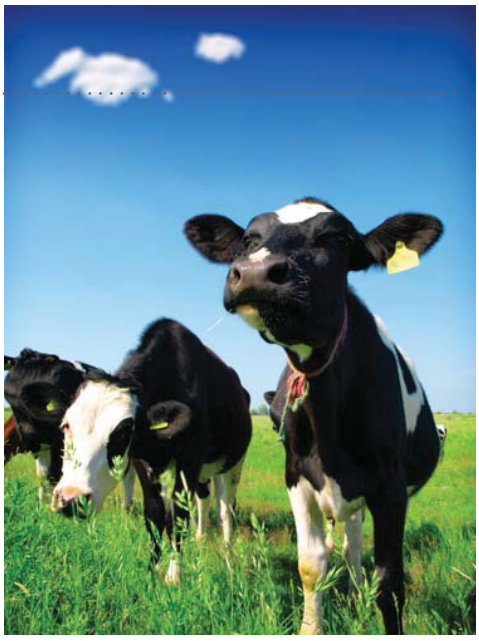
Smart Grid R&D

Dairy Digesters



Project Overview

This project connects two Sacramento County dairy anaerobic digesters to the SMUD power grid and links them to the smart grid. Anaerobic digesters are used to generate biogas from cattle waste collected from dairy farms. The biogas is then burned in an engine-generator to produce renewable electricity. The digesters keep climate-changing greenhouse gases out of the environment, while creating a revenue source for the farmers and supplying renewable energy to SMUD. A by-product of the digester is fertilizer-grade effluent for crops, reducing input costs for the dairy and avoiding chemical groundwater contamination. The construction of these two dairy digesters is possible through a Community Renewable Energy Deployment grant from the U.S. Department of Energy.

Project Features

Goals & Objectives

- Capture and destroy methane, a greenhouse gas which is up to 21 times more harmful than carbon dioxide and is believed to contribute to climate change.
- Generate renewable energy for use at the source point, replacing energy made from fossil fuels, and sell renewable energy to SMUD.
- Create revenue for the farmer in the form of land lease and manure supply ("fuel or feedstock") agreements.
- Learn about the challenges, requirements and benefits associated with the dairy digester program.
- Track potential energy cost savings.
- Encourage SMUD customers to install anaerobic digesters.
- Contribute to SMUD's and the state's renewable energy and greenhouse gas reduction goals.
- Improve soil composition and health.
- Eliminate pathogens from waste, allowing digested solids to be sold for animal bedding or compost.
- Bring local economic benefits though improved agri-business operation, job creation and increased tax revenue for the community.

Project Design & Features

Two digesters at the New Hope and Van Warmerdam dairies, both in Galt, CA, are complete and connected to the SMUD grid. An individual dairy cow can produce up to 120 pounds of waste a day,

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and decomposing livestock manure releases particularly harmful greenhouse gas into the environment.

Most Sacramento County dairies flush manure into on-site lagoons. Dairies equipped with anaerobic digesters convert the decomposing waste into biogas, a mixture of methane and carbon dioxide. Biogas is used to fuel an engine-generator that produces electricity.

In this project, two different types of anaerobic digesters are installed at the dairies: a covered lagoon and a tank digester.

At the Van Warmerdam dairy, a lagoon digester stores waste in an earthen pond with a plastic cover. As the waste decomposes, biogas is produced under the cover, which is transferred to a 600-kW engine-generator. The engine-generator runs during peak power periods—when electricity is most needed and prices are highest—and stores gas when electricity prices are lower. The effluent remaining is used as liquid fertilizer for crops.

At the New Hope dairy, the collected manure is pumped into a reinforced concrete tank, where biogas accumulates and then is transferred to a 450-kW engine-generator. The engine-generator will also run during peak hours. The effluent is then pumped into a storage pond and used as liquid fertilizer for crops.

Both systems reduce odors and fly populations compared to conventional open lagoon storage.

SMUD provided power purchase agreements and an option to buy greenhouse gas credits from the systems. SMUD also offered support from its renewable energy research staff and administrative support from the Grant and Accounting departments.

Each system received state and federal grants for installation.

Third-party project developers own these projects. The developers have a lease agreement with the farmers for the site and the manure supply. All the power is sold to SMUD and none is used at the farm. The farmers receive financial and environmental benefits from the project operation.

At-a-Glance Facts

Construction Completion: Spring 2013 for both digesters

Stabilized Biogas Production and Grid Interconnection: Late spring 2013

Key Milestones

- Program Development (Q1 2010 to Q4 2013)
- Project Monitoring [Q3 2013 to the end of PPA (20 years PPA)]

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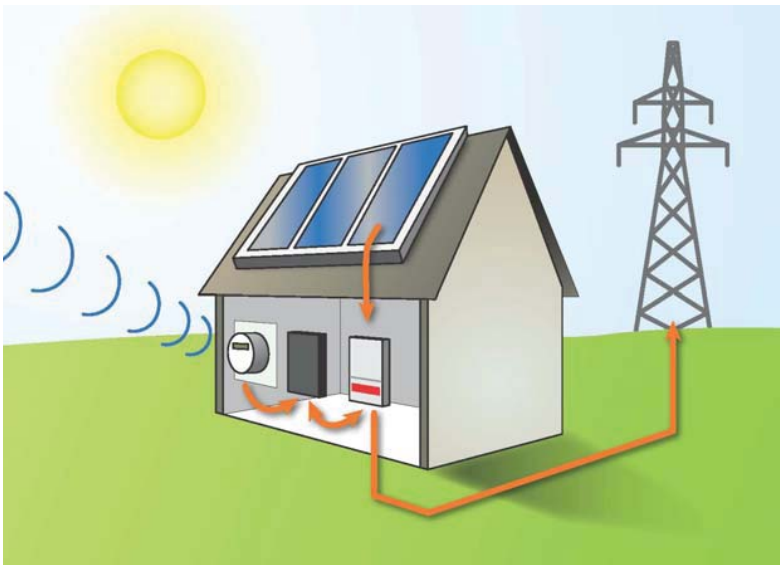
Smart Grid R&D

Residential Inverter Control Demonstration

Project Overview

The Residential Inverter Control Demonstration project examines some of the technical issues of integrating a residential solar energy converter (photovoltaic inverter) into a traditional electricity distribution system. Solar photovoltaics will be significant in increasing the use of renewable energy in California. This demonstration helps us understand the advantages and limitations of using advanced metering infrastructure for integrating small energy sources (distributed energy) into the electrical grid.



Project Features

Goals & Objectives

This research project will address a number of key questions related to the utility's overall technology strategy for integrating distributed renewable energy:

- To what extent can a smart meter be used to monitor and control a photovoltaic system?
- What challenges are associated with using advanced metering infrastructure for managing photovoltaics?
- What are the technical requirements for integrating inverters and smart meters; and what codes, standards, and reference designs must be developed?

Design & Features

The project will demonstrate the smart-meter-to-inverter wireless communications function, followed by an end-to-end demonstration at SMUD's Smart Grid test lab to demonstrate utility control of a residential inverter. The viability of this approach at a broader level will be assessed by leveraging other research conducted within SMUD and across the country.

Energy storage technologies can be integrated with distributed renewable energy resources such as photovoltaics to create value for customers and the utility. These technologies allow energy to be stored for use during peak loads, thereby reducing costs. This project will determine the impact of

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energy storage on a high photovoltaic penetration distribution feeder (power line), the possible reduction of the super peak load of the feeder, and the operational improvements that may be gained. These project benefits directly support SMUD's strategic directives for reliability, environmental protection, and research and development. Project technical objectives include:

- Controlling a photovoltaic energy storage inverter with a smart meter from SMUD's advanced metering infrastructure project.
- Developing a functional specification for a smart-meter-inverter interface that would enable management of a distributed photovoltaic storage system with advanced metering infrastructure.
- Helping to build a strategy for integrating energy storage and photovoltaics into the grid that can be replicated throughout SMUD's service area and the utility industry as a whole.

Benefits

The project supports federal and state goals to integrate large amounts of distributed renewable energy into the electrical grid, which is critical for California to achieve its renewable portfolio standard target of 33 percent renewable energy by 2030. Distributed solar photovoltaics, both rooftop and ground-mounted applications, represent the greatest opportunity for implementing distributed renewable energy in California during the next 10 years.

However, there are a number of important technical issues that will influence how much photovoltaic energy can be integrated. Controlling a photovoltaic energy storage inverter with a smart meter from SMUD's advanced metering infrastructure may prove to be a method for integrating large amounts of renewable energy into traditional electricity distribution systems without causing disturbances.

At-a-Glance Facts

This project will help SMUD determine how to leverage its investment in advanced metering infrastructure to manage distributed photovoltaic and energy storage resources. It will assess:

- Annual/seasonal kilowatt-hour impact
- Daily peak kilowatt impact
- Event peak kilowatt impact
- Customer bill impact
- Customer adoption rate
- Customer experience
- Reliability impact
- Cost-effectiveness for SMUD

Start date: March 1, 2009
End date: September 30, 2013

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"This project will consider the communication options available today and in the future to manage the intermittency of renewable energy and consider a demand-response option that will utilize photovoltaic inverters and SMUD's investment in advanced metering infrastructure."

— Obadiah Bartholomy, Project Manager

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Smart Grid R&D

Residential and Community Energy Storage

Residential Energy Storage System manufactured by Silent Power

Project Overview

Distributed solar photovoltaic power generation represents one of the greatest opportunities for implementing distributed renewable energy in California over the next ten years. Yet, solar photovoltaic power generation is an intermittent resource—cloudy weather can cause rapid, severe reduction in photovoltaic power production that impacts SMUD's ability to control voltage and ensure reliability of the distribution system. SMUD is conducting research on a number of strategies to mitigate these negative impacts from intermittent solar photovoltaic power generation. One potential mitigation technology is electricity storage.

Project Features

Goals & Objectives

The purpose of this research project is to demonstrate advanced lithium-ion storage batteries at customer and distribution transformer locations in the Anatolia III SolarSmart Homes community in Rancho Cordova. The goals are to:

- Stabilize the intermittency of photovoltaic energy generation.
- Mitigate the impact that large penetrations of photovoltaics can have on the reliability of the electrical grid.
- Reduce utility system peak electrical use (load).

SMUD has installed 15 residential energy storage systems and three community energy storage systems in the Anatolia III community and is testing various use cases for operating the storage systems to address grid integration issues associated with intermittent PV power production.

Design & Features

The U.S. Department of Energy under the DE-FOA-0000085 High Penetration Solar Deployment grant funded this demonstration project with SMUD. Co-funding was also provided by the California Energy Commission. The project partners are Navigant Consulting, SunPower Corp., GridPoint, and the National Renewable Energy Laboratory. The total project cost is $5.96 million.

The project will assess the impact of energy storage on a distribution feeder (power line) with a high penetration of photovoltaics power generation. The project supports SMUD's strategic directives for reliability, environmental protection, and research and development.

Technical objectives are to:

- Demonstrate the ability to integrate photovoltaic systems into the smart grid through two-way communication between the utility and photovoltaic inverters (solar energy converters).
  - Demonstrate communications between the utility and energy storage located both behind the meter and on distribution feeders.

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- Demonstrate communications and control capability using both broadband and the advanced-metering infrastructure network.
- Examine the capabilities and limitations of managing photovoltaic inverters through smart meters.

- Demonstrate energy storage as a potential solution for stabilizing (or "firming") the variable output of photovoltaics.
  - Both residential energy storage and community energy storage will be integrated with rooftop photovoltaics and operated in a utility distribution system.
  - The systems will be sized to test capacity for firming photovoltaics and measure the value to customers and utilities.

Benefits

The grant supports federal and state goals for integrating large amounts of energy generated from small renewable resources into the electrical grid.

Distributed renewable energy is critical for California to achieve its current renewable portfolio standard target of 33 percent renewable energy by 2030. Moreover, it is increasingly clear that distributed solar photovoltaics, both in rooftop and ground-mounted applications, represent the greatest opportunity for implementing distributed renewable energy in California during the next ten years. Several important technical issues will influence the number of photovoltaics that can be integrated at the distribution level.

Distributed energy storage systems may be a method through which large amounts of intermittent, renewable energy can be integrated into traditional distribution systems without causing disturbances. This project will investigate the level to which load management, peak load reduction, use of stored energy during peak loads, and integration can be accomplished through advanced storage technologies.

At-a-Glance Facts

- Commercial energy storage power rating: 30 kilowatt/30 kilowatt hours (10 homes – 1 hour, depending on load)
- Residential energy storage power rating: 5 kilowatts/7.7 kilowatt hours (1 home – 2 hours, depending on load)
- Project location in the Anatolia III SolarSmart Homes community in Rancho Cordova
  - Residential energy storage customers: 15
  - Commercial energy storage customers: 27
  - Baseline: 21
  - Customers monitored: 69
- Assessing rate impact from integrating photovoltaics and storage capability
- A customer home-energy management portal
- A utility portal—scheduling and fleet management of distributed storage.
- High-resolution data-monitoring of home load transformer load storage, and feeder data, including weather, power, voltage, current, photovoltaic production, and storage utilization

Budget: $5,962,409
Start date: April 1, 2010
End date: Sept. 30, 2013

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High Penetration DG Feeder & Substation Pilot

Project Overview

This project will provide valuable insight into the positive and negative impacts from high levels of variable distributed renewable generation on distribution feeders. These impacts will be evaluated by comparing conventional voltage regulating equipment with alternative systems to see which provides better reliability and power quality. Additionally, the potential impacts of reverse power flow through a typical distribution substation transformer can be demonstrated, analyzed, and evaluated for future planning purposes.

Project Features

Goals & Objectives

Compare conventional and alternative systems, such as dynamic load transfers and energy storage technologies, for reducing harmful impacts of solar generation (variability and reverse power flow) on a distribution feeder. This pilot will enable a comparison of each approach's effectiveness, cost of implementation, and operational flexibility.

Design & Features

SMUD retrofitted two distribution substations in Galt with advanced technology. The technology includes computer-controlled monitoring, voltage regulation and automated feeder tie points. The feeders from these substations have a significant amount of distributed generation from large-scale solar photovoltaic facilities and generation from dairy digesters. The distribution feeders will be monitored at various locations to get a comprehensive picture of impacts to the power network.

Benefits

This project will demonstrate technologies that may allow higher penetrations of renewable energy resources on SMUD's system while maintaining current levels of power reliability and power quality.

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At-a-Glance Facts

Project start: January 2013

Project end: May 2014

- Data will be gathered from distribution feeder with greater than 100-percent renewable generation during periods of minimum daytime loads.
- Technologies to be evaluated include centralized voltage regulation, distributed voltage regulation, dynamic load transfer, and dispatching of energy storage.

"Utilities need to look at alternative methods for mitigating the potentially negative impacts of higher penetrations of distributed renewable energy."

— Jeff Berkheimer

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Mitsubishi Energy Storage

Project Overview

Because wind and sunlight are intermittent, wind and solar power-generating resources produce electricity in varying amounts at different times. The rapid expansion of variable renewable energy resources across the United States and around the globe is complicating power system operations.

Mitsubishi Corp. has developed an energy storage system with the potential to support the wide use of variable, renewable power-generation resources by stabilizing the intermittent output of large photovoltaic (solar) power-generation systems.

Project Features

Goals & Objectives

The primary goals are to evaluate the effectiveness of energy storage for:

- Stabilizing the output of variable renewable power-generation resources,
- Shifting peak loads,
- Controlling the rate of the power output change (ramp rate control),
- Allowing the storage of power purchased at lower rates so it can be used when higher rates are in effect (energy time-shifting), and
- Supporting frequency regulation.

The project will provide insight into the optimal sizing and dispatch algorithms of an energy storage system in conjunction with an existing 3-megawatt photovoltaic plant. Since the plant is on a lightly loaded utility power line (feeder), we anticipate the photovoltaic array will supply more than 100 percent of the total feeder load and create significant voltage variability if not mitigated through operation of the energy storage system or other possible smart grid solutions.

Design and Features

- 500 kilowatt/125 kilowatt hour lithium-ion energy storage system
- 3-megawatt photovoltaic plant interconnected to a 12-kilovolt distribution feeder
- Potential capabilities to be evaluated: peak-

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load shifting, ramp rate control, renewable energy time shifting, and frequency regulation support.

Benefits

With this project, SMUD can evaluate how emerging advanced distributed energy storage may enhance and enable greater use of intermittent photovoltaics in our system while maintaining system reliability. It also will show how storage can help mitigate potential negative impacts from variable renewable generation resources, reduce peak loads, and potentially reduce the costs of serving peak loads. Additionally, this project may demonstrate how energy storage can help SMUD achieve its California Renewables Portfolio Standard and sustainability goals.

At-a-Glance Facts

- The project kicked off in October 2012.
- The energy storage system was installed in the second quarter of 2013.
- Mitsubishi Corp. will provide the energy storage system, and SMUD will provide all site infrastructure and operational support.
- Project completion: December 2015.

"Energy storage may prove to be instrumental in allowing utilities to install higher penetrations of renewable energy on distribution systems while maintaining current levels of power quality and reliability. This project will serve as a key benchmark in evaluating the effectiveness and operational efficiency of storage when installed in conjunction with a relatively high penetration of photovoltaics on a single distribution feeder."

— Jeff Berkheimer, Project Manager II

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MicroGrid

Project Overview

The purpose of this research project is to demonstrate a microgrid at SMUD's corporate headquarters. A microgrid is a network of generators and equipment linked to serve buildings with electricity, and heated and chilled water to supplement their heating and cooling systems. The microgrid can operate interconnected to the utility or independently during a utility outage.

Installed Tecogen Inverde 100 natural gas engines and related equipment

Goals & Objectives

SMUD's central utility plant serves the corporate campus with chilled and hot water for space conditioning. The microgrid is designed to provide power to the central utility plant and the nearby field reporting facility when interconnected to the utility or during a utility outage.

With this project, SMUD is addressing the following key research objectives:

- Demonstrate how a microgrid performs with real customers in a real-world operating environment.
- Separate and isolate the microgrid from the utility grid, while maintaining power reliability and quality.
- Explore how the following components or functions can be integrated and operated in the microgrid system:
  - Demand response – customers reduce their electricity consumption temporarily when the utility grid is running short of power generation capacity
  - Internal combustion engines
  - Solar photovoltaics
  - Thermal energy storage
- Determine whether microgrids can reduce the feeder's (utility power line's) peak load.
- Determine whether a microgrid can provide economic value to customers, the utility, or both.
- Demonstrate that a microgrid can operate safely in island mode in a real-world situation.
- Define the technical and operational implications of exporting power from a microgrid to the utility power distribution system.
- Explore whether a microgrid can work with

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small energy (distributed generation) sources in other applications.

Design and Features

A microgrid is designed, constructed, and demonstrated based on combined heat and power technology (engine-driven generators and an absorption chiller). The microgrid is integrated with the campus utility plant's central heating and cooling equipment, including a chilled-water storage tank. A fast-response static switch enables the microgrid to be isolated from the grid, without electrical disturbances to the central utility plant or field reporting facility. The switch also reconnects the microgrid to the utility distribution system once the utility outage is over. The project includes plans for commissioning the microgrid, monitoring its operation, analyzing the market for similar systems, and sharing research results.

Benefits

One advantage of a microgrid is reliability. It can operate while connected to the main utility grid and instantly disconnect if the power goes out. When isolated from the utility, the microgrid still provides electricity, heat, and cooling to its buildings. A microgrid can also offer customers higher-quality power. The system can disconnect whenever the utility grid's power quality threatens the stable operation of sensitive equipment, such as computers and other electronics.

At-a-Glance Facts

- Major components:
  - Three 100-kilowatt natural gas-fueled Tecogen Inverde 100 engine generators used in a combined with heat and power application
  - A Thomas & Betts Smart Switch that can isolate critical loads from the utility grid and transition them back onto it
  - A Trane Thermax absorption chiller, which uses heat recovered from the gas engines to provide chilled water
  - An existing 10-kilowatt solar photovoltaic system
- Monitoring and verification term: June 2013 through December 2014
- Grant Term: May 2009 through Dec. 2012

"Microgrids are an emerging Smart Grid technology that utilities, the military and customers are investigating to improve reliability for critical loads in a clean and efficient manner. This project, which is a partnership between SMUD's Energy Research and Development and Facility Services departments, is positioning SMUD to understand this emerging technology and its applicability for SMUD and our customers."

— Mark Rawson, Energy Research Technology Officer

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Smart Grid R&D

Residential Summer Solutions Study

Project Overview

This project measured the energy and peak savings of homes equipped with new pricing options, networked thermostats, and real-time energy data.

The project was completed in collaboration with Herter Energy Research Solutions, the prime contractor, and was co-funded by SMUD and the Demand Response Research Center through a California Energy Commission Public Interest Energy Research grant.

Project Features

Goals & Objectives

The main goal of this study was to support the educated design of future residential energy efficiency and demand response programs by determining how different types of real-time energy data and air-conditioning control would affect residential energy use.

The objectives were to:

- Determine the impacts on energy use and peak demand of real-time home-level energy information compared to appliance-level information.
- Determine the impacts on energy use and peak demand of a tiered residential rate compared to a time-based rate (TOU-CPP).
- Determine the impacts on energy use and peak demand of utility control of temperature compared to customer control.
- Evaluate customer satisfaction with thermostats, energy data, time-based rates, and utility or customer management of thermostats during events.
- Make recommendations on future program design with respect to customer education, automation, energy information, and electricity rates.

Design & Features

The study examined single-family residential customers' response to an advanced energy efficiency and demand response program that provided real-time energy information and advice along with automation of occasional price and load control events. The study recruited and randomly

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assigned customers to one of three groups using different levels of control:

- baseline information,
- real-time home information, or
- real-time appliance information.

Customers were given the option to sign up for an experimental time-of-use rate with critical peak events (TOU-CPP), and utility temperature control (ATC).

All participants were given internet gateways and programmable communicating thermostats. The two groups of participants with real-time information were given energy use and cost data on their thermostats and on a computer-based application. During the two-year study, 24 events were called on days with temperatures forecast to be more than 95°F. Participants were notified 24 hours in advance through multiple channels: email, text messaging, thermostat, and computer-based energy application.

Participants' hourly load data collected by SMUD from 2010 to 2012 was analyzed using a three-level mixed-effects regression model. In addition, pre- and post-study surveys were conducted and analyzed.

Benefits

This study has helped assess and shape the services and control levels that customers want from SMUD on home energy consumption and rates. It has provided a wealth of information that planners can use to design demand-response programs for both load and energy consumption, while yielding a high level of customer satisfaction. It has helped debunk the notion that customers dislike demand-response services, and illustrated that well-designed demand-response programs can leverage smart technology benefits to deliver energy data, automated response, and cost savings to customers, while reducing SMUD's need to buy expensive power to meet peak loads.

At-a-Glance Facts

A total of 313 participants were studied to show that customer-controlled thermostat automation combined with a TOU-CPP rate could provide 60 percent peak reduction on event days, 30 percent peak reduction on normal weekdays, and 10 percent overall energy savings, while real-time energy data of any type effected less than five percent savings in any form.

Technology Summary

- Submeters on home and appliance circuits
- Computer display of real-time energy use and costs
- Networked thermostat for automated DR and energy display

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Multifamily Summer Solutions Study

Project Overview

The Multifamily Summer Solutions Study measured the energy and peak savings of multifamily homes equipped with a new pricing option, networked thermostats, and real-time energy data. The project was completed in collaboration with Benningfield Group, Inc., the prime contractor, and was co-funded by SMUD and the California Energy Commission through a Public Interest Energy Research grant.

Project Features

The project involved the evaluation, purchase and installation of specially made rugged laptops. Appropriate software, including the upgraded mobile outage management system, was installed on the laptops. Laptops were installed and the conversion to the upgraded system was tightly coordinated with the Outage Management System (OMS) upgrade project.

Goals and Objectives

The objectives were to:

- Quantify the energy savings potential of in-home monitoring and display systems and heating, ventilation, and air conditioning automation in multifamily buildings.
- Determine which types of energy monitoring and control devices work best for multifamily buildings and why.
- Evaluate how technology, information, and time-based rates and/or customer management of thermostats affect residential customer comfort and satisfaction.
- Recommend future program design equipment, pricing, energy and load control, degrees and methods of automation, customer education, potential customers, and value.
- Obtain knowledge about integrating new technologies with SMUD's demand response management system capabilities, which can temporarily reduce energy consumption when demand is high.
- Determine whether smart controls and displays should be considered for new construction and whether requirements in the California multifamily building energy efficiency standards should be altered.

Design and Features

The study examined the response of customers in multifamily residences to advanced energy efficiency

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and demand response technologies that give them real-time energy information and advice along with automation of occasional price and load control events. The study was a single-stage cluster design, sampling from the largest 400 multifamily complexes in SMUD's service area—about 65,000 residents. Once property owners/ managers agreed to allow the installation of thermostats, all residents were solicited to take part. All participants were provided a time-of-use-critical peak pricing (TOU-CPP) rate and randomly assigned to one of three experimental information and automation groups:

- A group with no information or automation technology.
- A group with in-home displays showing real-time energy use and cost information but no automation.
- A group with in-home displays plus programmable communicating thermostats that could be set to respond automatically to the TOU-CPP rate and peak events.

Twelve events were called on days with maximum temperatures forecast to be higher than 95 degrees. Participants were notified of the events 24 hours in advance through email, text messaging, thermostats, and real-time energy displays.

Participants' hourly load data for 2013 was analyzed using a fixed-effects regression model. In addition, pre- and post-study surveys were conducted and analyzed.

Benefits

This study helped define what customers in the multifamily sector want from SMUD about home energy information, rates, and energy control. It provided customers with leading-edge technologies giving them electricity use information in real time and enabling them to control their energy use and manage their home comfort. It gives SMUD program planners information they can use to design demand response programs that reduce energy and provide a high level of customer satisfaction.

How residential customers use home energy information and management systems demonstrates the value to them of the smart grid technology and smart meters to provide energy information and bill savings to customers while reducing SMUD's need to buy expensive power to meet peak loads.

Lastly, this study gives the California Energy Commission information it can use to develop Title 24 building energy-efficiency standards for construction in the multifamily sector.

At-a-Glance Facts

A total of 315 participants will be randomly assigned to three groups:

- 105 TOU-CPP rate, only
- 105 TOU-CPP rate, with an in-home display
- 105 TOU-CPP rate, with an in-home display and a programmable communicating thermostat

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Benchmark Solar Forecasting

Project Overview

In the first project of its kind nationwide, SMUD's solar energy monitoring network will be used to assess the accuracy of solar forecasting. The results will improve forecasting products and help utilities plan for energy generation and make better decisions on power scheduling and trading. The pilot will monitor accuracy of solar forecasting over different times of day and seasons. A lab will collect and assess information from five solar forecasting companies.

Project Features

Goals and Objectives

- Determine how well solar forecasting currently predicts solar irradiance and photovoltaic output.
- Evaluate four to six commercial solar forecasting models over different time periods and from individual sites, as well as across SMUD's service area.
- Develop metrics to evaluate forecasting performance.
- Identify ways to improve solar forecasting.

Design & Features

This will be the first solar forecast performance evaluation in the nation using multiple regional forecasts. The project will use SMUD's 74 solar stations and eight feed-in sites. At least four solar forecasts predicting irradiance and power generation, from five days in advance to one hour in advance, will be collected and merged into a database that is updated hourly. SMUD will work with Sandia National Labs to assess accuracy. The data will be used to find shortcomings in forecasts and relay those flaws to federal weather research agencies and the forecasters, so they can improve forecast products. The data will also be supplied to SMUD's Energy Trading division to help in scheduling decisions.

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At-a-Glance Facts

Project start: August 2012

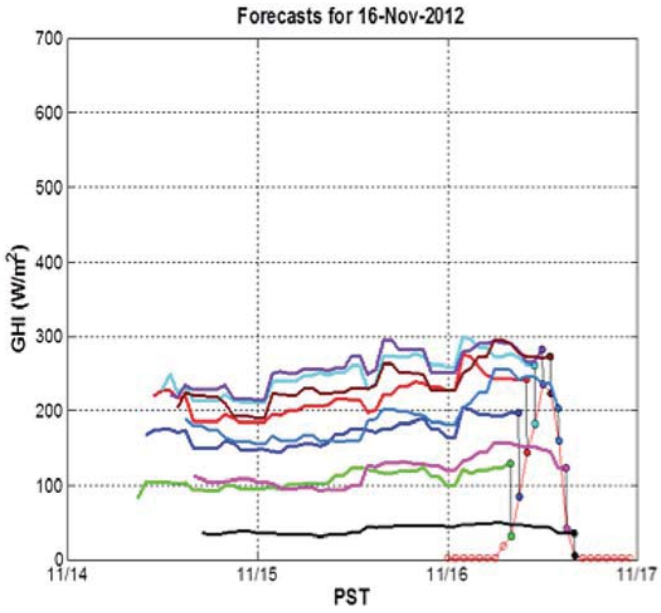
Project End: December 2013

Overall Budget: $300,000

Number of Forecasters: 4

"Accurate solar forecasting will be critical to valuing PV as a generation resource, and understanding its performance will help us plan for complementary resources."

— Obadiah Bartholomy, Project Manager



Forecast Changes Over Time

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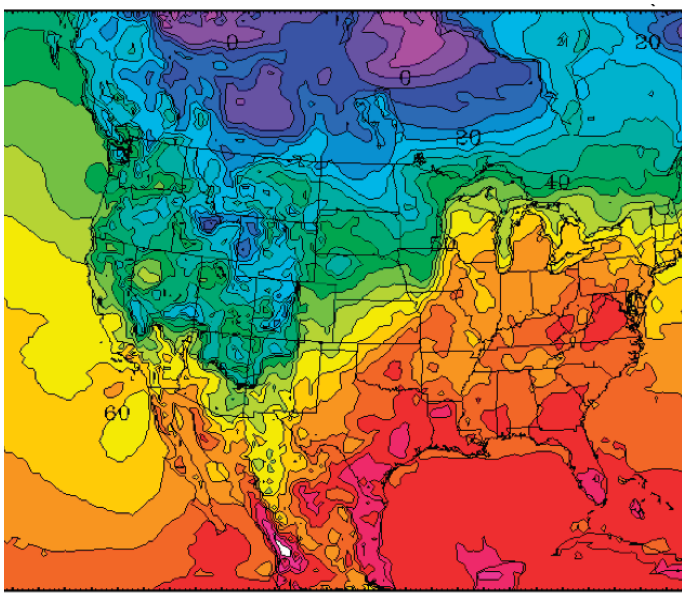
Integrating PV into Utility Planning and Operations Tool

Project Overview

This project will look at the impacts of smaller, distributed photovoltaic (PV) energy systems on specific feeders and the overall power grid. It also will assess the accuracy of forecasts of rooftop PV outputs. The information will be used to create battery storage plans for individual feeders and to help with power scheduling across SMUD's service area. The pilot also will simulate future PV output based on different scenarios of new PV systems being installed.

With this project we're looking at the impacts of distributed PV on specific feeders and in aggregate. Working with a private company, Clean Power Research of Napa, CA (http://www.cleanpower.com/), we'll validate the ability to forecast distributed rooftop PV output accurately down to one minute time periods on a specific feeder (to inform development of more accurate battery storage dispatch algorithms) and service-area-wide output for resource scheduling, both using satellite-based imagery and cloud-motion vectors.

The work also will simulate output variability for different growth scenarios for PV using historic solar resource data to understand voltage impacts on feeders and on aggregate load at very fine time and spatial resolutions.



Project Features

Goals & Objectives

- Evaluate the performance and value of short-term, satellite-based solar forecasts for battery dispatch at a residential transformer.
- Model and determine impacts on voltage, reverse power flows, load-tap changer operations for a high penetration feeder using SynerGee fed by satellite derived local variability model.
- Simulate future PV output in different growth scenarios.
- Use ground instruments to validate accuracy of satellite solar data.

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- Simulate output from existing set of distributed PV systems and several configurations of build-outs using satellite irradiance data. Validate simulation with actual meter data.
- Validate satellite irradiance data accuracy with network of ground instruments.

Design & Features

Work with Clean Power Research to evaluate short-term forecasting from one to 30 minutes ahead. The information will be provided to SMUD to develop a smarter dispatch schedule for a community energy storage device. This storage utilization will be compared to the operation of a community storage device controlled by sensing real-time changes in PV.

- Incorporation of simulated short-term variability of distributed PV systems into SynerGee distribution system planning tool feeder simulations. This will be used to evaluate impacts as a result of increasing PV penetrations on a feeder.
- Use historic solar resource data and smart meter data to peg output of SMUD's existing distributed PV, and then develop future scenarios of PV output with different configurations of PV buildouts.
- Validation of satellite-based irradiance measurement tool 'SolarAnywhere'™ using the 66-sensor, ground-based irradiance monitoring network.

Benefits

- Gain better understanding of accuracy and value of short-term forecasting for battery dispatch.
- Enhance understanding of impacts of high penetrations of PV.
- Provide improved estimates of regional variability of the solar resource for different possible future deployments of PV, such as heavily residential and commercial deployments vs. deployments that are more concentrated in larger, utility-scale installations.

At-a-Glance Facts

Project start: November 2011
Validate Solar Anywhere data: March 2013
Test short-term forecast for battery dispatch: April 2013
Evaluate variability impacts of SynerGee: September 2013
Deliver fleet-wide simulation of PV output for two to three scenarios: September 2013
Project End: December 2013
Overall Budget: $1,999,351
(SMUD cost share $114,000)

"Satellite-based approaches for measuring the solar resource hitting the ground have advanced significantly, and provide opportunities for forecasting and variability assessment that could transform our understanding of the resource value of distributed solar."

— Obadiah Bartholomy, Project Manager

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Smart Grid R&D

Solar Resource Monitoring and Forecast Validation

Project Overview

This project will look at the predictability and consistency of solar monitoring and forecasting over different timeframes and areas. SMUD deployed 71 solar monitoring sensors across the service area. The network will collect solar data, such as Global Horizontal Irradiance (GHI) and Direct Normal Irradiance (DNI), to paint a picture of the solar resources and variability in the Sacramento region. The information will also be used to evaluate and improve solar forecasting being done by Sandia National Labs and to craft recommendations for weather researchers

Irradiance Monitor with Data Logger

Project Features

Goals & Objectives

- Evaluate the solar resource variability in short time increments across the Sacramento region.
- Evaluate the performance of solar forecasts based on the National Digital Forecast Database (NDFD) forecasts of cloud cover.
- Evaluate the performance of a forecast based on ground sensors.
- Use data to create a framework for comparing results with satellite and other commercial solar forecasting systems.

Design & Features

- Install 66 global horizontal irradiance measurement devices and five "rotating shadowband radiometer" devices capable of measuring direct normal solar irradiance.
- Develop a solar forecast based on the NDFD sky cover forecast value.
- Develop a solar forecast based on ground irradiance measurements.
- Evaluate forecast performance using ground measurements.
- Evaluate solar resource variability.

Benefits

- Improve understanding of solar resource characteristics in Sacramento.
- Model increased penetrations of solar and

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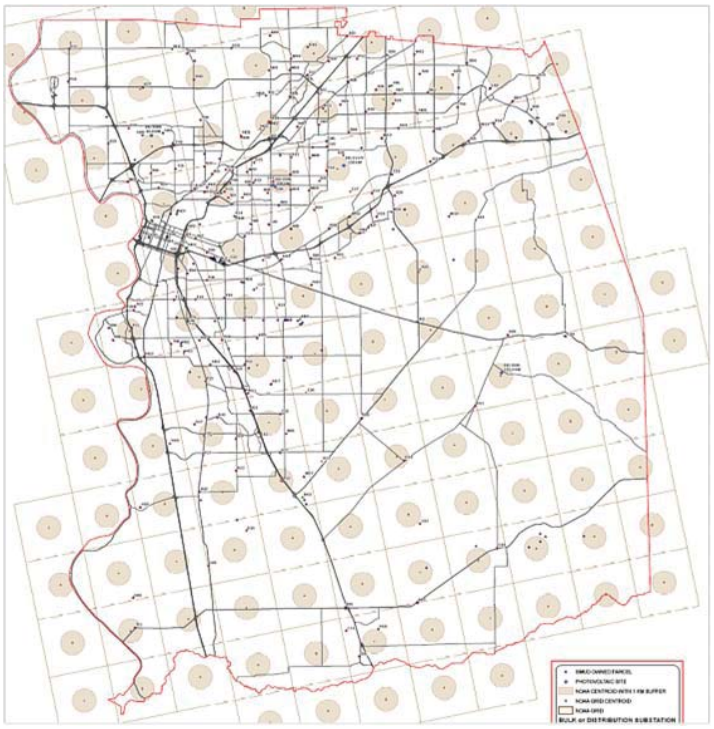
evaluate impacts on transmission system under different scenarios, allowing SMUD to better understand the costs and impacts of incorporating more solar into the power mix.

- Evaluate multiple solar forecasts to better understand forecast accuracy and resolution.

At-a-Glance Facts

Project start: October 2010
Deploy Solar Monitoring Network: June 2011
Begin Forecast Delivery: November 2011
Evaluate Forecast Performance: March 2013
Project End: June 2013
Overall Budget: $700,000



"Understanding our solar resource will build our level of confidence in the amount of solar we can construct on our system and the types of balancing resources necessary to manage it."

— Obadiah Bartholomy, Project Manager

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Smart Grid R&D

PEV Charging Grid Impact Study

Project Overview

Hybrid and electric vehicles have begun to enter the market in significant numbers. Drivers are buying these cars out of environmental concern, a desire to reduce dependence on petroleum fuels, and a preferred driving experience. The common element among most of these cars is a rechargeable battery.

While hybrid vehicles recharge the battery with the engine, plug-in hybrids and pure battery electric vehicles must take external power to charge their battery systems. Together these latter two types of cars are referred to as "plug-in electric vehicles" or PEVs. Studies have shown that most PEVs are recharged at the owner's home, usually in the hours immediately after arriving home from work. The total energy required to recharge a given PEV battery will vary, depending on the state of charge and total capacity. In the same way as a fuel tank can only hold so much gasoline (depending on the size of the tank); a battery can only store so much electric energy.

Charging PEVs will put a significant new load on the distribution grid with the possibility of adverse consequences that affect system reliability. Issues of interest include the possibility of overloading distribution transformers, localized voltage sags and "flicker," power quality degradation and overall reduction of system reliability and stability.

The PEV Charging Grid Impact Study will conduct field measurements of both residential energy usage and vehicle driving profiles. Of interest will be the effects of residential charging on the distribution grid.

Project Features

Design

The purpose of this project is to take a look at how PEV charging and PEV driving patterns interact and what, if any, effect(s) charging has on the local distribution grid. We will observe both power usage and PEV driving patterns in order to assess potential impacts.

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Power usage will be monitored using industry-standard power quality data recorders. These are simple to install and unobtrusive to the customer. The monitor will record data to allow observation of multiple parameters that will give a good picture of any adverse power conditions arising from PEV charging.

A separate data recording system will be installed in customer vehicles to give insight into the way vehicle use patterns might affect charging behavior, and hence, the grid. These monitors use data ports already in the car and install in moments. They will not change the way the car handles or performs. The vehicle data recorders will be used concurrently with the power quality data recorders to provide a synchronized view of vehicle and charging energy interaction.

Goals & Objectives

The PEV Charging Grid Impact Study goals and objectives are to measure and analyze the effects of residential charging on SMUD's distribution grid.

Benefits

- Field measurement of energy and power quality in a residential/PEV integrated application
- Improved understanding of significant new loads on the distribution system.
- Ability to anticipate the need for remedial or corrective action in advance of emergent circumstances
- Engagement of customers as stakeholders

At-a-Glance Facts

Field test population: Residential customers with a variety of PEVs

Number of project participants: 20 (initially) with the possibility of expanding

Project Deliverables

- Data collected from 20+ SMUD PEV customers who charge their vehicles at home
- Correlation of driving and charging cycles for real-world drivers to better understand their interplay, operational consequences, and cost/economics
- Analysis of power quality impact from home PEV charging
- Reports and recommendations for dealing with possibof le adverse affects of home charging

"Because of the possibility of adverse effects on the grid arising from a growing number of electric vehicles charging, SMUD is taking proactive measures to understand these effects and to take whatever steps are necessary to ensure reliable, trouble-free service to our customers."

— David Hatfield, Project Manager

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