**BEFORE THE PUBLIC UTILITIES COMMISSION OF THE**

**STATE OF CALIFORNIA**

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| Application of Southern California Edison Company (U 338-E) for Approval of Its Triennial Investment Plan for the Electric Program Investment Charge Program | A. 12-11-___ A1211004 |

**APPLICATION OF SOUTHERN CALIFORNIA EDISON COMPANY (U 338-E) FOR APPROVAL OF ITS TRIENNIAL INVESTMENT PLAN FOR THE ELECTRIC PROGRAM INVESTMENT CHARGE PROGRAM**

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Dated: **November 1, 2012**

**BEFORE THE PUBLIC UTILITIES COMMISSION OF THE**

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# APPLICATION OF SOUTHERN CALIFORNIA EDISON COMPANY (U 338-E) FOR APPROVAL OF ITS TRIENNIAL INVESTMENT PLAN FOR THE ELECTRIC PROGRAM INVESTMENT CHARGE PROGRAM

## I. INTRODUCTION

Southern California Edison Company (SCE) respectfully submits this application requesting approval of its triennial Investment Plan for the Electric Program Investment Charge (EPIC) program, which is attached as Exhibit 1. In Decision (D.) 12-05-037, the California Public Utilities Commission (Commission) mandated that the EPIC program administrators file applications for their triennial investment plans by November 1, 2012.[1] The EPIC program administrators are SCE, Pacific Gas and Electric Company, San Diego Gas & Electric Company, and the California Energy Commission (CEC).[2] SCE files this application in compliance with D.12-05-037 and without waiving any rights or arguments regarding the legality of the EPIC program, as discussed below.

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[1] D.12-05-037, Ordering Paragraph (OP) 11.
[2] *See id.*

## II. BACKGROUND

Shortly before the January 1, 2012 statutory expiration of the Public Goods Charge (PGC), the Commission initiated a rulemaking to determine the impact of the PGC's expiration.[3] On December 15, 2011, the Commission adopted the Phase 1 Decision in that rulemaking, D.11-12-035, requiring that the funding levels associated with the renewables and the research, development, and demonstration portions of the PGC remain in effect through a new Commission-mandated customer surcharge: the EPIC.[4] On January 19, 2012, SCE timely filed an Application for Rehearing of the Phase 1 Decision.[5]

On May 24, 2012, the Commission issued the Phase 2 Decision, D.12-05-037, which reaffirms the Commission's imposition of the EPIC and requires the large investor-owned utilities (IOUs) to continue collecting the EPIC from their customers until 2020 at an increased rate of $162 million per year (a total of more than $1.4 billion over the nine-year program).[6] SCE also filed a timely Application for Rehearing of the Phase 2 Decision, which remains pending.[7]

The stated purpose of EPIC is to fund applied research and development, technology demonstration and deployment, and market facilitation programs.[8] Approximately 80% of the total EPIC funding will be administered by the CEC and about 20% will be administered by the IOUs. Additionally, about 0.5% of the EPIC budget funds CPUC oversight of the program.[9]

The Phase 2 Decision requires program administrators to file coordinated triennial investment plans by November 1, 2012.[10] The first plan covers the period of 2012 through

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[3] *See* Order Instituting Rulemaking 11-10-003.
[4] *Id.*, OP 2-3.
[5] The Commission has not yet ruled on this Application for Rehearing.
[6] *See id.*, OP 1, 7.
[7] Neither SCE's submission of this application, nor its actions taken in compliance with D.12-05-037 (including collaboration with the other EPIC administrators), shall be construed as a waiver of any of SCE's arguments regarding the legality of the EPIC program.
[8] *Id.*, OP 1.
[9] *Id.*, OP 5.
[10] *Id.*, OP 11.

2014.[11] The Commission required the administrators to, among other things, map "the planned investments to the electricity system value chain, which includes (i) Grid operations/market design; (ii) Generation; (iii) Transmission; (iv) Distribution; and (v) Demand-side management."[12]

At least twice per year, during the development of the administrators' respective investment plans and during the execution of those plans, the administrators are required to consult with stakeholders. Stakeholders include representatives of the legislature, government agencies, utilities, the California Independent System Operator, consumer groups, environmental organizations, agricultural organizations, academics, the business community, the energy efficiency community, the clean energy industry, and other industry associations.[13]

## III. SUMMARY OF SCE'S INVESTMENT PLAN

SCE's Investment Plan for the 2012-14 program cycle represents a collaborative effort between SCE and the other program administrators, incorporates the input of stakeholders, and addresses the requirements specified in D.12-05-037. The Investment Plan proposes to use SCE's share of EPIC funds to enhance its Advanced Technology organization's existing smart grid efforts, an area that will most benefit customers and in which SCE has expertise and proven success.

SCE's Investment Plan consists of eight sections:

1. Background and Executive Summary
2. SCE's Technology Vision and Strategy
3. IOU-Administered Program Funding Allocation
4. Stakeholder Input
5. Discussion of Gaps

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[11] *Id.*
[12] *Id.*, OP 12.a.
[13] *Id.*, OP 15.

6. SCE's EPIC Investment Plan

7. Program Administration

8. State Policy Direction

The Background and Executive Summary provide an overview of the EPIC program and the Investment Plan. The section on SCE's Technology Vision and Strategy describes SCE's Smart Grid Roadmap and Smart Grid Deployment Plan.[14] The third section explains the allocation of EPIC funds by funding element and by administrator.

The Stakeholder Input section describes SCE's extensive collaboration with stakeholders. SCE hosted and participated in public workshops and solicited comments on its Investment Plan. This section also summarizes the comments submitted by interested parties.

In response to stakeholder input, the Energy Division requested that the IOUs conduct a "gaps" analysis to ensure that their proposed projects address beneficial areas and avoid duplication. The IOUs engaged the Electric Power Research Institute (EPRI) to conduct this analysis. EPRI concluded that there are gaps in current demonstration and deployment projects and that the IOUs' proposed projects could fill those gaps.

The EPIC administrators jointly developed an investment plan framework. The framework sets four categories: (1) Renewable and Distributed Energy Resources Integration, (2) Grid Modernization and Optimization, (3) Customer-Focused Products and Services Enablement and Integration, and (4) Cross Cutting/Foundational Strategies and Technologies. SCE's Investment Plan proposes projects for each of these areas, focusing on the ultimate goals of promoting greater reliability, lowering costs, increasing safety, decreasing greenhouse gas emissions, and supporting low-emission vehicles and economic development.

The Program Administration section explains SCE's approach to program coordination, contracting, intellectual property, project reporting, metrics, and remission of funds to the CEC.

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[14] On October 1, 2012, in R.08-12-009, SCE filed an annual report on its Deployment Plan. *See also* Application (A.) 11-07-001.

In compliance with D.12-05-037, this section also summarizes SCE's research, development, and demonstration activities for its approved energy efficiency and demand response portfolios. The final section details how the Investment Plan complies with the policies of Public Utilities Code sections 740.1 and 8360.[15]

## IV. PROCEDURAL REQUIREMENTS

### A. Statutory Authority (Rule 2.1)

This application is made pursuant to D.12-05-037, the Public Utilities Code, the Commission's Rules of Practice and Procedure, and prior decisions, orders, and resolutions of the Commission.

### B. Legal Name and Principal Place of Business (Rule 2.1(a))

SCE's full legal name is Southern California Edison Company. SCE is a public utility organized and existing under the laws of the State of California. The location of SCE's principal place of business is 2244 Walnut Grove Avenue, Rosemead, California, 91770. SCE is a wholly-owned subsidiary of Edison International, a public utility holding company incorporated in the State of Delaware.

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[15] As noted above, SCE's Investment Plan shall not be construed as a waiver of any of SCE's arguments regarding the legality of the EPIC program.

### C. Correspondence (Rule 2.1(b))

Correspondence or communication regarding this application should be addressed to:


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|---|---|
| Kris Vyas, Esq.<br>Southern California Edison Company<br>P.O. Box 800<br>2244 Walnut Grove Ave.<br>Rosemead, CA 91770<br>Telephone: (626) 302-6613<br>Facsimile: (626) 302-6693<br>Email: kris.vyas@sce.com | Case Administration<br>Southern California Edison Company<br>P.O. Box 800<br>2244 Walnut Grove Ave.<br>Rosemead, CA 91770<br>Telephone: (626) 302-4875<br>Facsimile: (626) 302-3119<br>Email: case.admin@sce.com |


### D. Proposed Categorization (Rule 2.1(c))

SCE proposes to characterize this proceeding as quasi-legislative, as defined in Rule 1.3(d).

### E. Need for Hearing, Issues to Be Considered, and Proposed Schedule (Rule 2.1(c))

The need for hearings and the issues to be considered depend upon the degree to which other parties might contest SCE's application. Assuming other parties contest SCE's application, SCE recommends that the Commission hold workshops to seek public comment on SCE's and the other administrators' investment plans. The workshops held during the investment plan development process facilitated stakeholder input and efficiently addressed the four EPIC administrators' investment plans. The same benefits would result from workshops held during the application process. In addition, the Commission has recognized the utility of workshops for the EPIC program by requiring the administrators to continue consulting with stakeholders at least twice per year.[16]

SCE proposes the following schedule:

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| Application Filed | November 1, 2012 |
| Protests and Responses | December 3, 2012 |
| Reply to Protests and Responses | December 13, 2012 |

[16] *See* D.12-05-037, OP 15.

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|---|---|
| Workshops | January – February, 2013 |
| Opening Briefs | March 11, 2013 |
| Reply Briefs | April 1, 2013 |
| ALJ Proposed Decision | May 1, 2013 |
| Comments on Proposed Decision | May 21, 2013 |
| Reply Comments | May 28, 2013 |
| Commission Decision | June 27, 2013 |

## F. Organization and Qualification to Transact Business (Rule 2.2)

A copy of SCE's Certificate of Restated Articles of Incorporation, effective on March 2, 2006, and presently in effect, certified by the California Secretary of State, was filed with the Commission on March 14, 2006, in connection with A.06-03-020, and is incorporated herein by reference.

A copy of SCE's Certificate of Determination of Preferences of the Series D Preference Stock filed with the California Secretary of State on March 7, 2011, and as presently in effect, certified by the California Secretary of State, was filed with the Commission on April 1, 2011, in connection with A.11-04-001, and is incorporated herein by reference.

A copy of SCE's Certificate of Determination of Preferences of the Series E Preference Stock filed with the California Secretary of State on January 12, 2012, and a copy of SCE's Certificate of Increase of Authorized Shares of the Series E Preference Stock filed with the California Secretary of State on January 31, 2012, and as presently in effect, certified by the California Secretary of State, was filed with the Commission on March 5, 2012, in connection with A.12-03-004, and is incorporated herein by reference.

A copy of SCE's Certificate of Determination of Preferences of the Series F Preference Stock filed with the California Secretary of State on May 5, 2012, and as presently in effect, certified by the California Secretary of State, was filed with the Commission on June 29, 2012, in connection with A.12-06-017, and is incorporated herein by reference.

## G. Service List

As directed by D.12-05-037, Ordering Paragraph 11, SCE is serving this application on the service lists for the rulemaking which established EPIC (R.11-10-003) and SCE's pending general rate case (A.10-11-015).

Respectfully submitted,

KRIS G. VYAS

/s/ Kris G. Vyas

By: Kris G. Vyas

Attorney for
SOUTHERN CALIFORNIA EDISON COMPANY

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November 1, 2012

<u>**VERIFICATION**</u>

I am a Vice President of Southern California Edison Company and am authorized to make this verification on its behalf. I am informed and believe that the matters stated in the foregoing pleading are true.

I declare under penalty of perjury that the foregoing is true and correct.

Executed this **1st day of November, 2012**, at Rosemead, California.

/s/ Kevin Payne

By: Kevin Payne
Vice President of Engineering and Technical Services

SOUTHERN CALIFORNIA EDISON COMPANY
2244 Walnut Grove Avenue
Post Office Box 800
Rosemead, California 91770

**Exhibit 1**

**Investment Plan for the Electric Program Investment Charge (EPIC) Program**

# Southern California Edison

## EPIC Triennial Investment Plan

November 1, 2012

# Table of Contents

# 1. Background and Executive Summary[1]

Shortly before the January 1, 2012 statutory expiration of the Public Goods Charge (PGC), the California Public Utilities Commission (CPUC or Commission) issued an Order Instituting Rulemaking (OIR) 11-10-003 to address funding and program issues related to the renewables and research, development, and demonstration (RD&D) portions of the expiring PGC funding.[2] On December 15, 2011, the CPUC adopted D.11-12-035, requiring that the funding levels associated with the renewables and RD&D portions of the PGC remain in effect through a new CPUC-mandated customer surcharge – the Electric Program Investment Charge (EPIC).[3] Pursuant to D.11-12-035, the investor-owned utilities (IOUs) were required to impose the EPIC "on all distribution customers in the same manner as the expiring" PGC as of January 1, 2012.[4]

On May 24, 2012, the CPUC adopted D.12-05-037, which reaffirms the CPUC's imposition of the EPIC in D.11-12-035 and requires the IOUs to continue collecting the EPIC from their customers from 2013 through 2020 at an increased rate of $162 million per year, to be used for applied research and development, technology demonstration and deployment, and market facilitation programs.[5] Approximately 80% of the total EPIC funding will be administered by the California Energy Commission (CEC) and about 20% will be administered by the IOUs. Additionally, about 0.5% of the EPIC budget is to be used to fund CPUC oversight of the program.[6]

D.12-05-037 requires the program administrators to file coordinated triennial investment plans covering 2012-2014 with the CPUC on or before November 1, 2012.[7] The investment plans must, among other things, "map[] … the planned investments to the electricity system value chain, which includes: (i) Grid operations/market design; (ii) Generation, (iii) Transmission; (iv) Distribution; and (v) Demand-side management."[8]

---

[1] Southern California Edison Company (SCE) submits this investment plan as required by Decision (D.) 12-05-037, Ordering Paragraph (OP) 11. Neither SCE's submission of this investment plan, nor its actions taken in compliance with D.12-05-037 (including collaboration with the other Electricity Program Investment Charge program administrators), shall be construed as a waiver of any of SCE's arguments regarding the legality of the Electricity Program Investment Charge program.

[2] *See* OIR 11-10-003, October 6, 2011.

[3] D.11-12-035 at OP 2.

[4] *Id.* at OP 2-3.

[5] D.12-05-037 at OP 1, 7-8. The total EPIC funding is to be adjusted on January 1, 2015 and January 1, 2018 commensurate with the average change in the consumer price index for the previous three years. *Id.* at OP 7. SCE's customers are responsible for 41.1% of the total funding. *Id.*

[6] *Id.* at OP 5. IOU administration is limited to technology demonstration and deployment. *Id.*

[7] *Id.* at OP 11.

[8] *Id.* at OP 12.

At least twice per year, during the development of the administrators' respective investment plans and during the execution of those plans, the administrators are required to consult with stakeholders, which may include representatives of the legislature, government agencies, utilities, the California Independent System Operator (CAISO), consumer groups, environmental organizations, agricultural organizations, academics, the business community, the energy efficiency community, and the clean energy or other industry associations.[9]

This first investment plan for the 2012-2014 program cycle represents a collaborative effort between SCE and the other program administrators, incorporates the input of stakeholders provided at the workshops, and addresses the discussion areas outlined by D.12-05-037.

SCE's investment plan proposes to dedicate its share of EPIC funds to enhance its Advanced Technology organization's existing smart grid efforts, an area that will most benefit customers and in which SCE has expertise and proven success.[10] To address stakeholder concerns expressed during workshops about the potential for duplicative work, the IOU administrators enlisted the Electric Power Research Institute (EPRI) – a respected and long-established national non-profit research institute – to host a discussion on utility industry gaps. EPRI concluded that there are a variety of gaps that need to be and can be filled with EPIC-funded RD&D.

By way of background, EPRI was founded in 1973 following U.S. Senate hearings that revealed a lack of funding for RD&D in the energy industry. Prior to California's deregulation of the electricity markets in 1996, California's IOUs and utilities across the nation conducted their RD&D in coordination with EPRI by pooling their resources to advance technological development. California's IOUs recovered the costs associated with such RD&D through the CPUC's rate-making application process.

Today, the use of EPIC funds would be maximized by permitting the IOUs, like the CEC, to engage in applied research and development in addition to technology demonstration and deployment. In addition to conducting important internally-directed research and development efforts, the IOUs would use EPIC funds to support EPRI's applied research and development programs. Nearly every other major utility in the nation, in addition to some worldwide actors in the energy field, participate in EPRI's programs. Restricting the IOUs' participation prevents California from meaningfully engaging in national industry-wide collaboration, which is not only detrimental to the advancement of technology, but also to the interests of customers who benefit from those technologies. Moreover, restricting the IOUs' participation in industry-wide

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[9] *Id.* at OP 15.

[10] More information about SCE's smart grid efforts is available in SCE's Application for Approval of its Smart Grid Deployment Plan, Application (A.) 11-07-001 and SCE's Annual Report on the Status of Smart Grid Investments, Rulemaking (R.) 08-12-009.

collaboration increases the risk that EPIC funds will be used, as stakeholders worry, to finance redundant investments.

Until the CPUC determines otherwise, this investment plan, in accordance with D.12-05-037, is limited to technology demonstration and deployment. Specifically, the IOUs developed a joint investment plan framework that identifies four program categories: (1) renewable and distributed energy resources integration, (2) grid modernization and optimization, (3) customer-focused products and services enablement and integration, and (4) cross-cutting/foundational strategies and technologies. Initiatives in each of the four categories may result in customer benefits in the form of greater reliability, lower costs, increased safety, decreased greenhouse gas emissions, and support for low-emission vehicles and economic development.

Initiatives for renewable and distributed energy resources integration aim to facilitate the safe and reliable interconnection of variable energy resources, such as wind and solar energy. Variable energy resources pose problems such as supply/load imbalance and voltage fluctuations. Projects in this area will demonstrate technologies that minimize grid disruptions and mitigate power quality issues. Such projects include demonstrations of inverter controls, adaptive protection schemes, and advanced voltage and volt-ampere reactive (VAR) controls. Energy storage also has the potential to support the integration of variable resources. SCE is currently evaluating storage technologies through two projects funded by the Department of Energy. SCE intends to apply EPIC funds to leverage the lessons learned from those projects.

Grid modernization and optimization addresses the need to replace aging infrastructure with new assets that can enhance reliability and safety. New devices capture and transmit increasing amounts of data. Projects in this field will analyze the data with the goal of providing a more accurate assessment of infrastructure performance. Potential projects include distribution circuit fault detection, substation automation, and intelligent fuses.

The third category recognizes that customers are now “prosumers,” both producers and consumers of electricity. SCE has nearly fully deployed its SmartConnect® meters. Potential demonstration projects will analyze smart meter data to enhance voltage and VAR control and identify outages. Customer-focused projects will also analyze the impact on the grid of residential energy storage units and electric vehicles. These projects are separate and apart from existing energy efficiency and demand response efforts and focus on the aspects of grid impacts and operations.

The final category, cross-cutting strategies, addresses the fundamental shift in grid design caused by distributed generation, energy storage, and other emerging technologies. Demonstration project areas include system architecture, cybersecurity, data analytics, and telecommunications and standards development. Architecture projects will enable technology integration. Cybersecurity projects will demonstrate how to mitigate the vulnerabilities of an increasingly automated grid. Data analytics projects can aggregate and analyze the vast amount of data collected throughout the electric system. This data will give operators a more strategic view of system operations. Telecommunications and standards development projects will ensure interoperability and maximize reliability, safety, and customer value from grid modernization. Finally, SCE will continue collaborating with academic and industry experts to train the workforce necessary to manage the advanced systems of the future.

The EPIC administrators have collaborated throughout the investment plan development process. To maximize EPIC's benefit to customers and the public, the administrators have agreed to continue collaborating by sharing information regarding investment plans, programs, and projects; avoiding the duplication of projects; establishing common evaluation, measurement, and verification protocols; soliciting and responding to comments from stakeholders; and adopting a common approach to intellectual property. The administrators will also jointly develop protocols to evaluate, measure, and verify the results of EPIC projects.

SCE has developed an administrative framework for managing EPIC. As permitted by the CPUC, SCE intends to allocate funds on a pay-for-performance basis. SCE will also follow the CPUC's preference to award EPIC funding on a competitive basis, but may issue noncompetitive awards in certain limited situations. SCE's contracting criteria will establish a preference for California-based entities, but this preference will not preclude SCE from selecting the best entity for a particular project. Intellectual property developed under EPIC may be retained by SCE or by the entity developing the intellectual property, depending on the project. SCE may also share intellectual property to promote open collaboration and competition. Relatedly, SCE intends to disseminate project results through academic, industry, and standards organizations.

Lastly, SCE's investment plan furthers the policies and intent underlying Public Utilities Code sections 740.1 and 8360. Specifically, the proposed projects are designed to promote customer benefits by enhancing the smart grid. In addition, California entities will have an advantage in seeking EPIC grants. Recognizing that not all projects will succeed and that one purpose of demonstration is to test viability and cost, SCE will nevertheless always endeavor to minimize funding projects with a low probability of success. The proposed projects are consistent with SCE's resource plan, including the loading order and safety and reliability objectives. They will also improve the environment and enhance public and employee safety. The IOUs will cooperate to the maximum extent possible to avoid duplicative research; however, as noted above, the IOUs could best avoid duplication by working with entities like EPRI and other research institutions. This type of industry-wide collaboration would be facilitated by the CPUC permitting the IOUs to use EPIC funds for applied research and development. Finally, as a broad plan aimed at technological modernization, this investment plan describes projects that are designed to address all ten of the state's smart grid policies described in Public Utilities Code section 8360.

## 2. SCE Technology Vision and Strategy

State and federal policymakers alike have recognized the need for a smarter, more robust electricity infrastructure if we are to rely on greater amounts of renewable generation, use electricity as a fuel for vehicles, enable consumers to become active participants in the energy supply chain, and ensure the continued reliability and vitality of our nation's energy economy. Advancing and deploying technologies to build a smarter grid is critical for California's energy future. A more advanced transmission and distribution grid, coupled with advanced technologies and devices in the customer's home, represents the pathway for SCE to meet California's landmark energy policy. Some of those ambitious policy goals include:

- Greenhouse Gas reductions (Assembly Bill (AB) 32);
- Zero Net Energy homes (ZNE);
- California Solar Initiative (CSI);
- Advanced Metering Infrastructure (AMI);
- California's Renewables Portfolio Standard (RPS);
- Low Carbon Fuel Standard (LCFS);
- Widespread use and charging of Plug-in Electric Vehicles;
- Governor Brown's Clean Energy Jobs Plan, which promotes a target of 12,000 megawatts of localized energy resources and presents significant challenges for distribution system operations, safety and reliability.

In 2009, SCE created its Advanced Technology organization to address the complexities of the smart grid and how the elements of a smart grid can interact from a technology and policy perspective. The Advanced Technology group has strengthened SCE's leadership role in smart grid development, and tightened partnerships with regulatory bodies, governmental agencies, and industry leaders. These collaboration efforts assist in establishing sound policies and standards to support smart grid development and integration. Furthermore, such collaboration also helps prevent adverse impacts to the energy supply and the public, and assists in providing long-term benefits for our customers. Advanced Technology's primary mission, which is consistent with both state and federal objectives, is to identify, develop, demonstrate, and evaluate an evolving portfolio of new technologies to create a smarter, more robust, resilient and efficient power grid. It is essential that SCE integrate these technologies into its existing electricity infrastructure if we are to balance rapidly-changing and diverse environmental and energy policy objectives with satisfying the customer's energy needs and expectations for reasonable rate impacts. SCE will administer the EPIC funding as part of its broader Advanced

Technology effort, which will ensure consistent planning and coordination with broader corporate and industry technology efforts. This will also serve to minimize EPIC administrative expenditures.

The centralization of SCE's smart grid efforts into one organization has already realized benefits by enabling SCE to better manage its resource and technology evaluation portfolio. Centralization was necessary to efficiently meet near-term smart grid objectives. These objectives included supporting the CPUC's Smart Grid OIR, Alternative-Fueled Vehicles OIR, Energy Storage OIR, the CEC's Smart Grid Roadmap, and the National Institute of Standards and Technology's efforts in developing smart grid standards.[11] SCE was able to successfully obtain federal stimulus funding from the U.S. Department of Energy for two landmark projects: the Irvine Smart Grid Demonstration (ISGD) and the Tehachapi Wind Energy Storage Project (TSP).

## 2.1 SCE's Smart Grid Strategy and Roadmap

Soon after the creation of Advanced Technology, SCE began an effort to update its technology planning efforts and develop a Smart Grid Strategy and Roadmap.[12] SCE has never conducted its technology planning in a vacuum, and even at the earliest beginnings of Advanced Technology, SCE reached out to industry experts, including IBM, Enernex, Cisco, Quanta and EPRI to obtain industry input. SCE also established and has maintained a Technical Advisory Board (TAB) comprised of members from academia, industry, research organizations and standards bodies to avoid stagnation and provide a broad, yet informed, perspective. SCE's Smart Grid Strategy and Roadmap received review and comment from the TAB, Pacific Gas and Electric Company (PG&E), and San Diego Gas & Electric Company (SDG&E). More recently, SCE published an article on its smart grid vision in the Institute of Electrical and Electronics Engineers (IEEE) Power and Energy Magazine.[13]

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[11] SCE is a strong supporter of the National Institute of Standards and Technology (NIST) Smart Grid Interoperability Panel (SGIP) standards process. Since its onset, SCE has participated in the effort and held leadership positions within the governing board, the architecture committee and various Priority Action Plans. SCE's Director of Advanced Technology was elected as a governing board member and Advanced Technology's Director of Engineering Advancement was elected into the SGIP's Implementation & Methods Committee (IMC).

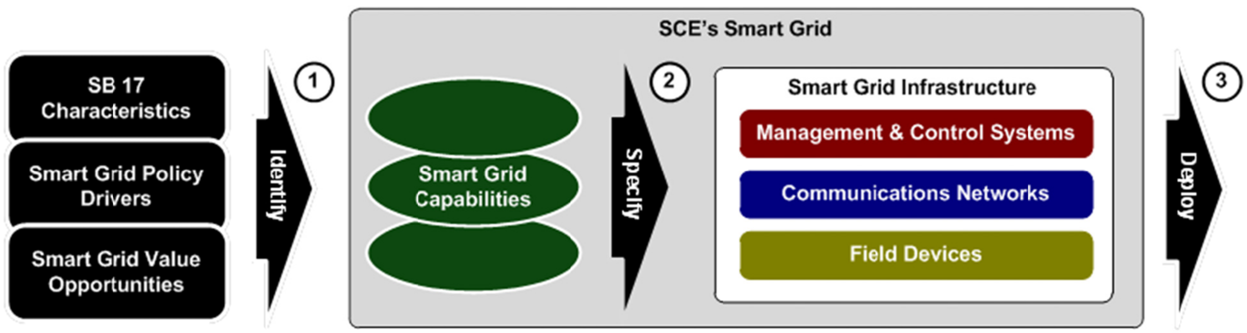
[12] SCE's Smart Grid Strategy and Roadmap is attached as Appendix A.

[13] Yinger, Robert and Kamiab, Ardalan. "Good Vibrations: Southern California Edison's Vision for Tomorrow's Smart Electric Grid." IEEE Power and Energy Magazine (Sept./Oct. 2011).

## 2.2 SCE's Smart Grid Deployment Plan

The evolution of SCE's technology and strategy is described in SCE's Smart Grid Deployment Plan.[14] In this document, SCE introduces its evolving approach to identifying key smart grid capabilities that SCE must enable to address the various smart grid policy drivers and value opportunities, determining the types of technologies and operational efforts needed to enable the capabilities, and evaluating the deployment readiness of such technologies and operational efforts.

Figure 1 - SCE Smart Grid Approach




Importantly, SCE's Smart Grid Deployment Plan provides a deployment baseline and smart grid roadmap with respect to the following areas:

- Customer Empowerment,
- Distribution and Substation Automation,
- Transmission Automation,
- Asset Management, and
- Platform Technologies

## 2.3 SCE's Administration of EPIC Demonstrations & Deployments

SCE will administer the EPIC funding as part of its broader Advanced Technology effort, which will ensure consistent planning and coordination with broader corporate and industry technology efforts. Since EPIC is designed to "be the primary vehicle for utility electric [research development & demonstration] proposals," it will eventually replace SCE's existing RD&D program and balancing account.[15] SCE notes that it has maintained a successful RD&D program since the inception of its RD&D one-way balancing account established in D.87-12-

[14] *See* footnote 10.

[15] D.12-05-037, Conclusion of Law 15.

066, the Commission's decision in SCE's Test Year 1988 General Rate Case (GRC).[16] SCE has and will continue to administer its RD&D program in a manner that is consistent with the policies embodied in Public Utilities Code section 740.1. Additionally, SCE will administer EPIC funds with the primary goal of producing customer benefits. In accordance with D.12-05-037, secondary considerations in SCE's administration may include societal benefits, GHG emissions reductions in the electricity sector at the lowest possible cost, the loading order, low-emission vehicles and transportation, economic development, and efficient use of customer monies. SCE will also administer EPIC funds to advance the smart grid objectives detailed in Public Utilities Code section 8360.

# 3. IOU-Administered Program Funding Allocation

D.12-05-037 allocates EPIC funding as shown in the following table:

| Funding Element | CEC | IOUs | CPUC | Total ($ millions) |
|---|---|---|---|---|
| Applied Research | 55 | 0 | 0 | 55 |
| Technology Demonstration and Deployment | 45 | 30 | 0 | 75 |
| Market Facilitation | 15 | 0 | 0 | 15 |
| Program Administration | 12.8 | 3.4 | 0 | 16.2 |
| Program Oversight | 0 | 0 | 0.8 | 0.8 |
| Total ($ millions) | 127.8 | 33.4 | 0.8 | 162 |

Within the IOU category, funds are allocated according to the amount that respective IOU customers pay into the EPIC fund, with a resultant allocation of 50.1% to PG&E, 41.1% to SCE, and 8.8% to SDG&E. In compliance with Ordering Paragraph 5 of D.12-05-037, SCE will utilize its allocated funding of approximately $37 million for technology demonstration and deployment projects, and will utilize its allocated program administration budget, consistent with the 10% administrative cap.

If SCE develops a need to shift funding to another funding area or create a new funding area, it will file a Tier 2 advice letter in compliance with Ordering Paragraph 14 of D.12-05-037.

[16] The Commission has approved the continuation of this important program in subsequent GRC decisions. While SCE's test year 2012 GRC application is pending a final decision, the Administrative Law Judge's proposed decision grants SCE's full request for RD&D funding. *See* Proposed Decision of ALJ Darling, A.10-11-015, at 106-07 (filed Oct. 19, 2012).

# 4. Stakeholder Input

The IOUs collaborated and held public workshops to fulfill the requirement of engaging stakeholders.[17] PG&E hosted a Northern California public workshop on August 16. SCE, on behalf of itself and SDG&E, held a Southern California public workshop on August 17. The EPIC public workshops provided a forum for stakeholders to provide input on the IOUs' investment plans. Stakeholders actively participated in the utilities' workshops and provided feedback on the IOUs' investment plans. At the Northern California workshop, participants were interested in ensuring that the utilities' EPIC projects would not be duplicative of former or existing research. In response, CPUC Energy Division staff requested the IOUs provide a gaps analysis in their investment plans to ensure that they cover the most needed demonstrations and deployments to maximize customer benefits and avoid any unnecessary duplication. In Southern California, a stakeholder raised the question of EPIC governance. Stakeholders were concerned about the structure of governance under EPIC and recommended using an approach similar to the now defunct California Utility Research Council (CURC). CURC was established in 1981 by the California Legislature, and codified as Public Utilities Code sections 9201-9203. Under CURC, the CEC, CPUC, and the IOUs met once per year to coordinate and promote consistency of RD&D programs and provide a forum for sharing information on energy RD&D in California. The purpose of CURC was to:

- Provide for consistency of RD&D programs with state energy policy;
- Avoid unnecessary duplication in customer funded RD&D efforts;
- Promote the free exchange of information and ideas regarding RD&D programs and projects; and
- Promote joint funding of RD&D projects.

SCE greatly appreciates the input stakeholders provided on the Joint PG&E, SCE and SDG&E EPIC Triennial Investment Plan Program Framework (See Figure 2, in Section 6). SCE has directly incorporated the stakeholders' recommendations into its investment plan in the following manner:

- In an effort to avoid duplicative projects and focus on areas of high importance with the potential to provide benefits to the customers funding the program, the IOU administrators participated in an EPRI-hosted workshop, the results of which are provided in the Discussion of Gaps (Section 5).
- To establish appropriate controls to maximize coordination among the IOU and CEC EPIC Administrators, and importantly, ensure Commission oversight of the respective

[17] *See* D.12-05-037, OP 15.

programs, SCE proposes a governance structure in its Program Administration section of its Investment Plan (see Section 7) that merges important aspects of CURC with the guidance provided in D.12-05-037.

Additionally, SCE also received written comments from California Institute for Energy and Environment (CIEE), Waste Management (WM) and EPRI. The parties' comments are summarized below:

CIEE submitted comments in response to a question posed by Energy Division staff regarding what kind of assumptions the IOUs will make about the resource mix in 2050 and in particular the amount of renewables development when defining or gauging the merit of EPIC research projects. In its comments, CIEE expressed the need to focus customer benefits on a time scale of decades rather than years and to adopt principles focusing on "no regrets", which favors technologies or projects that promise to yield some benefit regardless of which one of fundamentally plausible futures turns out to unfold and to preserve rather than foreclosing potentially desirable future options.

WM submitted comments advocating that the IOUs spend a portion of EPIC money to advance bioenergy. Specifically, WM encourages the IOUs to fund demonstration and deployment projects that demonstrate the commercial viability of biogas (onsite landfill-gas-to-energy) and biomethane (high-BTU pipeline-quality methane). WM also encourages the IOUs to advance emerging conversion technologies, such as anaerobic digestion and gasification to produce energy from biomass resources.

EPRI submitted comments reinforcing the importance of collaboration between the EPIC administrators and EPRI. EPRI is a strong collaborative resource for RD&D, as evidenced through its recent industry-wide applied R&D road-mapping efforts. These road mapping efforts enable EPRI to consistently identify and track research barriers. Furthermore, EPRI's collaborative funding model leverages utility customer dollars with outside funding sources to maximize investments for utility customers. Given EPRI's strong collaboration with the electric industry, EPRI has the unique ability to identify demonstration and deployment gaps to ensure that the EPIC administrators' investments in technology demonstration and deployment are not duplicative of areas already addressed in the US or internationally. EPRI thus provides a unique opportunity to leverage EPIC program funding.

EPIC administrators were also required by D.12-05-037 to present their investment plans to stakeholders in September. To fulfill this compliance obligation, SCE—on behalf of PG&E and SDG&E—hosted a webinar on September 28. The webinar sought stakeholder input on the utilities' proposed EPIC framework, areas of investment and programmatic administration and gave stakeholders the opportunity to provide written comments by October 4.

SCE received written comments regarding its webinar from the Natural Resources Defense Council (NRDC). NRDC supports the IOUs' proposed framework for implementing EPIC. NRDC believes there is considerable discretion for the administrators to identify projects that will benefit their customers. Furthermore, NRDC interprets the CPUC's decision as not setting a hard cap on funding, leaving the decision to the CPUC and EPIC administrators. More broadly, NRDC urges the IOUs to determine how to expand EPIC efforts on energy efficiency, given its importance in the loading order. Lastly, NRDC also urges the CPUC to allow IOU participation in EPRI programs and encourages the IOUs to request additional funding to support EPRI participation, if needed.

# 5. Discussion of Gaps

In response to concerns expressed at the IOU Northern California stakeholder workshop that EPIC projects could possibly duplicate past or existing demonstrations and deployments, the IOUs asked EPRI to host an EPIC Gaps Analysis workshop. As an independent, nonprofit organization, EPRI conducts broad public/private, collaborative research on behalf of the electric utility industry, customers and society and is uniquely positioned to help identify gaps which the IOU EPIC efforts could address. On September 12, representatives from each of the IOUs and Energy Division staff participated in the workshop at EPRI's headquarters in Palo Alto, California. The CEC was invited to participate, but had scheduling conflicts.

The IOUs began the workshop by discussing their jointly developed EPIC Program Framework of:

- Renewables and Distributed Energy Resources Integration;
- Grid Modernization and Optimization;
- Customer Focused Products and Services Enablement; and
- Cross-cutting, Foundational Strategies and Technologies.

The IOUs then discussed detailed initiatives within each of the investment program areas. For instance, for the Renewables and Distributed Energy Resources Integration Program Area, the IOUs might fund projects that focus on:

- Integrating distributed energy resources, generation and storage safely and reliably;
- Demonstrating adaptive protection strategies; and
- Increasing generation transparency and flexibility.

Similarly, for the Grid Modernization and Optimization Program Area, the IOUs might fund projects that address:

- Demonstrating strategies and technologies to optimize existing assets;
- Preparing for emerging technologies; and
- Designing and demonstrating grid operation of the future.

For the Customer Focused Products and Services Enablement Program Area, the IOUs might fund projects that target:

- Leveraging the SmartMeter Platform to derive customer service excellence;
- Integrating demand side management to optimize the grid; and
- Responding to emerging grid integration issues.

Lastly, for the Cross-cutting/Foundational Strategies and Technologies Program Area, the IOUs might fund projects that center on advancing:

- Smart Grid Architecture;
- Cybersecurity;
- Telecommunications; and
- Standards.

After the IOUs presented their proposed program areas and associated initiatives, EPRI subject matter experts (SMEs) from the Power Delivery Group gave presentations discussing whether any gaps existed within the IOUs' program framework based on the Power Delivery and Utilization Sector Roadmaps. In accordance with the IOUs' proposed framework, EPRI SMEs gave the following presentations:

- Industry Strategic Issues, Challenges and Initiatives (Todd Maki)

**Renewables and Distributed Energy Resources**

- Renewables Integration and Energy Storage (Haresh Kamath)

**Grid Modernization and Optimization**

- Asset Management Analytics (Richard Lordan)
- IntelliGrid (Don Von Dollen)

**Customer Focused Products and Services**

- Electric Vehicles (Mark Duvall)
- Energy Efficiency (Omar Siddiqui)

**Cross-Cutting, Foundational Strategies and Technologies**

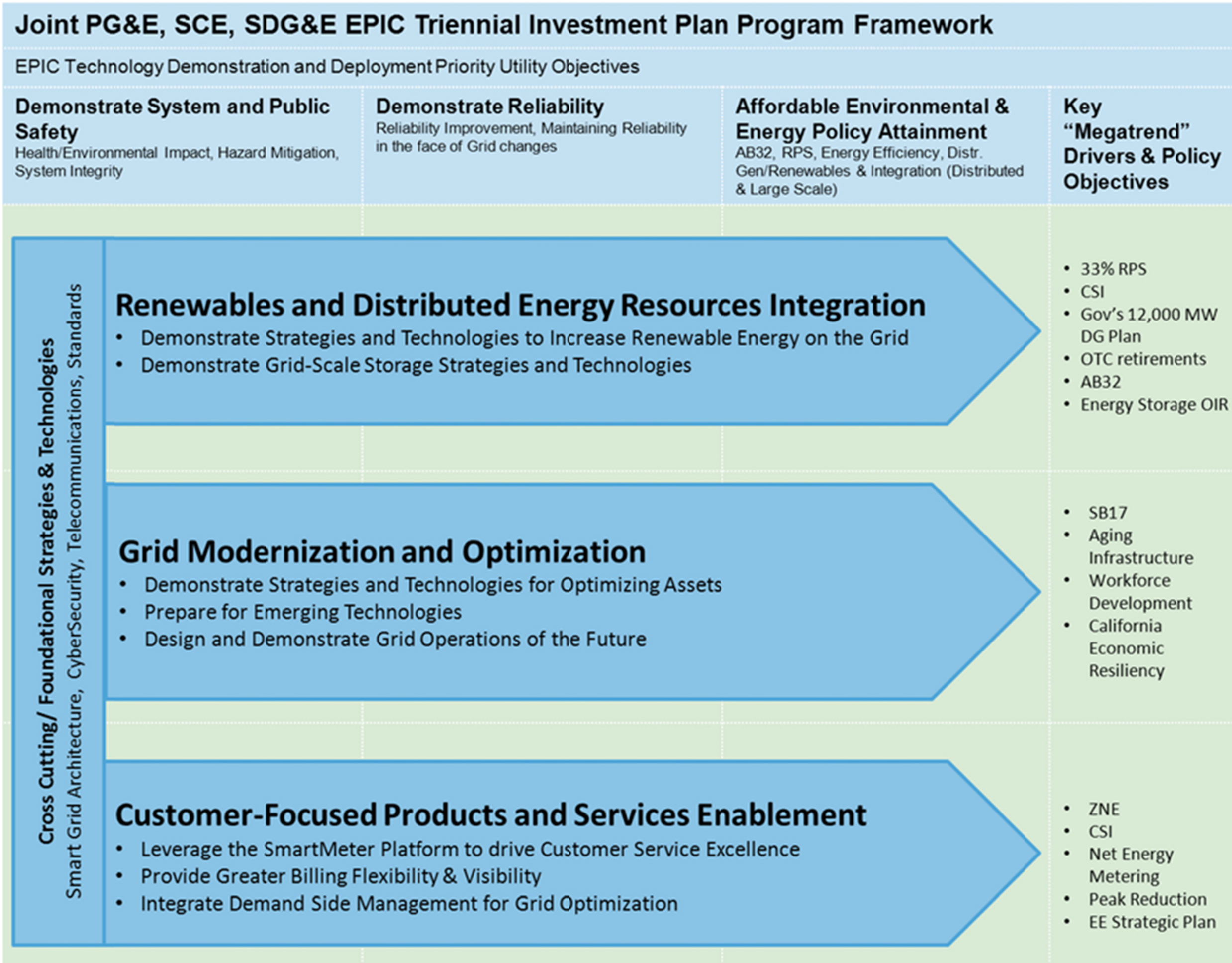
- Cybersecurity (Galen Rasche)

The crux of EPRI's SME presentations was that gaps in demonstrations and deployments currently exist in the program areas proposed by the IOUs. Furthermore, the IOUs have the ability to fill these gaps via the EPIC program. While gaps analyses are an important tool with which to avoid unnecessary duplication, EPIC administrators must continue to collaborate and discuss opportunities on an ongoing basis. These discussions should be formally memorialized in a structure similar to the CURC, to ensure EPIC administers regularly meet and discuss proposed EPIC projects.

# 6. SCE's EPIC Investment Plan

To develop a common approach to the respective administrators' investment plans, the CEC and the IOUs engaged in a collaborative effort, which included jointly hosting IOU workshops and participation in the CEC's workshops. The parties' joint effort is reflected in the framework set forth below.

Figure 2 - Joint IOU EPIC Triennial Investment Plan Program Framework




The IOU-administered portion of EPIC is composed of four program categories: (1) Renewable and Distributed Energy Resources Integration, (2) Grid Modernization and Optimization, (3) Customer-Focused Products and Services Enablement and Integration, and (4) Cross Cutting/Foundational Strategies and Technologies. While each of the funding categories has the potential to provide benefits to multiple components of the electricity system value chain (i.e., grid operations/market design, generation, transmission, distribution and demand-side management), the IOUs created the Cross Cutting Strategies and Technologies funding category to address foundational issues like grid communications, physical and cyber security, system architecture and data management. Under each of the funding categories are technology demonstration and deployment (TD&D) initiatives intended to further describe the funding category and demonstrate how they map to the Electricity System Value Chain. All of the funding categories are intended to result in customer benefits of greater reliability, lower costs and increased safety while also providing related benefits including societal benefits, GHG emissions mitigation and adaptation, and support for the California loading order, low-emission vehicles/transportation, economic development and/or efficient use of customer monies.

The Discussion of Gaps, described in Section 5, shaped the EPIC IOU funding categories and initiatives. A key consideration beyond the existing gaps is what work is already being done by others to fill those gaps. The IOUs are each members of EPRI and have worked with their subject matter experts and utilized their extensive roadmapping efforts in developing the funding categories. Additionally, California programs such as the CSI RD&D Program,[18] and Department of Energy (DOE)-funded projects, as well as similar efforts in North America, were reviewed. As the IOU program administrators move into project identification, additional coordination and collaboration will be needed. In furtherance of the policy embedded in Public Utilities Code section 740.1(d) and standard utility practices, the IOU EPIC TD&D projects will not unnecessarily duplicate efforts undertaken by other electric corporations or research organizations.

Continued collaboration and coordination are important to leverage all of the available resources to achieve and further develop California's energy policy.

## 6.1 Renewable and Distributed Energy Resource Integration

California has some of the most ambitious clean energy goals in the U.S. By 2020, California's goals include (1) reducing CO2 to 1990 levels, (2) 33% renewable energy statewide, (3) interconnecting 12,000 MW of locally-produced renewable generation, (4) dealing with the potential retirement of once-through-cooling power plants presently used for base load and peaking purposes,[19] and (5) operating all new residential dwellings on a Zero Net Energy basis. All of these policy goals imply significant increases in the amount of variable energy resources on California utility grids at the T&D systems.

Many types of renewable resources are eligible to meet California's policy goals. Some forms of renewable generation (e.g., geothermal and biomass) act much like the central stations of the past, presenting no new integration challenges. However, most of the utility-scale renewable energy generation being added to the grid has very different operating characteristics. The most common type, according to California policy objectives, will be renewable wind and solar,

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[18] The adopted CSI RD&D Plan suggests that 50-65 percent of CSI RD&D Program funds be dedicated to grid integration projects. The third CSI RD&D Program grant awards were made in March 2012 and grid integration of PV was a primary focus area with a stated objective of overcoming existing barriers to integration and acceleration of the integration and interconnection of high penetration PV into the electricity grid. The IOUs are familiar with those projects and are supporting many of them.

[19] *See* State Water Resources Control Board's Policy on the Use of Coastal and Estuarine Waters for Power Plant Cooling, adopted on May 4, 2010.

which are variable in nature. The Federal Energy Regulatory Commission (FERC) defines a variable energy resource (VER) as an energy source that: (1) is renewable; (2) cannot be stored by the facility owner or operator; and (3) has variability that is beyond the control of the facility owner or operator. VERs generate energy when natural conditions such as wind and sunshine allow it, presenting new challenges across the time spectrum of seconds, minutes, hours, days and months.

The principal objective of work in this funding category is to demonstrate emerging strategies and technologies that facilitate the integration of renewable energy resources into the SCE grid, such that these generating resources can be deployed within the timeframes required to meet the policy goals noted above.

***<u>Priority Initiatives</u>***

SCE has been involved with the integration of VERs since the early 1980's when the nation's first large wind generation stations were installed in the Tehachapi and Palm Springs areas. Challenges relating to interconnection and management of voltage and line loading were overcome through innovative design and operations. SCE worked closely with the National Renewable Energy Lab (NREL), wind manufacturers and developers to establish best practices in this area. Work is still underway to construct validated models of the various types of wind generators. In more recent years, SCE has been active in the areas of photovoltaic (PV) integration into the grid. This work falls into two areas, issues around interconnection of PV generation to the distribution grid and the larger grid integration issues around the effects of high penetration of PV in the transmission grid. In the distribution interconnection area, SCE has assembled detailed test procedures for inverters to address the voltage and frequency transients that routinely occur on the electric grid. The goal of this work is to construct numerical models that will predict the behavior of these devices when higher penetrations occur. SCE led the development of these test procedures with review by NREL, Sandia National Labs, Oak Ridge National Labs, Western Electricity Coordinating Council (WECC), and other utilities. The laboratory and field test results have been shared with national labs, utilities, inverter manufacturers, EPRI, the Utility Wind Integration Group, IEEE, and universities.

SCE has advanced knowledge in this field by authoring and presenting various papers. Recent papers include:

- IEEE Photovoltaic Specialists Conference Publication: "Fault Current Contribution from Single-phase PV Inverters," Keller, Kroposki, Bravo, Robles, 2011.
- IEEE 2011 General Meeting Paper: "Solar PV Inverter Testing for Model Validation," Bravo, Yinger, Robles, Tamae, 2011.

- IEEE Industrial Electronics Society 2012 Conference: “Power Hardware-in-the-Loop Testing of a 500 kW Photovoltaic Array Inverter,” Langston, Schoder, Steurer, Faruque, Hauer, Bogdan, Bravo, Mather, Katiraei, 2012.

In addition to these papers, presentations have been made at Distributech, WECC meetings, and Utility Wind Integration Group meetings (now the Utility Variable-Generation Integration Group).

A second goal of this work is to help establish standards and develop technologies for the integration of VERs. SCE has been active in the review and modification of IEEE 1547 (interconnection standard for distributed generation) and UL 1741 (Underwriters Lab standard for testing inverters). In the larger grid integration area, SCE has been active in the study of how variable generation will affect the stability and reliability of the broader transmission system. The issues here are the ability of system operators to maintain proper system generation load balance without overloading any transmission lines. The system operator also needs to understand how system voltage and frequency transients might cause loss of inverter based generation. This issue is being addressed with the need for inverter based generation to stay connected to the grid during short system transients. Accurate system and generation models are critical in performing these studies.

Much work still needs to be accomplished with respect to VER integration. Testing done to date has helped establish desired characteristics for inverter based generation powered by variable renewables. These desired characteristics now need to be incorporated into standards and products to be used by utilities to ease integration. Inverter manufacturers are becoming aware of utility needs in this area. Variable generation is now being installed on the SCE grid in large quantities in certain areas. Installation of detailed monitoring equipment in these high penetration areas will supply information to be used to validate high penetration models and uncover any incipient issues with grid integration. Validated system models need to be developed and used to simulate the behavior of the transmission grid with high penetrations of variable renewable generation (both solar and wind). Storage technologies and controls will need to be modeled and evaluated to assess what role these technologies can play to ease the integration of VERs.

California's IOUs worked collaboratively to develop the following priority initiatives, which were reviewed with EPRI's subject matter experts. This effort determined that these are high priority initiatives that fill gaps with respect to projects, information and data. SCE places a high priority on these initiatives, based on its extensive work with respect to renewable generation and its integration into the grid, its own white paper on the subject of energy storage,[20] and information arising from the Commission's Energy Storage OIR.[21] The initiatives are:

- Demonstrate Strategies and Technologies to Facilitate Integration of Variable Energy Resources; and
- Demonstrate Grid-Scale Storage Strategies and Technologies

SCE expects to utilize approximately $9 million of the funding allocated for this triennial investment plan to address renewable and distributed energy resource integration. The investments contemplated in this section will map to the following elements of the electricity system value chain: Grid Operations/Market Design, Transmission, and Distribution.

### 6.1.1 Demonstrate Strategies and Technologies to Facilitate Integration of Variable Energy Resources

***Problem or Opportunity to be Addressed***

Some VERs, such as solar, are available at times when customer loads are relatively high (although not necessarily at peak times). However, other resources, such as wind, are more available when there is less demand on the grid. This supply/load imbalance results in more frequent episodes of "over generation" when extraordinary steps must be taken to keep the grid in balance. During over-generation events, power prices can become negative, resulting in paying parties to take away excess generation and causing increased costs to SCE's customers.

With solar resources, the loss of sunshine due to intermittent cloud cover and fog burn-off produces erratic power output from the solar panels, creating voltage fluctuations that translate to poor power quality. These voltage fluctuations can occur across the time spectrum of seconds, minutes and hours. Solar panel inverter standards are currently insufficient to correct for many of the reliability issues that will need to be addressed with high penetrations of these VERs. Issues like low voltage ride through, voltage regulation and reactive power output capabilities will have to be addressed.

Natural gas-fueled power plants have operating characteristics that will be needed to serve customer load by responding to forecast or unexpected changes in the output of VERs. However, as California implements AB 32 and reduces carbon levels, it will be more difficult for some natural gas-fueled power plants to support system stability. Stability issues have the

[20] " Moving Energy Storage from Concept to Reality: Southern California Edison's Approach to Evaluating Energy Storage," *available at* http://www.edison.com/files/WhitePaper_SCEsApproachtoEvaluatingEnergyStorage.pdf.
[21] R.10-12-007.

potential of being further exacerbated by the once-through-cooling policy's effect on coastal power plants. Whatever natural gas-fueled plants remain or are added to the portfolio will need to be extremely flexible to provide the required response to accommodate the changes in grid operating patterns due to the growing amounts of VERs. Because California electricity customers use more electricity during peak hours, some gas plants are only necessary to meet those peaks. However, even flexible gas-fired power plants have limitations in how quickly they can go into operation. Unlike a car, one cannot simply turn a key and operate these resources at full capacity. Instead, power plants must operate at minimum generation levels overnight so that they are available to meet peak demands during the day. Required minimum overnight generation levels are another contributor to over-generation events and operating these plants at minimum load results in operating them at their most inefficient level.

Utility distribution systems were designed to receive power from transmission systems, which were connected to large, central generating stations in a "one-way flow of energy". Distributed resources that generate power behind the meter and flow back across the transformer and into the distribution feeder create the potential for new issues such as invalidating the coordination of protective relaying, voltage spikes and dips, harmonics, etc. Additionally, electric vehicles need to be tracked to ensure adequate grid capacity is available. When automotive bi-directional energy applications become reality, they will add additional complexity due to the mobility and size of these energy storage systems.

The distribution grid will evolve over the next several years and require management of these various issues. This evolution will require the integration of diverse data and energy management with a combination of centralized and decentralized control mechanisms to safely, reliably, and affordably enable this distribution system of the future. The most optimized management system requires definition, and very detailed and accurate system models and pilot demonstrations of a variety of management strategies will be required to ensure that the industry successfully defines an optimized market and control structure.

A potential opportunity in this area would be to demonstrate the control algorithms being developed by the California Institute of Technology (Caltech) through an Advanced Research Projects Agency – Energy (ARPA-E) grant. Caltech is developing a distributed voltage and VAR control system to manage the large number of interconnected devices. SCE is currently working with Caltech to build a representative model of SCE's distribution system using software originally developed by the Pacific Northwest National Lab. Once this model is completed and the control algorithms are finalized, SCE and Caltech will evaluate the effectiveness of the distributed voltage and VAR control system. Assuming that this evaluation indicates a positive result, the next step would be to demonstrate the control system on a portion of the SCE system. This type of control system could significantly contribute to both SCE's ability to manage reliability and power quality on the distribution grid, and it could also enhance SCE’s conservation voltage reduction program, resulting in greater savings to all customers connected to the controlled distribution circuit.

***<u>How the initiative will advance the strategy and overcome barriers</u>***

This initiative is important to examine a variety of strategies and technologies that facilitate the integration of variable energy resources into SCE's grid. These include strategies and technologies that minimize grid disruptions, increase the flexibility of generation resources to meet short-term variability related to VERs, and mitigate power quality issues.

While there are many examples of emerging technologies in this area, there is a clear need to further assess, evaluate and demonstrate the technologies on a pilot basis to prove the benefits prior to large scale deployment. The IOUs will need to demonstrate a variety of protection strategies and technologies to effectively integrate distributed energy resources into the system and optimize any benefits associated with such resources. It is important to test these technologies in concert with existing utility assets, protection schemes and operating systems to ensure they are backwards compatible and can be safely, reliably and affordably deployed.

Load flow analysis will need to be used to understand the steady state and dynamic behavior of these DER devices and their control schemes. Inverter controls will need to be tested, and the data generated from these tests will provide input for standards that will need to be changed to successfully integrate DER. Currently, the low voltage ride-through capability of some inverter devices has indicated the potential for disconnection from the distribution grid during transient undervoltage conditions. With significant penetration of solar PV and the increased number of inverters connected to the distribution grid, this diminished ride-through capability could exacerbate the transient condition by having generation disconnect at the time when it is most needed. Detailed system modeling and simulations can identify this problem, but demonstration of the phenomenon would be very helpful to determine mitigation strategies and influence standards bodies to require greater ride-through capability from inverter manufacturers.

For the transmission system, analyzing models with powerful computing systems like the Real Time Digital Simulator (RTDS) will ensure that the bulk power system is adequately protected and proper controls systems are in place to deal with the VERs across the Western Interconnect. Wide area voltage and VAR controls as well as adaptive relaying will need to be studied to ensure that voltage and angular stability can be maintained during contingencies. Remedial action schemes will need to be integrated with other protection schemes to ensure proper overlapping protection.

For example, as more renewable generation is interconnected to the system, SCE will need to develop additional remedial action schemes or build transmission capacity to incorporate the new resources. With the number of interconnection requests in the queue and the time needed to site and build transmission facilities, it is not likely that SCE will be able to add facilities quickly enough to meet the demand. Moreover, the interaction between the existing systems and newly developed systems continues to increase in complexity and requires a very detailed model of the power system to adequately evaluate the interdynamics. The RTDS allows for demonstration of control systems directly connected to a detailed simulated environment to address these complexities, develop solutions and test them in a safe environment. With this tool, SCE can demonstrate the correct operation of the control devices in-the-loop and over multiple scenarios to ensure proper performance when the systems are actually deployed onto the grid. While SCE's RTDS is currently being used in the development of a Centralized Remedial Action Scheme solution to safely and reliably address existing system demands and complexities, much more work is needed.

The following are commonly discussed impacts and barriers to the widespread adoption distributed and variable energy resources:

a. Frequency control,
b. Voltage regulation,
c. Reverse power flows,
d. Operational flexibility,
e. Reliability capacity and planning, and
f. Capacity margin.

***<u>SCE's Potential Demonstration Projects[22]</u>***

- Distribution Market Demonstration and Analysis;
- Inverter Controls;
- Power Electronics Transformer;
- Advanced Voltage and VAR Control of SCE's Transmission System; and
- Multi-step Capacitor Switcher.

The following table lists the potential demonstration projects and the drivers/barriers they are intended to address.

| SCE Project | Barriers Addressed |
|---|---|
| Distribution Market Demonstration and Analysis | a, b, d |

[22] Potential project descriptions are attached as Appendix B. The EPIC program administrators agree that additional collaboration is needed prior to selecting projects. This will help to eliminate any unnecessary duplication of efforts.

| | |
|---|---|
| Inverter Controls | a, b, d |
| Power Electronics Transformer | a, b, c, d, f |
| Advanced Voltage and VAR Control of SCE's Transmission System | a, b, d |
| Multi-step Capacitor Switcher | a, b, c, d |

### 6.1.2 Demonstrate Grid-Scale Storage Strategies and Technologies

***Problem or Opportunity to be Addressed***

Energy storage has the potential to provide many services that will be required to integrate more VERs at the transmission and, especially, the distribution level. For example, energy storage can provide ancillary services to CAISO, or can be used to improve reliability of distribution systems by mitigating the impacts of distributed energy resources or to accommodate more distributed resources by increasing available distribution asset capacity. After many years of industry discussion, energy storage now enjoys a growing sense of promise, as many expect it will become a viable part of the electric system over the next decade. However, there are still very real challenges to the cost-effective deployment of energy storage solutions. SCE has done a great deal of thinking on this topic as has the Commission, and there are a vast number of demonstration opportunities across a variety of technologies. SCE's initial approach was set forth in the white paper entitled "Moving Energy Storage from Concept to Reality: Southern California Edison's Approach to Evaluating Energy Storage", which was published in 2010. SCE's approach to energy storage involves a road map process which includes initial desktop work, battery chemistry testing, system evaluations, field demonstrations and pilot projects. Real world data is essential to the commercialization and the safe, reliable and affordable utilization of energy storage on the grid.

SCE has also taken the lead in evaluating energy storage technologies in the field via two DOE funded programs, the Tehachapi Wind Energy Storage Project (TSP) and the Irvine Smart Grid Demonstration (ISGD) program. While the 8MW/32MWh Battery Energy Storage System under TSP aims at evaluating the technology for mitigating the transmission level impacts of VER and providing services to the CAISO market, the ISGD program evaluates customer sited and utility sited energy storage devices to understand the impact at the distribution level.

TSP has already revealed that with larger systems, there is no practical way to test the system before operation due to the limitations of power capabilities at vendors' facilities. Limited facility power causes acceptance of energy storage systems at the factory with substantially de-rated capabilities, often breaking the system down to much smaller modular sub-systems. As such, a fully integrated system is not tested and complete integration of a system is deferred to site; as a result, testing of the system on the grid could induce safety and reliability concerns. Use of diesel generators at vendors' facilities to create a "grid" to perform testing of a larger system also proves to be an insufficient measure due to the "weak" character of the grid produced. SCE has identified the gap that exists between taking larger systems from the factory floor to direct connection to the grid and the necessary intermediate step of testing larger systems on a controlled grid-connected environment. By proposing the Megawatt-Class Containerized Energy Storage Interconnection Readiness program, SCE attempts to solve the issue of being able to test large storage systems "live" on the grid while also allowing for a test bed that can address the communications and controls aspect of the systems under test.

Under the ISGD program, SCE aims to demonstrate the operation of a community energy storage (CES) unit. A CES unit is the accepted term for a battery-based energy storage device with power capability in the range of 25-75kVA and energy storage capability in the range of 25-75 kWh, connected to the secondary of a utility transformer with the provision to be controlled remotely. Such a device can perform some autonomous functions based on feedback signals or it can provide schedule based operation based on time of day to perform such functions as peak shaving to help alleviate the peak loading on the distribution circuit. While SCE will be able to test the function of one CES unit during the ISGD program, this program does not offer the opportunity to test the behavior of multiple CES units being controlled by a centralized controller. Furthermore, the ISGD program does not attempt to and cannot define how best to operate a fleet of CES units due to its limitation in demonstrating a single CES unit. During the on-going course of the ISGD program, SCE has identified the limitation in testing individual devices on the distribution circuit and proposed to overcome these limitations by embarking on the following projects:

- Community Energy Storage Demonstration & Controls Evaluation - Ensuring individual unit operation in the lab and in the field to work in conjunction with a centralized controller, the specification of which will also be developed through the project;
- Modeling and Simulation for Mitigating DER variability with DES - Testing the centralized controller in a hardware in the loop environment to test the centralized controller's ability to control a fleet of devices under simulated grid conditions;
- Distributed Energy Storage Field Demonstration - Deploying various distributed energy storage devices of different power and energy ratings on the distributed circuit, connected to a centralized controller capable of controlling disparate storage units in a fleet environment.

In expanding upon the DOE co-funded initiatives already started with the TSP and the ISGD programs, SCE attempts to capture the missing elements in technically proving the steps necessary to take energy storage from "one-off" deployments to system-wide deployments with the necessary hardware, controls and infrastructure. In the process, SCE attempts to gather real world data essential to the commercialization and the safe, reliable and affordable utilization of energy storage on the grid, while leveraging the lessons learned from these DOE demonstration programs.

***<u>How the initiative will advance the strategy and overcome barriers</u>***

The CPUC Energy Storage Framework Staff Proposal in R.10-12-007 identifies the following nine energy storage adoption barriers:

a. Lack of definitive operational needs;
b. Lack of cohesive regulatory framework;
c. Evolving markets and market product definition;
d. Resource adequacy accounting;
e. Lack of cost-effective evaluation methods;
f. Lack of cost recovery policy;
g. Lack of cost transparency and price signals;
h. Lack of utility operating experience; and
i. Lack of well-defined interconnection process.

While IOU technology demonstration and deployment projects cannot solve each of the barriers, EPIC funding could be employed to address a number of the barriers and provide important data to address other barriers. In short, IOUs can demonstrate the value, technical performance, and costs of energy storage systems that facilitate integration of VERs into the grid. Various types of emerging energy storage technologies, fulfilling different roles, will need to be assessed, evaluated through laboratory studies, and demonstrated at field scale. Data gathered during these demonstrations will also be used to improve inverter standards, validate models and facilitate integration on the grid.

Simulations may be performed to determine the optimum location and siting of distributed energy storage or to analyze how energy storage would perform under various system contingencies, such as rapid changes in renewable resource generation levels, loss of a major conventional generation source, or loss of a transmission line. Control systems and software may be developed to aggregate distributed energy storage to support the transmission and distribution grid and the CAISO.

***SCE's Potential Demonstration Projects***

- Community Energy Storage Demonstration & Controls Evaluation;
- Megawatt-Class Containerized Energy Storage Interconnection Readiness;
- Distributed Energy Storage Field Demonstration;
- Modeling and Simulation for Mitigating DER variability with DES; and
- Tehachapi Wind Energy Storage Project.[23]

The following table lists the SCE proposed energy storage devices and how they address the barriers identified in the CPUC Energy Storage Framework Proposal.

| **SCE Project** | **Barriers Addressed** |
|---|---|
| Community Energy Storage Demonstration & Controls Evaluation | a, c, h, i |
| Modeling and Simulation for Mitigating DER variability with DES | a, c, h, i |
| Distributed Energy Storage Field Demonstration | a, b, c, d, e, f, g, h, i |
| Megawatt-Class Containerized Energy Storage Interconnection Readiness | a, c, e, f, h, i |
| Tehachapi Wind Energy Storage Project | a, b, c, d, e, f, g, h, i |

## 6.2 Grid Modernization & Optimization

The grid is comprised of the conductors, poles, substations, transformers, switches, circuits, operating centers, generation plants, system monitoring tools and equipment (such as SCADA system and protection devices) that need to work together in perfect synchronicity to deliver electricity safely and reliably.

There are many drivers that require the IOUs to use new methods and tools to both manage and maintain today's electric grid as well as to explore the "next generation", modernized grid that operates safely, reliably and cost efficiently in the 21st century.

All of California's IOUs are facing the challenges of aging infrastructure, while also facing the challenges of meeting the state's clean energy policy goals. The current infrastructure will need replacement before it degrades to the point of causing safety and reliability concerns, and

[23] In December 2009, SCE was notified that it would receive Public Interest Energy Research (PIER) funding to support this project. SCE has not received said funding and will use EPIC to support this effort.

existing utility infrastructure replacement programs are working to address these issues. With the potential for significant advances in technologies and the potential to satisfy both challenges, it makes sense for an IOU to deploy the technologies and solutions that best enable it to do so, rather than replacing like-for-like equipment and missing opportunities to improve the safety and reliability of the grid.

The operating requirements for the grid of the future are very different than those for which it was initially designed. SCE has fully utilized its RD&D funding to investigate and approve new automation technologies. This has allowed us to automate more than 550 substations, 2,290 distribution circuits and 15,000 pieces of field equipment (e.g., capacitors, automatic reclosers, remote controlled switches, and fault interrupters). Future technologies and operating strategies may provide opportunities for safe, reliable and cost effective improvements. While there have been new pockets of technology deployed at various places, there are no clear winners in developing the “grid of the future” or “turnkey” solutions that can be consistently applied to every electric grid. Because of original design differences, each of California's IOUs has different operating conditions, equipment deployments and approaches to addressing future requirements and existing challenges. Only recently have communications and computing technologies advanced to a point where utilities can leverage data from new and existing sources and explore methods of operating the grid more efficiently and to providing better service to customers.

Asset Management and Optimization is not only the continued introduction of new technologies but also the management of information concerning the asset. These information systems have improved over the last several years through the introduction of enterprise resource planning, geographical information and improved work scheduling systems. These critical systems are augmented by the evolving introduction of real-time monitoring devices. Additionally, information available from automated meters, synchrophasors, advanced distribution management system and other emerging data systems provide rich detail of the conditions experienced by the infrastructure system components. This “Big Data” issue is an emerging opportunity that will require demonstration of information integration and correlation of data to asset performance. Harnessing new technological advances in grid management, asset management and optimization has the potential to improve customer service, safety and reliability, cut long-term asset management and maintenance costs and help provide skilled jobs for Californians.

***Priority Initiatives***

California's IOUs worked collaboratively to develop the following priority initiatives, which were reviewed with EPRI's subject matter experts. This effort determined that these are high priority initiatives and that there are gaps with respect to projects, information and data.

- Demonstrate Strategies and Technologies for Optimizing Existing Assets;
- Prepare for Emerging Technologies;
- Design and Demonstrate Grid Operations of the Future.

SCE expects to utilize approximately $7.5 million of the funding allocated for this triennial investment plan to address grid modernization and optimization. The investments contemplated in this section will map to the following elements of the electricity system value chain: Grid Operations/Market Design, Transmission, and Distribution.

### 6.2.1 Demonstrate Strategies and Technologies for Optimizing Assets

***<u>Problem or Opportunity to be Addressed</u>***

SCE is faced with the need to replace aging utility infrastructure to maintain reliability. This, coupled with the need to change aspects of the system to meet a variety of state and federal energy policy objectives, including increasing infrastructure protection and security requirements, is challenging from both a resource and rate perspective. SCE must make the most of its existing equipment, while also complying with increasing requirements, if it is to continue providing reasonably priced, reliable and safe service to its customers.

Increasing amounts of data are captured by devices on the system through traditional systems like an Energy Management System (EMS) or a Distribution Management System (DMS), emerging data sources like advanced meters, and horizon technology like solid state transformers, current sensing circuit switchers, and storage devices. What are currently lacking in the industry are tools that can process this data and provide information concerning the historical stress of grid infrastructure components. Correlating this data to historical performance would provide a more accurate assessment of the state of the grid and allow either a longer life for the equipment or a proactive replacement of that equipment. Demonstrating this type of data analysis on a sufficiently large section of the distribution grid would be beneficial for understanding the improved forecasting of infrastructure life and infrastructure replacement. The maintenance of the foundational infrastructure will be necessary to enable the introduction of advanced technologies. Without this foundational infrastructure, the introduction of advanced control systems attempting to optimize new devices over improved telecommunication networks will be futile. Having a data analysis engine that can improve the evaluation of the state of the grid infrastructure would not only identify possible trouble spots but should indicate life extension opportunities as well.

The complexity of siting new transmission and generation requires ensuring the full value of existing resources is leveraged while the aging infrastructure must be maintained to provide the foundation for more advanced technology. Leveraging existing resources will include demonstrating opportunities to operate the transmission system in a more reliable manner through advanced mitigation systems. As described above in Section 6.1.1, the use of the Real Time Digital Simulator for evaluating remedial action scheme interdynamics would be beneficial in incorporating newly developed schemes into the existing framework. Similarly, there is an opportunity to investigate the optimization of these schemes to evaluate if they are minimizing generation and load disconnection. Reducing these disconnections while still maintaining the mitigation aspect of the protection system could be valuable from a reliability and a cost perspective.

Providing safe electric service to our customers is paramount. To that end, protective devices are installed at multiple levels throughout the grid to detect abnormally high current flow and de-energize the faulted conductors. There are rare cases where a damaged conductor may come in contact with a highly insulated surface or medium resulting in extremely small fault currents that cannot be detected by existing protection equipment. In this case, a damaged conductor can remain energized in a position where an individual could come in contact with the conductor. This special condition is referred to as a high impedance fault and is extremely difficult to detect. One of SCE's proposed projects is to test and demonstrate potential methods for detecting high impedance fault conditions on distribution circuits.

Animal interactions with electrical equipment also pose problems for utility operations and for customers. From 2009 to 2011, SCE experienced 211 animal-caused outages involving equipment at its distribution substations. Over the years, SCE has installed various animal deterrent products to reduce animal interactions but has had limited success.

***How the initiative will advance the strategy and overcome barriers***

Piloting new data capture, analytics, and visualization and correlation technologies will enable new condition-based and risk-based maintenance techniques designed to improve asset efficiency, flexibility and resiliency and extend the use of aging assets. Piloting new complementary equipment and techniques will allow improved operations while keeping the underlying deployed asset in service. This initiative will enable the modernization of the grid without immediate, wholesale equipment replacements and burdening SCE's customers with unreasonable rate increases.

The following are commonly discussed drivers for and barriers to the widespread adoption of technologies with the potential for enhancing the utilization of existing utility assets:

a. Electric system safety, security and reliability,
b. Regulatory and legislative requirements,
c. System limitations,

d. Operating capabilities,
e. Industry standards, and
f. Business case and operating information.

***SCE's Potential Demonstration Projects***

- High Impedance Fault Detection on Distribution Circuits;
- Substation Automation 3, Phase III Bulk Electric System;
- Substation Automation 3, Phase III Hybrid Solution;
- Risk Mitigation Demonstration;
- Substation Animal Deterrent; and
- Superconducting Transformer.[24]

The following table lists the potential demonstration projects and the drivers/barriers they are intended to address.

| SCE Project | Barriers Addressed |
|---|---|
| High Impedance Fault Detection on Distribution Circuits | a, c, |
| Substation Automation 3, Phase III Bulk Electric System | a, b, d, e, f |
| Substation Automation 3, Phase III Hybrid Solution | a, b, c, d, e, f |
| Risk Mitigation Demonstration | a, b, c, d, f |
| Substation Animal Deterrent | a, b, c, f |
| Superconducting Transformer | a, c, d, f |

### 6.2.2 Prepare for Emerging Technologies

***Problem or Opportunity to be Addressed***

According to Public Utilities Code section 8360, "[i]t is the policy of the state to modernize the state's electrical transmission and distribution system to maintain safe, reliable, efficient, and secure electrical service, with infrastructure that can meet future growth in demand and achieve" a variety of state policy objectives. In previous sections, SCE has discussed the incorporation of VER and DER and a variety of drivers. This section is focused on identifying and

[24] SCE requested PIER funding to support the demonstration of a superconducting transformer. SCE did not receive PIER funding and will use EPIC to leverage against almost $22 million in federal and private funding.

demonstrating solutions that address some of the same objectives, but are earlier in the development cycle or may be considered replacement technologies.

***How the initiative will advance the strategy and overcome barriers***

Demonstrating promising new transmission and distribution technology specifically aimed at addressing aging infrastructure needs and integrating non-conventional and distributed generation sources, physical security and cybersecurity needs will improve real time, integrated and seamless monitoring, communication and operation of the grid. Technologies with temperature and/or current sensors will provide detailed knowledge of actual system conditions and component loading. Intelligent alarming using sensors & algorithms can predict equipment health for pro-active management of system assets.

Substation equipment, such as circuit breakers, disconnects, and transformers are progressively being developed with intelligent sensors that will provide easier integration into substation automation systems. These sensors enable advanced enterprise applications such as condition based maintenance, asset management, and granular monitoring of substation apparatus health.

The following are commonly discussed drivers for and barriers to the widespread adoption of emerging utility system technologies:

a. Electric system safety and reliability,
b. Regulatory and legislative requirements,
c. System limitations,
d. Operating capabilities,
e. Industry standards, and
f. Business case and operating information.

***SCE's Potential Demonstration Projects***

- Remote Fault Current Indicators;
- Substation Line Disconnect Switching Indicator; and
- Intelligent Fuses.

The following table lists the potential demonstration projects and the drivers/barriers they are intended to address.

| SCE Project | Barriers Addressed |
|---|---|
| Remote Fault Current Indicators | a, d, f |

| | |
|---|---|
| Substation Line Disconnect Switching Indicator | a |
| Intelligent Fuses | a, b, c, d, f |

### 6.2.3 Design and Demonstrate Grid Planning and Operations of the Future

***Problem or Opportunity to be Addressed***

This investment plan discusses the fact that the grid of the future needs to support the increased presence of renewable resources and distributed generation, increased demands from customers for enhanced service and new products, and more efficient control of both the overall system and an expanding number of controllable assets. Technology is evolving quickly, and while not entirely keeping pace with policy and consumer demands, it is providing opportunities, methodologies and tools that can help utilities to better plan, test and operate their systems. This initiative is designed to identify these opportunities and demonstrate them in the utility environment. With respect to challenges, SCE and other utilities lack the deployed technologies needed to dynamically operate their transmission and distribution systems. While appropriate for the first hundred years of operation, future system requirements will define a grid that must react dynamically to rapidly changing conditions.

***How the initiative will advance the strategy and overcome barriers***

The next generation of Distribution Automation will need to leverage the full capabilities of the Distribution Management System (DMS) to integrate advanced field devices with reliable communication systems. This capacity can be realized quickly and cost-effectively by enhancing the existing equipment with the expanded functionalities of new equipment. This type of transition could reduce the number of customers affected and total customer minutes of interruption (CMI) over the utility's existing switch and a half automation scheme by quickly isolating the faulted section of a circuit, instead of the entire circuit being interrupted. To achieve these advancements SCE will pilot new technologies, their integration, and human situational awareness and interaction techniques to understand the engineer, planner and operator of the future and the "console" of the future and provide a bridge to connect workforce and technology transition issues.

The following are commonly discussed drivers for and barriers to the widespread adoption of future grid operations and planning technologies:

a. Electric system safety and reliability,
b. Regulatory and legislative requirements,
c. System limitations,

d. Operating capabilities,
e. Industry standards, and
f. Business case and operating information.

***<u>SCE's Potential Demonstration Projects</u>***

- Remote Intelligent Switcher;
- Substation Real Time Digital Simulator Mobile Testing Solution;
- Advanced Relay Testing Methodology; and
- Application of Advanced Early Warning System with Adaptive Protection

The following table lists the potential demonstration projects and the drivers/barriers they are intended to address.

| SCE Project | Barriers Addressed |
|---|---|
| Remote Intelligent Switcher | a, b, c, d, f |
| Substation Real Time Digital Simulator Mobile Testing Solution | a, c, d, f |
| Advanced Relay Testing Methodology | a, c, d, f |
| Application of Advanced Early Warning System with Adaptive Protection | a, c, d, f |

## 6.3 Customer-Focused Products and Services Enablement and Integration

Driven by state policies and new enabling technologies, California energy customers are experiencing more opportunities to participate in the energy sector than ever before. In the span of a few years, California has seen more than 10 million Smart Meters installed, a sharp decrease in the cost of photovoltaic (PV) panels, the rollout of plug-in electric vehicles (PEV) by startups and major auto manufacturers, a renewed effort in energy efficiency and demand response, and a standard for ZNE homes for new construction.

Customers are no longer just consumers of electricity. As “prosumers” (producers and consumers) of electricity, customers can be an active participant in supplying and (soon) balancing the electricity grid. Prosumers can buy PV, energy storage equipment, and PEVs and then use Smart Meters and equipment to monitor, control and operate their energy devices in an optimal manner. The CSI expanded on the use of rebates to subsidize the cost of installing distributed PV systems. CSI has been very successful in incentivizing the deployment of PV systems behind the meter. The rebate structure was designed to step down as more installations occurred in anticipation of lower costs as the technology matured. CSI has worked well as the cost of a PV module has decreased by about 75% in the last four years (system costs have also come down, but not as much as module costs). Improvements in the energy storage medium and control technologies have created the rebirth of the PEV industry in the U.S., with an emphasis on the trend-setting California market.

Smart Meter technology is nearly fully deployed in California. Smart Meters enable the utility to measure a customer's energy usage at a more granular level than was previously possible (e.g. every hour or every 15 minutes). This information can be used by customers to manage their energy costs more closely or by the utilities and third parties to design products that more closely reflect customer needs.

The California Legislature and the Air Resources Board (CARB) have established mandates to drive the market to alternate fuels including bio-diesel, ethanol, fuel cell, and electric. California's transportation "vision" currently projects the future to be fuel cell and battery electric vehicles with some cellulosic ethanol.

To reach California's goal of reduced carbon dioxide output (AB 32) will require a change in the way Californians use energy.

***<u>Priority Initiatives</u>***

In an informal meeting between the IOUs, the CEC and Energy Division, the entities discussed the need to prevent duplicative efforts between EPIC and the Emerging Technology Portfolios for Demand Response (DR) and Energy Efficiency (EE). In addition to providing the requested informational summary of the RD&D activities that SCE is conducting as part of its approved programs,[25] SCE is coordinating with its EE and DR program managers to develop EPIC programs that are separate and complementary to its existing Emerging Technology efforts. To that end, SCE plans to focus on programs that address system control and integration issues, rather than specific DR or EE products. SCE is also working with the CEC and the other IOUs to ensure that its efforts are not unnecessarily duplicative. Additional coordination and collaboration is needed, prior to any of the EPIC administrators pursuing projects in this area.

California's IOUs worked collaboratively to develop the following priority initiatives, which were reviewed with EPRI's subject matter experts. This effort determined that these are indeed high priority initiatives and that there are gaps with respect to projects, information and data.

- Leverage the Smart Meter Platform to Drive Customer Service Excellence;

[25] D.12-05-037, OP 12.b.iii.

- Integrate Demand Side Management to Optimize the Grid; and
- Respond to Emerging Grid Integration Issues.

SCE expects to utilize approximately $5.5 million of the funding allocated for this triennial investment plan to address customer-focused products and services enablement and integration. The investments contemplated in this section will map to the following elements of the electricity system value chain: Grid Operations/Market Design, Transmission, Distribution and Demand Side Management.

### 6.3.1 Leverage the Smart Meter Platform to Drive Customer Service Excellence

***Problem or Opportunity to be Addressed***

SCE's SmartConnect is nearly fully deployed. In addition to enabling customer choice and energy management capabilities, SCE plans to leverage this system to enable additional operational enhancements that will benefit its customers.

Outage Management Systems (OMS) are used by operators of electric distribution systems to assess outage conditions and assist in restoration of power. SCE's current system, which is generally consistent with the broader industry, provides information at the circuit level. There is no information with respect to the status of individual customers, and distribution circuits can be miles in length. In order to determine the cause of an outage and the extent of repairs needed to restore power, SCE dispatches a troubleman to patrol the circuit. With SmartConnect, when a customer’s voltage falls below a preset threshold, the smart meter is able to communicate that an outage situation exists. This communication, if accurately linked to OMS, will enable SCE to build a composite picture of the outage and better identify the customers impacted by the outage. Real-time metering information along with voltage data may also contribute to quicker identification of downed lines and could provide an important enhancement to public safety.

An additional meter-enabled enhancement is the ability to enable problem diagnosis, conservation voltage strategies, and automated Volt/VAR control. Prior to the installation of SmartConnect, SCE did not have the means to track voltages at the end of each of its distribution circuits—much less at each of its customers' premises—without deploying a field technician. With SmartConnect being nearly fully deployed, this type of information can be made available and used for a variety of purposes, including diagnosing distribution system issues before they become problems. With access to endpoint and customer voltage information, SCE has the ability to design Advanced Volt/VAR Control (AVVC) systems to better manage distribution voltages and demonstrate voltage reduction strategies. Voltage reduction strategies would effectively reduce power consumption, which translates into lower power procurements and in turn reduces the customer's electric bill.

***<u>How the initiative will advance the strategy and overcome barriers</u>***

OMS that can accurately retrieve outage management information from smart meters are capable of quickly responding to outages. Once OMS are effectively integrated with the utility AMI, there will be faster responses to outages and lower overall costs to both the utility and customers.

The Smart Meter's ability to provide analog voltage values for residential and small commercial and industrial (C&I) customers provides valuable information that can support the diagnosis of distribution issues. In the future, near-real time access to voltage data has the potential to enable SCE to remotely evaluate under- and over-voltage conditions and inform distribution system planners about potential problems.

The following are drivers for and barriers to leveraging the smart meter platform to drive customer service excellence:

a. Linkages between metering systems and grid operations,
b. Regulatory and legislative requirements,
c. System limitations,
d. Operating capabilities,
e. Business case and operating information.

***<u>SCE's Potential Demonstration Projects</u>***

- Beyond the Meter - Customer Device Communications, Unification and Demonstration;
- Outage Management and Customer Voltage Data Analytics Demonstration; and
- Regulatory Mandates - Submetering Enablement Demonstration.

The following table lists the potential demonstration projects and the drivers/barriers they are intended to address.

| SCE Project | Barriers Addressed |
|---|---|
| Beyond the Meter - Customer Device Communications, Unification and Demonstration | a, c, d, e |
| Outage Management and Customer Voltage | a, c, d, f |

| | |
|---|---|
| Data Analytics Demonstration | |
| Regulatory Mandates - Submetering Enablement Demonstration | b, c, d |

### 6.3.2 Integrate Demand Side Management to Optimize the Grid

***Problem or Opportunity to be Addressed***

Market Redesign Technology Upgrade (MRTU) is CAISO's new design for wholesale electricity markets, which commenced on March 31, 2009. Through these markets and through implementation of ancillary services (AS), CAISO ensures that there is sufficient energy capacity to meet electricity demand in California at any given time to maintain the stability of the electrical system. However, there are challenges for implementation of telemetry equipment capable of meeting CAISO requirements for ancillary services. First, CAISO-approved equipment costs are high, between $600 and $50,000 per unit. Second, technical requirements are complex: 4-second or 1-minute updates are required on resource loads; and 5-minute settlements are required when retail meters have 15 minute or 1 hour intervals. Third, an automated demand response (AutoDR) system is required in order for customers to react quickly enough to respond to AS dispatches. These challenges make it costly and technically challenging to extend an AS program to residential customers, which in the aggregate, have the potential to relieve the grid when most stressed.

***How the initiative will advance the strategy and overcome barriers***

Exploration of telemetry and broadband technologies for implementation among all customer segments, particularly among residential customers, is needed to achieve grid reliability and cost effectiveness. Open Automated Demand Response (OpenADR), which requires an active broadband connection, may be utilized to interconnect large C&I customers; ZigBee Smart Energy Profile 2.0 (SEP 2.0) with an Edison SmartConnect meter, may be utilized for residential or small and medium C&I customers.

Market participants, regulatory commissions and third party aggregators will increasingly desire to expand inclusion of DR customer loads into day-ahead and real-time energy markets. Inclusion of small C&I and residential customers will be needed to balance loads and relieve stress on the grid. In addition, as customer-facing technologies such as residential energy storage units (RESUs) and plug-in electric vehicles (PEVs) evolve, it will also become important to evaluate their impact on the grid.

The following are drivers for and barriers to integrating DSM to optimize the grid:

a. Linkages between metering systems and grid operations,
b. Regulatory and legislative requirements,
c. System limitations,
d. Operating capabilities,
e. Business case and operating information.

***SCE's Potential Demonstration Projects***

- Evaluation of Telemetry Equipment for Ancillary Services at Residential Endpoints; and
- Load Scanning to Identify Electric Vehicle Charging Locations.

The following table lists the potential demonstration projects and the drivers/barriers they are intended to address.

| SCE Project | Barriers Addressed |
|---|---|
| Evaluation of Telemetry Equipment for Ancillary Services at Residential Endpoints | a, b, c, d |
| Load Scanning to Identify Electric Vehicle Charging Locations | a, c, d |

### 6.3.3 Respond to Emerging Grid Integration Issues

***Problem or Opportunity to be Addressed***

The rollout of PEVs by startups and major auto manufacturers has provided an opportunity for customers to diversify their transportation fuel source. California consumers are leading the way in this market. The integration of PEVs into the electric grid is a key strategic objective, supporting California's AB 32 goal of reducing GHG emissions to the 1990 level by 2020.

The enablement of AMI in multi-dwelling units (MDUs) remains a challenge due to the location of the apartment dwelling with respect to the meter. The CEC's 2009 Residential Appliance Saturation Study estimates that over half a million SCE residential customers reside in 5+ unit MDUs.[26] Furthermore, it is estimated that most of these customers cannot utilize Home Area Network (HAN) enabling technologies, and therefore cannot participate in most utility EE or DR programs. Preliminary studies have shown that most 5+ unit MDUs have poor or no ability for ZigBee meter communications in the apartment. However, more studies are needed to better characterize the MDU environment. Evaluating how MDUs can leverage AMI technology is an industry-wide issue affecting many utilities throughout the nation.

[26] *Available at* http://www.energy.ca.gov/appliances/rass.

With the proliferation of PEVs and other technologies, like RESUs, SCE expects its distribution system assets will be impacted and, in some cases, over-loaded. SCE will need to more accurately correlate the load profile of its transformers to achieve their useful life and better understand and address the factors contributing to distribution transformer failures. SCE will leverage its SmartConnect capabilities to facilitate this effort.

One potential solution resides in identifying which homes are wired to which transformers. Accurate transformer associations will enable Outage Management and Customer Service groups to support restorations during outages. Distribution Planning can also use transformer load management (TLM) data for sizing transformers appropriately for load management and growth. Additionally, TLM data can be used to identify distribution transformer overload conditions and the corresponding reduction in the useful life of the asset. Finally, the PEV-Readiness group can utilize TLM information to provide more effective and efficient service for its PEV customers.

***How the initiative will advance the strategy and overcome barriers***

A reliable, safe and cost-affordable solution has yet to be developed for MDUs to be able to take advance of AMI technology. The most promising designs and concepts observed in the market today utilize either Power Line Carrier (PLC) or Broadband technology. In the PLC category, some have proposed aggregating ZigBee information using a meter collar, bridging the data to HomePlug Green PHY and sending it over the main wires. At the apartment dwelling, communications will be translated from Homeplug GreenPHY to either ZigBee or Wi-Fi, and from there relayed to an energy information display.

For Broadband, some have proposed aggregating ZigBee information from numerous meters and sending the information to a cloud server for viewing by tenants. Although some designs appear promising, there are several technical and logistical challenges that still need to be overcome before a reliable, safe and cost effective solution can be implemented at mass scale.

With respect to the expected proliferation of PEVs and RESUs, effective TLM data and information will support SCE's ability to schedule preemptive measures including maintenance or replacement to prevent catastrophic failures. Utilizing preemptive measures can avoid cleanup costs from failures and unnecessary field visits required to physically assess transformer-to-home associations. Accurate associations will also improve customer service and decrease costs associated with advanced notification of planned outages. SCE can leverage its existing AMI deployment to facilitate this effort.

The following are drivers for and barriers to responding to emerging grid integration issues:

a. Linkages between metering systems and grid operations,
b. Regulatory and legislative requirements,
c. System limitations,
d. Operating capabilities,
e. Business case and operating information.

***SCE's Potential Demonstration Projects***

- Multi-Dwelling Unit Evaluation Using Power Line Carrier or Broadband Technology; and
- Transformer Load Management Analysis - AMI Load Correlations, Electric Vehicles and Residential Energy Storage Unit Impacts.

The following table lists the potential demonstration projects and the drivers/barriers they are intended to address.

| SCE Project | Barriers Addressed |
|---|---|
| Multi-Dwelling Unit Evaluation Using Power Line Carrier or Broadband Technology | a, c, d, e |
| Transformer Load Management Analysis - AMI Load Correlations, Electric Vehicles and Residential Energy Storage Unit Impacts | a, d |

## 6.4 Cross Cutting/Foundational Strategies and Technologies

After nearly a century of building and operating a power delivery network that fuels economic and societal growth through access to stable and reliable electricity, the electric grid is undergoing a profound transformation. Progressive policy objectives and emerging energy technologies motivate the integration of renewable resources, distributed generation, electric transportation, energy storage and other emerging energy technologies which can undermine the basic principles that support grid reliability today. Specifically, the principles that support the stability and reliability of the electric grid include relying on large synchronous rotating mass in bulk generating plants to provide the inertia needed for the electric grid to manage most loading and transient events without impacting customers. Wind and solar power, distributed generation and power electronics, coupled with decommissioning of once-through-cooling plants, erode the inertia in the system that, if not compensated for, will reduce reliability and stability. Although much work needs to be done with regard to vetting new integration technologies, a thoughtfully designed, smarter electric grid will allow for the integration of new energy technologies with smart controls and will advance SCE's ability to meet policy objectives without degrading the stability of the electric grid.

In order to shift today's electric grid from a system that is robust and reliable largely due to the inertia provided by the rotating mass of traditional generation technologies to a smarter electric grid that increasingly relies on digital technology to maintain stability and achieve a higher level of resilience, utilities must apply a rigorous understanding of control systems theory, power systems protection, computer science and utility operations. Applying these diverse and specialized disciplines in a coordinated approach that yields cost efficient, manageable and reliable solutions requires a clear Smart Grid strategy and architecture approach. The key architecture challenge in evolving the electric grid is to ensure that the introduction of increased automation, connectivity and advanced control systems do not create a system too complex or fragile to manage.

Utility companies have tended to rely heavily on highly customized solutions that were organized in a silo of proprietary devices, communications, security, configuration and control systems. While this approach was efficient for an individual project with clear scope, schedule and cost objectives, if applied to grid modernization in today's context, the result would be a costly and fragile infrastructure that would negatively impact grid reliability. As the grid evolves to integrate new technologies necessary to meet the policy goals, new cross-cutting issues also arise. In order to ensure that the grid modernization efforts the IOUs invest in today will be capable of evolving to meet future needs, a common services architecture, which supports multi-vendor interoperability through the enforcement of standards; well defined architecture layers; and unified smart communications and cybersecurity platforms will be needed.

While large amounts of operations data are available through automation, technology advancements are providing enormous amounts of data relating to system and asset conditions that were never before available or were only accessible in disparate systems. As the utility infrastructures become increasingly digitized and embrace the architectures necessary to integrate distributed resources and provide data to end users, the challenge of cybersecurity and interoperability become more critical to assure the ongoing safe and reliable operation of the most critical infrastructure in the modern economy: the electric grid.

***Priority Initiatives***

California's IOUs worked collaboratively to develop the following priority initiatives, which were reviewed with EPRI's subject matter experts. This effort determined that these are indeed high priority initiatives and that there are gaps with respect to projects, information and data.

- System Architecture;
- Cybersecurity;
- Data Analytics;
- Telecommunications & Standards; and

- Technical Workforce.

SCE expects to utilize approximately $15 million of the funding allocated for this triennial investment plan to address cross cutting/foundational strategies and technologies. The investments contemplated in this section will map to the following elements of the electricity system value chain: Grid Operations/Market Design, Transmission, and Distribution.

### 6.4.1 System Architecture for Smart Grid

***Problem or Opportunity to be Addressed***

As discussed previously, SCE is faced with the need to replace aging utility infrastructure to maintain reliability. This, coupled with the need to change aspects of the system to meet a variety of state and federal energy policy objectives, including increasing infrastructure protection and security requirements, is challenging from both a resource and rate perspective. SCE must make the most of its existing equipment, while also complying with increasing requirements, if it is to continue providing reasonably priced, reliable and safe service to its customers.

In addition to deploying new technologies, advancements in communications and computing capabilities provide the opportunity to link systems together so the grid can operate in an environment with increasingly variable and distributed generation. As customer-owned distributed and variable generation increases, it will add to the complexity of operating the grid and require the deployment of advanced automation and protection strategies to stabilize the grid and keep reliability from eroding.

***How the initiative will advance the strategy and overcome barriers***

The most cost efficient approach to deploying Smart Grid capabilities is to organize technologies and systems in loosely coupled, standards-based layers capable of supporting common services. A Smart Grid common services architecture delivers the capability for any device in the forward deployed networks to access common services (such as cybersecurity, device management, network monitoring, etc.) in SCE's control centers. The common services architecture supports multi-vendor interoperability through the enforcement of standards across the architecture and drives implementation and operational costs down by simplifying the systems design through the elimination of silos that extend from the application layer through the security, communications and device layers. Demonstration of conceptual smart grid architectures (including networking of smart devices operated autonomously into a coordinated smart system adaptable to assimilating additional smart device types over time) that are adaptable to the differences in existing IOU systems would help transform existing operating platforms into those needed to support future system requirements.

The following are drivers for and barriers to leveraging the smart meter platform to drive customer service excellence:

a. Grid reliability due to diminishing inertia and high penetration DER;
b. Regulatory and legislative requirements;
c. Transactive and tariff based mechanisms to integrate and interact with DER resources;
d. Advanced control architectures for customer-owned DER;
e. Advanced cybersecurity and communications designs;
f. Smart inverter specifications and standards;
g. Advanced Distribution Automation;
h. Emerging energy technologies impact on the distribution network.

***<u>SCE's Potential Demonstration Projects</u>***

- Deep Grid Coordination; and
- Irvine Smart Grid Demonstration.[27]

The following table lists the potential demonstration projects and the drivers/barriers they are intended to address.

| SCE Project | Barriers Addressed |
|---|---|
| Deep Grid Coordination | a, b, c, d, e, f, g |
| Irvine Smart Grid Demonstration | a, e, g, h |

### 6.4.2 Cybersecurity

***<u>Problem or Opportunity to be Addressed</u>***

SCE has made significant progress on a foundational cybersecurity solution for the electric grid by developing Common Cybersecurity Services (CCS). SCE is actively engaged in technology transfer of advanced cybersecurity technologies from the defense and intelligence industry to the Smart Grid. CCS is designed to implement security mechanisms to enforce confidentiality, integrity and availability security services and policies that protect electronic information communication and control systems necessary for the management, operation and protection of

[27] In December 2009, SCE was notified that it would receive Public Interest Energy Research funding to support this project. SCE has not received said funding and will use EPIC to support this effort.

the SCE Smart Grid System of Systems (SoS). CCS is specifically designed to satisfy the requirements and standards developed by the Smart Grid Interoperability Panel Cyber Security Working Group and the impending North American Electric Reliability Corporation (NERC) Critical Infrastructure Protection (CIP) Version 5 requirements.

***How the initiative will advance the strategy and overcome barriers***

Implement and demonstrate a common cyber security service that complies with NIST, Federal Information Processing Standards (FIPS) and NERC standards and provides the level of cyber security necessary to mitigate the vulnerabilities inherent in the high levels of connectivity and automation found in Smart Grid technologies.

***SCE's Potential Demonstration Project***

- Technology Transfer Opportunity.

### 6.4.3 Data Analytics

***Problem or Opportunity to be Addressed***

Automation of the electrical system and increased use of smart metering has made it easier to collect large amounts of system data. Some of this data is collected in databases and some is left in field devices. Some data is only used on a periodic basis because there is no easy way to access it and perform the analytics necessary to make use of the data. In addition to SCE data, there are many databases that are publicly accessible (e.g. weather, traffic, social networks). The merging of all of these data sources can help SCE predict conditions that could negatively impact the operation of the electric system and thus better meet customer needs. Another aspect of data analytics is the visualization of the results. If done properly, visualization of the results can give system operators, maintenance staff and customer service representatives access to information, enabling them do their jobs more effectively and efficiently.

***How the initiative will advance the strategy and overcome barriers***

This initiative will address the issue of how to use all of the data being collected today from customer meters, substations, distribution automation devices and maintenance databases. If processed and presented in a clear, concise manner, this data will significantly benefit SCE operators, maintenance personnel, customer service staff and T&D engineers. This project would also allow the merger of data available from sources outside of SCE including weather, traffic patterns and social network feeds. Once data is processed, creative visualization of this data will be prepared for use by SCE system operators, engineers and maintenance personnel.

The use of data analytics can help SCE take full advantage of data that is being collected. These analytics can help reduce outage length, better identify outage locations, determine transformer loading, determine when equipment needs maintenance, predict the extent of system problems, better determine the penetration of distributed generation and help give operators a more strategic view of system operations.

Piloting new data capture, analytics and visualization and correlation technologies will enable new condition-based and risk-based maintenance techniques designed to improve asset efficiency, flexibility and resiliency and potentially extend the use of aging assets. Piloting new complementary equipment and techniques will allow improved operations while keeping the underlying deployed asset in service. This initiative will enable the modernization of the grid without immediate, wholesale equipment replacements and without burdening SCE's customers with unreasonable rate increases.

The following are drivers for and barriers to using existing and new data sources to better leverage existing assets and implement strategies to benefit the safe, reliable and affordable operation of SCE's electricity system:

a. Electric system safety, security and reliability,
b. Regulatory and legislative requirements/recommendations,
c. System limitations,
d. Operating capabilities,
e. Industry standards, and
f. Business case and operating information.

***<u>SCE's Potential Demonstration Projects</u>***

- Wide-Area Security Management and Control;
- State Estimation Using Phasor Measurement Technologies; and
- Substation Automation 3, Intelligent Alarming.

The following table lists the potential demonstration projects and the drivers/barriers they are intended to address.

| SCE Project | Barriers Addressed |
|---|---|
| Wide-Area Security Management and Control | a, b, c, d, e, f |

| SCE Project | Barriers Addressed |
|---|---|
| State Estimation Using Phasor Measurement Technologies | a, c, d, f |
| Substation Automation 3, Intelligent Alarming | a, c, d, f |

### 6.4.4 Telecommunications & Standards

***Problem or Opportunity to be Addressed***

SCE is a key leader in the development and support of interoperability standards. The strategic standards development effort is focused on enabling grid modernization while maximizing system reliability, safety and customer value. SCE believes that proper standards development and adoption will ultimately minimize the risk of full Smart Grid deployments.

It is important to acknowledge that extensive involvement in standards development can pose many challenges to an organization. Such challenges include finding internal resources, both human and financial, to support the relatively long and exhaustive process. Standards often require fairly senior staff that is experienced and knowledgeable. Senior staff is then under significant pressure to not only support important core job functions but to also support the standards development. From a financial perspective, organizations not only need to finance staff for participating in standards development and paying applicable fees, but additionally some organizations resort to consultants to fill in gaps when full-time staff is severely impacted and/or unavailable. Specifically, participation in International Electrotechnical Commission (IEC) standards can be rather difficult for regional electrical utilities to justify travel overseas.

***How the initiative will advance the strategy and overcome barriers***

SCE's vision of a smart grid requires the development, evaluation and implementation of open standards. SCE identified five categories that represent the basis for developing the smart grid: System Integration and Architecture, Data, Communication, Security, and Electrical Interconnection standards. SCE then identified existing standards within these major categories and identified "gaps" within the existing standards. SCE prioritized the standards and assigned resources to either lead, support or monitor the particular standard. Using this process, SCE identified over seventy applicable standards and assigned resources to lead or support over forty standards.

***SCE's Potential Demonstration Projects***

- SCE will use its EPIC projects to continue supporting the development of industry standards.

### 6.4.5 Technical Workforce

***Problem or Opportunity to be Addressed***

As the transmission and distribution grid continues to evolve with the deployment of new technologies and greater systems integration (i.e., variable generation, IT, communications, etc.), SCE must also continue to evolve work practices and tools to ensure it has the ability to provide, operate and maintain a safe, reliable and affordable grid. SCE anticipates a wide range of workforce challenges including managing and operating an increasingly complex infrastructure while maintaining customer privacy, transferring knowledge as an aging workforce retires and leveraging data from new technologies. To meet these challenges, SCE is committed to focusing on improving the efficiency, safety and effectiveness of its entire staff from field services to operational support.

***How the initiative will advance the strategy and overcome barriers***

SCE fosters collaborative ventures with leading research universities in the region, which have led to the creation of the Southern California Smart Grid Research Consortium. This group brings together academia and industry experts to help solve Smart Grid challenges through mutually beneficial basic and applied research opportunities. SCE believes that industry and university collaboration is of paramount importance to spur innovation and in developing new methods, ideas, and technologies for a cleaner, smarter energy future. The consortium has held annual workshops over the past three years, attracting increasing numbers of undergraduate, graduate and Ph.D. students, faculty, and private sector leaders to discuss research opportunities. SCE also collaborates with California's community colleges and technical schools to ensure a balance of research and practical application of new skills and knowledge. Additionally, SCE sponsors internships for students focused on a future in energy.

SCE will continue to work with the State of California and its schools and training institutes to develop a workforce of the future that can maintain and benefit from the grid of the future. For example, SCE has discussed a near term and practical approach to addressing some of the workforce issues with California State University, Sacramento. These discussions, which need further collaboration to result in actual projects, suggest engaging small, focused groups of SCE employees in defining the workforce knowledge, skills, and abilities expected to support Smart Grid technology deployments. Timed to a specific business validation project, a small employee work group would outline how the work would change in the environment created by that particular technology (e.g., substation automation). The team would represent a cross-section of the full workforce spectrum, from engineers to customer service representatives. Work group focus sessions will outline the knowledge, skills, and abilities that would be needed for this project.

A specification would be developed for educators to follow in developing curricula, emphasizing practical student learning outcomes. SCE would work with educators – internal and public postsecondary - to develop courses that can be delivered to employees and potentially be incorporated into degree or certificate programs. This combination of programs will result in a training delivery system that will enable the pilot project to scale to full deployment.

Given the huge variety of careers at SCE, different positions will need new and improved skill sets; however, all careers at SCE in the future will need to evaluate and leverage:

- New technologies for advanced work management;
- Knowledge management to ensure specialized information is disseminated as an aging workforce retires; and
- New communications and integration of systems to leverage increasing amounts of field data.

***SCE's Potential Demonstration Projects***

- Fund university engineering programs, senior design projects related to new loads, inverter controls, demand response technologies; and
- Fund university studies and model development to demonstrate technology readiness.

## 6.5 IOU Applied Research & Development

In D.12-05-037, the Commission stated "The investment plans for the EPIC program shall become the primary vehicle for considering utility proposals for electric research, development, and deployment (RD&D) purposes."[28] The Commission also contemplated other possible categories of expenditures when it stated, "Any additional fund shifting beyond 5% or to new categories of funding must be approved separately by the Commission."[29] Additionally, since EPIC is intended to become "the primary vehicle considering utility proposals for electric research, development and deployment (RD&D) purposes," SCE proposes that the Commission

[28] D.12-05-037, OP 17.
[29] D.12-05-037, OP 14.

allocate EPIC Applied Research and Development funding to the IOUs, consistent with long-standing research and development programs.

IOU engagement in EPRI's Annual Research Portfolio (ARP) programs is important and should be authorized. EPRI is one of the most cost-effective ways to track the progress of Applied R&D around the world. Today's applied R&D elsewhere in the world can be a future technology demonstration and deployment solution to California's needs. Involvement in EPRI's ARP is especially critical in a program like EPIC that is intended to last until at least 2020, so that IOUs can observe and provide input on future technologies.

Participation in EPRI ARP programs would enable the funds from California customers to be leveraged with funds from other utilities and governmental organizations worldwide. This aligns with the Commission's statement encouraging "the use and leveraging of matching funds whenever possible."[30] Collaborative, applied R&D through EPRI provides an average 10-to-1 funding leverage in EPRI ARP programs; that is, on average, for every one dollar each participant funds toward a program, there are an additional ten dollars of funding added from other program participants.

By engaging collaboratively through EPRI with industry experts and utilities around the world, the California IOUs are assured that projects and initiatives they invest in will build upon past progress. Nearly every other major utility in the U.S. participates in EPRI ARP programs – to not participate in them would make California and its IOUs an exception in the electricity sector and exclude them from much of the progress in applied R&D that is being made through collaboration. If California does not participate in global R&D collaboration, it would increase the opportunity for redundant investment in areas that have already been addressed in the U.S. or elsewhere. EPRI's members represent nearly 90 percent of the electricity generated and delivered in the United States, and international participation extends to approximately 30 countries, making EPRI participation by California IOUs a strong resource for collaborative, applied R&D to benefit California customers.

Global and national product development, as well as education and awareness campaigns, increase system and component volumes that support California consumers through reduction in costs of those electricity systems and vehicles.

[30] D.12-05-037, at 44.

# 7. Program Administration

The EPIC program is a coordinated statewide RD&D program.[31] The program administrators have engaged in numerous meetings and conference calls and have consulted with stakeholders in workshops during the development of their respective investment plans.[32] This investment plan incorporates important and valuable input from these stakeholder workshops, including the addition of a summary of gaps analysis, a brief discussion on IOU-administered, full-spectrum RD&D, and a California best practice for ensuring overall program coordination and collaboration.

To maximize customer benefits, the program administrators have agreed to pursue the following principles for cooperating and collaborating for EPIC-funded energy RD&D programs:

- **Information Sharing Coordinated Planning.** The EPIC Administrators will work together to address common goals, consistent with the State's energy and environmental policies and the guiding principles for energy RD&D as stated in the CPUC's EPIC decision. To this end, the EPIC Administrators will share information regarding their EPIC investment plans, programs and projects as much as practicable in order to maximize the efficient use of the funds and facilitate the dissemination of the results of the program efforts for the benefit of utility customers.
- **Leveraging Funding and Avoiding Duplication of Projects.** Consistent with the policy espoused in Public Utilities Code section 740.1, the EPIC Administrators have agreed to consult with each other to avoid unnecessary duplication of efforts and the waste of customer funds.
- **Consistent Evaluation, Measurement and Verification of RD&D Results.** The EPIC Administrators will work together to establish consistent and common evaluation, measurement and verification protocols for developing and reporting to the CPUC and stakeholders the performance and results of EPIC funded projects.
- **Coordinated Input and Advice from Stakeholders.** The EPIC Administrators will continue working together to schedule, solicit and respond to comments and advice from stakeholders on their respective proposed and on-going EPIC Plans and programs.
- **Intellectual Property.** The EPIC Administrators will work together and use best efforts to agree on common approaches to intellectual property rights to facilitate the dissemination and sharing of EPIC funded RD&D results for the benefit of electric utility customers and the State.

[31] D.12-05-037, Findings of Fact 9.

[32] *See* D.12-05-037, OP 15.

## 7.1 Program Coordination

D.12-05-037 requires stakeholder consultation but does not institute a formal advisory board. In addition to stakeholder consultation, SCE proposes an annual coordination meeting between program administrators and this Commission to discuss the respective EPIC portfolios, avoid any unnecessary duplication of effort and identify opportunities for joint funding and leveraging. While this would in no way preclude the administrators from communicating as often as needed to appropriately coordinate EPIC, it would provide a formal opportunity to discuss the respective portfolios with this Commission and provide for proper oversight. Moreover, this coordinating meeting is consistent with the now defunct California Utility Research Council (CURC) meeting, previously codified in Public Utilities Code sections 9201 - 9203.[33] CURC was raised at the August 17 EPIC Stakeholder Workshop as a model for coordinating the efforts of the EPIC administrators. To avoid unnecessarily duplicative efforts, as well as limit the administrative costs associated with conducting duplicative gap analyses, SCE proposes that EPRI participate in this annual meeting to provide an international overview of RD&D efforts and participate in the discussion of EPIC projects. As one of the foremost experts in electricity research, development and demonstration and the developer of various technology roadmaps and gap analyses, EPRI is uniquely positioned to assist the EPIC administrators in identifying needed demonstration activities and leveraging these efforts with the rest of the industry and other research organizations.[34] While the EPIC administrators would not be precluded from doing gap analyses to further identify opportunities and support project selection activities, EPRI would provide a standard framework from which the EPIC administrators and the CPUC could base their discussions.

## 7.2 Contracting

With respect to expenditures for technology demonstration and deployment projects, the Commission provides the option of allocating funds either on a grant basis or on a pay-for-performance basis.[35] While SCE appreciates and remains open to both options, the nature of the demonstration and deployment projects will typically call for the use of the pay-for performance option. This pay-for-performance option is generally used for all types of utility procurements, and for which SCE has long-standing and documented procurement policies and procedures. For the purposes of EPIC, SCE will follow these established policies and procedures. With respect to the Commission's preference to award EPIC funding on a

[33] These sections of the Public Utilities Code, enacted in 1984 (repealed in 2003 because IOUs no longer had RD&D programs requiring coordination), helped the customer-funded research efforts achieve goals that are entirely consistent with EPIC and Public Utilities Code section 740.1.

[34] EPRI's participation in this coordination meeting is also consistent with the CURC meetings.

[35] D.12-05-037, Findings of Fact 19.

competitive basis,[36] SCE generally agrees, but reserves the right to use non-competitive awards consistent with existing business practices.

The following are examples of when non-competitive awards may be used, which are entirely appropriate for research, development, demonstration and nascent technology awards:

- Material or services required are available from only one responsible source and no other supplier will satisfy utility requirements.
- Bidding is cost prohibitive relative to the cost of materials or services needed.
- An opportunity exists (under an established ceiling amount) to develop Diverse Business Enterprise suppliers.
- Equipment, materials, or services are obtained for trial testing, research or experimental work.
- The procurement provides special discounts, rates, or terms and conditions (e.g., cost share) that are not available in the market under normal competitive conditions.

In an attempt to better establish direct benefits for the customers funding EPIC, SCE will define selection criteria for EPIC projects with a preference for California academic institutions, research organizations and vendors. However, this will in no way preclude SCE from selecting the entity best able to successfully support a project or projects.

## 7.3 Intellectual Property

SCE agrees with and supports the Commission's decision to tailor intellectual property decisions to each specific project.[37] To adopt an overall policy at this time would be premature. For purposes of EPIC, SCE will generally use the following approaches with respect to intellectual property:

- Intellectual property developed under EPIC may be retained as a utility asset. [PG&E and SDG&E approach quoted in D.12-05-037 at p.78] This approach provides customer benefits by securing utility usage rights for a technology or process with the potential for broader benefits. Under the CPUC's Affiliate Transactions OIR (R.97-04-011), each of the IOUs has established a means to share Other Operating Revenues with customers.

[36] D.12-05-037, Findings of Fact 18: Projects should be selected for award of EPIC funding on a competitive basis unless the administrators have specifically detailed and justified exceptions to this in their approved investment plans.
[37] D.12-05-037, Conclusion of Law 28.

Under the respective mechanisms, commercialization of the intellectual property developed under EPIC may also provide a financial customer benefit.[38]

- Intellectual property developed under EPIC may be retained by the vendor, contractor or entity that developed the intellectual property.
- The IOU administrators may also pursue an "open innovation" approach to the intellectual property developed under EPIC. Under this approach, the IOU developing the intellectual property may file patents to protect the intellectual property, while making it freely available for broad industry adoption and utilization. This approach provides customer benefits by promoting open collaboration, interoperability, standards and broader vendor competition and diversity.

## 7.4 Project Reporting and Information Dissemination

Consistent with Ordering Paragraph 16 of D.12-05-037, SCE will prepare an annual report for its EPIC activities that includes a high-level summary for each project, the amount of funds expended to date and the anticipated customer benefits associated with the project.

SCE will also prepare a final report for its EPIC projects, describing the issue or problem addressed by the project, the approach and analysis, findings, and recommendations for subsequent efforts.

Consistent with existing business practices, SCE will publish papers, share testing results and make presentations to a variety of academic, industry and standards organizations, including: DOE, EPRI, IEEE, NIST, North American Energy Standards Board, North American SynchroPhasor Initiative, NREL, Sandia National Labs, Oak Ridge National Labs, WECC, and others. SCE will also use the experience gained from conducting EPIC projects to help inform this Commission, NERC, FERC and state and federal legislators on the state of energy technology. As noted in Section 2, SCE's Advanced Technology group has consistently made important contributions in a variety of CPUC rulemakings.

## 7.5 Metrics

As noted above, all of the EPIC Administrators will work together to establish consistent and common evaluation, measurement and verification protocols for developing and reporting to the CPUC and stakeholders the performance and results of EPIC funded projects. The development of consistent metrics for utilization across different program administrators will require additional collaboration, which was not possible under the established timeframes.

[38] SCE's Gross Revenue Sharing Mechanism, as approved by the CPUC, is published as Preliminary Statement G to SCE’s electric tariffs.

In compliance with Ordering Paragraph 12.c of D.12-05-037, the following are the metrics by which the success of SCE's Investment Plan should be judged:

- Potential energy and cost savings;
- Job creation;
- Economic benefits;
- Environmental benefits;
- Identification of barriers or issues resolved that prevented widespread deployment of technology or strategy;
- Effectiveness of information dissemination;
- Adoption of technology, strategy, and research data by others;
- Funding support from other entities for EPIC-funded research on technologies or strategies; and
- Other benefits.

## 7.6 Allocation of Programmatic Funding to the CEC

In an effort to safeguard EPIC funding from diversion and in compliance with CPUC directives,[39] the IOUs will provide administrative budget allocations to the CEC on a quarterly basis beginning on July 1, 2012, and to the CPUC on an annual basis beginning on July 1, 2012. Additionally, the IOUs will work with the CEC to establish processes to remit programmatic funding from the EPIC balancing accounts when funds are encumbered by the CEC. The IOUs propose a quarterly process that coincides with the administrative budget allocations and will consider funds encumbered when projects are approved by the CEC at a Business Meeting or other public venue where the CEC makes such decisions. After receiving appropriate approvals, the CEC will issue a letter to each of the utilities, detailing the projects and amounts approved and requesting the remittance of funding. This letter must be received 30 days prior to the expected quarterly remittance date. *The IOUs are in no way responsible for monitoring the CEC Business Meetings or other meetings for this purpose, nor is SCE responsible for validating the accuracy of the CEC request.* After receiving the request, each IOU will remit its portion of the funding requested (i.e., PG&E 50.1%; SCE 41.1% and SDG&E 8.8%) as established in Decision 12-05-037. This will provide ample lead time for the CEC to negotiate contracts for the "approved" projects.

In preliminary discussions with CEC management, this process was found to be acceptable.

[39] D.12-05-037, OP 9-10 and Conclusion of Law 23.

## 7.7 Energy Efficiency and Demand Response Emerging Technology Programs

Ordering Paragraph 12.b.3 of Decision 12-05-037 requires the IOU administrators to provide an informational summary of the research, development and demonstration activities they are undertaking as part of their approved energy efficiency and demand response portfolios. This section is intended to meet this requirement.

With respect to Energy Division staff concerns that the respective EPIC administrators may use EPIC funds to duplicate efforts in existing Energy Efficiency and Demand Response programs, SCE has neither the incentive nor the inclination to do so. SCE may use EPIC funding to make EE and DR data and information usable for system planning and operations purposes, but only to the extent that it does not infringe on existing programs.

### 7.7.1 Energy Efficiency

Through the Emerging Technologies Program (ETP), SCE undertakes research, development, and demonstration activities as part of its energy efficiency portfolio. The ETP mission is to support increased energy efficiency market demand and technology supply (the term supply encompassing breadth, depth, and efficacy of product offerings) by contributing to development, assessment, and introduction of new and under-utilized energy efficiency (EE) measures (i.e., outreach, technologies, practices, and tools), and by facilitating their adoption as measures supporting California's aggressive energy and demand savings goals.

SCE's Energy Efficiency ETP will leverage all complementary efforts and entities in support of its mission, including other statewide and local investor-owned utility energy efficiency programs; statewide utilities' emerging technologies programs; and energy efficiency innovation activities by external organizations such as private industry, industry trade organizations, corporate laboratories, the California Energy Commission's Energy Research and Development Division ("ER&DD"), the U.S. Department of Energy ("DOE") and national laboratories, and regional, national and international ETP partners including utility, academia, nongovernmental organizations, and other market stakeholders.

SCE's 2013 – 2014 Proposed Emerging Technologies Budget and Activities

| Emerging Technologies Sub-Program | Total 2013-2014 Proposed Budgets |
|---|---|
| Technology Development Support | $3,684,510 |
| Technology Assessments | $8,284,797 |
| Technology Introduction Support | $9,216,123 |
| **Total ETP** | **$21,185,430** |

Program Description

SCE will utilize three sub-program elements in a comprehensive effort to address the range of energy efficiency market barriers that ETP can either influence directly or through efforts supporting other energy efficiency and Integrated Demand-Side Management (IDSM) programs:

1. Technology Development Support: The ETP will look for targeted opportunities to support energy efficiency product development. Product development is the process of taking an early-stage technology or concept and transforming it into a saleable product. (Early-stage technologies are often the output of R&D work, hence product development bridges the gap between R&D and the market.) An example of an early-stage technology is a light-emitting diode. The product development process has resulted in televisions, computer monitors, illuminated signs, and lighting fixtures.
2. Technology Assessments Subprogram: Energy efficient measures that are new to a market or under-utilized for a given application will be evaluated for performance claims and overall effectiveness in reducing energy consumption and peak demand. ET assessments may utilize data/information from different sources including: in situ testing (customer or other field sites), laboratory testing, or paper studies may be used to support assessment findings. In addition to other findings and/or information, assessments typically would generate the data necessary for energy efficiency rebate programs to construct a work paper estimating energy and demand savings over the life of the measure. Assessment proposals are screened before an assessment is initiated.
3. Technology Introduction Support: This sub-program consists of placing a number of measures at customer sites as a key step to gain market traction and possibly gain market information. The measures will typically have already undergone an assessment or similar evaluation to reduce risk of failure. While the number of units in scaled field placements will vary widely, numbers typically larger than in an assessment of the technology are expected. Monitoring activities on each scaled field placement will be determined, as appropriate.

The ETP supports California's energy and demand savings targets as defined by the following regulatory and legislative sources:

- The Energy Efficiency Policy Manual;[40]
- The Energy Efficiency Rulemaking providing guidance for 2013-2014 portfolios (2013-2014 Decision);[41]
- The 2010-2012 Energy Efficiency (EE) Decision;[42]
- CPUC guidance in Rulemaking 06-04-010;[43]
- The CPUC's California Long Term Energy Efficiency Strategic Plan[44], with particular focus on the initiatives in the domains of residential and commercial ZNE buildings, HVAC industry transformation, as well as lighting innovation; and
- The California Global Warming Solution Act of 2006 (AB 32).

Specific examples of the projects currently in progress include:

- Residential Human Comfort Behavioral Study for Low Energy Cooling;
- ZNE Office Demonstration Showcase;
- Hot/Dry Air Conditioner;
- Commercial Tubular Daylighting System;
- Metal Halide Electronic Dimmable Ballast (EDB) Outdoor Reliability;
- Small Commercial LED and Controls;
- Hospitality Variable Refrigeration Flow Systems Field Assessment;
- Microwave Controlled Advanced Street Lighting;
- Oxygen Transfer Efficiency Optimization for Waste Water Treatment Plants;
- Ground Coupled Space Conditioning System Technical Potential;
- LED Street Lighting;
- ZNE Inverter Grid Impact Study; and
- Smart Multi-family Domestic Hot Water Recirculation Pump

### 7.7.2 Demand Response

SCE's Emerging Markets & Technology (EM&T) program executes projects to explore innovative and cost effective DR technologies, understand customer preferences and market

[40] Energy Efficiency Policy Manual, Version 4, July 2008.
[41] D.12-05-015.
[42] D.09-09-047.
[43] Order Instituting Rulemaking to Examine the Commission's post-2005 Energy Efficiency Policies, Programs, Evaluation, Measurement and Verification, and Related Issues.
[44] *Available at* http://www.cpuc.ca.gov/NR/rdonlyres/D4321448-208C-48F9-9F62-1BBB14A8D717/0/EEStrategicPlan.pdf

potential and provide input on DR codes and standards to enable customer participation in SCE's DR programs.

SCE's 2012 – 2014 Authorized EM&T Budget

| Program | Total 2012-2014 Authorized Budget |
|---|---|
| Emerging Markets & Technology | $7,303,969 |

Program Description

SCE's EM&T program will focus on three primary areas in an effort to evaluate new technology solutions, increase their adoption in the market, and improve participation in current and future DR programs:

1. Advance DR in codes and standards. This effort includes ongoing research and advocacy for the inclusion of DR capabilities in codes and standards such as California appliance and building efficiency regulations,[45] Leadership in Energy and Environmental Design (LEED), and EnergyStar. Participation in the development of national SmartGrid standards such as Smart Energy Profile and OpenADR are also part of this focus area.
2. Expand Residential, Commercial, and Industrial DR. This focus area includes identifying and testing new technology solutions such as communicating thermostats, energy displays, load controllers, energy management systems, gateways, energy storage devices, smart appliances, electric vehicle supply equipment (EVSE), building management systems, lighting controls, and other devices with DR potential. Lab testing is followed by field testing/pilots where the load impact, dispatch reliability, and DR strategies are quantified and documented for consideration in existing or future DR programs.
3. Explore Technical Aspects of Whole Market Integration. Efforts in this area focus on the requirements for DR to participate in the wholesale electricity market and integration of DR in broader Integrated Demand Side Management (IDSM) efforts. Activities include exploration of telemetry solutions, quantification of program performance, and collaboration with other SCE groups to develop and demonstrate IDSM solutions.

Additional detail regarding the EM&T program is provided in the following:

- D.12-04-045 (adopting DR activities and budgets for 2012 through 2014)

[45] *See* California Code of Regulations, titles 20 and 24.

- SCE EM&T Demand Response Projects Semi-Annual Report: Q1-Q2 2012[46]

Specific examples of the EM&T projects currently in progress include:

- DR opportunities with a Permanent Load Shift (PLS) system
- Development of a certification program for lighting professionals
- A market study evaluating DR potential in mid-size commercial buildings
- LED and advanced lighting controls DR field test
- A demand response partnership program to advocate DR LEED credits
- Augmenting AMI DR with broadband communication
- A home battery DR pilot
- Expanding residential DR as part of the Irvine Smart Grid Demonstration (ISGD) Project
- Evaluating Auto-DR capable thermostats for small commercial customers
- Evaluating DR technology for controlling residential pool pumps
- Determining DR potential of smart appliances
- Exploring potential for Agricultural water pumps to participate in an Ancillary Services DR program

# 8. State Policy Direction for IOU-Administered RD&D and Smart Grid Programs

As discussed more fully below, SCE's proposed investment plan furthers the policies and objectives of Public Utilities Code sections 740.1 and 8360.[47] In compliance with Ordering Paragraph 12.e, this section will detail how the investment plan framework applies the statutory principles in the respective Code sections. While not required under EPIC, the IOUs intend to fully comply with the Code sections in the administration of their respective programs. Research, development and demonstration funding and utility resources are of limited supply. From a California IOU perspective, it makes sense to adhere to the rationale and emphases established in these statutes.

[46] *Available at* http://www3.sce.com/sscc/law/dis/dbattach10.nsf/0/81AB34A8081EA8E888257A8A006371EA/$FILE/A1103001+et+al+2012-2014+DR+App+-+EM&T+Demand+Response+Projects+2012+Semi-Annual+Report.pdf.

[47] As noted above, SCE does not waive any of its arguments regarding the legality of the EPIC program.

## 8.1 Public Utilities Code Section 740.1

Public Utilities Code section 740.1 requires that this Commission consider a set of guidelines in evaluating the research, development and demonstration projects proposed by electrical and gas corporations.

The first guideline provides that projects should offer a reasonable probability of providing benefits to ratepayers. In other words, projects should focus on providing customer benefits, as opposed to general societal benefits. It should be noted that even when research, development and demonstration projects do not provide a direct benefit to customers, the results of the projects, both positive and negative, may often produce indirect benefits in the form of worthwhile information for future projects in a variety of areas. The IOU administrators will select projects that they hope will offer the best probability of direct customer benefits and will also utilize a preference for contracting with California entities in order to provide direct economic benefits.

The second guideline provides that expenditures on projects with a low probability for success should be minimized. While the IOUs will seek to minimize funding for such projects, it should be noted that technologies go through the demonstration phase to prove their viability and cost effectiveness and thus are not guaranteed to be successful.

The third guideline requires that projects remain consistent with the corporation's resource plan. It is unlikely that IOU administrators would ever be motivated to pursue projects that are inconsistent with their respective corporate resource plans. For purposes of this section, the IOU administrators interpret this guideline to mean projects should relate to the established loading order, broader state energy policy objectives, and IOU safety, reliability and affordability objectives

The fourth guideline compels IOUs to avoid unnecessarily duplicating research being done by another entity. This particular guideline was brought up as a concern at the joint IOU workshop and in discussions with Energy Division staff. As noted above, the IOU administrators receive no benefit in utilizing limited funding and resources to unnecessarily duplicate work done by others. To allay concerns of duplication, SCE has included a Discussion of Gaps in Section 5 (although it was not required per D.12-05-037) and is proposing to formalize certain aspects of now-defunct CURC as a California best practice in the administration of EPIC. This would include working with EPRI as part of EPIC administration and avoiding duplicating gap analyses for each IOU program administrator (See Program Administration, Section 7).

The final guideline involves each project supporting at least one of the following objectives: (1) environmental improvement; (2) public and employee safety; (3) conservation by efficient resource use or by reducing or shifting system load; (4) development of new resources and processes, particularly renewables resources and processes that further supply technologies; (5) and improving operating efficiency and reliability or otherwise reducing operating costs. Environmental improvement and public and employee safety are incorporated into each of the proposed EPIC Funding Categories.

- With respect to the conservation and load-shifting objective, these topics are primarily covered by existing IOU Energy Efficiency and Demand Response programs. Energy Division staff are concerned that there may be overlap between these existing efforts and EPIC. The IOU administrators have no intention or incentive to duplicate efforts and will focus EPIC funding in this area toward system and operations integration technologies and strategies. The Customer Products/Services Enablement and Integration Funding Category was designed to address this objective.
- IOU administrators are prohibited from conducting generation-only demonstration projects. As such, adherence to the objective to develop or further new supply side resources is achieved by demonstrating novel strategies and technologies that facilitate their safe and reliable integration into the grid. The Renewables & Distributed Energy Resources Integration Funding Category was designed to address this objective.
- The fifth and final objective under this section is to improve operating efficiency and reliability or otherwise reduce operating costs. As IOUs continue to replace aging infrastructure, they will deploy assets that support the system's ability to meet both existing and future requirements, while avoiding the unnecessary stranding of assets. The Advanced Asset Management & Optimization Funding Category was designed to address this objective.

## 8.2 Public Utilities Code Section 8360

Public Utilities Code section 8360 states that it is the policy of California to modernize the state's electrical transmission and distribution system to maintain safe, reliable, efficient, and secure electrical service, with infrastructure that can meet future growth in demand and achieve ten separate objectives, which together characterize a smart grid. The IOU administrators' proposed funding categories, described in SCE's EPIC Investment Plan (Section 6), were designed to address each of the ten objectives described in Public Utilities Code section 8360.

As described in Section 6.1 of this investment plan, the Renewable and Distributed Energy Resource Integration funding category is intended to support the safe, reliable and affordable integration of renewable and distributed energy resources. This funding category directly supports the integration aspect of Public Utilities Code section 8360(c) regarding the deployment and integration of cost-effective distributed resources and generation, including renewable resources. It also supports the deployment and integration of cost-effective advanced electricity storage as stated in section 8360(g) and the identification and lowering of unreasonable or unnecessary barriers to adoption of smart grid technologies, practices and services as stated in section 8360(j).

Section 6.2 of this document describes the Grid Modernization & Optimization funding category. This funding category directly supports the following paragraphs in Public Utilities Code section 8360:

(a) Increased use of cost-effective digital information and control technology to improve reliability, security and efficiency of the electric grid;

(b) Dynamic optimization of grid operations and resources, including appropriate consideration for asset management and utilization of related grid operations and resources, with cost-effective full cyber security;

Section 6.3 of this document describes the Customer Products/Services Enablement and Integration funding category. This funding category does not duplicate the efforts in existing SCE Energy Efficiency and Demand Response programs, but rather provides the funding and resources needed to directly support the following objectives in Public Utilities Code section 8360:

(d) Development and incorporation of cost-effective demand response, demand-side resources and energy-efficient resources.

(e) Deployment of cost-effective smart technologies, including real time, automated, interactive technologies that optimize the physical operation of appliances and consumer devices for metering, communications concerning grid operations and status and distribution automation.

(f) Integration of cost-effective smart appliances and consumer devices.

(g) Deployment and integration of cost-effective advanced electricity storage and peak-shaving technologies, including plug-in electric and hybrid electric vehicles, and thermal-storage air-conditioning.

(h) Provide consumers with timely information and control options.

(i) Develop standards for communication and interoperability of appliances and equipment connected to the electric grid, including the infrastructure serving the grid.

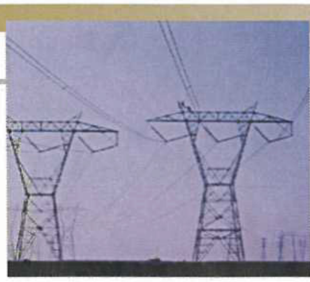
(j) Identification and lowering of unreasonable or unnecessary barriers to adoption of smart grid technologies, practices, and services.

Section 6.4 of this document describes the Cross Cutting Demonstration and Deployment funding category. The goal of this funding category is to provide foundational and cross-cutting utility systems, facilities and programs needed to support interoperability and cybersecurity in the application of new smart grid technologies. This funding category directly supports and is an essential element of each and every goal as described in Public Utilities Code section 8360.

# Appendix A

# ADVANCED TECHNOLOGY

Transmission & Distribution Business Unit



# Southern California Edison Smart Grid Strategy & Roadmap

SOUTHERN CALIFORNIA EDISON®

An EDISON INTERNATIONAL® Company

In 2007, Southern California Edison developed its first comprehensive Smart Grid Roadmap spanning transmission, distribution and customer facing technologies. Since that time, national and state policy regarding smart grid development has significantly grown including the passage of the landmark Energy Independence and Security Act of 2007 (EISA). In 2009, California passed its version in Senate Bill 17.

The purpose of this updated Smart Grid Strategy and Roadmap is to summarize SCE's activities and plans for development and implementation of a smarter grid as well as explain the organizing principles, decision framework and methods used to manage the adoption and adaptation of new technologies into our operation. While we hope that the document proves useful for all readers, it is intended primarily to convey SCE's perspectives on the smart grid for policy makers, the electric utility industry, and technology providers which serve our industry.

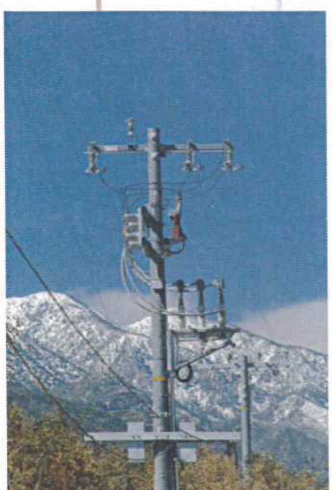
SCE is grateful for the supporting contributions by IBM, Enernex, Cisco, Quanta and EPRI to the development of this document that began with expanding the set of Use Cases to encompass the breadth of the smart grid. We also appreciate the earlier support by Bridge on the development of the 2007 roadmap that was the foundation for this effort. Finally, we appreciate the reviews provided by our Technology Advisory Board, PG&E and SDG&E, and Jesse Berst.

## Table of Contents

# 1. Introduction

## 1.1. Why do we need a smarter grid?

The United States has arrived at a critical juncture in its energy future. The stakes for addressing climate change, energy independence and infrastructure security could not be higher. Federal and state policymakers alike have recognized the need for a smarter, more robust electricity infrastructure if we as a country are to rely on greater amounts of renewable generation, use electricity as a fuel for vehicles, enable consumers to become active participants in the energy supply chain, and ensure the continued reliability and vitality of our nation's energy economy. Southern California Edison (SCE) must meet these challenges while continuing to operate the grid in a safe and reliable manner. SCE has served as a leader in fostering the development of advanced grid technologies and the adoption of technology to create a smarter grid.



SCE recognized the need for the development of a smarter grid more than a decade ago. This need was heightened with the wide range of climate and energy policy objectives introduced earlier in the last decade after the 2001 California Energy Crisis. Also, post dot-com venture investment in clean technology has yielded several emergent technologies that have made certain aspects of a smart grid more viable. In 2007, SCE developed a detailed smart grid technology roadmap across five themes described in our Smart Grid Vision in section 1.2. Many elements of this earlier roadmap are valid and continue to be pursued. However, over the past three years a number of additional policy targets have been introduced to create a very aggressive set of goals that have implications for development of a smarter grid. It is important to note that it is not entirely clear that all these policy targets are viable given the technology development and deployment timelines and customer rate impacts. Figure 1 below summarizes the current California policies affecting smart grid development.

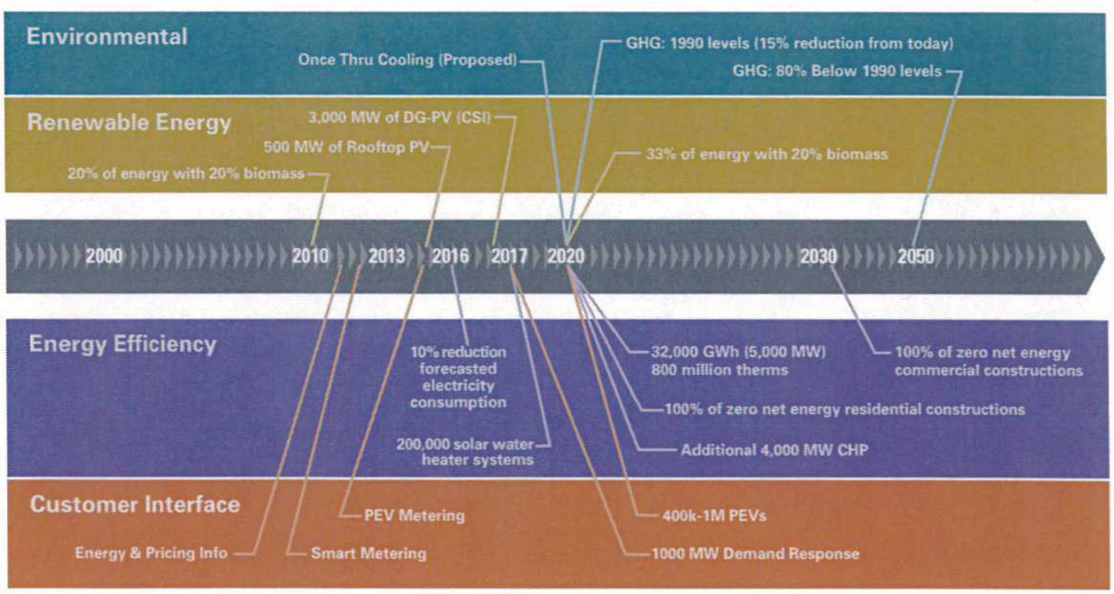



*Figure 1 - California Smart Grid Policy Timeline*

The breadth of the change required for modernizing the nation's electricity grid is highlighted by the policy objectives defined in the federal Energy Independence and Security Act of 2007 (EISA). This law identifies the following specific capabilities that should be enabled by a smart grid:

| 2007 EISA Smart Grid Policy |
| --- |
| 1. Increased use of digital information and controls technology to improve reliability, security and efficiency of the electric grid. |
| 2. Dynamic optimization of grid operations and resources, with full cyber-security. |
| 3. Deployment and integration of distributed resources and generation, including renewable resources |
| 4. Development and incorporation of demand response, demand-side resources and energy-efficiency resources. |
| 5. Deployment of smart (real-time, automated, interactive) technologies that optimize the physical operation of appliances and consumer devices for metering, communications concerning grid operations and status, and distribution automation. |
| 6. Integration of smart appliances and consumer devices. |
| 7. Deployment and integration of advanced electricity storage and peak-shaving technologies including plug-in electric and hybrid electric vehicles, and thermal storage air conditioning. |
| 8. Consumer access to timely information and control options. |
| 9. Development of standards for communication and interoperability of appliances and equipment connected to the electric grid including the infrastructure serving the grid. |
| 10. Identification and reduction of unreasonable or unnecessary barriers to the adoption of smart grid technologies, practices and services. |

*Table 1 - 2007 EISA Smart Grid Policy*

These same objectives were incorporated into a recent California law, Senate Bill (SB) 17, which was enacted in October, 2009. The law recognizes the need for a smarter grid to support California's ambitious energy and environmental policies such as the Renewables Portfolio Standard[1], greenhouse gas reduction law[2], energy efficiency standards including requirements for Zero-Net Energy Homes, distributed resource goals like the California Solar Initiative, demand response objectives and support for widespread consumer adoption of plug-in electric vehicles (PEV). In this context, SCE believes that many aspects of its smart grid vision would need to be operational by the year 2020 to enable a number of California's ambitious policy goals. In recognition of this challenge, SB 17 requires investor owned utilities to prepare a 2020 smart grid development plan and file it with the CPUC by July 1, 2011. The parameters of this development plan will be identified in the Smart Grid OIR in the summer of 2010.

While many details regarding development of a smart grid need to be resolved, including scope, standards, benefits, cost and timing, one thing is clear: We as an industry need to modernize our electric grid in order to support an increasing reliance on electricity to fuel the nation's economy.

***"...we'll also do more to retrofit America for the global economy. That means updating the way we get our electricity by starting to build a new smart grid that will save us money, protect our power sources from blackout or attack, and deliver clean, alternative forms of energy to every corner of our nation."***

***– President Barack Obama, January 2009***

*1 California's Renewables Portfolio Standard (RPS) requires that 20% of electricity sales be from renewable sources by 2010. In September 2009, Governor Schwarzenegger signed an Executive Order raising the RPS target to 33% by 2020. SCE supports development of cleaner energy resources and currently has the largest RPS portfolio in the nation, however we do not believe that a 33% RPS target is achievable by 2020.*

*2 California Assembly Bill 32 requires that carbon emissions be reduced to 1990 levels by 2020, and to 80% below 1990 levels by 2050.*

## 1.2. The SCE Smart Grid Vision

*"SCE's vision of a smart grid is to develop and deploy a more reliable, secure, economic, efficient, safe and environmentally-friendly electric system."*

SCE's vision of a smart grid is to develop and deploy a more reliable, secure, economic, efficient, safe and environmentally-friendly electric system. This vision covers all facets of energy from its production to transmission, distribution, and finally its efficient use in homes, businesses and vehicles. This smart grid will incorporate high-tech digital devices throughout the transmission, substation and distribution systems and integrate advanced intelligence to provide the information necessary to both optimize electric service and empower customers to make informed energy decisions.

Consistent with the 2007 EISA and the U.S. Department of Energy's and National Energy Technology Laboratory's Vision for the Modern Grid, SCE's smart grid will enable increased levels of intermittent and renewable resources (such as wind and solar power) and lead to greater use of Plug-in Electric Vehicles (PEV). To achieve these goals and the complete smart grid vision, the SCE smart grid will increase system flexibility; reduce greenhouse gas emissions; avoid the economic losses associated with catastrophic failures and wide-area blackouts; foster energy conservation, energy efficiency and demand response capabilities by providing customers with better energy use information and choices; reduce operating costs and improve reliability and safety by providing real-time information for system monitoring and system automation; improve maintenance and operations practices on the electrical grid; and facilitate the development of a "Clean Tech" economy, which is expected to include the creation of new jobs. We believe a true smart grid can help America achieve meaningful greenhouse gas reductions and a more secure energy future.


*Figure 2 - SCE Smart Grid Vision Themes*

The five key smart grid strategic themes, as depicted in Figure 2 on the previous page, serve as the basis for SCE's smart grid vision:

- ***Empower Customers*** to manage energy use and reduce their carbon footprint through the use of smart energy devices, PEV and distributed energy resources at customers' premises.
- ***Improve Workforce Safety and Productivity*** through smarter tools, advanced robotics, remote controlled devices, protective equipment and workforce mobility applications.
- ***Integrate Renewable and Distributed Energy Resources*** through new engineering designs for resource integration, protection schemes and circuits, storage technologies, power electronics and technology to provide system stability.
- ***Improve Grid Efficiency & Resiliency*** through innovative real-time power system measurement, controls, analytics and grid technologies including the application of high temperature superconducting materials.
- ***Provide Information and Connectivity*** through the development of an open standards-based, secure, resilient and extensible information and communications technology (ICT) infrastructure.

Several aspects of SCE's smart grid vision must be developed by 2020 in order to comply with ambitious state and federal policy goals related to climate change, clean energy and infrastructure security. However, it is impractical to think that all aspects of this Vision can be developed and implemented within 10 years given the nascent stage of many technologies and the ratepayer costs. As such, deployment of a smarter grid is a journey that will extend well beyond 2020. The remainder of this document describes the customer and societal value of the SCE smart grid, provides further definition around each of the SCE smart grid themes depicted in Figure 2, articulates strategies and methods which will be followed to help ensure success, and provides a roadmap describing the pathway and evolution of the SCE smart grid.

### 1.3. Smart Grid Value Proposition

Key objectives of SCE's smart grid development strategy include pursuit of technologies that provide significant customer value that exceeds the cost of implementation, as well as identifying best fit solutions to meet policy objectives that may not have direct operational benefits. Smart grid technology projects will likely involve a mix of both incremental and replacement investments that not only expand existing capabilities, but also build new capabilities.

Although SCE believes in taking a cost-effective approach to the deployment of smart grid technologies and systems, traditional cost/benefit models may not account for all of the value to be derived from smart grid investment decisions. A substantial portion of smart grid benefits are societal in nature and include achieving national and state priorities such as energy independence, reducing greenhouse gas emissions and increasing grid security, safety and reliability. These benefits are often difficult to quantify, may vary widely in their justification of various smart grid technologies, and are multi-faceted in terms of who receives benefits from them. Benefits may not only accrue to SCE customers, but also to California residents or our broader society. In addition, these benefits need to be considered within the context of the portfolio of smart grid technologies to be deployed at different times over the next twenty years and beyond.

SCE has identified 10 broad smart grid benefits categories. Accordingly, the smart grid has the potential to:

1. ***Provide Customer Benefits*** by improving grid reliability, enhancing customer communications, and by empowering customers to better manage their energy usage and costs.
2. ***Reduce Peak Demand*** through demand management programs and services.
3. ***Increase Energy Conservation & Efficiency*** by enabling integration of customer energy management systems and grid energy management systems; this integration can reduce system losses.
4. ***Reduce Operating Expenses*** by lowering the cost of planning and support functions, operating costs and energy costs.
5. ***Avoid, Reduce or Defer Capital Investments*** by increasing capacity utilization, extending the useful lives of grid assets, optimizing energy procurement practices, and investigating new technologies.
6. ***Increase Utility Worker Safety*** by providing tools and information that allow them to perform their work in a safer manner.
7. ***Improve Grid Resiliency and Reliability*** by reducing the frequency and duration of outages and service interruptions, and by improving power quality, accommodating greater diversity of energy resources, and increasing grid security.
8. ***Reduce Greenhouse Gas Emissions*** by integrating renewable energy resources with the electric delivery system, and promoting the adoption of electric vehicles.
9. ***Promote Energy Independence*** by facilitating electricity-based transportation.
10. ***Promote Economic Growth & Productivity*** by fostering the development of California's clean technology economy, and associated job growth.

SCE is already on a trajectory to significantly increase energy conservation, enable advanced demand response programs, reduce greenhouse gas emissions, and enable customer energy management through a combination of Edison SmartConnect™ (smart metering), demand response and energy efficiency initiatives[3]. Figure 3 below illustrates the 20 year NPV of the Edison SmartConnect™ residential and small commercial smart metering program.


| Costs | ($Millions) Nominal | '07 PVRR |
|---|---|---|
| Phase II Pre-Deployment | $ (45) | |
| Acquisition of Meters & Comm Network | (726) | |
| Installation of Meters & Comm Network | (285) | |
| Back Office Systems | (251) | |
| Customer Tariffs, Programs & Services | (117) | |
| Customer Service Operations | (82) | |
| Overall Program Management | (45) | |
| Contingency | (130) | |
| Post-Deployment | (1,582) | |
| **Total Costs** | **$ (3,263)** | **$ (1,981)** |
| **Benefits** | | |
| Meter Services | $ 3,909 | |
| Billing Operations | 187 | |
| Call Center | 96 | |
| Transmission & Distribution Operations | 92 | |
| Demand Response - Price Response | 1,044 | |
| Demand Response - Load Control | 1,242 | |
| Conservation Effect | 828 | |
| Other | 39 | |
| **Total Benefits** | **$ 7,437** | **$ 1,990** |
| **Net Benefits Excluding Societal** | **$ 4,174** | **$ 9** |
| **Societal Benefits** | | **295** |
| **Net PVRR** | | **$ 304** |

*Figure 3 - Edison SmartConnect™ Cost Benefit Information*

Other aspects of a smart grid are in the development phase, but it is clear that their future implementation will play a crucial role in enabling SCE to meet renewable energy goals, further reduce greenhouse gas emissions, and improve system reliability and safety.

3 *California Public Utilities Commission (CPUC) Proceedings: D.08-09-039; A.08-06-001; A.08-07-021.*

## 1.4. Smart Grid Definition

SCE defines the smart grid as an increasingly intelligent and highly automated electric power system that utilizes technology advancements in telecommunications, information, computing, sensing, controls, materials, in addition to other grid technologies. The smart grid will be able to better meet customers' energy demands, while also seamlessly integrating new sources of energy and delivering power over a network that is increasingly interoperable, efficient and resilient.

The smart grid of 2020 will comprise an expansive network of grid components. Millions of intelligent digital devices will continuously generate increasingly large amounts of data about the system's state. This data will ultimately yield visual and actionable information that can be used to optimize control of the electric system and empower customers to make informed energy decisions. In addition, a smart grid will enable customers to utilize electric power as a fuel source for their transportation needs.

The SCE smart grid will leverage emerging technologies such as transformers that utilize superconducting materials, new energy storage devices, advanced sensors and controls, 4G broad-band wireless telecommunications, and decision-support software. Implementing these technologies will lead to an SCE smart grid that continuously examines the electric system's status and iteratively simulates grid conditions while calculating contingencies. The smart grid system will be able to determine the most optimal set of coordinated control actions to mitigate abnormal system conditions, increase capacity utilization and improve power quality. In addition, the SCE smart grid will be able to assess the health of critical assets such as bulk power transformers. If a critical failure occurs, putting the stability of the system at risk, the network would automatically transfer load from the relevant transformer banks through automated reconfiguration of switches and transformer banks to prevent failure and maintain electric service.

The SCE smart grid vision is made possible by the five key strategic themes depicted in Figure 2 and portrayed as five overlapping rings. Each of these theme areas can be broken down into supporting objectives. In the following sections, we drill one level deeper in order to define these theme-specific objectives.

## 1.4.1. Customer Empowerment: Energy Smart Customer Solutions & Advanced Electric Transportation

### *Energy Smart Customer Solutions*

**Definition:** Empower customers to become active participants in the energy supply chain by providing them with information and new customer service options that enable management of their own energy consumption and reduction in carbon emissions

*The Edison SmartConnect™ advanced metering infrastructure program involves the planned installation of over 5 million advanced meters by 2012.*

California policy over the past decade has clearly recognized the benefits of enabling customer participation in the energy supply chain through the preferred loading order for energy efficiency and demand response, and through several regulatory policies that have led to smart metering, dynamic rate options and demand response programs for all customers. The foundational technology currently being deployed through Edison SmartConnect™ will provide a platform that can be utilized to leverage future customer technology. To take advantage of this platform, SCE continues to support the development of industry standards at the customer level and encourage third-party product development. We also identify opportunities for SCE technology adoption that further enables customers to manage their energy usage and monthly bills. Moreover, SCE is pursuing opportunities to leverage our smart metering infrastructure to improve utility operations and customer service.

| Theme Objectives | |
|---|---|
| Customer Situational Awareness | Develop capabilities to dynamically provide customers with information about relevant grid conditions (e.g. outages, grid events, power quality, etc.). |
| Customer Energy Management | Provide customers with pricing and usage information necessary to help them manage consumption and production of energy at their residences or places of business. |
| Customer Energy Storage | Evaluate customer energy storage applications such as enabling Zero Net Energy homes and buildings and improving DER effectiveness. |
| Customer Technology Advocacy | Represent the customers' interests in engaging technology providers to develop effective and interoperable new smart grid technologies and services. Actively support interoperability standards development and adoption to promote increased speed to market and broad compatibility of customer technology. |

### *Advanced Electric Transportation*

**Definition:** Provide support and infrastructure solutions for port and rail electrification, SCE fleet electrification, and electric vehicle charging.

*SCE possesses the largest private electric vehicle fleet and is involved in partnerships with EPRI, Ford and GM in developing Plug-In Electric Vehicles which can be integrated with the smart grid.*

The largest contributors to greenhouse gas emissions in Southern California are the Ports of Los Angeles and Long Beach, and truck and car traffic occurring on the extensive freeway system in the Los Angeles basin. Efforts are underway at the Port of Long Beach to use electricity rather than diesel-fueled power for ships in port, and to use electric rail or trucks for moving cargo from the port to inland rail hubs and distribution centers. SCE is an active supporter of these port electrification efforts and a contributor to the technology strategy for reducing overall port and related emissions. California approved a high-speed rail bond measure in 2009 that matches federal money to build a system across the state and to Las Vegas. SCE is supporting the engineering analysis for the integration of this new dynamic load. Similarly, a transformation in the passenger vehicle market is expected to be launched in 2010 with the arrival of mass market PEV. SCE has equipment testing in progress at our Electric Vehicle Technology Center that focus on advancing vehicle charging systems to integrate effectively into the grid and potentially market operations. SCE continues to collaboratively develop medium and heavy duty electric trucks to expand the electrification of our utility fleet as part of our broader commitment to the Edison Electric Institute's Electric Transportation pledge. SCE already has the largest electric vehicle fleet in the US utility industry with nearly 300 light duty vehicles that have driven over 18 million miles.

| Theme Objectives | |
|---|---|
| Port Electrification and High Speed Rail | Support California port electrification and high speed rail initiatives and explore other industrial non-road electric transportation applications. |
| Medium and Heavy Duty Electric Vehicles | Support development of advanced electric vehicle propulsion systems and adopt as appropriate into the SCE medium and heavy duty transportation fleet. |
| Electric Vehicle Charging Systems | Support development of electric vehicle charging systems for home, workplace, commercial, and public charging locations. Evaluate vehicle monitoring and control systems and adopt as appropriate. Actively support electric vehicle standards development and adoption. |

### 1.4.2. Workforce Safety & Effectiveness

**Definition:** Evaluate and adopt technologies that maximize workforce productivity, effectiveness and safety through application of enabling tools and technologies.

*Smart grid deployment, operations and maintenance at SCE will require new skill sets and a safe and productive workforce.*

As SCE deploys smart grid technologies and systems, its work practices and tools must evolve to safely and effectively deploy, operate and maintain the smart grid. SCE anticipates a variety of workforce challenges that include managing an increasingly complex infrastructure, replenishing an aging workforce and leveraging an increasing amount of field data, all while maintaining an unwavering focus on safety. To address these issues, SCE is focusing on improving the productivity, safety and effectiveness of its field and system operator workforce. This will require evaluation of new safety and mobile workforce computing technologies.

| Theme Objectives | |
|---|---|
| Workforce Safety Technologies | Investigate and leverage technologies and revised work processes to further enhance the safety of the SCE workforce. These technologies include robotics applications for inspections and field force personal safety technologies. |
| Organizational Preparedness | Ensure SCE is organizationally prepared for the deployment and operation of advanced technologies through internal skills development, external education programs, recruiting, knowledge management, and communications. |
| Workforce Productivity Technologies | Leverage emerging smart grid and communications technologies to enhance productivity of the SCE field workforce and system operators. Promising technologies include advanced work management, scheduling and routing. |

### 1.4.3. Renewable & Distributed Energy Resource Integration

**Definition:** Utilize intelligent monitoring, protection and control technology, and storage technology to effectively integrate and manage new sources of bulk and distributed renewable energy supply.

*In 2009, SCE obtained approval to cover 65 million square feet of unused Southern California commercial rooftops with 250 megawatts of the latest photovoltaic technology – enough generating capacity to meet the needs of approximately 162,000 homes.*

In 2009, California's Governor signed an executive order to increase the renewables portfolio standard from 20% to 33% by 2020. This target – one of the most aggressive RPS targets in the world – cannot be achieved without advances in grid technology and resource integration technology such as intelligent inverters and protection and control systems. Today's electric grid was not designed with these technologies and policy goals in mind and a significant effort is underway within SCE and across the industry and academia to address the necessary redesigning of the electric system. At the same time, SCE, like many industry stakeholders, recognizes the potential for various energy storage technologies to help better integrate intermittent resources and address some fundamental changes such as bi-directional power flow on distribution systems. SCE has a twenty-year technology evaluation and testing legacy with battery storage technologies that creates unique opportunities to actively support product development that is occurring at battery technology suppliers.

| Theme Objectives | |
|---|---|
| Renewables and DER Integration | Conduct studies and develop technical solutions that will help SCE accommodate increased RPS targets and distributed energy resource policies in both the transmission and distribution systems. |
| Dynamic Response Storage | Investigate and deploy dynamic response storage applications that support the integration of intermittent renewable energy resources by mitigating power quality issues and providing grid support. |
| Energy Shifting Storage | Investigate energy shifting storage applications to assist with the integration of intermittent renewable energy resources by storing surplus power during off-peak periods and supplying power during peak periods or periods of limited renewable resource output. |

### 1.4.4. Grid Efficiency & Resiliency

**Definition:** Utilize improved asset monitoring, data analytics and advanced materials to operate the existing grid at optimum performance levels that maximize efficiency, and to improve system planning and engineering processes for future grid development.

*SCE's Synchronized Phasor Measurement Systems (SPMS) project, with visualization capabilities for operator use, was awarded the "2007 T&D Automation Project of the Year" by Utility Automation & Engineering T&D Magazine.*

As part of its efforts to redesign the electric grid for the 21st century, SCE is assessing future requirements for grid efficiency and resiliency, as well as evaluating the technologies that will enable this future grid. SCE views grid efficiency as improving electric system and capital efficiency by using better intelligence and materials technology to optimize system planning and improve grid throughput. Resiliency includes the abilities to automatically monitor, assess and control the grid, to adapt to changing conditions, meet customer reliability and power quality requirements, and prevent catastrophic bulk-power system failures.

| Theme Objectives | |
|---|---|
| Grid Asset Performance | Maximize the efficiency and utilization of grid assets through improved asset monitoring and maintenance processes and technologies. |
| Enhanced System Planning | Develop advanced system analysis tools to store and compile smart grid data and to identify impacts of evolving technologies and markets on the planning and installation of grid infrastructure. |
| Grid Efficiency | Develop and apply technologies, such as Volt/Var control, to reduce losses and increase grid efficiency and capacity. |
| Advanced Grid Materials | Develop and apply technologies that include advanced materials to enhance equipment efficiency, safety, and environmental and performance characteristics. |
| Enhanced Grid Reliability | Evaluate and adopt smart grid technology which continues to enhance reliability and ensures compliance with National Energy Reliability Corporation (NERC) reliability standards while also allowing for increasing operational coordination across the entire grid. |
| High Impact Event Mitigation and Preparedness | Ensure that proper measures are being undertaken and technologies deployed to protect against and recover from low probability, high impact risks (e.g. electromagnetic pulse threats, cyber-terrorism, natural disasters, etc.). |

### 1.4.5. Information and Connectivity

**Definition:** Evaluate and adopt information and telecommunications technologies which provide scalability, flexibility and interoperability for data and information exchange across the entire grid supply chain from generation to customer. These technologies will be able to be easily integrated into a resilient and secure smart grid architecture which supports electric system operations.

*SCE currently has one of the most comprehensive telecommunications portfolios in the industry. It is comprised of 5,250 circuit miles of fiber optic communications, over 30,000 Netcomm radios, and a proprietary satellite communications system to monitor and control the electric system.*

Creating a 21st century electric grid requires significant investment in new information and telecommunication technologies. While several fundamental technologies exist in commercial form, many require adaptation from their present use in other industries or in military applications. SCE has an extensive ongoing effort to evaluate information and telecommunication technologies for electric system adoption. SCE is also designing a smart grid telecommunications network that will provide connectivity, security and intelligent processing through a "network-of-networks" consisting of inter-utility, intra-utility and field area networks. This integrated set of networks will facilitate data exchange and communications among customer devices, utility field devices, the field workforce, grid operators, utility computing systems and external parties such as the California Independent System Operator (CAISO).

A smarter grid will generate exponentially larger amounts of data. To meet this challenge, SCE is also designing an integrated, resilient, adaptive, and interoperable information "system-of-systems" to collect, interpret, and rapidly respond to this data. To ensure system survival in light of potential cyber-security threats, SCE is taking measures to provide comprehensive end-to-end security coverage. These measures address security concerns at a holistic, system-wide level and identify the impacts of any given vulnerability or threat to the entire system. SCE's cyber-security efforts involve external engagement with technology suppliers, standards organizations and policy makers, and internal engagement to address the security requirements of SCE systems.

| Theme Objectives | |
|---|---|
| Information and Communications Architecture and Engineering | Develop and implement a unified architecture that defines functional requirements and provides required availability, reliability, resiliency, interoperability, and security (ARRIS). |
| High Speed Backbone Telecommunications | Evaluate and deploy high speed telecommunications technology to interconnect substations and link to field area communications that will support utility and customer communications needs, and will enable the grid telecommunication systems to operate as an integrated network of networks. |
| Advanced Field Telecommunications | Evaluate and adopt telecommunications technologies to improve field area networks and link backhaul field area information, including customer information, to substations and utility operations. |
| Information Systems | Develop and implement highly reliable, secure and scalable information systems to meet future needs for data management, analytics and complex automation and control systems. |
| Cyber-security | Develop and implement common security services to resist attacks and dynamically respond to threats. |

## 2. Smart Grid Development Methodology

Much of SCE's smart grid vision and strategy needs to be realized over the next decade in order to meet state and federal policy initiatives and to accomplish company objectives. In order to execute on the broad smart grid vision outlined above, SCE has employed several methods that involve careful and customer-focused technology planning, internal and external alignment of resources, disciplined processes for technology evaluation, and an open standards-based approach to technology innovation. The following methods have been in use at SCE over the past five years and have resulted in our successful smart metering and synchrophasor deployment programs:

1. ***Customer-Focused Systems Engineering***
2. ***Open Innovation***
3. ***Technology Development Scenario Planning***
4. ***Proactive Standards Development***
5. ***Rigorous Technology Evaluation***

### 2.1. Customer-Focused Systems Engineering

*"Creates a structured framework in order to balance cost, schedule and technical constraints of smart grid deployment"*

An important aspect of smart grid deployment is the ability to balance cost, schedule and technical constraints with a thorough understanding of customer needs, business goals, and the maturity level of technologies available in the marketplace. SCE's Customer-Focused Systems Engineering approach addresses these complexities by providing a structured framework for understanding the value and risks inherent in deploying a complex "system-of-systems" and "network-of-networks" such as the smart grid.

Design thinking for a smart grid requires the more robust and holistic approach offered by systems engineering. Benefits of this approach include better solution quality, higher value solutions, lower project costs, reduced project risks and shorter project schedules.

SCE was an early implementer of the IntelliGrid methodology to gather smart grid requirements and develop architecture using a disciplined systems engineering approach. This approach was subsequently adopted by several other utilities (e.g., Consumers Energy, Florida Power & Light, Salt River Project, First Energy) and by NIST to develop their standards roadmap. This approach has been codified in IEC standard 62559[4].

4 *IEC standard 62559 - http://webstore.iec.ch/preview/info_iecpas62559%7Bed1.0%7Den.pdf*

The development of use cases is an important first step in the systems engineering process at SCE (www.sce.com/usecases). Use cases support the generation and documentation of requirement sets for smart grid technologies. The use cases accomplish this by focusing on business scenarios that identify the people, field technologies and information systems that must interact to achieve a business goal. At SCE, concepts from the Customer Focused Technology Planning® (CFTP®) framework have been adapted to help evaluate smart grid requirements resulting from the use case process. CFTP® is a methodology that has been used in a wide variety of industries to help guide technology strategy and evaluation by providing a means to identify and prioritize the deployment of smart grid technologies. It helps to ensure that the needs of customers and other key stakeholders are considered in a way that balances the risks and rewards of implementing new technologies. By incorporating CFTP® concepts into the Systems Engineering processes at SCE, the result is a methodology which we have called Customer-Focused Systems Engineering.

*"System engineering is a robust approach to the design, creation, and operation of systems. In simple terms, the approach consists of identification and quantification of system goals, creation of alternative system design concepts, performance of design trades, selection and implementation of the best design, verification that the design is properly built and integrated, and post-implementation assessment of how well the system meets (or met) the goals."*

*– NASA Systems Engineering Handbook, 1995.*

Our smart grid challenge and opportunity is to develop a technology game plan that appropriately balances state and federal policy objectives, our customers' needs, SCE's business objectives, and the adoption of new smart grid technologies. In light of this challenge, before we engage in any new smart grid opportunity, be it for emerging technology evaluation or commercial technology deployment, we first score and rank that opportunity using a standard rating system. This system considers three critical criteria: (1) alignment with business objectives (including customer value, improved grid operations and compliance with state and federal energy policies); (2) risks associated with adopting the technology; and (3) cost effectiveness. In the aggregate, potential smart grid investment opportunities over the next decade and beyond appear to follow a diminishing returns curve. SCE is therefore careful to consider opportunities based not only on their potential value, but also with contemplation of the risks of technology adoption.

As such, SCE's Customer-Focused Systems Engineering approach also includes a structured framework for understanding the value and risks inherent in deploying complex, network-centric systems such as the smart grid. SCE has developed several analytical models, including Technology Capability Maturity (TCM) and early Stage Technology Adoption Risk (eSTAR) models that are used to assist with early stage technology adoption and/or development decisions.

## 2.2. Open Innovation

SCE has a long history of following an open innovation approach to technology evaluation and adoption. Although Edison is recognized as a global leader in the development and implementation of advanced technologies, it is aware that smart grid deployment is a complex undertaking requiring a collaborative effort by many stakeholders. Therefore, SCE is actively pursuing an open innovation approach that involves working closely with many of the various stakeholder groups. These groups include customers, other utilities, policymakers, technology manufacturers, standards organizations, universities, national labs, and research institutes. This collaborative approach is needed to achieve common understanding on key issues and interests across these diverse groups.

*"Allows for the sharing of ideas and concepts across utilities, policy makers, vendors, and research groups to advance technology development and applied research"*

Open innovation allows for sharing of ideas and concepts across entities – utilities, policy makers, vendors, and research groups – to drive further applied research and technology development in needed areas, and to better understand the value proposition of smart grid components for our customers, utility operations and society as a whole. This approach builds consensus and critical mass in the industry in order to drive technology development to meet open and interoperable standards and new performance requirements. Notable collaboration efforts with other smart grid stakeholder organizations include the following:

- SCE is actively engaged with the Edison Electric Institute's (EEI) and the Electric Power Research Institute's (EPRI) smart grid initiatives and is the current chair for both EEI's and EPRI's Smart Grid Executive working groups.
- SCE co-chairs the Western Electric Industry Leaders (WEIL) technology collaborative.
- SCE founded the Southern California Energy Research Consortium involving local distinguished international research universities: Caltech, University of Southern California, University of California, Los Angeles, UC Irvine and UC Santa Barbara. SCE also collaborates with Massachusetts Institute of Technology, Stanford, University of Illinois, UC Berkeley, UC Davis and Carnegie Mellon.
- SCE is collaborating with several national research labs, including Lawrence Berkeley National Lab, National Renewable Energy Lab, Idaho National Lab and Pacific Northwest National Lab.
- SCE has technical exchange efforts underway with leading utilities in Asia, Australia, Europe, South America and Canada, in addition to our US utility collaborations.

### 2.3. Technology Development Scenario Planning

*"Ensures that SCE's smart grid strategy remains a viable technology adoption plan as driving forces alter the smart grid landscape"*

SCE engages in scenario planning as part of its strategy for ensuring success in achieving its smart grid vision. Over the past year, SCE's scenario planning efforts have resulted in the development of four potential pathways for the pace of technology development and adoption for the smart grid. A key objective of this analysis is to ensure that the SCE's smart grid strategy provides a viable adoption roadmap in any of the four potential pathways. These scenarios were created following a careful analysis of the critical driving forces affecting the smart grid, and after making some assumptions as to the degree of impact (positive or negative) that these forces might have on the pace of technology development and adoption. The following driving forces were considered:

- Economic Growth
- Policy Focus
- Technology Innovation & Adoption
- Energy Markets
- Customer Trends
- Environmental Developments

The goal for developing future scenarios is not to identify the most likely future but to examine how these important external forces may shape smart grid deployment through 2020 and beyond. The characteristics of the resulting scenarios are used by SCE to help prioritize and select smart grid technology projects. Those opportunities which seem to be relevant and viable across multiple future scenarios receive additional consideration, in comparison to those opportunities which might seem promising in a single future scenario but may look irrelevant or risky under other scenarios. In addition, for each future scenario, SCE has developed specific proactive responses based on the implications of that scenario. As evidence develops that the future is trending toward any given scenario, these "contingency plan" responses for the given scenario can be called into action.

SCE's smart grid future scenarios were developed by considering a spectrum of two of the most critical driving forces – Economic Growth and Policy Driven Innovation – placed along two axes as follows:

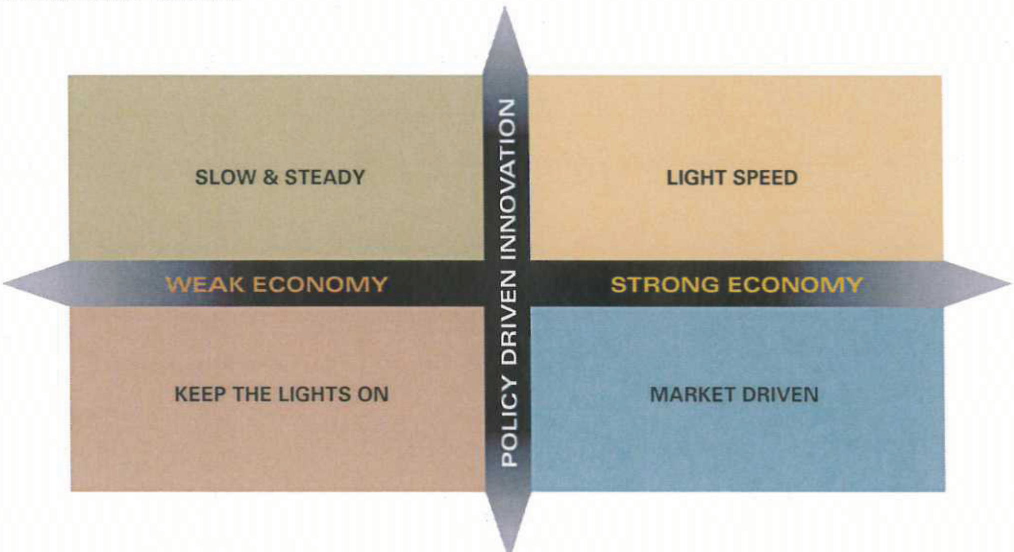



*Figure 4 - SCE Smart Grid Future Scenarios*

These four scenarios have been defined as follows:

- **Slow and Steady:** Policymakers continue to support utility investment in smart grid development and implementation. Progress towards energy and climate policy goals continues but is slowed by economic forces.
- **Light Speed:** Policymakers issue mandates for utility investment in smart grid deployment and provide financial support for technology innovation. A "clean tech" investment boom spurs technology innovation and development.
- **Market Driven:** Policymakers shift emphasis towards market driven outcomes for technology innovation and infrastructure investment. Strong economic growth and potential new market opportunities encourage new entrants into the energy market.
- **Keep the Lights On:** Continued economic stagnation squeezes consumers and industry, slowing venture and technology industry investment and innovation in smart grid technologies. Lower energy demand and a regulatory focus on rate containment reduce funding available for additional smart grid investment.

Across each of the four scenarios, SCE has identified potential data points as "signposts" which would suggest the extent of progression into one or more of the different pathways over time. Examples of signposts for the smart grid scenarios include, among others:

- The U.S. national unemployment rate (expressed as a percentage)
- Average gasoline prices ($/gal)
- Average natural gas prices (per mmBTU)
- Distributed resource cost effectiveness
- Consumer adoption rates for energy smart devices
- Consumer adoption of electric vehicles
- Customer response to dynamic pricing and usage information
- US economic GDP growth (as a percentage increase or decrease)
- Annual clean technology venture capital investment
- Industry and government investment in related technology R&D

SCE regularly monitors these signposts to determine whether there is movement in the direction of one or more of the developed scenarios, or if entirely new scenarios are emerging. This process will help identify the need for any adjustments to projects included in either of SCE's technology evaluation or deployment portfolios of smart grid projects. Because the smart grid will be developed and deployed over a long period of time (as is discussed in the smart grid development roadmap section that follows), periodic monitoring of these signposts will help SCE to understand if adjustments in the smart grid vision, strategy or development timing are required.

## 2.4. Proactive Standards Development

As the grid evolves and becomes "smarter" and more capable over time, standards must also evolve to support higher degrees of interoperability and to enable more advanced capabilities. When the concept of smart grid evolution is applied in the area of standards adoption, the implication is that at any point in time the industry will be characterized by a mix of old technology (or no technology at all), last-generation smart technology, current-generation smart technology, and "greenfield" technology opportunities, all of which must function together in an integrated manner. Also, given that many smart grid technology lifecycles are much shorter than a typical utility regulatory-to-deployment cycle, it is very likely that the grid will continuously evolve to the degree by which intelligence is both incorporated and leveraged. Smart grid interoperability standards will be critical in helping to bridge the gap between different generations of technologies and in supporting a gradual, multi-step transition to the smart grid vision.

*"Enables the adoption of standards that encourage interoperability of multiple generations of smart grid technologies"*

The issue of evolution is particularly important because smart grid investments tend to fall onto a continuum characterized by policy imperatives, system reliability and customer value. Policymakers and utilities must balance these considerations regarding certain smart grid investments before a complete set of standards has been adopted and benefit to customers dictates moving forward. In a number of instances across the nation, utilities and regulators have given much thought to balancing acceleration of customer benefits, project cost-effectiveness, and management of emerging technology risks. Smart grid systems that are planned and structured appropriately should be able to accept updated and new standards as they progress, assuming the following standards evolution principles[5] are recognized:

- Interoperability must be adopted as a design goal, regardless of the current state of standards.
- Interoperability through standards must be viewed as a continuum.
- Successive product generations must incorporate standards to realize the value of interoperability.
- Smart grid technology roadmaps must consider each product's role in the overall system and select standards-compliant commercial products accordingly.
- Standards compliance testing to ensure common interpretation of standards is required.

These principles are being followed by many utilities implementing smart grid systems today by requiring standard capabilities such as remote device upgradeability and support for robust system-wide security. In addition, standard boundaries of interoperability are being identified to allow smart grid investments to evolve in order to satisfy increasingly advanced capabilities.

5 *SCE adopted the Gridwise Architecture Council's constitutional principles for interoperability and the several papers that address the integration of interoperability standards over time. These documents can be found at: http://www.gridwiseac.org*

Determining what activities to prioritize and which smart grid standards to adopt and implement requires an understanding of the capabilities the standard supports in the context of the overall system. The smart grid is comprised of multiple integrated sub-systems. These include a "utility system" which is composed of many individual systems including transmission, distribution and customer systems within the utility, other entity systems comprised of the many unique customer systems, services and resource provider systems, and overall macro-systems such as a wide-area control system and RTO/ISO systems. As these "utility systems", other entity systems and macro-systems are linked, the result is a "System of Systems", as illustrated in Figure 5 below.

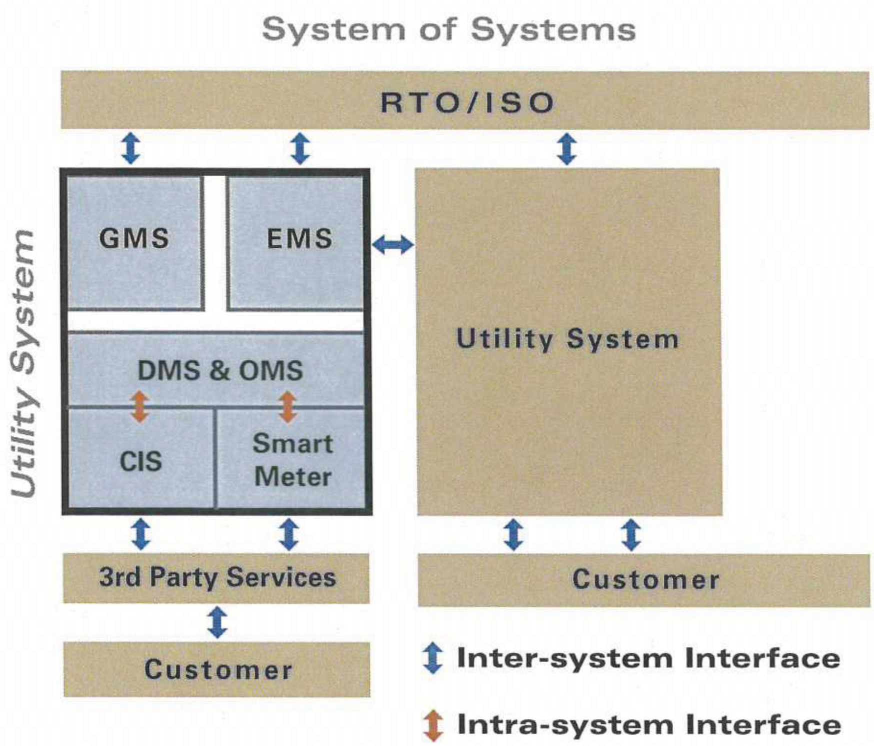



*Figure 5 - Smart Grid Systems of Systems*

Due to the importance of smart grid standards development, SCE has devoted considerable time and resources to standards efforts over the past ten years. Over the past five years SCE has testified at FERC, CPUC, CEC and the US House of Representatives on the need for standards and has also authored and co-authored several standards development papers in 2009. Furthermore SCE employees serve on a number of working groups and governing boards for National Institute of Standards and Technology (NIST), Institute of Electrical and Electronics Engineers (IEEE), Society of Automotive Engineers (SAE), Utility Communications Architecture International Users Group (UCAIug), Open Smart Grid (OpenSG), North American Synchrophasor Initiative (NASPI) and others. SCE intends to continue contributing to the thought leadership on the development of standards both at the state and national level.

## 2.5. Rigorous Technology Evaluation

*"Defines SCE's approach for testing, evaluating, and deploying emerging smart grid technologies"*

SCE is widely recognized in the electric utility industry as a leader in the evaluation, adoption and implementation of advanced technology. Edison has achieved this leadership position by creating a rigorous and repeatable technology evaluation and testing process. SCE's technology evaluation approach follows industry testing standards developed by, among others, the IEEE and the International Organization for Standards (ISO).

This testing and evaluation process is first used to test technology in a laboratory environment against its manufacturer's specifications. Once the technology's performance is verified to be in compliance with specifications, a next step involves additional testing in small scale field trials, typically following the same set of testing process steps as those used in the lab environment. If the technology's performance in the field trial is acceptable, and it is deemed to be commercially viable, the technology then proceeds through a formal "tech transfer" process where it is handed off to the appropriate engineering and operations divisions. SCE's internal engineering standards are then modified to include the new technology, so that the technology can be incorporated in the plans and designs for future grid development. In some cases, where it would be immediately beneficial for our customers, a new deployment project will be initiated to ensure that the given technology is rapidly deployed in locations throughout the SCE transmission and distribution network, as information technology infrastructure or within customer service operations.

SCE's rigorous technology evaluation process has been proven at its Electric Vehicle Technical Center (EVTC) with the testing of various electric vehicle energy storage systems, in the Edison SmartConnect™ program with both advanced metering infrastructure and peripheral HAN devices, and with advanced distribution grid technologies, notably at the Avanti "Circuit of the Future" test bed. Each of these examples utilized both laboratory testing and production-based field tests.

# 3. Smart Grid Engineering and Architecture

## 3.1. Smart Grid Electric System Design

*"Advanced system design concepts will enable the bi-directional flow of energy and information, integration of new supply and demand resources, and a network of networks between customers and market participants."*

Over the past 125 years, electric grid architecture and development was driven by scale economies and the need to reliably connect all of the nation's population to the grid. Scale economies drove monopoly infrastructure and large centralized generation over the past century. Rural electrification legislation extended electric service to the entire country. More recently, in the 1960's, as the federal interstate highway system interconnected our communities, so did the development of the high voltage transmission regional inter-ties. The resulting electric system was recognized by National Academy of Engineering as the greatest engineering achievement of the $20^{th}$ century. So why does a need exist to redesign the grid?

Over the past 30 years, three key factors have increasingly driven the need to rethink the nation's electric grid design:

- Renewable & Distributed Generation
- Customer Demand/Energy Management
- Information Technology applied to system operations and controls

Each of these factors was introduced around 1980. In the case of renewable and distributed generation, the passage of the Public Utility Regulatory Policy Act (PURPA) in 1978 spurred initial wind, solar and distributed co-generation development. In California, the 1981 regulatory de-coupling of sales and revenues for investor-owned utilities removed a key barrier to the widespread customer energy demand management that has followed. In 1981, the introduction of personal computers corresponded with the introduction of microprocessor based relays and control systems on the electric grid. The subsequent benefits of Moore's law in terms of computational power combined with telecommunications innovation led to advanced measurement and control systems.[6] Each of these three drivers has over time increasingly become a critical factor in driving change to traditional grid architecture.

By 2005, these three factors had converged to enable concepts like micro-grids, aggregated customer participation in wholesale markets and SCE's 500MW large roof-top solar program. These concepts and others require a different electric grid design. This design must i) enable bi-directional flow of information and energy back and forth between generation, the utility, and the customer, ii) operate as a unified network-of-networks between customers and market participants across a region, and iii) enable integration of a wide variety of supply and demand resources. In effect, this revised electric grid models the principles of the conceptual architecture for the internet. Figure 6 below illustrates the evolution of information networks from Bell's telephone to Web 2.0 and electric networks from Thomas Edison's Pearl Street Station to the

6 "Moore's law," Wikipedia, http://en.wikipedia.org/w/index.php?title=Moore%27s_law&oldid=344054138

envisioned Grid 2.0. Grid 2.0 is the result of integrating millions of intelligent devices through an advanced telecommunications network linked to sophisticated computing systems that monitor, analyze and automatically control the entire electric grid, which itself has undergone an engineering redesign to improve operating performance, accommodate intermittent renewable and distributed resources and resist cyber or physical threats.

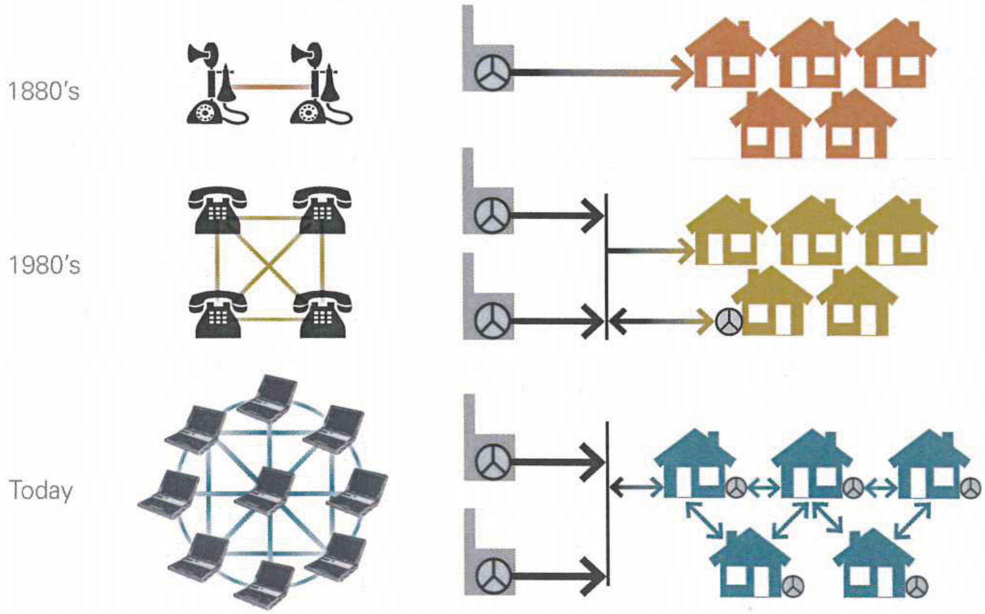



*Figure 6 - Information & Electric Network Evolution, Source: SCE adapted from Wikipedia*

The following sections explore in more detail several design elements of SCE's Grid 2.0 electric system vision.

### *Transmission and Substation Design*

Changes to transmission system and substation design will be required to improve electric grid reliability within the utility and across the western region in light of increasing levels of renewable and other low-carbon generation. In addition, design enhancements must consider the goal of achieving a more efficient grid that optimizes throughput and reduces system losses.

The deployment of a synchrophasor-based wide-area situational awareness system will begin to support the accurate information needs required for real-time decision making by both the utilities and independent system operators in order to better understand and respond to system disturbances. Over time it is anticipated that wide-area situational awareness will evolve to also include wide-area control (WAC) and wide-area protection (WAP) applications. These advanced applications will require the exchange, processing and management of data/messages not only from phasor measurement devices, but also from various types of Intelligent Electronic Devices (IED). These IEDs include protective relays, programmable controllers and stand-alone digital fault recorders. Examples of wide-area control and wide-area protection applications that would be enabled include coordinated and automated reactive power control based on wide-area measurements, adaptive system islanding and resynchronization, and advanced protection mechanisms such as centralized remedial action scheme (C-RAS) systems.

In addition to wide-area monitoring and control technology, advanced materials will also begin to be utilized in transmission and substation design. New equipment incorporating advanced materials, such as superconducting fault current limiting transformers, will begin to be deployed to increase system performance, to improve energy savings by reducing power consumption and system losses, and reduce stress on protection systems. Moreover, these deployments will provide improvements in power quality and reliability in an environment that will increasingly be characterized by intermittent energy sources. Today's conventional (and aging) substation transformers have been cited as the source of up to 40% of total grid energy losses. Fractional improvements in the efficiency of this equipment would lead to significant reductions in the carbon footprint resulting from typical grid operations.

Finally, with environmental policies driving increased levels of renewable energy resources interconnected to the grid, transmission systems will be designed to incorporate large amounts of energy storage that can provide dynamic response and energy shifting capabilities to mitigate the intermittency, ramping, and dump power issues associated with renewable generation. Furthermore, because these new renewable energy resources are typically low-inertia generation sources, and because California's proposed once-through-cooling policies may lead to accelerated decommissioning of higher-inertia coastal generation plants, future transmission designs will likely need to incorporate the interconnection of equipment to provide increased system inertia, such as synchronous condensers.

### *Distribution System Design*

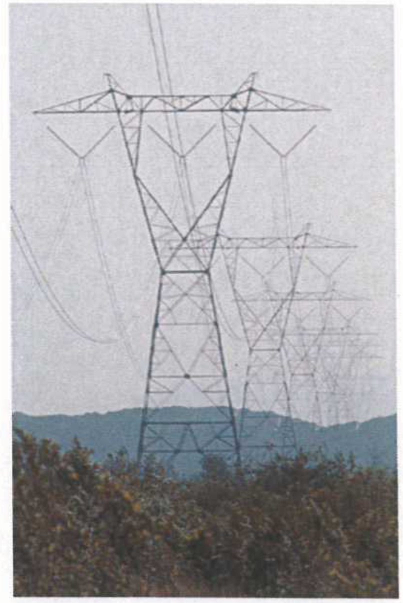
Distribution circuits that were originally designed for one-way power flow are increasingly called upon to support two-way power flow associated with distributed energy resources, including distributed renewable and storage resources which may have variable output. Two-way power flow presents a technical challenge for traditional methods of distribution system voltage regulation and protection. Looped and networked distribution circuit designs are being explored as alternatives to the traditional radial design of these circuits, such that advanced protection, monitoring, and system operation technologies can be readily applied to support mitigation of issues resulting from increased two-way power flow.

Distribution automation technologies will evolve and be widely included in distribution system design to extend intelligent control throughout the entire distribution grid and beyond, inclusive of distributed energy resources, buildings and homes. Advances in distribution automation will be driven by:

- The need to improve reliability, particularly as existing system components age. More flexible and intelligent switches and interrupters on distribution circuits will help to minimize the extent of outages and speed restoration through Fault Detection, Isolation and Restoration (FDIR).
- Increased penetration levels of distributed energy resources, most notably renewable distributed generation and energy storage. These resources can help achieve renewable portfolio goals and provide grid support capabilities, but can also destabilize the grid if not managed correctly.
- Increased need for demand response and advanced load control to mitigate peak demand issues. Advanced distribution automation can offer a more precise level of control over demand side resources, allowing for increased levels of demand response to be achieved without significantly impacting the comfort or convenience of customers. Load control will be available to respond to various electric system needs, ranging from lack of generation resources to local distribution system overloads.
- The need to limit distribution line losses and to operate circuits more efficiently in a future characterized by carbon constraints, increasing energy prices and customer requirements for improved power quality. We anticipate that this will be achieved in part through Advanced Volt VAR Control (AVVC), which maintains better Conservation Voltage Reduction (CVR) at the service point.

Distribution system design will also begin to incorporate advanced materials. One example is found in the development of intelligent and communicating distribution transformers, which can provide performance metrics and monitoring information on transformer life. In addition, new distribution level energy storage technologies, called "community energy storage," will start to be designed into distribution circuits. This should buffer distribution-connected renewable generation, provide localized load leveling and power factor correction, and serve as a source of backup power for customers. To help control and manage distributed storage and other distributed energy resources such as photovoltaic installations, communicating smart inverters will also begin to be incorporated into circuit automation and distribution management schemes which will extend all the way to behind-the-meter generation and storage resources.

## *Advanced Protection*



New protection and control systems will be used to manage increasing amounts of bulk renewables, distributed energy resources, and dynamic and dispatchable demand side resources. This will require adding a variety of complex digital controllers and protection devices to both new and retrofitted circuits.

Voltage instability in the transmission networks has directly led or contributed to wide-area blackouts around the globe. Improved timeliness in the recognition of these instabilities is crucial to effective control and protection interventions. There is growing worldwide interest in using synchrophasor technology to supply very fast measurements of system electrical variables that can provide effective real-time voltage stability indicators. These indicators can in turn be used to automatically trigger protection schemes, pre-defined load shedding algorithms, or intelligent devices such as Static VAR Compensators (SVCs) in an attempt to mitigate voltage stability issues. In addition, C-RAS systems are being deployed in critical transmission corridors to coordinate and optimize the multiple remedial action schemes in place at those locations. Such corrective action schemes could include generation runback or tripping, load shedding or system configuration changes. C-RAS also uses synchrophasor data as an input and operates through a high-speed communications network to increase the speed of SCE's response to events on the transmission network.

At the distribution level, when today's standard radial circuits experience a fault caused outage, the typical result is that the entire circuit loses power until a manual switching process can be completed. With a looped circuit design incorporating smart grid technologies such as Universal Remote Controlled Interrupters (URCI), a new protection mechanism can be established so that the fault can be isolated automatically in less time than it takes for the circuit breaker at the substation to trip. This would allow for the remainder of the circuit to be fed independently from both supply ends, with little or no loss of power to customers served by that circuit.

## 3.2. Smart Grid Information System Architecture

In addition to the need for an updated Smart Grid Electric System Design, SCE will also need to develop and adopt a complementary enterprise-wide Smart Grid Information Systems Architecture. To achieve each of the elements of the SCE smart grid vision, this future architecture will need to be agile and flexible in order to meet increasing data management and analytics demands, support unanticipated needs, and readily enable the integration of new smart grid technologies that emerge over time.

*"An agile and flexible information systems architecture will fulfill data management and analytics demands allow integration of emerging smart grid technologies, and provide robust cyber-security"*

Information demands will include not only those from the utility to support operations, but also from customers and third parties looking to support their own near real-time decision making needs. At the same time that it provides flexibility and interoperability with varied and evolving technologies, the SCE Smart Grid Information Systems Architecture will also need to incorporate robust cyber-security features in order to meet constantly changing and uncertain security challenges. The NIST Smart Grid Framework 1.0 in Figure 7 below provides a reference model for SCE's Smart Grid Information Systems Architecture. It is comprised of integrated layers incorporating the various elements in the emerging system of systems including markets, generation, grid operations, customers, field components, operational and information applications, services, and multi-level networked telecommunications.

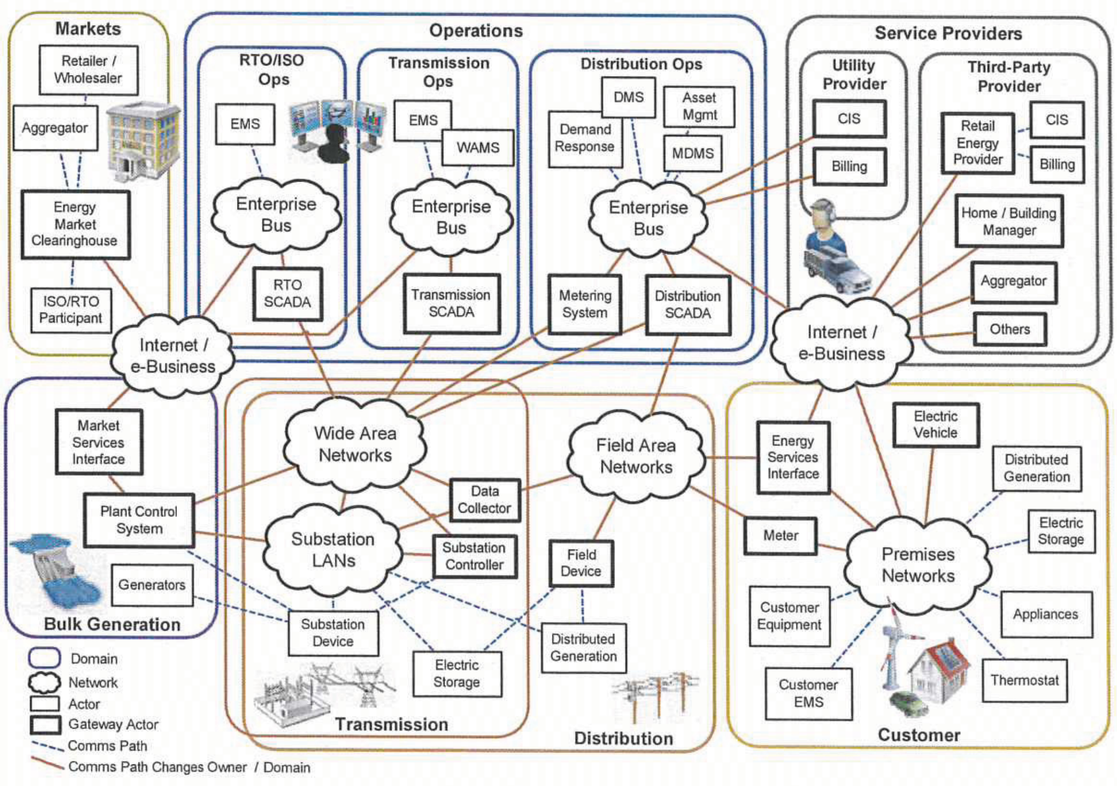



*Figure 7 - NIST Smart Grid Framework 1.0*

The SCE Smart Grid Information Systems Architecture must also provide for a graceful transition from existing systems to the future state. SCE believes that by integrating legacy systems with new technology in a layered, loosely coupled architecture, the ability to achieve the smart grid vision is enabled while minimizing capital costs for deployed information systems. SCE's proposed smart grid *Secure Common Operating Environment (SCOE)* architecture has been designed to help meet systems integration and cyber-security challenges posed by the SCE smart grid vision. It also leverages the collaborative efforts of the NIST Architecture Team that developed the initial version of the NIST Smart Grid Conceptual Model during Phase I of the NIST effort.

The NIST Architecture Team was a group of distinguished IT architects from technology providers, consultants, researchers and utilities that came together in the Summer 2009 to build a conceptual information reference model for the smart grid. The result of this team's efforts was the NIST Smart Grid Framework 1.0. SCE hosted and actively participated in the NIST Architecture Team under NIST's Smart Grid Interoperability program. Since the formal creation of the Smart Grid Interoperability Panel (SGIP), the responsibilities of the Architecture Team to maintain and evolve the NIST Smart Grid Conceptual Model have been transferred to the new Smart Grid Architecture Committee (SGAC) – one of two permanent committees within the SGIP. Many of the original members of the original NIST Architecture Team are now members of the SGAC, including two of SCE's smart grid architects. Their continued participation will ensure that the SCE smart grid architecture remains in step with the architectural models and templates produced by the SGAC.

Figure 8 below presents a depiction of SCE's proposed smart grid SCOE architecture.

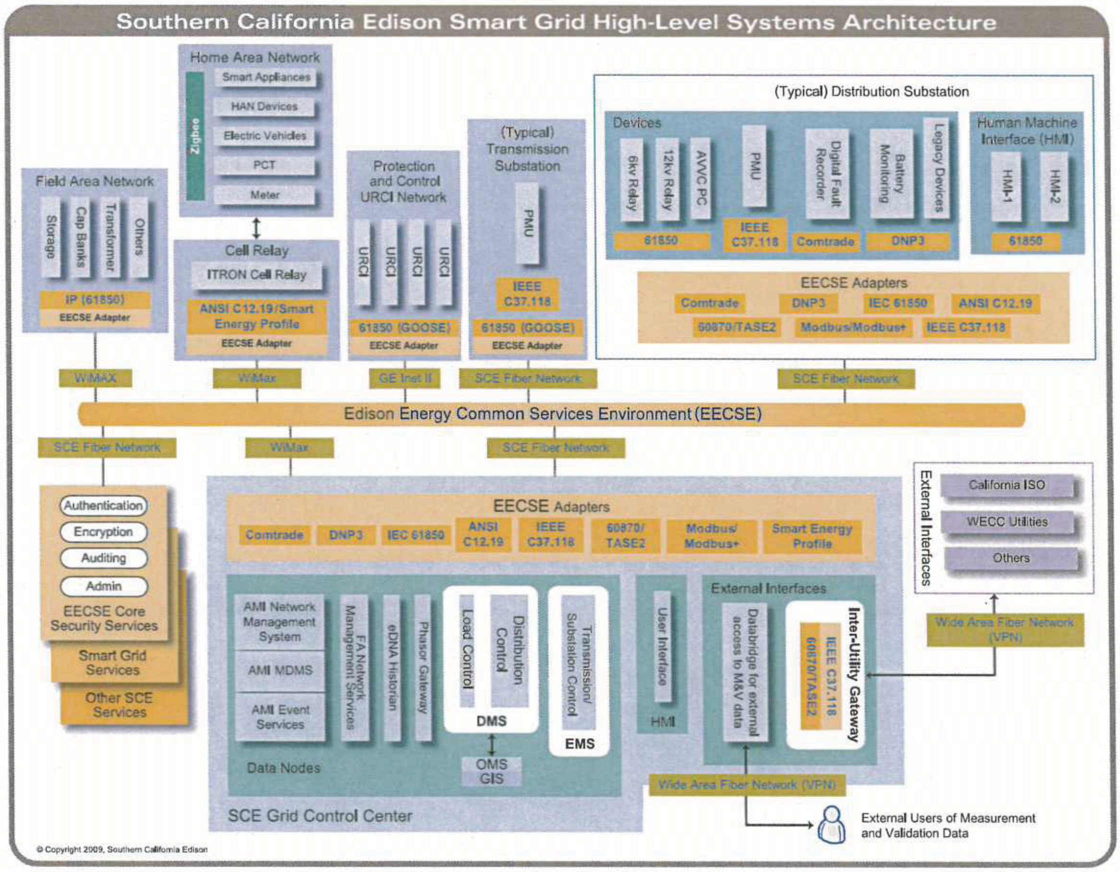



*Figure 8 - SCE's Proposed Smart Grid Architecture*

This top level smart grid information systems architecture depicts the automation component interfaces across the end-to-end solution, and it includes the communication protocols and standards that will be used to integrate the devices, systems and services across the various network domains. The architecture will ensure interoperability, utilizing a common service environment that incorporates the latest industry standards. It will accommodate SCE's AMI meters, HAN devices, substation devices, energy storage, distributed renewable generation, grid control systems, security and network management systems, as well as other new or future smart grid technologies. The architecture also takes into account the low latency communication performance requirements for managing and dispatching control commands, and sending and receiving measurement data critical to establishing wide-area and deep situational awareness across the electric grid. The resulting telecommunication network-of-networks will utilize a variety of backbone and field area wireless technologies that will be Internet Protocol (IP) centric. As such, this approach will allow for compliance and risk and security management, as well as ensure functional quality, scalability, manageability and system performance.

One major challenge faced by any smart grid architecture is how to interface with customer and third party owned devices and systems. This key interface must not only be highly secure but also balance the interests for customer control of the devices and home area network. SCE has expended significant effort over the past five years considering this engineering challenge in close collaboration with many stakeholders across the world. This effort led to the development of an approach that allows customer control of their home area network, through their gateway or that of a services provider, while establishing a clear demarcation point at the smart meter. This design recognizes the customer's right to voluntarily connect to the meter to access their real-time energy usage information. The architecture does not require connection to the meter for any other information exchange which can be provided through the internet or other non-utility means of communications. SCE has adopted the home area network architecture developed by OpenHAN to address the issues above and has served to guide development of Smart Energy Profile 2.0, OpenADE and ZigBee IP 2.0.

Another architectural challenge is addressing cyber-security. Secure communications between smart grid devices and the utility is a basic requirement of the SCE Smart Grid Information Systems Architecture. The smart grid necessitates a secure information technology backbone to support U.S. smart grid policy, as described in the 2007 EISA, Title XIII. SCE will be testing and demonstrating components of this SCOE architecture framework with its forthcoming Irvine Smart Grid Demonstration (ISGD) project. Lessons learned from this project will provide the input to further develop commercial technologies and the requisite integration for secure communications with and between smart grid technologies. SCE expects that the resulting architecture will further inform cyber-security and interoperability standards, and ultimately accelerate smart grid deployment efforts.

SCE is also actively involved in the permanent SGIP working group on cyber-security. This NIST lead SGIP group, called the Smart Grid Cyber Security Working Group (SGCSWG), is collaborating closely with EPRI, DOE, utilities, and other industry players through the ASAP-SG project that SCE is funding to accelerate the effort. SCE's SCOE architecture is designed to fully support the requirements and architectural elements coming out of the SGIP SGCSWG and evolve with them as they are adjusted and extended over time.

# 4. Smart Grid Development Roadmap

Previous chapters defined SCE's vision for the smart grid, the components of a strategic approach and methodology for achieving that vision, and the architectural and design elements needed to support it. This chapter presents SCE's high-level development roadmap for the smart grid. This roadmap identifies the types of technologies that SCE plans to pursue over the course of the next two decades in order to make the SCE smart grid vision a reality.

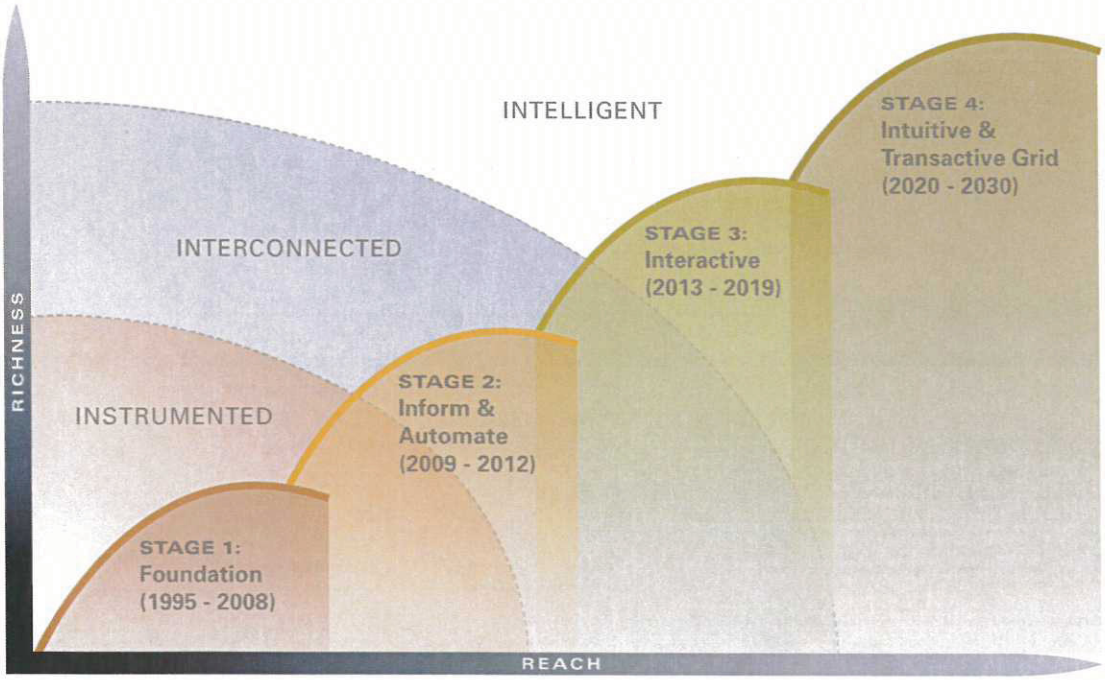



*Figure 9 - Smart Grid Development Roadmap - Stages of Evolution to 2030* [7]

The smart grid will evolve in complexity and scale over time as the richness of systems functionality increases and the reach extends to greater numbers of intelligent devices. The fundamental elements of evolution as defined by IBM are Instrumented, Interconnected, and Intelligent. Instrumented involves the deployment of measurement capabilities across the grid from phasor measurement units to smart meters. Interconnected involves both the linkage of devices through pervasive telecommunications networks and also the integration of operational applications, such as the integration of distribution management systems with advanced load control. Intelligent involves the synthesis of the information, controls and integrated systems in combination with analytics and artificial intelligence to create an intelligent, self-optimizing and resilient energy platform that enables broad market participation and highly reliable quality of service. This evolution will not follow a strictly linear path, but will instead consist of four overlapping steps, as depicted in Figure 9 above, which will transition from one phase to the next as innovations in smart grid technologies emerge and become commercially available.

7 *Adapted from IBM presentation at CPUC Smart Grid Workshop on March 18, 2010*

Within each development roadmap stage, there are two portfolios of activities to be managed simultaneously. The smart grid deployment project portfolio includes smart grid technologies that are commercially ready for deployment. The technology evaluation portfolio includes initiatives to identify, evaluate and test emerging technologies which may be deployed during a later stage. Figure 10 below illustrates the distinction between these two portfolios in terms of technology maturity over time.

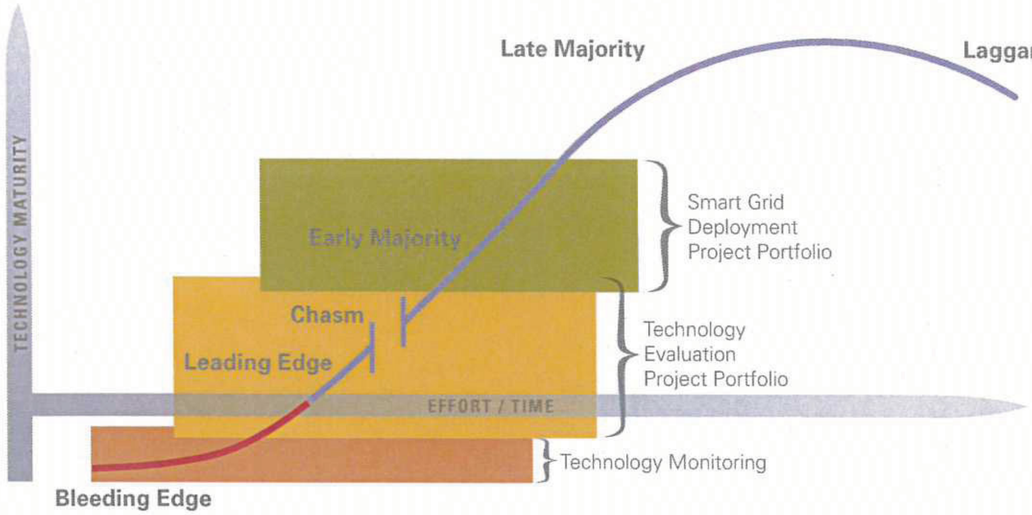



*Figure 10 - Smart Grid Project Portfolios as a Function of Maturity*

Technology evaluation portfolio projects are those which fall into the 'Bleeding Edge' or 'Leading Edge' areas of the maturity curve. These projects require further evaluation of emerging technologies to better understand the capabilities such technologies would contribute to the smart grid vision, their progress towards technical maturity, and the corresponding value that they might unlock. SCE will pursue projects in the technology evaluation portfolio by working closely with partners at research universities, research institutes and national labs, and by monitoring technology evaluation efforts at other utilities. SCE has had a long history of early collaboration that has led to successful adoption or adaption of grid technologies, including distribution automation and the previously mentioned smart metering and synchrophasors. Most of SCE's advanced technology labs[8] are currently ISO-certified and all of our labs will be certified within the next stage of the smart grid development roadmap.

Smart grid deployment portfolio projects, on the other hand, involve the planning and execution of deployment plans for commercially available smart grid technologies. Although these technologies have "crossed the chasm" of the maturity curve, given the urgency of California and national policy goals they increasingly fall within the "Early Majority" or later areas of curve (Figure 10). Historically, SCE and most utilities have preferred to adopt technology later in its maturity lifecycle, allowing for greater confidence in the implementation and operation. Earlier adoption and adaption introduces significant project risks that SCE believes can be substantially mitigated through an effective technology evaluation process as described previously in Section 2. SCE employs best practices from the Project Management Institute and the Software Engineering Institute for execution and deployment of technology projects.

*8 SCE has extensive technology test facilities that are used to evaluate supplier products. See the appendix for a reference to a document which summarizes SCE's laboratory capabilities.*

The sections which follow provide descriptions of each of the smart grid development roadmap stages depicted in Figure 9, along with high level plans for the types of potential deployment and technology evaluation projects to be included within each stage.

### 4.1. Stage 1: Foundation (1995-2008)

Stage 1 of the smart grid development roadmap refers to foundational work in the deployment of advanced measurement and control systems that was completed from the mid 1990s through 2008. SCE's smart grid accomplishments over this period included early experience with wide-area measurement and control technologies, pioneering efforts in Synchronized Phasor Measurement Systems, industry leadership in substation and distribution system automation and the rollout of smart metering to large commercial and industrial (C&I) customers. SCE also launched Energy Manager, an online portal for large C&I customers to access their smart meter data. SCE's early smart grid deployments were based on addressing the highest value opportunities first, across transmission, distribution and customer engagement. Table 2 below provides some additional highlights of SCE's Stage 1 smart grid accomplishments. SCE has received a number of awards for its early smart grid efforts. These awards include the 2007 T&D Automation Project of the Year for SCE's Synchronized Phasor Measurement System, the 2006 Utility Planning Network's North American Smart Metering Project of the Year, and the 2003 Peak Load Management Alliance Outstanding Research Award for Electricity Pricing Research Projects.

| SCE Smart Grid Development Statistics | |
|---|---|
| Total synchrophasors on bulk transmission system | 27 |
| Advanced EMS System | ✔ |
| Total substations automated (% of 900 substations) | 56% |
| Total substation transformers with DGA | 0% |
| Total substations with low latency, high bandwidth telecoms | 33% |
| Distribution management and load control systems | ✔ |
| Total circuits with outage mitigation (% of 4,400 circuits) | 41% |
| Total circuits with field automation (% of 4,400 circuits) | 41% |
| Total microprocessor relays | 31% |
| Total fiber optic cable miles | 3,100 |
| Total renewable resource capacity integrated | |
| Transmission | 2,784 MW |
| Distribution | 2.4 MW |
| Total Demand Response Capacity | 1,548 MW |
| Smart Metering | |
| Large C&I | 100% |
| Residential and Sm C&I | 0% |

*Table 2 - Smart Grid Development Roadmap Stage 1 Statistics*

## 4.2. Stage 2: Inform & Automate (2009-2012)

### *Stage 2 Smart Grid Deployment Plan*

Building upon a set of initial smart grid technologies deployed during Stage 1, SCE is currently executing a $1.5 billion capital deployment plan for advanced information, measurement and automation systems through 2012. SCE's largest investment is in deploying smart meters to all 5 million SCE customers with the completion of the Edison SmartConnect™ program. As part of this program SCE will be launching a smart communicating thermostat program along with an online customer portal for customers to access their smart meter usage information. A rebate program is also included to buy down the cost of home area network devices that customers can use to access real time information from their Edison SmartConnect™ meter.

This period will also include the deployment of phasor measurement units across all of SCE's 500kV and 230kV substations, in conjunction with a western region deployment of synchrophasors coordinated by the Western Electric Coordinating Council (WECC). SCE is also making significant improvements in its grid operations and control systems to support increasing amounts of renewable resources and distributed energy resource integration. Our efforts include a focus on expanding our protection and control systems involving C-RAS and wide-area controls. SCE is also planning capital upgrades to accommodate the mass-market introduction of PEV in our service area. Each of these investments includes state-of-the-art cyber-security capabilities and technologies that are NIST open standards based. Figure 11 depicts SCE's smart grid deployment projects that are currently authorized for Stage 2 of its smart grid roadmap.

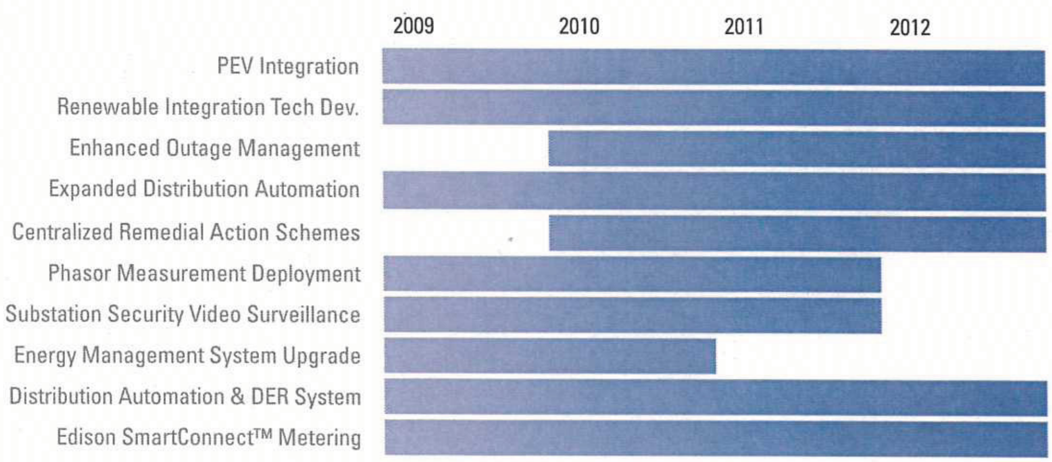



*Figure 11 - Stage 2 Smart Grid Deployment Timeline*

### *Stage 2 Smart Grid Technology Evaluation Plan*

Technology evaluation efforts during Stage 2 will be primarily focused on:

- Evaluation of energy storage
- Integration of renewable and distributed energy resources
- Development and interoperability testing of home area network devices and vehicle charging equipment
- Ongoing development of interoperability and cyber-security standards
- Electric system studies and engineering analysis regarding operational impacts from dynamic resources, bi-directional distribution flows and new operating paradigms
- Workforce safety and productivity technologies

A priority in terms of technology evaluation projects during Stage 2 will be execution of Department of Energy (DOE) American Recovery & Reinvestment Act (ARRA) stimulus projects. In 2009, the DOE awarded SCE several grants to support its various smart grid efforts. These projects include:

**Irvine Smart Grid Demonstration**- Demonstrate an integrated, scalable smart grid system that includes all of the interlocking pieces of an end-to-end smart grid system, from the transmission and distribution systems to consumer applications like smart appliances and electric vehicles. The demonstration will include a number of homes retrofitted to be zero net energy compliant with solar PV, energy smart appliances, home energy storage and energy efficiency upgrades. This demonstration also includes a Waukesha superconducting substation transformer and focuses on the interoperability and interactions between the various field technologies and information and communications systems. This project will also explore dynamic links between distributed resources and wholesale markets and bulk power system operations with CAISO.

**Tehachapi Wind Energy Storage-** Deploy and evaluate an 8 MW utility-scale lithium-ion battery technology to improve grid performance and aid in the integration of wind generation into the electric supply. This project is being done in partnership with CAISO. The project will evaluate a wider range of applications for lithium-ion batteries that may spur broader demand for the technology, bringing production to a scale that will make this form of large energy storage more affordable.

Other DOE ARRA and non-ARRA projects in which SCE is a sub-recipient or participant include: EPRI PHEV Bucket Truck, WECC Wide-Area Disturbance Monitoring, High Penetration Solar Deployment, American Superconductor Fault Current Limiter Project, and Application of Advanced Wide-Area Early Warning Systems with Adaptive Protection. SCE has also received several CEC research grants and has pending applications for additional funds from CEC and CPUC to support the ARRA projects, other research areas and to study the integration of distributed energy resources resulting from the California Solar Initiative.

Another technology evaluation portfolio priority during Stage 2 will be SCE's continued engagement in the near term priority standards development efforts found in Table 3 below.

| Theme | Near Term Priority Standards |
|---|---|
| Customer Empowerment | Automated Data Exchange (ADE) Standards development and pilot for delivery of data to customer-authorized third parties |
| | PEV Communications Standards Identification and Development |
| | PEV Charging Infrastructure Standards Development |
| | Interoperability Standards for various in-home smart grid devices such as smart appliances, home energy management systems, displays etc. |
| Workforce Safety & Effectiveness | Next Generation Worker Safety Standards |
| Renewable & Distributed Energy Resource Integration | Renewable & Distributed Energy Resource Integration Standards |
| | Energy Storage Standards Development |
| Grid Efficiency & Resiliency | Grid Control Standards (Distribution/Substation Automation, Phasor Measurement, etc.) |
| Information and Telecommunications Technology & Cyber-security | Field Area Communications Standards Analysis and Development |
| | Home Area Network Communication Standards |
| | Cyber-security Standards |
| | Interoperability and Data Management Standards |

*Table 3 - Stage 2 Near Term Priority Standards Development*

Finally, there are a limited number of near-term analytical studies, as well as lab-based and field-based technology evaluation projects, that support stimulus projects and/or technologies that might be considered for the longer term deployment portfolio for 2013-2020. Highlights of such study and evaluation projects for Stage 2, listed by smart grid definition domain, are included in Table 4 on next page.

For additional information, please review the sited documents in the appendix for more details regarding Stage 2 deployment and technology evaluation projects. At the completion of Stage 2, SCE expects to have a robust measurement, control and automation infrastructure in place. These achievements will set the stage for further investments to support California's policy objectives and SCE's business objectives to meet 2020 targets.

| Theme | Project Title | Partners |
|---|---|---|
| Customer Empowerment | 3rd Party Product Compatibility Testing – In-Home Displays, Demand Response Technologies | PG&E, SDG&E, CAISO |
| | Energy smart appliance and device testing | GE, UC Irvine |
| | PEV Integration Technology Development and Testing | Itron, Ford, GM |
| | Vehicle to Grid Engineering Assessment | Calstart |
| | Medium and Heavy Duty Vehicle Development | Ford, Eaton, Altec |
| Workforce Safety & Effectiveness | Field Worker Safety Equipment Development | TBD |
| | Smart Grid Knowledge Management Development | Cal Poly Pomona, CSULA |
| | Systems Operations Visualization | IDEO |
| | Robotics Demonstration | TBD |
| Grid Efficiency & Resiliency | Advanced Wide-Area Monitoring and Control System Applications | DOE |
| | Avanti "Circuit of the Future" Test Bed extension | DOE |
| | System Inertia Loss Mitigation Studies | PSERC |
| | Air Conditioner Stalling Project | TBD |
| | Smart Inverter Evaluation and Demonstration | Various |
| | Electro-magnetic pulse (EMP)/ Geomagnetic disturbances (GMD) Hardening | DOE, NERC |
| | 138kV Transmission High Temperature Superconducting FCL demonstration | American Superconductor |
| | Superconducting Distribution Sub-Transformer | Waukesha |
| | Grid Efficiency | EPRI, GE |
| Renewable & Distributed Energy Resource Integration | Renewable Integration Grid Impact Study | TBD |
| | System Inertia Loss Mitigation Studies | PSERC |
| | Tehachapi Wind Energy Storage Demonstration | A123, DoE, CAISO, CEC, Cal Poly Pomona |
| | Wind Power Storage Assessment | CEC, UWIG |
| | Home Battery Pilot Program | TBD |
| | Community Energy Storage Program | Tesla, GE, Others |
| | Compressed Air Energy Storage (CAES) | EPRI, PG&E |
| Information and Telecommunications Technology & Cyber-security | Complex Systems Architecture | Caltech |
| | Advanced Cyber-security Systems | USC ISI, Carnegie Mellon |
| | Distributed Control Systems Architecture | Stanford |
| | Field Area Network Technology Demonstration | GE |
| | Smart Grid Information Systems Architecture | TBD |

*Table 4 - Stage 2 Technology Evaluation Projects*

### 4.3. Stage 3: Interactive (2013-2019)

#### *Stage 3 Smart Grid Deployment Plan*

Stage 3 of the SCE smart grid roadmap will focus on those technologies that leverage prior investments and retrofit new technologies to begin the process of building Grid 2.0. The anticipated evolution from Grid 1.0 to Grid 2.0 is depicted in Table 5 below for various different grid characteristics. Among other attributes, Grid 2.0 will result in full automation of the energy delivery system across the entire value chain, focusing on increased levels of interaction between smart grid devices, the utility, and customers. It will consist of both "hard grid" assets that incorporate new physical materials such as advanced energy storage and super-conducting equipment, and "soft grid" assets such as next generation computing and analytics systems which unlock the full value of the smart grid for both the utility and its customers. Several documents, including "Grid 2.0: The Next Generation" which is highlighted as a source for Table 5, suggest a fully decentralized grid. By 2030, SCE expects a highly interactive and hybrid grid that includes large central resources and increasing numbers of decentralized supply and demand resources. This is not unlike the hybrid information networks of today that link large centralized data centers, cloud computing, highly distributed personal computing and smart phones.

| Grid 1.0 | Grid 2.0 |
|---|---|
| Centralized | Decentralized |
| One-way | Multi-way |
| Limited Feedback | Constant Feedback |
| Small Number of Large Investments | Large Number of Small Investments |
| Emphasis on Throughput of Energy | Emphasis on Investment and Infrastructure |
| Active Producers, Passive Consumers | Producers and Consumers Linked and Active |
| Focus on Supply of Electricity and Gas | Focus on Providing Heat and Power |
| Expertise is Centralized | Expertise is Distributed |
| Supply Based on Predictions of Demand (Predict-and-Provide) | Demand and Supply Linked to and Influenced by Each Other |

*Table 5 - Grid 1.0 evolution to Grid 2.0*[9]

This renewed electric system will enable seamless integration of large renewable and distributed generation resources. It will also support the deployment of energy storage technologies to support state and federal legislation and policy goals such as greenhouse gas reduction, RPS and electric transportation initiatives. Grid 2.0 will also incorporate the next generation of broadband wireless and field area telecommunications technologies needed to support requirements for high speed, low latency information exchange among highly distributed devices. Smart grid systems efforts will include the integration of advanced data analytics and intelligent systems into SCE's existing grid control systems, resulting in a complex system-of-systems to provide

9 Source - Grid 2.0: The Next Generation

totally integrated grid control and real time information regarding the state of the grid at any point between generator and customer. As a result, the opportunity to reliably link customer demand response and other smaller distributed resources into CAISO wholesale market operations will emerge and the requisite ability to coordinate operational dispatch between wholesale market objectives and distribution grid objectives will also be enabled.

SCE's envisioned smart grid investment roadmap for the 2013 – 2019 period is identified in Figure 12 in section 4.5 below. Initiation of many of these projects will depend upon successful technology evaluation efforts over the 2010 – 2017 time period. It should be noted that each of the deployment efforts we include in the roadmap is subject to future CPUC and/or Federal Energy Regulatory Commission (FERC) approval and funding, once plans are submitted though general rate cases or other regulatory proceedings. SCE is and will be committed to evaluating and deploying best-fit solutions to meet our customers' needs and policy goals without sacrificing system reliability or customer service. The discussion below provides additional information about some of the key technology areas to be included in the Stage 3 smart grid deployment plan.

***Integration of Customer Devices*** will continue to be explored through additional and more sophisticated demonstrations that link customer distributed supply and demand resources into wholesale market and utility grid operations. A key technical hurdle to be addressed involves the conceptual design of a robust multi-agent system that can manage the potential for a trillion transaction market to be dynamically linked to grid operations. An intermediate step is to demonstrate the linkage of customer devices to the advanced distribution system described below.

***Advanced Distribution and Substation Automation*** will upgrade SCE's current version 1.0 distribution automation systems to an advanced 2.0 system that leverages the capabilities evaluated through the Irvine Smart Grid Demonstration projects and the Avanti Circuit of the Future. Examples of advanced distribution automation technologies include fault interrupters, advanced voltage/var control (AVVC), and high-speed communications technologies providing communications all the way to the customer meter and "beyond the meter" devices. The 2.0 system also includes the anticipated increase in the number and variety of distributed generation and demand side resources that may be linked both to wholesale market operations and SCE's grid operations. Advanced substation automation technologies will provide automation for greater fault tolerance and will lead to replacement of switched capacitors with static VAR compensators for increased efficiency and voltage control.

Advanced distribution and substation automation efforts will be focused on improving SCE's abilities to monitor and manage increasing levels of bulk and distributed renewable energy resources, to enable advanced demand side management functionality, and to operate the grid more efficiently by limiting system losses.

***Wide-Area Control and Advanced Synchrophasor Applications*** will support grid operations by offering increased intelligence and control over the transmission network. Advanced Wide-Area Control deployments will include digital fault recorder (DFR) installation, transmission/substation capacitor upgrades to support advanced volt/var control at the transmission level, and further deployments of FACTS devices which can be operated or adjusted in response to near real-time analysis of syncrophasor data. This effort would also include integration of advanced centralized back-office and distributed software to support management of sensory and control devices required for wide-area control.

***4G Wireless Telecommunications Network*** will be deployed in order to meet the future communications needs of both utility grid operations and customers requiring near-real time availability of their energy information. A 4G telecomm network will enable monitoring and control of increasing levels of distributed energy resources and allow for the coming shift from centralized to distributed peer-to-peer control of network devices. The network will allow SCE to manage communications with proliferating smart grid sensors and devices (including those located behind the customer meter), enable advanced mobile work-force automation, provide next generation backhaul for the smart metering system and support high volume, low latency requirements for near-real time system state measurement and control.

***Advanced Analytics*** will enable smarter, faster decisions by utility personnel, automated utility information systems, and customers. Analytics systems will provide analytical tools which leverage integrated databases containing smart grid data collected from Edison SmartConnect™ meters, customer devices, distribution and substation automation infrastructure, phasor measurement unit (PMU) devices, and smart inverters associated with distributed energy resources, among other data sources. Visualization and intelligent alarming tools will use the results of these data analytics tools to provide useful and actionable information to system operators responsible for real-time decision making. Engineers and system planners will be able to make improved design decisions based on intelligence derived from system loading and asset performance metrics, resulting in improved grid optimization. Customer service representatives will have access to analytical tools to help them guide customers towards optimal rate, product, and service selection choices. These are only a few of the many potential future examples of smart grid data-driven decision making made possible by advanced analytics systems.

***Energy Storage Deployment*** involves widespread development and deployment of energy storage technologies throughout SCE's smart grid system. Energy storage has the potential to support the electric system with various applications such as reliability, power quality, and generation resource or energy functions, as well as provide customer-side energy management. For example, California's current and proposed energy policies relating to intermittent renewable resource integration are pushing the need for energy storage as an asset that can be used to mitigate renewable energy intermittency and enable energy shifting to harmonize differing periods of peak demand and peak renewable supply. The next few years will be critical to identify and test the feasibility of these applications and to determine how best to integrate them with the smart grid.

***Inertia Loss Mitigation Technology*** will support power system stability in light of potential system inertia losses associated with a reduction of local generation sources. California's proposed once-through-cooling regulation has the potential to negatively impact Southern California's ability to retain existing in-basin generation. Loss of this generation will likely cause a significant loss of system inertia, which is critical for stability. Although studies are needed to better understand this issue, SCE expects the projected loss of inertia will require mitigation by repurposing the existing generation to provide a synchronous condenser function. Where that is not possible, deployment locations for new synchronous condensers will be identified.

### *Stage 3 Technology Evaluation Plan*

Stage 3 technology evaluation initiatives will include technologies that were in the earliest stages of development during Stage 2. In addition this stage will consider studies which will pursue unanswered questions and next steps resulting from the ARRA stimulus projects including the Irvine Smart Grid Demonstration Project, the Tehachapi Wind Energy Storage Project, and others. Technology evaluation efforts in Stage 3 will likely focus on the following areas, among others:

| Theme | Project Title |
|---|---|
| Grid Efficiency & Resiliency | Development of grid asset lifecycle management systems |
| | Development of transmission and distribution system power flow and voltage control systems to reduce system losses |
| Renewable & Distributed Energy Resource Integration | Development of 2G and 3G energy storage technologies (electrochemical and non-electrochemical) |
| | Advanced monitoring & control of intelligent inverters associated with distributed energy resources |
| Customer Empowerment | Exploration of advanced measurement and charging control for electric vehicles |
| | Development of a unified communications schema with and between networks of evolving and increasingly interactive customer technologies |
| Information and Telecommunications Technology & Cyber-security | Development of advanced analytic and visualization tools to support interpretation of increasing volumes of data |
| | Assessment and development of unified cyber-security systems across multiple computing and telecommunications platforms |
| Workforce Safety & Effectiveness | Evaluation and development of knowledge management expert systems to support the anticipated large turnover in utility workforce due to retirements |

*Table 6 - Stage 3 Technology Evaluation Projects*

### 4.4. Stage 4: Intuitive & Transactive Grid (2020-2030)

The 2020 decade will see continued deployment of Grid 2.0 capabilities across SCE's system as well as the introduction of highly distributed intelligent controls that will increasingly involve machine-to-machine transactions. Stage 4 of the smart grid development roadmap assumes full convergence of information and energy systems, as well as continued breakthroughs in computing architectures, cyber-security, internet technologies, autonomous multi-agent control systems, artificial intelligence applied to electric system operations, wireless telecommunications, energy storage, power electronics, energy smart consumer devices, consumer information technology and sensing technologies. Results should include wider deployments of distributed computing technologies for faster system response times, the integration of many more sensory and control nodes at the distribution and customer levels, and the ability to manage and precisely react to supply and demand imbalances at the micro level or, through aggregation, at any level or nodal point across the T&D grid.

We currently anticipate that several significant milestones will be achieved during the decade of 2020 to 2030. SCE anticipates that renewable resources will reach 33% of power delivered on its system. Plug-in electric vehicles in SCE's service area should exceed one million before 2025. The decade will see the mass introduction of zero net energy residential and commercial buildings in California that may incorporate onsite renewable supply, energy storage, high efficiency envelopes, energy smart appliances/devices and autonomous control systems interfaced to grid and wholesale market operations. This will result in an integrated network with the potential of 20 million agents (people & devices) on SCE's system. Also, vehicle-to-grid, microgrids and dynamic scheduling across the western region using distributed resources will become operationally and economically feasible options. As such, Grid 2.1 would need to provide a ubiquitous, highly reliable and secure network that seamlessly integrates a wide variety of demand and supply resources to enable broad market participation by consumers, suppliers and autonomous devices involving trillions of micro-transactions per year.

Table 7 below highlights several of the technology innovation activities that will be pursued over the next five years to help spur the development of commercial solutions in the 2020 decade. These items frequently involve very long development and testing cycles for broad commercial introduction on a utility system. SCE recognizes the need to begin the technology development lifecycle and is partnering on each of these areas with universities, research institutes, national labs and other utilities to facilitate the development process and sharing of knowledge.

| Theme | Project Title |
|---|---|
| Grid Efficiency & Resiliency | Electric grid as an increasingly complex network of networks<br>• Applied research and design to manage the increasing complexity for transmission, distribution and customer systems and their integration<br>• Redefining the limits of optimization at acceptable levels of instability risk<br>• Identifying potential system inertia deficiencies and solutions |
| | Application of high-temperature superconducting materials to grid equipment<br>• Superconducting transformers & fault current limiters<br>• Superconducting cable<br>• Superconducting Magnetic Energy Storage (SMES) |
| Renewable & Distributed Energy Resource Integration | Development of 2G & 3G energy storage technologies (electrochemical and non-electrochemical) |
| | Advanced monitoring & control of intelligent inverters associated with distributed energy resources |
| Customer Empowerment | Evaluation and development of vehicle-to-grid capability |
| | Converting the electric grid to support a trillion micro-transactions market dynamically driving grid operations thru multi-agent based control systems dynamics |
| Information and Telecommunications Technology & Cyber-security | Evaluation and development of business applications using artificial intelligence to manage critical business operations |
| Workforce Safety & Effectiveness | Continued evaluation of potential adaptive technologies from other industries such as defense and transportation |

*Table 7 - Stage 4 Technology Evaluation Projects*

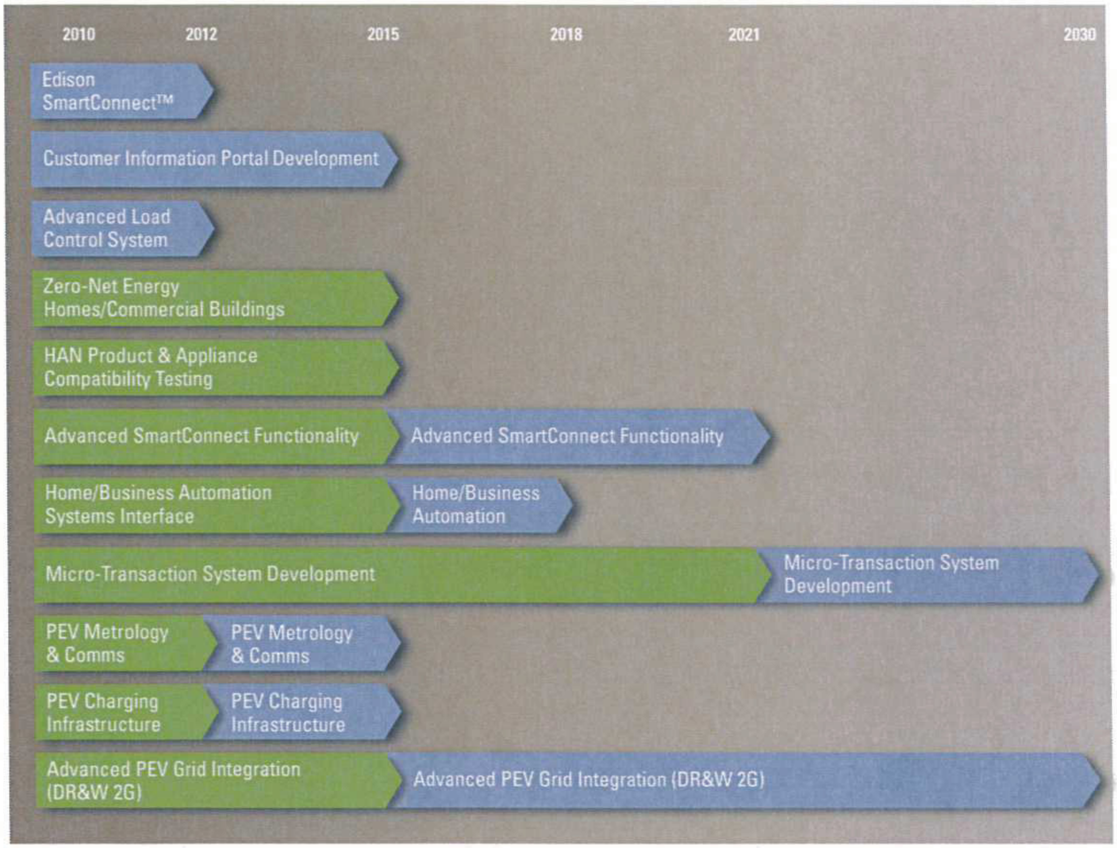
### 4.5. Summary of Technology Roadmap

The development of the smart grid will be a journey that will likely take 30 years to fully accomplish, with key milestones along the way. A significant near-term milestone is the completion of the deployment of SCE's smart metering to all of its five million customers by the end of 2012. The next key milestone is enabling the many state and federal climate and energy policy objectives targeted for 2020. These and other policy milestones create significant timing and time alignment challenges related to the relative maturity of the technologies required to meet these goals, as well as key dependencies and predecessor relationships between unique technology deployments. In an attempt to address these challenges, SCE is simultaneously pursuing capital projects to deploy smart technologies and managing a large portfolio of concurrent technology evaluation activities with development periods spanning 5 years, 10 years and 20 years. The net result of these activities is the transformation of the electric grid and utility operations to a grid for the 21st century. The challenge of course is that this transformation is occurring as SCE is replacing most of its existing core grid infrastructure, supporting the development of an economy that is increasingly reliant on cleaner, but intermittent, electricity resources and anticipating the retirement of 50% of its workforce by 2020. As such, the pace and cost of the transformation from today's electric grid to the smart grid are critical questions. These issues must be explicitly considered in the development of smart grid investment policy because reasonable cost and reliability of electric service are essential to our customers. The evolution of this transformation is illustrated in the technology roadmap summarized in Figure 12 on the following pages.

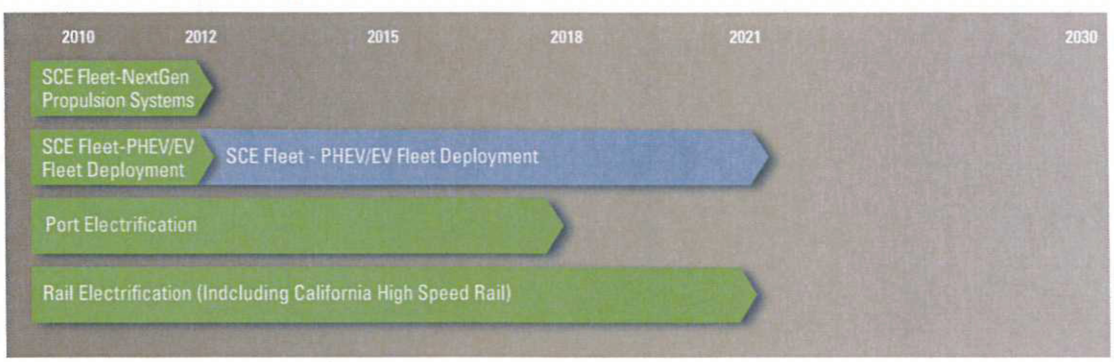
## Customer Empowerment

■ Technology Evaluation ■ Deployment

### *Customer Energy Smart Solution*

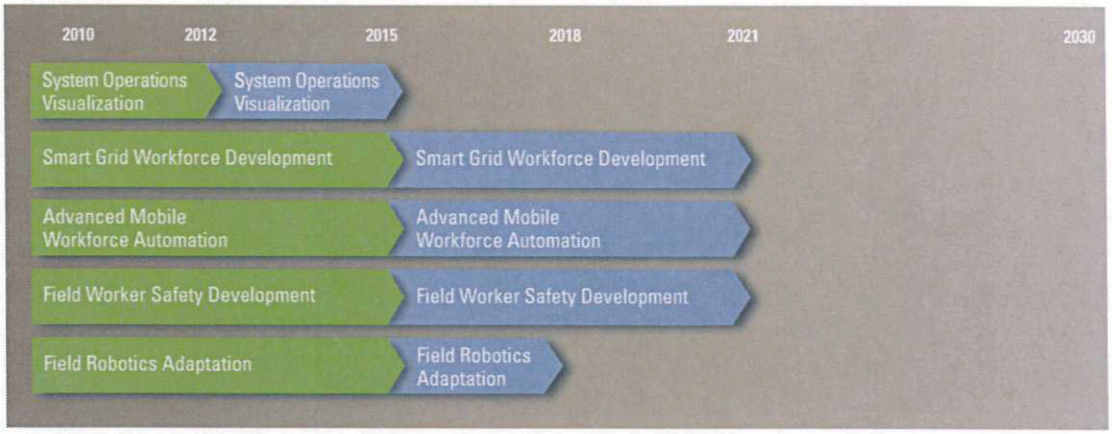



### *Advanced Electric Transportation*



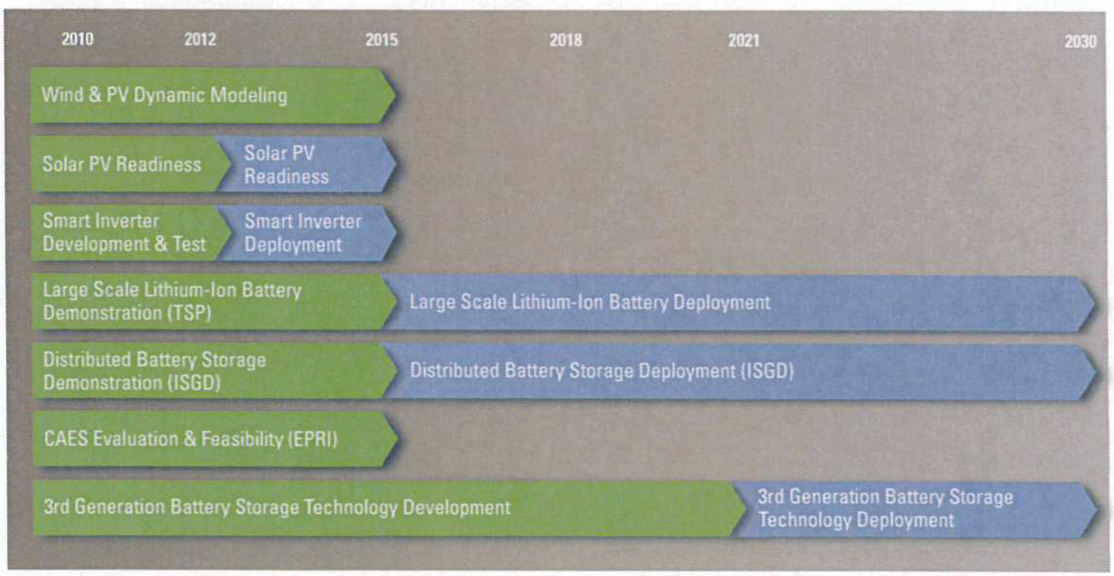
## Workforce Safety & Effectiveness

■ Technology Evaluation ■ Deployment




## Renewables & DER Integration

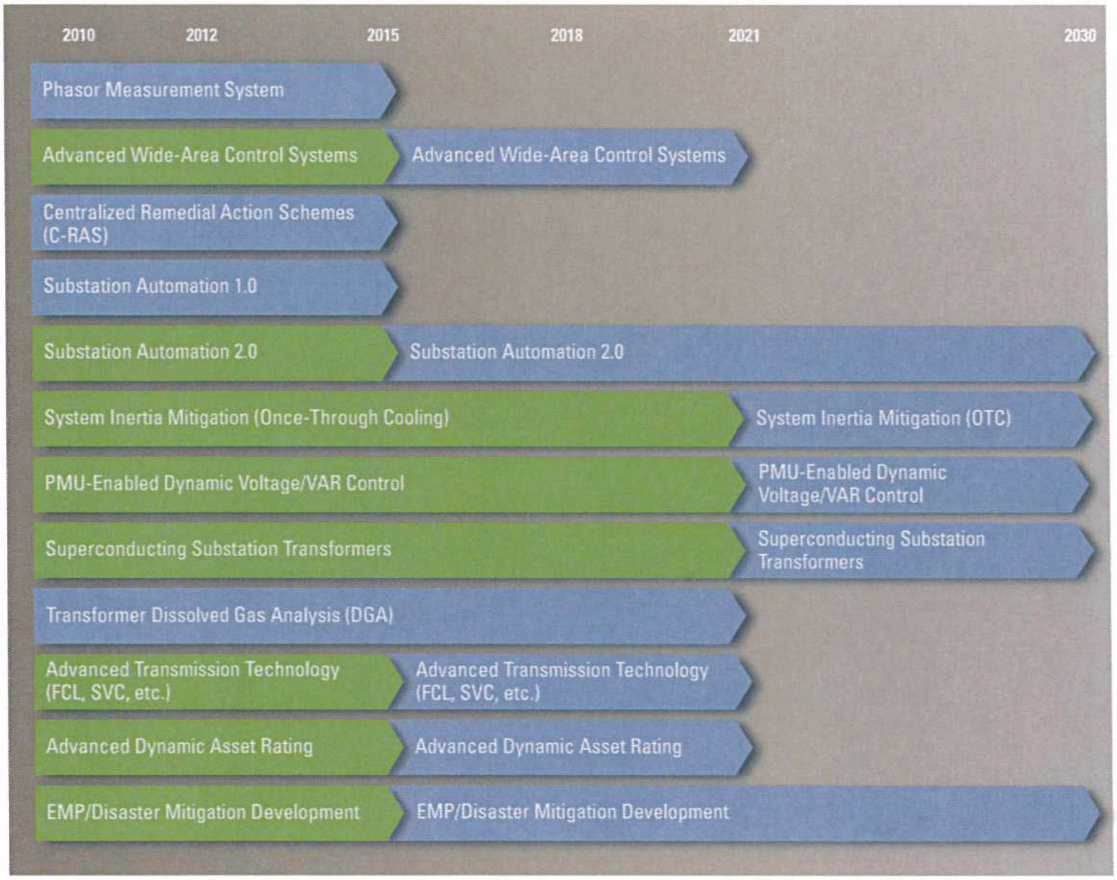
■ Technology Evaluation ■ Deployment



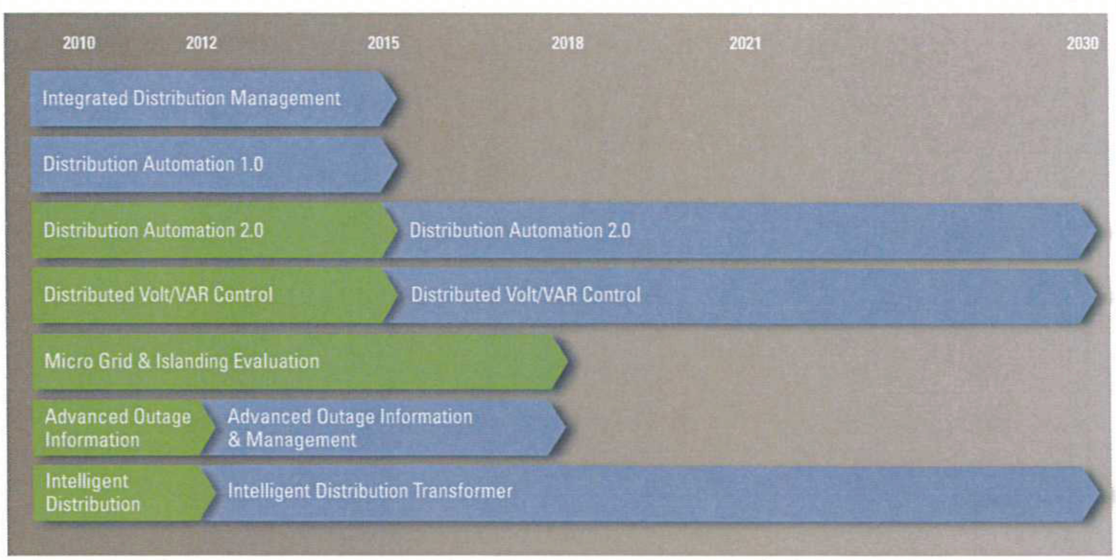
## Grid Efficiency & Resiliency

■ Technology Evaluation ■ Deployment

### *Transmission/Substation*




### *Distribution*



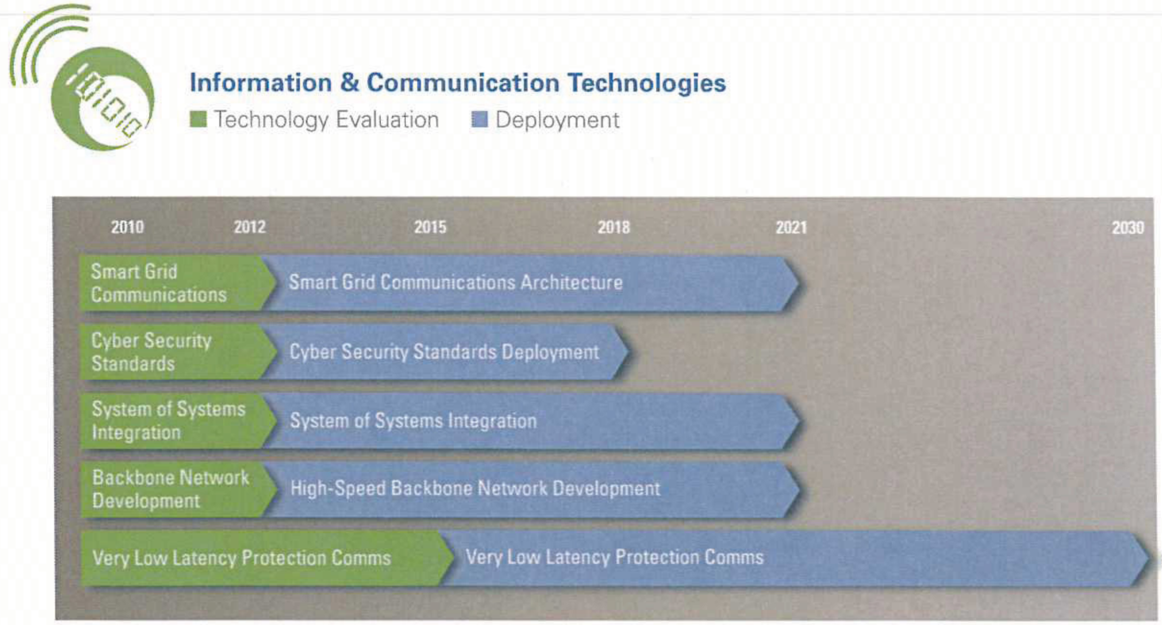



*Figure 12 - Summary Technology Roadmap*

### 4.6. Managing and Maintaining the SCE Smart Grid Development Roadmap

Because of the staged and staggered deployment approach described above, the SCE smart grid development roadmap must be flexible, particularly in the later years, and able to handle adjustments and changes to the scope and sequencing of deployments. Re-evaluating and reconsidering the smart grid deployment roadmap will be an important periodic activity as detailed business cases are developed for specific smart grid initiatives, as lessons are learned through technology deployment experience, and as policy drivers and business objectives change and evolve. To be able to respond to such adjustments, SCE has created a function within its Advanced Technology organization to manage and update its Smart Grid Strategy and Roadmap on an ongoing basis. This effort will track both smart grid deployment and technology evaluation project portfolios. It will closely monitor changes to state and federal policy, corporate goals, business case developments, and emerging technology innovation, as well as broader macro-economic and energy market developments (i.e. scenario planning 'signposts'), to identify necessary course corrections to the staged roadmap over time.

# 5. Appendices

## 5.1. SCE Smart Grid Reference Documents

### *Relevant SCE Documentation*

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Irvine Smart Grid Demonstration <http://www.sce.com/PowerandEnvironment/smartgrid/> 2009.

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Smart Grid Standards Adoption <http://www.sce.com/PowerandEnvironment/smartgrid/> 2009.

Smart Grid Standards Adoption Lifecycle
<http://www.sce.com/PowerandEnvironment/ smartgrid/> 2009.

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## 5.2. External Smart Grid Reference Documents

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United States Department of Energy. Smart Grid System Report. 2009 <www.oe.energy.gov/DocumentsandMedia/SGSRMain_090707_lowres.pdf>

NIST Framework and Roadmap for Smart Grid Interoperability Standards Release 1.0: National Institute for Standards & Technology, September 2009

GTM Research. Leeds, David J. The Smart Grid in 2010. 2009 <www.gtmresearch.com/report/smart-grid-in-2010>

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GridWise Architecture Council (GWAC) Financial Benefits of Interoperability
<http://www.gridwiseac.org/pdfs/financial_interoperability.pdf>

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"Moore's law," Wikipedia,
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California Senate Bill 17
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CPUC Smart Grid OIR Phase I Final Decision
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California Water Resources Control Board: Draft Policy on the Use of Coastal and Estuarine Waters for Power Plant Cooling (Once Through Cooling)
<http://www.swrcb.ca.gov/water_issues/programs/npdes/docs/cwa316/otcpolicy112309_clean.pdf>

FERC Smart Grid Policy Statement
<http://www.ferc.gov/whats-new/comm-meet/2009/071609/E-3.pdf>

NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 1.0
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# SCE Smart Grid Vision

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For more information on Advanced Technology and the SCE Smart Grid, please visit **www.sce.com/smartgrid**, or contact us at **AdvancedTechnology@sce.com**

# Appendix B

## PROJECT NAME: DISTRIBUTION MARKET DEMONSTRATION AND ANALYSIS

| EPIC DESCRIPTION | PROJECT EXPLANATION |
|---|---|
| **Technology or strategy to be demonstrated** | Southern California Edison (SCE) envisions a smart grid that utilizes advancements in energy, communications, computing, sensing, and control technologies to support the growth in distributed generation technologies, increased penetration of electric vehicles, and the evolution of demand response, energy efficiency and other energy management services. Realizing this vision will require a next generation distribution grid. Many of the technologies envisioned in this next generation distribution grid are currently being deployed in SCE's Irvine Smart Grid Demonstration (ISGD) program. The next step is to begin demonstrating the optimization of these interconnected resources and developing market concepts that will efficiently enable emerging technologies while maintaining safety and reliability.<br>This demonstration project will leverage ongoing work with the California Institute of Technology as part of an Advanced Projects Research Agency – Energy (ARPA-E) to develop a distributed volt/VAR control system that envisions multiple devices connected to control systems to optimize voltage and VAR control. The project would extend this interconnected and optimized network of devices to include an active distribution grid market that enables supply and demand balancing within a geographic area.<br>The value of this optimization will be demonstrated initially using Grid LAB-D, a software tool developed by the Pacific Northwest National Lab (PNNL). The Grid LAB-D model includes the distribution network and a detailed behind the meter model of connected load and resources that includes the thermal characteristics of the building. This detail allows for accurate analysis of the impacts of emerging technology and the effectiveness of control of these devices, demand response programs, and energy efficiency potential for a particular section of SCE's Distribution system. |
| **Concern, problem or gap to be addressed** | The existing demonstration at Irvine includes a detailed investigation of individual components of the smart grid and their impacts on the distribution grid. The demonstration project does not suggest a particular market structure or a mechanism to optimize the resources across a geographical section of SCE's distribution grid. In addition existing distribution planning tools do not provide engineers and operators with the adequate and granular modeling necessary to analyze the integration challenges and opportunities that intermittent renewable and distributed generation present to the grid. In addition to these technical issues, a comprehensive model to evaluate customer behavior, optimized rate structures, and customer rate impacts that scales to the entire SCE system would provide a tool for analyzing adoption trends. Ongoing development of programs (e.g., demand response, energy efficiency) and technologies (e.g., smart meters, in-home displays, etc.) will change how customers consume and manage energy. |
| **Pre-commercial technology or strategy aspect** | Gridlab-D is a tool developed by Pacific Northwest Labs for power systems analysis. Gridlab-D can perform a simulation that shows the interaction amongst power flow, control systems, and economic factors simultaneously. |
| **How the project avoids duplication from other initiatives** | There have not been demonstrations of distribution grid market concepts indicating the value of interconnected devices. |
| **Prioritization: High priority project** | This system will provide a demonstration and detailed modeling and simulation to provide data to evaluate renewable integration dynamics on the distribution system. This information will be helpful in identifying critical engineering, operational and financial impacts from the complex dynamics of the distribution system. The tool will require cooperation from regulatory and operational integration across multiple organizations, leveraging existing methods and models that have been developed by these organizations. The effort will also integrate multiple stakeholders' perspectives with SCE's distribution policies. |

| EPIC DESCRIPTION | PROJECT EXPLANATION |
|---|---|
| **EPIC primary or secondary principles met** | This demonstration shows clear ratepayer benefits by providing greater reliability by addressing the operational challenges of integrating renewables and optimizing distributed generation into the grid. The demonstration also provides greater safety of the grid through an increased understanding of the simultaneous interaction between power flow, control systems and economic factors. Furthermore this is an efficient use of ratepayer funds because it helps promote Greenhouse gas emissions mitigation by helping to integrate greater penetration of renewable resources, distributed generation, electric vehicles and possibly energy storage into SCE’s grid. |

## **PROJECT NAME:** INVERTER CONTROLS

| EPIC DESCRIPTION | PROJECT EXPLANATION |
|---|---|
| **Technology or strategy to be demonstrated** | This project will test and demonstrate photovoltaic (PV) inverter functionality above and beyond current standards to better help accommodate higher levels of PV based Distributed Generation (DG). Greater functionality is needed from next generation inverters to address voltage, stability and operational flexibility issues. SCE will work with a partner vendor to test and demonstrate the needed additional functionality of the next generation of inverters. Key functions that SCE will test include:<br>• Low voltage ride though<br>• Anti-islanding schemes that do not involve positive feedback disturbing system voltage and frequency<br>• Participation in volt / VAR schemes and regulation<br>• Participation in frequency / watt schemes<br>• Remote communication and control functionality<br>• System disturbance / oscillation damping<br>• Minimize fault contribution<br>• Minimize transient switching overvoltage |
| **Concern, problem or gap to be addressed** | Integrating significant penetration levels of PV based DG onto SCE's grid is difficult due to the current generation of inverters lacking necessary functionality to address voltage, stability and operational flexibility issues. Research performed at SCE's labs and at other labs has shown the need to improve the design and control systems PV inverters. Test and demonstration of the bullet items above could yield positive results which would facilitate the integration of PV based DG. This will also aid in the development of industry standards. |
| **Pre-commercial technology or strategy aspect** | This project seeks to test physical hardware and devices that may be used in the next generation of PV inverter systems. The functionality to be tested and demonstrated is not commercially available in the United States. |
| **How the project avoids duplication from other initiatives** | This project is unique in the fact that it seeks to test and demonstrate hardware performance. Other projects involve modeling inverters, but this will be the first time SCE will test and demonstrate the additional functionality needed from inverters to accommodate higher levels of PV penetration on SCE's grid safely and reliably. |
| **Prioritization: High priority project** | To accommodate higher levels of PV based DG from CPUC customer-based programs such as the California Solar Initiative (CSI), Self-Generation Incentive Program (SGIP) and the Feed-In Tariff (CREST) programs, SCE will need additional functionality from the next generation of inverters to maintain system reliability. This demonstration is crucial toward testing such additional functionality. |
| **EPIC primary or secondary principles met** | This demonstration shows clear ratepayer benefits by addressing greater reliability of the grid by helping to integrate higher levels of PV-based DG. Furthermore, it helps promote grid safety by ensuring the distribution grid can integrate intermittent PV-based DG without compromising the integrity of the grid. For these aforementioned reasons, the project is an efficient use of ratepayer monies and has the potential to promote economic development by giving greater opportunities for increased penetration of PV-based DG into SCE's grid. |

## **PROJECT NAME:** POWER ELECTRONIC TRANSFORMER (PET)

| EPIC DESCRIPTION | PROJECT EXPLANATION |
|---|---|
| **Technology or strategy to be demonstrated** | With a Power Electronic Transformer (PET), planners and field engineers could have a method to provide higher quality power to customers who are sensitive to voltage fluctuations. Additionally, customers with distributed energy resources (DER) are contributing power to the grid without any restrictions; if enough customers were to do this, an entire circuit could experience voltages that are too high. The PET can be used to manage voltage fluctuations caused by high penetrations of rooftop solar PV generation and dynamic loads such as Electric Vehicle (EV) charging stations. It can also be designed to provide small amounts of reactive power and harmonic compensation. While this is not intended to replace the standard distribution transformer, it could be another tool to ensure system reliability and customer satisfaction. |
| **Concern, problem or gap to be addressed** | For a number of customers, voltage fluctuations of any kind are extremely detrimental to their business processes. While there are a number of technologies and strategies for ensuring reliable service to customers, no method currently exists to provide higher quality power. High penetration of rooftop PV generations, EV charging, welding machine, and modern electronic appliances can cause undesired power quality such as voltage fluctuation, undesired current and voltage waveforms due to harmonic distortion. |
| **Pre-commercial technology or strategy aspect** | SCE is working with a company that has developed a conceptual product for a power electronic transformer and will demonstrate this product as a part of the project. However, this product is not yet commercially available and the SCE team is working with the company to help demonstrate and verify the operational and performance characteristics. |
| **How the project avoids duplication from other initiatives** | Within SCE, there are no other groups that are working on a similar project. SCE has also benchmarked other investor-owned utilities (IOUs) across the state, and there does not appear to be any similar work being performed. |
| **Prioritization: High priority project** | This project is of high priority because it can help mitigate voltage fluctuations due to the proliferation of distributed energy resources (DER) and plug-in electric vehicles (PEVs) coming online in the near future. Much of this is driven by policies such as California's 33% Renewables Portfolio Standard, the Governor's goal for 12,000MW of localized energy resources, and greenhouse gas reduction goals such as Assembly Bill 32. |
| **EPIC primary or secondary principles met** | The PET project provides clear electricity ratepayer benefits by enhancing SCE's ability to provide safe, reliable, and affordable energy services, and is an efficient use of ratepayer monies. This project could result in a more uniform voltage profile for a circuit and facilitate greenhouse gas (GHG) emissions mitigation by enabling distributed energy resources to reliably interconnect with SCE's distribution grid. It can improve power quality by mitigate voltage fluctuation and capable of providing some reactive power and harmonic compensation. |

## **PROJECT NAME:** ADVANCED VOLTAGE AND VAR CONTROL OF SCE TRANSMISSION SYSTEM

| EPIC DESCRIPTION | PROJECT EXPLANATION |
|---|---|
| **Technology or strategy to be demonstrated** | To reliably and safely integrate renewables into the grid, SCE needs to determine the optimal voltage schedule of high voltage buses (500 & 230 kV), and maintain substation voltages closer to scheduled set-points. The set-points will be determined by a central supervisory coordinator (a companion project) that is formulated based on an optimal power flow, thus reducing line losses. This project will increase renewables integration by improving VAR reserves via coordinating switching of continuous and discrete VAR control devices, improve system operational reliability by continuously monitoring system proximity to voltage instability from intermittent renewables as seen by substation measurements, and also improve longevity of expensive discrete control devices such as transformer banks load tap changer (LTC) by reducing switching actions. Washington State University (WSU) will be the project technical lead and will assist SCE in evaluating the results of the controller in monitoring mode. Internal engines and parameters of the algorithms will be tuned and modified by WSU based on feedback from SCE engineers and substation operators. |
| **Concern, problem or gap to be addressed** | The project will demonstrate efficient voltage regulation of different voltage levels at Devers substation while minimizing the number of switching actions. Reducing the number of tap changer operations enhances the longevity of the banks while also reducing maintenance costs. Further, the project will monitor and eliminate circular VAR flows among multiple parallel transformer banks at the substation. Circular VAR flows if left uncorrected lead to unnecessary flow of reactive power back and forth among parallel transformers, leading to increased heating losses while also depleting valuable VAR resources. In addition, the project will coordinate the switching of discrete devices to keep static VAR compensator (SVC) VAR output to be near zero under normal operating conditions. This is consistent with current operating practice at Devers to keep the full VAR capability of SVC available for fast dynamic response. Lastly, the project will provide early detection of unusual operating conditions related to highly stressed system scenarios that are seen from significantly different system responses after routine switching events. |
| **Pre-commercial technology or strategy aspect** | Presently, substation operators manually switch without any objective to optimize the operation. This project will demonstrate that automation of switching operations will improve grid reliability by basing switching automation on optimal reactive power flow formulation and establishment of an optimal strategy for switching VAR resources in and out. |
| **How the project avoids duplication from other initiatives** | This project will for the first time, demonstrate new automation technology for substation switching operations to integrate renewable with the goal of improving grid reliability and decreasing equipment maintenance costs at substations. A large list of publications reporting research studies in this area were reviewed, and no project similar to this was found. To avoid nationwide duplication, SCE has published preliminary results from the project at IEEE PES General meeting (summer of 2012), and submitted another paper for publication in IEEE Transactions in Power System. This journal is widely used by other utilities engineers and academia. These efforts minimize any chance of duplication. |
| **Prioritization: High priority project** | This project is of high importance because SCE is committed to helping California achieve its clean energy goals by working to integrate increasing penetration of renewables, while maintaining safety and reliability of the grid at an affordable cost to customers. This demonstration will help monitor and eliminate circular VAR flows from among multiple parallel transformer banks at the substation, which is important for SCE to eliminate because if left uncorrected could lead to unnecessary flow of reactive power back and forth among parallel transformers leading to increased heating losses while also depleting valuable VAR resources. Furthermore this demonstration project will decrease equipment maintenance costs by reducing the number of tap changer operations, which enhances the longevity of the banks. |

| EPIC DESCRIPTION | PROJECT EXPLANATION |
|---|---|
| **EPIC primary or secondary principles met** | The Voltage and VAR Control of SCE's Transmission System meets the primary and mandatory principle of providing ratepayer benefits. Specifically this project will improve grid reliability by helping to monitor and eliminate circular VAR flows from among multiple parallel transformer banks at the substation. The project also will lower costs by reducing the number of tap changer operations and increasing the longevity of transformer banks, thus decreasing equipment maintenance costs. |

## PROJECT NAME: MULTISTEP CAPACITOR SWITCHER

| EPIC DESCRIPTION | PROJECT EXPLANATION |
|---|---|
| **Technology or strategy to be demonstrated** | The Multistep Capacitor Switcher project will demonstrate a new capacitor switching device for mitigating distributed energy resource (DER) integration problems created by undesirable voltage levels (i.e., too high or low). This project will provide the ability to incrementally add reactive power to the distribution circuit at the point of capacitor connection. Presently, the typical size for overhead and underground capacitors is 1200kVAR and 1800kVAR, respectively. When the capacitor is switched on, the full reactive power amount is injected into the circuit. The switching device would provide for stages of 600kVAR increments at a time as needed. For example, an 1800kVAR padmounted capacitor would have 3 stages in the “on state” to choose from, 600kVAR, 1200kVAR, and 1800kVAR. The benefit from being able to choose which stage is appropriate for a particular operating condition is that the voltage at the capacitor point of connection can be controlled more accurately. |
| **Concern, problem or gap to be addressed** | Undesirable voltage levels created by distributed generation on a distribution circuit can lead to customer and power system equipment failure, line congestion, and excessive energy consumption. Since voltage on a distribution circuit is highest at the source (e.g., substation bus) and degrades as you move farther away from the substation, capacitors are used to regulate voltage by injecting reactive power into the circuit at the point of connection. At SCE, 1200kVAR or 1800kVAR-sized overhead and underground capacitors are used on 12kV and 16kV distribution circuits; however, since these circuits are designed to inject their full reactive power amount, the capacitors can create conditions where the circuit voltage is either too high at the end of the line or varies in its slope (e.g., too high and low at different parts of the circuit). The multistep capacitor switcher could be used to remove reactive power in stages when DER results in increased voltage on the system. |
| **Pre-commercial technology or strategy aspect** | This project will demonstrate the concept of a variable reactive power source for mitigating undesirable voltage levels caused by distributed generation, using a combination of pre-commercial capacitors, fuses, switches and enclosure designs. |
| **How the project avoids duplication from other initiatives** | Presently at SCE, three phase capacitors are used when switched on and inject their full reactive power per phase into the circuit. This project is unique because it will be the first to demonstrate an apparatus capable of providing variable reactive power output. |
| **Prioritization: High priority project** | Given California’s 33% Renewables Portfolio Standard, the Governor’s goal for 12,000MW of localized energy resources, and other clean energy goals, related to distributed generation, SCE is placing a high priority on projects that help integrate DER technologies, such as solar PV-based generation in a safe and reliable manner. |
| **EPIC primary or secondary principles met** | The Multistep Capacitor Switcher project provides clear electricity ratepayer benefits by enhancing SCE’s ability to provide safe, reliable, and affordable energy services, and is an efficient use of ratepayer monies. This project could result in lower energy consumption, and a more uniform voltage profile for a circuit. An automated capacitor switch will improve grid reliability, reduce energy consumption and procurement costs, and help ensure that customer and power systems equipment function properly. In addition, it may be possible for the automated capacitor switch to be used in conjunction with the new Advanced Volt/VAR Control (AVVC) project currently being incorporated into SCE's Distribution Management System (DMS) to help SCE operators lower the average system voltage on all distribution circuits fed from a substation, as well as fine tune the voltage profile for each circuit. |

## **PROJECT NAME:** COMMUNITY ENERGY STORAGE AND CONTROLS EVALUATION

| EPIC DESCRIPTION | PROJECT EXPLANATION |
|---|---|
| **Technology or strategy to be demonstrated** | The utility industry has long been governed by the need to instantaneously match supply with demand; now with the integration of variable energy resources on the grid and the many regulatory drivers, including the California Public Utilities Commission Energy Storage Order Instituting Rulemaking (R.10-12-007), it faces the challenges of utilizing new technologies, such as energy storage systems, and ensuring reliable, affordable, and safe electricity during periods of low, intermittent, or disrupted generation. This project will characterize the performance and validate the reliability improvement that can be provided by integrating Community Energy Storage (CES) devices into SCE's distribution circuits to provide substantial reliability improvements both locally and when aggregated and controlled as a fleet. This project will also validate use cases for CES devices in voltage regulation, demand relief, Distributed Energy Resource (DER) smoothing, back-up power, reactive power support and feeder relief. A collaboration effort with National Renewable Energy Laboratory (NREL) will be leveraged to analyze the energy storage thermal behavior. Energy storage used in conjunction with renewables resources clearly supports the Clean Energy Jobs Plan and the California Renewable Energy Small Tariff. Energy storage technology connected to the grid is a recognized path to provide peak reduction, or to better integrate renewable resources by mitigating the intermittency and variability of these resources (SBX1-2, 33% Renewable Energy by 2020). This program contributes to SCE's grid modernization activities by providing data to support the Energy Storage OIR and operation, installation and control of CES devices within the Irvine Smart Grid Demonstration (ISGD) project. |
| **Concern, problem or gap to be addressed** | SCE has identified distributed energy storage, as in the case of CES deployment, as one of the most promising storage options. However, as detailed in SCE's Moving Energy Storage from Concept to Reality whitepaper, though few niche applications appear cost effective today, several exhibit high potential and could be cost-effective in the near term. As large-format battery production scales up due to increasing numbers of PEVs and technology improvements, costs of energy storage systems should decrease dramatically. |
| **Pre-commercial technology or strategy aspect** | Existing strategy in the industry to deploy CES Units is to aggregate these units and control the units as a fleet via a centralized controller. There have been no deployments of the centralized controller strategy to date and SCE, through CES & Controls Evaluation, aims to take the existing strategy and technology of a centralized controller out of the conceptual and lab domain and validate operation of a few CES units in the field via a centralized controller. |
| **How the project avoids duplication from other initiatives** | Under the ISGD project, SCE is deploying a single CES unit. While the CES Unit individually has autonomous functionality such as local voltage regulation and back-up power for residential loads connected, it does not offer an opportunity to test the CES Unit's capability in a fleet operation where additional uses such as demand relief at the fleet level, DER smoothing, reactive power support and feeder relief. |
| **Prioritization: High priority project** | This is high priority project as, today, there are no strategies deployed to control CES Units as a fleet and therefore no path to demonstrating the CES Units' capabilities when operated as a fleet vs. autonomous, non-synchronized collection of disparate units with no centralized control. |
| **EPIC primary or secondary principles met** | This project supports EPIC's guiding principle to provide electricity ratepayer benefits, defined as promoting greater reliability, lower costs, and increased safety. Additionally, this project demonstrates the potential to help improve reliability, support green job creation and provide support for peak power reduction thereby supporting the complementary guiding principles to support societal benefits; economic development; and the efficient use of ratepayer monies. |

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# **PROJECT NAME:** MEGAWATT-CLASS CONTAINERIZED ENERGY STORAGE INTERCONNECTION READINESS

| EPIC DESCRIPTION | PROJECT EXPLANATION |
|---|---|
| **Technology or strategy to be demonstrated** | This project aims to investigate anticipated and actual behavior of MW-class containerized Energy Storage prior to field deployment, and validate the behavior of the same equipment once deployed in the field. In this manner, the project seeks to evaluate the safe operation of the Battery Energy Storage System (BESS), to provide the necessary training for field deployment of the BESS and also to evaluate the distribution grid reliability enhancements and improvements that the BESS can provide. This project directly supports CPUC Energy Storage OIR, (R. 10-12-007), promoting distributed generation and renewable integration policies through testing and evaluating distributed energy storage systems. Storage technologies help to reduce peak demand by shifting of energy from on-peak to off-peak. Moreover, they also help to better integrate renewable resources by mitigating inherent intermittency and variability of these resources (SBX1-2, 33% Renewable Energy by 2020). |
| **Concern, problem or gap to be addressed** | Manufacturers of MW-scale BESS are challenged with the ability to provide facilities where they can perform complete Factory Acceptance Tests (FAT) of equipment. As a result, utility personnel must accept equipment with testing under pseudo-grid staging and performing testing on site after the BESS is delivered. This project seeks to reduce the risk of field deployment and is an important mitigation factor for Battery Energy Storage System (BESS) penetration on the distribution grid. |
| **Pre-commercial technology or strategy aspect** | The existing method of performing factory acceptance testing of large scale (1MW and up) energy storage systems are limited to reducing and de-rating the capability of the actual system to manageable smaller and modular ratings. This presents a condition where the actual full rated system is never tested and accepted as the actual integrated unit. |
| **How the project avoids duplication from other initiatives** | SCE has identified the gap in the inability of manufacturers to test full rated energy storage systems in a grid connected manner at their facility due to the facility power limitations. This constraint results in large systems being deployed on the grid without ever being tested and factory accepted as an integrated unit. This is the only project that takes energy storage system from the factory floor to an intermediate site to test grid integration under actual grid conditions prior to deploying at the final point of common coupling. |
| **Prioritization: High priority project** | This project is high priority due to the current lack of knowledge regarding the integration of large scale energy storage systems with the electric grid. This lack of knowledge leads to the deployment of BESS on the grid and having to troubleshoot and perform system tuning during integration at the final point of common coupling. This presents a safety and reliability concern if the large BESS are not coordinated with the present state of the grid. Furthermore, as large-format battery production scales up due to increasing numbers of PEVs and technology improvements, the costs of energy storage systems should correspondingly decrease. To this end, a larger number of applications could become economically viable within the next five to 10 years, requiring a facility that can accommodate the testing of the larger sized BESS before deploying on the grid. |
| **EPIC primary or secondary principles met** | This project supports EPIC's guiding principle to provide electricity ratepayer benefits by supporting increased reliability through storage technologies ability to help shift peak demand by shifting energy demand from on-peak to off peak. Moreover, this project continues to advance energy storage and intermittent renewable power, helping to mitigate greenhouse gas emission and supporting economic development of renewable technologies in the electricity sector. |

## **PROJECT NAME:** DISTRIBUTED ENERGY STORAGE FIELD DEMONSTRATION

| EPIC DESCRIPTION | PROJECT EXPLANATION |
|---|---|
| **Technology or strategy to be demonstrated** | This project will validate reliability improvements that can be provided with higher penetration of Distribution Energy Storage (DES) when distributed strategically on a particular circuit, especially in instances where reliability of lower voltage circuits (e.g., 4kV circuit) are acute and often have limited solutions requiring full circuit revamps in most instances. It's expected that when DES are aggregated and controlled as a fleet, the aggregated solution will provide substantial reliability improvements at the circuit level whether such circuits have high or low Distributed Energy Resources (DER) penetration. Areas of reliability improvements include reactive power support, feeder relief, DER smoothing (with higher levels of DER penetration), voltage regulation at multiple points along the circuit, and potentially the ability to provide back-up power to a larger load base. |
| **Concern, problem or gap to be addressed** | The utility industry has long been governed by the need to instantaneously match supply with demand; now with the integration of variable energy resources on the grid and the many regulatory drivers, including the CPUC's Energy Storage OIR (R. 10-12-007), it faces the challenges of utilizing new technologies, such as energy storage systems, and ensuring reliable, affordable, and safe electricity during periods of low, intermittent, or disrupted generation. Distributed energy storage systems such as CES, was identified as one of the most promising storages option by SCE's strategic planning work. As detailed in SCE's Moving Energy Storage from Concept to Reality whitepaper, though few niche applications appear cost effective today, several exhibit high potential and could be cost-effective in the near term. |
| **Pre-commercial technology or strategy aspect** | The current state of energy storage device deployments in the field consist of "one-off" installments where demonstration aims at solving a specific operational use or testing separate operational uses to understand the technical and economic viability. |
| **How the project avoids duplication from other initiatives** | The approach of deploying individual energy storage devices to solve one operational use at the point of common coupling, operating autonomously does not lend itself well to the demonstration of distributed energy storages in a circuit wide implementation where all the benefits of the aggregated storage such as feeder relief, reactive power support, DER smoothing, voltage regulation at multiple points based on a fleet based control strategy can be realized. This project is the only one of its kind where multiple energy storage devices in various power and energy ratings can be combined and deployed in the field to be operated as a fleet via a centralized control strategy. |
| **Prioritization: High priority project** | This is high priority project as, today, there are no strategies deployed large number of DER units and therefore no path to demonstrating the DER's capabilities when operated as a fleet vs. autonomous, non-synchronized collection of disparate units with no centralized control. |
| **EPIC primary or secondary principles met** | This project supports EPIC's guiding principle to provide electricity ratepayer benefits as demonstrated through its ability to help improve reliability when DES are aggregated and controlled as a fleet. This aggregated solution will provide substantial reliability improvements at the circuit level whether such circuits have high or low DER penetration. This further contributes to the complementary principle to provide an efficient use of ratepayer funding by supporting load management and helping to avoid overload conditions. |

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# **PROJECT NAME:** MODELING AND SIMULATION FOR MITIGATING DER VARIABILITY WITH DISTRIBUTED ENERGY STORAGE

| EPIC DESCRIPTION | PROJECT EXPLANATION |
|---|---|
| **Technology or strategy to be demonstrated** | Variability of the power output of Distributed Energy Resources (DER) makes it challenging for the operator to predict circuit behavior. Distributed energy storage (DES) can reduce and in many cases eliminate this variability by optimizing the charge and discharge of energy storage based on the variability of DER. This project seeks to help evaluate the use and optimization of energy storage devices in distribution circuits where penetration of DER is high. Centralizing and automating the operation of a fleet of DES devices will also give system operators the ability to focus on other more-important system issues while the DES controller operates in the background to present a more predictable resource. |
| **Concern, problem or gap to be addressed** | This project will support policy goals related to the integration of renewable resources, especially in meeting the 33% RPS and zero net energy (ZNE) goals, and will also directly support SCE's efforts to address Governor Brown's proposal for 12,000 MW of localized energy resources (LER) by 2020. While this proposal has not been codified, SCE expects the CPUC and/or CA Legislature to open proceedings on this topic. The CEC has already begun to address LERs as part of its Integrated Energy Policy Report. Additionally, Governor Brown's staff requested that SCE develop a program proposal for discussion. The main intent of the project is to assess the performance of controlling the DES devices as a fleet, individual DES devices can be modeled as ideal sources (only if models are not available) without affecting the overall assessment of the control algorithms. The cost of not doing this project would impede SCE's efforts to understand the impact of ZNE homes, and mitigation techniques for high levels of intermittent distributed generation. |
| **Pre-commercial technology or strategy aspect** | This project offers the opportunity to test an actual controller with many simulated units in aggregation using the RTDS to simulate different grid conditions to prove out its ability to effectively perform wide area control and grid support functions before deploying the centralized controller on the grid. |
| **How the project avoids duplication from other initiatives** | In the DOE-ARRA funded ISGD project SCE deployed a single CES unit; this demonstration builds on the lessons learned from the ISGD project and will use an actual controller with many simulated CES units to assess distributed energy storage's value for wide-area control on the grid and the associated benefits and costs. |
| **Prioritization: High priority project** | This is a high priority demonstration because this is the only project of its kind where the strategy of controlling multiple CES Units as a fleet via a centralized controller can be tested in the lab as hardware in-the-loop. This project is also important, because once a few CES Units are modeled and the centralized controller is placed as hardware on the simulated environment, even more CES Units can be modeled and the centralized unit's capabilities of controlling CES units in quantities of 100's to 1,000's can be validated in the lab environment, prior to deploying on the grid. |
| **EPIC primary or secondary principles met** | This demonstration addresses primary and complimentary guiding principles of ratepayer benefits. Specifically this demonstration will improve grid reliability by modeling CES Units as a fleet to maximize CES Units' potential for supporting grid operations. The project also addresses lower costs by reducing the need for additional ancillary services. Furthermore, the project provides efficient use of ratepayer funds because it has the potential to shift generation to meet peak power demand. |

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## PROJECT NAME: TEHACHAPI WIND ENERGY STORAGE PROJECT

| EPIC DESCRIPTION | PROJECT EXPLANATION |
|---|---|
| **Technology or strategy to be demonstrated** | The Tehachapi Wind Energy Storage Project (TSP) will evaluate the performance of an 8 MW, 4 hour (32 MWh) Battery Energy Storage System (BESS) to improve grid performance and assist in the integration of large-scale variable energy resources. Project performance will be measured with 13 specific operational uses: provide voltage support and grid stabilization; decrease transmission losses; diminish congestion; increase system reliability; defer transmission investment; optimize renewable-related transmission; provide system capacity and resources adequacy; integrate renewable energy (smoothing); shift wind generation output; frequency regulation; spin/non-spin replacement reserves; ramp management; and energy price arbitrage. Most of the operations either shift other generation resources to meet peak load and other electricity system needs with stored electricity, or resolve grid stability and capacity concerns that result from the interconnection of variable energy resources. SCE will also demonstrate the ability of lithium-ion battery storage to provide nearly instantaneous maximum capacity for supply-side ramp rate control to minimize the need for fossil fuel-powered back-up generation. |
| **Concern, problem or gap to be addressed** | This project will help to validate the storage system's ability to integrate intermittent renewables resources in a transmission-constrained area. These characteristics of the demonstration project typify the operational challenges of increasing penetration of renewables on SCE's grid. The project's results and recommendations will be highly scalable to other areas of California and the United States that are seeking to expand the production of renewable power. |
| **Pre-commercial technology or strategy aspect** | This project evaluates advanced energy storage and combines the benefits of Flexible AC Transmissions Systems (FACTS) devices. The BESS technology uses advanced prismatic cell design lithium ion batteries. Furthermore, the project also utilizes a new integration strategy at the system level to interact in a semi-automated operating mode. |
| **How the project avoids duplication from other initiatives** | This project demonstrates existing technology for a new application for the first time. The energy storage technology was previously used in transportation, but is now being applied to the electric grid. DOE, through its ARRA grant further ensures the work will not duplicate other demonstrations. |
| **Prioritization: High priority project** | To meet California's clean energy goals, such as AB32 and 33% Renewables Portfolio Standard (RPS), greater amounts of renewables will need to be integrated into SCE's grid, while maintaining stabilityand reliability. This demonstration is crucial toward understanding how BESS can best help to provide reliability and operational support for the electric grid. |
| **EPIC primary or secondary principles met** | The Tehachapi Wind Energy Storage Project provides clear ratepayer benefits. Specifically this demonstration will improve grid reliability by determining how to best maximize BESS potential to support grid operations. The project also addresses lower costs by reducing the need for ancillary services and shifting generation resources to meet peak power demand. |

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## **PROJECT NAME:** HIGH IMPEDANCE FAULT DETECTION ON DISTRIBUTION CIRCUITS

| EPIC DESCRIPTION | PROJECT EXPLANATION |
| --- | --- |
| **Technology or strategy to be demonstrated** | The High Impedance Fault Detection (HIF) on Distribution Circuits project will demonstrate the ability of protection relays that use HIF algorithm to detect HIF signatures such as harmonics and waveform changes and avoid being affected by load noises and other system operation conditions. The HIF algorithm will detect high impedance faults in order to trip the circuit and de-energize a downed power line. This demonstration will initially occur in a controlled lab environment by generating actual faults in a high voltage laboratory, recording the faults onto a COMTRADE data file, and then using that file to simulate high impedance faults and demonstrate detection strategies on SCE's Real-Time Digital Simulator. Upon validation in the lab, SCE will install a limited number of relays in the field to demonstrate the success of this high impedance fault detection strategy on an energized circuit. |
| **Concern, problem or gap to be addressed** | High impedance faults occur when a power line makes unwanted contact with a tree limb, asphalt, sand, or with some other surface, or object which restricts the flow of fault current to a level below that detected by normal protection equipment. This leaves the downed power line energized, and can be dangerous for employees and the public if they come into contact with the electrical wires, potentially causing serious injury or fatality. |
| **Pre-commercial technology or strategy aspect** | At this time, there is no proven solution (combination of hardware & software) that is commercially available for High Impedance Fault Detection on distribution circuits. This project will demonstrate two protection relays that use the third harmonic method of detecting high impedance faults. One of these relays is not yet commercially available, but will be available for demonstration purposes during the course of this project. In addition, this project is the only known use of an RTDS for simulating high impedance faults and demonstrating the effectiveness of high impedance fault detection strategies. |
| **How the project avoids duplication from other initiatives** | SCE is confident that this project is unique since high impedance fault traces from protective devices capturing actual circuit events are difficult to obtain due to the unpredictable nature of high impedance fault occurrences. Leveraging the capabilities of SCE's Advanced Technology Labs, it is possible to record fault current traces onto COMTRADE files for simulation purposes and protective device testing. |
| **Prioritization: High priority project** | The High Impedance Fault Detection on Distribution Circuits project is a high priority for SCE as safety is the company's number one priority. Downed power lines that remain energized have the potential to cause personal injury and property damage. Effective mitigation strategies are critical to ensuring that customers and employees remain safe around electricity. |
| **EPIC primary or secondary principles met** | The High Impedance Fault Detection on Distribution Circuits project provides clear electricity ratepayer benefits by enhancing SCE's ability to provide safe, reliable, and affordable energy services, and represents an efficient use of ratepayer monies. If successful, the strategy demonstrated in this project would allow SCE to protect its customers from high impedance faults by de-energizing downed power lines before any person or piece of equipment comes into contact with them. In addition, successful high impedance fault detection would help prevent fires caused by downed power lines coming into contact with flammable material such as dry grass. |

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## PROJECT NAME: SUBSTATION AUTOMATION 3, PHASE III BULK ELECTRIC SYSTEM

| EPIC DESCRIPTION | PROJECT EXPLANATION |
|---|---|
| **Technology or strategy to be demonstrated** | The Substation Automation-3 (SA-3) Phase III Bulk Electric System project will demonstrate next generation substation automation design (SA-3) on SCE's bulk electric system. This project will involve replacing and upgrading substation networking and communication equipment at one transmission-level substation to support the International Electrotechnical Commission (IEC)IEC61850 standard. This international-based standard design cost-effectively supports interoperability, redundant design, substation situational awareness and auto-configuration functionality, increasing power system reliability and efficiency. It will also provide a comprehensive automation solution that is fully compliant with the latest North American Electric Reliability Corporation's (NERC) Critical Infrastructure Protection (CIP) standards. Further, an integrated and centrally managed cybersecurity solution will be demonstrated to meet and exceed existing cybersecurity requirements, and demonstrate security. |
| **Concern, problem or gap to be addressed** | Moving to an open, non-proprietary communications standard will enable SCE to procure the most cost-effective and highest performing substation equipment, regardless of the vendor. The SA-3 Phase III Bulk Electric System, if demonstrated to be successful, will provide a low-cost, effective transition plan from legacy substation automation systems to the new interoperable SA-3 system based on the IEC 61850 standard. This project will also address NERC CIP requirements, cybersecurity, and the lack of substation situational awareness at the transmission-level. |
| **Pre-commercial technology or strategy aspect** | Major components of the SA-3 Phase III Bulk Electric System project are not known to be commercially available, and will be demonstrated to better understand the operational and performance characteristics of the given technology. These components include a parallel redundant local area network (LAN) and supervisory control and data acquisition (SCADA) remote terminal unit (RTU) / Gateway design with auto-configuration via IEC-61850 SCL files, Common Cybersecurity Services (CCS), and incremental differencing. In addition, the latest IEEE and IEC protocols will be introduced and integrated into the transmission substation system. |
| **How the project avoids duplication from other initiatives** | The SA-3 Phase III Bulk Electric System project will be SCE's first IEC 61850 compliant substation automation design applied at a transmission-level substation. The pre-commercial technologies mentioned above, as well as the specific IEEE and IEC protocols demonstrated will be unique to the bulk electric system. |
| **Prioritization: High priority project** | If this project is successful, SA-3 would allow SCE to remotely monitor device health and securely access real-time transmission-level substation data necessary for reliably and efficiently operating the bulk electric system. It would also provide SCE with more flexibility in procuring the best substation equipment by moving to an open, non-proprietary communications standard. Further, this project is necessary to demonstrate a next generation transmission-level substation automation solution that is secure from physical and cyber-attacks, as well as NERC CIP compliant. |
| **EPIC primary or secondary principles met** | The SA-3 Phase III Bulk Electric System project provides clear electricity ratepayer benefits by enhancing SCE's ability to provide safe, reliable, and affordable energy services, and is an efficient use of ratepayer monies. SA-3's implementation on the bulk electric system will allow grid operators to better monitor and control SCE's transmission system, increasing overall system reliability. |

# PROJECT NAME: SUBSTATION AUTOMATION 3, PHASE III HYBRID SOLUTION

| EPIC DESCRIPTION | PROJECT EXPLANATION |
|---|---|
| **Technology or strategy to be demonstrated** | The Substation Automation-3 (SA-3) Phase III Hybrid Solution project will demonstrate the ability to integrate the SA-3 substation automation design standard with existing legacy Substation Automation System (SAS) and Substation Automation-2 (SA-2) substation systems. One distribution substation will be selected to host this demonstration in order to better understand issues unique to these substations. If this demonstration of SA-3 system integration is successful, this will lead to a new standard for existing SCE substation SCADA / automation design. More importantly, this demonstration project could provide a cost-effective transition plan from obsolescent SAS systems and SA-2 systems to an SA-3 system. It will also provide advanced features such as remote access to substation devices and data transfer to SCE's Enterprise historian eDNA while providing a comprehensive automation solution that is fully compliant with the latest North American Electric Reliability Corporation's (NERC) Critical Infrastructure Protection (CIP) Cybersecurity standards. |
| **Concern, problem or gap to be addressed** | SCE has approximately 280 substations based on its first substation automation design standard, Substation Automation System (SAS), and 70 substations that evolved from SAS to become the more open second generation system, Substation Automation-2 (SA-2). The original SAS system is based on a proprietary network only compatible with a small number of devices. The SA-2 system improved on this limitation by adopting an open standard Ethernet network, but did not provide backward compatibility with SAS. Phase II of the Substation Automation-3 (SA-3) program moved away from proprietary protocols by adopting an open standards system without the limitations of SAS and SA-2. This now leaves the possibility of having substations with a combination of SAS and SA-3 or SA-2 and SA-3 systems in cases where it is not economically feasible to replace a station's existing automation system that has not yet past its life cycle while new major equipment is being installed. Both SAS and SA-2 demand a cost-effective upgrade process which supports transition to the latest standard (SA-3) while allowing our legacy systems to run their life cycle. Some of the early installations of SAS are now past their life cycle, and finding replacement equipment is becoming increasingly difficult. This project will also allow for transitioning failed SAS equipment to SA-3 with minimum effort. |
| **Pre-commercial technology or strategy aspect** | Major components of the SA-3 Phase III Hybrid Solution project are not known to be commercially available, and will be demonstrated to better understand the operational and performance characteristics of the given technology. These components include a parallel redundant local area network (LAN) and supervisory control and data acquisition (SCADA) remote terminal unit (RTU) / Gateway design with auto-configuration via IEC-61850 SCL files, Common Cybersecurity Services (CCS), and incremental differencing. In addition, the latest IEEE and IEC protocols will be introduced and integrated into these hybrid distribution substation systems. |
| **How the project avoids duplication from other initiatives** | The SA-3 Phase III Hybrid Solution project is a unique solution for cost-effectively upgrading SCE's 350 substations with legacy SAS and SA-2 network designed automation systems. These automation systems are now approaching 20 years of life and protective relays and other components are beyond their life expectancy. The SA-3 Phase III design introduces an effective way to monitor and transition these legacy systems to a design which supports IEC 61850, centrally managed cybersecurity, and the installed SAS and SA-2 network protocols. The introduction of this hybrid design is crucial to the effective transition management of the 350 substations with 7000 IEDs which have or will soon approach their replacement threshold. |

| EPIC DESCRIPTION | PROJECT EXPLANATION |
|---|---|
| **Prioritization: High priority project** | This is a high priority project for SCE since approximately 350 legacy substation automation systems are in need of upgrading from SAS or SA-2. The SA-3 Phase III Hybrid Solution project will demonstrate a Substation Automation / SCADA standard design which allows SCE a strategy for transitioning the 350 legacy Substation Automation Systems cost-effectively based on both load growth project schedules and obsolescence criteria. Risks of not doing this project include the potential failure through obsolescence of up to 7000 IEDs in 350 substations over the coming decade. |
| **EPIC primary or secondary principles met** | The SA-3 Phase III Hybrid Solution project provides clear electricity ratepayer benefits by enhancing SCE's ability to provide safe, reliable, and affordable energy services, and is an efficient use of ratepayer monies. SA-3's implementation as a hybrid solution at substations will allow grid operators to better monitor and control SCE's grid, increasing overall system reliability. |

## PROJECT NAME: RISK MITIGATION DEMONSTRATION

| EPIC DESCRIPTION | PROJECT EXPLANATION |
|---|---|
| **Technology or strategy to be demonstrated** | The Risk Mitigation Demonstration project will validate mitigation strategies for various outage scenarios by using a Real-Time Digital Simulator (RTDS). Utilizing the power system modeling capabilities of the RTDS, different mitigation steps will be demonstrated, along with protection equipment, to determine their effectiveness during cascading and evolving power system disturbance events. One of the outage situations to be studied will be the 2011 Arizona – San Diego blackout. SCE will recreate the conditions and events of the September 8, 2011 blackout, examine alternative mitigation steps, and determine potential effectiveness. Benefits though extend beyond being able to demonstrate and validate mitigation strategies, as this demonstration could also serve as a tool to better train system operators and engineers on system dynamics and potential actions for responding to future disturbances. |
| **Concern, problem or gap to be addressed** | This project will address the need for more accurate tools to study different system contingencies brought up by the Federal Energy Regulatory Commission (FERC) and North American Electric Reliability Corporation (NERC) report on the Arizona-San Diego blackout. To SCE's knowledge, the RTDS is the only tool with the speed and accuracy to comprehensively address some of the issues identified with the existing methods of studying contingencies and outages, especially given the increasing complexity of the power grid. In the NERC report, it was recommended that Transmission Operators (TOP) consider the effect of relays that automatically isolate facilities without providing operators sufficient time to take mitigating measures. The hardware-in-the-loop capability of the RTDS is ideal to investigate the performance of different protective relays during disturbances. The relay action at different phases of a cascading event can be evaluated, as well as the effectiveness of any mitigation steps on these relays. |
| **Pre-commercial technology or strategy aspect** | To SCE's knowledge, the RTDS is the only tool with the speed and accuracy to comprehensively address some of the issues identified with the existing methods of studying contingencies and outages. As a result, SCE will be pioneering a new approach to demonstrating mitigation strategies for various outage scenarios. |
| **How the project avoids duplication from other initiatives** | There are no known projects that utilize RTDS hardware and software to perform risk mitigation demonstrations. This is primarily due to the limited number of RTDS systems available to utilities and national labs in the United States. |
| **Prioritization: High priority project** | This is a high priority project as it will help SCE respond to reliability policies and questions pointed out by FERC and NERC in the 2011 Arizona - San Diego outage report. As the electric system evolves and becomes more complex, some of the existing tools will no longer be adequate for identifying issues that occur during dynamic system conditions. Minimum hardware testing (e.g., protection relays) is not sufficient as it can sometimes result in misoperation of devices, therefore, utilities will need to rely on more robust tools such as the RTDS to fully comprehend the operational and performance characteristics of protection devices and mitigation strategies. Further, this demonstration may also offer complementary benefits such as providing a training tool for system operators who respond to system disturbances. |
| **EPIC primary or secondary principles met** | The Risk Mitigation Demonstration project provides clear electricity ratepayer benefits by enhancing SCE's ability to provide safe, reliable, and affordable energy services, and is an efficient use of ratepayer monies. If successful, this project will improve overall system reliability by validating mitigation strategies to prevent future blackouts similar to the 2011 Arizona – San Diego blackout. |

## PROJECT NAME: SUBSTATION ANIMAL DETERRENT

| EPIC DESCRIPTION | PROJECT EXPLANATION |
|---|---|
| **Technology or strategy to be demonstrated** | The purpose of this project is to demonstrate a new device for conditioning small animals from traveling into areas of high voltage equipment and conductors within SCE substations. This project would demonstrate the effectiveness of a new device designed to discourage small animals from contacting energized equipment and bus ways by exhibiting a "road closed" methodology. It is anticipated that a successful device could be used to retro-fit existing SCE distribution substations and be applied while equipment remains energized. |
| **Concern, problem or gap to be addressed** | From 2009 to 2011, SCE experienced 211 animal caused outages involving substation equipment or bus ways within its distribution substations. Over the years, SCE has installed various industry animal deterrent products to reduce animal convergence within their substations, but only a few of SCE's substations have experienced limited success in deterring small animals from high voltage equipment and conductors. |
| **Pre-commercial technology or strategy aspect** | Most animal deterrent devices used around electrical equipment are "covers" to prevent accidental contact between an animal and any energized electrical equipment. SCE's strategy is to demonstrate a new active animal deterrent that will minimize the need to "cover" exposed electrical equipment, but limit the animal's behavior around energized electrical equipment. |
| **How the project avoids duplication from other initiatives** | No other initiatives have been identified that provide a "non cover-up" approach for deterring animals from contacting electrical substation equipment. Successful demonstration of a new non-cover deterrent product will be a leap forward from current products including barrier fencing. |
| **Prioritization: High priority project** | This is a high priority project for SCE given the substantial number of animal caused outages over the past three years. Successful demonstration of a substation animal deterrent device would benefit SCE and its customers by reducing operating costs since fewer repairs would be necessary, preventing power outages caused by animals, and creating a safer environment for animals that traverse within distribution substations. |
| **EPIC primary or secondary principles met** | The Substation Animal Deterrent project provides clear electricity ratepayer benefits by enhancing SCE's ability to provide safe, reliable, and affordable energy services, and is an efficient use of ratepayer monies. Preventing animals from coming into contact with energized substation equipment will reduce the number of animal caused outages, helping to improve overall system reliability. Further, this project will increase safety and reduce equipment maintenance costs as a result of small animals being deterred from high voltage equipment and conductors. |

# **PROJECT NAME:** SUPERCONDUCTING TRANSFORMER (FORMERLY WAUKESHA HTS TRANSFORMER)

| EPIC DESCRIPTION | PROJECT EXPLANATION |
|---|---|
| **Technology or strategy to be demonstrated** | SCE has pledged to support an ARRA-funded project of SuperPower Inc. (SP) and SPX Transformer Solutions (formerly Waukesha Electric Systems). The two companies have agreed to work together to develop a 28 MVA High Temperature Superconducting, Fault Current Limiting (HTS-FCL) transformer. SCE will provide input in the development, installation and operation of the transformer at MacArthur substation. This project was previously approved under the now defunct CEC PIER program. The project will demonstrate that this SPX designed HTS-FCL Transformer can operate as an equivalent to SCE's existing 28 MVA B-Banks. It will operate for two years beginning in September of 2014 through 2016. |
| **Concern, problem or gap to be addressed** | Excess fault duty is a growing concern for SCE and other utilities. Other FCL devices are under development, but these devices take up room in the MacArthur substation that is seldom available. This demonstration is intended to host the aforementioned transformer at the substation in conjunction with the ISGD project in order to demonstrate a combination of emerging technologies in one location. However, completion of the ISGD project is not strictly necessary in order to host the transformer. The most significant risk for project completion lies in the transformer construction and testing phases. These hurdles are scheduled to be cleared before construction expenditures begin at the substation, which shields EPIC funds from being spent without a successful project. |
| **Pre-commercial technology or strategy aspect** | This SPX Transformer will incorporate fault current limiter (FCL) functionality in the transformer itself. This new FCL functionality would eliminate the need for the extra space, and be a practical solution to high short circuit duty issues for SCE and the electric industry. |
| **How the project avoids duplication from other initiatives** | The SPX transformer will be a first and only of its kind in the world, completely avoiding duplication of any other known project. It is being designed to be as close to a commercial product as possible. As such it will be of significant value to American manufacturing. This project enjoys exceptional leverage from DOE and participant funding on the order of 30:1. |
| **Prioritization: High priority project** | Excess fault duty directly affects reliability and safety of the grid and is a growing concern for SCE and the electric industry. This project will demonstrate a HTS-FCL Transformer (SCX) designed as an equivalent to SCE's existing 28 MVA B-Banks. The SCX with its fault current limiting capability is a possible solution to excess fault duty. |
| **EPIC primary or secondary principles met** | The Superconducting Transformer project shows clear ratepayer benefits. This project will improve reliability and safety of the grid by addressing the operational issue of excess fault duty. The project also could potentially lower costs by mitigating the need to replace transformers that have been affected by excess fault duty. |

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## PROJECT NAME: REMOTE FAULT CURRENT INDICATORS

| EPIC DESCRIPTION | PROJECT EXPLANATION |
|---|---|
| **Technology or strategy to be demonstrated** | The Remote Fault Current Indicators project will demonstrate using low-cost remote fault current indicators with wireless communications capabilities to assist in rapid fault finding for SCE's troublemen, as well as monitoring operating currents and load for distribution grid planning purposes. If proven to be successful, remote fault current indicators could integrate with SCE's Distribution Management System (DMS) to enable Fault Detection, Isolation, and Restoration (FDIR) schemes that would minimize circuit outages and restore power to customers quicker than is possible today. Further, the low-cost remote fault current indicators being demonstrated have the potential to communicate from underground circuits, which could significantly enhance underground circuit reliability for utilities across the United States. |
| **Concern, problem or gap to be addressed** | SCE operates an extensive distribution grid of overhead and underground circuits. In the event of a fault, SCE field crews currently drive along the circuit and test different sections until they are able to identify the specific location of the fault. Power cannot be restored until the field crew identifies the correct location of the fault and can begin restoration work. One example of this problem is located in Death Valley, where SCE's troublemen are located four hours away from a 40 mile long circuit. |
| **Pre-commercial technology or strategy aspect** | The primary component of this demonstration is a low-cost fault current indicator with a built-in radio. A California start-up company developed both the hardware and the low-cost communication network to support it. SCE will demonstrate this radio and communications solution to validate its operational and performance characteristics. |
| **How the project avoids duplication from other initiatives** | This project is unique from other initiatives because it is the first to demonstrate next generation fault current indicators with wireless communication capabilities for both underground and overhead applications. Specifically, it wasn't feasible to demonstrate communicating fault current indicators for underground distribution circuits in the past since no pre-commercial or commercial technology was available. |
| **Prioritization: High priority project** | This is a high priority project as distribution circuit fault interruptions currently require field personnel to identify and isolate the faulted circuit. In some areas this requires long driving times and distances to isolate and test the circuit to see if the fault can be found. Also, if there is a fault in an underground circuit, troublemen have to open up underground vaults to see if a light-emitting diode (LED) indicator is flashing, which represents the presence of a downstream fault. Cost-effective remote fault current indicators could transmit their information to SCE's DMS, providing field crews with better fault location data, avoiding the need to manually open up underground faults, and minimizing service interruption time for customers. |
| **EPIC primary or secondary principles met** | The Remote Fault Current Indicators project provides clear electricity ratepayer benefits by enhancing SCE's ability to provide safe, reliable, and affordable energy services, and is an efficient use of ratepayer monies. Successful demonstration of functional remote fault current indicators would minimize the impact of outages and lead to quick load restoration. Further, this project meets the complementary guiding principle of economic development since the radio technology and communications vendor is a growing start-up based in San Diego. |

## PROJECT NAME: SUBSTATION LINE DISCONNECT SWITCHING INDICATOR

| EPIC DESCRIPTION | PROJECT EXPLANATION |
|---|---|
| **Technology or strategy to be demonstrated** | The Substation Line Disconnect Switching Indicator project will demonstrate the ability to provide a visual indication to a field worker performing switching operations on a substation line disconnect. This project will demonstrate the effectiveness of a tool that indicates to the operator whether the line disconnect is loaded prior to switching, and if they are operating the correct disconnect. This information could provide an additional safeguard to current safety procedures. |
| **Concern, problem or gap to be addressed** | The ability to know whether a substation disconnect switch is loaded or not is critical to ensuring the safety of substation personnel. There have been occasions where substation personnel have been injured because they opened the wrong line disconnects even though procedures exist to prevent switching errors. Mishaps can occur if a substation line disconnect carrying load is opened. These switches are not designed to break load and a flash can occur, potentially causing serious injury to field crews working at the substation. |
| **Pre-commercial technology or strategy aspect** | The concept to be demonstrated will have the ability to provide a visual indication to the operator whether the line disconnect is loaded prior to switching. To SCE's knowledge, this is not yet commercialized or available as an off-the-shelf product. |
| **How the project avoids duplication from other initiatives** | This is a unique demonstration project focused on a specific safety issue of concern to SCE. To SCE's knowledge, no other initiatives internally or externally address this safety concern. |
| **Prioritization: High priority project** | SCE's number one priority is the safety of its customers and employees. This project will help keep SCE linemen safe from loaded line disconnects from being opened by mistake, even though procedures are in place to prevent these types of mistakes. A substation line disconnect switching indicator would be a beneficial tool and augment SCE's existing safety procedures. |
| **EPIC primary or secondary principles met** | The Substation Line Disconnect Switching Indicator project provides clear electricity ratepayer benefits by enhancing SCE's ability to provide safe, reliable, and affordable energy services, and is an efficient use of ratepayer funds. SCE is fully committed to ensuring that all employees return safely home. |

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## PROJECT NAME: INTELLIGENT FUSES

| EPIC DESCRIPTION | PROJECT EXPLANATION |
|---|---|
| **Technology or strategy to be demonstrated** | The Intelligent Fuses project will demonstrate a prototype intelligent fuse capable of isolating branch line faults for temporary and permanent faults. By using intelligent fuses, the fuse will open instead of blowing out during a temporary fault, and will reclose automatically without needing to dispatch a field crew. This means that power will automatically be restored to customers in a matter of seconds, instead of having to wait for a field crew to identify the location of the blown fuse and replace it. Wireless communications built into the fuse will also be demonstrated for notifying the operator the status of the intelligent fuse, open or closed. If the fuse remains open, the operator will notify a field crew that there is a permanent fault on that branch line. |
| **Concern, problem or gap to be addressed** | A temporary fault on a branch line can cause protective devices called fuses to blow and disconnect a section of the line, leaving affected customers without power. SCE only becomes aware of the outage when a customer calls, and then a field crew is dispatched to patrol the line and identify the location of the blown fuse. Since it's a temporary fault, no repairs are necessary, and power is restored once the blown fuse is replaced. While this manual process works, opportunities exist to reduce the outage time for customers affected by temporary faults by leveraging advancements in fuse technologies. |
| **Pre-commercial technology or strategy aspect** | No reclosing fuses are commercially available that possess the wireless communications capability that is integral to this demonstration project. This communications capability notifies system operators the status of the intelligent fuse so that they can determine whether a field crew needs to be dispatched due to a permanent fault on the line. |
| **How the project avoids duplication from other initiatives** | SCE is not aware of any initiatives focused on demonstrating the application and performance of intelligent fuses. Further, it is unlikely that this technology has already been demonstrated since there are no reclosing fuses commercially available that possess wireless communication capabilities. |
| **Prioritization: High priority project** | This is a high priority project as the unique fuse design could potentially improve reliability for customers by restoring power back within seconds after a temporary fault, instead of having to wait for a field crew to replace a traditional fuse that has blown. This project could also help SCE reduce operating costs as field crews would not need to be dispatched to replace the fuse for temporary faults since intelligent fuses would automatically reclose. |
| **EPIC primary or secondary principles met** | The Intelligent Fuses project provides clear electricity ratepayer benefits by enhancing SCE's ability to provide safe, reliable, and affordable energy services, and is an efficient use of ratepayer funds. If successful, this project will help with grid reliability, reduce outages and lower costs for equipment maintenance. |

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## PROJECT NAME: REMOTE INTELLIGENT SWITCHER

| EPIC DESCRIPTION | PROJECT EXPLANATION |
|---|---|
| **Technology or strategy to be demonstrated** | The objective of the Remote Intelligent Switcher project is to demonstrate a new intelligent switch to be used in conjunction with a new automated distribution circuit switching scheme that will minimize the quantity of customers impacted by faults, provide quick load restoration, and provide advanced communications to aid in system trouble shooting. The next generation of distribution circuit switching scheme proposes to expand on the existing scheme by using the circuit's breaker, two smart mid-point switches, and a smart tie switch effectively dividing the circuit load into thirds. Communication between switches will support the IEC61850 standard protocol. Used in conjunction with other smart devices such as intelligent fuses and remote fault current indicators, faults on circuit mainlines as well as branch lines can now be detected and isolated. The goal of this more advanced switching scheme is to ensure that at least two-thirds of the circuit load can be restored quickly. |
| **Concern, problem or gap to be addressed** | The existing automation scheme used at SCE for load restoration utilizes a "switch-and-half" plus circuit breaker scheme. This is comprised of the circuit breaker at the substation protecting the entire distribution circuit, a mid-point remote controlled switch (RCS) which approximately divides the circuit load in half, and an end point tie switch used to transfer load to, or pick up load from an adjacent circuit. The circuit breaker and mid-point switch are coordinated to identify the location of a fault, minimize customers affected, and to minimize the amount of time of service interruptions. The mid-point switch is used to restore service and transfer one half of the circuit load if the fault is determined to be on the front half of the circuit. SCE's Netcomm radio communication system is used to provide coordination between RCS's. The proposed new switching scheme would demonstrate quicker load restoration from one-half to two-thirds of total circuit loading. It will also demonstrate that in most fault conditions, the faulted circuit section will be isolated quickly while the remaining majority of customers would enjoy uninterrupted service. |
| **Pre-commercial technology or strategy aspect** | This project will demonstrate the following combination of switching scheme technologies and capabilities for the first time: 1) The switches to be used are actual fault sensing and interrupting devices, which will be coordinated together and with the circuit's main circuit breaker, 2) The time to restore load will be reduced, 3) A greater amount of load can be quickly restored, and 4) Using communication technology between switching devices, operator intervention is reduced or alleviated. |
| **How the project avoids duplication from other initiatives** | The Remote Intelligent Switcher demonstration project is unique because it incorporates load interrupting switches that have the ability to detect and interrupt faults, and utilizes communications technologies to automate fault isolation and load restoration activities. SCE's existing switching scheme does not possess these capabilities. Further, SCE is not aware of any other initiatives attempting to achieve an equal level of automation in their switching schemes. |
| **Prioritization: High priority project** | This project is important to SCE because the projection is that fault isolation and problem troubling shooting will be greatly enhanced; there will be a reduction in Customer Minutes of Interruption (CMI), with the result being greater service reliability and customer satisfaction. |
| **EPIC primary or secondary principles met** | The Remote Intelligent Switcher project provides clear electricity ratepayer benefits by enhancing SCE's ability to provide safe, reliable, and affordable energy services, and is an efficient use of ratepayer monies. If successful, this project would demonstrate increased ability to reduce load restoration and outage times. |

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## PROJECT NAME: SUBSTATION REAL TIME DIGITAL SIMULATOR MOBILE TESTING SOLUTION

| EPIC DESCRIPTION | PROJECT EXPLANATION |
|---|---|
| **Technology or strategy to be demonstrated** | The Substation Real-Time Digital Simulator (RTDS) Mobile Testing Solution project will demonstrate the feasibility of using a mobile RTDS to perform Factory Acceptance Tests (FAT) and Site Acceptance Tests (SAT) for substation projects. These tests are typically performed manually and take several weeks to months depending on the size of the project to complete. A mobile RTDS system would aid test personnel in performing the FAT and SAT tests in a more streamlined manner. If this demonstration is successful, the project should help reduce manual testing efforts and the introduction of errors, omissions and anomalies by automating and standardizing FAT and SAT testing processes. It is expected that this demonstration will take place during the FAT and SAT portions of the Substation Automation-3 (SA-3) Phase III Bulk Electric System and Hybrid Solution projects. The schedule for this project would be coordinated with these other projects. |
| **Concern, problem or gap to be addressed** | The current engineering and construction procedures for new substation automation and protection systems require a FAT to be performed at the manufacturing site to test the integrity of the fabricated system, and preliminary testing of protection and automation features. After the FAT is performed, the system is considered ready for construction and is sent to the substation to be installed. As the equipment is installed, it goes through a second set of testing called the SAT, this is the last test of the equipment prior to it being put into service. Both of these test procedures are performed manually by test personnel taking from several weeks to months to perform. This project will demonstrate the viability of using a portable Real-Time Digital Simulator to automate portions of these test procedures that can result in reduced testing time and cost savings. |
| **Pre-commercial technology or strategy aspect** | SCE sees this demonstration project as a unique opportunity to utilize the modeling and computing capabilities of the RTDS for SCE's FAT activity required for each substation automation system validation prior to production commissioning. It is additionally felt that this demonstration can also be applied to SAT activity with resulting reduction of costs and manual effort. To SCE's knowledge, neither of these strategies are currently practiced by the utility industry. |
| **How the project avoids duplication from other initiatives** | This demonstration project is unique as FAT and SAT testing has traditionally been performed manually by test technicians. SCE is not aware of any other initiative attempting to automate FAT and SAT activities by using a mobile application of the RTDS. |
| **Prioritization: High priority project** | This is a high priority project due to the amount of time required to perform FAT and SAT testing being a significant labor portion all substation projects. Streamlining this process by leveraging RTDS technology will provide measurable cost savings (possibly up to 50%) in every substation project and reduce the total project time, while improving the quality of the tests being performed. Successful implementation of this technology will offer substation test technicians an additional tool that standardizes test procedures while making their work safer and more efficient. |
| **EPIC primary or secondary principles met** | The Substation RTDS Mobile Testing Solution project provides clear electricity ratepayer benefits by enhancing SCE's ability to provide safe, reliable, and affordable energy services, and is an efficient use of ratepayer monies. If this project is successful, SCE should realize significant cost savings in the area of FAT and SAT testing for substations, and experience efficiencies in substation construction. |

## PROJECT NAME: ADVANCED RELAY TESTING METHODOLOGY

| EPIC DESCRIPTION | PROJECT EXPLANATION |
|---|---|
| **Technology or strategy to be demonstrated** | More comprehensive testing of protective relay schemes at high voltage transmission lines such as 500kV systems are needed. The 500kV system lines are critical to SCE's grid because, in some cases, these are the main ties with neighboring utilities and bring a large amount of power to SCE's service territory. It is critical that SCE test these lines thoroughly when commissioning them before they are put in-service. This real-time digital simulator (RTDS) project will provide the necessary tools, process and methodology to accomplish this objective. When this project is completed, SCE test technicians will be provided with more accurate tools to test relay protection equipment during commissioning and routine maintenance. It will be a great addition to the existing tools which only give a limited number of scenarios (disturbances) to be tested and focus on the testing of protection elements, and not on the testing of system protection. This project does not support any existing regulatory proceedings. However, relay testing falls under North American Electric Reliability Corporation (NERC)/Western Electricity Coordinating Council (WECC) bulk power reliability criteria. |
| **Concern, problem or gap to be addressed** | The project will address more thorough testing of system protection and increase its reliability by exposing the equipment to larger and more realistic system disturbances as well as aid in testing the communication delays that are inherent on the system. The tools developed will potentially reduce the number on hours required to test given that additional extensive test scenarios will be able to be developed on site therefore eliminating the need to re-schedule additional tests. It will also provide more accurate and extensive reporting results. |
| **Pre-commercial technology or strategy aspect** | The RTDS uses a new and unique technology under development to synchronize its simulation at two remote locations (substations). A special card will be developed to achieve the real time acquisition using Global Positioning System (GPS) technology and integrated to the RTDS. |
| **How the project avoids duplication from other initiatives** | The portable RTDS is a first of its kind tool which will take a grid simulator and integrate GPS technology to two remotely located synchronized simulators running precisely at the same time. This demonstration will allow for the injection of voltages and current at both ends of the transmission line from a precise model of the power system. |
| **Prioritization: High priority project** | This project has a high potential for opportunity and low risk given that it could increase system reliability by identifying any potential field installation errors such as wiring and/or communication systems. It also may uncover any unforeseen relay setting discrepancies and/or errors not discovered during relay setting preparation and verification phases; therefore, potentially saving SCE time and resources in the testing of relay protection system. The risk of not pursuing this project is great, because if SCE failed to catch errors during any end-to-end testing using existing methods and tools, there is the potential for adverse transmission reliability. For instance, if an error occurs at a critical line such as a tie line, the outcome of such relay scheme mis-operation could be a penalty from NERC/WECC reliability coordinators. |
| **EPIC primary or secondary principles met** | This demonstration meets both primary and complementary guiding principles for ratepayer benefits. The RTDS project will increase reliability and potentially lower costs by being able to test equipment more rigorously before it goes into service. Furthermore this project also provides a societal benefit by ensuring bulk power is secure and reliable. |

## **PROJECT NAME:** APPLICATION OF ADVANCED EARLY WARNING SYSTEM WITH ADAPTIVE PROTECTION

| EPIC DESCRIPTION | PROJECT EXPLANATION |
|---|---|
| **Technology or strategy to be demonstrated** | The purpose of this project is to build on previous research, which found that phasor measurement unit (PMU) data may be helpful in preventing the possibility of false trips and the possibility of cascading blackouts. The project selects two specific applications for large scale demonstration of concepts. The first application is the use of a "voting scheme" from a set of phasor measurement units (PMUs) to adapt the operation of protection system. The second application is a monitoring and alarming application for distance relays. In addition to the above protection applications, a protection information tool (PIT) will be developed to assist operators in the interpretation of synchrophasor data. This is a demonstration project largely funded by DOE with SCE cost share contribution. SCE, PG&E, CIEE, Virginia Tech University, and Mississippi State University are collaborating to demonstrate the concepts developed by universities for the application of wide-area synchrophasor data in adaptive protection. |
| **Concern, problem or gap to be addressed** | In recent blackouts on Power Systems of North America, it has been noted that during the cascading phenomena which leads to blackouts, some protection systems operate in an unanticipated fashion and such operations are often a significant contributing factor in the sequence of events leading to cascading outages. Previous research funded by the CEC indicated that the use of wide-area synchrophasor measurements can be of significant value to reduce the likelihood of false trips by protection systems and reduce the likelihood of contributing to a cascading blackout. |
| **Pre-commercial technology or strategy aspect** | This technology has been developed recently by Virginia Tech University. Under a Department of Energy (DOE) award, SCE and PG&E are deploying a pilot version of this technology to assess its performance in real-time operation. No commercial version of this technology is available in the market. |
| **How the project avoids duplication from other initiatives** | This project demonstrates for the first time how the application of synchrophasor technology in adaptive protection can help reduce the likelihood of false trips and the possibility of cascading blackouts on SCE's grid. Furthermore, this project is being co-funded by DOE, thus reducing the possibility of duplication. |
| **Prioritization: High priority project** | SCE is committed to continuously improving the reliability and safety of its grid. This project is crucial in helping to analyze data from PMUs to reduce the possibility of false trips by protection systems and reduce the likelihood of cascading blackouts. |
| **EPIC primary or secondary principles met** | The Application of Advanced Early Warning System with Adaptive Protection provides clear ratepayer benefits by increasing reliability and safety of the grid by helping to mitigate the possibility of false trips and cascading blackouts. The demonstration also has potential to lower costs by preserving equipment from having to be replaced after a cascading blackout. |

## **PROJECT NAME:** BEYOND THE METER: CUSTOMER DEVICE COMMUNICATIONS UNIFICATION AND DEMONSTRATION

| EPIC DESCRIPTION | PROJECT EXPLANATION |
|---|---|
| **Technology or strategy to be demonstrated** | Large emerging technologies such as Photovoltaic systems (PVs), Plug-In Electric Vehicles (PEVs) and Residential Energy Storage Units (RESUs) are quickly gaining popularity among consumers in SCE's service territory. The increased rate of adoption among these technologies is attributed to various factors including reduced product costs, improved technology and higher costs of energy, particularly gasoline and electricity. These technologies pose both technical challenges and opportunities for distribution system operators. Utility back-office systems and advanced networking applications located in the device and on the premise offer greater potential for proper coordination between the consumer and the electric utility. This project will develop and execute a comprehensive and unified plan for enabling device to grid communications for large customer-owned emerging technologies including inverters, RESUs and electric vehicle charging equipment. The coordination plan will include industry harmonization, standards development and laboratory demonstration. |
| **Concern, problem or gap to be addressed** | Currently, the industry at large does not have a cohesive and or collective approach to enabling device-to-grid communications for emerging customer technologies. Without a unified approach, there is a significant risk of duplication and/or stranded assets in utility back-office investments. The lack of control of these technologies can lead to future system reliability concerns. This project will help develop a cohesive approach to all three device families and ensure a common path of utility integration leveraging the same or similar back-office systems. This project attempts to address communications and control of not only photovoltaic systems, but other large customer-owned emerging technologies including residential energy storage devices and vehicle charging. Lastly, the project will identify potential gaps in communication standards and initiate the necessary steps to bridge such gaps in standards development organizations. |
| **Pre-commercial technology or strategy aspect** | The technologies investigated by this project are either in early prototype stage and or nonexistent. The objective is to develop a strategy to analyze the status of the technology, collaborate with product manufacturers to develop a path for PEV-Grid communications enabled devices and demonstrate their application in a laboratory setting. Some of the project funding will be used to commission a vendor to develop a device for each technology category using Open Standards and specific communication requirements. |
| **How the project avoids duplication from other initiatives** | This project avoids duplication by combining similar technologies (PEVs, Solar Inverters & Residential Energy Storage). Rather than focusing on a single solution to advance a single technology this project would combine several “like” technologies and develop a generalized solution for Device to Grid Communications addressing advanced applications. This type of approach helps to establishes flexible and future-proof solutions. |
| **Prioritization: High priority project** | PEVs and solar inverters are quickly gaining popularity among residential consumers. Unfortunately market available technologies for these applications do not have the means of communicating to the grid for the enablement of advanced “smart” applications. Such communications would allow utilities to develop DR and other programs that could encourage further adoption. |
| **EPIC primary or secondary principles met** | This project supports EPIC’s guiding principle to provide electricity ratepayer benefits by promoting lower costs through enhanced optimization of device-to-grid communications for emerging customer technologies. Furthermore, this project will demonstrate the feasibility and benefits of advanced consumer devices supporting the complementary principles to provide societal benefits and efficient use of ratepayer monies. |

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## **PROJECT NAME:** OUTAGE MANAGEMENT AND CUSTOMER VOLTAGE DATA ANALYTICS DEMONSTRATION

| EPIC DESCRIPTION | PROJECT EXPLANATION |
|---|---|
| **Technology or strategy to be demonstrated** | This project will demonstrate sensing node technologies which provide measurements of voltage, current, consumption and kilovars (kVARs) at select AMI endpoints. Specific applications include outage management and Advanced Volt/VAR Control (AVVC). For outage management, the objective is to improve customer service during an outage and give the utility more insight into fault detection, restoration, and maintenance during an outage. In the area of AVVC, the objective is to utilize customer voltage data to improve voltage distribution and voltage reduction strategies. |
| **Concern, problem or gap to be addressed** | Besides voltage and current measurement at substations, few monitoring devices for measurements are installed within the distribution system. In the case of outage management, lack of data results in less than optimal processing of faults and maintenance scheduling.<br><br>The smart meter's ability to provide analog voltage values for residential customers provides valuable information that can support the diagnosis of distribution issues. In addition, voltage reduction strategies would effectively reduce power consumption, which translates into lower power procurements and in turn reduces the customer's electric bill. |
| **Pre-commercial technology or strategy aspect** | Outage management focuses on detecting, locating and clearing of faults. SCE's current system, which is generally consistent with the broader industry, provides information at the circuit level. The current fault identification practice is based on trouble calls and manual switching. Maintenance is performed either with a run-to failure strategy or with a fixed ahead-of-the-time planned schedule, which does not require operational data.<br><br>Prior to the installation of SmartConnect®, SCE did not have a means to track voltages at the end of each of its distribution circuits or at each of its customers' premises. With SmartConnect®, being almost fully deployed, customer voltage data can be made available and used for a variety of purposes, including diagnosing distribution system issues before they become problems. |
| **How the project avoids duplication from other initiatives** | Research performed by other departments is focused on improving fault detection and restoration at the location of the fault, which is on the high-voltage side. However, this effort aims to enhance outage management and AVVC capability by monitoring the grid on the customer side of the transformer. |
| **Prioritization: High priority project** | This is a high priority project, distribution systems experience a high frequency of faults caused by weather, component wear and other reasons. Reducing outage time caused by faults will help to improve reliability and continue to meet high customer quality of service requirements. |
| **EPIC primary or secondary principles met** | This project supports EPIC's guiding principle to provide electricity ratepayer benefits as demonstrated through its ability to increase the effectiveness of fault detecting, locating and clearing faults through the distribution network. This is an efficient use of ratepayer funding as it helps to increase reliability and return service more efficiently during an outage event. |

## **PROJECT NAME:** REGULATORY MANDATES: SUBMETERING ENABLEMENT DEMONSTRATION

| EPIC DESCRIPTION | PROJECT EXPLANATION |
|---|---|
| **Technology or strategy to be demonstrated** | SCE would like Electric Vehicle (EV) customers to subscribe under time-of-use (TOU) rates that incentivize them to charge their vehicle off-peak. Currently, in order to qualify for certain TOU rates, customers must install a second service panel to capture the energy consumed by EV charging. Generally, the cost and time associated with installing the second panel is a major deterrent to greater customer adoption of these rates. As a result, the CPUC mandated California IOUs to develop and adopt a submetering protocol. This mandate creates an untraditional model of customer-owned metering for the IOUs. Furthermore, SCE does not currently have a method for disaggregating submetering data from the premise meter data. This project will test evaluate the developed protocol to demonstrate the various methods of collecting and disaggregating load from the premise meter in a controlled laboratory setting - manually and automatically. |
| **Concern, problem or gap to be addressed** | This project is needed to better understand submeter technology and properly make decisions that will not result in stranded assets and an incorrect protocol. The Low Carbon Fuel Standard (LCFS) project to automate the disposition of carbon credits is dependent on the work in this submetering project. Potentially, the submetering functionality developed for EV charging may be leveraged for other emerging technologies. |
| **Pre-commercial technology or strategy aspect** | Although many device manufacturers claim to have submetering capabilities, the reality is that none of the current market available products produce accurate, standardized and reliable data for utility billing. The intent of this project is to go beyond protocol development and demonstrate the various methods by which submetering can become feasible. This project will evaluate and demonstrate devices, communication capabilities, application of standardized formats / processes and utility back-office functions. |
| **How the project avoids duplication from other initiatives** | Enabling submetering requires active participation between utilities and third party service providers. This demonstration will require close collaboration with all interested stakeholders at every phase. In addition, progress reports, findings, lessons learned and recommendation will be shared with the industry to promote proper development of submetering and help avoid duplicative efforts. |
| **Prioritization: High priority project** | The risk of not doing the project could result in the ratification of an untested and technically flawed submetering protocol. In addition, without utility leadership we run the risk of inoperable, complex and non-standardized processes. The ramifications of subtractive billing can lead to very costly back-office upgrades and hence utilities must ensure the protocol is feasible and interoperable among all third party service providers. Submetering has ramifications on other technologies including inverters and energy storage devices and the results of this project can apply to these technologies proving a broader value to SCE. The Submetering Enablement Demonstration should be considered a high priority project. |
| **EPIC primary or secondary principles met** | This project supports EPIC's guiding principle to provide electricity ratepayer benefits as demonstrated by its ability to shift EV charging off peak thereby helping to promote greater system reliability. Furthermore, this project supports low-emission vehicles/transportation by helping to break down the cost barriers associated with EV adoption. This increased adoption complements polices to reduce GHG emissions. |

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## **PROJECT NAME:** EVALUATION OF TELEMETRY EQUIPMENT FOR ANCILLARY SERVICES AT RESIDENTIAL ENDPOINT

| EPIC DESCRIPTION | PROJECT EXPLANATION |
|---|---|
| **Technology or strategy to be demonstrated** | This project will demonstrate telemetry gateway equipment capable of meeting CAISO's requirements for bidding residential DR loads into ancillary service (AS) markets, which is consistent with CAISO's Market Redesign Technology Upgrade (MRTU). MRTU utilizes automated systems to enable bidding, scheduling, dispatching and settlement of standard generation resources. |
| **Concern, problem or gap to be addressed** | Prior to bidding DR loads into an AS market, an energy service provider or DR aggregator must meet stringent requirements related to geographic dispatch, event variability, DR provider direct participation, dispatch systems, metering and settlement. In particular, telemetry requirements require that the resource load, if less than 1 MW must be capable of sending revenue meter data to an aggregation point at least once a minute. In addition, the telemetry device, located at the customer site, must be capable of sending metering data over the Internet or to a private CAISO Energy Communications Network (ECN) every 4 seconds. Given the high costs of telemetry equipment, it is currently cost-prohibitive to include small residential loads. |
| **Pre-commercial technology or strategy aspect** | SCE is exploring alternatives for meeting or modifying the telemetry requirements with less expensive telemetry solutions with CAISO. Until the telemetry issue can be resolved, SCE intends to offer programs to only large commercial & industrial (C&I) customers with loads exceeding 200 kW. SCE has noted that it cannot expand this offering until this market, including its costs and benefits, is better understood. |
| **How the project avoids duplication from other initiatives** | This project focuses on demonstrating telemetry data at residential customer endpoints. Previous pilots have focused on offering an AS tariff program to large(C&I customers. |
| **Prioritization: High priority project** | This is a high priority project. D. 09-08-027 ordered SCE to transfer at least 10 percent of its DR resource loads into one or more Proxy Demand Resource (PDR) products to increase the amount of DR that is bid into energy and AS markets. SCE responded by filing Advice Letter 2501-E, wherein it proposed to offer an AS tariff program to a few large C&I customers, and thereby facilitate compliance with the PDR mandate. Due to the high costs of telemetry, SCE was not able to offer the AS tariff program to customers with less than 200 kW. Residential loads are less than 20 kW and therefore cannot participate is AS markets; this is unfortunate because, in aggregate, residential loads represent a significant portion of the total load on the grid. Inclusion of these customers will serve to meet the CPUC's, CEC's, and CAISO's desire for increased DR load bidding into its wholesale energy and ancillary service markets. |
| **EPIC primary or secondary principles met** | This project supports EPIC's guiding principle to provide electricity ratepayer benefits as demonstrated through its ability to help support greater reliability and decreased customer costs associated with DR scheduling and corresponding electricity dispatch from the increased customer DR subscription associated with telemetry gateway equipment. |

## PROJECT NAME:

### LOAD SCANNING TO IDENTIFY ELECTRIC VEHICLE CHARGING LOCATIONS

| EPIC DESCRIPTION | PROJECT EXPLANATION |
|---|---|
| **Technology or strategy to be demonstrated** | Today, the IOUs are sourcing data for those customers who have not consented to have their data shared with the utility primarily from in-market personal electric vehicle (PEV) manufacturers (also known as Original Equipment Manufacturers or OEMs). To supplement data obtained from OEMs, IOUs also obtain copies of electrical permits from local governments and direct notification from customers, although neither source provides exhaustive data. The IOUs anticipate several changes in the marketplace that will likely require accessing different notification data sources. For instance, as the market for used PEVs develops, the IOUs will not be able to identify the relocation of these vehicles through OEMs. In addition, as EV manufacturers shift to selling the large majority of EVs off-the-lot, the IOUs anticipate receiving a smaller percentage of customers consenting to share their information. This project aims to utilize load scanning of Edison SmartConnect™ meter customer usage and demand data to identify new EV charging locations in SCE's territory in a cost-effective and efficient manner. |
| **Concern, problem or gap to be addressed** | The Load Scanning project supports the "CPUC Phase 2 decision establishing policies to overcome barriers to electric vehicle deployment and complying with public utilities code section 740.2, R.09-08-009, (AFV OIR) Ordered in D11-07-029." This project is dependent on the deployment of SmartConnect™ and access to AMI (Advanced Metering Infrastructure) data. Of the three notification options currently under consideration (3rd party notification and electrical permits from local governments, DMV registration information and Load Scanning), Load Scanning has the potential to be the least costly, most efficient and timely source for locating where new customers are charging an EV. Demonstrating the capability of using Load Scanning to identify specific types and levels of demand could have numerous other applications as SCE customers continue to expand their use of emerging technologies such as solar, battery storage, electric vehicles including 480 volt fast charging, etc. |
| **Pre-commercial technology or strategy aspect** | This demonstration for the first time will leverage SCE's data warehouse and SmartConnect™ meter customer usage and demand (AMI) data to identify new EV charging locations in SCE's territory through a robust load scanning algorithm and automated reporting. |
| **How the project avoids duplication from other initiatives** | The actual load scanning solution that will produce automated reports identifying new charging locations will have to integrate requirements specific to SCE, including data structure, data warehouse, other queries impacting the data warehouse, and internal processes. No other effort is currently under way to develop such a load scanning solution at SCE. |
| **Prioritization: High priority project** | SCE is committed to increasing the number of PEVs in its service territory. As the market for used PEVs matures SCE will not be able to identify the relocation of these vehicles and customers may not be willing to share their data with the utility. Consequently, this demonstration is crucial in providing a cost-effective solution for determining the most effective locations for new EV charging station in SCE's service territory. |
| **EPIC primary or secondary principles met** | The Load Scanning to Identify EV Charging Locations project meets primary and complimentary guiding principles for ratepayer benefits. This demonstration lowers cost by identifying a solution for determining the most effective locations for new EV charging stations. Furthermore this project provides Greenhouse gas emissions mitigation by promoting greater penetration of PEVs in SCE's service territory. |

## **PROJECT NAME:** MULTI-DWELLING UNIT EVALUATION USING POWER LINE CARRIER OR BROADBAND TECHNOLOGY

| EPIC DESCRIPTION | PROJECT EXPLANATION |
|---|---|
| **Technology or strategy to be demonstrated** | SCE will demonstrate innovative Power Line Carrier (PLC) and Broadband technology capable of enabling the advanced metering infrastructure (AMI) in multi-dwelling units (MDUs). Demonstrations will evaluate integration with utility back office systems, including SCE's Advanced Load Control System. Depending on market availability, demonstrations may showcase integration with consumer smart energy devices which utilize Internet Protocol-compatibility, including Wi-Fi Smart Energy Profile 2.0 devices. Part of these demonstrations will include innovative PLC for plug-in hybrid electric vehicle (PEV) smart charging equipment. |
| **Concern, problem or gap to be addressed** | Enabling AMI capabilities and benefits in MDUs remains a challenge due to the location of the apartment units with respect to their smart meters. The California Energy Commission's 2009 Residential Appliance Saturation Survey estimates that over half a million SCE residential customers reside in MDUs with five or more units. Furthermore, SCE and Itron field studies have shown that most MDUs with five or more units have poor or no ZigBee meter communications in the apartment. As a result, most MDU customers cannot utilize smart meter or HAN-enabling technologies, and therefore, cannot participate in most energy efficiency (EE) or demand response (DR) programs. This project will motivate and incent the vendor community to: 1) better characterize the MDU environment; and 2) develop one or more feasible MDU solutions. |
| **Pre-commercial technology or strategy aspect** | A reliable, safe and affordable solution has not been developed. The most promising designs and concepts observed in the market today utilize either PLC or Broadband technology. One proposed strategy, which uses PLC, aggregates ZigBee information using a meter collar, bridges the data to Homeplug GreenPHY, and sends it over the mains wires; then at the apartment, communications is translated from Homeplug GreenPHY to either ZigBee or Wi-Fi; from there, the information is sent to an energy information display. Another strategy, which uses Broadband, aggregates ZigBee information from numerous meters and sends the information to a cloud server for viewing by tenants that have an active broadband connection. To date, no MDU solution has proven feasible. |
| **How the project avoids duplication from other initiatives** | This effort focuses on collaborating with the vendor community to design, develop, lab test and demonstrate innovative PLC Homeplug GreenPHY technologies for use in MDU and PEV smart charging applications. Advanced Technologies is uniquely equipped with a PLC Lab capable of testing the latest PLC smart grid technologies. Additionally, engineering staff have developed expertise on the use of PLC standards and testing methodologies, and have forged strong relationships with the PLC vendor community. |
| **Prioritization: High priority project** | This is a high priority project because MDUs and PEVs represent a significant portion of utilities' total energy demand on the grid. By integrating these customer loads into their AMI, utilities will be able to manage energy usage for the purpose of EE and peak load reduction. |
| **EPIC primary or secondary principles met** | This project supports EPIC's guiding principle to provide electricity ratepayer benefits by helping to facilitate increased customer participation within both EE and DR programs. This adoption is consistent with California's loading order and additionally helps to provide increased societal benefits realized through both system reliability improvements and greenhouse gas mitigation. |

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**PROJECT NAME:** TRANSFORMER LOAD MANGEMENT ANALYSIS – AMI LOAD CORRELATIONS, ELECTIC VEHICLES AND RESIDENTIAL ENERGY STORAGE UNIT IMPACTS

| EPIC DESCRIPTION | PROJECT EXPLANATION |
|---|---|
| **Technology or strategy to be demonstrated** | This project supports outage management and customer-facing operations by leveraging existing AMI system communication and measurement infrastructure with transformer load management (TLM) data. This includes making accurate home-to-transformer associations, which serve to assist the development of theft detection, outage management, and asset management technologies.<br><br>In the area of theft detection, a better theft detection technique includes measuring the full energy output of a distribution transformer, and then comparing that to the energy consumption registered in the associated meters. The full output of the transformer should be analogous to the consumption of customer meters after factoring in secondary distribution line losses and any unmetered loads, such as streetlights. Missing energy can serve as evidence that one or more customers could be stealing energy.<br><br>For asset management, demonstrations will show how TLM data can be used to size transformers for load management and growth as well as help identify distribution transformer overload conditions. |
| **Concern, problem or gap to be addressed** | Energy theft is a serious financial issue as well as a major public safety concern for many utilities, costing billions annually. Numerous utilities across North America are struggling with increasing theft occurrences. Moreover, with the continued advancement of plug-in hybrid electric vehicles (PEVs) and other technologies, like residential energy storage units (RESU), SCE expects its distribution system assets to be impacted and in some cases overloaded. SCE will need to more accurately correlate the load profile of its transformers to achieve their useful life and better understand and address the factors contributing to distribution transformer failures. SCE will leverage its SmartConnect® capabilities to facilitate this effort. |
| **Pre-commercial technology or strategy aspect** | Utility security personnel presently rely on tips from employees and the public to find electricity theft. Following up on those tips is a labor-intensive process that, unfortunately, involves investigating more false leads than good ones. Other methods that rely on smart meters are also limited. |
| **How the project avoids duplication from other initiatives** | Other efforts have focused on evaluating distribution-system sensors and control devices for the purposes of fault detection or substation-level operations support. This project focuses on sensor and control device technology placed more downstream (on the customer side of the transformer); in particular, it will focus on the effective use of TLM data for for the purposes of energy theft detection, outage management, asset management, and customer operational support.. |
| **Prioritization: High priority project** | This project is considered high priority. TLM-based evaluations will help support SCE's ability to schedule pre-emptive measures such as asset maintenance and/or replacement to help mitigate system failures. In addition, this data can help avoid costs by creating transparency regarding the potential of scheduling unnecessary field visits to physically assess transformer-to-home associations and costs related to system cleanup and failures. Accurate associations will also help to improve customer service and lower costs associated with advanced notification of planned outages. Importantly, SCE can leverage its existing AMI deployment to facilitate this effort. |
| **EPIC primary or secondary principles met** | This project supports EPIC's guiding principle to provide electricity ratepayer benefits as demonstrated by its ability to help deter energy theft through increased use existing AMI system communication and measurement infrastructure with TML data. Furthermore, this project supports the increased adoption of low-emission vehicles/transportation and corresponding greenhouse gas mitigation through the use of TLM data to facilitate efficient transformer sizing needed to address increased growth and resulting load management. |

## PROJECT NAME: DEEP GRID COORDINATION

| EPIC DESCRIPTION | PROJECT EXPLANATION |
|---|---|
| **Technology or strategy to be demonstrated** | This project will demonstrate, evaluate, analyze and explore options that address the impacts of increasingly higher penetration of Distributed Energy Resources (DER) including increased adoption of customer-owned DG (Distributed Generation) on SCE's distribution network and the overall "reliable" power delivery cost to SCE customers across all tiers. This demonstration project is in effect the next step to the Irvine Smart Grid Demonstration (ISGD) project. The ISGD project demonstrates the impacts and characteristics of various energy technologies on the distribution network while this Deep Grid Coordination project will demonstrate how to manage the new energy technologies to contribute to the overall health and reliability of the system while providing benefits to customers that have invested in DER equipment. SCE's analysis and demonstration will study the effects of integrating emerging and innovative DER technologies with the grid, focusing predominantly on customers with the ability to generate power with renewable energy sources that are also connected to the grid for "reliability" and "stability" reasons. This project demonstrate the need for the utility (SCE) to implement Smart Grid technologies and corresponding DER resource management mechanisms necessary for stabilizing the grid as DG adoption increases and more importantly consider possible economic models and plug & play tariff structures that would help SCE adapt to the changing regulatory policies, provide customer benefits and promote greater grid reliability at an affordable cost. |
| **Concern, problem or gap to be addressed** | As DER technologies increase in reliability and reach economic parity with electricity supplied by the utility, SCE and other utilities will be required to adapt to integrate these new customer-owned resources using automation and tariff or economic mechanisms to maintain grid reliability. The introduction of customer-owned, disparate energy sources in across our distribution network requires more automation to stabilize the grid and manage DER equipment that has the potential to either support or erode the reliability of the grid. Grid reliability in a future with high and increasing penetration of customer-owned DER depends on defining a framework that allows utilities to dispatch signals to customer-owned equipment to support the electric grid when needed and provides benefit to customers across SCE's control area. Without the tariff, pricing or market mechanisms to manage and interact with customer-owned DER, frequency, voltage and distribution balancing challenges could severely impact grid reliability over time.<br><br>SCE's objective for this demonstration is to deploy Smart Grid technologies at the distribution level to interact with customer owned and operated DER in a manner that allows for higher penetration of DER on constrained distribution circuits because the customer-owned equipment actively participates in supporting the reliability of the circuit. Specifically, SCE will demonstrate that the voltage and frequency issues commonly seen on constrained distribution circuits with high penetration of variable DG can be managed by dispatching instructions to smart inverters connected to the customer's equipment in order to elicit VAR support/supplemental reactive power as well as frequency response to support the distribution network. Additionally, aside from distribution level ancillary service support for specific distribution circuits, SCE will also demonstrate the capability for the utility to serve as the balancing authority for a distribution network with high degree of DER adoption and test plug & play tariffs as well as market mechanisms to determine the highest value engagement models from both a customer perspective and a grid reliability perspective.<br><br>This demonstration will also provide a means to quantify the costs and benefits of Smart Grid technologies in terms of overall energy coordination and consumption, operational efficiencies and other environmental benefits. This study will provide a recommended structure to balance energy consumption patterns with variable renewable DER technologies such that normal operations of the grid at all levels are improved or maintained. This active management of DER to ensure grid reliability is referred to as "Deep Grid Coordination". |

| EPIC DESCRIPTION | PROJECT EXPLANATION |
|---|---|
| **Pre-commercial technology or strategy aspect** | SCE will employ both commercially available and experimental technologies in a unique architecture focused on demonstrating new distributed control designs, economic models, customer configuration mechanisms and utility reliability management strategies that benefit customers and improve distribution network reliability in areas with high penetration of DER. SCE intends to work with the California Institute of Technology on economic modeling and leverage the experimental technologies and capabilities of SCE's Advanced Technologies Lab to demonstrate the readiness of new technologies used in a new way to manage customer-owned DER and grid reliability. |
| **How the project avoids duplication from other initiatives** | The Deep Grid Coordination project is unique in its focus on distribution circuit management and developing a framework for leveraging customer owned DER to support grid reliability. SCE is unaware of any other projects in North America underway or planned that overlap with the proposed scope of this project. |
| **Prioritization: High priority project** | In an effort to support the realization of public policy and CPUC sustainable energy objectives such as the 33% renewable energy, Zero Net Energy homes, once-through cooling and Plug-in electric vehicle initiatives, SCE has been working and studying the effects of increased adoption of DER, renewable energy and emerging energy technology integration on the reliability of SCE's transmission, distribution power delivery systems for several years. This project will provide SCE the opportunity to model and demonstrate the effects of DER penetration and provide a deep grid coordination solution benefiting major stakeholders in a way that provides a clear path towards a common goal, working to resolve issues related to integration of distributed renewables in a fair and cost-effective structure. |
| **EPIC primary or secondary principles met** | SCE's proposed Deep Grid Coordination project meets both primary and secondary EPIC principles. The project will provide clear electricity ratepayer benefits and societal benefits by demonstrating a framework for customer-owned DER integration that makes the equipment the customer invested in more valuable, provides mechanisms for fair cost allocation for investments made in automation to integrate customer-owned DER and promotes greater reliability, increased safety, and/or enhanced environmental sustainability at a fair cost by providing SCE with the ability to dispatch and call upon customer-owned DER for reliability services when needed. |

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## **PROJECT NAME:** IRVINE SMART GRID DEMONSTRATION

| EPIC DESCRIPTION | PROJECT EXPLANATION |
|---|---|
| **Technology or strategy to be demonstrated** | ISGD is a comprehensive demonstration that will span the electricity delivery system. The project will use phasor measurement technology to enable pricing node verification of demand response participation. The project will also deploy the latest generation of international standards based (IEC 61850) substation automation technologites at the MacArthur Substation. The project will extend beyond the substation to evaluate distribution automation technologies, including looped 12 kV distribution circuit topology utilizing Universal Remote Circuit Interrupters (URCI) each of which includes a single low-latency radio that is compliant with the IEC 61850 standard. Advanced Volt/VAR Control (AVVC) capabilities will also be used to demonstrate conservation voltage reduction (energy savings). The project scope also includes customer homes, where it will demonstrate the integration, monitoring, control, and efficacy of Home Area Network (HAN) devices such as smart appliances, energy storage, solar photovoltaic systems and electric vehicle charging. The project will assess the impact of device-specific Demand Response, as well as load management capabilities involving residential and community energy storage devices and plug-in electric vehicle charging equipment. Demand Response events will use HAN protocols that are being adopted by Advanced Metering Infrastructure programs such as Edison SmartConnect™. SENet will enable end-to-end interoperability and provide a level of cyber security that is essential to Smart Grid development and adoption across the nation. The project will also consider the impacts on the workforce of the future by assessing training needs and preparing appropriate training materials. |
| **Concern, problem or gap to be addressed** | The objective of ISGD is to validate the ability of Smart Grid technologies to operate effectively and securely when deployed in an integrated framework. The project will provide a means to quantify the costs and benefits of these technologies in terms of overall energy consumption, interoperability, support for distributed energy integration, operational efficiencies, and societal and environmental benefits, and to evaluate the maturity of the technologies. |
| **Pre-commercial technology or strategy aspect** | ISGD will allow the project team to test and validate the applicability of demonstrated Smart Grid elements and their respective technical maturity for the Southern California region and the nation as a whole. Finally, the project team expects to support the development of interoperability and cyber security standards based on the project's Secure Energy Network (SENet). |
| **How the project avoids duplication from other initiatives** | SCE is leveraging existing approved RD&D by receiving up to $39.6 million in matching funds from the U.S. Department of Energy (DOE) to conduct a first-of-its-kind "end-to-end demonstration" of numerous Smart Grid technologies which it believes are necessary to meet state and federal policy goals. The Irvine Smart Grid Demonstration (ISGD) project will test the interoperability and efficacy of key elements of the grid, from the transmission level through the distribution system and into the home. ISGD will be a deep vertical dive that tests multiple components of an end-to-end Smart Grid. Thus, the project will provide a living laboratory for simultaneously demonstrating and assessing the interoperability of, and interaction between, various Smart Grid technologies and systems. ISGD will be deployed in the City of Irvine, an excellent demonstration site typical of some heavily populated areas of Southern California in climate, topography, environmental concerns, and other public policy issues. |
| **Prioritization: High priority project** | SCE considers this a high priority project. This prioritization is based on the ISGD project being a "first of its kind" smart grid demonstration that will test the interoperability of smart grid technologies spanning the entire electricity delivery system, from transmission, through distribution and into the customer home. SCE's plans to work closely with the DOE and NETL to accelerate the standards process for smart grid applications also makes this a critical initiative. |

| EPIC DESCRIPTION | PROJECT EXPLANATION |
|---|---|
| **EPIC primary or secondary principles met** | This project will demonstrate and test the interoperability of smart grid technologies. Through this demonstration, this project supports EPIC's guiding principle to provide electricity ratepayers benefits including increased reliability, lower costs and increased safety. The ISGD project is a valuable use of ratepayer monies as it is the first of its kind and will help to further advance the smart grid and utility operations. Furthermore, it will help to test end use customer technologies such as energy information displays to help increase customer awareness concerning load management and demand use. |

## PROJECT NAME:

### WIDE-AREA SECURITY MANAGEMENT AND CONTROL

| EPIC DESCRIPTION | PROJECT EXPLANATION |
|---|---|
| **Technology or strategy to be demonstrated** | The purpose of the Wide-Area Security Management and Control project is to effectively coordinate between transmission system control devices through SCE's system to prevent cascading outages and maintain system security. This demonstration consists of three sub-projects: (1) Wide Area-Monitoring and Control of WEC Transfer Paths Using Real-Time Digital Simulator (RTDS) Phase 2 (2) Establishing Alarm Limits on Bus Voltage Angles for Grid Stress Assessment and Control Phase 2 (3) Wide-Area Security Management and Control.<br>1. The first sub-project, Wide-Area Monitoring and Control of WECC Transfer Paths Using Real-Time Digital Simulator (RTDS)-Phase 2, lays the foundation for inter-area oscillation control that is present in the Western Interconnection, including SCE, and it is a component of the SCE plan for Wide-Area Monitoring, Protection and Control. The objective is to develop an experimental framework for testing transient stability, frequency response, and oscillations damping of the Western Interconnection using a Real-Time Digital Simulator (RTDS). The modeling/analysis of WECC inter-area oscillation was done in Phase 1. In Phase 2, SCE will look to apply the model developed in Phase 1 for large-scale renewable energy resources and development of control strategies to dampen oscillations.<br>2. The second sub-project, Establishing Alarm Limits on Bus Voltage Angles for Grid Stress Assessment and Control-Phase 2 will develop a contingency based analysis that will be used to investigate the influence of power transfer patterns and contingencies on phase angle relationships. These studies will suggest actions that system operators can take in order to avoid reaching an unstable operating condition.<br>3. The last sub-project, Wide-Area Security Management and Control will review the system security in SCE's bulk system against extreme contingencies. The basic premise for these strategies is that a failure in one area of the grid should not result in blackouts elsewhere, and that such situations could be minimized by a well-designed, maintained, operated and coordinated power grid. Examples of strategies to be considered are smart pre-planned islanding, real and reactive power flow control in transmission systems (FACTS), real-time RAS, and system integrity protection systems. |
| **Concern, problem or gap to be addressed** | New technologies such as distributed generation present valuable opportunities for meeting California's clean energy policies. However these new technologies if not properly coordinated and integrated into SCE's grid, could result in degraded reliability due to over-voltage and two-way power flow issues. Sub-projects proposed in this project are developed in support of providing solutions for these challenges. This demonstration is crucial in helping to provide solutions for the complexities of the future transmission grid. This project will evaluate different methods to effectively coordinate between transmission system control devices through SCE's system to prevent cascading outages and maintain system security. |
| **Pre-commercial technology or strategy aspect** | In the past, power system control was limited due to shortcomings in sensor and communications technologies, however with the advent of synchrophasor technology and advancement of data communications technologies it now has the ability to provide the necessary components of power system control when it reaches an alert state. No significant work has been done in this area. |
| **How the project avoids duplication from other initiatives** | This project will be the first to demonstrate how coordination between transmission system control devices can prevent cascading outages and improve grid reliability and system security. |
| **Prioritization: High priority project** | The electric grid in California will face a number of new reliability challenges as intermittent resources such as distributed generation continue to proliferate on SCE's grid. To ensure system reliability and security is maintained and cascading outages are prevented, this project is crucial in developing a solution for coordinating transmission system devices throughout SCE's system. |
| **EPIC primary or secondary principles met** | The Wide-Area Security Management and Control project provides clear ratepayer benefits. This demonstration shows greater reliability and increased safety by coordinating new technologies to mitigate operational issues associated with greater penetration of DG, such as potential over-voltage and two-way power flow that could erode the safety and reliability of SCE's grid. |

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## PROJECT NAME:

### STATE ESTIMATION USING PHASOR MEASUREMENT TECHNOLOGIES

| EPIC DESCRIPTION | PROJECT EXPLANATION |
|---|---|
| **Technology or strategy to be demonstrated** | The focus of this project is to investigate and implement a state estimator that utilizes phasor measurement unit (PMU) data as well as supervisory control and data acquisition (SCADA) data. The project will evaluate the integration of PMU technology in Energy Management System (EMS) environments. The purpose of this project is to use additional information provided by PMUs to enhance the existing SCADA-based state estimator. An important tool for EMS is state estimation (SE) and this project will improve system operational reliability by continuously monitoring the grid. Based on measurements taken throughout the power system network, SE calculates the variables of the power system, while checking if these estimates are consistent with the real time measurements. Traditionally, input measurements were usually obtained through the SCADA system. The measurements obtained by SCADA are not synchronized, which reduce the accuracy of the SE during dynamic phenomena in the bulk power system. The PMUs provide highly synchronized, real-time, and direct measurements of voltage phasors at the installed buses, as well as current phasors of adjacent branches that can be used as input to the state estimator and provide better than one microsecond global positioning system (GPS) synchronization accuracy. |
| **Concern, problem or gap to be addressed** | This project eliminates shortages of information about estimating the state of the power system. Such information is essential for an adequate analysis of power system performance. Application of PMU technology in SE is expected to significantly improve existing state estimation algorithms regarding accuracy, observability, convergence, bad data detection and topology estimation properties. Early detection of unusual operating conditions related to highly stressed system scenarios that are seen from significantly different system responses after routine switching events would be extremely beneficial to maintaining grid reliability. |
| **Pre-commercial technology or strategy aspect** | This demonstration will use the existing SCADA-based state estimator, but will leverage additional PMU data for the first time to improve the accuracy of the SE during dynamic phenomena in the bulk power system. |
| **How the project avoids duplication from other initiatives** | No production level state estimator is available in the market, and this project will attempt to demonstrate enhancements over existing state estimators. To further avoid duplication nationwide, regular presentations will be made at NASPI (North American Synchrophasor Initiative) meetings. Results of the study and demonstration records will be published in electrical journals, to inform other interested users. |
| **Prioritization: High priority project** | Maintaining and improving grid reliability is a high priority at SCE. State estimation using PMUs will improve analysis of power dynamic performance by mitigating shortages of information about electromechanical transients. This demonstration is also a high priority because it will improve the accuracy of estimation algorithms and will thus aid in early detection of unusual operating conditions related to highly stressed system scenarios that are seen from significantly different system responses after routine switching events. |
| **EPIC primary or secondary principles met** | The SE using PMUs project meets the threshold of providing ratepayer benefits. The project will specifically improve grid reliability and safety by providing more information about electromechanical transients which negatively affects equipment performance and will improve grid safety and reliability by detecting unusual operating conditions related to times when the grid is highly stressed. |

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## PROJECT NAME: SUBSTATION AUTOMATION 3, PHASE III INTELLIGENT ALARMING

| EPIC DESCRIPTION | PROJECT EXPLANATION |
|---|---|
| **Technology or strategy to be demonstrated** | The objective of this project is to demonstrate an intelligent alarming system in which system operators are presented with the pertinent information and no longer overwhelmed by a large number of alarms. A successful demonstration will provide system operators access to additional detailed information than they can today from the supervisory control and data acquisition (SCADA) system, but presented in a manner in which better informed operating decisions can be made. This project will demonstrate an intelligent algorithm that can reliably pinpoint the event triggering the alarms, and provide recommendations for in-service implementation. |
| **Concern, problem or gap to be addressed** | Existing SCE substation automation systems provide Energy Management System (EMS) operators visibility to control, status and alarms at approximately 350 substations. The alarms generated by SCADA are intended to show operators failures and protective operations on the substation. The way substations are designed; there are many situations in which a single point of failure generates a chain reaction in which operator screens are filled with an avalanche of alarms leaving the operators to find the source of the problem among dozens and sometimes hundreds of alarms. |
| **Pre-commercial technology or strategy aspect** | This demonstration project will include a pre-commercial intelligent alarming algorithm and program/interface. This intelligent alarm processing algorithmic solution will then be integrated into the Substation Automation-3 (SA-3) IEC 61850 system database. This will effectively be generated by the auto-configuration features of the SA-3 system and be unique to the industry. |
| **How the project avoids duplication from other initiatives** | The planned Intelligent Alarm Process System will be interoperable and integrated into the SA-3 IEC 61850 substation automation system database. This design will allow the automatic configuration and configuration management features of SA-3 IEC 61850 to apply to the intelligent alarm processor (IAP) design as well. These features make this demonstration project unique to the industry due to the state of the art auto-configuration and configuration management elements. |
| **Prioritization: High priority project** | The continuing flood of nuisance alarms facing system operators, as well as a forecast increase in substation situational awareness provided by SA-3 makes this a high priority project for SCE. This intelligence is only valuable if managed effectively. This project will address these issues by analyzing the various substation scenarios and implementing an intelligent alarming system that can identify the source of the problem and give substation operators only the relevant information needed to make operating decisions. |
| **EPIC primary or secondary principles met** | The SA-3 Phase III Intelligent Alarming project provides clear electricity ratepayer benefits by enhancing SCE's ability to provide safe, reliable, and affordable energy services, and is an efficient use of ratepayer monies. An effective intelligent alarming system would increase overall system reliability by pinpointing the cause of outages sooner, allowing SCE to restore power quicker. |

**BEFORE THE PUBLIC UTILITIES COMMISSION OF THE**

**STATE OF CALIFORNIA**

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|---|---|
| Application of Southern California Edison Company (U 338-E) for Approval of Its Triennial Investment Plan for the Electric Program Investment Charge Program | A. 12-11-___ |

**NOTICE OF AVAILABILITY OF SOUTHERN CALIFORNIA EDISON COMPANY (U 338-E) OF ITS EPIC TRIENNIAL INVESTMENT PLAN SUPPORTING APPLICATION FOR APPROVAL OF ITS TRIENNIAL INVESTMENT PLAN FOR THE ELECTRIC PROGRAM INVESTMENT CHARGE PROGRAM**

Pursuant to Rule 1.9 of the California Public Utilities Commission's Rules of Practice and Procedure, Southern California Edison Company (SCE) hereby provides this Notice of Availability of its EPIC Triennial Investment Plan, which is identified as Exhibit 1 to its Application for Approval of Its Triennial Investment Plan for the Electric Program Investment Charge Program.

This document and its accompanying appendices may be viewed, printed, and downloaded through SCE's website. To access this document, follow the steps below:

- Go to www.sce.com
- Click on "Regulatory Information" at the bottom of the page
- Click on "CPUC Open Proceedings" on the left side of the page
- Type "A.12-11-XXX" in the search box

As an alternative to accessing this document on SCE's website, SCE will provide a print copy of the document and its accompanying appendices to any party upon request. To request a print copy of these materials, please direct your request to SCE as follows:

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Southern California Edison Company
P.O. Box 800
Rosemead, CA 91770
Telephone: (626) 302-3104
Facsimile: (626) 302-1048
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Respectfully submitted,

KRIS G. VYAS

/s/ Kris G. Vyas
By: Kris G. Vyas

Attorney for
SOUTHERN CALIFORNIA EDISON COMPANY

2244 Walnut Grove Avenue
Post Office Box 800
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Facsimile: (626) 302-6997
E-mail: kris.vyas@sce.com

Dated: November 1, 2012

## CERTIFICATE OF SERVICE

I hereby certify that, pursuant to the Commission's Rules of Practice and Procedure, I have this day served a true copy of **APPLICATION OF SOUTHERN CALIFORNIA EDISON COMPANY (U 338-E) FOR APPROVAL OF ITS TRIENNIAL INVESTMENT PLAN FOR THE ELECTRIC PROGRAM INVESTMENT CHARGE PROGRAM** on all parties identified on the attached service list(s) **R.11-10-003 and A.10-11-015**. Service was effected by one or more means indicated below:

☒ Transmitting the copies via e-mail to all parties who have provided an e-mail address.

☒ Placing the copies in sealed envelopes and causing such envelopes to be delivered by hand or by overnight courier to the offices of the Commissioner(s) or other addressee(s).

**CHIEF ALJ Karen Clopton**
**CPUC**
**505 Van Ness Avenue**
**San Francisco, CA 94102**

☒ Placing copies in properly addressed sealed envelopes and depositing such copies in the United States mail with first-class postage prepaid to all parties for those listed on the attached non-email list.

☐ Directing Prographics to place the copies in properly addressed sealed envelopes and to deposit such envelopes in the United States mail with first-class postage prepaid to all parties.

Executed this November 1, 2012, at Rosemead, California.

__/s/ Henry M. Romero________________________
Henry M. Romero
Project Analyst
SOUTHERN CALIFORNIA EDISON COMPANY

2244 Walnut Grove Avenue
Post Office Box 800
Rosemead, California 91770

## CERTIFICATE OF SERVICE

I hereby certify that, pursuant to the Commission's Rules of Practice and Procedure, I have this day served a true copy of **NOTICE OF AVAILABILITY OF SOUTHERN CALIFORNIA EDISON COMPANY (U 338-E) OF ITS EPIC TRIENNIAL INVESTMENT PLAN SUPPORTING APPLICATION FOR APPROVAL OF ITS TRIENNIAL INVESTMENT PLAN FOR THE ELECTRIC PROGRAM INVESTMENT CHARGE PROGRAM** on all parties identified on the attached service list(s) **R.11-10-003 and A.10-11-015**. Service was effected by one or more means indicated below:

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**CHIEF ALJ Karen Clopton**
**CPUC**
**505 Van Ness Avenue**
**San Francisco, CA 94102**

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Executed this November 1, 2012**,** at Rosemead, California.

____/s/ Henry M. Romero______________________
Henry M. Romero
Project Analyst
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