

DR9.08: Irvine Smart Grid Demonstration, a Regional Smart Grid Demonstration Project

TESTING OF SMART GRID CAPABILITIES – CITY OF IRVINE

With a vision of safely providing a more reliable and affordable electric system, Southern California Edison Company (SCE) was awarded up to \$39.6 million in matching funds from the U.S. Department of Energy (DOE) to conduct the Irvine Smart Grid Demonstration (ISGD). This demonstration tested the interoperability and effectiveness of key elements of a modernized electric grid—from the transmission level through the distribution system and into the customer premises. This end-to-end demonstration of smart grid technologies is helping SCE address several profound changes impacting the electric grid’s operation, including increased use of renewable resources, more intermittent generation connecting to the distribution system, the ability of customers to actively manage the way they use electricity, and policies and mandates focused on improving the environment and promoting energy security.

ISGD operated primarily in the City of Irvine (Irvine) in Orange County, California, and many of the project components are located on or near the University of California, Irvine (UCI) campus. Key project participants included UCI, General Electric (GE), SunPower Corporation, LG Chem, Space-Time Insight (STI), and the Electric Power Research Institute (EPRI).

ISGD’s evaluation approach included four distinct types of testing: simulations, laboratory tests, commissioning tests, and field experiments. ISGD used simulations and laboratory testing to validate a technology’s performance capabilities prior to field installation. Commissioning tests ensured the field installation was effective and that the respective component was working as intended. The purpose of the field experiments was to evaluate the physical impacts of the various technologies on the electric grid and to evaluate the associated benefits.

The project included four domains. Each domain included one or more sub-projects with distinct objectives, technical approaches, and research plans. There were eight sub-projects within these four domains:

Domain	Sub-project
Smart Energy Customer Solutions	1. Zero Net Energy Homes 2. Solar Car Shade
Next Generation Distribution System	3. Distribution Circuit Constraint Management Using Energy Storage 4. Distribution Volt/VAR Control 5. Self-healing Distribution Circuits 6. Deep Grid Situational Awareness
Interoperability & Cybersecurity	7a. Secure Energy Net 7b. Substation Automation 3
Workforce of the Future	8. Workforce of the Future

INTRODUCTION

What Is This Technology?

SMART GRID

In short, what makes an electric grid “smart” is digital technology that allows for two-way communication between the utility and its customers, as well as detection along the transmission lines. Like the Internet, a Smart Grid consists of controls, computers, automation, and new technologies and equipment working together. But in this case, these technologies will work with the electrical grid to respond digitally to quickly changing electric demand.

Smart grid technology represents an unprecedented opportunity to move the energy industry into a new era of reliability, availability, and efficiency that will contribute to economic and environmental health. During the transition period, it will be critical to carry out testing, technology improvements, consumer education, development of standards and regulations, and information sharing between projects to ensure that the benefits become a reality.

What We Did?

SMART GRID DEMO AT CITY OF IRVINE AND UNIVERSITY OF CALIFORNIA

ISGD operated primarily in Irvine, in Orange County California, approximately 35 miles south of the City of Los Angeles. With a population of nearly 250,000 people, Irvine is widely recognized as one of the safest master-planned, business-friendly communities in the country. It is home to UCI and a number of corporations, including many in the technology sector.

ISGD was carried out on two 12 kV distribution circuits (Arnold and Rommel circuits) that are fed by MacArthur Substation located in the City of Newport Beach, California. MacArthur Substation is supplied by Santiago Substation located 10 miles east in Irvine. In addition to the two circuits fed by MacArthur Substation, portions of the ISGD project were conducted within 38 homes on the UCI campus (faculty housing), and at a UCI parking facility.

HIGH LEVEL PROJECT MAP





SMART ENERGY CUSTOMER SOLUTIONS

The project successfully demonstrated how customer technologies with demand response capabilities could help—both individually and in concert with each other—to manage customer load and reduce circuit peaks. Residential and neighborhood energy storage were helpful in shifting loads, leveling demand, and providing backup power. Energy storage was also helpful in achieving ZNE under one of the ZNE methods evaluated. When operating energy storage to optimize for ZNE, five of the nine homes achieved ZNE. Solar PV and light emitting diode (LED) lighting upgrades had the greatest impact in achieving ZNE.



NEXT-GENERATION DISTRIBUTION SYSTEM

The project successfully demonstrated that centralized control of substation and distribution capacitors under DVVC could substantially reduce overall system voltage and customer energy use without requiring any change in customer behavior. Depending on the type of distribution circuit, DVVC can provide energy savings of 1% to 4%. Energy storage sited on a distribution circuit was also effective in helping to reduce distribution circuit constraints.



INTEROPERABILITY & CYBERSECURITY

The project team successfully demonstrated that it could fully configure an SA-3 human machine interface (HMI) within minutes instead of weeks. It also demonstrated the viability of the SA-3 substation gateway as a means for configuring substations, performing password management, and retrieving relay fault files.



WORKFORCE OF THE FUTURE

The project team successfully developed and delivered the necessary training to SCE personnel who worked with the various ISGD technologies. This effort highlighted the broader implications of a larger scale deployment of similar technologies. Some job classifications will likely need new types of skills, while new jobs classifications will also probably emerge. For example, a Data Scientist could help manage and gain insights from the large volume of data generated by the various smart grid components.

Table 1: Irvine Smart Grid Demonstration Key Milestones

Key Milestones	Milestone Dates
Submit National Environmental Policy Act application and receive Categorical Exclusion from DOE	07/19/2010
Submit Interoperability & Cybersecurity Plan to DOE	10/24/2011
Submit Project Management Plan to DOE	07/31/2012
Complete engineering design and specifications	12/31/2012
Begin 24 months of measurement and verification activities	07/01/2013
Submit updated Metrics & Benefits Reporting Plan to DOE	12/12/2013
Submit first Technology Performance Report	06/03/2014
Submit second Technology Performance Report	01/31/2015
Completed field testing	06/30/2015
Complete data analysis and submit Final Technical Report	12/29/2015

CONCLUSIONS

What We Concluded?

SIGNIFICANT BENEFITS

Economic Benefits

- Deferred generation capacity investments
- Deferred transmission capacity investments
- Deferred distribution capacity investments
- Reduced equipment failures
- Reduced distribution equipment maintenance costs
- Reduced electricity losses
- Reduced electricity costs

Reliability Benefits

- Reduced sustained outages
- Reduced restoration costs
- Reduced momentary outages
- Reduced sags and swells

Environmental Benefits

- Reduced carbon dioxide emissions
- Reduced SOX, NOX and PM-2.5 emissions

Security Benefits

- Reduced oil usage
- Improved cybersecurity

These Findings are based on the report “Irvine Smart Grid Demonstration, a Regional Smart Grid Demonstration Project” which is available from the ETCC program website, <https://www.etcc-ca.com/reports>.

Next Steps and Recommendations

There are a few areas for managing smart grid technology and operations that should be explored regarding implementation of smart grid on a large scale:

SMART ENERGY CUSTOMER SOLUTIONS

Collaboration among industry stakeholders is necessary to improve communications interoperability for key customer loads, such as electric vehicles and air conditioning. A key objective for future demonstrations would be to evaluate methods to monitor and control the growing number of distributed energy resources (DERs) to resolve grid challenges.

NEXT-GENERATION DISTRIBUTION SYSTEM

SCE is beginning a system-wide implementation of DVVC due to the successes achieved by ISGD. Future versions of DVVC may also include control of smart inverters, which could support the participation of a larger number of utility- and customer-owned DERs in providing voltage and VAR support. Additional capabilities worthy of further investigation include control systems that use DERs for volt/VAR control, power flow optimization, and micro-grid support. SCE is continuing to evaluate FAN technologies that could support future distribution automation needs. SCE is also continuing to work with energy storage vendors to improve the reliability and functionality of energy storage devices.

INTEROPERABILITY & CYBERSECURITY

SCE is beginning a system-wide implementation of its SA-3 platform as a result of the success achieved by ISGD. Project team members are also collaborating with vendors and standards development organizations for standards updates that will help address some of the interoperability challenges the team faced on ISGD. SCE is also expanding the substation gateway functionality to satisfy NERC CIP v.5 requirements.

WORKFORCE OF THE FUTURE

As the industry continues to evolve at a rapid pace, it will be important for utilities to instruct a culture of continuous learning by offering cross-training opportunities and other types of on-demand learning. This will help utilities to attract and retain employees who thrive in the industry's rapidly evolving environment.