

**APPENDIX A**  
**PG&E's Smart Grid Deployment**  
**Plan**

**PACIFIC GAS AND ELECTRIC COMPANY**

**SMART GRID DEPLOYMENT PLAN  
2011 - 2020**

**JUNE 2011**

**SMART GRID TECHNOLOGIES  
ORDER INSTITUTING RULEMAKING 08-12-009**

**CALIFORNIA PUBLIC UTILITIES COMMISSION**



**PG&E SMART GRID DEPLOYMENT PLAN: TABLE OF CONTENTS**

**1 EXECUTIVE SUMMARY ..... 1**

1.1 PG&E’s Smart Grid Deployment Plan Is a Fundamental Change in the Use of  
Technology to Serve Its Customers ..... 2

1.2 PG&E’s Smart Grid Deployment Plan Has Been Benchmarked With Other Public  
Utilities, Technology Leaders, Smart Grid Policymakers, PG&E’s Customers and  
Other Stakeholders ..... 3

1.3 PG&E’s Smart Grid Vision ..... 4

1.4 PG&E’s Strategic Objectives for its Smart Grid Deployment Plan ..... 5

1.4.1 Engaged Consumers..... 5

1.4.2 Smart Energy Markets ..... 5

1.4.3 Smart Utility ..... 6

1.4.4 Foundational and Cross Cutting Smart Grid Infrastructure..... 6

1.5 PG&E’s Smart Grid Projects and Initiatives ..... 7

1.6 PG&E’s Smart Grid Deployment Plan Builds on Its Existing Leadership in Energy  
Efficiency, Demand Response and Renewable Energy Programs ..... 9

1.7 PG&E’s SmartMeter™ Platform is Essential to PG&E’s Smart Grid Plan ..... 10

1.8 PG&E’s Smart Grid Deployment Plan Builds on Safety and Reliability Investments in  
PG&E’s Electric Grid ..... 11

1.9 PG&E’s Smart Grid Deployment Plan is Driven by and Supports California’s Energy  
and Environmental Policies..... 11

1.10 How PG&E’s Smart Grid Deployment Plan Is Organized and Presented..... 14

1.11 PG&E’s Smart Grid Deployment Plan is Not an End in Itself, but Part of PG&E’s  
Commitment to Improve Safety and Reliability, Empower Customers and Operate  
Sustainably ..... 14

**2 PG&E’S SMART GRID VISION ..... 17**

2.1 Introduction ..... 18

2.2 PG&E’s Smart Grid Vision ..... 18

2.3 PG&E’s Definition of the Smart Grid..... 18

**PG&E SMART GRID DEPLOYMENT PLAN: TABLE OF CONTENTS (CONTINUED)**

2.4 Drivers of PG&E’s Smart Grid Vision ..... 20

2.5 PG&E’s Smart Grid Vision Restated ..... 25

2.5.1 Engaged Consumers (Smart Customers) ..... 25

2.5.2 Smart Energy Markets ..... 26

2.5.3 The Smart Utility ..... 27

2.6 The Relationship of PG&E’s Smart Grid Vision and Smart Grid Strategy ..... 28

**3 PG&E’S SMART GRID STRATEGY ..... 31**

3.1 Introduction ..... 32

3.2 PG&E’s Overall Smart Grid Strategy ..... 32

3.3 PG&E’s Smart Grid Strategic Objectives ..... 33

3.4 Program Area: Engaged Consumers ..... 35

3.4.1 Enable SmartMeter™ Supported Customer Applications ..... 35

3.4.2 Enable Dispatch and Integration of Demand Response Resources..... 35

3.4.3 Support the Expanding Market for Electric Vehicles ..... 36

3.5 Program Area: Smart Energy Markets ..... 36

3.5.1 Accurately Forecast Market Conditions..... 36

3.5.2 Integrate and Manage Large-scale Renewable Resources..... 36

3.6 Program Area: Smart Utility..... 37

3.6.1 Grid Outage Detection Isolation and Restoration ..... 37

3.6.2 Grid System Monitoring and Control..... 37

3.6.3 Manage Grid System Voltage and Losses ..... 38

3.6.4 Manage Transmission and Distribution Asset Condition ..... 38

3.7 Program Area: Foundational and Cross-Cutting Infrastructure ..... 39

3.7.1 Provide Foundational and Cross-Cutting Utility Systems, Facilities and Programs  
Necessary to Continuously Improve the Application of New Smart Grid  
Technologies ..... 39

3.8 Customer Outreach and Education Plan to Support the Smart Grid Strategy ..... 40

3.9 Methodology for Selecting and Prioritizing Smart Grid Projects and Initiatives  
Consistent With SB 17 Goals and PG&E’s Smart Grid Strategy ..... 40

**PG&E SMART GRID DEPLOYMENT PLAN: TABLE OF CONTENTS (CONTINUED)**

- 3.9.1 Enable SmartMeter™ Supported Customer Applications ..... 42
- 3.9.2 Enable Dispatch and Integration of Demand Response Resources..... 42
- 3.9.3 Support the Expanding Market for Electric Vehicles ..... 43
- 3.9.4 Accurately Forecast Market Conditions..... 43
- 3.9.5 Integrate and Manage Large-scale Renewable Resources..... 43
- 3.9.6 Grid Outage Detection Isolation and Restoration ..... 43
- 3.9.7 Grid System Monitoring and Control..... 43
- 3.9.8 Manage Grid System Voltage and Losses ..... 44
- 3.9.9 Manage Transmission and Distribution Asset Condition ..... 44
- 3.9.10 Provide Foundational and Cross-Cutting Utility Systems, Facilities and Programs  
Necessary to Continuously Improve the Application of New Smart Grid  
Technologies ..... 44
- 3.10 PG&E’s Strategic Goals for Supplier Diversity Spending Under the Smart Grid Plan  
and Consistent With the Commission’s General Order 156..... 44
- 3.11 Responses to Smart Grid Strategy Questions in Compliance With the Commission’s  
Smart Grid Deployment Plan Decision 10-06-047 ..... 46
  
- 4 DEPLOYMENT BASELINE..... 50**
- 4.1 Introduction ..... 51
- 4.2 Current State of PG&E’s Grid ..... 53
- 4.2.1 Generation ..... 54
- 4.2.2 Electric Transmission and Distribution ..... 57
- 4.3 Smart Grid Baseline Projects ..... 63
- 4.3.1 Engaged Consumers..... 70
- 4.3.2 Smart Energy Markets ..... 73
- 4.3.3 Smart Utility ..... 77
- 4.3.4 Foundational and Cross-Cutting Initiatives..... 84
- 4.4 Assessment of Privacy Issues ..... 88
- 4.5 Conclusion..... 89

**PG&E SMART GRID DEPLOYMENT PLAN: TABLE OF CONTENTS (CONTINUED)**

<b>5</b>	<b>SMART GRID-RELATED CUSTOMER PROGRAMS</b>	<b>91</b>
5.1	Introduction	92
5.1.1	SmartMeter™-Enabled Information Presentment Tools	92
5.1.2	SmartMeter™-Enabled Time-Varying Pricing Products	93
5.1.3	Customer Energy Efficiency	93
5.1.4	Demand Response	93
5.1.5	Distributed Generation	94
5.1.6	Electric Vehicle Readiness	94
5.2	SmartMeter™-Enabled Information Presentment Tools	95
5.2.1	“My Energy” Web Tools	95
5.2.2	Energy Alerts	96
5.2.3	Home Energy Reports	97
5.2.4	Energy and Carbon Management System	98
5.3	SmartMeter™-Enabled Time-Varying Pricing Products	99
5.3.1	Time-of-Use	100
5.3.2	Peak Day Pricing	100
5.3.3	Peak Time Rebate	101
5.4	Customer Energy Efficiency	102
5.5	Demand Response	105
5.5.1	PeakChoice™	107
5.5.2	Base Interruptible Program	107
5.5.3	Demand Bidding Program	107
5.5.4	Aggregator Programs	108
5.5.5	SmartAC™ Program	108
5.5.6	Technology Incentive Program	109
5.5.7	Automated Demand Response Program	109
5.5.8	Permanent Load Shift	110
5.6	Distributed Generation	110
5.6.1	California Solar Initiative	111
5.6.2	Self-Generation Incentive Program	112

**PG&E SMART GRID DEPLOYMENT PLAN: TABLE OF CONTENTS (CONTINUED)**

- 5.6.3 Net Energy Metering..... 113
- 5.6.4 DG Policy and Operational Activities ..... 113
- 5.7 Electric Vehicle Readiness..... 114
- 5.8 Empowering Communities..... 117
- 5.9 Conclusion..... 118
  
- 6 SMART GRID ROADMAP ..... 120**
- 6.1 Introduction ..... 121
- 6.2 Proposed High Priority Smart Grid Roadmap Projects – Selection Criteria ..... 121
- 6.3 Proposed Smart Grid Roadmap Projects by Program Area ..... 123
- 6.4 Proposed Smart Grid Roadmap High Priority Projects – Engaged Consumers ..... 125
- 6.5 Proposed Smart Grid Roadmap High Priority Projects – Smart Energy Markets ..... 131
- 6.6 Proposed Smart Grid Roadmap High Priority Projects – Smart Utility..... 134
- 6.7 Foundational and Cross-Cutting Infrastructure Initiatives ..... 142
- 6.8 Conclusion..... 151
  
- 7 COST AND BENEFITS ESTIMATES ..... 153**
- 7.1 Introduction ..... 154
- 7.2 Approach..... 157
- 7.3 Cost Per Customer ..... 159
- 7.4 Project Cost Estimates by Program Area ..... 160
- 7.5 Engaged Consumers..... 160
- 7.6 Smart Energy Markets ..... 161
- 7.7 Smart Utility ..... 162
- 7.8 Foundational and Cross-Cutting Infrastructure Initiatives ..... 164
- 7.9 Conclusion on Cost Estimates..... 167
- 7.10 Benefits Estimates..... 167
- 7.11 Introduction ..... 167
- 7.12 Approach..... 171
- 7.13 Quantifiable Benefits ..... 175

**PG&E SMART GRID DEPLOYMENT PLAN: TABLE OF CONTENTS (CONTINUED)**

- 7.14 Achievement of Energy and Environmental Policy Goals..... 181
- 7.15 Engaged Consumer Projects ..... 182
- 7.16 Smart Energy Markets Projects ..... 185
- 7.17 Smart Utility Projects ..... 186
- 7.18 Foundational and Cross-Cutting Infrastructure Initiatives ..... 190
- 7.19 Discussion of Other Benefits..... 194
- 7.20 Conclusion..... 195
  
- 8 CUSTOMER OUTREACH AND EDUCATION..... 197**
- 8.1 Introduction ..... 198
- 8.2 Outreach Objectives ..... 199
- 8.3 Overview of PG&E’s Customer Audience ..... 202
- 8.4 PG&E-Specific Customer Research ..... 202
- 8.5 Lessons Learned From Past Outreach and Education Efforts..... 205
- 8.6 Smart Grid in the Context of Other Customer Awareness and Education Efforts ..... 208
- 8.7 Planned Outreach and Education Activities ..... 209
- 8.8 Customer Inquiry ..... 210
- 8.9 Customer Contact Employee Education and Training ..... 211
- 8.10 External Organizations and Partnership Outreach ..... 212
- 8.11 Awareness and Education Outreach – Mass Media ..... 214
- 8.12 Earned Media Outreach..... 215
- 8.13 Online and Social Media ..... 215
  
- 9 GRID SECURITY AND CYBER SECURITY STRATEGY ..... 217**
- 9.1 Background ..... 218
- 9.2 Strategy and Approach Framework ..... 219
- 9.3 Cyber Security: A Governing Process..... 221
- 9.4 Cyber Security: Risk Assessment..... 225
- 9.5 Cyber Security: Smart Grid Design and Architectural Approach ..... 227
- 9.5.1 Design Principles ..... 228



**PG&E SMART GRID DEPLOYMENT PLAN: TABLE OF CONTENTS (CONTINUED)**

- 9.5.2 Technology Design: A Layered, Defense-In-Depth Approach..... 229
- 9.5.3 Architectural Design Process ..... 231
- 9.5.4 Individual Component Design Process Viewpoint ..... 233
- 9.5.5 System-of-Systems Design Process Viewpoint ..... 233
- 9.5.6 Applying the Design Process to the Smart Grid Initiatives ..... 234
- 9.6 Physical Security..... 236
- 9.7 Privacy..... 238
- 9.7.1 PG&E’s Commitment to Customer Privacy Protection..... 238
- 9.7.2 Overview of Private Customer Data PG&E Collects..... 239
- 9.7.3 Protection of Private Customer Data; Customer Consent..... 241
- 9.7.4 Customer Access to Their Private Data ..... 244
- 9.7.5 Maintaining Customer Data..... 245
- 9.8 Conclusion..... 246
  
- 10 SMART GRID METRICS..... 247**
- 10.1 Introduction ..... 248
- 10.2 Consensus Interim Smart Grid Metrics..... 248
- 10.3 PG&E’s Interim Smart Grid Metrics ..... 249
- 10.4 Customer/Advanced Metering Infrastructure Metrics ..... 250
- 10.5 Plug-in Electric Vehicle Metrics ..... 265
- 10.6 Energy Storage Metrics..... 266
- 10.7 Grid Operations Metrics ..... 267
- 10.8 Review of and Revisions to Interim Metrics ..... 275
- 10.9 Appropriate Reporting Period ..... 276
- 10.10 Conclusion..... 276
  
- 11 CONCLUSION ..... 278**

# **Chapter 1 – Executive Summary**

## **1.1 PG&E's Smart Grid Deployment Plan Is a Fundamental Change in the Use of Technology to Serve Its Customers**

Pacific Gas and Electric Company's (PG&E) Smart Grid Deployment Plan is not just a plan, it represents a *fundamental change* to the way PG&E uses technology to serve its customers and operate its business. Compliant with California Senate Bill (SB) 17 and the decisions and policies of the California Public Utilities Commission (CPUC or Commission) implementing SB 17, PG&E's Smart Grid Deployment Plan represents a disciplined and integrated approach to using new monitoring and control technology to support PG&E's mission of providing safe, reliable, responsive and environmentally sustainable service to its customers.

PG&E developed this plan with a clear focus on what our customers need and value as well as California public policy. PG&E's customers will see many benefits from the Smart Grid in the coming years, including the ability to lower energy bills by controlling energy use. Today, through SmartMeter™ technology, customers already can view energy use hourly and daily online to help understand how and when they use energy.

In the future, pricing signals will help customers save money by shifting their energy use to times of the day when energy prices are lower. Customers will also enjoy increased reliability of service, including faster outage detection and restoration, as well as greater convenience from faster response to service requests.

The Smart Grid will integrate wind and solar supplies to give customers more clean and renewable energy. The Smart Grid will also support more widespread customer adoption of rooftop solar as well as "smart charging" programs that encourage the use of zero-emission electric vehicles while helping protect the safety and reliability of the energy grid.

PG&E considers it a privilege to serve its customers and to help bring them these energy innovations.

## **1.2 PG&E’s Smart Grid Deployment Plan Has Been Benchmarked With Other Public Utilities, Technology Leaders, Smart Grid Policymakers, PG&E’s Customers and Other Stakeholders**

Since early 2008, PG&E has been reaching out and benchmarking its Smart Grid activities and plans with other key Smart Grid leaders, experts, utilities, and customers. Early on, PG&E engaged directly with the Electric Power Research Institute (EPRI) and Southern California Edison Company and San Diego Gas and Electric Company, to develop and present to the California Energy Commission (CEC) the *“Defining the Pathway to the California Smart Grid of 2020”* report. After more than two years of collaboration, PG&E, EPRI and the other California utilities presented the Smart Grid report to the CEC in December 2010. PG&E also has consulted widely with and benefited from the insights of Smart Grid experts and stakeholders over the last two years, including the Environmental Defense Fund (EDF), the Silicon Valley Leadership Group, the GridWise Alliance, the Center for Democracy and Technology, the U.S. Department of Energy, the CEC, as well as the numerous parties and stakeholders who have participated actively in the workshops and comments presented in the CPUC’s Smart Grid rulemaking proceeding. More directly, PG&E has extensively benchmarked its Smart Grid priorities with other utilities and technology leaders across the country, with the assistance of IBM and its breadth of operating experience and technology development expertise on behalf of its U.S. and global clients.

The direct and continuing input and opinions of PG&E’s customers have been crucial in the development of PG&E’s Smart Grid Deployment Plan, especially the insights and “lessons learned” from PG&E’s “first in California” deployment of SmartMeter™ technology to customers throughout its service area. Without these “lessons learned,” there is no way that PG&E’s Smart Grid Plan could be framed as a realistic, executable blueprint for PG&E’s Smart Grid investments in the future. PG&E has applied many of

these SmartMeter™ lessons learned from its customers directly to the customer outreach part of its Smart Grid Plan, described in more detail in Chapter 8.

As this Plan moves forward through the review process and is updated, PG&E looks forward to further “benchmarking” and advice and guidance from its customers, other utilities, and Smart Grid experts and leaders in California and around the country.

### **1.3 PG&E’s Smart Grid Vision**

PG&E’s vision for the Smart Grid begins with the definition of the Smart Grid. PG&E defines the Smart Grid as a modernized electricity infrastructure which integrates advanced communications and control systems to create a highly automated, responsive, and resilient power delivery system that will both optimize service and empower customers to make informed energy decisions. These advanced communications and control systems will enable the Smart Grid to continuously send, receive, and process data on system conditions, component health, and reliability, as well as to share information among customers, intelligent electronic devices, generators, the California Independent System Operator, market participants, and energy service providers.

Using this definition, ***PG&E’s vision for the Smart Grid is to provide customers safe, reliable, secure, cost-effective, sustainable and flexible energy services through the integration of advanced communications and control technologies to transform the operations of our electric network, from generation to the customer’s premise.***

PG&E applies this vision to development of its Smart Grid strategy and objectives.

## 1.4 PG&E's Strategic Objectives for its Smart Grid Deployment Plan

PG&E's Smart Grid Deployment Plan adopts **10 high-priority Smart Grid strategic objectives in four program areas** to guide PG&E's Smart Grid investments and initiatives over the next decade:

### 1.4.1 Engaged Consumers

1. **Leverage SmartMeter™ Technology for Direct Customer Benefit** – This strategic objective is to take advantage of the SmartMeter™ capability to stimulate industry-wide innovation, and implement programs, standards and technologies that can be used by customers and third parties to create and provide energy solutions and tools for customers.
2. **Improve the Use of Demand Response Resources for Operational Efficiency** – This strategic objective is to enable better use of demand response resources in energy and ancillary service markets and thereby increase the efficient use of these resources and reduce the environmental impact of supply-side energy resources.
3. **Support the Expanding Market for Electric Vehicles** – This strategic objective is to appropriately invest in the necessary transmission and distribution (T&D) infrastructure and monitoring systems to accommodate and support the mass market adoption of electric vehicles.

### 1.4.2 Smart Energy Markets

1. **Improve the Forecasting of Market Conditions** – This strategic objective is to improve the ability to match energy supplies and energy demand while maintaining the reliability of the grid and increasing the use of renewable energy to meet statutory requirements.
2. **Integrate and Manage Large-Scale Renewable Resources** – This strategic objective is to enhance PG&E's ability to integrate large-scale renewables into the grid in order to allow for more widespread deployment of clean

resources and technologies that reduce the carbon footprint of PG&E's generation portfolio while maintaining energy system reliability.

### **1.4.3 Smart Utility**

1. **Enhance Grid Outage Detection, Isolation, and Restoration** – This strategic objective is to leverage advanced communications technology and control systems to assist utility operators and repair personnel to locate damaged equipment or outage areas, isolate the problem and restore service to unaffected areas quickly, thereby minimizing customer outage time.
2. **Enhance Grid System Monitoring and Control** – This strategic objective is to deploy advanced monitoring and control technologies to provide more in-depth understanding of grid equipment and conditions to identify emerging problems before they result in system disruptions.
3. **Manage Grid System Voltage and Losses** – This strategic objective is to use advanced technologies to enhance PG&E's capability to maintain voltage levels within required levels, and to use the same sensing, telecommunications and control systems to reduce energy usage by customer equipment and reduce electric losses in the utility delivery system.
4. **Manage Transmission and Distribution Asset Condition** – This strategic objective is to improve the utility's ability to monitor real-time asset conditions in substations, which will help improve operational efficiency as well as provide advanced warning of potential issues that can result in equipment failures.

### **1.4.4 Foundational and Cross-Cutting Smart Grid Infrastructure**

1. **Provide Foundational and Cross-Cutting Utility Systems, Facilities and Programs Necessary to Continuously Improve the Application of New Smart Grid Technologies** – This strategic objective is to improve the foundational and cross-cutting systems and programs in information

technology, telecommunications, and cyber security; technology testing, evaluation and standards development; workforce development; and customer engagement that are necessary in order to achieve PG&E's other Smart Grid strategic objectives.

## 1.5 PG&E's Smart Grid Projects and Initiatives

To support these strategic objectives and program areas and building on PG&E's extensive Smart Grid projects already underway, PG&E has identified 21 incremental Smart Grid projects, including:

- 14 business area projects;
- 4 foundational information technology initiatives to support the business area projects; and
- 3 supporting area projects.

Collectively, these projects and initiatives could achieve approximate benefits over the next 20 years of:

- **\$600 million to \$1.4 billion in lower energy procurement costs.**
- **\$200 million to \$400 million in avoided capital costs.**
- **\$100 million to \$200 million in avoided operating and maintenance costs.**
- **10 to 20 percent improvement in system reliability.**
- **1.4 to 2.1 million metric tons of avoided carbon dioxide (CO<sub>2</sub>) emissions.**

These collective benefits offset the estimated costs of these projects and initiatives, which PG&E forecasts on a preliminary basis to be approximately **\$800 million to \$1.25 billion in capital and \$500 million to \$700 million in cumulative operating expense** over the next 20 years. These cost and benefit estimates are necessarily conceptual, preliminary and subject to significant change at this early stage of Smart Grid project and portfolio development. The scale of deployment and market conditions also are likely to change significantly, and PG&E intends to update and refine these estimates based on additional market information and the results of pilot and demonstration projects over time.



PG&E's Smart Grid program costs and benefits are summarized in Table 1-1 below.

**Table 1-1: Smart Grid Program Cost & Benefits**

Proposed New Smart Grid Projects		Potential Incremental Benefits <sup>(2)</sup>	
<b>Engaged Consumers</b>		<b>Economic Benefits</b>	
Demand Response (DR) Optimization	Capital	Avoided Energy Procurement Costs	\$600M - \$1,400M
DR Forecasting	\$ 25M - 55M	Avoided Capital Investments	\$240M - \$360M
Expanded Home Area Networks (HAN)	Annual O&M <sup>(1)</sup>	Avoided O&M Costs	\$140M - \$190M
Open Automated Data Exchange	\$ 1.5M – 2M	<b>TOTAL</b>	<b>\$990M - \$1,950M</b>
<b>Smart Energy Markets</b>		<b>Reliability Benefits</b>	
DR in Wholesale Markets	Capital	Outage Distribution (SAIDI)	10% - 20%
Enhanced Energy Forecasting	\$ 30M - 50M	Outage Frequency (SAIFI)	10% - 20%
	Annual O&M		
	\$ 0.5M - \$2M	<b>Environmental Benefits</b>	
<b>Smart Utility</b>		CO <sub>2</sub> Reduction (Tons)	1.5M - 2.1M
Grid System Voltage Control	Capital	CO <sub>2</sub> Reduction Value	\$15M - \$84M
Advanced Distribution Automation	\$ 630M – \$850M		
DR Integration in T&D Operation	Annual O&M		
Wireless Line Sensors	\$8M - \$11	<b>Non-Quantifiable Benefits</b>	
Substation Automation Interoperability		Customer Empowerment	
Substation Asset Management		Enable New Pricing Programs	
Advanced Outage Management		Enable New DR & Efficiency Programs	
<b>Foundational and Cross Cutting</b>		Reduce Environmental Footprint	
Cyber Security	Capital	(Water Use, Particulate Matter)	
Telecommunications	\$ 115M - \$295M	Increase Renewables & Distributed Gen	
Data Management	Annual O&M	California Economic Development	
	\$ 15M - \$25 M		
Technology Testing, Evaluation & Standards			
Customer Outreach & Education			
Workforce Development			

Cost and benefits estimates are based on preliminary, conceptual estimates derived using benchmark information, preliminary designs and estimates for comparable PG&E projects. Actual estimates will vary and are subject to testing and pilot results.

<sup>1</sup> Annual O&M expenses averaged over project start-up and operational phase.

<sup>2</sup> Accumulated benefits estimated over a 20-year study period.

A more detailed description of PG&E's proposed Smart Grid initiatives and projects, including capabilities, costs and benefits, is provided in Chapters 6, 8, and 9 of PG&E's Smart Grid Deployment Plan.

## 1.6 PG&E's Smart Grid Deployment Plan Builds on Its Existing Leadership in Energy Efficiency, Demand Response and Renewable Energy Programs

PG&E's Smart Grid Deployment Plan builds upon over 30 years of leadership in customer Energy Efficiency, Demand Response and Renewable Energy Programs.

These existing programs demonstrate that PG&E and California are not newcomers to the use of technology to improve service to our customers. PG&E's Smart Grid Deployment Plan is focused on technologies that support and enable expansion of these long-standing programs to provide new incremental customer and environmental benefits, as well as raising the bar for "clean tech" innovations and inventions to support sustainable business practices and address global climate change.

PG&E has been a strong, national champion for *energy efficiency*, implementing a diverse array of programs, services and campaigns aimed at helping our customers save energy and money. In total, PG&E's programs have avoided the release of approximately 168 million metric tons of CO<sub>2</sub> into the atmosphere, based on cumulative lifecycle savings, and helped customers save more than \$24 billion on their energy bills.

While energy efficiency programs result in permanent reductions in energy usage, PG&E's *demand response* programs provide incentives for customers to temporarily reduce or shift their energy use on days when demand for energy is at its highest. For years, PG&E's customer demand response programs have provided a fiscally and environmentally responsible way to respond to these spikes in electric demand, avoiding the need to build and maintain additional power plants that would only be needed for relatively few hours during the year. PG&E's programs offer incentives to customers who volunteer to temporarily reduce their electricity use when demand could outpace supply.

In addition to energy efficiency and demand response programs, PG&E continues to make significant investments in new sources of renewable energy, including wind, solar, geothermal, biomass and small hydro resources. These investments create jobs, reduce air pollution and greenhouse gas emissions, and move us toward a low-carbon economy in California and across the nation. In addition to procuring more renewables to meet the state's 33 percent renewable portfolio standard goal by 2020, PG&E is leading in helping achieve California's goal to connect 3,000 megawatts (MW) of customer-installed solar capacity by December 2016, moving the state toward a cleaner energy future and helping to lower the cost of solar installations for customers. Through the California Solar Initiative, PG&E has supported the interconnection of more than 40,000 customer-owned solar systems to the grid, more than any utility in the nation. PG&E's efforts were recently recognized by the Solar Electric Power Association in its June 2011 annual Top 10 Utility Solar Rankings which named PG&E as the top utility for the second year in a row for the highest MW of installed solar generation in the United States.

## **1.7 PG&E's SmartMeter™ Platform is Essential to PG&E's Smart Grid Plan**

PG&E's SmartMeter™ program is the largest in the country, with over 8 million meters already installed. SmartMeters™ will provide customers and the utility access to near real-time streams of energy usage data. SmartMeters™ put real information in the hands of consumers, one of the most significant improvements in the customer's energy experience. In addition, SmartMeters™ allow the utility to offer pricing programs designed to enable sound energy policy for the state of California. And SmartMeters™ provide a host of operational benefits, including detecting outages faster and with more precision, better accuracy than traditional meters, and the ability to switch on a new customer without having to send out a truck and a crew to do the job.

There also is enormous innovation in smart appliances—washers, refrigerators, dish washers, for example—that can communicate with PG&E’s SmartMeters™ or via the internet, and be set to operate when power prices are cheapest, based on current market conditions. PG&E’s SmartMeters™ and new internet applications are creating the opportunity for in-premise networking to employ in-home displays or online applications that let people see their usage, anticipate their bills, compare usage to other similar homes, and empower them to make their own choices about their energy use.

## **1.8 PG&E’s Smart Grid Deployment Plan Builds on Safety and Reliability Investments in PG&E’s Electric Grid**

In addition to its traditional utility infrastructure investments, PG&E is implementing ***advanced monitoring and automation technologies in our transmission and distribution system***. PG&E is participating with other utilities, the California Independent System Operator and the Western Electricity Coordinating Council in a project to install synchrophasor technology across the Western Interconnection to provide operators unprecedented insight into grid conditions. PG&E is also increasing the deployment of traditional T&D system automation equipment to provide operators with greater information and remote control capabilities. Further, PG&E is in the final stages of piloting advanced distribution automation equipment that will be installed at key locations in its distribution system to isolate outages and restore service to affected customers automatically as part of its Cornerstone Improvement Project.

## **1.9 PG&E’s Smart Grid Deployment Plan is Driven by and Supports California’s Energy and Environmental Policies**

In addition to PG&E’s existing energy efficiency, demand response and renewable energy programs, PG&E’s Smart Grid Deployment Plan is shaped by several key operational, business and public policy “drivers.” PG&E views the evolution and development of the Smart Grid as critically important in providing efficient utility services to our customers, serving their long term energy needs, and achieving both

state and federal energy and environmental policy objectives. These drivers shape our Smart Grid vision and guide our Smart Grid strategic objectives in order to increase customer satisfaction, improve PG&E’s utility services, and enable California to meet its energy and environmental policy goals. These operational, business, and public policy drivers are: *safety, reliability and security; customer empowerment; efficient and flourishing electricity markets; environmental sustainability; and consumer and technological advancement.*

1. ***Safety, Reliability, and Security*** – A fundamental operational and business imperative for PG&E is to ensure that it continuously maintains and improves the safety, reliability, and security of the basic electricity services it provides to customers.
2. ***Customer Empowerment*** – A key driver of the Smart Grid at PG&E and throughout the nation is to provide customers with more choices and control of their energy consumption, demand and investment decisions. Smart Grid technologies have the potential to give customers cleaner, more reliable and flexible energy products and services.
3. ***Efficient and Flourishing Electricity Markets*** – PG&E relies on thousands of suppliers, vendors and contractors in electricity markets to provide it with the electricity products, services and tools needed to continuously improve the quality and cost-effectiveness of services to customers. As new technologies develop in these electricity markets, a key driver of the Smart Grid is the efficiency, openness and robustness of those markets. This includes enabling access by third parties to information about the grid; creating a “standards-based platform” for deployment of a wide range of energy technologies and management services; and enabling the sale of Demand Response, Energy Efficiency, distributed generation, and energy storage products and services into energy markets on an “equal footing” with traditional generation sources.

4. ***Environmental Sustainability*** – An overarching driver of PG&E’s Smart Grid Plan, across all goals, objectives, investments and projects, is the need for the Smart Grid to not only promote environmental sustainability in all of PG&E’s operations and services, but also to further leverage the Smart Grid’s ability to reduce and minimize environmental impacts of PG&E’s operations and services to customers in a cost-effective and feasible manner. For PG&E, this is not merely a public policy driver; it is a fundamental driver of our entire business.
5. ***Consumer and Technological Advancement*** – The Smart Grid is a journey, not an end-state. Throughout this proceeding and leading up to these Smart Grid Plans, PG&E and other parties have repeatedly pointed out that the Smart Grid is not an “end” in itself, but in fact is a “process” that will utilize a set of disciplined methodologies for evaluating, demonstrating, piloting, scaling up and ultimately deploying new technologies to improve electricity facilities and services. This Smart Grid “journey”—including the methodical process of researching, developing, evaluating, and demonstrating new Smart Grid technologies and then repeating the process when such technologies are rendered obsolete or less cost-effective than newer technologies—is a fundamental driver of PG&E’s Smart Grid Vision and Plan.

The Smart Grid “journey” also requires foundational and supporting investments in basic information technology systems and platforms, including investments in basic telecommunications and security systems, without which individual Smart Grid projects and programs are infeasible or cost-ineffective. Finally, the Smart Grid “journey” requires investments in customer engagement and “human capital,” including customer outreach and workforce development, because the Smart Grid is a fundamental effort to “empower” customers as direct partners of the utilities in managing their energy future.

## **1.10 How PG&E's Smart Grid Deployment Plan Is Organized and Presented**

PG&E's Smart Grid Plan is presented in the following chapters:

- *PG&E's Smart Grid Vision*
- *PG&E's Smart Grid Strategy*
- *PG&E's Smart Grid Deployment Baseline*
- *PG&E Smart Grid Related Programs*
- *PG&E's Smart Grid Roadmap*
- *Cost and Benefit Estimates*
- *Customer Outreach and Education*
- *PG&E's Grid Security and Cyber Security Strategy*
- *PG&E's Smart Grid Metrics*

In each of these chapters, PG&E provides a more detailed discussion and description of its Smart Grid Deployment Plan, including demonstrating how it complies with the requirements of SB 17 and the Commission's Decision 10-06-047 implementing SB 17. In addition, each of these chapters incorporates the helpful advice and guidance provided by the EDF during its participation in the Commission's Rulemaking 08-12-009 and in EDF's recent "Evaluation Framework for Smart Grid Deployment Plans," issued in June 2011 in collaboration with Herter Energy Research Solutions.

## **1.11 PG&E's Smart Grid Deployment Plan is Not an End in Itself, but Part of PG&E's Commitment to Improve Safety and Reliability, Empower Customers and Operate Sustainably**

PG&E's Smart Grid Deployment Plan is not an end in itself, but a part of PG&E's overall commitment to earn our customers' trust and confidence by using cost-effective technology to bring our overall customer service and operating performance to industry-leading standards for safety, reliability, security and sustainability.

PG&E and other public utilities face big challenges over the next decade. PG&E, our customers and our leaders, as a society, need to become more energy educated and efficient. PG&E needs to use the best know-how and technologies available to make renewable resources an ever-expanding part of our energy mix. PG&E needs to use conventional sources of energy more efficiently and sustainably. PG&E needs to continuously improve the safety and reliability of our T&D assets and operations, even while the grid is being transformed to empower customers and electricity markets. PG&E needs to upgrade its systems and services to make the most of the opportunities that electric vehicles present.

PG&E will carefully test and evaluate new, promising technologies, but then only use those technologies that are proven and cost-effective, to realize the potential of the Smart Grid to help usher in a new era where all of these opportunities for customer choice, renewable energy, and improved grid safety and reliability become possible.

While PG&E is optimistic about its Smart Grid Deployment Plan, PG&E is also realistic. The Smart Grid is going to take time and it is a long journey. And to complete the journey, it is going to take all stakeholders working together—consumers, policymakers and utilities.

In preparing its Smart Grid Deployment Plan, PG&E used the best information available to describe the highest priority Smart Grid projects and initiatives in terms of feasibility, technology maturity, customer value and cost effectiveness in meeting energy and environmental policy goals. However, the actual costs, benefits and project schedules will undoubtedly change over time with changes in customer participation, cost effectiveness, technology evolution, organizational and systems readiness and changes in energy and environmental policies. For these reasons, PG&E is following a disciplined process of testing and evaluating the technologies and their associated benefits as part of informing specific business cases, and overall implementation of its Smart Grid



Deployment Plan. PG&E's Smart Grid Deployment Plan will undoubtedly change, and PG&E will make adjustments as more experience is gained through the project testing, evaluation and development phases.

With this Smart Grid Deployment Plan, PG&E is ready to embark on the Smart Grid journey, and looks forward to working with the Commission, customers, policymakers and stakeholders every step along the way.

# Chapter 2 – PG&E’s Smart Grid Vision

## **2.1 Introduction**

The purpose of this chapter is to describe PG&E's Smart Grid Vision, consistent with the public policy objectives identified by Senate Bill (SB) 17 (Padilla), Commission Decision 10-06-047, the Environmental Defense Fund (EDF) and other parties to this proceeding.

## **2.2 PG&E's Smart Grid Vision**

*PG&E's vision for the Smart Grid is to provide customers safe, reliable, secure, cost-effective, sustainable and flexible energy services through the integration of advanced communications and control technologies to transform the operations of our electric network, from generation to the customer's premise.*

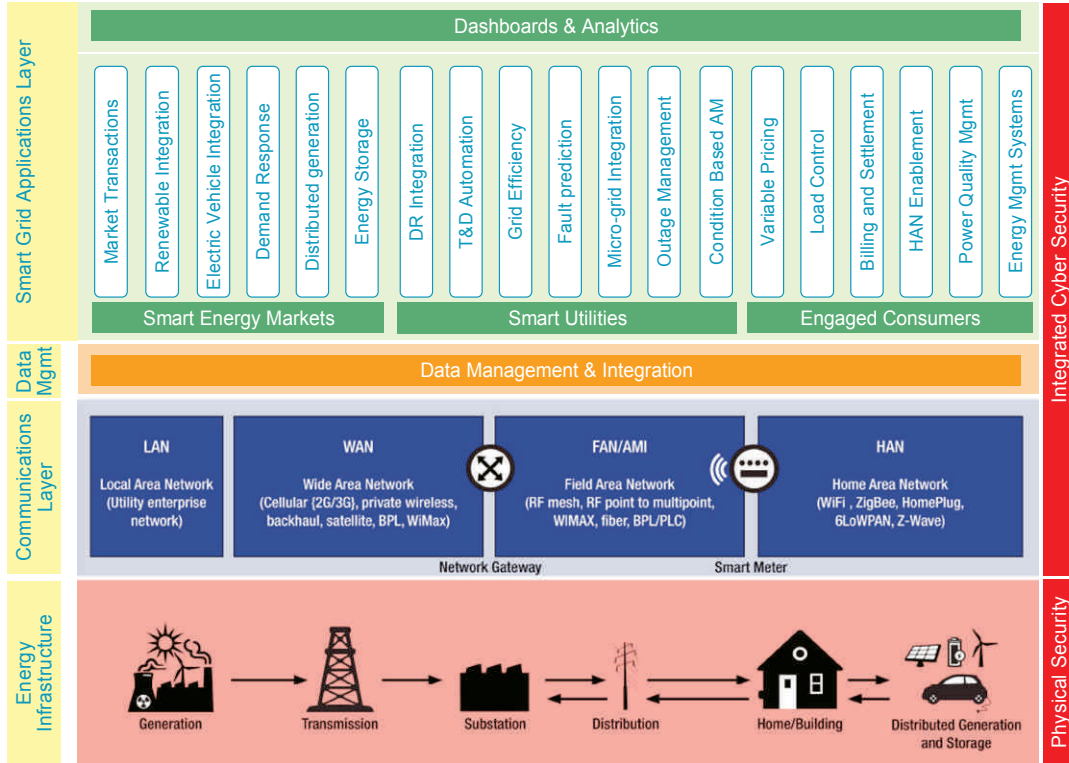
## **2.3 PG&E's Definition of the Smart Grid**

PG&E's Smart Grid Vision begins with defining the Smart Grid. The concept of the Smart Grid by nature is broad and can encompass wide and differing set of goals, expectations and assumptions, depending on one's frame of reference. PG&E's challenge in defining the Smart Grid is to maintain focus on PG&E's fundamental public utility obligation to safely and reliably serve its customers and at the same time demonstrate the value of Smart Grid investments necessary to fulfill that obligation.

*PG&E defines the Smart Grid as a modernized electricity infrastructure which integrates advanced communications and control systems to create a highly automated, responsive, and resilient power delivery system that will both optimize service and empower customers to make informed energy decisions. These advanced communications and control systems will enable the Smart Grid to continuously send, receive, and process data on system conditions, component health, and reliability, as well as to share information among customers, intelligent electronic devices, generators, the California Independent System Operator, market participants, and energy service providers.*

Figure 2-1 illustrates this definition and reflects the integration of advanced communications and control systems with associated privacy and security requirements to provide the desired applications for the benefit of the customer, the utility and energy markets.

**Figure 2-1: PG&E’s Smart Grid Definition**



PG&E’s Smart Grid vision and definition reflects the fact that PG&E serves a growing and diverse population of businesses and residents that must have reliable access to energy to meet their personal needs and to ensure the State’s economic growth. Advances in technology, the need for greater Energy Efficiency (EE) and environmentally sustainable operations, and the transformational shift towards the customer as the key constituent and active participant in energy supply, demand and distribution decisions are critical factors behind PG&E’s vision.

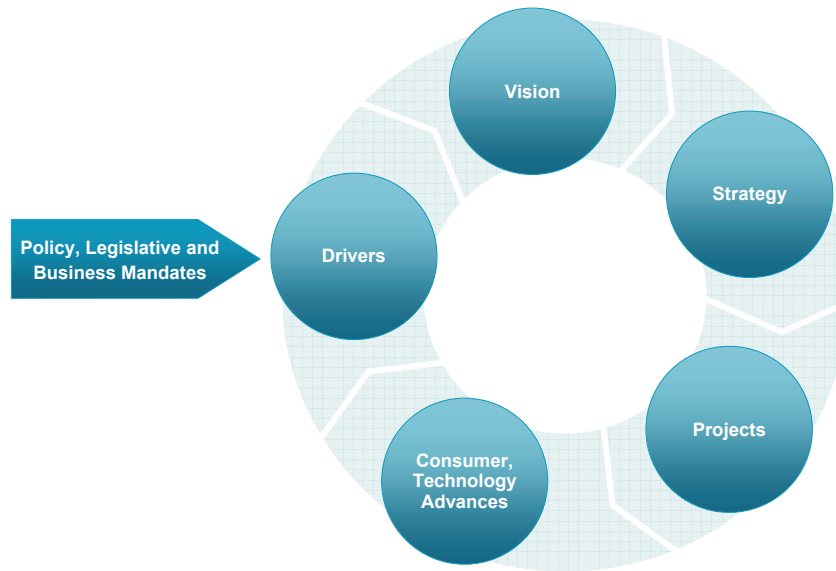
PG&E's vision for the Smart Grid also is fundamentally based on making sound, cost-effective investments to enhance core utility grid operations, provide the foundation for increased customer-centric energy solutions, and manage customer costs as well as enhance energy efficiency as we look to the future. This creates an imperative that PG&E's Smart Grid initiatives demonstrate and drive customer value while continuing to emphasize PG&E's core public utility service obligations and competencies.

## **2.4 Drivers of PG&E's Smart Grid Vision**

PG&E's Smart Grid Vision is shaped by several key customer-focused, operational, and public policy "drivers." PG&E views the evolution and development of the Smart Grid as critically important in providing efficient utility services to our customers, serving their long-term energy needs, and achieving both state and federal energy and environmental policy objectives. These drivers shape our Smart Grid vision and guide our Smart Grid strategic objectives in order to increase customer satisfaction, improve PG&E's utility services, and enable California to meet its energy and environmental policy goals.

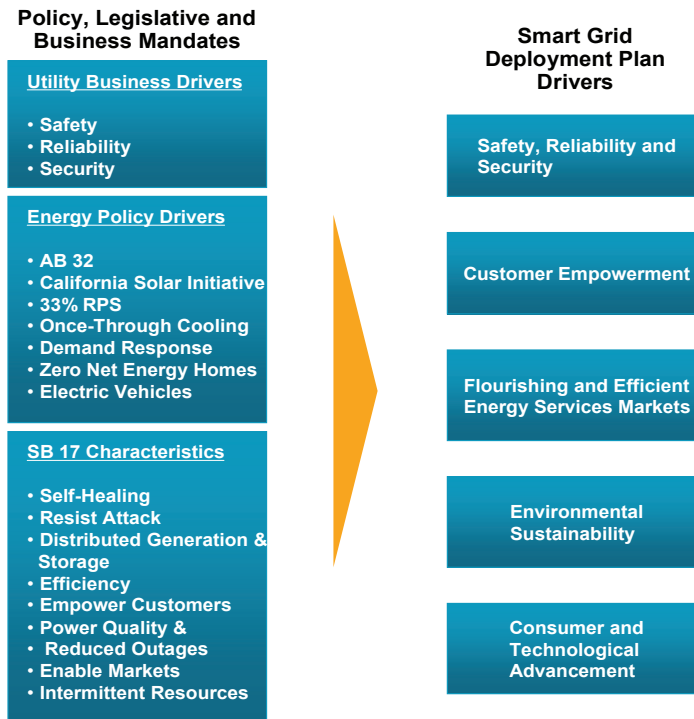
Figure 2-2 below illustrates the process PG&E's employs to shape its Smart Grid Plan, which begins with PG&E's Smart Grid vision and drivers and results in a Smart Grid strategy and a series of Smart Grid projects and advances in technology in response to the drivers and vision. This process—PG&E's Smart Grid journey—is explained in more detail below.

**Figure 2-2: PG&E's Smart Grid Journey**



The imperatives of PG&E's public utility obligation to serve its customers and California's progressive energy and environmental policies lead to five key Smart Grid drivers that are essential elements in PG&E's Smart Grid Vision as shown in the Figure 2-3 below.

**Figure 2-3: PG&E’s Smart Grid Drivers**



**Safety, Reliability, and Security** – A fundamental operational and business imperative for PG&E is to ensure that it **continuously maintains and improves the safety, reliability and security of the basic electricity services** provided to customers. This imperative includes several of the objectives identified in SB 17 and Decision 10-06-047, including the ability of utility systems and facilities to resist attack; be self-healing and resilient; run more efficiently and reduce operating and maintenance costs; and provide higher-quality power and reduce outages.

**Customer Empowerment** – A key driver of the Smart Grid throughout the nation and the world is to **provide customers with more choices and empowerment in their energy consumption, demand and distribution decisions**. Smart Grid technologies have the potential to give customers cleaner, more reliable and flexible energy products and services. Given these expanded choices, customers and society will enjoy increased direct and qualitative benefits in their cost of living, quality of life and overall consumer

satisfaction, as well as direct reductions in customers' environmental footprint. This customer empowerment driver directly addresses several of the objectives in SB 17 and Decision 10-06-047, including empowering customers to directly participate in grid operations; accommodating all electricity generation, storage, EE, and Demand Response (DR) options that customers may desire, including customer-owned and Distributed Generation (DG), as well as intermittent generation such as solar, wind and other renewable energy sources.

**Efficient and Flourishing Electricity Markets** – PG&E relies on thousands of suppliers, vendors and contractors in electricity markets to provide it with the electricity products, services and tools needed to continuously improve the quality and cost-effectiveness of services to customers. As new technologies develop in these electricity markets, a key driver of the Smart Grid is the efficiency, openness and robustness of those markets.

**Without flourishing and efficient electricity markets, PG&E's overall Smart Grid strategies and goals are unachievable.** This efficient and flourishing electricity markets driver addresses several of the objectives of SB 17 and Decision 10-06-047, including enabling electricity markets to flourish; accommodating all generation and storage options; and enabling penetration of intermittent power generation sources such as solar, wind and other renewables. In addition, this driver addresses areas identified by the EDF, such as enabling maximum access by third parties to the grid; creating a “welcoming platform” for deployment of a wide range of energy technologies and management services; and enabling the sale of DR, EE, DG, and energy storage products and services into energy markets on an “equal footing” with traditional generation sources.

**Environmental Sustainability and Minimizing Environmental Impacts** – An overarching driver of PG&E's Smart Grid Vision and Plan, across all goals, objectives, investments and projects, is the need for the Smart Grid to not only foster **environmental sustainability** in all of PG&E's operations and services, but also to go further and



**leverage the Smart Grid’s ability to reduce and minimize environmental impacts of PG&E’s operations and services to customers in a cost-effective and feasible manner.**

For PG&E, this is not merely a public policy driver; it is a fundamental driver of our entire business. This driver is consistent with EDF’s proposal that the Smart Grid be judged on the extent to which it significantly reduces the total environmental footprint of the current electric generation and delivery system in California.

**Consumer and Technological Advancement** – The Smart Grid is a journey, not an end-state. Throughout this proceeding and leading up to these Smart Grid Deployment Plans, PG&E and other parties have repeatedly pointed out that the **Smart Grid is not an “end” in itself, but in fact is a “process” that will utilize a set of disciplined methodologies for evaluating, demonstrating, piloting, scaling up and ultimately deploying new technologies to improve electricity facilities and services.** This Smart Grid “journey”—including the methodical process of researching, developing, evaluating, and demonstrating new Smart Grid technologies and then repeating the process when such technologies are rendered obsolete or less cost-effective than newer technologies—is a fundamental driver of PG&E’s Smart Grid Vision and Plan. Many of the Smart Grid projects, initiatives and technologies in PG&E’s Smart Grid Plan are nascent and not yet commercially scalable or deployable without further research, development or piloting. Likewise, the Smart Grid “journey” includes the essential prerequisite of national and uniform standards for new Smart Grid technologies and products. **Without uniform and national standards, most Smart Grid products and services simply are not commercially feasible** because they are not mass marketable. Finally, the Smart Grid “journey” includes the necessary prerequisite that **many Smart Grid technologies require foundational and supporting investments in basic information technology systems and architecture,** including investments in basic telecommunications and security systems, without which individual Smart Grid projects and programs are infeasible or cost-ineffective. Thus, this Smart Grid “journey” is also a fundamental driver of PG&E’s Smart Grid Vision, and informs PG&E’s decisions on which

Smart Grid projects and investments are sufficiently feasible and cost-effective over the next 10 years of the Smart Grid Plan, and which projects and investments must await further research, development and piloting before significant additional expenditures.

## **2.5 PG&E’s Smart Grid Vision Restated**

Taking into account the definition of the Smart Grid and the Smart Grid drivers discussed in the previous section of this chapter, PG&E’s Smart Grid vision can be restated as follows:

***PG&E’s vision for the Smart Grid is to provide customers safe, reliable, secure, cost-effective, sustainable and flexible energy services through the integration of advanced communications and control technologies to transform the operations of our electric network, from generation to the customer’s premise.***

The key elements and capabilities of PG&E’s Smart Grid vision can be described using the three elements listed in Decision 10-06-047: **Engaged Consumers (Smart Customers), Smart Energy Markets, and the Smart Utility.**

### **2.5.1 Engaged Consumers (Smart Customers)**

PG&E’s Smart Grid vision is to enable new automated and interactive technologies to engage consumers to manage their current energy use—for example, use of Home Area Networks, online energy management tools, and “smart” appliances—while also enabling them to cost-effectively and conveniently use and manage future and significant new sources of demand such as hybrid and electric vehicles (EV). PG&E’s vision is to **enable these customer-side capabilities while also ensuring that the grid can accommodate future energy needs and potentially significant loads more efficiently.**

The Smart Grid enables and empowers engaged consumers by providing them with the information and tools necessary to make informed choices about their energy use and consumption. Customers can better monitor their electricity usage and adopt cost-effective strategies to save money on energy. Customers can choose to participate directly in the Smart Grid by adopting “smart” appliances, EVs or other emerging technologies increasingly being provided by a wide variety of third parties.

Over the next 10 years, changes in demand, retail energy markets, power supply and policy requirements will significantly impact PG&E’s customers and their energy needs. PG&E recognizes that it must adapt to serve the needs of its customers in the future. This includes increasing the number of programs promoting EE, becoming grid-ready for the adoption of EVs, increasing the mix of intermittent renewable generation into the power grid, implementing time-variant pricing, and providing a flexible energy infrastructure to support new supply and demand options that are as of yet unknown.

As customer needs change and diversify, PG&E’s utility operations must be able to change and diversify, while maintaining reliability and security and without introducing significant new costs.

### **2.5.2 Smart Energy Markets**

PG&E’s Smart Grid vision is to deploy Smart Grid technologies that enable efficient markets that can integrate intermittent, distributed and sustainable energy resources into the overall grid infrastructure. This will be focused on the integration of clean and renewable generation such as solar power, wind, and other renewable energy sources, as well as new customer-owned resources such as energy storage. This vision also includes development and implementation of cost-effective and environmentally beneficial Demand-Side Management programs. **PG&E’s Smart Grid investments will allow customers, third-parties, and other stakeholders to more directly participate in a broader, more open and more efficient energy market.** By providing timely

information and decision tools, PG&E's Smart Grid platform will give customers the opportunity to exert direct influence and control in energy markets and utility operations.

In a Smart Energy Market, operators of energy resources, including customer-side resources, can directly participate in energy markets by receiving and responding to relevant information. The Smart Grid will facilitate this interaction through the implementation of enhanced technologies based on common interoperability standards. Smart Energy Markets will cost-effectively communicate to customers and other market participants sufficient price, tariff and usage information to facilitate and enable DR, EE, distributed and renewable generation, energy storage and other market and customer-centric products and programs. Key elements that will enable Smart Markets include developing a market structure and pricing policies that promote cost-effective development and participation of all resources. PG&E intends to invest in programs and technologies that communicate pricing and other relevant information to all resource suppliers, effectively facilitating increased competition within energy markets as well as the integration of new resources within the wholesale market.

### **2.5.3 The Smart Utility**

PG&E's Smart Grid vision is to feasibly and cost-effectively increase the use of digital information, automation and control technologies to dynamically change and improve utility operations and resources for system efficiency, cost-savings, reliability, and safety. This modernization of our transmission and distribution systems is at the core of building the reliable, secure, cost-effective and sustainable energy infrastructure of the future and forms the foundation necessary to bring increased cost-savings and benefits of the Smart Grid to customers.

Utilities have been investing in 'smarter' grid technology for many years. However, for many utilities in the United States, the Smart Grid and development of associated

capabilities represent the single-largest, focused overhaul of the nation's electric grid infrastructure in modern times. This is essential to meet the power needs of the population not only in the short term, but also to provide the platform to deliver new sources of sustainable energy, some perhaps yet to be developed, over the next century. By continuing to build upon the existing foundation now, utilities will be better prepared to meet demand, fill energy gaps, and enable a stronger, more sustainable and more resilient infrastructure with sufficient bandwidth and capability to deliver energy safely, securely, cost-effectively and reliably throughout the 21st century. Execution of this vision to prepare the grid will follow incremental steps through the development of these Smart Utility elements in PG&E's Smart Grid Plan.

## **2.6 The Relationship of PG&E's Smart Grid Vision and Smart Grid Strategy**

PG&E's Smart Grid vision is the foundation for PG&E's Smart Grid strategy and for the investments and projects which execute that strategy. PG&E's Smart Grid vision will be carried out in close coordination with PG&E's broader utility operating plans over the next 10 years and beyond. This approach will allow PG&E to selectively focus on and implement high-priority, cost-effective investments that yield benefits to customers and to society in the form of a modernized electrical grid. At the same time, the vision will govern PG&E's longer-term research, development and evaluation of future Smart Grid technologies that emerge and become feasible and cost-effective over the next 10 years.

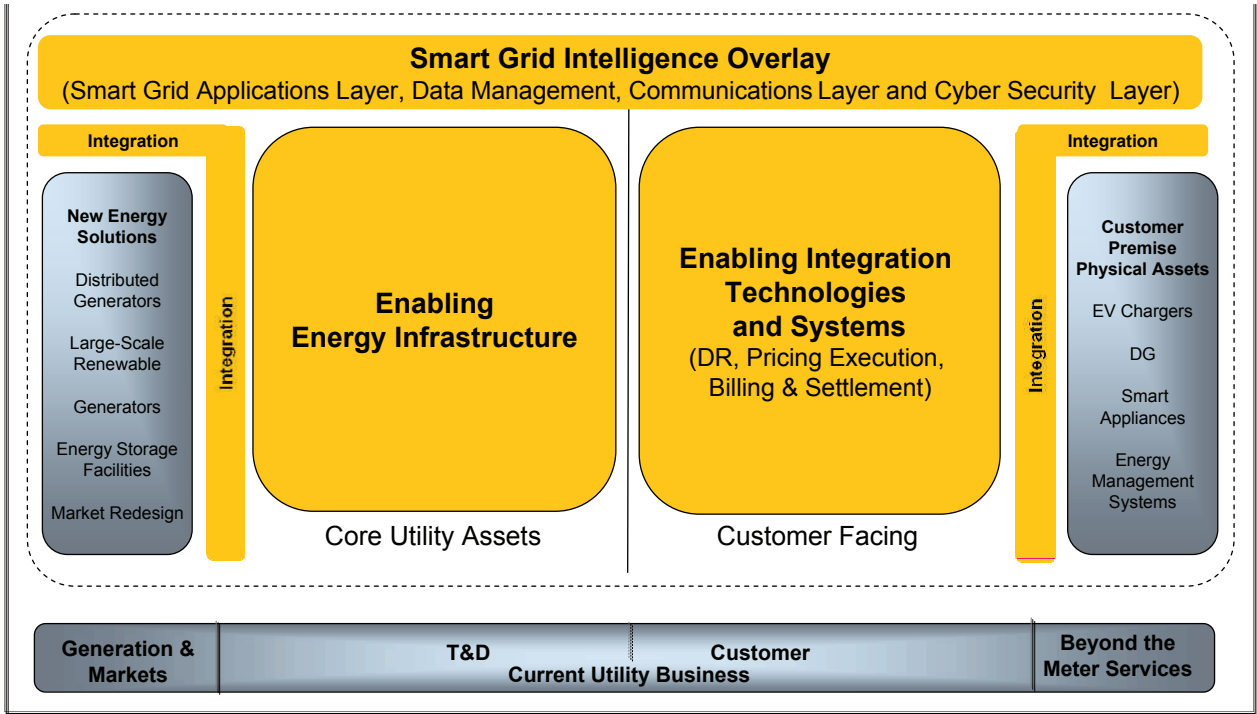
PG&E's Smart Grid vision recognizes the critical distinction between the role of a utility as *integrator* and *manager* of Smart Grid technologies and the role of a utility as *owner* or *direct provider* of those technologies. As reflected in the plan, PG&E does not intend to direct its Smart Grid investments into competitive electricity generation beyond the bus-bar nor into customer energy management services and products beyond the meter. PG&E does intend to direct its priority Smart Grid investments to its core electric

transmission, distribution, customer service, and electricity procurement utility business. This also includes the telecommunications and information systems that are needed to create the Smart Grid energy infrastructure of the future, together with the supporting programs and technologies to effectively integrate and manage “beyond the meter” customer-empowered assets. Enablement of new customer-directed or supplier-directed energy solutions that are feasible, cost-effective and environmentally sustainable is a priority element in PG&E’s Smart Grid vision.

PG&E’s Smart Grid investment focus as well as the industry’s generally accepted definition of the Smart Grid is presented in Figure 2-4 “Industry Definition of Smart Grid” below, with the center part of the graph representing the focus of PG&E’s Smart Grid vision, and the left and right sides representing the areas of PG&E’s Smart Grid vision where PG&E will enable and integrate, but not own, Smart Grid technologies and capabilities.

The “Enabling Energy Infrastructure” portion generally equates to the “Smart Utility” element in PG&E’s Smart Grid Vision. The “Enabling Integration Technologies and Systems” enablement portions generally equate to “Engaged Consumers.” The “New Energy Solutions” portion generally equates to the “Smart Energy Markets” element of the vision. Finally, the “Smart Grid Intelligence Overlay” portion generally equates to the foundational and technology innovation, testing and standards elements that are required to support all three characteristics of the Smart Grid listed in Decision 10-06-047.

**Figure 2-4: Industry Definition of Smart Grid**



Note: Yellow areas represent PG&E’s Smart Grid investment focus.

Chapter 3 of this Deployment Plan, “PG&E’s Smart Grid Strategy,” describes the strategic and measurable objectives of PG&E’s Smart Grid Deployment Plan necessary to execute the elements of PG&E’s Smart Grid Vision and to establish the priorities for PG&E’s future Smart Grid investments and projects.

## **Chapter 3 – PG&E’s Smart Grid Strategy**



### **3.1 Introduction**

To support achieving its vision for the Smart Grid and to guide selection of priority Smart Grid projects and initiatives to include in its Smart Grid Plan, PG&E has developed an overall Smart Grid Strategy that identifies specific and measurable strategic objectives to guide its Plan. These strategic objectives logically and consistently “cascade” down from the Smart Grid drivers and Smart Grid vision described in Chapter 2. In turn, the specific Smart Grid investments and projects identified in the “Smart Grid Roadmap” in Chapter 6, and the evaluation of the costs and benefits of those investments and projects in Chapter 7 that follows the Roadmap, logically and consistently follow the measurable strategic objectives in this chapter.

In this chapter PG&E will describe:

1. PG&E’s Overall Smart Grid strategy
2. Strategic and measurable Smart Grid objectives
3. Summary of the specific Customer Outreach and Education plan that supports the Smart Grid strategy and that is described in Chapter 8 of the Plan
4. Methodology for selecting and prioritizing Smart Grid projects and initiatives consistent with SB 17 goals, Commission Decision 10-06-047 and PG&E’s Smart Grid strategy
5. PG&E’s strategic goals for supplier diversity spending under the Smart Grid Plan and consistent with the Commission’s General Order (GO) 156
6. Responses to Smart Grid strategy questions in compliance with the Commission’s Smart Grid Deployment Plan Decision 10-06-047

### **3.2 PG&E’s Overall Smart Grid Strategy**

PG&E’s overall Smart Grid Strategy is to install and operate a utility energy and information system infrastructure that meets all the characteristics described in SB 17 and to use Smart Grid technologies to support PG&E’s mission to provide safe, reliable,

responsive and environmentally sustainable service to its customers. Under this strategy, PG&E will focus its Smart Grid investments on technologies in its core regulated utility business that cost-effectively meet customer needs, improve reliability, and meet state and federal energy and environmental policy objectives.

PG&E is pursuing projects and initiatives to engage customers by providing information about their energy use and options for managing that energy use, so they can make choices to control their costs and reduce the impacts of their energy use on the environment. PG&E will further engage customers in their energy choices by upgrading its energy and information systems infrastructure to support the reliable integration of electric vehicle charging, higher levels of customer-owned and renewable distributed generation such as rooftop solar panels and a greater variety of energy service providers to provide new and innovative services directly to customers.

Under its Smart Grid strategy, PG&E's role is primarily as an enabler of new customer solutions and not as the direct retail provider of such services. However, PG&E is actively involved in developing the processes, industry standards, customer tools and education necessary to enable the potential customer benefits achievable through robust and open retail markets for new and improved customer energy solutions. Under PG&E's strategy, the Smart Grid is a journey—not an end—by which California will be able to modernize its electric grid. PG&E will adjust its strategy over time to achieve and exceed the energy and environmental policy goals in its Plan, including addressing climate change, enhancing the reliability of electric service, and providing customers with more choices and tools for managing their electricity use.

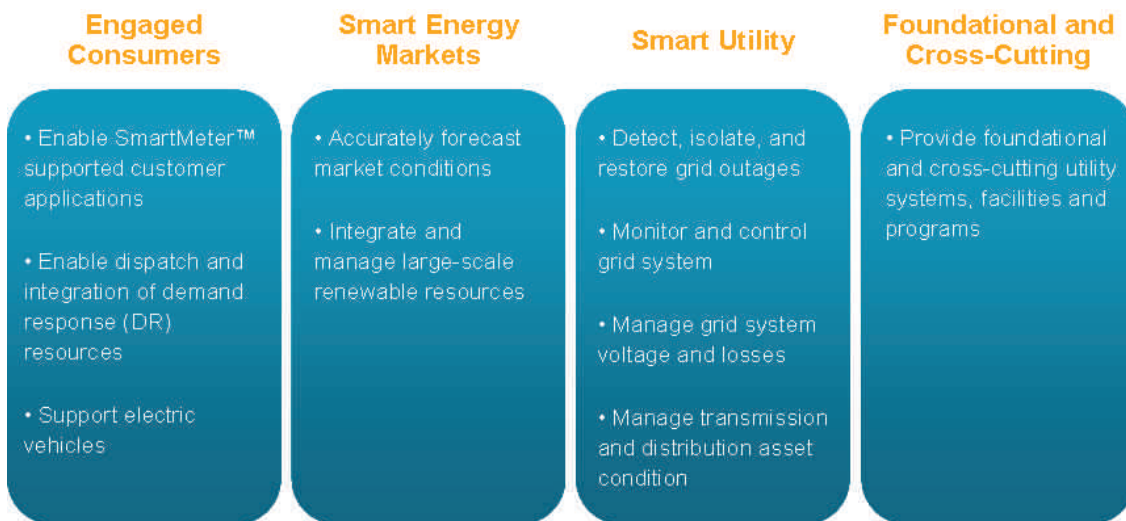
### **3.3 PG&E's Smart Grid Strategic Objectives**

PG&E has employed a capabilities-based approach to establish its Smart Grid strategic objectives. This was essential to arrive at a targeted set of Smart Grid investments and initiatives in a conceptually broad area and to prioritize those investments and

initiatives that will achieve the most desirable future state by enhancing operations and improving customer services consistent with PG&E’s Smart Grid vision and the Smart Grid drivers. In addition, PG&E has examined areas where existing assets, such as its SmartMeter™ infrastructure, can be leveraged to achieve its Smart Grid strategic objectives more quickly and minimize the costs of achieving those objectives.

PG&E has identified ten high-priority strategic objectives organized in four program areas that are included in its Smart Grid Strategy and Deployment Plan. These are summarized in Figure 3-1 below, and discussed in more detail in the sections that follow.

**Figure 3-1: PG&E’s Smart Grid Program Areas and High Priority Strategic Objectives**



Development and achievement of these strategic objectives will guide PG&E’s framework for specific Smart Grid and Smart Grid-related projects and initiatives over the next 10 years.

### **3.4 Program Area: Engaged Consumers**

#### **3.4.1 Enable SmartMeter™ Supported Customer Applications**

One of PG&E's strategic objectives is to implement programs, standards and technology that can be leveraged by customers and authorized third parties to create innovative energy solutions for the customer. While not directly investing in "beyond the meter" solutions, PG&E plays a critical role in ensuring that new customer-side innovations, products and applications are supported and enabled by SmartMeters™ and adhere to strong standards that support the safety, reliability, and security of the electric grid. Development of this capability also is supported by PG&E's participation in the Home Area Network, Open Automated Data Exchange, and other national, standards-based initiatives to further the development of secure end-to-end data exchange standards among customers, utilities and authorized third party energy usage data service providers. SmartMeters™ and enhanced upstream information systems provide the means to engage customers and provide them a wider variety of tools and choices in energy use decisions, support new service offerings like electric vehicle charging, and enable non-utility retail energy service providers to help them meet their energy usage goals. Further, SmartMeters™ provide critical information back to grid control systems to support increased penetration of distributed customer-owned generation like rooftop solar panels.

#### **3.4.2 Enable Dispatch and Integration of Demand Response Resources**

PG&E's strategic objective also is to enable better integration and dispatch of Demand Response (DR) resources supported or managed by PG&E or other demand aggregators. This will allow a more efficient use of DR resources and better integration with the California energy markets. This objective is focused on engaging consumers either directly or through a third party to make informed choices in energy markets that affect the demand for power generation and the associated environmental impacts of that demand.

### **3.4.3 Support the Expanding Market for Electric Vehicles**

Electric Vehicles (EV) are a key element in reducing greenhouse gases as well as reducing fossil fuel dependence generally. However, the predicted increase in EVs over the next ten years will also impact the operations of the electric grid, notably in neighborhoods with high concentrations of EVs where potential increase in energy demand may impose significant new, aggregated loads on the utility infrastructure. PG&E's strategic objective is to support EV markets and related customer services by investing in its transmission and distribution (T&D) infrastructure to be able to accommodate and encourage these new sources of load and thereby support the mass market adoption of EVs. Further, PG&E will provide the technologies to support time-of-use pricing options for charging EVs in a cost effective and environmentally sound manner to shift EV loads off-peak and to more efficiently spread the costs of T&D infrastructure generally.

## **3.5 Program Area: Smart Energy Markets**

### **3.5.1 Accurately Forecast Market Conditions**

California's energy and environmental policy goals require at least 33 percent of electricity sold in the state to come from renewable energy by 2020. A critical strategic objective for meeting these goals while maintaining reliable power to customers is the ability to accurately forecast the energy source and volume of supply flowing onto the grid at any given time and match the supply to demand. PG&E's strategic objective is to invest in the forecasting technology and leverage existing infrastructure such as distribution automation and the SmartMeter™ network to meet this goal while maintaining and enhancing the reliability and integrity of the power system.

### **3.5.2 Integrate and Manage Large-scale Renewable Resources**

Integration and control of large scale renewables is important to California's energy and environmental goals, including reducing greenhouse gas emissions and other criteria pollutants. However, inherent issues of intermittency from renewable sources such as

wind and solar can undermine the ability to deliver power reliably to customers. PG&E's strategic objective is to enhance its capabilities in integrating and controlling large scale renewables to reduce the potential for energy fluctuations and allow for more widespread deployment of renewables and efficient energy delivery to customers. This strategic objective includes enhanced monitoring and control systems for the grid as well as testing and deploying technologies to support use of DR solutions to address renewable resource integration challenges.

### **3.6 Program Area: Smart Utility**

#### **3.6.1 Grid Outage Detection Isolation and Restoration**

In order to improve grid reliability and customer satisfaction while also reducing operating costs, PG&E's strategic objective is to leverage advanced communications technology and control systems to assist utility operators and repair personnel to locate damaged equipment or outage areas, isolate the problem and restore service to unaffected areas quickly, thereby minimizing customer outage time. The combination of Grid Outage Detection Isolation and Restoration with distribution automation systems will allow operators to significantly improve grid reliability in terms of frequency and duration of outages.

#### **3.6.2 Grid System Monitoring and Control**

Also in order to improve grid reliability and power quality, PG&E's strategic objective is to deploy advanced monitoring and control technologies to provide more in depth understanding of grid equipment and conditions to identify emergent problems before they result in system disruptions. For example, synchrophasor technology can detect transmission system conditions inside and beyond PG&E's service area boundaries before the condition creates problems impacting customer reliability or energy costs. Further, synchrophasor technology and distribution system sensors can more closely monitor grid conditions to reliably and safely support higher penetrations of renewable resources that do not behave like conventional generators challenging traditional grid

management models. This strategic objective and the associated capabilities is critical to PG&E's goal to maintain and improve the reliability of utility services delivered to customers in light of a number of technological challenges faced by the grid of the future.

### **3.6.3 Manage Grid System Voltage and Losses**

Maintaining voltage within required limits is critical to safely and reliably integrating new energy sources, such as customer-based rooftop solar photovoltaic (PV) systems into both the customer premise as well as the electric grid. PG&E's strategic objective is to enhance this capability to maintain voltage levels within required levels. Further, the same sensing, telecommunications and control systems can be used to reduce energy usage by customer appliances and reduce the electric losses in the utility delivery system. PG&E is developing technologies and systems utilizing existing and planned investments already underway such as SmartMeters™ and distribution automation that will support this strategic objective. Managing grid system voltage and losses directly translates into customer energy savings.

### **3.6.4 Manage Transmission and Distribution Asset Condition**

Utility infrastructure, including substation transformers and voltage control equipment, are critical assets with corresponding high impact on customer service reliability and costs to replace or take out of service for maintenance. PG&E's strategic objective is to improve the utility's ability to monitor real-time asset conditions in substations, which will help increase operational efficiencies as well as provide advanced warning of potential issues that can result in power failures.

### **3.7 Program Area: Foundational and Cross-Cutting Infrastructure**

#### **3.7.1 Provide Foundational and Cross-Cutting Utility Systems, Facilities and Programs Necessary to Continuously Improve the Application of New Smart Grid Technologies**

Certain utility-wide systems, facilities and programs are essential to the cost-effective and feasible application and deployment of new Smart Grid technologies. For example, PG&E's Information Technology (IT) and telecommunications systems must have adequate capacity and "bandwidth" as well as adequate security to support many new Smart Grid applications and technologies. Likewise, PG&E's technology testing and other technology evaluation programs must have laboratory and testing capability to cost-effectively evaluate and pilot new Smart Grid technologies before scaling up for deployment. Further, PG&E must be able to leverage these technical capabilities to shape industry standards necessary to support the reliable and secure technology integration that will be the hallmark of the Smart Grid. PG&E also needs to continuously recruit the diverse and technically capable workforce and suppliers necessary to execute on its Smart Grid strategy—without diverse and technically-proficient workers and suppliers, PG&E's Smart Grid Deployment Plan is just a plan. Finally, PG&E's customer-side Smart Grid-enabling objectives require robust, sophisticated and well-planned outreach and communications to the appropriate segments of PG&E's 15 million customers. Thus, PG&E's strategic objective is to improve the foundational and supporting systems and programs in IT, technology testing, evaluation and standards development, workforce development and customer engagement that are necessary in order to achieve each of its other Smart Grid strategic objectives.

The 10 Smart Grid strategic objectives outlined above are based on the key customer, energy policy and operational drivers that PG&E expects will continue to shape the energy and environmental landscape over the next 10 years and beyond. These strategic objectives also align with PG&E's overall Smart Grid goals of: (1) providing safe, reliable, cost-effective and environmentally-sustainable utility service; (2) making needed investments in core utility infrastructure; and (3) supporting and enabling



diverse and robust energy markets through the development of open and uniform national standards for new energy products and services.

Achievement of these strategic objectives is critical to PG&E's Smart Grid vision in order to achieve the desired outcome of providing safe, reliable, efficient and sustainable energy service in the future. While these 10 strategic objectives represent PG&E's highest Smart Grid priorities at this time, PG&E understands and expects that these objectives will further evolve with customer needs, future technological advancements and energy and environmental policy goals in the next decades.

### **3.8 Customer Outreach and Education Plan to Support the Smart Grid Strategy**

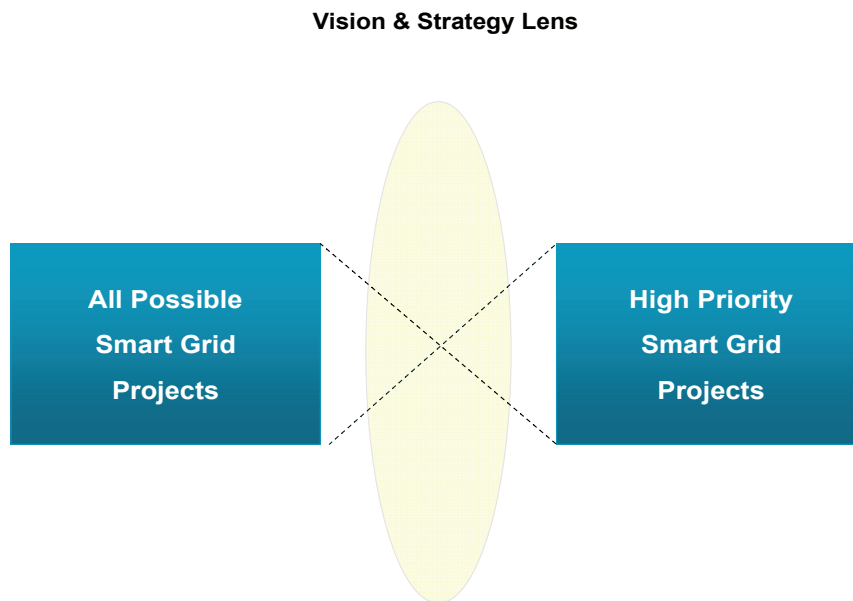
Customer engagement with the Smart Grid is absolutely critical to achieve the ultimate potential of the modern grid. To support its commitment to this essential element in its Smart Grid Plan, Chapter 8 describes PG&E's Customer Outreach and Education Plan for the Smart Grid in more detail. PG&E's Outreach and Education Plan recognizes that the Smart Grid is a broad concept covering many aspects of PG&E's operations and services. As described in more detail in Chapter 8, PG&E's objective on customer engagement is strategic—PG&E's objective is to provide its customers with a clear picture of the benefits of the Smart Grid in ways that make sense to those customers and that align and coordinate its customer outreach efforts on individual Smart Grid projects and initiatives across multiple programs to reinforce the broader operating, societal and environmental benefits of the Smart Grid.

### **3.9 Methodology for Selecting and Prioritizing Smart Grid Projects and Initiatives Consistent With SB 17 Goals and PG&E's Smart Grid Strategy**

PG&E used SB 17's goals and characteristics of the Smart Grid as key drivers in developing its Smart Grid Strategy and strategic objectives. PG&E used its strategic objectives to narrow its focus from all of the projects or initiatives that the Smart Grid

could enable to the set of projects that should be pursued now to provide significant value to its customers in terms of safe, reliable and sustainable service and cost savings while also meeting the state’s progressive energy and environmental policy goals. PG&E’s Smart Grid strategic objectives are the “lens” through which PG&E’s Smart Grid Vision is translated into the high-priority projects and initiatives in PG&E’s Smart Grid Roadmap, described in Chapter 6. In other words, at any given time, the Smart Grid definition encompasses a “universe” of all possible Smart Grid projects, investments and initiatives, without reference to relative needs, costs, benefits, and operational priorities. PG&E’s Smart Grid Strategy provides the strategic criteria by which all these “possible” Smart Grid projects and initiatives are compared, contrasted and sorted between “possible” Smart Grid investments and “priority” Smart Grid investments.

**Figure 3-2: Focusing on High Priority Smart Grid Projects**



5

In addition to using Smart Grid strategic objectives to focus on the areas that provide the greatest value to customers and in achieving energy policy goals, PG&E considered the maturity of technologies necessary to meet the objectives without taking

unnecessary technology risks. Further, to the extent promising technology is under development but not yet ready for commercial scale deployment, PG&E has proposed initiatives to test, evaluate and support the implementation of industry standards for new emerging technologies as part of its deployment plan.

The following demonstrates how each of PG&E's 10 Smart Grid strategic objectives directly meets or addresses the criteria and goals established by SB 17 and the Commission's Decision 10-06-047.

### **3.9.1 Enable SmartMeter™ Supported Customer Applications**

This strategic objective directly aligns with SB 17 characteristics of empowering consumers to actively participate in the operation of the grid, accommodate all generation and energy storage options, create a platform for deployment of a wide array of energy technologies and management services, enable and support the sale of DR, energy efficiency, distributed generation and storage into wholesale energy markets as a resource on equal footing with traditional generation resources and significantly reduce the total environmental footprint of the current electric generation and delivery system in California.

### **3.9.2 Enable Dispatch and Integration of Demand Response Resources**

This strategic objective directly aligns with SB 17 characteristics of empowering consumers to actively participate in the operation of the grid, enable electricity markets to flourish, enable and support the sale of DR into wholesale energy markets as a resource on equal footing with traditional generation resources and significantly reduce the total environmental footprint of the current electric generation and delivery system in California.

### **3.9.3 Support the Expanding Market for Electric Vehicles**

This strategic objective directly aligns with SB 17 characteristics of empowering consumers to actively participate in the operation of the grid, create a platform for deployment of a wide array of energy technologies and management services and significantly reduce the total environmental footprint of the current electric generation and delivery system in California.

### **3.9.4 Accurately Forecast Market Conditions**

This strategic objective directly aligns with SB 17 characteristics to enable electricity markets to flourish, run the grid more efficiently and significantly reduce the total environmental footprint of the current electric generation and delivery system in California.

### **3.9.5 Integrate and Manage Large-scale Renewable Resources**

This strategic objective directly aligns with SB 17 characteristics to accommodate all generation and energy storage options, enable penetration of intermittent power generation resources, enable electricity markets to flourish and significantly reduce the total environmental footprint of the current electric generation and delivery system in California.

### **3.9.6 Grid Outage Detection Isolation and Restoration**

This strategic objective directly aligns with SB 17 characteristics to be self-healing and resilient, provide higher quality of power and avoid outages, create a platform for deployment of a wide array of energy technologies and run the grid more efficiently.

### **3.9.7 Grid System Monitoring and Control**

This strategic objective directly aligns with SB 17 characteristics to be self-healing and resilient, provide higher quality of power and avoid outages, create a platform for deployment of a wide array of energy technologies, run the grid more efficiently,

accommodate all generation and energy storage options, enable penetration of intermittent power generation resources, enable electricity markets to flourish and significantly reduce the total environmental footprint of the current electric generation and delivery system in California.

### **3.9.8 Manage Grid System Voltage and Losses**

This strategic objective directly aligns with SB 17 characteristics to be self-healing and resilient, provide higher quality of power and avoid outages, create a platform for deployment of a wide array of energy technologies, run the grid more efficiently, accommodate all generation and energy storage options, enable penetration of intermittent power generation resources and significantly reduce the total environmental footprint of the current electric generation and delivery system in California.

### **3.9.9 Manage Transmission and Distribution Asset Condition**

This strategic objective directly aligns with SB 17 characteristics to be self-healing and resilient, provide higher quality of power and avoid outages and run the grid more efficiently.

### **3.9.10 Provide Foundational and Cross-Cutting Utility Systems, Facilities and Programs Necessary to Continuously Improve the Application of New Smart Grid Technologies**

This strategic objective directly aligns with all of the SB 17 Smart Grid characteristics.

## **3.10 PG&E's Strategic Goals for Supplier Diversity Spending Under the Smart Grid Plan and Consistent With the Commission's General Order 156**

PG&E is committed to Smart Grid supplier diversity. Supplier diversity is an essential element to successfully providing electric and natural gas service to approximately 15 million customers in northern and central California. PG&E has demonstrated its

ongoing commitment to supplier diversity and will continue this work as it deploys and enables Smart Grid programs and technologies within its service territory.

PG&E’s supplier diversity program is an important element to PG&E’s Smart Grid Deployment Plan because it represents a natural and logical extension of PG&E’s core electric delivery business. While PG&E’s investments in advanced technologies may generate new economic opportunities, they may also create unique challenges for maintaining supplier diversity. With some recent sourcing initiatives successfully completed in emerging technology categories, including an estimated 60 percent supplier diversity spend into a solar PV project, PG&E will leverage its current supplier diversity programs to effectively address Smart Grid supplier diversity in new opportunity areas.

As part of its Smart Grid deployment program, PG&E will implement a multi-year approach to support its corporate supplier diversity programs and help achieve its GO 156 minority, women and service disabled veteran-owned business goals. The table below provides PG&E’s four-year Company-wide minority, women, and service-disabled veteran-owned business enterprises (MWDVBE) goals that will guide its Smart Grid Plan:

**Table 3-1: MWDVBE Short, Mid and Long-Term Goals**

<b>Category</b>	<b>Short-Term 2011</b>	<b>Mid-Term 2013</b>	<b>Long-Term 2015</b>
MBE	5%	10%	15%
WBE	2%	3%	5%
DVBE	0.38%	0.75%	1.50%
<b>Total MWDVBE</b>	<b>6.88%</b>	<b>13.25%</b>	<b>21.50%</b>

PG&E will apply its Supplier Diversity Program to its Smart Grid strategy to ensure a continued achievement of supplier diversity goals. The following section provides a brief description of some of these key program aspects as they relate to the Smart Grid:

- **Goal Development and Alignment:** *PG&E will identify a Smart Grid Supplier Diversity Champion to set targets and plans to achieve Smart Grid supplier diversity goals.*
- **Communications and Training:** *PG&E will continue to educate both internal and external stakeholders about PG&E's Supplier Diversity Program and its application in the Smart Grid space.*
- **Prime Supplier Program and Subcontracting Performance:** *PG&E will work with the Smart Grid prime contractors to engage qualified diverse suppliers in subcontracting opportunities. Last year, PG&E's prime suppliers reported more than \$264 million in spending on diverse subcontractors. PG&E achieved these results by requiring prime suppliers to set goals and accurately report WMDVBE subcontracting monthly, detailing their progress towards these goals; audits ensured development and growth of their diverse subcontractors and business solution partners. PG&E will also work to ensure that Smart Grid prime suppliers are held accountable for supporting supplier diversity objectives.*

### **3.11 Responses to Smart Grid Strategy Questions in Compliance With the Commission's Smart Grid Deployment Plan Decision 10-06-047**

*How will PG&E evaluate whether third party communications networks can provide cost effective communications that meet security and performance requirements of Smart Grid? How will PG&E consider both existing and future service provider capabilities (cost effectiveness, security and performance)?*

A critical enabler of the Smart Grid concept is advancement in telecommunications technologies. For example, two-way communications in metering has been a driving force behind virtually all utility smart meter projects proposed in the past five years. Telecommunications technology is expected to continue to drive expansion of Smart Grid capabilities over the next several years. PG&E's current telecommunications

network is comprised of a combination of utility owned network assets as well as public network services (“third party communications networks”). This combination is constantly evolving as utility requirements, commercial offerings and utility investments change.

Smart Grid deployments will require enhancements of PG&E’s core and edge telecommunications network for enterprise-wide telecommunications over the next 10 years. Under its Smart Grid Plan and strategy, PG&E will be evaluating alternatives for expanding and enhancing its network including public network products, public network partnerships, lease versus buy options for Radio Frequency spectrum and other options. All of these network implementation approaches will be carefully weighed to provide the best possible solution at the lowest cost to our customers. PG&E expects its network to continue to be comprised of a combination of utility owned assets and commercially provided services based on cost and service level performance requirements.

PG&E will evaluate the cost-effectiveness, security and performance of third party communications network providers both formally through competitive Requests for Proposals and Requests for Bids and informally through normal business contacts and industry information. PG&E currently has commercial relationships with many of the major public telecommunications network providers, small and medium sized local telecommunication providers as well as numerous private network owners in its service territory. This evaluation process will document the specific security and performance requirements necessary to support the Smart Grid and other telecommunications needs.



*What is the feasibility and cost effectiveness of offering Open Automated Demand Response Coexisting with Smart Energy Profile 2.0?*

The feasibility and cost effectiveness of the Open Automated Demand Response (OpenADR) standard is uncertain and dependent on the development of third-party vendor products that rely on it instead of other standards-based products and services, such as those relying on Smart Energy Profile (SEP) 2.0. PG&E was an early adopter of the OpenADR protocol working in close coordination with the Lawrence Berkeley National Laboratory. PG&E continues to use this protocol in DR pilots and demonstrations with interested commercial and industrial customers. The expansion of this protocol into a greater number of commercially available products and services depends on adoption of this standard by more vendors entering this arena. PG&E will continue to participate in the evolution of this protocol through standards development processes. However, as with other technologies being developed in the absence of standards, PG&E will carefully consider the maturity of OpenADR product offering before it will be able to make major investments in its information and telecommunications systems to shift more broadly to OpenADR.

PG&E has also been actively involved in the standards development and testing products using SEP standards. PG&E testing and analysis has shown that the current versions of SEP are not sufficiently mature to support large scale deployments. The SEP products have been targeted to the residential and small business consumer markets. PG&E has been actively involved in the development and support for an enhanced version of SEP known as SEP 2.0. PG&E expects that SEP 2.0 will address the shortcomings of earlier versions. However, approval of SEP 2.0 is taking longer than expected creating uncertainty in the best approach for advancing ZigBee wireless communications module-based products that can work in conjunction with PG&E's SmartMeters™.

Given the fact that these communication standards are still in development and not yet fully adopted across all consumer products in this area, it is uncertain whether it is or will be feasible and cost effective for both protocols to coexist as the market for standards-based consumer energy usage devices develops and matures.

## **Chapter 4 – Deployment Baseline**

## 4.1 Introduction

PG&E is in the process of transforming its electric grid into a more reliable and smarter grid. Aligned with PG&E's Smart Grid Vision, PG&E already is in the process of enabling a greater level of automation and integration across the utility enterprise through the addition of advanced sensing, computing, communications, and control technologies to the existing grid infrastructure. The purpose of this chapter is to describe this baseline deployment of Smart Grid technologies, projects and initiatives which are already underway at PG&E.

As part of its core utility operations, PG&E continues to invest substantially in its electric transmission and distribution system to expand and improve its physical assets, strengthen safety and reliability, and meet the needs of customers. Within electric operations, a major focus is continuing to upgrade targeted circuits and install new equipment to improve reliability. This work going forward is detailed in a comprehensive multi-year Electric Transmission and Distribution Modernization Plan that PG&E has been implementing since 2010. The plan enables PG&E to safely and reliably meet the electric demands of customers in Northern and Central California in the years ahead by strategically replacing aging infrastructure, optimizing the use of assets, automating systems, and meeting regulations and higher standards.

This Deployment Baseline chapter describes the key generation, transmission, and distribution characteristics of PG&E's system as of December 31, 2010. The focus on this chapter is to highlight PG&E's baseline portfolio of completed and in-flight Smart Grid investments (also referred to as "Smart Grid Baseline Projects") that are either: (1) in-service as of December 31, 2010; or (2) approved by a regulatory decision and currently in-flight, with a planned in-service date before 2020.

PG&E's Smart Grid investments are a subset of the company's entire portfolio of projects, directly supporting the Commission's Smart Grid objectives for "modernization

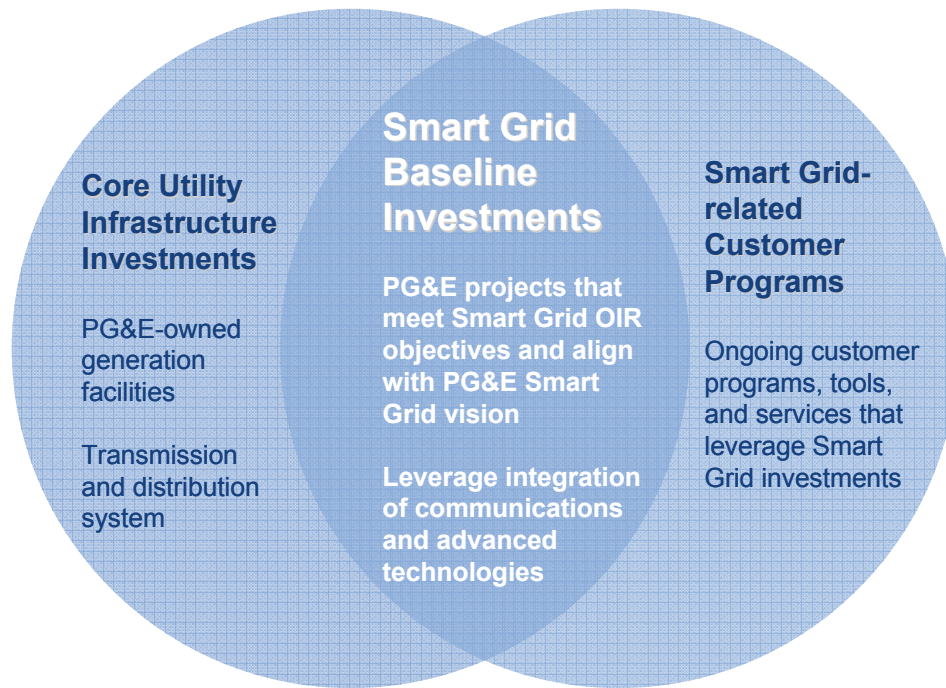
of the electrical grid to maintain reliable and secure electrical service with infrastructure that can meet future growth in demand while achieving several other objectives such as integration of distributed generation resources, demand-side resources and ‘smart’ technologies.”<sup>1</sup>

It is important to note that while there are a number of PG&E programs that provide customers with information, tools, incentives, and value-added services, from detailed information on electricity use to EE and voluntary Demand Response (DR) programs, PG&E does not include all of these in its Smart Grid Baseline, just as PG&E does not include all investments in generation, transmission, and distribution assets in its Smart Grid Baseline. Rather, many customer programs are considered “Smart Grid-related” because they provide customers with tools to leverage smarter grid technology and capability. Smart Grid-related customer programs are detailed in Chapter 5.

---

<sup>1</sup> SB 17 (Padilla) – Electricity: Smart Grid Systems.

**Figure 4-1: Smart Grid Baseline Investments Are a Subset of the Company’s Entire Portfolio of Projects**



Lastly, PG&E fully recognizes that the evolution of the Smart Grid will introduce security and privacy challenges and hence PG&E must be prepared to evolve its security program, technology, and processes as a core foundational initiative. The Grid Security and Cyber Security Strategy chapter (not this Deployment Baseline chapter) details PG&E’s approach to security, including physical and cyber security, as well as the privacy framework to demonstrate PG&E’s overall approach to securing the smart grid, smart grid technologies and customer data.

## **4.2 Current State of PG&E’s Grid**

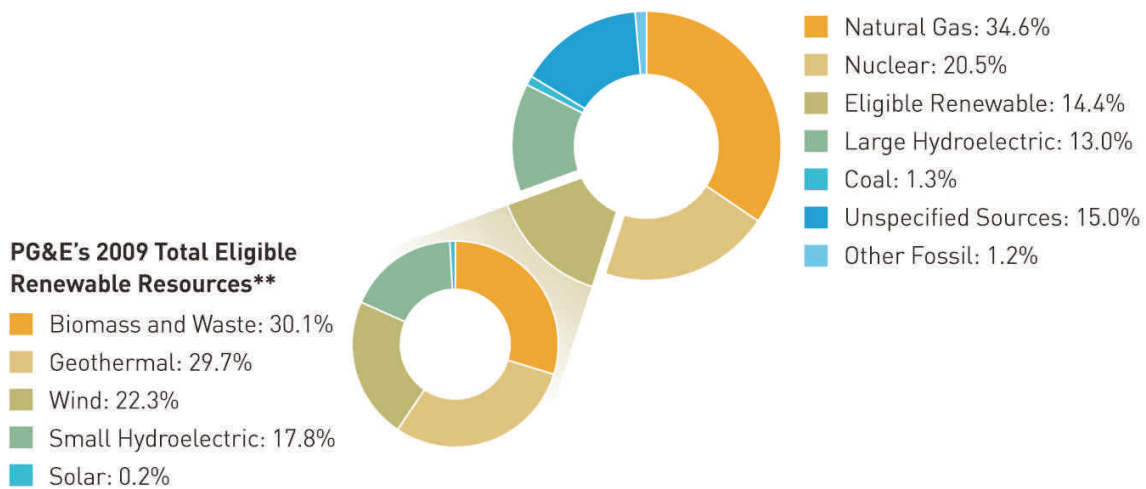
The key generation, transmission, and distribution characteristics of PG&E’s system as of December 31, 2010, are described below, along with a discussion of major capital programs that are part of PG&E’s core utility operations. This information provides context for the Smart Grid Baseline investments that are described in Section 4.4.

## 4.2.1 Generation

### *Delivering Low-Emission Energy*

PG&E delivers some of the nation's cleanest energy to customers. PG&E is planning for the future by exploring and investing in new technologies that harvest energy from renewable resources, as well as state-of-the-art, cleaner sources of fossil fuel-based power to meet growing demand. PG&E serves 5 percent of the country's population, yet emits less than 1 percent of the total carbon dioxide (CO<sub>2</sub>) emissions associated with the nation's electricity production. On average, approximately half of the electricity PG&E delivers to its customers comes from a combination of renewable and greenhouse gas-free resources.

**Figure 4-2: PG&E's Overall Electricity Supply Mix for 2009<sup>2</sup> Includes Both Energy PG&E Generated and the Energy PG&E Purchased From Third Parties**



\* "Unspecified Sources" refers to electricity generated that is not traceable to specific generation sources by any auditable contract trail and "Other Fossil" includes diesel oil and petroleum coke (a waste byproduct of oil refining).

\*\* As defined in Senate Bill 1078, which created California's Renewable Portfolio Standard (RPS), an eligible renewable resource includes geothermal facilities, hydroelectric facilities with a capacity rating of 30 megawatts (MW) or less, biomass facilities, selected municipal solid waste facilities, solar facilities and wind facilities.

<sup>2</sup> PG&E's 2010 energy mix was not available at the time of its initial Smart Grid Deployment Plan filing.

### *Investing in Renewables*

PG&E has a long history of developing, generating and purchasing renewable power. PG&E is aggressively adding more renewables to its power mix under California's RPS and now has contractual commitments to have more than 20 percent of its future deliveries come from renewables.

In April 2010, PG&E received approval for a 5-year program to develop up to 500 MW of clean solar photovoltaic (PV) power in its Northern and Central California service area, one of the largest undertakings of its kind in the country. The program, once complete, will generate enough solar power to meet the needs of about 150,000 homes in PG&E's Northern and Central California service area. The program will consist of up to 250 MW of utility-owned PV generation and another 250 MW provided by independent developers. The moderately sized projects targeted by PG&E's initiative, ranging from 1 MW to 20 MW, should require less time to plan and build than many large projects that have faced lengthy delays. Projects to be owned by PG&E will be located near company substations to reduce the costs and delays of interconnecting them to the power grid. The inauguration of PG&E's 2 MW Vaca-Dixon PV solar station in Vacaville represents the first major project under the 5-year program.

PG&E can also now purchase power from customers who install eligible renewable generation up to 1.5 MW in size. Customers can choose a full "buy/sell" option, which means PG&E will purchase all of the electricity their facility generates, or they can choose to use some of the electricity for their own needs and PG&E will purchase only the excess.

### *Leveraging Cleaner Conventional Sources*

As of December 31, 2010, PG&E-owned generation facilities have a total operating capacity of 7,342 MW, comprising of highly efficient natural gas plants, hydroelectric facilities, and nuclear. All PG&E-generated facilities are located in California.



**Table 4-1: PG&E-Owned Generation Facilities as of  
December 31, 2010 Total 7,342 MW**

Generation Type	County Location	Number of Units	Net Operating Capacity (MW)
<b>Nuclear:</b>			
Diablo Canyon	San Luis Obispo	2	2,240
<b>Hydroelectric:</b>			
Conventional	16 counties in northern and central California	107	2,684
Helms pumped storage	Fresno	3	1,212
Hydroelectric subtotal:		110	3,896
<b>Fossil fuel:</b>			
Colusa Generating Station <sup>(1)</sup>	Colusa	1	530
Gateway Generating Station <sup>(2)</sup>	Contra Costa	1	530
Humboldt Bay Generating Station <sup>(3)(4)</sup>	Humboldt	9	146
Fossil fuel subtotal:		11	1,206
<b>Total</b>		<b>123</b>	<b>7,342</b>

(1) The Colusa Generating Station became operational in December 2010 with 530 MW of base capacity and 127 MW of enhanced capability.

(2) The Gateway Generating Station consists of 530 MW of base capacity and 50 MW of enhanced capability.

(3) Humboldt Bay Generating Station became operational in September 2010.

(4) The Humboldt Bay Power Plant fossil facilities, two operating fossil fuel-fired plants and two mobile turbines, were retired at the end of September 2010.

PG&E is making long-term investments in conventional generation that, under specific state requirements, must meet a GHG emissions performance standard equivalent to an efficient, combined-cycle natural gas plant. These efforts include developing new, highly efficient and flexible natural gas-fueled plants that will be owned and operated by PG&E, as well as long-term contracts with third parties. PG&E’s current fossil generation fleet has a combined maximum normal operating capacity of 1,206 MW:

- **Gateway Generating Station, Antioch, CA:** Gateway began operations in January 2009 and is a state-of-the-art 530 MW combined cycle natural gas power plant that uses approximately 97 percent less water and discharges 98 percent less wastewater than a traditional “wet” cooled plant.
- **Colusa Generating Station, Maxwell, CA:** Similarly designed to Gateway, Colusa is a 530 MW combined cycle facility that began operations in December 2010. Colusa uses dry cooling and a zero liquid discharge system that recycles wastewater.

- **Humboldt Bay Generating Station, Eureka, CA:** *PG&E's Humboldt Bay Generating Station is a new 146 MW natural gas plant that began operations in July 2010. This station is 33 percent more efficient than the old fossil-fueled plant it is currently retiring.*

PG&E has also received CPUC approval to purchase the Oakley Generating Station, a 624 MW combined cycle natural gas facility that is forecast to be the most efficient power plant of its kind in California when PG&E takes ownership, which is scheduled for 2016.

#### *Carbon-Free Hydro and Nuclear*

PG&E's Hydro system consists of 110 generating units at 68 powerhouses. These generating units have a combined maximum normal operating capacity of 3,896 MW and produce an average of 11,672 gigawatt-hours (GWh) per year. Included in PG&E's hydro system is 295 MW of RPS-eligible small hydro facilities.

Finally, PG&E's 2,240 MW Diablo Canyon nuclear power plant continues to provide safe, carbon-free electric power for customers. As the regulatory process for relicensing this essential facility moves forward, PG&E's focus remains on ensuring safe and reliable operations.

## **4.2.2 Electric Transmission and Distribution**

### *Creating a Sustainable Grid for the Future*

PG&E's electric transmission and distribution (T&D) network is one of the largest in the country. It covers 70,000 square miles in Northern and Central California, serving over 15 million California customers. Major facilities include over 18,600 miles of transmission lines, 860 substations, 140,000 miles of distribution lines, and more than a million distribution transformers. These facilities form an electric network that connects

in-area generation sources and bulk energy transmission from the Western United States and Canada to deliver energy to PG&E's customers.

One of PG&E's primary responsibilities is to provide safe and reliable electric service to customers, at the most affordable cost, and within approved funding from regulatory decisions. PG&E continues to place a great emphasis on reliability, safety, and operational flexibility of the electric transmission and distribution system. PG&E plans to achieve this objective through a combination of measures designed to upgrade and modernize its aging electric transmission and distribution assets, including:

- *Modernizing through advanced automation, monitoring and control technology.*
- *Focusing capital investments to improve reliability performance, reduce operation and maintenance expenses, and manage congestion costs.*
- *Standardizing design and equipment specifications to streamline facility installations and replacements, take full advantage of environmentally responsible technologies, and reduce procurement costs with economy of scale.*
- *Using performance and condition-based assessments to improve reliability, increase maintenance effectiveness, prioritize repair and replacement, and extend asset life.*
- *Improving human performance for both normal operations, and during storms, with better planning, preparation, training, and tools.*

Tables 4-2 and 4-3 below provide a current snapshot of PG&E's electric T&D system characteristics.

**Table 4-2: PG&E's Electric T&D System Characteristics as of December 31, 2010**

Service Area	70,000 square miles
Service Area Population	15 million people (1 of every 20 Americans)
Electric Distribution Customer Accounts	5.1 million (4.5 million residential; 0.6 commercial, industrial, and other)
Miles of Electric Transmission and Distribution Lines	159,829 miles
Length of Transmission Lines in Circuit Miles by Voltage	18,616 miles
500 kilovolts (kV)	1,328 miles
230 kV	5,415 miles
115 kV	6,207 miles
70 kV	1,618 miles
60 kV	4,048 miles
Length of Distribution Lines in Circuit Miles by Voltage	141,213 miles
44kV	12 miles
34 kV	2 miles
21 kV	30,156 miles
17 kV	4,508 miles
12 kV	103,961 miles
4 kV	2,574 miles
Miles of Overhead Lines as a Percentage of Total	80%
Miles of Underground Lines as a Percentage of Total	20%
Number of Substations	864
Transmission	140
Distribution	724
Transmission: Percentage of Substations Breakers With Automated Control (SCADA)	61%
Transmission: Advanced Energy Management System (EMS)	4 (1 active, 3 redundant)
Transmission: Remedial Action Scheme (RAS)	500kV RAS, SF Peninsula RAS
Transmission: Phasor Measurement Units (PMU)	Test PMUs at 11 transmission substations
Transmission: Number of Modular Protection Automation and Control (MPAC) Buildings	58 (4 more in 2011)
Distribution: Percentage of Substation Breakers with SCADA	50%
Distribution: Number of Circuits	3,124
Distribution: Number of Circuits with Fault Location, Isolation and Service Restoration (FLISR)	6 circuit pilot of the new technology

### *Multi-Year Electric T&D Modernization Plan*

PG&E has been implementing a multi-year Electric T&D Modernization Plan since 2010. The Plan captures programs and projects that focus on improving the safety, reliability, and operational flexibility of PG&E's electric system. They include initiatives that:

- *Improve customer service reliability.*
- *Address worst performing circuits.*
- *Replace and upgrade aging grid infrastructure.*
- *Perform corrective maintenance and system improvement work.*
- *Connect new business and support economic growth.*
- *Install new equipment proactively to accommodate future demand and requirements such as Electric Vehicles (EVs) and smart grid advancements.*
- *Install state of the art SCADA and automation technologies.*
- *Support California's clean energy policy by connecting carbon-free and renewable resources from central station and distributed installations.*

### *Major Programs of Modernization Plan*

A major focus of the Plan revolves around increasing overall electric system safety (both public and employee), reliability and modernization of the electric transmission and distribution assets. PG&E is making capital investments to modernize its electric system to reduce the frequency and duration of electric service outages. This includes investments focusing on increasing equipment capability as well as redundancy and switching flexibility. These measures and programs include:

### *Cornerstone Improvement Program*

PG&E has received Commission approval for a 3-year, \$357-million program, to improve service reliability by implementing a number of electric distribution reliability improvement projects. The program, called the Cornerstone Improvement Program, includes initiatives that aim at increasing the capacity and interconnectivity of

distribution lines and substations, implementing distribution automation on distribution circuits in urban and suburban areas and installing switching devices on rural distribution circuits to reduce the number of customers affected should outages occur. The distribution automation component of the Cornerstone Improvement Program, in particular, leverages state-of-the-art Fault Location, Isolation and Service Restoration (FLISR) technology, and is part of PG&E's Smart Grid Baseline portfolio of projects (see Section 4.4). These initiatives are expected to result in substantial reliability improvements for PG&E's customers.

#### *SCADA and Automation*

PG&E plans to upgrade and install new automation infrastructure to improve remote control and monitoring using SCADA. PG&E will also increase the penetration of microprocessor protective relays with enhanced fault identification and location capabilities. PG&E's goal is to complete these upgrades on 100 percent of all transmission circuit breakers by 2014 and 100 percent of all critical distribution circuit breakers by 2015. This will enable PG&E to reduce service interruption duration should an outage occur. Given the foundational visibility and control capabilities provided by the transmission and distribution SCADA build-out programs, they are actively managed as part of PG&E's Smart Grid Baseline portfolio of projects (see Section 4.3).

#### *Substation Transformer Replacement*

Substation power transformers are the single most important equipment in an electric substation. Substation power transformers are used to step down electricity from high voltage (ranging from 60 kV to 500 kV) down to a lower distribution voltage level. An outage of a substation power transformer could interrupt service to tens of thousands of customers. PG&E is managing the performance of its power transformers by following a well-designed maintenance practice. PG&E also proactively replaces power transformers that exceed a certain level of failure risk. On average, PG&E

replaces 18 distribution class power transformers and six transmission class power transformers annually.

#### *Substation Reliability Improvements*

PG&E has undertaken a program to evaluate situations where improving substation bus configurations can significantly reduce overall customer outage minutes and interruption frequency. This program is designed to minimize the customers who will experience sustained outages, and reduce the restoration time for those who do. This bus improvement reliability program focuses on evaluating transmission buses (60 kV-230 kV) to identify buses that can be modified or reconfigured to provide significant improvement to the reliable operation of the bus and service to customers. This program also provides the additional benefits of supporting compliance of transmission system reliability requirements and help ease operational and maintenance constraints.

#### *Electric Transmission and Distribution Line Reliability*

PG&E's electric transmission lines are relatively more reliable when compared with substation and distribution line facilities. However, a transmission line outage, when it occurs, could affect a very large number of customers due to the transmission line's higher voltage and electricity carrying capability. To that end, PG&E has been systematically improving the performance of its transmission line facilities. Annually, PG&E has been focusing on improving the performance of 10 to 15 of its worst performing transmission circuits. The improvement plan involves an end-to-end detailed field review to develop comprehensive improvement recommendations. In addition, opportunities to address transmission line reliability issues such as design upgrades are also identified during planned maintenance patrols and inspections. Furthermore, when a transmission line outage occurs, PG&E has established an Outage Review Team (ORT) that, at a regional and total system level, reviews and

completes a root cause analysis and takes necessary action to mitigate impacts and prevent recurrence.

Similarly, for electric distribution circuits, PG&E has developed the Targeted Circuit Initiative to identify work to improve the reliability of the worst performing distribution circuits. The work for any one circuit will typically involve a mixture of installing new fuses, reclosers, fault indicators and animal and bird guards, reframing poles to increase phase separation, and repairing or replacing existing equipment. PG&E's plans call for completing 80-90 circuits annually.

#### *Transmission (Transformer and Line) Design Improvement*

PG&E's transmission system is comprised of approximately 380 "radial" circuits, many of which are 60 kV and 70 kV circuits. A transmission facility is considered radial if its outage results in sustained outage(s) to one or several customers. Outages of these facilities could have a major impact to electric customers across the territory. This program identifies transmission facilities causing sustained outages due to inadequate or unavailable back ties or transfer capabilities to alternate sources. The ultimate goal is to improve the 60- and 70-kV transmission system to be able to withstand a single contingency event and eliminate customer impact entirely or to mitigate to a momentary outage.

### **4.3 Smart Grid Baseline Projects**

In this section, PG&E describes its baseline portfolio of completed and in-flight Smart Grid investments (also referred to as "Smart Grid Baseline projects").

As mentioned earlier, Smart Grid Baseline projects are a subset of the company's entire portfolio of projects that directly leverage the integration of communications and advanced control technologies. These projects provide capabilities that align with PG&E's vision to empower customers, enhance grid performance, and enable smart energy markets.



PG&E's Smart Grid Baseline is defined to include projects that are either: (1) in-service as of December 31, 2010; or (2) approved by a regulatory decision and currently in-flight, with a planned in-service date before 2020. The remaining estimated expenditures for in-flight baseline projects beyond 2010 totals \$1.43 billion. For some projects (e.g., multi-year capital projects), the remaining expenditures are budgeted amounts that are subject to future revenue requirement approvals. The projects fall under each of the following PG&E Smart Grid program areas described in PG&E's Smart Grid Strategy chapter (Chapter 3) earlier:

1. Engaged Consumers
2. Smart Energy Markets
3. Smart Utility
4. Foundational and Cross-Cutting Infrastructure

**1. Engaged Consumers:** PG&E's Smart Grid Baseline projects in the Engaged Consumers area consist of the SmartMeter™ program and Home Area Network (HAN) enablement project. These projects, which integrate wireless communications with energy metering technology, enable a platform to support the development of innovative products and services to help customers improve home energy management and reduce their carbon footprint. As illustrated in Figure 4-3, as the Smart Grid evolves, it will build on this technological platform to allow customers to automate home energy management through HAN or other devices, as well as take advantage of off-peak rates to "smart charge" electric vehicles (EV) and other appliances. Communications between customer premise devices and PG&E's system will also enable PG&E to better match energy supply with demand, reduce the possibility of shortages, and reduce customer vulnerability to outages.

**Figure 4-3: Smart Grid Technologies Enable Increasing Levels of Sophistication in Customer Energy Usage**



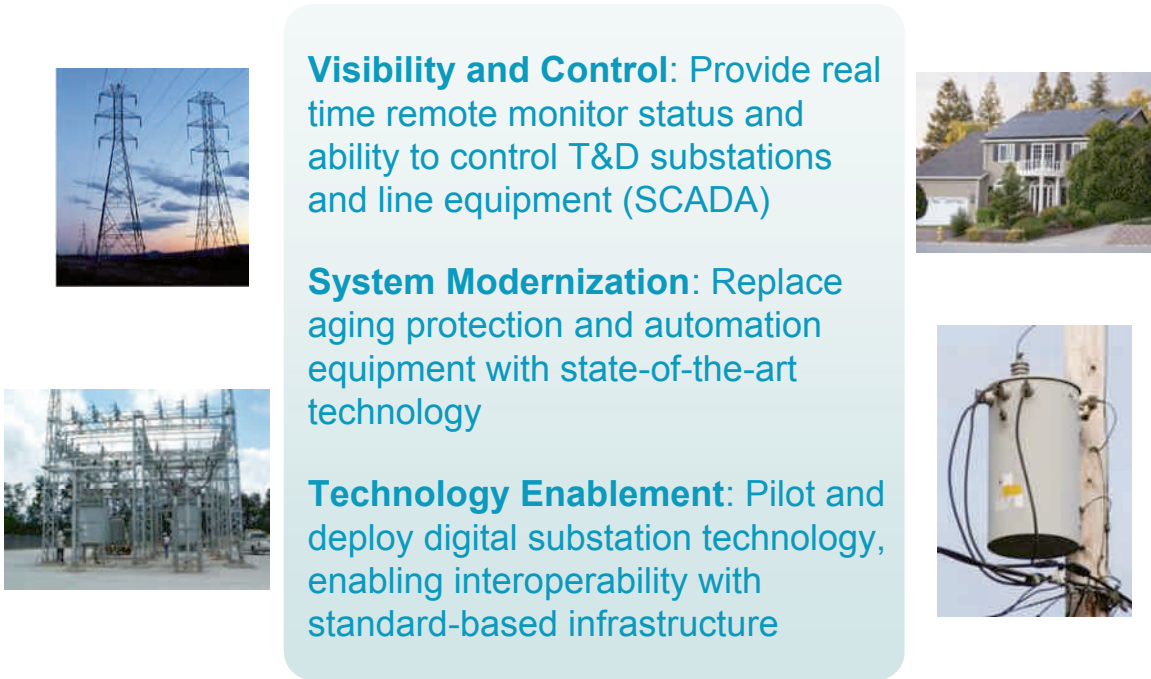
As noted earlier, while there are a number of PG&E programs that provide customers with information, tools, incentives, and value-added services, from detailed information on electricity use to EE and voluntary DR programs, PG&E does not include all of these in its Smart Grid Baseline, just as PG&E does not include all generation, transmission, and distribution asset investments into its Smart Grid Baseline. Rather, many customer programs are considered “Smart Grid-related” because they provide customers with tools to leverage smarter grid technology and capability. The definition and details of Smart Grid-related customer programs are detailed in the next chapter (Chapter 5).

**2. Smart Energy Markets:** PG&E has made and continues to make investments to accommodate the growing array of renewable and distributed electric generation, new electric loads accompanying the adoption of PEVs, and future energy storage technologies. Renewable electric generation—both centralized (e.g., large solar power plants and wind farms) and decentralized (e.g., rooftop solar systems; energy storage)—introduces variability and unpredictability to the electric grid. In the Smart Energy

Markets area, PG&E is making investments to optimize supply and demand of energy resources, and integrate both generation and non-generation resources (e.g., DR) while maintaining a high level of system performance. For example, PG&E is partnering with the California Independent System Operator (CAISO) to examine the feasibility of using DR resources to address ramping requirements and intra-hour renewable resource output variability. Also included in Smart Grid Baseline investments are energy storage projects that, if successfully demonstrated, have the potential to store electricity generated from wind and solar farms and be dependably dispatched when needed. In addition, PG&E is supporting the deployment of technologies that can accommodate a growing fleet of PEVs to charge at times when power generation is ample and inexpensive.

**3. Smart Utility:** A major focus of PG&E's grid investments to date has been on increasing overall electric system safety, reliability, efficiency, and modernization of aging electric T&D assets. Pertaining to the Smart Grid area, PG&E is making capital investments to achieve increased visibility and control of the T&D system by 2015 through the widespread deployment of SCADA devices on substations and circuits. At the distribution level, PG&E is making investments to reduce the frequency and duration of outages with investments in advanced distribution automation systems as part of its Cornerstone Improvement Project. At the transmission level, through the deployment of advanced technologies that enable wide area monitoring as part of the Western Interconnection Synchrophasor Project, PG&E will be able to monitor system abnormalities to prevent rare but highly disruptive transmission system-wide outages.

**Figure 4-4: A “Smart” Electric Transmission and Distribution Grid Leverages State-of-the-Art Technologies to Provide Better Visibility and Control of Grid Conditions**



**Visibility and Control:** Provide real time remote monitor status and ability to control T&D substations and line equipment (SCADA)

**System Modernization:** Replace aging protection and automation equipment with state-of-the-art technology

**Technology Enablement:** Pilot and deploy digital substation technology, enabling interoperability with standard-based infrastructure

In the T&D asset management area, PG&E’s practices have traditionally focused on maximizing the utilization of electric T&D assets and minimizing capital investments to the greatest extent possible. While this approach was appropriate in past decades, it has become less sustainable as assets age and the cost of ongoing repair, maintenance, and customer outages drive the need for accelerated replacements as well as aggressive and proactive management of asset health and maintenance. New technology solutions enable PG&E to be proactive, rather than reactive in maintaining its grid infrastructure. PG&E is investing in condition-based maintenance technologies that enable tracking and managing of asset information, as well as provide engineers with better tools to plan maintenance, replacement, and capacity enhancements.

**4. Foundational and Cross-Cutting Infrastructure:** A foundational Information Technology (IT) infrastructure and numerous cross-cutting supporting initiatives enable PG&E’s baseline investments to become operable. Investments in IT include underlying

telecommunications infrastructure to meet latency, bandwidth, frequency, and reliability requirements, as well as underlying data management infrastructure to meet data storage and integration requirements to fully leverage the information collected by new systems and tools. Because many of the baseline investments to date leverage individual technology platforms that have limited ability to be interoperable and scalable, PG&E is maturing its foundational architecture components to support a more integrated “system of systems” approach. In order to secure the growing sets of information overlaying the physical grid, PG&E is also strengthening its cyber security program to build critical capabilities to analyze, detect, prevent, and respond to the newest generation of cyber attacks. In recent years, PG&E has been building up its advanced technologies lab capabilities to support testing and piloting of new technologies in a safe and controlled environment prior to field deployment.

The following Table 4-3 presents a list of all completed and in-flight Smart Grid Baselines projects as of December 31, 2010. In-flight projects are listed with their approximate planned completion date and forecasted remaining spend.

**Table 4-3: PG&E Completed and In-Flight Smart Grid Baselines Projects as of December 31, 2010**

Smart Grid Program Area	Project Title	Planned Completion Date	Remaining Spend (Millions)
Engaged Consumers	SmartMeter™ Program	July 2012	\$325.2
Engaged Consumers	SmartMeter™ HAN Enablement Program – Phase 1	August 2012	\$14.4
Smart Energy Markets	Electric Power Research Institute (EPRI) PEV DR Pilot	August 2011	\$0.8
Smart Energy Markets	Proxy Demand Resources (PDR) Program – Phase 1	June 2011	\$1.1
Smart Energy Markets	Commercial and Industrial (C&I) DR Participating Load Pilot (PLP)	December 2009	Completed
Smart Energy Markets	Intermittent Renewable Resource Management (IRRM) Pilot	December 2011	\$1.6
Smart Energy Markets	Compressed Air Energy Storage (CAES) Demonstration Project	April 2014	\$50.0
Smart Energy Markets	Sodium Sulfur (NaS) Battery Energy Storage Demonstration Project	December 2012	\$9.3
Smart Utility	Transmission Substation SCADA Program	December 2014	\$113.5
Smart Utility	Distribution Substation SCADA Program	December 2015	\$216.3
Smart Utility	MPAC Installation Program	December 2015	\$322.7
Smart Utility	Regional Synchrophasor Demonstration Project	April 2013	\$42.9
Smart Utility	SmartMeter™: Outage Management Integration Project	July 2012	\$3.5
Smart Utility	SmartMeter™: Transformer Loading Management Project	July 2012	\$0.6
Smart Utility	Cornerstone Improvement Project – Feeder Automation	December 2013	\$155.3
Smart Utility	Distribution Management	December 2016	\$25.0

Smart Grid Program Area	Project Title	Planned Completion Date	Remaining Spend (Millions)
	System (DMS) Project		
Smart Utility	Enterprise Geographic Information System (GIS) Project	December 2015	Under Review
Smart Utility	Condition-Based Maintenance (CBM) – Substation Project	July 2012	\$7.7
Smart Utility	CBM – Distribution Network Project	June 2012	\$3.0
Smart Utility	Network SCADA/Monitoring Project	December 2016	\$73.6
Smart Utility	Load Forecasting Automation Program	May 2012	\$3.3
Foundational and Cross-Cutting	Data Historian Foundation Project	December 2012	\$12.3
Foundational and Cross-Cutting	Advanced Detection and Analysis of Persistent Threats (ADAPT) Cyber Security Project	December 2013	\$31.9
Foundational and Cross-Cutting	SmartMeter™ and Network Operations Center Project	July 2012	\$7.6
Foundational and Cross-Cutting	Applied Technology Services (ATS) – Advanced Technology Performance Lab	December 2010	Completed
Foundational and Cross-Cutting	ATS – Smart Grid Test Center (SGTC)	December 2010	Completed
Foundational and Cross-Cutting	ATS – Distribution Test Yard (DTY)	May 2012	\$5.2
Foundational and Cross-Cutting	Foundational Architecture	Ongoing	Embedded in Baseline Projects
Total Remaining Spend:			\$1,426

### 4.3.1 Engaged Consumers

#### *SmartMeter™ Program*

PG&E's SmartMeter™ Program is nearing completion to install Advanced Meter Infrastructure (AMI) technology for virtually all of PG&E's electric and gas customers over a 5-year period (2007 to 2012). SmartMeter™ technology enables PG&E's

customers to understand how and when they use energy. This technology will serve as the foundation for tools that allow customers to automate their home energy management and enable multiple technologies as illustrated in Figure 4-5. The SmartMeter™ system improves infrastructure integrity and helps PG&E manage energy demand and supply. It enables the utility to provide more reliable service. Through these functionalities, the SmartMeter™ Program represents the vital first step towards the creation of a Smart Grid, which in turn fosters a clean energy economy and sustainable economic expansion. As of December 31, 2010, the SmartMeter™ Program has achieved the following milestones:

- *Total Meters/Modules in service: 7,474,163*
- *Electric: 3,829,130*
- *Gas: 3,645,033*
- *PG&E customers accessing their energy usage information via the online "My Account" tool (www.pge.com) in the past 12 months: 1,592,345*
- *SmartMeter™ online usage inquiries (monthly web views of Total Load and Rate Analysis Chart pages): 403,807*
- *SmartRate™ participants: 24,242*
- *"Energy Alerts" participants: 28,625*
- *"EBill" customers: 1,609,711*

Other planned programs which leverage SmartMeters™ include:

- *SmartMeter™ Energy Highlights: Energy use analysis and comparisons to better inform customers*
- *Personalized Energy Advice: In-flight program to provide comparative energy usage, analysis of usage, energy conservation tips*

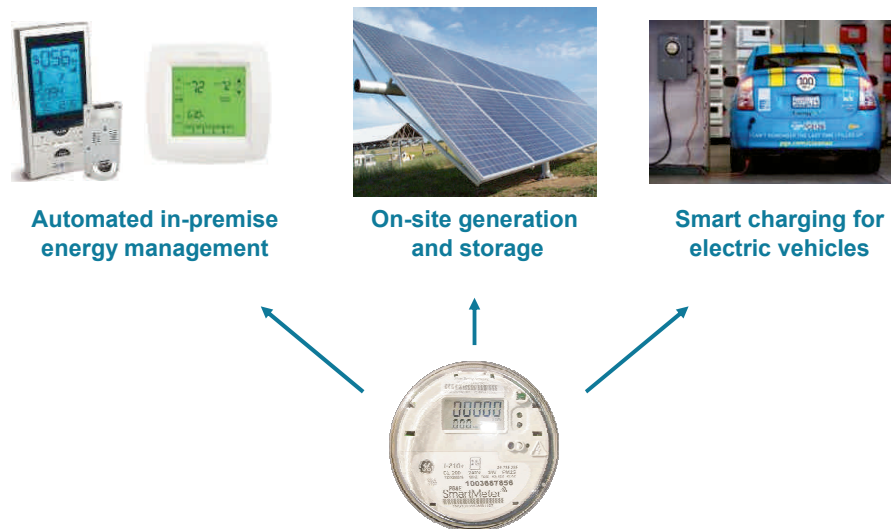
Status as of December 2010: In flight



Planned Completion Date: July 2012

Remaining Spend: \$325.2M

**Figure 4-5: The SmartMeter™ Platform is Foundational to Enabling a Variety of Customer Technologies**



#### *HAN Enablement Program – Phase 1*

The HAN Enablement Phase 1 program consists of the development of IT systems to allow customers to register and commission a PG&E-approved, standards-compliant HAN device with PG&E's AMI network to receive data from a SmartMeter™. For Phase 1, PG&E is deploying support to test in-home devices with selected PG&E customers. In addition to supporting customers who seek to outfit their homes with energy management devices, this program also gathers performance data to supports the development of new markets for home energy management and intelligent home devices.

Status as of December 2010: In flight

Planned Completion Date: August 2012

Remaining Spend: \$14.4M

### 4.3.2 Smart Energy Markets

#### EPRI PEV DR Pilot

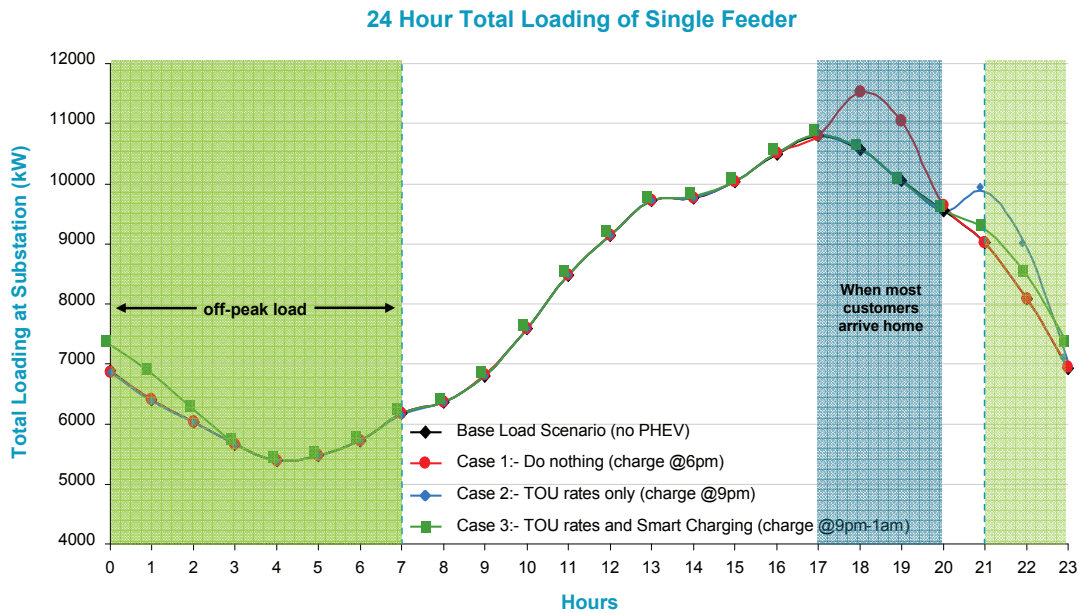
The EPRI PEV DR Pilot will test baseline functionalities of PEV charging hardware by conducting an end-to-end system connectivity to evaluate potential residential smart charging capabilities utilizing the load management software over the AMI network. The charging hardware will be ZigBee-enabled and will have the functionality to provide charging information for billing to the load management software and the AMI back-end system, while receiving charging schedule and user preference control commands from the load management software. Figure 4-6 illustrates some of the findings of EV studies by EPRI.

Status as of December 2010: In flight

Planned Completion Date: August 2011

Remaining Spend: \$0.8M

**Figure 4-6: PG&E is Collaborating With EPRI to Better Understand Customer PEV Charging Behavior**



Source: EPRI

*Proxy Demand Resources (PDR) Program – Phase 1*

PG&E is in the process of developing the required interfaces to enable its retail end-use customers to directly participate in the CAISO's PDR – Phase 1 program. The CAISO's PDR Phase 1 program provides utilities with the necessary tools to forecast and bid available DR resources for a specific day in the CAISO energy market, as well as to implement back-end systems needed for bill settlements.

Status as of December 2010: In flight

Planned Completion Date: June 2011

Remaining Spend: \$1.1M

*Commercial and Industrial (C&I) DR Participating Load Pilot (PLP)*

Known as the PLP, this project is an end-to-end "bid to bill" demonstration for certain commercial and industrial customers to provide non-spinning reserves to the CAISO market. The CAISO and PG&E utilize OpenADR (Open Automated Demand Response)<sup>3</sup> standard as the communications platform, which is the same platform that is currently being used for PG&E's Automated Demand Response (Auto-DR) Program.

Status as of December 2010: Completed in 2009

Remaining Spend: Completed

*Intermittent Renewable Resource Management (IRRM) Pilot*

In the IRRM pilot, PG&E is leveraging work from the C&I DR PLP to provide regulation services to CAISO market. The objective of the IRRM pilot is to demonstrate technically

---

<sup>3</sup> OpenADR is a fully automated signaling platform from a utility, Independent Service Operator/Regional Transmission Organization or other appropriate entity to provide automated connectivity to customer end-use control systems and strategies. OpenADR provides a foundation for interoperable information exchange to facilitate automated DR.

whether customer load can provide second by second frequency needs and follow CAISO controls to mitigate frequency issues and other possible grid problems.

Status as of December 2010: In flight

Planned Completion Date: December 2011

Remaining Spend: \$1.6M

#### *Compressed Air Energy Storage (CAES) Demonstration Project*

In 2009, PG&E received a Department of Energy (DOE) award as part of the ARRA Smart Grid Demonstration Grant program to fund the CAES project. The purpose of this project is to perform a feasibility study to determine the technical and economic feasibility of an approximately 300 MW CAES plant using a porous rock structure for air storage at a location within California. CAES technology will compress air into an underground porous rock formation using power produced during non-peak hours, and then will release the stored air to generate electricity during periods of peak demand. If demonstrated to work with porous rock formation, CAES technology has the potential to facilitate the interconnection of renewable generators and maintain grid reliability, meet the on-peak needs of the grid, minimize environmental impact, and mitigate the power fluctuation and energy management (e.g., ramping and regulation) issues associated with intermittent renewable resources.

Status as of December 2010: In flight

Planned Completion Date: August 2015 (Phase 1)

Remaining Spend: \$50M (of which \$25M is the DOE award)

#### *Sodium Sulfur (NaS) Battery Energy Storage System (BESS) Demonstration Project*

In this project, PG&E will utilize NaS battery technology to demonstrate the provision of high-value energy storage services on the T&D system. The NaS BESS is a versatile storage solution, designed to provide quick, short-duration charge/discharge as well as

slower, long-duration cycles. This flexibility allows each battery system to potentially capture a wide-range of benefits. In this demonstration, two projects will seek to aggregate and value these benefits by developing and evaluating operating profiles designed to improve service reliability, provide ancillary services, and enhance the value of renewable resource integration.

Project 1 – 4 MW/28 MWh NaS BESS: In addition to mitigating reliability and power quality events for an on-site customer, this project will offer basic load leveling. The battery will also be able to respond to a regulation signal from the CAISO and may simulate the smoothing of renewable generation.

Project 2 – 2 MW/14 MWh NaS BESS: Located at a major PG&E substation, this unit will provide load leveling, optimize a nearby solar PV installation, and participate in the CAISO ancillary services market.

Status as of December 2010: In flight

Planned Completion Date: December 2012

Remaining Spend: \$9.3M

**Figure 4-7: PG&E's Sodium Sulfur Batter Demonstration Project Will Test and Demonstrate a Variety of Energy Storage Applications**



Sodium-Sulfur (NAS) Battery

**6 MW / 42 MWh sodium sulfur (NaS) battery**

**Goal to improve reliability and power quality**

**Test ability to provide ancillary services**

- Load-following
- Frequency regulation

**Test ability to cost-effectively integrate intermittent renewable resources**

### **4.3.3 Smart Utility**

#### *Transmission Substation SCADA Program*

Under the Transmission Substation SCADA program, PG&E is in the process of installing new SCADA on the transmission system to provide PG&E's Electric Operations and the CAISO with full visibility into the transmission system, significantly improving efficiency and operational flexibility. PG&E's goal is to achieve 100 percent visibility and control of all transmission substations by 2014, adding or replacing SCADA for approximately 300 substations and approximately 700 breakers.

Status as of December 2010: In flight

Planned Completion Date: December 2014

Remaining Spend: \$113.5M

### *Distribution Substation SCADA Program*

The Distribution Substation SCADA program focuses on increasing SCADA penetration to support future Distribution Control Center consolidation and to improve reliability for PG&E customers. PG&E's goal is to achieve 100 percent visibility and control of all critical distribution substation breakers by 2015, adding or replacing SCADA for approximately 300 substations and approximately 1,000 breakers.

Status as of December 2010: In flight

Planned Completion Date: December 2015

Remaining Spend: \$216.3M

### *Modular Protection Automation and Control (MPAC) Installation Program*

The multi-year MPAC program aims to deploy pre-engineered, fabricated, and standardized control buildings in transmission substations. The program is designed to improve reliability of the transmission system by replacing aging infrastructure and modernizing facilities. These activities are performed in an integrated manner with other PG&E projects such as capacity expansion projects, bus conversions, deficiency and aging asset replacement, control room condition improvements, reliability, and control center consolidation efforts.

Status as of December 2010: In flight

Planned Completion Date: December 2015

Remaining Spend: \$322.7M

### *Regional Synchrophasor Demonstration Project*

In 2009, the DOE awarded \$54 million to the Western Electricity Coordinating Council's Synchrophasor project to improve grid reliability and transmission efficiency as part of the American Recovery and Reinvestment Act of 2009 (ARRA). This regional project involves nine partner entities, including PG&E. As an award sub-recipient receiving

\$22 million, PG&E will install or replace synchrophasor technology, also known as PMUs, throughout its service territory, network them together, and provide the data in a secured interface to PG&E’s electric transmission operators, neighboring utilities, and the CAISO. Synchrophasor technology provides precise, real-time measurement of electrical qualities from across the electricity grid. These devices enable system operators and planners to measure the state of the electrical system and manage power quality.

Status as of December 2010: In flight

Planned Completion Date: April 2013

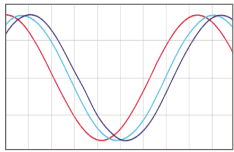
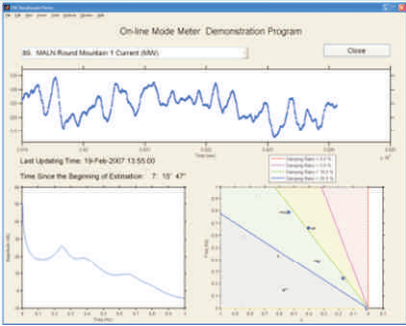
Remaining Spend: \$42.9M (of which \$22M is funded through the DOE grant)

**Figure 4-8: PG&E’s Synchrophasor Project is a Regional Collaboration With Nine Partner Entities to Deploy Synchrophasor Technology to Improve Transmission System Reliability**

**Synchrophasors:** Measure electrical waves in near real time

Collaborate with transmission system operators across **Western Interconnection**

Evaluate benefits of phasor monitoring for managing **grid reliability**



*SmartMeter™: Outage Management Integration Project*

The SmartMeter™ Outage Management Integration project integrates the SmartMeter™ "Last Gasp" and Restoration messages into PG&E’s Outage Management System for



outage notification to operators and dispatchers and improved outage restoration. The project will deliver: (1) the capability to create trouble reports from AMI alarms when an associated customer call has been received; (2) the capability to ping a transformer to determine if an outage is larger than it was inferred to be; (3) the capability to identify and display probable secondary fault locations based on unique alarm events and prior inference locations; and (4) the capability to ping individual meters to determine whether they have been restored.

Status as of December 2010: In flight

Planned Completion Date: July 2012

Remaining Spend: \$3.5M

*SmartMeter™: Transformer Loading Management Project*

The SmartMeter™ Transformer Loading Management project enables T&D electric planning engineers and estimators to access actual customer usage data from SmartMeter™ for analysis in equipment sizing and voltage analysis. The solution will enable PG&E to report transformer (or multiple transformers) load based on interval usage data and the ability to drill down to month, week, day, and Service Point level to see the peak usage. The solution will also identify transformer (or multiple transformers) by load category (over loaded, under loaded) over the entire SmartMeter™ population.

Status as of December 2010: In flight

Planned Completion Date: July 2012

Remaining Spend: \$0.6M

*Cornerstone Improvement Project – Feeder Automation*

In June 2010, the CPUC approved PG&E's 3-year Cornerstone Improvement Project, which includes major initiatives that will increase the capacity and interconnectivity of

distribution lines and substations, implement distribution automation on distribution circuits in urban and suburban areas, and install reclosers and fuses on rural circuits to reduce the number of customers affected by outages. These initiatives are expected to result in reliability improvements for PG&E customers. The Feeder Automation component of Cornerstone Improvement Project involves implementing feeder automation on approximately 400 distribution circuits. The project scope includes automating mainline protection equipment utilizing FLISR schemes to restore unaffected customers within five minutes.

Status as of December 2010: In flight

Planned Completion Date: December 2013

Remaining Spend: \$155.3M

#### *Distribution Management System (DMS) Project*

The DMS project is a strategic systems implementation for the electric distribution system to provide increased grid visibility and control capability. DMS is an industry-leading technology solution that is increasingly being embraced by utilities across the country to help consolidate and automate core functions within distribution operations. The DMS is intended to improve upon the traditional paper-based and/or manual approaches used primarily by utility personnel today to better monitor, control, and optimize the performance of the distribution system.

Status as of December 2010: In flight

Planned Completion Date: December 2016

Remaining Spend: \$25M

#### *Enterprise Geographic Information System (GIS) Project*

The enterprise GIS project will develop a foundational, enterprise-wide data repository of all gas, electric, transmission and distribution geospatial asset information. The

converted data in the new GIS system will be in a common electronic format and integrated with SAP, which is PG&E's Enterprise Resource Planning system. With this foundation in place, additional business enablement projects will be launched that build upon the base GIS solution to fully exploit its capabilities.

Status as of December 2010: In flight

Planned Completion Date: December 2015

Remaining Spend: Under Review

#### *Condition-Based Maintenance (CBM) – Substation Project*

CBM is a PG&E program to implement advanced maintenance strategies and solutions to identify and fix issues with T&D assets before these issues cause equipment breakdowns. CBM allows decisions to be based on equipment condition or events, providing the ability to do the right maintenance at the right time and minimizing unplanned work. The CBM technology solution for electric transmission substation provides the platform for equipment readings, temperature, and other data points to provide equipment lifecycle predictive analysis. The solution will automate many of the manual processes that are used today including: (1) review of station inspection and test data to identify abnormal conditions; (2) update maintenance trigger plans from oil condition assessment results, counter readings, etc.; and (3) equipment ranking for replacement decisions. The tool is also designed to provide easy access to inspection and test data to asset strategy and engineering personnel that do not have it readily available today. The data will be used to adjust maintenance triggers and for capital investment strategy.

Status as of December 2010: In flight

Planned Completion Date: July 2012

Remaining Spend: \$7.7M

### *Condition-Based Maintenance (CBM) – Distribution Network Project*

The distribution network CBM project will deploy an application to accurately monitor underground equipment in the downtown San Francisco and Oakland secondary network systems to guide maintenance activities based on real-time operating conditions. Currently performance analysis and condition assessments rely on manually intensive procedures. The CBM technology solution for electric distribution network will provide capabilities for field personnel to capture maintenance process and data electronically via rugged computers, to upload data to the work management system to record work and trigger additional work if necessary, and to receive, store, and trend equipment conditions for the analysis of asset health for asset management decisions on maintenance and replacement strategies.

Status as of December 2010: In flight

Planned Completion Date: June 2012

Remaining Spend: \$3M

### *Network Supervisory Control and Data Acquisition (SCADA) Monitoring Project*

The project will install new monitoring and control systems on the downtown San Francisco and Oakland secondary network systems including full remote control on network protectors (including remote setting of relays), and primary switches. The monitoring itself includes voltages, currents, temperature, oil level and chamber pressures. It may also include moisture, hydrogen level and other dissolved gas monitoring depending on feasibility and available technologies. For vaults, the monitoring system will include SCADA battery, water detection and may include others such as distributed generation monitoring and motion detection, depending on future strategy, needs, feasibility and available technologies. Real-time data collected from the equipment may be used for triggering of alarms for operation or maintenance activities, and trending for asset management decisions on maintenance and replacement strategies. The new SCADA system will also have remote operating capabilities that

include vacuum switch control, network protector open/close, station transfer trip of the network protectors and group open/close. These new control features will improve personnel safety and system operability.

Status as of December 2010: In flight

Planned Completion Date: December 2016

Remaining Spend: \$73.6M

#### *Load Forecasting Automation Program*

The Load Forecasting Automation program will automate existing manual electric distribution system load forecasting to increase accuracy of the process and improve forecast documentation. Current and future SCADA data will be gathered and stored within the existing data historian system and will become an input to the new forecasting tool. Circuits with SCADA will provide hourly load data into the historian system and non-SCADA circuits will provide a single monthly peak load from monthly substation inspections. Additionally, this project will replace analogy bank demand meters with electronic recording meters.

Status as of December 2010: In flight

Planned Completion Date: May 2012

Remaining Spend: \$3.3M

### **4.3.4 Foundational and Cross-Cutting Initiatives**

#### *Data Historian Foundation Project*

This project will implement enhanced data historian software for managing and analyzing operational data with select user groups in electric transmission (including the Synchrophasor Project), gas operations, power generation, and energy procurement. When deployed and integrated with other electric systems such as EMS and SCADA, the new data historian will serve as the central data archiving and analysis system for all

time-series operational data. This solution enables PG&E operators, engineers, managers and executives to analyze, visualize, and share operational and business data in a manner that not only makes the most sense to them, but also informs intelligent decision-making throughout the utility value chain. The benefits of this capability include productivity improvements, situational awareness, reliability improvements, and regulatory compliance.

Status as of December 2010: In flight

Planned Completion Date: December 2012

Remaining Spend: \$12.3M

*Advanced Detection and Analysis of Persistent Threats (ADAPT) Cyber Security Project*

The ADAPT project will take a proactive, preventative approach to cyber threat and incident management. This multi-phased project will build critical capabilities for PG&E to analyze, detect, prevent, and respond to the newest generation of cyber attacks. The project will also install cyber security software and hardware and establish a corresponding operational team and business processes to ensure effective, secure deployment of new Smart Grid and other related technology across the organization.

Status as of December 2010: In flight

Planned Completion Date: December 2013

Remaining Spend: \$31.9M

*SmartMeter™ Operations Center (SMOC) Project*

The SMOC project implements telecommunication network operations management capabilities to support PG&E's SmartMeter™ network to handle growth in the number of deployed meters, effectively monitor the increased amount of data communications from the meters, bring new SmartMeter™-related customer services on-line efficiently, and enable timely customer response as well as proactive reliability and availability

management. This scope includes designing and implementing a new SMOC for the day-to-day operations of the existing installed systems and ensure vendor production and operational commitments.

The Operations Center will be expanded in the future to extend capabilities to support SmartMeter™ and Smart Grid strategies. The SMOC will become a central hub to manage the operations of the SmartMeter™ network, grid network systems, and telecommunications network.

Status as of December 2010: In flight

Planned Completion Date: July 2012

Remaining Spend: \$7.6M

*Applied Technology Services (ATS) – Advanced Technology Performance Lab (ATPL)*

Based in PG&E's ATS facility in San Ramon, the ATPL is a multi-functional test lab for emerging technologies in EE, DR, clean air transportation, home area networks, and other Smart Grid areas. With the installation of test equipment and communication network inside the lab, it now has robust capabilities to test the performance of numerous types of equipment and devices used by PG&E, including power plant equipment and other generation-related performance testing.

Status as of December 2010: Construction Completed; Lab activities are ongoing

Planned Completion Date: Ongoing

*ATS – Smart Grid Test Center (SGTC)*

Another function being built out in the ATS facility is the new SGTC. The SGTC will test and evaluate Smart Grid technologies prior to full-scale utility implementation. The SGTC will be networked with other labs and facilities and serve as the hub for data collection, monitoring, control and evaluation. The SGTC will include isolated

communications networks to allow safe and thorough testing without risking network security issues. For example, for a current Smart Grid project, the Regional Synchrophasor Demonstration Project described above, the test center is being used to install and test phasor measurement units from different vendors in an environment that simulates the transmission grid control center.

Status as of December 2010: Construction completed; Test Center activities are ongoing

Planned Completion Date: Ongoing

#### *ATS – Distribution Test Yard (DTY)*

A third addition to the ATS facility is the DTY. The DTY will serve as a laboratory, substation, and simulated distribution circuit facility for monitoring and evaluating various new distribution tools, equipment, and applications. It will include the necessary substation and line equipment with isolated communications networks to allow safe and thorough testing without risking network security issues. This DTY will be part of the overall ATS end-to-end test capability for distribution systems of the future.

Status as of December 2010: In flight

Planned Completion Date: May 2012

Remaining Spend: \$5.2M

#### *Foundational Architecture*

PG&E's "Foundational Architecture" is not a project in itself, but rather an ongoing set of activities to build IT capabilities to support current baseline investments.

For example, PG&E has invested in the necessary communication capabilities to enable remote monitoring and control of the T&D system. These telecom and network upgrades support multiple initiatives including transmission and distribution SCADA build-out, the Synchrophasor project, the Cornerstone Improvement Program, and other grid automation programs. PG&E has also defined components of a high-level



Smart Grid architecture to support baseline investments, including implementing a baseline architecture for Data Centers, Field Information, HAN, Synchrophasors, and SCADA systems.

As PG&E's Smart Grid architecture evolves, the legacy model to develop solutions for individual systems will not be able to support communication needs, meet security requirements, scale, and guarantee consistent and accurate data. The necessity across all current and future Smart Grid initiatives for security, reliability, and accurate data combined with the increasing amount of data, system-to-system interfaces, and sharing of information creates the requirement for a common set of foundational architectural elements.

PG&E's future Smart Grid architecture for telecommunications, cyber security, and enterprise information management will fundamentally transform a legacy of individual systems into a highly integrated "system of systems." Central to this work will be the creation of a common communications fabric and architecture, a common security architecture, and a common information and application integration architecture. Over time, all applications and services will utilize these common foundational components, which will greatly simplify integration and scaling capabilities. This vision and plan are described in the Roadmap chapter (Chapter 6).

#### **4.4 Assessment of Privacy Issues**

PG&E is committed to protecting customer privacy and has multiple standards, policies, and procedures which ensure compliance with Federal and State laws and Commission orders aimed at protecting private customer information. PG&E describes its current privacy initiatives and addresses the questions raised by the CPUC in Decision 10-06-047 in the Grid Security and Cyber Security Strategy chapter (Chapter 9).

## 4.5 Conclusion

The Smart Grid represents a vision for a modern electric system that uses the latest sensing, communication and automated control technologies to help utilities and their customers make better-informed energy decisions and create a smarter and more efficient and reliable electric grid.

As described in the Current State of PG&E's Grid section, PG&E proudly delivers a portfolio of clean energy resources to customers and aggressively invests in renewable resources to meet customer demand for electricity and help California attain its clean energy and GHG reduction goals. The pace of PG&E's investment in traditional transmission and distribution infrastructure, however, has historically been moderate and deliberate as utility equipment is built durable enough to withstand the long life cycles, weather, and operating changes. Recognizing that aging and failing assets, if unattended, will inhibit PG&E's ability to provide quality electric service to customers, PG&E is strategically modernizing its transmission and distribution system to improve grid reliability and safety, and provide capacity upgrades to accommodate increased customer demand in the future.

As demonstrated by PG&E's Smart Grid Baseline portfolio of projects, PG&E has already begun to deploy Smart Grid equipment and technologies on a limited scale in its service territory. PG&E has invested to date and continues to invest in a number of advanced grid technologies that include industry-leading products that have been deemed reliable and ready for deployment after testing and piloting in the lab, as well as field demonstration and validation from the utility industry. PG&E has laid the groundwork with SmartMeters™ and is actively supporting underlying standards, systems and technologies to enable home area network devices. From giving customers more information so they can better manage their energy use to enabling electric vehicle "smart charging," PG&E is poising the Smart Grid to support a more sustainable energy system. One important aspect will be to better integrate intermittent sources of

renewable energy, such as wind and solar, into the grid while maintaining T&D system performance. Looking ahead, PG&E will continue working collaboratively with key stakeholders both in California and across the nation, to strengthen the foundation for a Smart Grid that will—over time—deliver new opportunities for customers and provide core infrastructure for clean and sustainable energy supplies.

## **Chapter 5 – Smart Grid-Related Customer Programs**

## **5.1 Introduction**

PG&E's Smart Grid Deployment Plan builds on numerous customer programs already in place or under development that provide tools and information for consumers to manage their energy use, reduce cost, and improve their environmental energy footprint. PG&E's comprehensive energy strategy includes both the core Smart Grid program areas described in Chapter 4, as well as "Smart Grid-related" programs and products designed to meet its customers' current and future power needs. To provide the complete picture of all core and Smart Grid-related investments, this chapter describes the numerous programs in place that provide customer benefits made possible in whole or in part by PG&E Smart Grid programs and investments, or that build on those programs and investments. These programs and investments include, *inter alia*, on-line information platforms, expanding Customer Energy Efficiency (CEE) and Demand-Side Management programs and, where necessary or appropriate, procuring additional renewable power resources before turning to efficient traditional generation sources. PG&E expects that these complementary programs will be enhanced in the future as the Smart Grid provides richer information to improve program and product design.

The Smart Grid-related customer programs are categorized below. Each program category has its own means of leveraging the Smart Grid infrastructure, helping to improve grid performance and generating customer and environmental benefits.

### **5.1.1 SmartMeter™-Enabled Information Presentment Tools**

PG&E offers a variety of SmartMeter™-Enabled Information Presentment Tools (e.g., "My Energy" Web Tools, "Energy Alerts," and "Home Energy Reports") to empower customers to know when they use energy and to better manage their energy use to potentially conserve or shift usage away from "peak" periods. These tools will continue to evolve rapidly to meet the ever changing needs of customers for useful information.

### **5.1.2 SmartMeter™-Enabled Time-Varying Pricing Products**

PG&E's SmartMeter™-Enabled Time-Varying Pricing Products are designed to create economic incentives and encourage customers to actively manage their energy costs by reducing use and/or shifting their usage to "off-peak" times. These products help realize the vision of policymakers and the industry that advance metering can enable time-variant pricing to deliver on key energy policy objectives. Smart Meters™ and related technologies are important building blocks of the Smart Grid and are one of the ways for customers to control their energy costs while achieving broader societal energy policy objectives.

### **5.1.3 Customer Energy Efficiency**

For more than 30 years, PG&E has been a strong, national champion for Energy Efficiency (EE), implementing a diverse array of programs, services and campaigns aimed at helping customers save energy and money. In total, PG&E's programs have avoided the release of 168 million metric tons of carbon dioxide (CO<sub>2</sub>) into the atmosphere, based on cumulative lifecycle gross energy savings, and helped customers save more than \$24 billion on their energy bills. Going forward, PG&E's EE programs will implement a number of innovative strategies that leverage smart grid capabilities to better integrate EE with other clean energy solutions, such as Demand Response (DR), customer-owned solar, and emerging home energy network technologies.

### **5.1.4 Demand Response**

While EE programs result in permanent reductions in energy usage, PG&E's DR programs provide incentives for customers to temporarily reduce or shift their energy use on days when demand for energy is at its highest. Occasional heat waves and storms, plus the periodic need for unscheduled power plant or transmission line repairs and maintenance, can temporarily strain California's electrical supply. For many years, PG&E's customer DR programs have provided a fiscally and environmentally

responsible way to respond to these spikes in electric demand, avoiding the need to build and maintain additional power plants that would only be needed for relatively few hours during the year. The Smart Grid projects described in this plan leverage this experience by optimizing the deployment of DR resources and help DR providers integrate their products and services with other market participants.

### **5.1.5 Distributed Generation**

The California Solar Initiative (CSI) is intended to install 3,000 megawatts (MW) of new, customer-owned solar capacity by December 2016, moving the state toward a cleaner energy future and helping to lower the cost of solar installations for customers. PG&E administers residential and commercial customer solar installation rebates as part of its role in CSI implementation. PG&E has connected more than 45,000 customer-owned solar systems, far more than any other utility in the nation.

### **5.1.6 Electric Vehicle Readiness**

To plan effectively for an increasing penetration of Electric Vehicles (EV) in PG&E's service area, PG&E is working in partnership with a host of stakeholders to test EV "smart charging" technologies to ensure the technologies charge vehicles at night, when demand on the grid is low, and stagger charging to meet customer needs while minimizing impact on the local electric distribution system. PG&E is also helping to develop the underlying codes and standards for EVs, working with national and international organizations to ensure that EVs charge and communicate in similar ways. PG&E is also working with vehicle manufactures, dealerships and customers in anticipation of the broader adoption of EVs, increasing outreach and education on the benefits of these vehicles, as well as key issues such as the best time to charge them. PG&E established a cross-department team to develop processes to efficiently handle new requests for EV charging services and rate incentives as well as to make traditional grid upgrades to support reliable integration of these vehicles into the grid. Further, PG&E is also developing strategies to leverage the embedded technologies within the

SmartMeter™ devices, planning for time-of-use (TOU) rates which will be critical to help shift vehicle charging to off-peak times and providing overall customer savings.

In June 2011, the United States Environmental Protection Agency presented PG&E with a Clean Air Excellence Award for its work in advancing EV charging stations across its service territory. The Clean Air Excellence Awards Program was established in 2000 and recognizes efforts to help make progress in achieving cleaner air. PG&E is the first utility in a decade to win this award.

Each of the program areas are discussed in more detail below.

## **5.2 SmartMeter™-Enabled Information Presentment Tools**

One of the most important benefits of the SmartMeter™ project is the provision of more granular usage data that customers can use to better manage their energy use.

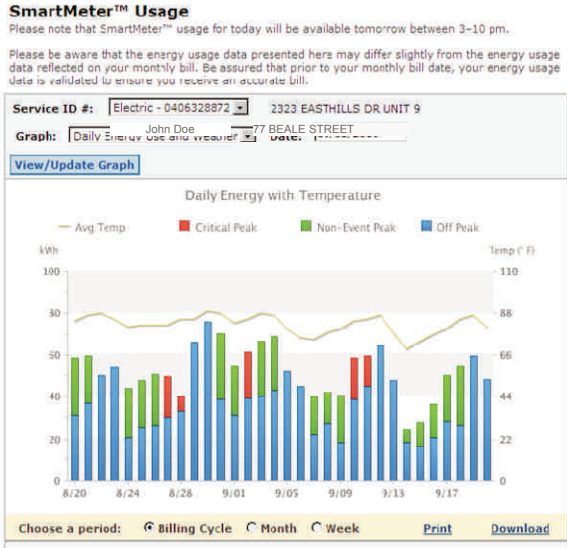
Leveraging this rich data set, PG&E offers both information and pricing programs to help customer better understand and manage their energy usage and energy costs. The information programs include:

### **5.2.1 “My Energy” Web Tools**

PG&E’s customer website (“My Energy”) allows residential, small and medium business, and small agricultural customers to view usage (Figure 5-1), price and cost, and take advantage of various rate analysis tools. The usage information is displayed in a variety of formats including year-to-year comparison, peak/off-peak hourly and 15 minute interval data (depending on the granularity of the SmartMeter™ data), bill-to-date and monthly bill forecast. The “My Energy” website will also include a rate calculator which will calculate the customer bill under a variety of available rate plans.



**Figure 5-1: Customers Can View Their Energy Usage Through SmartMeter™-enabled Information Tools**



Secure customer access through PGE.com

Energy use by hour (electric) or day (gas)

View by billing cycle, month, or week

For SmartRate customers, colors designate critical peak, peak, and off-peak

Temperature overlay

### 5.2.2 Energy Alerts

PG&E has implemented the Energy Alerts program which notifies customers (sample texts can be seen in Figure 5-2 below) when they cross the higher-rate Tiers 3, 4, 5 or are forecasted to cross Tiers 3, 4, 5 by the end of a billing period. Sample alerts can be seen in Figure 5-2 below. This program is being offered to residential customers with electric SmartMeters™ who are on electric Rate Schedules E-1, E-6, E-7 and E-8. This service will soon be available to virtually all five million electric customers. As of December 31, 2010, 30,000 customers have signed up.

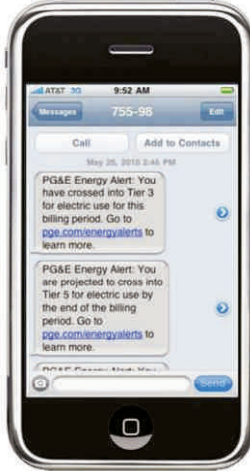
**Figure 5-2: Customers Can Receive Alerts of Energy Usage as They Approach or Cross Higher Tiers**

**Provide customers early warning of high usage**

- When actual usage-to-date crosses Tier 3, 4, 5
- When usage is forecast to cross Tier 3, 4, 5 by end of billing period

**Delivered via:**

- Email
- Text message
- Outbound phone call



### 5.2.3 Home Energy Reports

As part of its EE portfolio, PG&E has developed personalized mailers to provide customers with comparative energy information and energy saving tips, known as Home Energy Reports (Figure 5-3). This program is in the initial roll-out stage and will ultimately be offered to 1.25 million residential customers by the end of 2013.

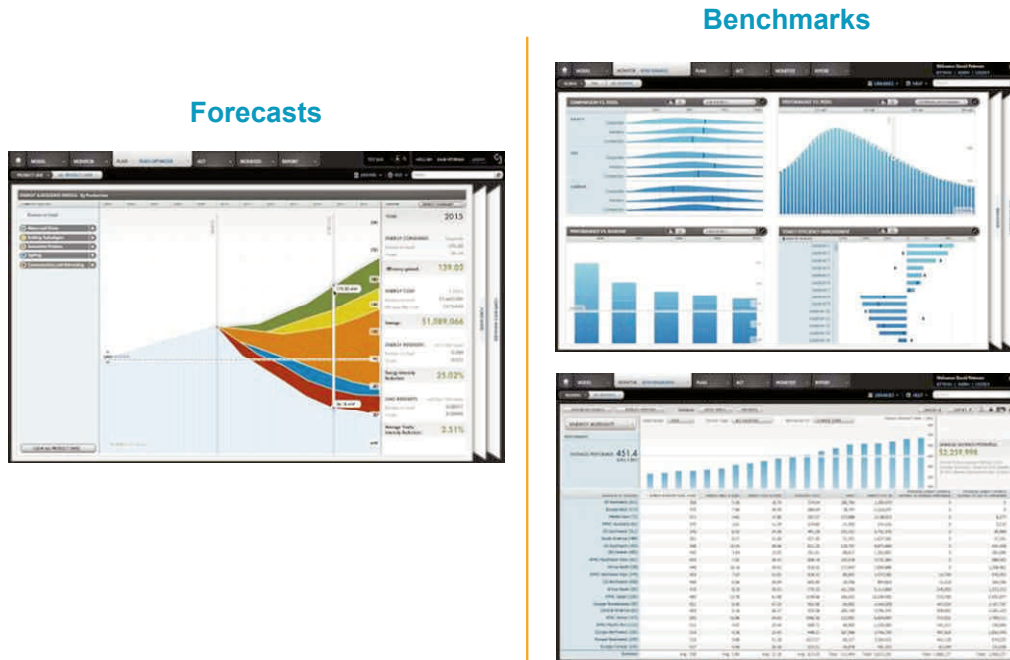
**Figure 5-3: Personalized Information Helps Customers Effectively Take Action to Reduce Their Energy Usage**



### 5.2.4 Energy and Carbon Management System

PG&E is developing an Energy and Carbon Management System (ECMS) program to provide tools specifically for Commercial and Industrial customers to monitor and manage their energy usage and greenhouse gas (GHG) emissions (Figure 5-4). The first deployment will consist of five customers, each over 500 kilowatts (kW), and each within a different industry segment. Later deployments will include customers over 500 kW. Functionality will be rolled out in phases beginning with the ability to monitor and report energy, cost, and GHG emissions. Subsequent phases will extend the functionality to include the ability to mitigate and monetize the impacts, including EE and DR project modeling and recommendations, fault detection, and scenario planning and what-if analysis, EE project tracking and reporting, and business case development.

**Figure 5-4: PG&E Is Developing Enterprise Energy Management Tools for Commercial and Industrial Customers**



### 5.3 SmartMeter™-Enabled Time-Varying Pricing Products

Time-varying pricing products, such as Peak Day Pricing (PDP), TOU and Peak Time Rebate (PTR) take advantage of SmartMeter™ capabilities that are currently being implemented across PG&E’s service territory. Charging customers different rates based on varying system conditions is intended to more closely align retail and wholesale electric prices for generation, creating economic incentives for customers to actively manage their energy costs by shifting electricity use from when it costs more to when it costs less. There are a number of pricing programs implemented today and others envisioned for the future. The SmartMeter™ has enabled PG&E and other utilities to cost-effectively offer all customers these types of rate programs which provide significant customer and societal benefits. The following is a high-level description of each of the pricing products that are offered by PG&E:

### **5.3.1 Time-of-Use**

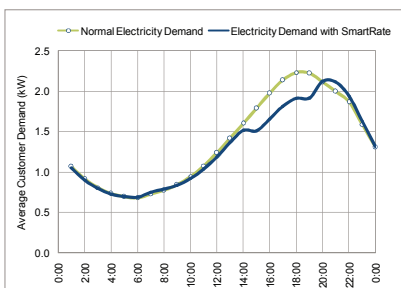
TOU pricing plans are structured to charge lower prices during off-peak and partial-peak periods and higher prices during seasonal and daily peak demand periods. Customers who are able to shift energy use away from peak periods to partial-peak or off-peak periods can take control of their energy costs effectively lowering their electric bills. Shifting load away from the peak demand period also lowers PG&E's costs and helps the environment by potentially reducing the number of new generation facilities required and decreasing the amount of energy purchased from other sources.

### **5.3.2 Peak Day Pricing**

PDP is a Time Varying Pricing product that involves a TOU rate schedule with peak event day surcharges on certain "trigger" days. A PDP event day is triggered on week days when the average temperature forecast is above 98 degrees.

PDP is currently voluntary for residential customers and offered under the product name SmartRate™ (Figure 5-5). All large business and agricultural customers are defaulting to PDP with the option to "opt-out" and remain on a standard TOU rate or opt-in to a DR Program.

**Figure 5-5: PG&E’s SmartRate Summer Pricing Plan Provides Residential Customers a Discount on Their Normal Rate When They Shift Electricity Usage on “Peak” Days**



#### Recruitment

10,000 voluntary participants in 2008; 24,000 in 2009

23,100 currently active participants (June 2011)

#### Experience

2008: Across 9 called events, the average residential customer achieved a **reduction of 16.6%**

2009: Across 15 called events, the average residential customer achieved a **reduction of 15%**

2010: Across 13 called events, the average residential customer achieved a **reduction of 16.9%**

#### Retention

90% of 2008 customers remained on the plan in 2009

95% of 2009 customers intended to remain on the plan in 2010

96% of customers remain on SmartRate (June 2011)

### 5.3.3 Peak Time Rebate

PTR involves setting a customer usage “target” based on their recent peak-period electric usage (their average usage on the several days just prior to when a PTR event is scheduled), and then awarding the customer with rebates if they use less electricity than the target. These rebates would be offered on a limited number of days each summer, when electric demands are expected to be at their highest levels.

Implementation of PTR is pending a decision by the Commission. If it is approved as proposed, PG&E anticipates offering PTR in the summer 2012 for approximately 500,000 residential customers, mostly in the Central Valley, and then extending it to nearly all residential customers for the summer 2013. This schedule is pending Commission authorization.

## 5.4 Customer Energy Efficiency

PG&E’s EE programs are funded by customers through “public purpose program” charges embedded in gas and electric rates. This funding allows PG&E to offer a diverse portfolio of programs that includes a mix of rebates and financial incentives, training and education, support for commercializing new and emerging technologies and other activities, such as advocacy for stronger building codes and appliance standards.

PG&E’s EE programs and goals are authorized by the Commission on a 3-year program cycle. For the 2006-2008 cycle, PG&E exceeded the Commission’s energy savings goals, saving customers more than \$650 million on their energy bills. In 2009, PG&E exceeded the Commission’s goals again, achieving savings of 1,593 gigawatt-hours (GWh), 273 MW and 25.3 million therms. For the 2010-2012 cycle, PG&E has a budget of \$1.3 billion—the largest investment in EE by any United States (U.S.) utility. PG&E’s savings goals for the 3-year period are 3,110 GWh, 703 MW and 48.9 million therms. In 2010, PG&E exceeded the Commission’s goals again, achieving savings of 2,060 GWh, 357 MW, and 16.8 million therms. These results helped save customers more than \$332 million on their energy bills and avoided the emission of more than 1 million metric tons of CO<sub>2</sub> and nearly 200 tons of nitrogen oxide (NO<sub>x</sub>).

**Table 5-1: 2010 Energy Savings From EE Programs**

<b>Annual<sup>1</sup> Energy Savings From Customer Energy Efficiency Programs</b>			
	<b>2010 Actual Savings<sup>2</sup></b>	<b>2010 CPUC Goal<sup>3</sup></b>	<b>2010 % of Goal</b>
Megawatts (peak)	357	218	164%
Gigawatt-hours (total)	2,060	964	214%
Million Therms	16.8	15.6	108%

<sup>1</sup> Annual energy savings refer to the first-year impacts associated with installed customer EE projects.

<sup>2</sup> Data (gross energy savings) is taken from Table 1 of the 2010 Energy Efficiency Annual Report, filed with the CPUC on May 2, 2011.

<sup>3</sup> Source is CPUC Decision 09-09-047.

**Table 5-2: Past 5-Year Energy Savings From EE Programs**

<b>Annual<sup>1</sup> Energy Savings From Customer Energy Efficiency Programs, 2006 - 2010</b>					
	<b>2006 Actual Savings<sup>2,3</sup></b>	<b>2007 Actual Savings<sup>3,4</sup></b>	<b>2008 Actual Savings<sup>3,4</sup></b>	<b>2009 Actual Savings<sup>5</sup></b>	<b>2010 Actual Savings<sup>6</sup></b>
Megawatts (peak)	143	298	458	273	357
Gigawatt-hours (total)	784	1,824	2,838	1,593	2,060
Million Therms	11	23	39	25.3	16.8

<sup>1</sup> Annual energy savings refer to the first-year impacts associated with installed customer EE projects.

<sup>2</sup> Data (net energy savings) is updated from Tables 1 and 2 of the Energy Efficiency Program Portfolio Annual Report for 2006, filed with the CPUC on November 15, 2007.

<sup>3</sup> Net actual energy savings, as measured against net energy savings goals for 2006 through 2008 established in CPUC Decision 04-09-060.

<sup>4</sup> Data (net energy savings) is updated from Tables 1 and 2 of the Energy Efficiency Program Portfolio Annual Report for 2007 and 2008, both filed with the CPUC on May 1, 2009.

<sup>5</sup> Data (gross energy savings) is derived from the 2009 4th Quarter Report to the CPUC, dated March 26, 2010. The gross energy savings are measured against gross energy savings goals for 2009 through 2012 established in CPUC Decision 09-09-047. Prior to 2009, energy savings were measured in “net” energy savings.

<sup>6</sup> Data (gross energy savings) is taken from Table 1 of the 2010 Energy Efficiency Annual Report, filed with the CPUC on May 2, 2011.

**Table 5-3: Lifecycle Energy Savings From EE Programs**

<b>Lifecycle<sup>1</sup> Energy Savings From Customer Energy Efficiency Programs</b>					
	<b>2006 Actual Savings<sup>2,3</sup></b>	<b>2007 Actual Savings<sup>3,4</sup></b>	<b>2008 Actual Savings<sup>3,4</sup></b>	<b>2009 Actual Savings<sup>5</sup></b>	<b>2010 Actual Savings<sup>6</sup></b>
Gigawatt-hours (total)	5,644	16,530	26,625	14,354	19,670
Million Therms	128	376	643	484.2	352.5

<sup>1</sup> Lifecycle energy savings refer to the estimated EE savings over the expected lifetime of the installed CEE projects.

<sup>2</sup> Data (net energy savings) is updated from Tables 1 and 2 of the Energy Efficiency Program Portfolio Annual Report for 2006, filed with the CPUC on November 15, 2007.

<sup>3</sup> Net actual energy savings, as measured against net energy savings goals for 2006 through 2008 established in CPUC Decision 04-09-060.

<sup>4</sup> Data (net energy savings) is updated from Tables 1 and 2 of the Energy Efficiency Program Portfolio Annual Report for 2007 and 2008, both filed with the CPUC on May 1, 2009.

<sup>5</sup> Data (gross energy savings) is derived from the 2009 4th Quarter Report to the CPUC, dated March 26, 2010. The gross energy savings are measured against gross energy savings goals for 2009 through 2012 established in CPUC Decision 09-09-047.

<sup>6</sup> Data (gross lifecycle energy savings) is taken from Table 1 of the 2010 Energy Efficiency Annual Report, filed with the CPUC on May 2, 2011.



**Table 5-4: Annual Avoided Emissions From EE Programs**

Annual <sup>1</sup> Avoided Emissions from Customer Energy Efficiency Programs					
	2006 <sup>2</sup>	2007 <sup>3</sup>	2008 <sup>3</sup>	2009 <sup>4</sup>	2010 <sup>5</sup>
CO <sub>2</sub> Avoided (metric tons)	47,482	977,342	1,561,350	595,178	1,020,885
NO <sub>x</sub> Avoided (tons)	7	185	307	167	215

<sup>1</sup> Annual energy savings refer to the first-year impacts associated with installed customer EE projects.

<sup>2</sup> Data (net energy savings) is updated from Tables 1 and 2 of the Energy Efficiency Program Portfolio Annual Report for 2006, filed with the CPUC on November 15, 2007.

<sup>3</sup> Data (net energy savings) is updated from Tables 1 and 2 of the Energy Efficiency Program Portfolio Annual Report for 2007 and 2008, both filed with the CPUC on May 1, 2009.

<sup>4</sup> Data (gross energy savings) is derived from the 2009 4th Quarter Report to the CPUC, dated March 26, 2010. The gross energy savings are measured against gross energy savings goals for 2009 through 2012 established in CPUC Decision 09-09-047. Prior to 2009, energy savings were measured in “net” energy savings.

<sup>5</sup> Annual tons of CO<sub>2</sub> and NO<sub>x</sub> Avoided are taken from Table 2 of the 2010 Energy Efficiency Annual Report, filed with the CPUC on May 2, 2011; an update was filed in June 2011.

**Table 5-5: Lifecycle Avoided Emissions From EE Programs**

Lifecycle <sup>1</sup> Avoided Emissions from Customer Energy Efficiency Programs					
	2006 <sup>2</sup>	2007 <sup>3</sup>	2008 <sup>3</sup>	2009 <sup>4</sup>	2010 <sup>5</sup>
CO <sub>2</sub> Avoided (metric tons)	595,840	9,402,316	15,681,699	6,847,629	10,657,916
NO <sub>x</sub> Avoided (tons)	85	2,093	3,653	2,583	2,896

<sup>1</sup> Lifecycle energy savings refer to the estimated EE savings over the expected lifetime of the installed CEE projects.

<sup>2</sup> Data (net energy savings) is updated from Tables 1 and 2 of the Energy Efficiency Program Portfolio Annual Report for 2006, filed with the CPUC on November 15, 2007.

<sup>3</sup> Data (net energy savings) is updated from Tables 1 and 2 of the Energy Efficiency Program Portfolio Annual Report for 2007 and 2008, both filed with the CPUC on May 1, 2009.

<sup>4</sup> Data (gross energy savings) is derived from the 2009 4th Quarter Report to the CPUC, dated March 26, 2010. The gross energy savings are measured against gross energy savings goals for 2009 through 2012 established in CPUC Decision 09-09-047. Prior to 2009, energy savings were measured in “net” energy savings.

<sup>5</sup> Lifecycle tons of CO<sub>2</sub> and NO<sub>x</sub> Avoided are taken from Table 2 of the 2010 Energy Efficiency Annual Report, filed with the CPUC on May 2, 2011; an update was filed in June 2011.

**Table 5-6: Annual Energy Savings Goals From EE Programs**

Annual <sup>1</sup> Energy Savings Goals from Customer Energy Efficiency Programs				
	2010 Goal <sup>2</sup>	2011 Goal <sup>2</sup>	2012 Goal <sup>2</sup>	2010-2012 Goal <sup>2</sup>
Megawatts (peak)	218	234	251	703
Gigawatt-hours (total)	964	1,032	1,114	3,110
Million Therms	15.6	16.2	17.1	48.9

<sup>1</sup> Annual energy savings refer to the first-year impacts associated with installed CEE projects.

<sup>2</sup> CPUC Decision 09-09-047 established gross energy savings goals for 2009 through 2012.

Moving forward, PG&E is focusing EE programs even more on the customer—from how programs are designed to how they are ultimately delivered. Doing so will give customers greater control of their own energy use and more opportunities to save energy and money. While EE programs generally do not explicitly depend on a “smart grid,” there is increasing reliance on the grid and grid automation efforts to develop and deliver new EE programs. Specifically, the 2010-2012 EE programs will implement a number of innovative strategies to better integrate EE with other clean energy solutions, such as DR, customer-owned solar, and emerging home energy networks technologies. For example, PG&E will implement a new statewide program to reward customers for shifting from simply replacing a single appliance to adopting “whole house” energy-saving retrofits. This \$100 million statewide program aims to reduce energy use by 20 percent in 130,000 homes through the end of 2012 by encouraging customers to take comprehensive energy-saving steps such as installing air sealing, insulation; Heating, Ventilation and Air Conditioning; lighting and high-efficiency appliances. PG&E is also strengthening its coordination with California’s other investor-owned utilities to standardize key statewide EE offerings and incentives—making it easier for customers to participate while improving program efficiency from economies of scale.

## **5.5 Demand Response**

PG&E’s DR programs are designed to enable customers to contribute to energy load reduction during times of peak demand. These programs are an important mechanism to improve transmission and distribution system reliability and avoid building new peaking power plants. Customers also receive financial benefits from better managing their usage and reducing peak carbon emissions.

PG&E offers a variety of DR programs, which vary based on how much electricity a customer can reduce and how quickly they can respond to requests to reduce energy use, among other factors. These include Demand Bidding Program (DBP), Base

Interruptible Program (BIP), Aggregator Managed Portfolio, Capacity Bidding Program, Automated Demand Response (AutoDR), and Technology Incentive (TI). The programs operate in a variety of ways, ranging from cycling residential air conditioning units on and off, to fully automated “load shedding” strategies controlled by computers, to emergency programs where large industrial customers voluntarily reduce their electricity demand in less than an hour.

PG&E’s DR programs can be generally categorized in two groups—tariff based or energy contribution based. In both cases, customers benefit financially by reducing consumption during peak periods by either avoiding paying for electricity at a premium rate or in the form of an incentive for their participation. Most DR programs offer financial incentives for business owners who curtail their facility’s energy use during times of peak demand. PG&E offers additional incentives for DR-enabling technologies, which allow customers to automatically respond to a DR event, improving the program’s effectiveness. Other platforms such as Home Area Network and programs offered via web communications are being developed and implemented to expand and support these DR programs.

PG&E’s DR programs have performed very well historically. The energy savings in 2010 from all programs were nearly 3 million kilowatt-hours (kWh). The programs also avoided the need for 692 MW of power generation capacity in 2010, which was slightly slower than the 2010 target, but higher than the 500 MW of load reduction in 2009. PG&E expects its DR capability to grow by more than 250 MW by 2011.

**Table 5-7: 2010 DR Load Reduction**

<b>Impact of PG&amp;E’s DR Programs</b>		
	<b>2010 Actual</b>	<b>2010 Target</b>
Load Reduction (MW)	692	766

The following is a list of the DR programs offered by PG&E to date:

### **5.5.1 PeakChoice™**

Occasional sharp increases in demand for electricity affect all California businesses. While instances of high demand and short supply are rare, finding fiscally and environmentally responsible ways to deal with peak demand is everyone's responsibility. The PeakChoice™ program puts the customers in control of choices and options that let them customize their contribution to power reliability.

### **5.5.2 Base Interruptible Program**

The BIP pays the customers incentives to reduce their facilities' load to or below a level that is pre-selected by them. This pre-selected level is called the Firm Service Level (FSL). BIP gives the customers 30 minutes advance notice, and pays between \$8.00/kW to \$9.00/kW per month incentive. BIP provides a monthly incentive payment to the customer even if no events are called. However, failure to reduce load down to or below the FSL during an event will result in a charge of \$6.00/kWh for any energy use above the FSL.

### **5.5.3 Demand Bidding Program**

The DBP pays an incentive to reduce electric load when notified of a DR event day by PG&E. This is a relatively low-risk DR program that allows the customers to submit load reduction bids for a DBP event, which can be called on a day-ahead or day-of basis. For any event, the customer may elect to submit or not submit a bid. If bid is submitted, the customer can still choose to forgo reducing electric load without penalty. The bid must be for a minimum of two consecutive hours within the planned event window and must meet a minimum reduction of 50 kW each hour.

#### **5.5.4 Aggregator Programs**

Acting as intermediaries between the customer and PG&E, aggregators offer DR program options not available through PG&E. Aggregators are independent third parties authorized to work with PG&E to reduce the state's energy usage during periods of peak demand, high wholesale-electrical prices, system constraints, and emergencies.

#### **5.5.5 SmartAC™ Program**

The SmartAC™ Program offers customers an opportunity to help prevent summer energy supply emergencies from disrupting their day-to-day operations. In the SmartAC™ Program, PG&E will install a free SmartAC™ thermostat to help customers manage their heating and cooling needs year round. If there is an energy supply emergency, between May 1 and October 31, the SmartAC™ device will receive a signal to use slightly less power to help avoid power interruptions. Figure 5-6 illustrates the impact of a SmartAC™ event.

Joining the SmartAC™ program empowers customers in doing their part to help prevent power interruptions in their communities. And, if an event is called at an inconvenient time, customers do have the option to opt-out and easily return their air conditioner to its normal settings.

**Figure 5-6: Sample Impact of a SmartAC™ Event**



### 5.5.6 Technology Incentive Program

The TI program provides incentives to customers for the installation of recommended DR-enabling technologies while participate in PG&E’s DR programs such as PDP, PeakChoice, and DBP. In this program, PG&E pays participants \$125/kW of peak load reduction achieved, up to 50 percent of the project cost. Customers who participate in PG&E’s AutoDR program may receive an additional \$125/kW (a total of \$250/kW), up to 100 percent of the project cost.

### 5.5.7 Automated Demand Response Program

The AutoDR program is a type of enabling technology incentive program that utilizes a communications infrastructure to transmit customers’ DR signals to PG&E and implements load reductions automatically through their facility’s energy management and control system. Customers are provided with funds to pre-program their energy management and control systems. Automatically, PG&E sends a signal via the Internet

to these energy control systems during times of high electricity prices or system emergencies, which initiates a series of pre-programmed, pre-authorized demand reduction strategies.

PG&E's role in the AutoDR program is to provide the platform that facilitates the integration of the enabling technology (acquired by the customer) and DR event management system and to financially incent customers based on their achieved load reduction.

### **5.5.8 Permanent Load Shift**

The purpose of this program, often referred to as "Shift & Save," is to store thermal cooling capacity during off-peak hours and/or partial-peak hours in order to meet thermal cooling load in subsequent on-peak hours. The program's targeted customers are bundled service, commercial, industrial, agricultural and large residential customers in PG&E's electric service territory. Permanent Load Shift (PLS) consists of two implementers: Cypress Ltd. and Trane USA. Even though a PG&E Program Manager is responsible for overseeing the program, the full responsibility for administering the proposed program and delivering the actual load shift results, relative to an established baseline, rests with the implementer.

## **5.6 Distributed Generation**

PG&E plays an important role in assisting customers who choose to integrate solar and other alternative energy sources at their homes and businesses. By administering the CSI, PG&E is helping to achieve California's goal to create 3,000 MW of new, customer-installed solar capacity by December 2016, moving the state toward a cleaner energy future and helping to lower the cost of solar installations for customers. Other incentives for solar water heating, fuel cells and wind systems give PG&E a full offering of customer distributed generation programs.

With the improving economics of renewable and other on-site generation (Distributed Generation, or DG) and increasing energy costs, more customers are seeking to install generators that interconnect to the grid to reduce the amount of power they purchase from the utility. For the purposes of PG&E's DG programs and most statewide DG policies, DG is defined as generation that is: (1) on the customer side of the meter; (2) primarily offsets customer load; and (3) is connected at distribution voltages (and therefore typically less than 5 MW). Many innovative technologies and initiatives (e.g., islanding and energy storage) are being developed in this market to expand the applicability of DG. Critical to managing grid reliability with the proliferation of on-site generation is the ability to forecast, monitor and control integration of these devices into the grid. PG&E already manages a number of programs that support DG integration and anticipates accelerating growth in these and other similar programs. Specifically, these programs include:

### **5.6.1 California Solar Initiative**

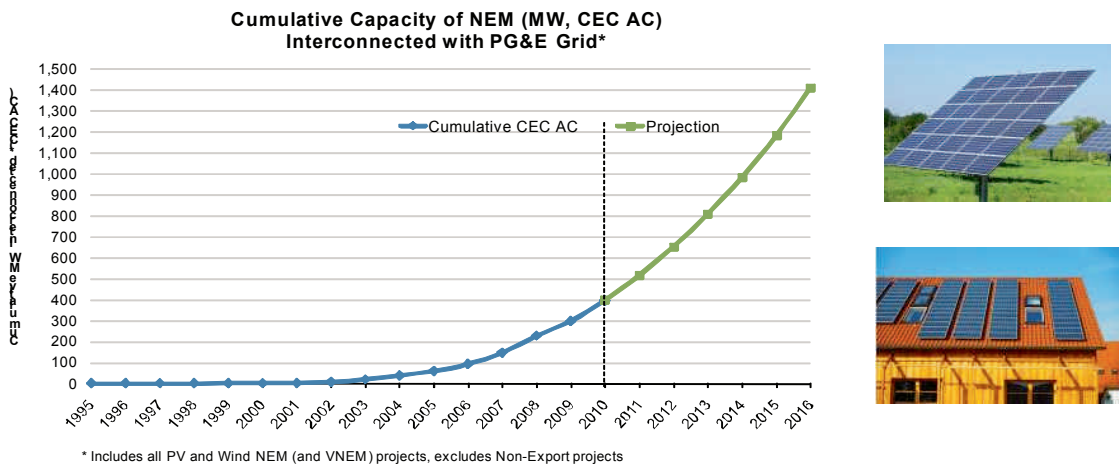
PG&E administers the CSI in its service territory to support customer-side distributed solar photovoltaic (PV) generation. PG&E supports the CSI via “direct” program administration—including incentive processing, CSI-funded marketing and outreach, CSI-funded measurement and evaluation—and via “indirect” support of the program and DG in general, including interconnection services, call centers, training opportunities (e.g., classes, webinars).

In 2010, PG&E interconnected more than 10,000 customer-owned solar PV systems to the electric grid. This brought the total to more than 45,000 interconnected solar systems at the end of 2010 (Figure 5-7), more than any other utility in the U.S. In fact, these customers represent roughly 35 percent of the country's solar installations, while PG&E serves about 5 percent of the U.S. population.



Through the CSI program, PG&E has the potential to provide more than \$760 million in solar rebates to customers over a 10-year period. Through 2010, PG&E awarded approximately \$411.6 million for a cumulative total installation of 220 MW.<sup>4</sup> PG&E continues to work collaboratively with regulators, the other program administrators and key industry stakeholders on options to ensure the goals of the program can be met.

**Figure 5-7: More Than 45,000 PG&E Customers Have Onsite Solar Generation**



### 5.6.2 Self-Generation Incentive Program

PG&E administers the SGIP in its service territory to support customer-side distributed DG (excluding PV). PG&E supports the SGIP via “direct” program administration—including incentive processing, SGIP-funded marketing and outreach, SGIP-funded measurement and evaluation—and via “indirect” support of the program and DG in general, including interconnection services, call centers, training opportunities (classes,

<sup>4</sup> All customer solar interconnection to date total 490 MW, which includes all installations administered from the CSI program and past incentive programs. Prior to January 2007, customer-side solar was administered through the Self-Generation Incentive Program (SGIP) (for systems > 30 kW) and the California Energy Commission’s (CEC) Emerging Renewables Program (systems < 30 kW). The 490 MW also includes customers that did not receive incentives, and PV systems/customers that are on or not on Net Energy Metering (NEM).

webinars), etc. As of December 2010, PG&E has completed nearly 700 projects (169 MW) with an additional 127 projects underway.

### **5.6.3 Net Energy Metering**

PG&E offers NEM to customers with DG. Various forms of NEM are available, depending on the DG technology and system size, including Standard NEM (for “small” PV and wind systems), Expanded NEM (for larger PV and wind systems), net energy metered biodigesters (biofuel technologies), Net Energy Metering for Fuel Cell Customers-Generators (fuel cell technologies), and net energy metering-multiple tariff (for facilities with multiple DG technologies). Customer benefits vary by NEM type, but generally, customers on NEM tariffs benefit by receiving: (1) credits for energy exported to the grid; (2) reduced or eliminated interconnection study fees; and (3) reduced or eliminated non-bypassable charges. NEM policy will continue to provide incentives for expansion of DG deployment that will require Smart Grid capability to integrate the various technologies contemplated.

### **5.6.4 DG Policy and Operational Activities**

PG&E is actively participating in the various DG policy discussions at the legislature and the CPUC, and has a department whose sole mission is to provide interconnection services. The Company continues to prepare for the proliferation of DG installations, and the Smart Grid investments are critical to managing grid reliability as these efforts continue.

Typically, DG systems are not directly “visible” to PG&E, and PG&E cannot integrate the output of these systems into its daily grid operations. Historical DG performance data are in some cases available to PG&E and can be used to inform long-term planning, but are not useful for shorter-term (or real-time) horizons. Smart Grid monitoring and control capability can provide for better visibility of DG resources, allowing more to be connected to the grid without compromising system performance.

Furthermore, PG&E is engaged in internal and external research (e.g., through projects funded by the CSI Research, Development and Demonstration Program) to increase understanding of penetration limits and optimal mitigation strategies. Future Smart Grid capabilities, such as Volt/VAR optimization based on voltage readings from SmartMeters™, may facilitate increased accommodation of DG on the electric grid.

## **5.7 Electric Vehicle Readiness**

In anticipation of a steady adoption of Plug-in Electric Vehicles (PEV) in PG&E's service territory (Figure 5-8), PG&E has been engaged in a number of activities to support grid readiness for PEVs. Different types of PEV charging equipment have different voltage requirements and load impacts, which varies by manufacturer and vehicle model. PG&E is preparing to ensure compatibility with these different PEV makes and models, and that the PG&E infrastructure is ready to handle the potential clustering of EVs. Specific efforts underway include the following:

PG&E continues to monitor and evaluate technology developments in the PEV industry, both for technical feasibility and to validate the vehicle/charging station business model. Figure 5-9 illustrates a model of Smart Charging for electric vehicles. In addition, PG&E is embarking on a Multi-unit Dwelling (MUD) project with the city of San Francisco and an Electric Vehicle Supply Equipment vendor to assess the MUD landscape and ultimately create a standard installation guide for MUDs which will serve as PG&E's baseline for municipal/Home Owner Association education and outreach on MUD installations. Further, PG&E is active in the standards development process co-led by the utilities and automakers under the organizations such as National Institute of Standards and Technology, Society of Automotive Engineers, and the Electric Power Research Institute Infrastructure Working Council. PG&E monitors the evolution of technologies that would allow vehicle-to-home and vehicle-to-grid applications in the future.

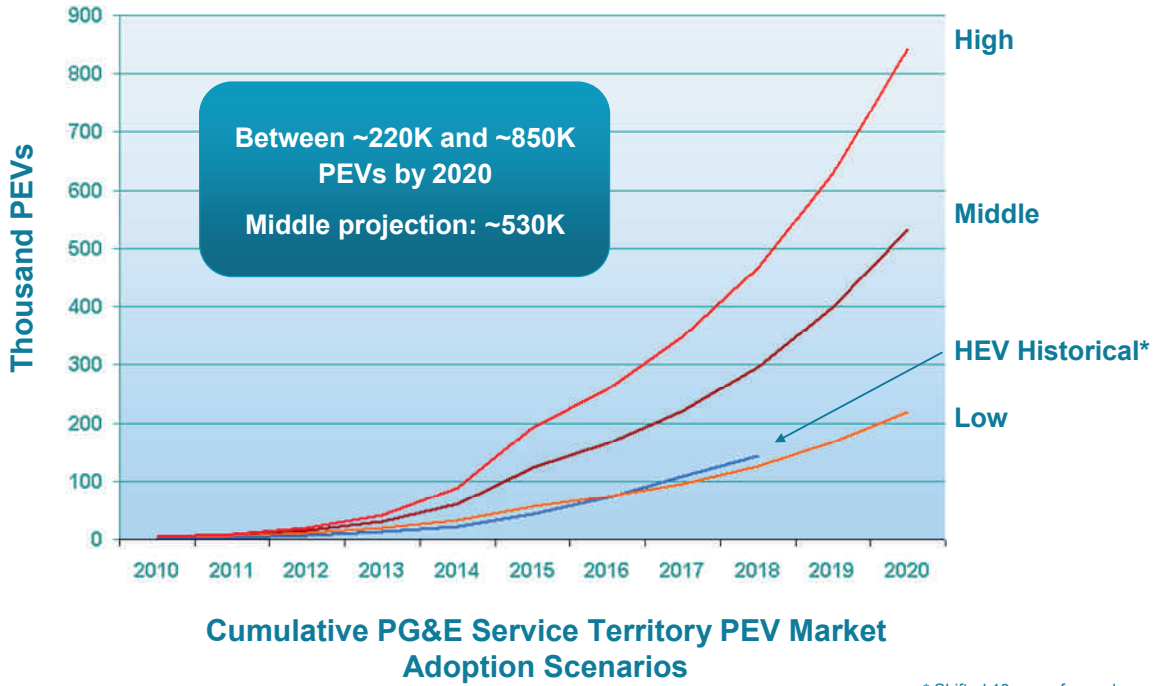
PG&E is actively involved in the CPUC's ongoing Alternative-Fueled Vehicle Order Instituting Rulemaking proceeding (R.09-08-009). Phase 1 determined that private charging companies will not be regulated as utilities. Phase 2 is currently in process to determine the role of the utility beyond the meter, utility ownership (or not) of submeters, submeter protocol and electric vehicle charging rates. PG&E is beginning work to develop rates as part of its customer readiness work, as described below.

PG&E is preparing its operations to make it simple for customers to set up home charging equipment. This includes training and process management in affected departments including the contact centers, service planning, metering, account management, and distribution engineering. Further, PG&E is working with major automakers on a notification process that shares customer address information while protecting customer privacy so the local distribution transformer can be checked prior to the customer obtaining the PEV. In addition, PG&E is working with the four other major California utilities and legislative partners as part of the California PEV Collaborative on ways to develop a scalable, cost-effective process across the state. PG&E has developed easy-to-understand materials for customers, updated its website, and created an online rate calculator tool (also used by the customer service representatives at PG&E's customer contact centers) that helps customers analyze their current costs of electricity and gasoline and how different EV service options will save them money.

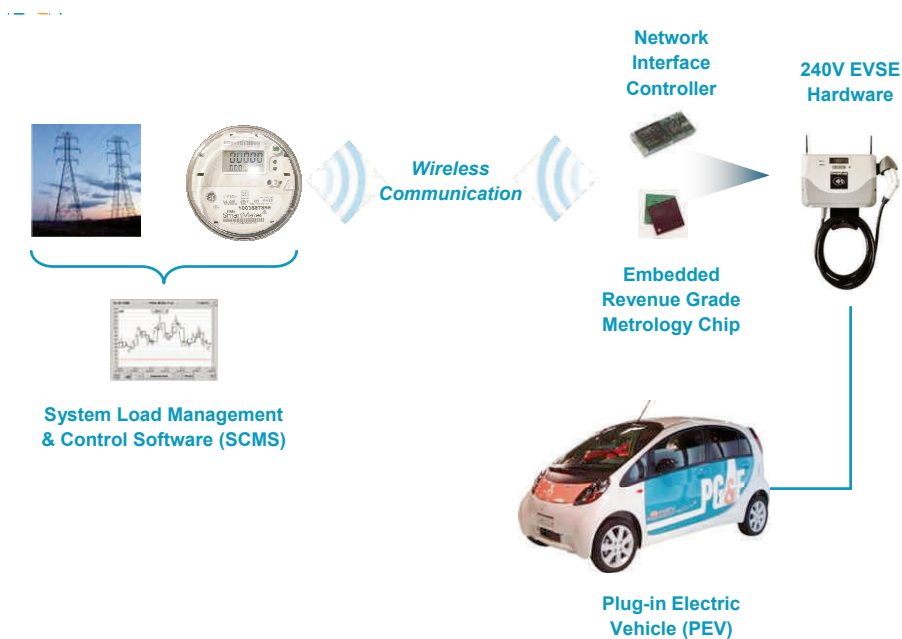
PG&E is very active at the local, state, and federal level with various PEV groups. This includes the Bay Area EV Strategic Council, the California PEV Collaborative, and the Electric Drive Transportation Coalition. PG&E has also partnered with stakeholder groups including automakers, policy makers (e.g., CEC, CPUC), legislators, civic leaders, environmental groups (e.g., National Resources Defense Council, Friends of the Earth), and technology startups. Lastly, in partnership with the other California electric utilities,

PG&E continues to communicate to cities, counties, and municipal coalitions to educate them on the numerous facets of electric vehicles.

**Figure 5-8: PG&E Is Preparing Its Grid Infrastructure to Handle Increasing Consumer Adoption of EVs in the Next 10 Years**



**Figure 5-9: PG&E Is Monitoring and Evaluating EV Smart Charging Technology Developments**



## 5.8 Empowering Communities

PG&E seeks to empower communities and engage them to participate in PG&E's customer programs and Smart Grid initiatives. One such means of empowering communities to adopt new technologies is helping them install highly efficient, light-emitting diodes (LED) streetlights, which use 50 percent less electricity and last up to five times longer. More than 20 cities have worked with PG&E to convert their streetlights to LEDs. Through the program, PG&E offers incentives to customers in its service area who own and maintain streetlights and are on its LS-2 rate. Customers who replace or upgrade their existing streetlights with new PG&E-approved LED streetlights are eligible for lower pricing and rebates. In 2010, 10 cities converted more than 3,900 streetlights to LED, saving more than 1.3 million kWh per year and resulting in rebates of nearly \$700,000.

PG&E also takes special measures to reach out to customers that have been affected by the distressed economy and have struggled to remain current with their bills, including

their energy bills. For example, PG&E's Energy Partners program currently offers income-qualified customers free energy education, weatherization measures and energy-efficient appliances to reduce gas and electric usage. Through the program, certified contractors install attic insulation, replace doors, provide weather stripping and make other minor home repairs, concluding with a home safety inspection.

PG&E also provides options such as the Single-Family Affordable Solar Housing Program, and the Multifamily Affordable Solar Housing Program for low income and linguistically isolated communities. PG&E currently provides information on all its programs in multiple languages and intends on further developing solutions for linguistically isolated communities. As the Smart Grid evolves, PG&E is committed to continuously reaching out to these groups to leverage the Smart Grid in innovative ways, such as taking advantage of EE, DR programs, and solar generation incentives to cost-effectively create sustainable, green communities.

## **5.9 Conclusion**

PG&E has a long history of offering innovative programs and services to help customers save energy and money, beginning with PG&E's groundbreaking EE programs that launched in the 1970s. Today, PG&E offer customers a full portfolio of options, including some of the nation's leading programs and incentives for EE, DR, and solar installation. PG&E is also actively assisting the growing number of customers who are purchasing PEVs to connect to the grid and charge their vehicles safely and efficiently.

In this chapter, PG&E has outlined six program areas which it terms as Smart Grid-related. While not directly considered to be Smart Grid baseline investments, these programs are fundamentally aligned with the objectives pursued by PG&E's Smart Grid vision, specifically in the areas of customer empowerment, enabling flourishing markets, and creating a more energy efficient, renewable energy based future.

By actively learning from its customers, PG&E will continue to develop additional programs that will leverage the Smart Grid infrastructure and allow for more empowered customers, a better integration of DG resource and EVs, and a positive environmental impact.



## **Chapter 6 – Smart Grid Roadmap**

## **6.1 Introduction**

The Smart Grid Roadmap describes the high-priority Smart Grid initiatives and projects that PG&E intends to consider and implement over the next ten years consistent with its Smart Grid Vision and Strategy. These priority initiatives are grouped by the previously-described four program areas – Engaged Consumers, Smart Energy Markets, Smart Utility, and Foundational and Cross Cutting Infrastructure. In total, PG&E has identified 21 projects and initiatives that will enable PG&E to advance the strategic objectives and vision of the Smart Grid.

## **6.2 Proposed High Priority Smart Grid Roadmap Projects – Selection Criteria**

PG&E's Roadmap is based on analysis of PG&E's current capabilities and operating needs against the strategic objectives PG&E seeks to achieve on the journey towards the Smart Grid. PG&E examined its current utility infrastructure, business process maturity, organizational know-how, and cost effectiveness to identify and select the set of projects that were deemed to yield the most benefits for customers and markets while also advancing California's energy and environmental policy goals, including operating sustainably, providing its customers with more choices and control over their energy consumption, and reducing PG&E's environmental "footprint" over the short-term and long-term. Specifically, these policy goals have a significant focus on green house gas emission reduction through customer choice, DR, EE and integration of renewables.

Many of these projects fall under the umbrella of implementing innovative new technologies that allow greater transparency and integration between the utility, its customers and energy markets. Examples include enhancing existing distribution assets with new computerized sensing equipment to self-identify and correct status changes in those assets before they impact the customer. Other examples include implementing a new energy delivery infrastructure to effectively integrate renewables and new energy

markets into the grid without compromising the grid's overall reliability, safety, or efficiency.

In total, PG&E has identified 21 new high-priority Smart Grid initiatives that build upon the deployment baseline described in the previous chapters as well as provide incremental benefits for customers, markets and society. Of those 21 initiatives: four proposed investments directly support the Engaged Consumers program area; two proposed investments support Smart Energy Markets; eight proposed investments support the Smart Utility area; and the remaining seven proposed investments support Foundational and Cross-Cutting Infrastructure initiatives necessary to create the robust foundation for the Smart Grid.

The drivers and benefits associated with the 21 initiatives and projects are those identified in PG&E's Smart Grid Vision and Strategy. PG&E took this fact into account when evaluating these projects against other possible projects and in performing high level preliminary cost and benefit calculations for each project. Many of the high priority projects respond to the same or similar drivers and deliver the same or similar categories of benefits. For example, the demand response (DR) projects cut across the Engaged Consumers, Smart Energy Market and Smart Utility program areas. PG&E reviewed all potential DR projects together to avoid the double counting of costs and benefits and to provide as accurate as possible comparison for purposes of the identifying projects for the PG&E Smart Grid Deployment Plan.

PG&E has applied a pragmatic approach to selecting these high-priority projects. As some Smart Grid technologies are still relatively new and yet to be proven in large operating environments, PG&E has selected a number of Smart Grid enabling projects that are most appropriate to PG&E's environment and that seek to minimize the inherent risks associated with new technology by phasing the deployment of the technologies and projects. In fact, several of PG&E's foundational initiatives are

designed specifically to implement foundational changes in PG&E’s systems and processes at the outset, in order reduce the risks of new technologies that may still need to be proven through laboratory or pilot testing. For example, PG&E’s Foundational initiatives would increase its ability to conduct pilots in a simulated production environment and also to first develop and deploy information, security and telecommunications architecture and data standards that enable overall Smart Grid technology interoperability and integration.

PG&E has also assessed the impact of the high-priority projects on its operating environment, its needs for a diverse and technology-savvy workforce as well as the needs of PG&E customers to understand and take advantage of the new technologies and empowerment presented by the projects. The importance of internal alignment, educational outreach, training and customer awareness are critical to achieving success on PG&E’s high priority Smart Grid projects and maximizing the benefits of the Smart Grid generally. A description of some of these key foundational and supporting initiatives, including customer education and outreach and workforce development, is summarized at the end of this chapter.

### 6.3 Proposed Smart Grid Roadmap Projects by Program Area

PG&E’s 21 new proposed Smart Grid projects fall into the following four program areas identified in PG&E’s Vision and Strategy:

**Table 6-1: PG&E Proposed Smart Grid Projects by Program Area**

Program Area	Summary of Smart Grid Initiatives	# of Projects
Engaged Consumers	Increase customer participation, choice and empowerment in energy related decisions through initiatives providing access to energy usage data, more effective DR integration, expanded Home Area Network (HAN) two-way communications, applications to support new DR options and options for electric vehicle load control and integration, and other efforts aimed at increasing energy data exchange and interoperability. These initiatives are intended to not only serve customers sustainably and cost effectively, but also to support	4

Program Area	Summary of Smart Grid Initiatives	# of Projects
	development of new energy service offerings by third party providers.	
Smart Energy Markets	Improve energy market efficiency by incorporating “bottoms up” energy measurements available from SmartMeters™ and distribution system data acquisition points to improve energy procurement and dispatch forecasting in day ahead and real time energy and A/S markets. These initiatives will enhance and inform current “top down” system-level and California Independent System Operator (CAISO) forecasts with the net potential benefits of reducing traditional energy procurement costs, expanding renewable energy sources and their integration, and reducing traditional electricity generation and its related environmental impact.	2
Smart Utility	Implement advanced control techniques, telecommunications and technology into the existing grid to improve safety, reliability, security and operational efficiency. These initiatives help create the modernized, intelligent grid that embeds energy and environmental policy objectives into the fabric of the grid infrastructure. For example: the reliable integration of more distributed and renewable resources, net reduction of electricity use and corresponding reduced environmental impact.	8
Foundational and Cross-Cutting Infrastructure	Deploy foundational infrastructure and processes to support the Engaged Consumer, Smart Energy Markets and Smart Utility program areas. These initiatives include developing rigorous testing and evaluation capabilities to “de-risk” Smart Grid technologies before they are deployed; creating a more secure and robust telecommunications, data and network architecture to support the Smart Grid; and workforce development and customer outreach programs necessary to the safe and successful development of the Smart Grid.	7

A description of the specific projects and initiatives within each program area is provided below. The scope, costs and benefits of the projects are preliminary and subject to further development and refinement in connection with specific applications and requests PG&E may file at the CPUC and Federal Energy Regulatory Commission (FERC) in the future to seek approval and cost recovery for the projects and initiatives.

## 6.4 Proposed Smart Grid Roadmap High Priority Projects – Engaged Consumers

PG&E is proposing projects that will empower consumers, enable more energy choices and reduce energy use and environmental impacts by improving and integrating DR and pricing programs into consumer decision making. These programs would be used to reduce peak loads in the PG&E system, both across large geographic regions as well as in localized neighborhoods. This is particularly important in the context of other Smart Grid initiatives that have the potential to significantly alter current energy use patterns and demand (for example, integration of intermittent energy sources and electric vehicle charging), and even climate changes that impact load on the grid. PG&E’s Engaged Consumer initiatives will help to increase transparency between customers and the utility while enabling better accuracy in forecasting and managing demands on the grid and energy resources, helping increase system-wide and regional energy reliability and efficiency in the future Smart Grid environment.

The table below summarizes PG&E’s Engaged Consumer projects.

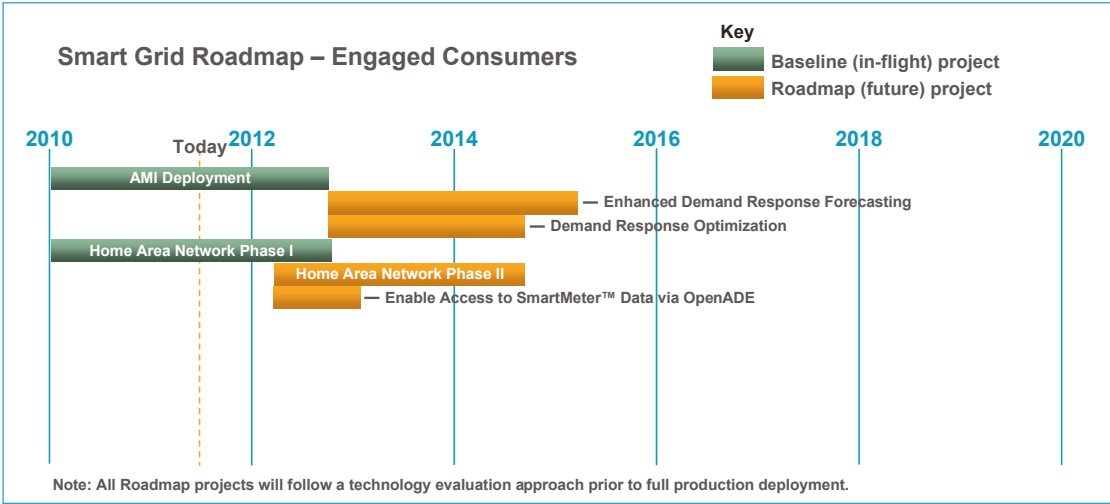
**Table 6-2: PG&E’s Engaged Consumers Projects**

Project #	Project Name	Summary Description
1	Integration of Enhanced DR Forecasting	Integrate improved, best-available sources of load data such as weather, consumer end uses, customer information and meter data to improve accuracy of DR forecasting and dynamically forecast based on more predictable customer response to DR events.
2	DR Optimization	Develop a DR optimization engine that combines demand side resource data and improved forecasts with generation cost and availability information to more intelligently and cost effectively dispatch DR resources tailored to electric needs while maximizing the value of available DR programs.
3	HAN Phase II – Pricing and Load Control Signals	Enable customers to more effectively participate in time-variant pricing, energy efficiency and DR programs and manage their consumption through automation and improved energy usage information. Create the ability for PG&E to provide price and load control signals to customers and directly to Electric Vehicle charging equipment and various smart appliances to support customer selected control options potentially

Project #	Project Name	Summary Description
		reducing costs for consumers, improving system reliability and reducing the environmental impacts of unnecessary electricity generation.
4	Enable Access to SmartMeter™ data via Open Automated Data Exchange (OpenADE)	This project will enable customer controlled and authorized third party access to PG&E customer meter consumption data, including energy usage data through the use of OpenADE standards. PG&E will develop a gateway and set of standards-based interfaces that facilitate third party access to customer usage information to support the offering of new, third-party energy services, increase customer control over their energy usage and potentially reduce customer energy costs.

The preliminary schedule for initiation and deployment of these projects is depicted in the following Roadmap.

**Figure 6-1: Smart Grid Roadmap — Engaged Consumers**



The following narratives provide a description of each of the Engaged Consumers projects and its benefits, key drivers, considerations and proposed project timeline.

**Table 6-3: Engaged Consumers Project #1 – Enhanced DR Forecasting**

Engaged Consumers Project #1 – Enhanced DR Forecasting
<p><b>Description:</b></p> <p>This project proposes to enhance DR Forecasting through the development and implementation of an integrated forecasting model incorporating factors and features such as the following:</p> <ul style="list-style-type: none"> <li>• Integration of actual DR event measurements from a sample of near real-time SmartMeter™ data with weather, customer approved HAN usage measurements, customer automation, and DR program features into DR forecasting algorithms.</li> <li>• Improved local DR forecast granularity to inform energy procurement decisions (DR resource availability, duration and price) and transmission and distribution (T&amp;D) decisions (DR resource availability by circuit and substation, amount, duration and time) for use in day ahead and real time energy and ancillary service markets and T&amp;D contingency or to avoid outages.</li> <li>• Development and implementation of a dynamic validation model to measure response of DR events and improve certainty of response of DR programs and resources.</li> </ul> <p>The proposed solution would be a new forecasting engine with feedback from SmartMeter™ and other demand measurement systems allowing PG&amp;E to create forecasts dynamically and under different baseline assumptions.</p>
<p><b>Benefits:</b></p> <p>Reduction in consumer costs resulting from:</p> <ul style="list-style-type: none"> <li>• Improved bidding in CAISO energy and A/S markets</li> <li>• Improved energy bidding during scarcity pricing events in the CAISO markets</li> <li>• Improved effectiveness of DR programs</li> </ul> <p>This project, together with Engaged Consumers Project 2 and Smart Utility Project 1 contribute to realizing the benefits described above.</p>
<p><b>Drivers:</b></p> <ul style="list-style-type: none"> <li>• Empower consumers to actively participate in the operations of the grid, generation and energy storage options.</li> <li>• Development and incorporation of DR, demand-side resources, and EE resources in energy markets.</li> <li>• Operate the grid more efficiently and sustainably.</li> <li>• Increased ability to achieve EE and DR goals.</li> <li>• Increase the use of digital information to allow consumers to actively participate in wholesale energy markets.</li> <li>• Enable integration of customer EVs.</li> </ul>
<p><b>Considerations:</b></p> <p>A variety of technology solutions need to be evaluated to provide the desired DR forecasting improvement including developing the new engine in-house, purchasing a stand-alone system, or purchasing a solution that is integrated with baseline technology projects such as the planned Distribution Management System (DMS) platform. A key consideration will be developing and implementing a solution that can build off existing systems as well as support future new functionality and evolving DR program offerings by PG&amp;E and third party providers. The implementation schedule for the Foundational initiatives is also a key consideration for success of the project and benefits realization.</p>
<p>Project Implementation Schedule: 2012 – 2015</p>



**Table 6-4: Engaged Consumer Project #2 – Demand Response Optimization**

Engaged Consumers Project #2 – Demand Response Optimization
<p><b>Description:</b>            Develop a Demand Response (DR) optimization engine that combines demand side resource data and improved forecasts with generation cost and availability information to more intelligently and cost effectively dispatch DR resources tailored to electric needs while maximizing the value of available DR programs.</p> <p>A DR optimization system can create DR events based on automated input from energy procurement and transmission and distribution (T&amp;D) systems to optimize the portfolio across the range of DR programs that meets the DR needs while maximizing the value of the specific DR program resource. The system would create a dynamically updated customer registry to optimize DR program delivery based on set criteria (for example, by type of program, geography, number of calls left and load opportunity).</p> <p>This project supports integration of DR programs in PG&amp;E’s energy procurement and T&amp;D operations allowing customer programs to play a role in bidding in the CAISO market, better tracking of resource availability, and addressing grid conditions.</p>
<p><b>Benefits:</b>            Reduction in consumer costs resulting from:</p> <ul style="list-style-type: none"> <li>• Improved bidding in CAISO energy and A/S markets</li> <li>• Improved energy bidding during scarcity pricing events in the CAISO markets</li> <li>• Improved effectiveness of DR programs</li> </ul> <p>This project, together with Engaged Consumers Project 1 and Smart Utility Project 1 contribute to realizing the benefits described above.</p>
<p><b>Drivers:</b></p> <ul style="list-style-type: none"> <li>• Empower consumers to actively participate in the operations of the grid, generation and energy storage options.</li> <li>• Development and incorporation of DR, demand-side resources, and EE resources in energy markets.</li> <li>• Operate the grid more efficiently and sustainably.</li> <li>• Achievement towards EE and DR goals.</li> <li>• Increase the use of digital information to allow consumers to actively participate in wholesale energy markets.</li> <li>• Enable integration of customer EVs.</li> </ul>
<p><b>Considerations:</b>            Similar to Engaged Consumers Project #1, a variety of technology solutions need to be evaluated to provide the desired DR operational improvement including developing the new engine in-house, purchasing a stand-alone system, or purchasing a solution that is integrated with baseline technology projects such as the planned Distribution Management System (DMS) platform. A key consideration will be developing and implementing a solution that can build off existing systems as well as support future new functionality and evolving DR program offerings by PG&amp;E and third party providers. The solution would be developed for dispatchable resources only.</p> <p>The implementation schedule for the Foundational initiatives is also a key consideration for success of the project and benefits realization.</p>
<p>Project Implementation Schedule: 2012 – 2014</p>

**Table 6-5: Engaged Consumer Project #3 – Home Area Network (HAN) Phase II – Pricing and Load Control Signals**

Engaged Consumer Project #3 – HAN Phase II – Pricing and Load Control Signals
<p><b>Description:</b>            Enable customers to better participate in time-variant pricing and DR programs and manage their consumption through automation and better information. This initiative will create the ability for PG&amp;E to provide price and load control signals to engaged consumers, as well as Electric Vehicles (EV) and various smart appliances that the customer may choose to adopt.</p> <p>PG&amp;E has identified three discrete projects in this area that build upon the HAN foundational platform to develop more significant customer offerings and expand the DR opportunities for residential and Small and Medium Business customers with HAN-enabled SmartMeters™.</p> <p>These projects include:</p> <ol style="list-style-type: none"> <li>(1) A technology assessment of HAN-enabled demand response functionality in a lab environment before implementing DR messaging at the production scale.</li> <li>(2) An enhanced information technology infrastructure to communicate event and pricing signals and direct load control signals; evaluate the benefits of these types of programs; obtain feedback and identify new program opportunities.</li> <li>(3) An evaluation of HAN-based electric vehicle charging equipment capability to respond to DR signals.</li> </ol> <p>The scope of this roadmap initiative expands and builds on HAN Phase I and the HAN-DR Integration project presented in the 2012-2014 DR Budget Application filing and identifies additional DR programs that leverage those new capabilities.</p>
<p><b>Benefits:</b>            The benefits of HAN phase II are:</p> <ul style="list-style-type: none"> <li>• Avoided capacity costs by enabling smart appliances (e.g. air conditioners, electric water heaters, dryers, etc.) and EVs to reduce their load impact in periods of high needs leveraging the HAN price / load control signals.</li> <li>• Supporting and integrating electric vehicle charging (in homes, businesses, etc.) and enabling customer-side energy management tools to optimize and reduce consumer electricity costs at the customer’s choice.</li> </ul>
<p><b>Drivers:</b></p> <ul style="list-style-type: none"> <li>• Empower consumers to actively participate in the operations of the grid, generation and energy storage options.</li> <li>• Development and incorporation of DR, demand-side resources, and EE resources in energy markets.</li> <li>• Operate the grid more efficiently and sustainably.</li> <li>• Increased ability to achieve EE and DR goals.</li> <li>• Increase the use of digital information to allow consumers to actively participate in wholesale energy markets.</li> <li>• Enable integration of customer EVs.</li> </ul>
<p><b>Considerations:</b>            This project relies on the active participation of empowered customers, appliance manufacturers and other third-party providers in enabling and making informed energy related choices. Steady adoption of HAN devices including smart home appliances will increase the benefits of these initiatives. In addition, policy decisions related to residential time-variant rates will further determine the benefits of these programs as well as potentially help drive adoption.</p>

Engaged Consumer Project #3 – HAN Phase II – Pricing and Load Control Signals
Industry approval and release of the Smart Energy Profile 2.0 standards, assessment of Advanced Metering Infrastructure communication channels for signals, and market development are also factors in the full-scale deployment and operation of HAN related programs.
The implementation schedule for the Foundational initiatives is also a key consideration for success of the project and benefits realization.
Project Implementation Schedule: 2012 – 2014

**Table 6-6: Engaged Consumer Project #4 – Enable Access to SmartMeter™ Data Via OpenADE**

Engaged Consumer Project #4 – Enable Access to SmartMeter™ Data Via Open OpenADE
<p><b>Description:</b> This project will enable customer controlled and authorized third-party access to PG&amp;E customer meter data, including energy usage data through the use of OpenADE standards. PG&amp;E will develop the gateway and set of interface standards that will facilitate third party participation in DR programs in an interoperable and transparent manner.</p>
<p><b>Benefits:</b> The benefits of providing universal access to SmartMeter™ data accrue not only to the engaged consumer but also to businesses that can develop new innovative solutions for customers based off of the installed SmartMeter™. By supporting interoperable standards and data access, PG&amp;E helps to drive innovation and competition in beyond the meter products and services. Potential benefits that could be derived based on future beyond the meter market development include:</p> <ul style="list-style-type: none"> <li>• Broadened set of customer-centric energy management products and services.</li> <li>• Enablement of energy cost reduction products and services to the customer.</li> <li>• Increased customer participation and interaction in making energy efficient and renewable energy choices that reduce customers’ and the utility’s carbon footprint and emission of greenhouse gases.</li> <li>• Customer-driven load management by using data to manage household electricity timing, duration, use and source of use.</li> </ul>
<p><b>Drivers:</b></p> <ul style="list-style-type: none"> <li>• Empower consumers to actively participate in the operations of the grid, generation and energy storage options.</li> <li>• Run the grid more efficiently and sustainably.</li> <li>• Achievement towards energy efficiency and demand response goals.</li> <li>• Development and incorporation of DR, demand-side resources, and EE resources in energy markets.</li> <li>• Market enablement for 3<sup>rd</sup> party solutions.</li> </ul>
<p><b>Considerations:</b> Although success of this initiative is not directly dependent on customer adoption, the level of customer adoption as well as the ability of the competitive marketplace to create desirable products and services which use a customer’s energy usage data, will affect the cost-effectiveness of the fixed and variable costs needed to provide third-party access to the data. PG&amp;E will continue to play a role in encouraging adoption, namely through support and development of strong data security standards, and by driving the OpenADE standard that promulgates free and open competition among solution providers.</p>
Project Implementation Schedule: 2012

## 6.5 Proposed Smart Grid Roadmap High Priority Projects – Smart Energy Markets

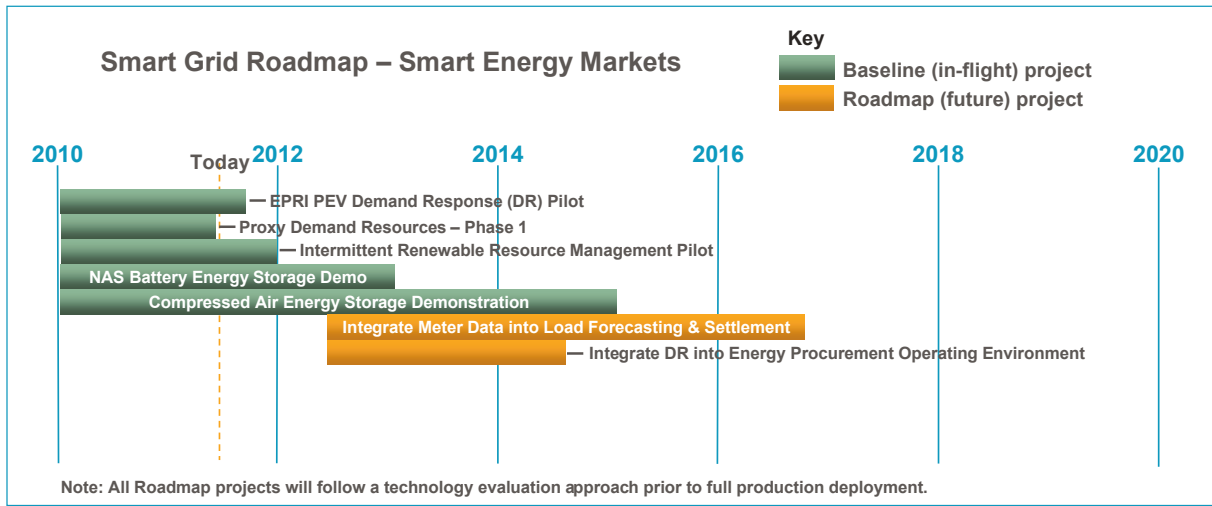
PG&E is proposing projects that directly improve energy procurement and efficiency at the system and CAISO level. These projects support California’s energy and environmental policy goals, help integrate and manage diverse renewable energy sources into the grid, and allow customers to participate directly in energy markets. PG&E’s Smart Energy Market projects take the traditionally “top down” energy procurement approach, add “bottom’s up” forecasting capabilities, and integrate demand response and other programs into the CAISO and ancillary service energy markets. This allows PG&E, the energy markets, and customers to act in a coordinated manner to drive efficient energy procurement, utilize alternative and renewable sources of energy, and reduce green house emissions and other environmental impacts. The table below summarizes PG&E’s Smart Energy Market projects.

**Table 6-7: PG&E’s Smart Energy Market Initiatives**

Project #	Project Name	Summary Description
1	Integrate Meter Data into Load Forecasting and Settlement	Improve forecasting capabilities for bidding into the energy procurement markets of the CAISO.
2	Integrate DR into Energy Procurement Operating Environment	Integrate DR programs with PG&E’s energy procurement operations and bidding in the CAISO energy and A/S markets.

The preliminary schedule for initiation and deployment of these projects is depicted in the following Roadmap.

**Figure 6-2: Smart Grid Roadmap — Smart Energy Markets**



The following narratives provide a description of each of the Smart Energy Market projects and its benefits, key drivers, considerations and the project timeline.

**Table 6-8: Smart Energy Markets Project #1 — Integrate Meter Data Into Load Forecasting and Settlement**

Smart Energy Markets Project #1 – Integrate Meter Data Into Load Forecasting and Settlement
<p><b>Description:</b>                      This project aims to develop more accurate short term forecasts through “bottoms-up” aggregation of direct load measurement rather than “top-down” estimates derived from system-wide generation and transmission measurements. An initial step of this project involves mapping customer revenue meters and associated characteristics to associated upstream distribution level devices (e.g. feeder meters, line sensors) and CAISO pricing nodes. Forecasting tools then interact with aggregated, and relatively frequent updates of customer demand data received from distribution-level devices and other relevant state condition information (e.g. weather, occurrence of DR event, etc.) and deliver hour-ahead and day-ahead projections of region-wide load. Improved load forecasts and understanding of load conditions may reduce procurement costs incurred on behalf of customers in CAISO market transactions and improve the quality and timeliness of transaction settlement activity.</p>
<p><b>Benefits:</b></p> <ul style="list-style-type: none"> <li>• Potential reductions in costs associated with short-term procurement which is primarily through reduced exposure to purchases and sales in a volatile real-time market.</li> <li>• Potential reductions in costs and improved accuracy and timeliness in CAISO settlement activity.</li> </ul>
<p><b>Drivers:</b></p> <ul style="list-style-type: none"> <li>• Ability to accurately forecast grid market conditions.</li> <li>• Enable data / information to understand how the utility system is actually operating during varying times and seasons in PG&amp;E’s territory which will assist in long term energy procurement activities.</li> </ul>
<p><b>Considerations:</b></p>

Smart Energy Markets Project #1 – Integrate Meter Data Into Load Forecasting and Settlement
An increased number of input sources increase the chance of error and difficulty to detect anomalies. The utility CAISO forecasts need synchronization to avoid excessive backstop procurement by CAISO. The testing and validating of granular load measurements and load forecasting model will require historical data that is not currently being captured. Project estimates depend on an increased deployment of distribution level meters.
The implementation schedule for the Foundational initiatives is also a key consideration for success of the project and benefits realization.
Project Implementation Schedule: 2012 – 2016

**Table 6-9: Smart Energy Markets Project #2 — Integrate DR Into Energy Procurement Operating Environment**

Smart Energy Markets Project #2 — Integrate DR Into Energy Procurement Operating Environment
<p>Description:</p> <p>This project integrates DR programs with PG&amp;E’s energy procurement operations and bidding in the CAISO market. There are specific requirements from the CAISO which are: (1) Make at least 10 percent of the megawatts enrolled in the DR programs comply with the requirements of CAISO’s Proxy Demand Resource (PDR); (2) Make at least one new or existing DR program or option within a program comply with the 10-minute dispatch notification time requirements for participation in the CAISO’s Ancillary Services (A/S) market as either PDR or Participating Load; and (3) PG&amp;E shall address integration of its reliability-based demand response programs into the wholesale Reliability Demand Response Product developed by the CAISO.</p>
<p>Benefits:</p> <p>Reduction in consumer costs resulting from:</p> <ul style="list-style-type: none"> <li>• Improved bidding in CAISO energy and A/S markets</li> <li>• Improved energy bidding during scarcity pricing events in the CAISO markets</li> <li>• Improved effectiveness of DR programs</li> </ul> <p>This project, together with Engaged Consumers Project 2 and Smart Utility Project 1 contribute to realizing the benefits described above.</p>
<p>Drivers:</p> <ul style="list-style-type: none"> <li>• Enable and support the sale of DR into wholesale energy markets as a resource, on equal footing with traditional generation resources.</li> <li>• Operate the grid more efficiently and sustainably.</li> <li>• Increase ability to achieve EE and DR goals.</li> <li>• Increase the use of digital information to allow consumers to actively participate in wholesale energy markets.</li> <li>• Enable integration of customer EVs.</li> </ul>
<p>Considerations:</p> <p>There is a need for clarification of the rules for enabling programs and third party bidding on CAISO markets. The implementation schedule for the Foundational initiatives is also a key consideration for success of the project and benefits realization.</p>
Project Implementation Schedule: 2012 – 2016

## 6.6 Proposed Smart Grid Roadmap High Priority Projects – Smart Utility

PG&E is proposing projects to improve reliability, improve the efficiency of the utility infrastructure, and extend critical asset life while also integrating renewables and DR into utility operations. These proposed projects will improve reliability, and at the same time integrate inherently variable renewable energy through the use of advanced system controls, telecommunications and monitoring equipment. Such devices deployed systematically throughout the T&D system will help to provide timely and accurate information to operators, enable faster outage response and help to manage critical asset life and capital costs by providing better, real or near-real time asset information. Further, these programs will help reduce the environmental impacts of electricity generation by improving the efficiency of the system through reduction of losses using voltage reduction and DR to reduce overall system peak loads both system-wide as well as in locally impacted areas.

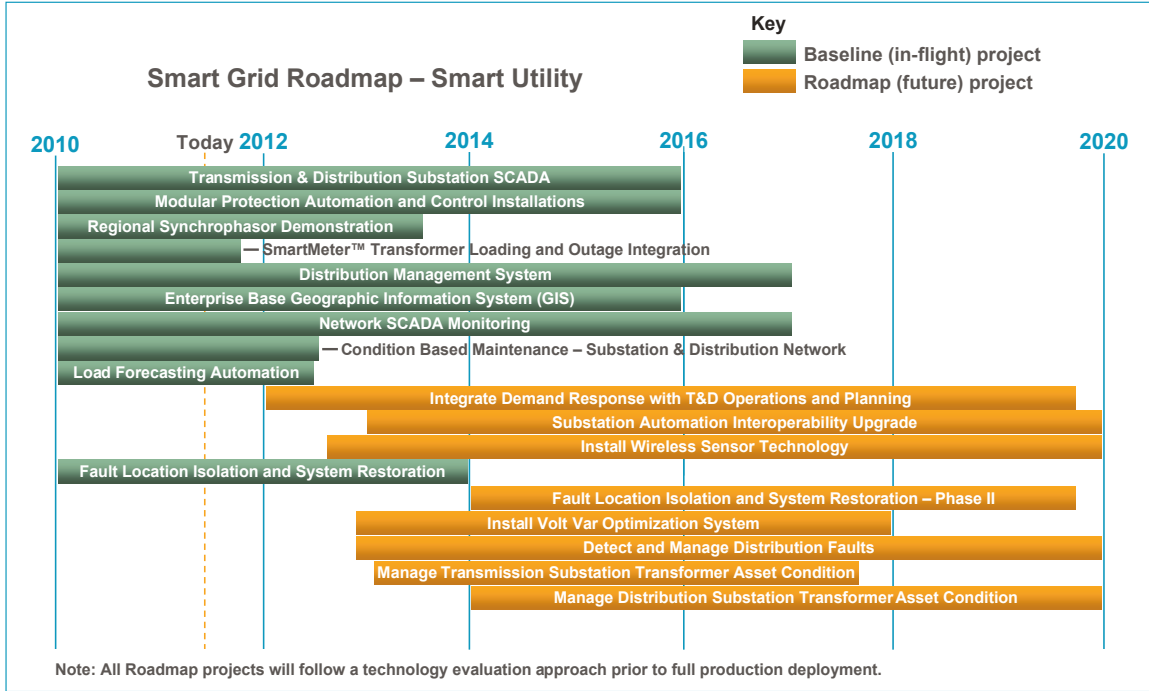
The table below summarizes PG&E’s Smart Utility projects.

**Table 6-10: PG&E’s Smart Utility Initiatives**

Project #	Project Name	Summary Description
1	Integrate DR with T&D Operations and Planning	Analysis of available DR resources and integration into T&D operations and planning
2	Substation Automation Interoperability Upgrade	Upgrade of substation automation equipment and systems
3	Install Wireless Sensor Technology	Deploy wireless sensors for fault locating and loading data using the SmartMeter™ telecommunications network
4	Fault Location, Isolation and Service Restoration (FLISR)	Deploy additional automated FLISR capabilities
5	Install Volt Var Optimization System	Deploy a Volt Var Optimization system to reduce losses and reliably integrate distributed renewables
6	Detect and Manage Distribution Faults	Install analytical software that uses available data to pinpoint the faulted location on distribution feeders
7	Manage Transmission Substation Transformer Asset Condition	Install dissolved gas monitoring equipment on transmission substation transformers
8	Manage Distribution Substation Transformer Asset Condition	Install dissolved gas monitoring equipment on distribution substation transformer load tap changers

The preliminary schedule for initiation and deployment of these projects is depicted in the following Roadmap.

**Figure 6-3: Smart Grid Roadmap — Smart Utility**



The following narratives provide a description of each of the Smart Utility projects and its benefits, key drivers, considerations and the project timeline.

**Table 6-11: Smart Utility Project #1 — Integrate DR With T&D Operations and Planning**

Smart Utility Project #1 — Integrate DR With T&D Operations and Planning
<p><b>Description:</b>            This project will be conducted in several phases:            Phase I of this project seeks to expand the use of DR in T&amp;D operations by performing an analysis of current and future available DR resources against T&amp;D operational and planning future needs.</p> <p>Phase II utilizes the information from Phase I to assess, understand, integrate and propose strategies to meet T&amp;D operational and planning needs. Phase II evaluates software tools and future integration with a utility scale distribution management system. Future phases will deploy the systems in the control room environment.</p> <p>This initiative focuses on the entire T&amp;D utility landscape and will use information from a SmartAC™ pilot that will be in place by 2012 summer. Specifically, PG&amp;E is targeting approximately 6 distribution</p>



Smart Utility Project #1 — Integrate DR With T&D Operations and Planning
<p>planning areas and use of SmartAC switches during the summer peak period. This evaluation project will enable the Utility to assess customer-sign up to the SmartAC DR program as well as potential impact to peak loads when the SmartAC program is called.</p>
<p><b>Benefits:</b> The anticipated benefits of a DR program and integration with T&amp;D operations and planning are as follows:</p> <ul style="list-style-type: none"> <li>• Reduced peak demand during various significant times of the year as needed.</li> <li>• Reduced new energy generation as well as reduction in operating expensive, environmentally impactful peaking generation facilities.</li> <li>• Reduced customer energy costs during peak pricing periods.</li> <li>• Reduce or deferred installation of distribution capacity upgrades due to reduction in peak demand.</li> </ul> <p>Integration of DR programs with operations translates to customer benefits in terms of reduced customer costs. Customers who chose to participate in DR programs help promote electric market efficiency, utility operational efficiency, and reduce generation needs both in short term peaks as well as over the longer term.</p>
<p><b>Drivers:</b></p> <ul style="list-style-type: none"> <li>• Empower consumers to actively participate in the operations of the grid, generation and energy storage options.</li> <li>• Development and incorporation of DR, demand-side resources, and EE resources in energy markets.</li> <li>• Operate the grid more efficiently and sustainably.</li> <li>• Achievement towards EE and DR goals.</li> <li>• Increase the use of digital information to allow consumers to actively participate in wholesale energy markets.</li> <li>• Enable integration of customer EVs.</li> </ul>
<p><b>Considerations:</b> Integration of DR into the market creates more complicated management of the grid from the CAISO, Utility and customer view. More choices increase complexity and require new processes and procedures to properly integrate these new resources.</p> <p>The implementation schedule for the Foundational initiatives is also a key consideration for success of the project and benefits realization.</p>
<p>Project Implementation Schedule: 2012 – 2019</p>

**Table 6-12: Smart Utility Project #2 — Substation Automation Interoperability Upgrade**

Smart Utility Project #2 – Substation Automation Interoperability Upgrade
<p><b>Description:</b> This initiative entails upgrades to substation automation and protection equipment and the installation of supporting fiber-optic cables and digital telecommunications equipment in place of analog substation communications infrastructure for select existing and all new substations.</p> <p>This installation uses International Electrotechnical Commission (IEC) Standard 61850 compliant equipment to cost effectively assure cyber security and interoperability between critical substation devices and operations control centers. This project proposes to test and pilot the concept prior to</p>

Smart Utility Project #2 – Substation Automation Interoperability Upgrade
converting 6-10 Transmission Substations per year.
<p>Benefits:</p> <p>Benefits include the following:</p> <ul style="list-style-type: none"> <li>• Avoided capital and operations and maintenance costs on the utility’s annual engineering, materials, construction and maintenance costs.</li> <li>• Longer term reliability benefits through the managed replacement of aging assets with modern, resilient infrastructure.</li> <li>• Cyber security and interoperability between devices and operation control centers.</li> <li>• Reduction in the potential for employee accidents and environmental safety hazards from simplified, less hazardous installation procedures and equipment that is inherently more modern and safe (fiber cables do not produce sparks and do not carry current, increasing safety to employees as well as preventing spark-caused substation damage).</li> </ul>
<p>Drivers:</p> <ul style="list-style-type: none"> <li>• Provide for a higher quality of communication facilities that assists in reducing future outages by replacing aged assets.</li> <li>• Operate the grid more efficiently by reducing installation costs and future yearly maintenance costs.</li> <li>• Increased use of digital information and controls technology to improve long-term reliability, security, and efficiency of the electric grid.</li> <li>• Development of standards for communication and interoperability of equipment connected to the electric grid, including the infrastructure comprising the grid.</li> </ul>
<p>Considerations:</p> <p>PG&amp;E will seek to evaluate this equipment and technology over a multi-year evaluation period before implementation at full-scale. One of the considerations inherent in this approach is that standards are continuing to evolve and vendor experience is currently limited in the United States (U.S.).</p>
Project Implementation Schedule: 2013 – 2020

**Table 6-13: Smart Utility Project #3 — Install Wireless Sensor Technology**

Smart Utility Project #3 — Install Wireless Sensor Technology
<p>Description:</p> <p>This project proposes to test, evaluate and pilot wireless overhead line sensors on select distribution feeders and then install at a commercial level on high impact distribution feeders. The installation of wireless fault sensors will improve fault finding capabilities and provide distribution feeder loading information. The installation will pinpoint the outage/equipment damage location reducing the overall outage time for customers impacted. The installation will also provide near-real time loading data to assist in day-to-day operations and future planning needs. Additionally, wireless sensors would integrate into the “Detect and Manage Faults” project in the future by providing more granular information closer to the actual fault location.</p>
<p>Benefits:</p> <ul style="list-style-type: none"> <li>• Installation of wireless sensors promotes employee and public safety as PG&amp;E will be able to more quickly locate and secure damaged equipment.</li> <li>• Pinpointing of exact trouble locations reduces driving time and associated vehicle emissions for trouble service personnel.</li> <li>• Improved system wide and regional reliability by identifying and resolving outage issues more quickly.</li> <li>• First responders will respond to the area pinpointed by the wireless sensor reducing travel time which improves utility operating efficiency, work processes and patrolling costs.</li> </ul>

Smart Utility Project #3 — Install Wireless Sensor Technology
<p>Drivers:</p> <ul style="list-style-type: none"> <li>• Provide higher quality reliability by reducing customer outage time as PG&amp;E is able to respond quicker to find the outage location.</li> <li>• Run the grid more efficiently and sustainably by reducing patrolling time and cost.</li> <li>• Increased use of digital information and controls technology to improve reliability, security, and efficiency of the electric grid.</li> <li>• Development of standards for communication and interoperability of appliances and equipment connected to the electric grid, including the infrastructure serving the grid.</li> </ul>
<p>Considerations:</p> <p>Although wireless sensors are a new technology, they are close to commercialization in the utility industry and can be ready for production deployment after a period of evaluation and testing. As part of this roadmap, PG&amp;E will conduct rigorous evaluation and testing to ensure technology and process readiness prior to full scale deployment.</p>
<p>Project Implementation Schedule: 2012 – 2023</p>

**Table 6-14: Smart Utility Project #4 — Fault Location, Isolation and Service Restoration**

Smart Utility Project #4 — Fault Location, Isolation and Service Restoration
<p>Description:</p> <p>This project continues the installation of FLISR systems approved in the Cornerstone Filing. Phase II will implement the FLISR system on an additional 400 circuits across the PG&amp;E system to reduce customer outage impacts. The original Cornerstone project (Phase I) will be completed by the end of 2013 with Phase II proposed to start in 2014 and end in 2019.</p>
<p>Benefits:</p> <ul style="list-style-type: none"> <li>• Improves customer reliability by using technology to restore power to customers quickly, providing information back to a central location on the overall status of the area.</li> <li>• First responders will respond to the area pinpointed by the FLISR system reducing travel time which improves utility operating efficiency, work processes and patrolling costs.</li> </ul>
<p>Drivers:</p> <ul style="list-style-type: none"> <li>• Provide higher quality of power and avoids longer term customer outages.</li> <li>• Run the grid more efficiently and sustainably by reducing patrolling time and cost.</li> <li>• Increased use of digital information and controls technology to improve reliability, security, and efficiency of the electric grid.</li> <li>• Development of standards for communication and interoperability of appliances and equipment connected to the electric grid, including the infrastructure serving the grid.</li> </ul>
<p>Considerations:</p> <p>PG&amp;E still needs to finalize its plans after the piloting and production deployment of the Cornerstone approved FLISR systems to assess their costs and benefits.</p>
<p>Project Implementation Schedule: 2014 – 2019</p>

**Table 6-15: Smart Utility Project #5 — Install Volt Var Optimization System**

Smart Utility Project #5 — Install Volt Var Optimization System
<p><b>Description:</b>                      This project proposes to install an electric distribution system voltage optimization control system on select distribution feeders that have high penetrations of solar photovoltaic (PV) generation or high distribution system losses. Extensive studies have shown a direct correlation between controlled voltage reductions and peak demand reductions and end-use appliance EE. In addition, improved control of distribution system capacitors can reduce the power losses in the distribution system. Further, improved voltage control can increase the amount of solar PV that can be safely and reliably interconnected in the distribution system. Using voltage measurement and optimization algorithms, the proposed system would control one or all of the following pieces of equipment: (1) substation transformer, bus or feeder regulators; and (2) distribution line regulators, and (3) line capacitors to achieve the desired electricity demand reductions, voltage profile and line loss reductions. The system would use input from these line devices along with SmartMeter™ voltage measurements. The distribution system voltage optimization control system would lower the overall feeder voltage to the lowest possible level consistent with regulatory requirements 24 hours a day all year long producing better results than current technology set primarily for peak and minimum demand periods. After laboratory testing and controlled field trials, PG&amp;E expects to install equipment to manage the voltage on approximately 400 distribution feeders over the next several years.</p>
<p><b>Benefits:</b></p> <ul style="list-style-type: none"> <li>• Current industry views are that reducing the voltage by 1 percent provides a 0.5 to 0.8 percent reduction in demand.</li> <li>• Consumer energy usage and costs would be reduced by lowering the voltage.</li> <li>• T&amp;D system losses would be reduced by lowering the voltage.</li> <li>• Demand and the corresponding energy procurement costs would be reduced by lowering the voltage.</li> <li>• Distributed renewable generation penetration can be increased by maintaining the voltage within desired operating ranges to reduce the potential for high voltage impacting operation of the PV systems or effecting the customer equipment operations.</li> </ul>
<p><b>Drivers:</b></p> <ul style="list-style-type: none"> <li>• Reduce customer energy usage and costs without impacting customer end-uses.</li> <li>• Reduce electricity generation emissions by lowering customer energy usage and power demand.</li> <li>• Improving the efficiency of the grid by reducing distribution system losses.</li> <li>• Improving the safety and reliability of the grid.</li> <li>• Supporting the integration of distributed renewable resources.</li> <li>• Increasing the use of digital information and controls technology to improve reliability, security, and efficiency of the electric grid.</li> </ul>
<p><b>Considerations:</b>                      The electric distribution system voltage optimization control system technology is relatively new to the utility industry and will continue to evolve. Numerous utilities across the U.S. are deploying these systems using a variety of technologies, architectures and telecommunications equipment. Technology advances may make existing systems obsolete and require regular upgrades to assure continued vendor product support and reasonable operations and maintenance costs. Additionally, automated distribution system voltage optimization is a new process for utility operations and engineering personnel requiring significant training and process redesign prior to implementation at production scale.</p>
<p>Project Implementation Schedule: 2013 – 2017</p>

**Table 6-16: Smart Utility Project #6 — Detect and Manage Distribution Faults**

Smart Utility Project #6 — Detect and Manage Distribution Faults
<p><b>Description:</b>                      This project proposes to install decision support tools to pinpoint the location of an outage and the damaged equipment causing the outage. This tool uses the fault data received at distribution systems devices compared to data from system analysis tools based upon the distribution circuit characteristics. This analysis tool provides more exact locations to operators and first responders to find damaged equipment. This system will be deployed on both the overhead and underground distribution feeder systems. Assistance on the underground system to locate the actual outage location to a more defined area will assist the distribution operations personnel and first responders locate underground system damage that is more difficult to find. This technology will increase the ability to pinpoint damaged equipment to a more exacting location than the wireless sensor can do by itself. Future circuit designs are expected to use both wireless sensors and this proposed software tool to support outage restoration.</p>
<p><b>Benefits:</b></p> <ul style="list-style-type: none"> <li>• Promotes public and employee safety as PG&amp;E will be able to more quickly locate and secure damaged areas.</li> <li>• Pinpointing of exact trouble locations reduces driving time and associated vehicle emissions for trouble service personnel.</li> <li>• Improved system wide and regional reliability by identifying and resolving outage issues more quickly.</li> <li>• First responders will respond to the area pinpointed by the decision support tool reducing travel time which improves utility operating efficiency, work processes and patrolling costs.</li> </ul>
<p><b>Drivers:</b></p> <ul style="list-style-type: none"> <li>• Provide higher quality reliability by reducing customer outage time as PG&amp;E is able to respond quicker to find the outage location.</li> <li>• Run the grid more efficiently and sustainably by reducing patrolling time and cost.</li> <li>• Increased use of digital information and controls technology to improve reliability, security, and efficiency of the electric grid.</li> <li>• Development of standards for communication and interoperability of appliances and equipment connected to the electric grid, including the infrastructure serving the grid.</li> </ul>
<p><b>Considerations:</b>                      The Detect and Manage Distribution Faults is a newer technology that is being used at a few utilities but with growing numbers of utilities considering it. Testing to make sure it works properly needs to happen prior to full scale commercialization.</p>
<p>Project Implementation Schedule: 2013 – 2020</p>

**Table 6-17: Smart Utility Project #7 — Management of Transmission Substation Transformer Asset Condition**

Smart Utility Project #7 — Management of Transmission Substation Transformer Asset Condition
<p><b>Description:</b>                      This project proposes to install Dissolved Gas Analysis (DGA) monitoring equipment on the transformer tank and Load Tap Changer (LTC) tank. DGA analysis is used to understand the physical condition of the transformer to assess life expectancy and future operations. DGA analysis samples the oil for gasses that are created by the breakdown of the internal transformer materials allowing engineers to compare these statistics against normal values to assist in mitigation plans to reduce the potential for future failures or identify replacement prior to an in-service failure.</p>

Smart Utility Project #7 — Management of Transmission Substation Transformer Asset Condition
<p><b>Benefits:</b></p> <ul style="list-style-type: none"> <li>• This project allows PG&amp;E to manage its critical substation assets more reliably and cost effectively.</li> <li>• Incrementally improve reliability as these critical substation assets provide power to a significant number of customers across PG&amp;E’s service territory and a failure can affect a significant number of utility customers.</li> <li>• This data allows utility personnel to understand and manage the assets increasing the ability to optimize maintenance and operations practices and costs.</li> </ul>
<p><b>Drivers:</b></p> <ul style="list-style-type: none"> <li>• Run the grid more efficiently optimizing maintenance and operations practices and costs.</li> <li>• Increased use of digital information and controls technology to improve reliability, security, and efficiency of the electric grid.</li> <li>• Development of standards for communication and interoperability of appliances and equipment connected to the electric grid, including the infrastructure serving the grid.</li> </ul>
<p><b>Considerations:</b>  PG&amp;E is already doing dissolved gas analysis by taking oil samples and sending to the lab for analysis. This technology builds upon some information the utility already has. New transformers already come with this monitoring system.</p>
<p>Project Implementation Schedule: 2013 – 2017</p>

**Table 6-18: Smart Utility Project #8 — Management of Distribution Substation Transformer Asset Condition**

Smart Utility Project #8 — Management of Distribution Substation Transformer Asset Condition
<p><b>Description:</b>  This project proposes to install DGA monitoring equipment on distribution substation LTCs. DGA analysis is used to understand the physical condition of the LTC to assess life expectancy and future operations. DGA analysis samples the oil for gasses that are created by the breakdown of the internal transformer materials allowing engineers to compare these statistics against normal values to assist in mitigation plans to reduce the potential for future failures or identify replacement prior to an in-service failure.</p>
<p><b>Benefits:</b></p> <ul style="list-style-type: none"> <li>• This project allows PG&amp;E to manage its critical assets more reliably and cost effectively.</li> <li>• Incrementally improve reliability as these critical substation assets provide power to a significant number of customers across PG&amp;E’s service territory and a failure can affect a significant number of utility customers.</li> <li>• This data allows utility personnel to understand and manage the assets increasing the ability to optimize maintenance and operations practices and costs.</li> </ul>
<p><b>Drivers:</b></p> <ul style="list-style-type: none"> <li>• Run the grid more efficiently optimizing maintenance and operations practices and costs.</li> <li>• Increased use of digital information and controls technology to improve reliability, security, and efficiency of the electric grid.</li> <li>• Development of standards for communication and interoperability of appliances and equipment connected to the electric grid, including the infrastructure serving the grid.</li> </ul>

Smart Utility Project #8 — Management of Distribution Substation Transformer Asset Condition
<p>Considerations:  PG&amp;E is already doing dissolved gas analysis by taking oil samples and sending to a lab for analysis. This technology builds upon information the utility already has. New transformers already come with this monitoring system.</p>
Project Implementation Schedule: 2014 – 2023

**6.7 Foundational and Cross-Cutting Infrastructure Initiatives**

Achieving the vision and objectives of the Smart Grid entails not only the application of new technologies to specific tasks and operational objectives, but also a foundational shift in PG&E’s operational infrastructure and systems.

Specifically, certain foundational investments must be made to safely, reliably and securely deliver the Engaged Consumers, Smart Energy Markets and Smart Utility projects that drive PG&E’s Smart Grid vision.

PG&E is proposing to increase its foundational capabilities in key technology areas including cyber security, telecommunications and information management architecture. These are core improvements that must be well-planned in advance and sufficiently robust to support the increased technological complexity and interoperability envisioned in the future Smart Grid.

In addition, a well-trained, competent and “tech-savvy” workforce and supply chain, as well as educated customers, are also essential to the successful development and deployment of many of PG&E’s Smart Grid projects, particularly those that depend upon customer participation and customer services. Thus, PG&E also has identified the areas of Customer Outreach, Workforce Development and Supplier Diversity to be key cross-cutting, found.

The table below summarizes PG&E’s Foundational and Cross-Cutting Infrastructure Initiatives.

**Table 6-19: PG&E’s Foundational and Cross-Cutting Infrastructure Initiatives**

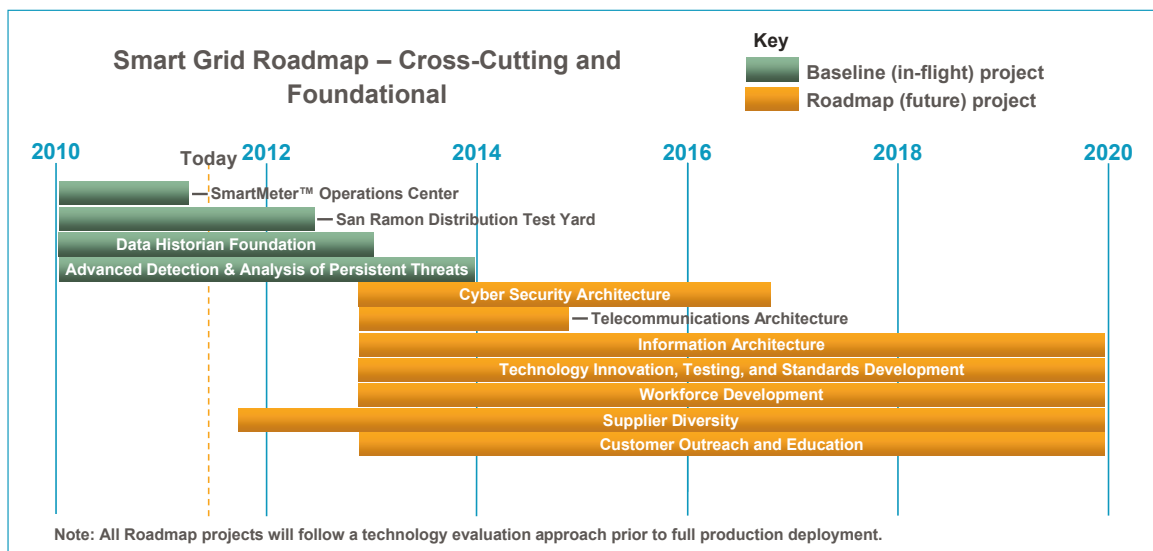
Project #	Project Name	Summary Description
1	Cyber Security Architecture	Implement an improved common security architecture which implements controls and ensures the protection and security of information communicated across multiple systems and interfaces.
2	Telecommunications Architecture	<p>Develop and implement a common telecommunications architecture which enables the necessary internal and external systems to have the ability to communicate in a common format with integrated, embedded security as part of the overall network architecture and design.</p> <p>This investment is specific only to the Smart Utility, Engaged Consumer, and Smart Energy Markets initiatives included in this filing. This telecommunications investment is incremental to and does not include further more comprehensive investment in PG&amp;E’s telecommunications network that will be required to support other PG&amp;E initiatives not included within the scope of this Smart Grid Deployment plan such as further Electric and Gas Supervisory Control and Data Acquisition (SCADA) deployment, Cornerstone Feeder Automation and a number of other key business initiatives. PG&amp;E is currently assessing the 3-10 year telecom/network capacity, latency, and availability requirements to meet emerging needs pertaining to its Gas T&amp;D, Electric T&amp;D, and Generation businesses.</p>
3	Information Management Architecture	Develop and implement a common information management architecture across key PG&E systems to ensure data accuracy, consistency and interoperability across systems and business processes as required to meet the data collection, monitoring and management needs associated with the portfolio of Smart Grid projects.
4	Technology Innovation, Testing and Standards Development	Increase the capabilities of PG&E’s testing, analysis and research and development team and facilities to verify performance of Smart Grid technologies within a lab environment before deployment to the public and grid, in order to “de-risk” Smart Grid projects involving new technology prior to deployment decisions. Working together with national standards bodies, communicate and leverage lab findings to inform and develop common standards that accelerate and mature new Smart Grid related technologies, products, and processes.
5	Workforce Development	PG&E will enhance its workforce development programs to enable its workers and contractors to be able to understand, plan, operate and maintain an increasingly complex utility infrastructure as the technological complexity of the grid increases.
6	Supplier Diversity	PG&E will expand and improve its Supplier Diversity Program to ensure the continued achievement of supplier diversity goals applicable to Smart Grid projects and initiatives.



Project #	Project Name	Summary Description
7	Customer Outreach	Perform outreach to customers to engage them in understanding the Smart Grid, PG&E's Smart Grid Plan and projects, and the benefits, both at the individual and societal level, that the Smart Grid seeks to achieve. Support customers in understanding the information that will be available to them to use Smart Grid-enabled tools and projects to make energy choices, participate in energy markets and more efficiently manage their energy use.

The preliminary schedule for initiation and deployment of these foundational and cross-cutting infrastructure initiatives are depicted in the following Roadmap.

**Figure 6-4: Smart Grid Roadmap —Foundational and Cross-Cutting Infrastructure Initiatives**



The following narratives provide a description of each of the Smart Grid Foundational and Cross-Cutting Infrastructure Initiatives and their benefits, key drivers, considerations and the project timeline.

**Table 6-20: Smart Grid Foundational & Cross-Cutting Infrastructure Initiative #1 — Cyber Security Architecture**

Smart Grid Foundational & Cross-Cutting Initiative #1 — Cyber Security Architecture
<p><b>Description:</b>            PG&amp;E intends to enhance its security processes, technology, and programs to meet the needs in the new Smart Grid environment. Creation of an enhanced, secure foundation is critical to the success of many individual Smart Grid projects as each project can potentially introduce new risks into the PG&amp;E environment or lead to compromised customer or sensitive utility data if appropriate security is not inherently designed into the foundation.</p> <p>PG&amp;E intends to develop the secure foundation for the Smart Grid by enhancing capabilities across key security domains. This includes investments in Identity &amp; Access Management, Cryptography &amp; Key Management, Network Security Design, Threat Intelligence &amp; Information Sharing, Device Management, and Risk Assessment programs and technologies.</p> <p>Note: Cybersecurity and protection of sensitive information is critical to the success of PG&amp;E’s Smart Grid initiatives. Refer to Chapter 9 which discusses PG&amp;E’s Cyber Security and Privacy Strategy in further detail.</p>
<p><b>Benefits:</b></p> <ul style="list-style-type: none"> <li>• Secure system to provide safe and reliable service 24 hours a day, 365 days a year to customers.</li> <li>• Security processes compliant with industry, regulatory and international accepted Smart Grid standards.</li> <li>• Ability to monitor and detect intrusions proactively and share information with other utilities on new emerging cyber threats.</li> </ul>
<p><b>Drivers:</b></p> <ul style="list-style-type: none"> <li>• Protection of infrastructure as well as protection of customer, utility and industry information while implementing the goals of the Smart Grid.</li> <li>• Provide safe, reliable and secure utility system in the context of increasing sources and sophistication of cyber threats.</li> </ul>
<p><b>Considerations:</b>            Programs will be developed in this foundational area informed by industry standards including National Institute of Standardization and Testing and other standards that are still evolving in the industry. While these standards are still evolving, PG&amp;E has identified foundational security initiatives that include both technology elements as well as awareness related programs which will be essential for the workforce to effectively identify and proactively respond to potential cyber security threats in the Smart Grid environment.</p>
<p>Project Implementation Schedule: 2012 – 2016</p>

**Table 6-21: Smart Grid Foundational & Cross-Cutting Infrastructure Initiative #2 — Telecommunications Architecture**

Smart Grid Foundational & Cross-Cutting Initiative #2 — Telecommunications Architecture
<p><b>Description:</b>            PG&amp;E will meet near-term and long-term future telecommunications needs by developing and implementing a multi-tier, multi-service telecommunications infrastructure architecture, consisting of a core and an edge network.</p> <p>Smart Grid projects require an exponential increase in the ability for customers, markets and utilities to securely and reliably communicate on a near-real time basis. New communication models include customer to utility, customer to market, and smart “equipment to equipment.” PG&amp;E’s telecommunication infrastructure must be enhanced to facilitate this increased communications and also developed in a systematic, economic manner that allows for re-use of communications infrastructure.</p> <p>A blend of technologies will be needed to address the diverse performance needs and geography of the PG&amp;E service territory. Increased SCADA density, Phasor Measurement Units, cyber security, and network management requirements will drive capacity, latency, and quality of service requirements that must be built into future networks.</p>
<p><b>Benefits:</b></p> <ul style="list-style-type: none"> <li>• Robust infrastructure to support Smart Grid communications needs and effectively integrate all uses.</li> <li>• Increased reliability of the grid through improved operations, as well as lower customer costs and utility losses in the long term through the use of integrated and near-real time communications.</li> <li>• Flexible telecommunications infrastructure designed and constructed to cover the long term objectives from the utility, customer and renewable energy market perspective.</li> <li>• Utility investment in foundational Smart Grid infrastructure that can be used as a platform to drive new innovations that support Smart Energy Markets, Smart Utility and Smart Energy Market goals.</li> </ul>
<p><b>Drivers:</b></p> <ul style="list-style-type: none"> <li>• Nationally recognized mandate to modernize aging infrastructure to improve reliability, security, and efficiency of the electric grid.</li> <li>• Support the exponentially increased flow of digital information and increased interaction between consumers, markets, third parties and the Utility.</li> <li>• Adopting industry-wide standardization on open protocols, and advancement of network capabilities to meet energy policy mandates and infrastructure modernization regulatory objectives.</li> </ul>
<p><b>Considerations:</b>            Upgrade of utility telecommunication infrastructure requires in some cases migration away from closed systems and legacy-specific technologies to a more integrated communications system capable of supporting the long-term needs of customers, markets and the Utility. Considerations include evaluating and selecting new telecommunications technology, implementing utility-owned infrastructure or utilizing third parties, and ensuring the telecommunications foundation is developed in a scalable and flexible manner.</p>
<p>Project Implementation Schedule: 2012 – 2015</p>

**Table 6-22: Smart Grid Foundational & Cross-Cutting Infrastructure Initiative #3 — Information Architecture**

Smart Grid Foundational & Cross-Cutting Initiative #3 — Information Architecture
<p><b>Description:</b>            PG&amp;E intends to invest in a core set of Information Management and processing capabilities to allow participants in the Smart Grid to have timely access to the best available data to drive their energy related decisions. The Information Architecture foundation includes enhanced decision support tools to more accurately analyze, predict, and respond to energy impacting events based on data processed from a multitude of systems and stakeholders. The high level areas of foundational information architecture investments include the following:</p> <ul style="list-style-type: none"> <li>• Master Data Management across business processes and systems.</li> <li>• Enhancement of PG&amp;E’s current operational data store capabilities.</li> <li>• Common services including Service Oriented Architecture and framework to support Smart Grid systems and data interoperability.</li> <li>• Enhanced business intelligence and analytic capabilities to support storing and processing of disparate sources of data.</li> <li>• Data governance program and standards to support the enhanced information architecture and management foundation.</li> </ul>
<p><b>Benefits:</b></p> <ul style="list-style-type: none"> <li>• Improved accuracy and consistency of information distributed to stakeholders both inside and outside the organization.</li> <li>• More rapid and reliable planning and execution by energy markets, the Utility and customers based on access to data.</li> <li>• Flexibility and agility to meet dynamic market demands by creating a “one lens” view of all relevant data that traditionally may have resided in disparate systems with limited interoperability.</li> </ul>
<p><b>Drivers:</b></p> <ul style="list-style-type: none"> <li>• Creation of the necessary information platform to support DR, reliably integrate demand-side resources, and communicate events timely that impact market, customer and utility EE activities.</li> <li>• Increased use of digital information and controls technology that necessitate revamping of PG&amp;E’s existing information architecture to support the goals of the Smart Grid.</li> <li>• Provide higher quality decisions around planning for infrastructure upgrades via enhanced information (e.g. capacity, reliability).</li> <li>• Use and incorporation of new sources of data to enhance strategies to reduce green house gases and dependence on foreign energy sources.</li> </ul>
<p><b>Considerations:</b>            Many of the projects that underlie the creation of the Smart Grid fundamentally rely on the sharing of information across multiple systems and stakeholders both within and external to the utility in a common format. A foundational investment in enterprise information architecture and enhanced information management systems is critical to ensuring that Smart Grid programs can access and share data consistently and accurately.</p>
<p><b>Project Implementation Schedule: 2012 – 2020</b></p>

**Table 6-23: Smart Grid Foundational & Cross-Cutting Infrastructure Initiative #4 —  
Technology Innovation, Testing and Standards Development**

Smart Grid Foundational & Cross-Cutting Initiative #4 — Technology Innovation, Testing and Standards Development
<p><b>Description:</b> PG&amp;E intends to strengthen its Technology Innovation and Testing capabilities by combining technology and infrastructure testing capabilities into a single, fully-functional environment that can create an “end-to-end” test on Smart Grid components. This is essential to de-risk, evaluate and pilot new technologies prior to full scale deployment.</p> <p>As the Smart Grid environment intertwines grid infrastructure with advanced communications and control technology, PG&amp;E testing facilities will be enhanced to test new types of equipment, work processes and integrated systems that impact the utility from both an infrastructure and technology perspective (i.e., distributed generation, electric vehicles, line sensor equipment, etc.). The advanced facility and the associated team will investigate and test devices, equipment, communications, applications, and systems in an integrated manner that mimics the Smart Grid and the new customer, market and utility interactions. The facility will emphasize testing using “what if” scenarios to reduce costs and risks to deployment.</p> <p>In addition, PG&amp;E will collaborate with industry and academia through the lab to further engage with and inform industry standards. This is particularly important in order to achieve interoperability between the large and diverse set of devices that are intended to interoperate as part of the Smart Grid.</p>
<p><b>Benefits:</b></p> <ul style="list-style-type: none"> <li>• De-risk projects and reduce the potential for system safety or reliability issues by thoroughly testing new technologies prior to deployment.</li> <li>• Inform standards at the industry and state level based on quantitative testing results, reducing implementation costs and risks for new Smart Grid initiatives industry wide.</li> <li>• Reduce the risk of large scale capital investments in unproven or unready technologies by ensuring thorough testing prior to production deployment.</li> </ul>
<p><b>Drivers:</b></p> <ul style="list-style-type: none"> <li>• Need to fully assess reliability of new and emerging technology prior to introducing to the grid.</li> <li>• Need for accelerated and efficient adoption of new technology that enhances modernization, reliability and safety after thorough pilot testing and evaluation.</li> <li>• Reduced overall costs and risks of utility scaled Smart Grid deployments by testing and piloting in controlled environments first.</li> </ul>
<p><b>Considerations:</b> There is a significant need as the complexity of the utility infrastructure increases to test and pilot systems and equipment in an end to end fashion to reduce risk, ensure benefits and manage costs. Build-out of this lab environment is critical to successful deployment of the Smart Grid initiatives and projects described in the roadmap as well as future initiatives and projects.</p>
<p><b>Project Implementation Schedule: 2012 – 2020</b></p>

**Table 6-24: Smart Grid Foundational & Cross-Cutting Infrastructure Initiative #5 — Workforce Development**

Smart Grid Foundational & Cross-Cutting Initiative #5 — Workforce Development
<p><b>Description:</b>            Develop the Smart Grid workforce along two parallel tracks: (1) scale training programs required for mass deployment based on knowledge and skill elements captured during each demonstration pilot; and (2) create a pipeline of new workers and facilitate ongoing skills development for employees and the public by building career pathway programs in partnership with the California post-secondary education system. Significant new workforce skills and knowledge are required for successful Smart Grid design, deployment, operation, maintenance, and customer care. PG&amp;E will develop internal training programs through experience with demonstration pilot projects and scale them for mass deployment. Smart Grid career pathways will be built through partnerships with California’s post-secondary education system to enable the public as well as PG&amp;E employees to develop the requisite skills and knowledge for the future.</p>
<p><b>Benefits:</b></p> <ul style="list-style-type: none"> <li>• Developing a Smart Grid workforce will provide for an employee base with the requisite skills to support a modernized infrastructure that integrates California energy policy goals as well as societal goals in terms of reducing of greenhouse gases and minimizing the carbon footprint of energy use.</li> <li>• Provides for a low-risk path to scale internal training and build workforce capacity and capability to continuously up-skill the workforce.</li> <li>• Increased partnerships with public education programs to create flexibility for today’s workforce, educate the public on energy objectives as well as provide the future workforce to with the right skills and tools to further energy policy goals and objectives.</li> </ul>
<p><b>Drivers:</b></p> <ul style="list-style-type: none"> <li>• The utility infrastructure equipment and systems are changing as part of the Smart Grid evolution which means there are new skill requirements for engineering, operations, maintenance and customer care personnel.</li> <li>• As the workforce reaches retirement age there will be an increasing need for a skilled future workforce, and also one that reflects the demographics of the local communities, which is a PG&amp;E value and Corporate commitment.</li> <li>• Increased need for industry leadership to help support and augment California’s post-secondary system and to address future workforce needs.</li> </ul>
<p><b>Considerations:</b>            There are workforce pipeline challenges associated with low academic achievement rates projected for the fastest-growing segments of the emerging workforce. California’s school resources for curricula that map to industry needs is limited, there is a low percentage of teachers with competencies related to the Smart Grid and there are a low percentage of students entering post-secondary education in Science, Technology, Engineering and Math.</p>
<p><b>Project Implementation Schedule: 2012 – 2021</b></p>

**Table 6-25: Smart Grid Foundational & Cross-Cutting Infrastructure Initiative #6 — Supplier Diversity**

Smart Grid Foundational & Cross-Cutting Initiative #6 — Supplier Diversity
<p><b>Description:</b>            PG&amp;E is committed to Smart Grid supplier diversity. PG&amp;E has demonstrated its ongoing commitment to supplier diversity and will continue this work as it deploys and enables Smart Grid programs and technologies within its service territory. PG&amp;E will apply its Supplier Diversity Program to its Smart Grid Deployment Plan to ensure the continued achievement of supplier diversity goals. Some of the key program aspects as they relate to the Smart Grid are:</p> <ul style="list-style-type: none"> <li>• <b>Goal Development and Alignment:</b> PG&amp;E will identify a Smart Grid Supplier Diversity Champion to set targets and plans to achieve Smart Grid supplier diversity goals.</li> <li>• <b>Communications and Training:</b> PG&amp;E will continue to educate both internal and external stakeholders about PG&amp;E’s Supplier Diversity Program and its application in the Smart Grid space.</li> <li>• <b>Prime Supplier Program and Subcontracting Performance:</b> PG&amp;E will work with the Smart Grid prime contractors to engage qualified diverse suppliers in subcontracting opportunities.</li> <li>• <b>Other Supplier Diversity Program elements in support of the Smart Grid deployment plan include:</b> outreach, certification monitoring, safety, green supply chain program, communications and training, contract compliance and reporting.</li> </ul>
<p><b>Benefits:</b>            Through its Supplier Diversity Program, PG&amp;E has been working for 30 years to bring more minority, women, and service-disabled veteran-owned business enterprises into its supply chain. PG&amp;E’s Supplier Diversity Program enables the company to engage in more creative and innovative solutions to the challenges we face, while at the same time enhances the diversity of California businesses and enriches the communities where our customers and employees live and work. The program also supports the company’s broader commitment to diversity and inclusion.</p>
<p><b>Drivers:</b>            The CPUC established General Order 156 (GO 156) over two decades ago to develop and implement programs to increase the utilization of minority, women and service disabled veteran-owned businesses by California utilities. GO 156 establishes overall procurement target goals as follows:</p> <ul style="list-style-type: none"> <li>• 15 percent minority-owned business enterprises</li> <li>• 5 percent for women-owned business enterprises</li> <li>• 1.5 percent for service-disabled veteran-owned business enterprises</li> </ul>
<p><b>Considerations:</b>            While PG&amp;E’s investments in advanced technologies may generate new economic opportunities, they may also create unique challenges for maintaining supplier diversity. With some recent sourcing initiatives successfully completed in emerging technology categories, including an estimated 60 percent supplier diversity spend into a solar PV project, PG&amp;E will leverage its current supplier diversity programs to effectively address Smart Grid supplier diversity in new opportunity areas.</p>
<p><b>Project Implementation Schedule:</b> 2011 – 2020</p>

**Table 6-26: Smart Grid Foundational & Cross-Cutting Infrastructure Initiative #7 — Consumer Outreach and Education**

Smart Grid Foundational & Cross-Cutting Initiative #7 — Consumer Outreach and Education
<p><b>Description:</b>            PG&amp;E plans to implement a targeted consumer outreach program beginning in 2014 and continuing through subsequent years, tailored to the goals and objectives of the Smart Grid and PG&amp;E’s Smart Grid plan, particularly the “customer-facing” projects and initiatives in PG&amp;E’s Plan. PG&amp;E’s customer outreach and education work prior to launching the outreach program will include foundational work to prepare PG&amp;E systems and employees for the changes associated with the Smart Grid and PG&amp;E’s Smart Grid projects.</p> <p>One important foundational concept of PG&amp;E’s outreach will be to effectively connect Smart Grid, customer pricing tools and SmartMeters™ to enhance existing outreach programs that give customers a holistic view of how they can manage their energy usage. PG&amp;E has a number of outreach mechanisms in place that can be expanded and tailored to include Smart Grid messaging. By implementing this approach, PG&amp;E can streamline customer communications and lessen the risk of confusion among the customer base.</p> <p>PG&amp;E defines successful customer outreach as achieving the following objectives:</p> <ul style="list-style-type: none"> <li>• Prepare all PG&amp;E employees, with a particular initial focus on Contact Center Representatives and all customer-facing employees, for inquiries about the Smart Grid, particularly “customer-facing” Smart Grid projects and benefits.</li> <li>• Create awareness of the Smart Grid and its benefits among all customers.</li> <li>• Mitigate concerns of the Smart Grid’s impact for all customers.</li> <li>• Forge effective partnerships with consumer groups, vendors, contractors and other third parties to help educate customers with focused interests, affiliations and concerns.</li> <li>• Design specific outreach programs in conjunction with public policymakers who represent their constituents’ interests, questions and concerns.</li> </ul>
<p><b>Benefits:</b>            Smart Grid education will build on existing education efforts related to SmartMeter™, Time-of-Use pricing and other rates, EE, DR and other programs, and will provide a larger context of understanding about what the Smart Grid is, what PG&amp;E’s Smart Grid Plan and projects can do for customers and why it is relevant to customers.</p>
<p><b>Drivers:</b>            PG&amp;E plans to help customers understand the Smart Grid and PG&amp;E’s Smart Grid Plan and how it will benefit them, and provide education and information about the details of Smart Grid to mitigate any concerns they may have.</p>
<p><b>Considerations:</b>            The deployment of education and awareness efforts about the Smart Grid requires significant customer research. Targeted research must be completed prior to launching any Smart Grid outreach efforts.</p>
<p><b>Project Implementation Schedule:</b> 2014 – 2020</p>

## 6.8 Conclusion

The Roadmap details PG&E’s proposed incremental investments in Smart Grid initiatives and projects. PG&E identified and selected these proposed Smart Grid projects by applying the strategic objectives as described in the Smart Grid Strategy chapter.



Furthermore, PG&E selected these projects as high priority projects based on the drivers and elements of its Smart Grid Vision.

PG&E's high-priority projects in this Smart Grid Roadmap are pragmatic and focused to meet California's environmental and energy policies and to provide a foundational infrastructure to meet future changes in those policies. The Smart Grid is a journey, not an end-state, and therefore PG&E's direction is proceed cautiously based on conservative benefit and cost analysis, and to test out and prove the feasibility of Smart Grid technologies prior to full scale deployment. This means that PG&E will test individual device capabilities first, then pilot individual capabilities at a small utility scale, then pilot capabilities on multiple distribution circuits or for statistically significant customer samples, and then if benefits show the need for further deployment, then deploy across its utility infrastructure after full review and approval by the CPUC or FERC, as appropriate.

In the next chapter, PG&E provides its preliminary detailed evaluation of the costs and benefits of these proposed Smart Grid projects and initiatives.

## **Chapter 7 – Cost and Benefits Estimates**

## 7.1 Introduction

As part of its Smart Grid Deployment Plan, PG&E has developed conceptual and provisional cost and benefits estimates to quantify, where possible, the costs and benefits of its proposed incremental Smart Grid projects and initiatives as outlined in the Roadmap section. This chapter does not address costs and benefits for previously authorized work, which is summarized in the Baseline section of the Deployment Plan.

PG&E developed project costs in accordance with the requirements of CPUC Decision 10-06-047. PG&E followed CPUC guidance in estimating costs by providing conceptual and provisional level numbers for the periods of 2011–2015 and 2016–2020. To provide an equal basis for projection of costs and benefits, PG&E assumes an average project life of 20 years and provided costs and benefits over the entire project life. Given the inability to project the evolution of Smart Grid technologies and associated costs into the future, the company has focused its project scoping and conceptual cost estimating efforts on the 0–5 year time horizon. For projects initiating or extending beyond the 5-year horizon, there exists considerably more uncertainty in technology, scope, cost and benefits.

Because the Deployment Plan is not a vehicle for cost recovery authorization for projects, detailed planning-level cost estimates have not been calculated and are not presented. Furthermore, in many cases the Smart Grid technologies and solutions are evolving, thereby introducing additional uncertainties for any cost estimation. PG&E intends to provide more detailed and specific Smart Grid related investment proposals as part of its next General Rate Case filing or, alternatively, in a separate cost recovery application.

The conceptual and provisional cost estimates for the Smart Grid projects and initiatives presented reflect significant uncertainties and represent PG&E's best current estimates at this early stage of project and portfolio development. Uncertainty around costs

stems from the fact that many of the projects involve nascent technologies for which accepted market prices have not yet emerged. Further, the scale of deployment, and therefore the costs (and benefits) of some projects, may change significantly based upon factors such as customer adoption of new technologies (e.g., roof-top solar generation, electric vehicles and smart appliances), which are difficult to control and/or predict. Although the cost estimates represent PG&E's best efforts at this time, PG&E expects that these costs will change considerably over time, with additional information from the market and project pilots.

PG&E's cost estimates follow standard costing practices. The cost estimating process began with the articulation of a project-specific objective, scope, schedule and solution components (where technology has matured to the point of market availability). Where pilot projects and laboratory testing was deemed necessary to de-risk projects, costs were estimated for the entire project lifecycle, from laboratory testing to commercial scale deployment. Contingencies and uncertainties were accounted for by applying ranges to the fixed and variable costs. Synergies and dependencies between projects were also identified, although valuation of synergies was necessarily limited.

The Roadmap section of the Deployment Plan outlines the set of proposed, incremental Smart Grid projects including 14 projects and seven Foundational and Cross-Cutting Infrastructure projects. As outlined in Table 7-1 below, PG&E estimates that the incremental capital investment needed to deploy the proposed projects could range between \$800 million and \$1.25 billion over the average expected project life of 20 years. The company estimates that the annual Smart Grid program expenses could range from \$25 million to \$40 million. As previously noted, these costs are preliminary and conceptual. Project-specific cost estimates can be found in Sections 7.5-7.8 below.

**Table 7-1: PG&E Incremental Smart Grid Project Portfolio Cost Estimate**

Domain	Total Capital (\$MM)	Average Annual Expense (\$MM)	Projects
<b>Engaged Consumers</b>	\$25 - \$55	\$1.5 - \$2	<ul style="list-style-type: none"> <li>• Integration of Enhanced Demand Response (DR) Forecasting</li> <li>• DR Optimization</li> <li>• Home Area Network (HAN) Phase II – Pricing and Load Control Signals</li> <li>• Enable Access to SmartMeter™ Data via Open Automated Data Exchange (OpenADE)</li> </ul>
<b>Smart Energy Markets</b>	\$30 - \$50	\$0.5 - \$1	<ul style="list-style-type: none"> <li>• Integrate Meter Data into Load Forecasting and Settlement</li> <li>• Integrate DR into Energy Procurement Operating Environment</li> </ul>
<b>Smart Utility</b>	\$595 - \$850	\$5 - \$7	<ul style="list-style-type: none"> <li>• Integrate DR with Transmission and Distribution (T&amp;D) Operations and Planning</li> <li>• Substation Automation Interoperability Upgrade</li> <li>• Install Wireless Sensor Technology</li> <li>• Fault Location Isolation and System Restoration (FLISR)</li> <li>• Install Volt Var Optimization System</li> <li>• Detect and Manage Distribution Faults</li> <li>• Manage Transmission Substation Transformer Asset Condition</li> <li>• Manage Distribution Substation Transformer Asset Condition</li> </ul>
<b>Foundational and Cross-Cutting Infrastructure</b>	\$115 - \$295	\$15 - \$25	<ul style="list-style-type: none"> <li>• Cyber Security Architecture</li> <li>• Telecommunications Architecture</li> <li>• Information Management Architecture</li> <li>• Technology Innovation, Testing and Standards Development</li> <li>• Workforce Development</li> <li>• Supplier Diversity</li> <li>• Customer Outreach</li> </ul>
<b>Total</b>	\$800 - 1,250	\$25 - \$40	

All costs in this chapter are presented on a nominal basis and reflect project costs over an average project life of 20 years. PG&E presents all costs in ranges to reflect the considerable uncertainty around the project scope, solution and future costs. Project-specific costs are presented below by Smart Grid program area. While all cost and performance estimates embody significant uncertainty, the magnitude of uncertainty varies from project to project. PG&E’s confidence in cost and performance data for a specific technology is a function of the technology’s maturity, industry penetration

(i.e., amount of technology-specific cost and performance data available), susceptibility to exogenous factors, and expected project timeline. Furthermore, all cost and performance estimates necessarily require significant modification prior to final project specifications to account for the specifics of PG&E's system, service territory and diverse customer base.

## **7.2 Approach**

In order to assess the value of the projects identified as high-priority, PG&E conducted a large-scale integrated planning and estimating effort aimed at developing costs for its projects and assesses the performance and potential benefits of the portfolio.

For each project, a cross-functional team of subject matter experts was assembled to provide guidance on project scope, schedule, cost and performance. Project scope excluded Smart Grid-related project elements (e.g., development of new energy pricing structure or new DR programs). Each team developed a mutually agreed upon objective and scope. Based on the scope, the teams assembled a list of cost and performance categories.

For each cost category and for each quantifiable benefit category, a basic algorithm was developed to quantify the costs (or performance) based on a penetration rate needed to achieve the project goals. Each cost algorithm typically contained a unit cost and an estimate of the number of units needed to attain the project objectives and, where appropriate, fixed costs. Project costs were assigned over an estimated average project life of 20 years accounting for variability in asset life across different solution components, such as software (short-lived) and energy infrastructure capital (long-lived). In order to conduct this level of analysis, PG&E broadly classified costs as capital (Information Technology (IT) software, hardware, Telecom, or T&D infrastructure), and expense (IT, program, and O&M).

PG&E arrived at unit costs, accounting for available PG&E-specific considerations, through a variety of sources including: benchmarking with publicly available information, vendor estimates, engineering judgment, and industry information. Similarly, PG&E derived project performance improvement estimates from benchmarking, internal estimates, vendor estimates, and publicly available performance. Both the cost and benefit estimates were validated through a consulting engagement with a firm active in the Smart Grid and IT market.

Depending on the nature of the project, schedule and technology maturity, PG&E applied uncertainty factors to individual component costs to reflect a reasonable range of uncertainty over the project life. PG&E typically applied higher uncertainty factors to projects involving nascent technologies and those scheduled for implementation in years 6–11.

It should be noted that PG&E chose not to conduct least-cost analysis at this preliminary stage, but instead developed benefits and cost estimates for its proposed incremental Smart Grid portfolio. A least cost analysis would require that PG&E have insight into all competing alternatives technologies and the associated cost and performance data for these technologies over the next 10 years. PG&E believes that the cost and benefit analysis provides a clearer and more defensible estimate of the value of Smart Grid projects at this preliminary stage.

PG&E generated project performance improvement estimates in a manner similar to that used to develop cost estimates. However, PG&E was unable to quantify many of the expected performance outcomes due to the high level of uncertainty surrounding specific solutions and exogenous variables. Further, the attribution of performance to a specific project is complicated by interdependencies between business area projects (i.e., Engaged Consumes, Smart Energy Markets, and Smart Utility) and the Foundational and Cross-Cutting Infrastructure Initiatives. In many cases, the Foundational and

Cross-Cutting Initiatives are integral to achieving the performance and therefore, the associated benefit of performance cannot be attributed to a single project. Nonetheless, PG&E developed conceptual and provisional estimates of the below performance factors for the incremental Smart Grid portfolio. The performance estimates and benefits are discussed in more detail in the Benefits section of this chapter below.

- *Avoided Energy Procurement Costs*
- *Avoided or Deferred Capital Investment*
- *Avoided Operations & Maintenance Costs*
- *Reliability Improvements*
- *Greenhouse Gas Emission Reductions*

### **7.3 Cost Per Customer**

At the direction of Commission Decision 10-06-047, PG&E presents below the average cost per customer of its Smart Grid portfolio. However, PG&E advises against using this metric for decision-making purposes because the metric assumes that costs will be borne equally by all customers rather than users of the services provided by the Smart Grid. While this underlying assumption is likely valid for the near-term, one key strategic objective of the Smart Grid strategy is to rationalize energy markets. Smart Grid projects and technologies will enable alternative rate structures and price signals that will more accurately allocate costs of services to users of the services, thereby helping to rationalize energy service pricing and avoid cross-subsidization.

The average, nominal cost per customer account is expected to be approximately \$12-\$20/year for each customer account, or \$4-\$7/ year for each customer.<sup>5</sup> This range

---

<sup>5</sup> Assumes incremental Smart Grid project costs are spread over PG&E's approximate 5.1 million customer accounts and 15 million total customers.



represents only costs per customer and would be reduced if benefits were applied as well.

## 7.4 Project Cost Estimates by Program Area

Below is a summary of the Smart Grid deployment plan costs organized by Smart Grid program area. All costs are nominal and reflect considerable uncertainty and are not intended to be used for planning or cost-recovery purposes. The cost estimates are categorized as conceptual (2011–2015), provisional (2016–2020), and beyond 2020. The costs are presented in ranges reflecting total project capital and expense within the given timeframe. The ranges were derived by applying uncertainty factors to each project element to reflect other risk factors such as technology risk, commodity price risk, and project implementation risk.

The conceptual and provisional cost estimates provided in the tables below reflect the capital and O&M expense required for commercial scale deployment and, therefore, assume the successful completion of pilot projects for those projects that require a phased implementation approach. Project costs (and the associated benefits) would decrease significantly or the projects eliminated if pilot testing proved unsuccessful. This phased project deployment approach limits the utility's and customer's exposure to ineffective technologies and decreases the likelihood of incurring unnecessary costs.

## 7.5 Engaged Consumers

As described in the Vision and Roadmap chapters, PG&E's proposed investments in projects within the Engaged Consumers program area will provide customers, authorized third-parties and PG&E with access to the information and tools necessary to manage customers' energy use, consumption and cost while meeting their evolving energy needs. These projects address a host of key drivers identified in PG&E's Smart Grid Vision including **Customer Empowerment, Environmental Sustainability and Flourishing & Efficient Energy Services Markets**. Dependencies exist between the

successful implementation of these projects and the benefits associated with the “Integrate Demand Response into the Energy Procurement Operating Environment” project.

The conceptual and provisional cost estimates for PG&E’s proposed Engaged Consumers projects are displayed in Table 7-2 below. The project capital costs are primarily IT- and Telecom-related and focus on enabling customers to engage in direct or indirect (i.e., through third party providers) management of their energy resources, usage, or costs. The Engaged Consumers program design contemplates that the platform systems will be in place by 2015 and subsequently the program will shift its focus to program and tariff design. Thus, costs for the Smart Grid elements of the project are front-loaded. Key elements that will affect the benefits attributable to the Engaged Consumers projects, but are not factored into the cost analysis include customer program design and marketing and tariff design.

**Table 7-2: Engaged Consumers Projects – Capital and Expense Estimate**

Project #	Project Name	Capital				Expense			
		Year 1 - 5 2011 - 2015	Year 6-10 2016 - 2020	Year 11- 20 2021 - 2030	Total 20 Years	Year 1 - 5 2011 - 2015	Year 6-10 2016 - 2020	Year 11- 20 2021 - 2030	Total 20 Years
1	Integration of Enhanced Demand Response (DR) Forecasting	\$2 - 3	\$0 - 0	\$0 - 0	\$2 - 3	\$3 - 5	\$1 - 1	\$0 - 0	\$3 - 6
2	Demand Response Optimization	\$6 - 11	\$0 - 0	\$0 - 0	\$6 - 11	\$3 - 5	\$1 - 1	\$0 - 0	\$4 - 7
3	Home Area Network (HAN) Phase II – Pricing and Load Control Signals	\$15 - 28	\$0 - 0	\$0 - 0	\$15 - 28	\$10 - 19	\$2 - 4	\$0 - 0	\$12 - 23
4	Enable Access to SmartMeter data via Open Automated Data Exchange (OpenADE)	\$6 - 11	\$0 - 0	\$0 - 0	\$6 - 11	\$2 - 4	\$0 - 0	\$0 - 0	\$2 - 4
<b>Total Engaged Consumers Projects</b>		<b>\$28 - 53</b>	<b>\$0 - 0</b>	<b>\$0 - 0</b>	<b>\$28 - 53</b>	<b>\$18 - 34</b>	<b>\$3 - 6</b>	<b>\$0 - 0</b>	<b>\$22 - 40</b>

## 7.6 Smart Energy Markets

As described in the Vision and Roadmap, PG&E’s investments in the Smart Energy Markets program area are focused on projects that support efficient and flourishing energy markets by enabling the integration of cost-effective, price-responsive customer and third-party provider energy resources and services. PG&E’s Smart Grid investments will allow customers, third-parties, and other stakeholders to more directly participate in a broader, more open and more efficient energy market by providing timely information and decision tools. Proposed investment in projects within the Smart

Energy Markets program area will address the key Smart Grid drivers of **Customer Empowerment, Environmental Sustainability, and Flourishing & Efficient Energy Services Markets**. As described in the Roadmap Section, elements of the two Smart Energy Markets projects are expected to be mandated by Market Redesign and Technology Upgrade and DR Energy policies.

The conceptual and provisional cost estimates for PG&E’s proposed Smart Energy Markets projects are displayed in Table 7.3 below. The proposed projects focus investments on technologies that communicate pricing, availability and location of decentralized energy resources, and other relevant information. These investments are primarily in IT- and Telecom-related systems. Key elements that will enable Smart Energy Markets, but are not included in the cost analysis include market structures and pricing policies that promote cost-effective development and participation of energy resources. These projects are synergistic with projects in other Smart Grid program areas including: HAN – Phase II, Open Automated Data Exchange, and Integrate DR into Transmission & Distribution Operations.

**Table 7-3: Smart Energy Markets Projects – Capital and Expense Estimate**

Project #	Project Name	Capital				Expense			
		Year 1 - 5 2011 - 2015	Year 6-10 2016 - 2020	Year 11- 20 2021 - 2030	Total 20 Years	Year 1 - 5 2011 - 2015	Year 6-10 2016 - 2020	Year 11- 20 2021 - 2030	Total 20 Years
1	Integrate Meter Data into Load Forecasting and Settlement	\$12 - 18	\$6 - 9	\$0 - 0	\$18 - 26	\$0 - 0	\$0 - 0	\$0 - 0	\$1 - 1
2	Integrate Demand Response into Energy Procurement Operating Environment	\$8 - 14	\$4 - 7	\$0 - 0	\$11 - 21	\$8 - 15	\$3 - 6	\$0 - 0	\$11 - 21
<b>Total PG&amp;E Smart Energy Markets Projects</b>		<b>\$20 - 32</b>	<b>\$10 - 16</b>	<b>\$0 - 0</b>	<b>\$30 - 47</b>	<b>\$8 - 15</b>	<b>\$4 - 7</b>	<b>\$0 - 0</b>	<b>\$12 - 22</b>

## 7.7 Smart Utility

As described in the Vision and Roadmap, PG&E’s proposed investments in the Smart Utility program area represent a core piece of the company’s strategy to leverage digital information, automation and control technologies to build the safe, reliable, secure, cost-effective and sustainable energy infrastructure of the future. These investments will serve as the platform to provide a more robust and dynamic energy infrastructure necessary to meet California’s ambitious and challenging energy and environmental

policy objectives while continuing to provide cost-effective, safe, reliable, sustainable and high-quality service. Proposed investment in projects within the Smart Utility program area will address the key Smart Grid drivers of **Safety, Reliability, & Security** and **Environmental Sustainability**. While none of the projects is explicitly required by energy policy or legislative mandates, the Substation Automation Interoperability Upgrade project is designed to prepare PG&E to meet a future implicit or expected mandate around the use of IEC 61850.

The conceptual and provisional cost estimates for PG&E’s proposed Smart Utility projects are displayed in Table 7-4 below. This program area represents the largest capital investment focus for PG&E’s incremental Smart Grid investment. Project scope, schedule and costs for many of the Smart Utility projects reflect the need to conduct pilot projects in a production environment prior to commercial-scale deployment. The costs below represent the capital and O&M expenses required for commercial scale deployment and assume that pilot projects have been successfully completed. The commercial scale project costs for the Smart Utility projects are driven primarily by investments in long-lived power delivery system assets, asset monitoring equipment, and system-state measurement and communication devices as described in the Roadmap chapter.

**Table 7-4: Smart Utility Projects – Capital and Expense Estimate**

Project #	Project Name	Capital				Expense			
		Year 1 - 5 2011 - 2015	Year 6-10 2016 - 2020	Year 11- 20 2021 - 2030	Total 20 Years	Year 1 - 5 2011 - 2015	Year 6-10 2016 - 2020	Year 11- 20 2021 - 2030	Total 20 Years
1	Integrate Demand Response with T&D Operations and Planning	\$0 - 0	\$15 - 25	\$0 - 0	\$15 - 25	\$2 - 4	\$2 - 4	\$15 - 25	\$19 - 34
2	Substation Automation Interoperability Upgrade	\$7 - 11	\$2 - 3	\$0 - 0	\$8 - 14	\$0 - 0	\$1 - 2	\$2 - 3	\$3 - 5
3	Install Wireless Sensor Technology	\$8 - 11	\$51 - 68	\$34 - 45	\$93 - 124	\$0 - 0	\$1 - 2	\$4 - 5	\$5 - 7
4	Fault Location Isolation and System Restoration (FLISR)	\$62 - 79	\$116 - 146	\$0 - 0	\$178 - 225	\$2 - 2	\$28 - 35	\$79 - 100	\$108 - 136
5	Install Volt Var Optimization System	\$31 - 43	\$161 - 224	\$0 - 0	\$192 - 266	\$4 - 6	\$2 - 2	\$2 - 3	\$8 - 10
6	Detect and Manage Distribution Faults	\$9 - 13	\$30 - 41	\$14 - 19	\$52 - 73	\$1 - 2	\$7 - 9	\$14 - 19	\$22 - 30
7	Manage Transmission Substation Transformer Asset Condition	\$14 - 17	\$9 - 11	\$0 - 0	\$23 - 29	\$1 - 1	\$3 - 4	\$7 - 8	\$11 - 14
8	Manage Distribution Substation Transformer Asset Condition	\$16 - 20	\$37 - 46	\$22 - 27	\$76 - 93	\$0 - 0	\$2 - 3	\$7 - 9	\$10 - 12
<b>Total PG&amp;E's Smart Utility Initiatives</b>		<b>\$147 - 193</b>	<b>\$421 - 564</b>	<b>\$70 - 91</b>	<b>\$638 - 848</b>	<b>\$11 - 15</b>	<b>\$47 - 61</b>	<b>\$129 - 172</b>	<b>\$186 - 249</b>

## 7.8 Foundational and Cross-Cutting Infrastructure Initiatives

As described in the Vision and Roadmap, PG&E's proposed investments in the Foundational and Cross-Cutting Infrastructure Initiatives are intended to establish a base of people, process and technology to support its Smart Grid strategic objectives. The Foundational initiatives include: implementing a customer outreach program; creating the secure and robust telecommunications, data and network architecture; developing rigorous technology and standards testing and evaluation capabilities; training the workforce of the future, and; engaging with diverse suppliers. The capabilities provided by these projects yield significant value that can be leveraged by multiple projects across the program areas and are an essential component to the realization of benefits from the proposed Smart Grid project portfolio. The Foundational and Cross-Cutting Infrastructure Initiatives provide a common platform for Smart Grid projects thereby increasing the efficiency and cost-effectiveness in attaining PG&E's key Smart Grid drivers: **Customer Empowerment, Environmental Sustainability, Flourishing & Efficient Energy Services Markets, and Consumer & Technological Advancement.**

As described in the Roadmap, a proactive **Customer Outreach** program would support PG&E's Smart Grid strategy by enabling the attainment of Customer benefits and participation. The program will help ensure that customers understand what the Smart Grid is and how it will benefit them. PG&E will also partner with customers to deliver insight into the customers' role in the Smart Grid and specific tools and resources they can use to take advantage of new Smart Grid-related services and programs. Project costs, primarily expense, are intended to fund the development and deployment of a robust and effective customer outreach program.

As discussed in the Roadmap, PG&E's **Cyber Security** project will address a wide variety of security risks associated with the application of technology to the current operating and control systems, such as theft of customer information, disruption caused by an

Internet virus, or sabotage of control systems used to remotely manage or monitor operations. This project is intended to help meet the policy drivers including SB 17 and North American Electric Reliability Corporation (NERC) Critical Infrastructure Protection (CIP) Standards. Project costs entail both capital and expense intended to fund the development and deployment of base physical and IT security system elements, security monitoring programs and systems, compliance auditing, metric reporting, vulnerability assessment and management, and security standards.

As described in the Roadmap, the foundational **Data Management Architecture (DMA)** and **Telecom** Architecture initiatives will provide a firm, but adaptive and scalable platform that is essential to realizing the economic and policy benefits of an integrated, efficient, secure and cost-effective Smart Grid. The DMA project is comprised of a number of enterprise-wide applications necessary to support the Smart Grid project portfolio, including a central data bus, a real-time operational data bus, and upgrades to field data collection systems. The costs below include capital for system design and testing and IT hardware, software and system integration, as well as expense for systems O&M. The architectures will be piloted and scaled in conjunction with the program area projects that they support. As PG&E implements projects beyond those in its proposed portfolio, this foundational data management architecture will serve as a platform for growth and scaling, which will be funded on a project-by-project basis. This agile architecture has potential for longer term cost savings since it can be expanded at relatively low incremental cost to deploy innovative technology solutions that support future line-of-business projects across the enterprise.

As discussed in the Roadmap, the maturity of Smart Grid technologies ranges from conceptual to commercially available. **Technology Innovation, Testing and Standards Development** will accelerate the maturation of new technologies and products and enable PG&E to influence standards. As these tested and proven technologies become standardized, PG&E and consumers will realize benefits from reduced cost and risk, as

well as increased reliability. Further, in order to verify and enable operational integration of new technology solutions and robust, competitive market for Smart Grid solutions, it is necessary for PG&E to take an active role in developing and testing technologies and standards. Project costs are primarily capital needed to upgrade PG&E's testing facilities and to purchase testing equipment and expense needed to fund the O&M of the testing facilities.

As described in the Roadmap, application of Smart Grid technology to the current power delivery system will require significant new workforce skills and knowledge in order to attain PG&E's strategic objectives and the associated benefits. A comprehensive **Workforce Development** program will create a new pipeline of workers and external parties (i.e., third-party contractors and market participants) familiar with the new, Smart Grid-related operating requirements and standards. Project costs are primarily expense, and are intended to fund the development and deployment of training programs.

As described in the Roadmap, PG&E will leverage its existing Supplier Diversity program to meet its Smart Grid Deployment Plan strategic objectives and to ensure the continued achievement of supplier diversity goals. PG&E does not anticipate the need for Smart Grid-specific funding for this project.

**Table 7-5: Foundational and Cross-Cutting Infrastructure Initiatives – Capital and Expense Estimate**

Project #	Project Name	Capital				Expense			
		Year 1 - 5	Year 6-10	Year 11- 20	Total	Year 1 - 5	Year 6-10	Year 11- 20	Total
		2011 - 2015	2016 - 2020	2021 - 2030	20 Years	2011 - 2015	2016 - 2020	2021 - 2030	20 Years
1	Cyber Security Architecture	\$18 - 53	\$13 - 38	\$0 - 0	\$30 - 91	\$1 - 1	\$34 - 51	\$9 - 13	\$44 - 66
2	Telecommunications Architecture	\$11 - 21	\$12 - 22	\$0 - 0	\$23 - 43	\$1 - 2	\$6 - 9	\$1 - 2	\$8 - 12
3	Information Architecture	\$28 - 83	\$18 - 55	\$0 - 0	\$46 - 139	\$9 - 13	\$19 - 29	\$3 - 4	\$31 - 46
4	Technology Innovation, Testing and Standards Development	\$9 - 14	\$4 - 7	\$0 - 0	\$14 - 20	\$33 - 54	\$67 - 108	\$6 - 10	\$106 - 173
5	Workforce Development	\$0 - 0	\$0 - 0	\$0 - 0	\$0 - 0	\$4 - 7	\$4 - 7	\$1 - 2	\$9 - 17
6	Supplier Diversity					0.00	0.00	0.00	0.00
7	Customer Outreach	\$0 - 0	\$0 - 0	\$0 - 0	\$0 - 0	\$78 - 117	\$4 - 6	\$0 - 0	\$82 - 123
<b>Total PG&amp;E Foundational and Cross-Cutting Infrastructure Initiatives</b>		<b>\$66 - 171</b>	<b>\$47 - 122</b>	<b>\$0 - 0</b>	<b>\$113 - 293</b>	<b>\$126 - 195</b>	<b>\$134 - 210</b>	<b>\$20 - 31</b>	<b>\$280 - 437</b>

## **7.9 Conclusion on Cost Estimates**

PG&E's Smart Grid Deployment Plan cost estimates are based on an assessment of PG&E-specific considerations, publicly available data, vendor quotes and other source data. PG&E has provided conceptual (2011–2015) and provisional (2016–2020) cost estimates for projects organized by Smart Grid program area. Consistent with the Roadmap section, the costs estimates address cost associated with lab testing, production scale pilot testing and commercial-scale deployment through 2020. The costs reflect considerable uncertainty and should not be used for planning or cost-recovery purposes. The costs include project-specific estimates of capital and average annual maintenance (O&M) expense of \$800 million–\$1.25 billion and \$25 million–\$40 million, respectively. Benefits were calculated at the portfolio level and are presented in the Benefits Estimates section of the Deployment Plan.

## **7.10 Benefits Estimates**

### **7.11 Introduction**

PG&E believes that a disciplined and customer-oriented Smart Grid strategy will generate substantial long-term benefits for its customers, its employees and society as a whole. In this section, PG&E presents its approach to estimating Smart Grid benefits characterization, which includes identifying, and where possible, quantifying and monetizing the benefits stemming from its incremental Smart Grid projects.

PG&E has included in the latter parts of this chapter a discussion of the benefits already being accrued or expected to result from the significant Smart Grid related investments, programs and operations underway at PG&E. Further, PG&E in cooperation with the Silicon Valley Leadership Group, an organization representing a broad array of business and local government agencies in the Silicon Valley, is conducting a study of the economic benefits of the Smart Grid industry on that critical region in PG&E's service



area. PG&E has included a summary of the preliminary findings from that study in this chapter as well.

As previously described, PG&E's Smart Grid strategy is to focus on developing capabilities that most effectively respond to the Smart Grid strategic drivers: customer empowerment; safety, reliability and security; environmental sustainability; flourishing and efficient energy markets; and consumer technological advancement. The breadth of these strategic drivers results in benefit streams and an array of benefit recipients. These benefits range from quantifiable to qualitative and from monetizable to policy-driven benefits with societal or indirect value (e.g., system reliability improvement, greenhouse gas emission reductions).

PG&E presents below in Table 7-6 its conceptual and provisional estimate of quantifiable benefits from its proposed Smart Grid portfolio. These estimates are preliminary and were arrived at using best efforts and following protocol outlined in standard benefit analysis tools, such as the Electric Power Research Institute (EPRI) benefits framework entitled "*Methodological Approach for Estimating the Benefits and Costs of Smart Grid Demonstration Projects*".<sup>6</sup> The estimates reflect significant uncertainties due to the early stage of project and portfolio development and technology evolution. Uncertainty around benefits stems from the fact that many of the projects involve nascent technologies for which accepted performance data is unavailable. The scale of deployment and therefore the benefits of some projects may change significantly based upon factors such as customer adoption of new technologies (e.g., roof-top solar generation, electric vehicles and new appliances) which are difficult to control and/or predict. Furthermore, it is possible that PG&E has not anticipated the full range of benefits or synergistic impacts of a project or technology. Although the

---

<sup>6</sup> Final Report No. 1020342, "Methodological Approach for Estimating the Benefits and Costs of Smart Grid Demonstration Project, January 2010.

benefit estimates represent PG&E's best efforts at this time, PG&E expects that the actual benefits will differ substantially from the estimates.

In general, the quantifiable benefits from the proposed Smart Grid projects fell into the following categories: avoided energy procurement costs, avoided T&D capital investment, avoided O&M costs, reliability improvements and environmental improvements. The nominal value of PG&E's conceptual estimate of accumulated financial benefits from the proposed project portfolio include customer energy cost savings of between \$600 million and \$1.4 billion, avoided or deferred future capital costs of between \$240 million and \$360 million, and avoided O&M costs of between \$140 million and \$195 million. Additional benefits associated with the proposed Smart Grid plan include reduced greenhouse gas emissions of 1.4 million to 2.1 million tons of CO<sub>2</sub>e, and improved system reliability of 10 to 20 percent as measured by traditional outage frequency and duration metrics. Finally, the Smart Grid projects contribute to PG&E's ability to attain a broad range of benefits in support of energy and policy objectives.

Benefits are presented at the portfolio level because interdependencies between functional program area projects domains (i.e., Engaged Consumers, Smart Utility and Smart Energy Markets) and the Foundational and Cross-Cutting Infrastructure Initiatives affect project performance and benefits. In many cases, the Foundational and Cross-Cutting Initiatives are integral to achieving the performance and therefore, the associated benefit cannot be attributed to a single project. Nonetheless, Smart Grid projects are expected to yield a broad array of potential benefit streams that will accrue to multiple stakeholders including customer, the utility and society in general.

In quantifying the benefits, PG&E assumed commercial-scale deployment of the Foundational and Cross-Cutting Infrastructure Initiatives and the costs and benefits of which are shared among the projects. Since it is impossible to attribute costs or

performance enhancement of the Foundational and Cross-Cutting Infrastructure Initiatives to individual projects, it is inappropriate and misleading to present project specific Benefit-to-Cost ratios. Instead, PG&E has presented the benefits at the portfolio level to reflect the interdependent nature of the Foundational and Cross-Cutting Infrastructure Initiatives and the Business projects. In addition to the quantifiable benefits, many benefit streams are unquantifiable but substantive. In all cases, the decision to include a project as part of the propose portfolio was made based on consideration of the economic value, attainment of energy and environmental policy objectives, customer impact, and clear policy mandates.

**Table 7-6: PG&E Incremental Smart Grid Project Portfolio Benefit Estimate**

Benefits	Nominal Value (\$MM)	Key Variables
Avoided O&M Costs	\$140 - \$195	<ul style="list-style-type: none"> <li>• Projected efficiency improvements</li> <li>• Internal labor estimates</li> </ul>
Avoided Transmission & Distribution Capital Investment	\$240 - \$360	<ul style="list-style-type: none"> <li>• Incremental investment in Substation Equipment avoided (and PG&amp;E specific value)</li> <li>• Energy capacity supplied by project</li> <li>• E3 Values for Avoided Distribution Capacity<sup>7</sup></li> </ul>
Avoided Energy Procurement Cost	\$600 - \$1,400	<ul style="list-style-type: none"> <li>• Avoided Incremental Generating Capacity</li> <li>• E3 Values for Avoided Generation Capacity</li> <li>• Avoided Energy</li> <li>• E3 Values for Avoided Capacity</li> <li>• Avoided Peak and Real Time Procurement</li> <li>• Avoided Energy</li> <li>• E3 Values for Ancillary Services</li> </ul>
<i>Avoided Capacity Cost</i>	<i>\$75 - \$330</i>	
<i>Avoided Energy Cost</i>	<i>\$500 - \$1,040</i>	
<i>Avoided Ancillary Services Cost</i>	<i>\$20 - \$30</i>	
Total Accumulative Benefits	\$975 - 1,955	

<sup>7</sup> Energy + Environmental Economics (E3) Avoided Cost Calculator (01/11/11)  
 Developed in support of the Commission’s Demand Response Cost-effectiveness Protocols (R. 07-01-041)  
[http://www.ethree.com/public\\_projects/cpucdr.html](http://www.ethree.com/public_projects/cpucdr.html)

Reliability Benefits	Improvement	Key Variables
SAIDI Improvement	13% - 20%	<ul style="list-style-type: none"> <li>• Projected percent improvement in outage response time</li> <li>• Project penetration rate</li> <li>• Projected percent improvement in outage frequency</li> <li>• Project penetration rate</li> <li>• Projected percent improvement in outage response time</li> <li>• Project penetration rate</li> </ul>
SAIFI Improvement	12% - 18%	
CAIDI Improvement	10% - 17%	
Environmental Benefits	Nominal Value	Key Variables
Criteria Pollutants NOx SOx	2,000 - 3,000 tons 6,000 - 7,000 tons	<ul style="list-style-type: none"> <li>• Avoided Energy Usage</li> <li>• PG&amp;E-owned Generation Emissions Factor</li> <li>• Average U.S. Emissions Factor</li> <li>• Percent of Energy Supply generated by PG&amp;E</li> </ul>
Total Accumulative CO <sub>2</sub> e Reduction	1.4M - 2.1M tons CO <sub>2</sub> e \$15M - \$84M	<ul style="list-style-type: none"> <li>• Avoided Energy Usage</li> <li>• PG&amp;E Energy Supply Emissions Factor</li> <li>• AB 32 floor and ceiling prices for CO<sub>2</sub>e</li> </ul>

Notes: The benefit estimates are presented in nominal dollars and are based on the 20 year project study period.

## 7.12 Approach

In order to estimate the performance of its proposed project portfolio, PG&E conducted a large-scale integrated planning and estimating effort aimed at assessing the performance and potential benefits of the portfolio.

PG&E developed a benefits framework to help it identify, organize and quantify Smart Grid-related benefits. The framework was compiled based upon a broad review of Smart Grid benefit analysis tools available today including tools developed by the EPRI<sup>8</sup>, SB 17 Smart Grid characteristics, the CPUC’s Smart Grid deployment plan decision (D.10-06-047), California Energy Commission’s report *Defining the Pathway to the California Smart Grid of 2020*<sup>9</sup>, U.S. Department of Energy and commercially available products. PG&E’s Smart Grid benefits framework is presented in Table 7-7. The

<sup>8</sup> EPRI Final Report No. 1020342, “Methodological Approach for Estimating the Benefits and Costs of Smart grid Demonstration Projects,” January 2010

<sup>9</sup> California Energy Commission, *Defining the Pathway to the California Smart Grid of 2020*. Draft

benefits range from quantifiable to qualitative and from monetizable to policy-driven benefits with societal or indirect value (e.g., system reliability improvement, greenhouse gas emission reductions).

For each project, a cross-functional team of subject matter experts provided guidance on project objective, scope, schedule, cost and performance. Based on the objective and scope, each project was expected to result in a number of benefits based on the project's expected performance. PG&E developed basic algorithms to quantify project performance in light of synergies with other line of business projects and Foundational programs.

Each benefit algorithm typically contained a unit performance estimate and a project deployment penetration (e.g., 20% of all distribution feeders). PG&E arrived at indicative values for performance improvement estimates and economic values, accounting for PG&E-specific considerations through a variety of sources including: benchmarking with publicly available information, vendor estimates, engineering judgment, and industry information. For benefits that are monetizable, public source estimates such as E3's Avoided Capacity and Energy values were used. Project benefits were assigned over an estimated average project life of 20-years accounting for variability in asset life across different solution components, such as software (short-lived) and energy infrastructure capital (long-lived).

Depending on the nature of the project, schedule and technology maturity, PG&E applied uncertainty factors to benefits to reflect a reasonable range of uncertainty over the project life. As with its costs, PG&E typically applied higher uncertainty factors to benefits for projects involving nascent technologies and those scheduled for implementation in the 6–10 year timeframe.

It is important to note that considerable incremental benefit may be obtained by developing and deploying new energy pricing structures and programs in tandem with the Smart Grid projects. However, PG&E did not attempt to quantify the impact of such future Smart Grid-related programs. Therefore, the current benefit estimates for some program-dependent projects such as HAN and the DR projects may be conservative.

For the new, proposed Smart Grid project portfolio, excluding baseline projects, PG&E established a list of potential quantifiable and non-quantifiable benefits. Using the approach described above, PG&E developed conceptual and provisional estimates of the following benefits:

- *Avoided Energy Procurement Costs*
  - Avoided Generating Capacity
  - Avoided Energy Procurement
  - Avoided Ancillary Services Procurement
- *Avoided or Deferred Transmission & Distribution Capital Investment*
- *Avoided Operations & Maintenance Costs*
- *Reliability Improvements*
- *Environmental Benefits*
  - Priority Pollutant Reductions
  - Greenhouse Gas Emission Reductions

PG&E was unable to quantify all of the anticipated benefits of Smart Grid projects due to the high level of uncertainty surrounding specific solutions and exogenous variables. Further, the attribution of performance to a specific project is complicated by interdependencies between program areas (i.e., Engaged Consumers, Smart Energy Markets and Smart Utility) and the Foundational and Cross-Cutting Infrastructure Initiatives. In many cases, the Foundational and Cross-Cutting Infrastructure Initiatives are integral to achieving the performance and therefore, the associated benefit of performance cannot be attributed to a single project. Nonetheless, Smart Grid projects

are expected to yield a broad array of potential benefit streams that will accrue to multiple stakeholders including customer, the utility and society in general.

Benefit estimates reflect considerable uncertainty and should not be used for planning or cost-recovery purposes, without further refinement and validation. In many cases, these benefits estimates reflect different levels of dependence on utility controlled (e.g., project execution) and external variables (e.g., natural gas prices), and therefore exhibit different benefit-realization risk profiles. The extent to which some customer benefits are realized is particularly subject to uncertainty including: industry standards; effective policy design and implementation; customer adoption rates of new technologies; and public education and outreach campaigns.

**Table 7-7: Smart Grid Benefits Quantification and Allocation Framework**

Benefit	Quantifiable	Monetizable	Recipient		
			Customer	Utility	Society
Promotes Public Safety			X	X	X
Avoided Energy Costs	X	X	X		
Increases Customer Empowerment			X		
Maintains or Improves Reliability	X		X		
Improves Customer Service			X		
Promotes Electric Market Efficiency			X		
Improves Utility Operating Efficiency	X	X	X	X	X
Avoided Capital or O&M Costs	X	X	X	X	
Enables Compliance				X	
Reduces GHG Emissions	X		X		X

Benefit	Quantifiable	Monetizable	Recipient		
			Customer	Utility	Society
Improves Environmental Footprint	X		X		X
Improves Energy Independence					X
Promotes Sustainable Economic Prosperity					X
Promotes Employee Safety				X	
Improves Work Processes				X	
Provides Career Development Opportunities				X	

### 7.13 Quantifiable Benefits

Below, PG&E presents the quantifiable Smart Grid benefits. The tables outline the benefit, the contributing projects and the values underlying the quantification and monetization of benefits.

#### Avoided Energy Procurement Cost Benefits

Table 7-8 below outlines the proposed Smart Grid projects and the variables that contribute to the **Avoided Energy Procurement Cost Benefits**. This benefit is comprised of three sub-categories of benefit: avoided generating capacity, avoided energy procurement costs and avoided ancillary service (A/S) benefits.

PG&E based its avoided capacity calculations on the ability of projects to offset demand for incremental generating resources by either increasing operational efficiency (e.g., Volt-VAR) or leveraging demand-side resources to displace energy demand (e.g., HAN). This is a function of the technology penetration rate, future demand reduction capacity in the areas deployed, and the technology's effectiveness at making the demand reduction available for productive use. Values for energy capacity are based on publicly available estimates from Energy + Environmental Economics (E3).



Avoided energy costs are comprised of: (1) general energy avoidance resulting from efficiency gains and (2) targeted high-value deployment of demand-side resources to reducing the cost of potential real-time energy spikes. By lowering line voltage, the Volt-VAR optimization project is expected to improve the efficiency of PG&E’s energy delivery system and improve customer Energy Efficiency (EE). Both the utility energy savings and the customer energy savings are captured in the estimates of this benefit. PG&E attributed value of reducing the cost of potential energy price spikes to the ability of the new DR projects to more effectively dispatch demand side resources in the event of real-time energy price spikes.

PG&E based its estimates of A/S on the incremental use of its existing, dispatchable DR programs to supply A/S. To estimate the A/S benefits, the capacity from planned direct load control DR programs was assumed to earn historical spinning reserve revenues four peak hours per day.

**Table 7-8: Economic Benefit – Avoided Energy Procurement Cost Benefits**

Benefit	Value (\$ Millions)	Value Basis	Contributing Projects
Avoided Energy Procurement Cost			
Avoided Generation Capacity Cost	\$76 - 333	55 MW (Annual Peak) Avoided Capacity E3 Value for Avoided Capacity Internal Estimate of Avoided Investment in Upgrades	HAN – Phase II Pricing and Load Control Signals Volt-VAR Optimization System Foundational and Cross-Cutting Infrastructure Initiatives
Avoided Energy Cost	\$502 - 1041	5,000 - 7,000 gigawatt-hour (GWh) Avoided Energy E3 Value for Avoided Energy 150 - 200 GWh Peak Pricing Event Avoided Internal Estimate for Peak Price Event	Volt-VAR Optimization System Integration into Wholesale Markets DR Optimization DR Forecasting Enhancements Cross-Cutting Initiatives

Benefit	Value (\$ Millions)	Value Basis	Contributing Projects
Avoided Energy Procurement Cost			
Avoided Ancillary Services	\$18 - 30	E3 Value for Ancillary Services 260 MW of Ancillary Service Avoided	DR Integration into Wholesale Markets DR Optimization DR Forecasting Enhancements Foundational and Cross-Cutting Infrastructure Initiatives

### **Avoided Transmission & Distribution Capital Investment**

Table 7-9 below outlines the proposed Smart Grid projects contributing to the **Avoided Transmission & Distribution Capital Investment** benefit category. These benefits were calculated based on benchmarking of similar projects at other utilities and internal estimates based on experience. The benefit is primarily a function of the penetration rate of the project, and the need for new capital investment. Projects displace new investments in T&D infrastructure through one of two means: (1) preventing or deferring the replacement of existing assets, or (2) reducing the cost of future assets. The Substation Automation Interconnectivity Upgrade project is designed to directly reduce the cost of future substation assets. All other projects prevent or defer the replacement of existing assets. PG&E would not realize the benefits of these projects without a solid information processing and communications platform provided by the Foundational Projects.

**Table 7-9: Economic Benefit – Avoided Transmission & Distribution Capital Investment**

Benefit	Value (\$ Millions)	Value Basis	Contributing Projects
Avoided Transmission & Distribution Capital Investment	\$239 - 360	34 MW (Annual Peak) Avoided Capacity  E3 value for Generating Capacity  Avoided Investment (Cost-Basis) for Substation Upgrades or Transformer Replacement	Integrate DR with Transmission & Distribution Operations and Planning  Manage Transmission Substation Transformer Asset Condition  Manage Distribution Substation Transformer Asset Condition  Substation Automation Interoperability Upgrade  Foundational and Cross-Cutting Infrastructure Initiatives

**Avoided Operations & Maintenance Costs**

Table 7-10 below illustrates which proposed Smart Grid projects and initiatives contribute to the Avoided **Operations & Maintenance Costs**. These benefits primarily result from implementing Smart Grid systems that increase the efficiency of work through enhanced ability to more precisely locate outages, remote performance of work, or reduced complexity of work. To quantify the increase in efficiency, PG&E estimated the project impact on a unit basis (e.g., 5% improvement/feeder) and multiplied this value by the project penetration. The value was then monetized by multiplying average labor rates for the affected business by the total percentage improvement.

**Table 7-10: Economic Benefit – Avoided Operations & Maintenance Costs**

Benefit	Value (\$ Millions)	Value Basis	Contributing Projects
Avoided Operation & Maintenance Costs	\$139 - 193	Percent efficiency improvement (benchmarking) Number of Feeders Addressed or Number of Transformer Banks Addressed Unit Cost for Labor	FLISR Install Wireless Sensor Technology Detect and Manage Distribution System Faults Manage Transmission Substation Transformer Asset Condition Manage Distribution Substation Transformer Asset Condition Substation Automation Interoperability Upgrade Foundational and Cross-Cutting Infrastructure Initiatives

**Reliability Improvements**

Table 7-11 below presents the proposed Smart Grid projects that contribute to the **Reliability Improvements**. Similar to the projects contributing to the Avoided O&M cost benefits, these benefits primarily result from implementing Smart Grid systems that increase the efficiency of response time to outages by more precisely locating outages. Another path for reliability realization is the prediction and prevention of outages. To quantify the increase in reliability, PG&E estimated the project impact on a unit basis (e.g., 10% to 20% improvement/feeder) and multiplied this value by the project penetration. The reliability benefit was not monetized.

**Table 7-11: Reliability Improvements**

Benefit	Value Basis	Contributing Projects
SAIDI Improvement	Percent improvement in reliability (benchmarking) Number of Feeders Addressed	Fault Location Isolation and Restoration Install Wireless Sensor Technology Detect and Manage Distribution System Faults

Benefit	Value Basis	Contributing Projects
		Foundational and Cross-Cutting Infrastructure Initiatives
SAIFI Improvement	Percent improvement in avoiding outages (benchmarking)	Manage Transmission Transformer Substation Asset Condition
	Number of Substation Transformer Banks Addressed	Manage Distribution Substation Transformer Asset Condition
CAIDI Improvement	Percent improvement in reliability (benchmarking)	Fault Location Isolation and Restoration
	Number of Feeders Addressed	Install Wireless Sensor Technology
		Detect and Manage Distribution System Faults
		Foundational and Cross-Cutting Infrastructure Initiatives

### Environmental Benefits

Table 7-12 below illustrates which proposed Smart Grid projects and initiatives contribute to the **Environmental Benefits**. For this category of benefit, PG&E focused its efforts on quantifying the impact of Smart Grid projects on air emissions in the form of Greenhouse Gases (represented as CO<sub>2</sub> equivalents) and select Criteria Pollutants (i.e., SO<sub>x</sub> and NO<sub>x</sub> and Particulate Matter 10). PG&E's Smart Grid-related environmental benefits result from emission reductions due to avoided energy usage. The air emissions reductions were quantified by multiplying a publicly available emissions factor (i.e., emissions mass /GWh) for PGE's energy supply portfolio by the energy avoided (GWh) to achieve total avoided pollution over the life of the project.

PG&E considered estimating the benefit from water savings. However, none of its generating plants or contracted power relies on freshwater for once-through cooling (OTC) and or has industrial discharges - only storm water discharges - to freshwater. None of the electricity suppliers with whom PG&E has power purchase agreements use freshwater for OTC technology. PG&E acknowledges that it purchases about a quarter of its electricity from the wholesale market, and this power is procured from power pools - which are unspecified sources. Thus, the company is not able to track the fraction of this delivered electricity back to a specific generator to determine if the

generator uses once-through cooling. Although Smart Grid projects may result in reduced water consumption for some utilities, this is not a primary driver or benefit for PG&E. Nonetheless, as PG&E further develops and refines its Smart Grid metrics and benefits estimating methodology, it will seek to measure indirect benefits attributable to Smart Grid projects, such as reduction in water consumption in its operations and by suppliers and customers.

**Table 7-12: Environmental Benefits**

Environmental Benefits	Value Basis	Contributing Projects
CO <sub>2</sub> e Reduction	PG&E Energy Supply Emissions Factor	Volt-VAR Optimization
	5,600 GWh avoided	Foundational and Cross-Cutting Infrastructure Initiatives
Criteria Pollutant Reduction	PG&E Energy Supply Emissions Factor	Volt-VAR Optimization
	5,600 GWh avoided	Foundational and Cross-Cutting Infrastructure Initiatives

### 7.14 Achievement of Energy and Environmental Policy Goals

PG&E's expects that its proposed Smart Grid portfolio will enable it to achieve energy and environmental policy goals directly or indirectly. Some projects, such as HAN Phase 2, OpenADE and DR, directly respond to explicit or implicit Smart Grid-related policy objectives. Other projects are necessary to mitigate the impact of policy objectives on the reliability or quality of services. For instance, Volt-VAR Optimization is necessary to manage voltage fluctuation and avoid voltage limit violations occurring as a result of increasing penetration of customer-owned rooftop solar photovoltaic systems. The tables preceding each of the following subsections illustrates the linkage between proposed projects and Smart Grid-related objectives. The degree to which policy objectives will be achieved or impacts will be mitigated is difficult to predict. However, in most instances, projects are not fully justified by the policy attainment benefits alone, but must be justified based upon a combination of policy attainment, economic benefit, and customer benefit (quality, reliability and empowerment).

## 7.15 Engaged Consumer Projects

The Engaged Consumer program area projects support the attainment of explicit and implicit policy mandates around integrating customer loads into wholesale energy markets and empowering customers by providing richer data directly to the customer or indirectly to a third party energy service provider.

**Table 7-13: Engaged Customer Projects - Policy Objectives and Drivers**

Engaged Consumer Projects	Smart Grid Drivers				
	Customer Empowerment	Safety, Reliability & Security	Environmental Sustainability	Flourishing & Efficient Energy Markets	Consumer & Technological Advancement
HAN – Phase II	X			X	X
Open Automated Data Exchange	X			X	X
DR Optimization	X	X	X	X	
DR Forecasting Enhancements	X	X	X	X	

The **HAN – Phase II** project is envisioned as a system over which PG&E will communicate pricing signals, grid-state condition and other data that will enable customers to efficiently manage their energy usage through automated or customer-initiated response. HAN technology would allow PG&E to more pro-actively partner with customers to shift electric vehicle charging to off-peak hours, reducing capacity constraints and deferring associated demand for incremental generation and distribution capital investments. It would also allow for expanded DR programs to mass markets. Benefits realization is highly dependent upon adoption of an open and secure standard.

PG&E is committed to providing customers with the information, tools and the capability to manage their energy use and understand their choices and options. HAN capability is an important emerging capability. The sector is evolving rapidly and markets for HAN devices and services are seen as promising, high growth markets.

The adoption of national standards is a key enabler of markets for mass marketed high technology devices such as HAN-enabled devices. For these reasons, PG&E's deployment of HAN connectivity is now focused on complying with terms of the recent Security and Privacy Proposed Decision (PD) and enabling devices that conform to the Smart Energy Profile (SEP) 2.0 standard. For PG&E, supporting SEP 2.0 devices, and enabling utility metering architecture, provides the most cost-effective and scalable retail HAN enablement strategy, while simultaneously addressing PG&E's security requirements. Investments in SmartMeters™ or HAN architectures that use the earlier standard, SEP 1.x, may lock utilities into a higher cost, lower flexibility and proprietary platform that could be problematic to scale in the retail channel and may not meet the requirements of the National Institute for Standards & Technology Smart Grid Interoperability Panel.

Unfortunately, SEP 2.0 has not yet been adopted as the national HAN standard, and may not be adopted in time for SEP 2.0 HAN devices to be commercially available on the schedule for HAN pilots proposed by the PD. Consequently, PG&E and its customers may be exposed to the risk of stranded costs if utilities to move forward with HAN deployments that rely solely and prematurely on 1.x devices. In addition, HAN-enabled in-home displays are now facing competition with, and the potential to be superseded by, broadband-based internet-connected and mobile applications.

In light of these developments on national HAN standards and in HAN markets, PG&E is continuing to be involved in getting SEP 2.0 adopted as the industry standard as part of its HAN-enablement plans. In order to mitigate stranded cost risks, PG&E intends to continue to collaborate and share information with the other California utilities and Commission staff on HAN testing and pilot studies, and to design and deploy HAN pilots in PG&E's service territory in a manner that take into account the need for adoption of the national SEP 2.0 standard before commercial HAN deployment



PG&E's ability to share customers' energy usage data with customer-authorized third parties through an OpenADE program could result in benefits to the customer by providing access to energy service providers that can aggregate customer services and provide value that individual customers may not be able or willing to achieve. Benefits realization is highly dependent upon the development of a robust energy service provider market, the services provided to customers by third-parties and the associated fees.

The DR Optimization and DR Forecasting Enhancements projects will enhance the effectiveness of other projects that directly enable customers to participate in the real-time and day ahead energy and A/S markets and increase the usefulness of DR to T&D grid operators. These projects are designed to predict PG&E's system DR availability and optimally allocate this DR between uses in the wholesale energy market and grid operations environment. In addition to the quantifiable benefits of avoided energy, avoided energy services and avoided capital for new generating plants, these projects will support renewable integration by providing regulation services. Further, the ability to integrate DR programs that provide dispatchable and highly-targeted peak DR resources at sufficient scale into the distribution system could reduce demand and thereby defer capacity upgrades to the distribution system, thereby deferring capital investment and increasing grid efficiency through optimization of existing capital assets. Attaining these benefits would require close coordination across multiple lines-of-business and careful planning of both the DR programs, and integration of DR into the operating system.

## 7.16 Smart Energy Markets Projects

**Table 7-14: Smart Energy Markets Projects – Policy Objectives and Drivers**

Smart Energy Market Projects	Smart Grid Drivers				
	Customer Empowerment	Safety, Reliability & Security	Environmental Sustainability	Flourishing & Efficient Energy Markets	Consumer & Technological Advancement
Integrate Meter Data Into Load Forecasting and Settlement				X	
Integrate DR into Wholesale Energy Markets	X	X		X	

The Integrate Meter Data into Load Forecasting and Settlement project will develop more accurate short-term energy demand forecasts through “bottoms-up” aggregation of direct load measurement to supplement current “top-down” forecasting methods based on system-wide generation and transmission measurements. This would allow the utility to more accurately predict and bid for energy resources, thereby potentially reducing costs associated with short-term procurement or sale of short- or long-energy purchases in the real-time markets. Improved insight into system-wide demand from the bottoms-up forecasting would increase the efficiency of the energy market and potentially reduce exposure to real-time procurement or sale of energy wholesale market, thereby reducing procurement costs. The benefits associated with this project are dependent upon the assumption that a significant differential in wholesale energy pricing exists between day-ahead and real-time procurement. The use of meter data in wholesale settlement process could reduce costs and improve accuracy and timeliness of the settlement process.

The Integrate DR into Wholesale Energy Markets project will allow the utility to integrate DR programs that provide A/S and other energy products into wholesale markets. By making currently inaccessible DR resources available on the wholesale market this project would enable competition among energy resource providers in the energy markets. Realization of these benefits would require close coordination across

multiple lines-of-business and careful planning of both the DR programs, and integration of DR into the wholesale markets. The success of this project is dependent upon the implementation of the DR Forecasting and DR Optimization projects outlined above in the Engaged Consumer section, as these projects are designed to predict DR availability and optimally allocate DR between wholesale and grid operations environment.

## 7.17 Smart Utility Projects

**Table 7-15: Smart Utility Projects – Policy Objectives and Drivers**

Smart Utility Projects	Smart Grid Drivers				
	Customer Empowerment	Safety, Reliability & Security	Environmental Sustainability	Flourishing & Efficient Energy Markets	Consumer & Technological Advancement
Integrate DR into T&D Operating Environment		X	X	X	
Communicating Line Sensor Deployment		X			
Advanced Distribution Feeder Automation		X			
Detect and Manage Distribution System Faults		X			
Volt-VAR Optimization	X	X	X		
Substation Automation Inter-operability Upgrade		X			
DR Integration into Transmission & Distribution Operating Environment	X	X			
Condition-Based Management		X			

The projects proposed within the Smart Utility Area are expected to primarily deliver quantifiable benefits related to outage duration and frequency and potentially lower costs of responding to outages. In addition, PG&E believes that the proposed Volt-VAR project will help to integrate distributed renewable energy, lower distribution system line losses, and reduce customers’ energy usage. The Substation Automation

Interoperability Upgrade Project will result in significant savings through avoided capital costs, enhanced security and safety, and supports future system automation evolution.

Communicating line sensors will enable distribution system operators to identify and more closely guide PG&E personnel to outage locations. While this system alone will not pinpoint the outage it is expected to significantly reduce the search-area for field personnel and thereby reduce both the outage duration and the response cost. Further, where the line sensor deployment overlaps with the Volt-VAR system, voltage data from the remote line sensors may be integrated into the Volt-VAR operational data streams. This synergy would help to reduce the cost of deploying the Volt-VAR system and provide additional monitoring points along distribution system feeders. Benefits realization is dependent upon a number of factors including the ability to leverage existing communication networks, share data across a common DMA with distribution automation systems including System Control and Data Acquisition (SCADA), the Distribution Management System and an Outage Management System.

The Detect and Manage Distribution System Faults project processes data from a number of sources including line sensors, the SmartMeter™ network and SCADA to help detect and pinpoint faults. This system enhances the capability of the line sensors project and is expected to deliver a number of incremental quantifiable and unquantifiable benefits. The project's quantifiable benefits include reduced outage time and outage response costs. Additionally, the project would be designed to increase PG&E's predictive capability for fault detection through comparing current grid-state conditions with historical grid conditions in real-time. This could result in avoided outages. Finally, the system could be capable of detecting historically challenging grid-state issues such as high-impedance faults, unbalanced load and nested faults. The ability to identify high-impedance faults could lead to reduced public safety exposure as high-impedance faults have typically been difficult to detect and respond to as quickly as desired.

The Advanced Feeder Automation project would automate restoration providing “self-healing” capability to approximately 400 of PG&E’s distribution circuits. This project would expand distribution automation capabilities that are part of PG&E’s approved Cornerstone project to PG&E’s next worst-performing circuits. The primary benefits of the project are reduced outage duration, reducing the number of customers affected by outages and lowering outage management costs. Realization of the benefits is dependent upon integration into the Distribution Management System.

Volt-VAR Optimization provides a broad array and significant magnitude of quantifiable and non-quantifiable benefits. Deployment of an integrated Volt-VAR system would allow the utility to optimize the operation of distribution system voltage and VAR support equipment across voltage regulation device segments on approximately 400 high-impact circuits. The system would enable PG&E to lower line voltage and manage voltage regulating equipment within a narrower bandwidth on these feeders with the goal of reducing line losses, reducing customer energy usage, and reducing peak demand. Quantifiable benefits include those associated with avoided energy and the associated greenhouse gas emissions reductions and deferred capital from reduced peak demand. The project would also enable PG&E to integrate renewables by enhancing our ability to provide VAR-support and manage voltage violations from customer-connected distributed generation. Therefore, this project, if deployed as designed, would support multiple policy objectives related to integrating improved distribution system operational efficiency, greenhouse gas reductions, renewable portfolio standards, and customer empowerment. Realization of these benefits is dependent upon effective integration of multiple data sources into the Volt-VAR optimization engine across an enterprise data management system, as well as integration of the optimization engine into the Distribution Management System.

The Substation Automation Interoperability Upgrade project would replace, upgrade and install new substation network and communication equipment to support digitization of substations in compliance with IEC 61850 communications protocol. In most cases, the deployment would be included as part of planned, major re-work at substations where protection and automation upgrades are required. In some instances, the avoided cost-savings could be on the order of millions of dollars per substation. Further, by upgrading the substations in compliance with IEC 61850, PG&E would position itself to be compliant with expected adoption of IEC 61850 by NERC as a reliability standard and would enhance substation telecommunications network security.

The Integrate DR into T&D Operating System project will allow the utility to integrate DR programs that provide dispatchable and highly-targeted peak DR resources at sufficient scale into the distribution system with the goal of reducing demand and thereby deferring capacity upgrades to the distribution system. This would result in deferment of capital investment and increased grid efficiency through optimization of existing capital assets. Attaining these benefits would require close coordination across multiple lines-of-business and careful planning of both the DR programs, and integration of DR into the operating system. The success of this project is dependent upon the implementation of the DR Forecasting and DR Optimization projects outlined above in the Engaged Consumers section, as these projects are designed to predict DR availability and optimally allocate DR between wholesale and grid operations environment.

The Condition-Based Management project would provide targeted online monitoring of high-value and aging transmission substation transformers and distribution substation load-tap changers. This would support optimization of existing substation equipment assets, by targeting maintenance or replacement actions based on actual measured data potentially extending the life of the monitored assets. Additionally, the data from the monitors can identify potential problems more accurately avoiding catastrophic

transformer failure and prolonged outages or abnormal operating configurations following an equipment failure. Finally, this system could result in the reduction of operating and maintenance costs from automating the manual data collection process, which is currently done on-site.

## 7.18 Foundational and Cross-Cutting Infrastructure Initiatives

**Table 7-16: Foundational and Cross-Cutting Infrastructure Initiatives – Policy Objectives and Drivers**

Foundational and Cross-Cutting Infrastructure Initiatives	Smart Grid Drivers				
	Customer Empowerment	Safety, Reliability & Security	Environmental Sustainability	Flourishing Energy Markets	Consumer & Technological Advancement
Cyber Security Architecture	Required	Required	Required	Required	Required
Telecommunications Architecture	X	X	X	X	X
Information Architecture	X	X	X	X	X
Technology Innovation, Testing & Standards Development					
Workforce Development					
Supplier Diversity	X	X	X	X	X
Customer Outreach	X	X	X	X	X

The capabilities provided by the Foundational and Cross-Cutting Infrastructure Initiatives yield significant value that can be leveraged by multiple projects across the enterprise and are an essential component to the realization of benefits from the proposed Smart Grid project portfolio.

PG&E's **Cyber Security** initiative will address a wide variety of security risks associated with the application of technology to the current operating and control systems, such as theft of customer information, disruption caused by an internet virus, or sabotage of control systems used to remotely manage or monitor operations. The evolution of the Smart Grid has ramifications for security and privacy and hence the utility must be

prepared to evolve its security program, technology, and processes as a core foundational initiative to meet the strategic objectives of safety, reliability, customer empowerment, flourishing and efficient energy markets, environmental sustainability, and consumer and technological advancement as characterized in this Smart Grid deployment plan. The cyber security foundational initiative will allow PG&E to more readily achieve operational benefits with respect to customer service, reliability, demand management, and energy supply. Without this level of focus on cyber security, the Smart Grid systems will be operating at unacceptable levels of risks which eventually become an obstacle to achieving the strategic objectives aligned to success of the Smart Grid. These risks must be well assessed and understood in the context of the increasingly complex and newly emerging technology architecture introduced to enable the Smart Grid automation. Once quantified, risk reduction metrics demonstrate non-monetary benefits directly tied to ensuring the safe and reliable operation of the Smart Grid systems. This is based on the threats, the likelihood, and the anticipated impact a security breach would have on system operation. Less risk means better resiliency and system sustainability and enhanced levels of system health. Through the cyber security process, PG&E seeks to maintain an acceptable balance between levels of risk to derive the optimal expected benefit given the diminishing returns and high costs associated with cyber security expenditures that seek to eliminate all residual risk to zero. Security controls in people, process, and technology that counteract the risks that surface will be designed up-front and early as an integral part of the systems engineering lifecycle for Smart Grid. As a result, a holistic physical and cyber security program that is designed to continuously address and mitigate risks that threaten safe and reliable operations and customer privacy is required. The Smart Grid deployment plan outlines PG&E's approach to security, including physical and cyber security, as well as the privacy framework to demonstrate the overall programmatic approach to securing the smart grid, smart grid technologies and customer data.



The foundational **Telecom Architecture** and **Information Architecture** initiatives will provide a firm, but adaptive platform that is essential to realizing the economic and policy benefits of an integrated, efficient, secure and cost-effective Smart Grid. The architecture will allow for easily accessible, meaningful, accurate and timely data exchange between users, businesses, individual customers and a variety of technology systems, resources and intelligent devices; provide improved network performance with increased capacity, latency, and quality of service; protect against existing and emerging threats to the utility industry; and enable increased interoperability needed for many of the Smart Grid initiatives. This new foundational architecture will be leveraged by the proposed Smart Grid initiatives to create cost and operational synergies. In addition, PG&E expects to increase reliability and create operational efficiencies by reducing system complexity and risk.

Furthermore, building a foundational architecture creates a platform for growth and scaling over time. This agile architecture has potential for longer term cost benefits since it can be expanded at relatively low incremental cost to deploy innovative technology solutions that support future line-of-business projects across the enterprise.

A proactive **Customer Outreach and Education** program for Smart Grid would support the Smart Grid strategy by enabling the attainment of Customer benefits and buy-in. At the broadest level, the program would ensure that Customers understand what the Smart Grid is and how it will benefit them in various direct and indirect ways including improved service and reliability, integration of more renewable resources into the power grid and less need for new power plants in the longer term. On a more personal level, customers will gain insight into their role in the Smart Grid and specific tools and resources they can use to take advantage of new services enabled by the Smart Grid such as Time of Use (TOU) pricing and EE programs. This will increase the benefits received through the set of projects within the Engaged Consumers program area.

Finally, customers will receive information to allay any concerns they may have related to the implementation of the Smart Grid, such as privacy, security or access.

**Standards Development** is necessary in order to provide the increased interoperability required for the deployment of Smart Grid technologies. As the utility industry evolves toward a deep dependence on standards there is a need for an increased focus by PG&E to assist in the development of these standards so they can be influenced to meet the interests of the utility and consumer. In addition, being involved in standards development will give PG&E greater access to cutting edge technology and an evolving knowledge base, which will speed up deployment for projects and provide economic considerations up front.

**Technology Innovation and Testing** in a laboratory setting goes hand in hand with **Standards Development** and the deployment of new Smart Grid technologies. Lab testing will accelerate the maturation of new technologies and products and enable PG&E to influence standards. As these tested and proven technologies become standards, PG&E will realize benefits from reduced cost and risk, as well as increased reliability. In addition, a continued focus on technology innovation will enable PG&E to create an increased technological knowledge base which is required to effectively implement new Smart Grid technologies. This knowledge combined with agile work processes will support the proposed Smart Grid initiatives by offering speed and flexibility in deployment and moving risks earlier into a project life cycle where costs are minimized and there is sufficient time to remediate or manage identified risks.

Application of Smart Grid technology to the current power delivery system will require significant new workforce skills and knowledge in order to attain PG&E's strategic objectives and the associated benefits. A comprehensive **Workforce Development** program will create a new pipeline of workers trained to operate new Smart Grid-enables systems as they come online. Furthermore, for mass deployment of its

proposed project portfolio, PG&E will be reliant on external parties (i.e., third-party contractors and market participants) who must be familiar with the new, Smart Grid-related operating requirements and standards. Therefore, training programs will be required in order to effectively implement and operate the new technologies and attain the Smart Grid portfolio benefits.

### **7.19 Discussion of Other Benefits**

In addition to benefits that can be realized from the roadmap projects discussed in this document, customers will continue to realize benefits achieved through baseline investments in the Smart Grid. The benefits PG&E believes can be realized through baseline investments are discussed in detail in the Deployment Baseline and Smart Grid-related Customer Programs chapters of this document.

Furthermore, PG&E believes that deployment of the Smart Grid nationally has significant economic development potential for its service area and California generally. The actual economic development benefits will be a function of demographics of the industries and customers in their service territories to determine areas for growth in the Smart Grid space. Areas located in PG&E's service territory such as the greater Bay Area and Silicon Valley are populated with a high concentration of high tech companies, research centers and technology workforce talent that are actively engaged in developing and providing Smart Grid related products and services. Additionally, these geographic areas have a culture of early technology adoption among consumers which provides a unique opportunity for PG&E to build and gain momentum to drive Smart Grid innovation and technology.

In 2010, PG&E, in partnership with the City of San Jose and the Silicon Valley Leadership group, established the Silicon Valley Task Force (Task Force), which brings leaders from industry, the public sector, non-profit organizations and academia together to better educate the public about smart grid technology and its importance in aiding California's

long-term environmental sustainability and economic development. It is envisioned that the dialogue among these participants will help determine the level of acceptance among consumers and which products and services can be brought to market. The Task Force commissioned a study of economic development potential created in the Bay Area and Silicon Valley by deployment of the Smart Grid globally. The study is scheduled for release later this year but preliminary results indicate five Smart Grid sectors have high concentrations in the Bay Area and the Silicon Valley. These industries include: Power Management & Energy Efficient Products, Energy Storage, Distributed Energy Generation, Electricity T&D, and IT. Since the 1995, the establishment of companies and employment within these industries has increased and is expected to continue to grow as the Smart Grid is further developed.

The deployment of the Smart Grid will generate an enormous amount of data that will require processing, storing, protection from cyber attacks, management, analyzing and accessibility by various users. This is where the Silicon Valley's core IT industry is expected to be particularly well positioned to take advantage of the opportunities presented by deployment of the Smart Grid. The Bay Area and Silicon Valley are well positioned to lead in the development and deployment of Smart Grid-related technology and to realize economic development benefits.

## **7.20 Conclusion**

PG&E has presented a best-efforts estimate of the conceptual and provisional estimates of accumulated financial benefits for its incremental Smart Grid portfolio. The benefit estimates reflect considerable uncertainty around project execution, technology maturity, customer uptake of technology solutions, evolution of industry supported standards, and robust competition among third-party providers of energy services. The nominal value of the benefits from customer energy cost savings are between \$595 million and \$1.4 billion, benefits from avoided or deferred future capital costs are between \$240 million and \$360 million, and benefits from O&M cost savings are

between \$140 million and \$190 million. Additional benefits associated with the proposed Smart Grid plan include reduced greenhouse gas emissions reductions of 1.5 million and 2.1 million tons of CO<sub>2</sub>e and 10 percent – 20 percent improvements in system reliability as measured by traditional outage frequency and duration metrics SAIDI, SAIFI and CAIDI.

# **Chapter 8 – Customer Outreach and Education**

## 8.1 Introduction

In this chapter, PG&E describes the extensive customer research, outreach and education needed for the Smart Grid and the associated opportunities and challenges. Industry, government, consumer advocacy groups, political action groups, utilities and other stakeholders have defined the Smart Grid in numerous and often conflicting ways. For some PG&E customers, the Smart Grid could be an interesting and understandable evolution for the energy grid. For others, it could be an obscure, confusing and potentially frightening term. Given PG&E's large and diverse customer base (both geographically and demographically), there are almost certainly a wide array of Smart Grid knowledge levels, interests, understandings and opinions represented. To create a cohesive understanding and appropriately educate customers about the Smart Grid, PG&E plans to implement an outreach plan that integrates Smart Grid messaging with various energy education campaigns and communication channels. PG&E will implement its outreach plan beginning in 2014 if the Smart Grid Plan and funding for the outreach plan are approved by the Commission.

Above all, the customer must be placed at the center of Smart Grid development plans to ensure that customer benefits and the customer's role are clearly communicated. Customers must have the tools and knowledge to personally benefit from the Smart Grid in the ways most impactful to them as individuals and families. The scale of educating customers about the Smart Grid, given the mass and diverse demographic makeup of PG&E's customer territory is a large undertaking. Smart Grid education will build on existing education efforts related to SmartMeter™, time-of-use pricing and other dynamic pricing rates, EE, DR and others, and will provide a larger context of understanding about what the Smart Grid is, what it can do for the customers and why it is relevant to customers.

Importantly, PG&E recognizes the need for an ongoing, two-way dialogue with customers about the Smart Grid. Communication is the first step towards

empowerment, and as we outreach to customers and attempt to empower them to participate in Smart Grid benefits, we will need to learn directly from them whether our efforts and communications are beneficial. Key to this dialogue will be effective partnerships with third parties who can help facilitate the iterative learning process for PG&E. As the utility pilots and deploys Smart Grid projects, customer feedback loops must be an integral part of the process.

## **8.2 Outreach Objectives**

PG&E plans to help customers understand the Smart Grid and how it will benefit them, and provide education and information about the details of Smart Grid to mitigate any concerns they may have. To accomplish this basic awareness of Smart Grid, PG&E must establish a baseline level of understanding across all customer classes. This baseline includes a summary of the current state of California's energy grid and its limitations and the drivers behind the transition to a Smart Grid. The objective of educating customers about the Smart Grid is to help customers understand the context of how today's energy infrastructure works, how the Smart Grid will help meet overall EE and environmental protection goals, and how the Smart Grid will benefit them as an individual consumer. Further, Smart Grid education efforts must leverage earlier and complementary outreach, such as SmartMeter™ communications, and build upon these efforts to convey that the Smart Grid is the technical foundation for tools that increase access to, and usability of, customers' energy use data. PG&E intends to connect the message of the Smart Grid to the tools and time-varying pricing rates it enables, to help customers better understand how they may save money by conserving energy, shifting usage and making informed energy use choices in the new pricing environment.

In addition, customer outreach must address concerns and diminish fears that may result from lack of, or misinformation. For example, anecdotally, as represented in media coverage and other public forums, customers' concerns about the Smart Grid include, but are not limited to:



- **Higher Bills** – Misperceptions around dynamic pricing and Smart Grid costs may lead customers to conclude that the Smart Grid’s purpose is to raise energy rates for customers, leading to increasingly higher bills.
- **Privacy and Security** – The privacy and security concerns are distinct but intertwined. Customers may be concerned that in the Smart Grid environment, their private usage data could be sold for profit by utilities or other companies, used without their knowledge or permission or accessed through a malicious security breach. Additionally, some customers could have concerns that utilities, governments or other stakeholders may employ “Big Brother” tactics to gain a granular view of daily personal habits as evidenced by energy consumption (for example, when certain appliances are used and when a customer is at home or not at home).
- **Energy Rationing** – Customer concerns around Smart Grid “energy rationing” could include the assumption that by employing Smart Grid technologies, utilities and other stakeholders may forcefully ration the amount of energy a customer may use at any given time.
- **Lack of Access and Benefit for Specific Groups (e.g., Elderly, Low-Income or Disabled Customers)** – Some consumer advocacy groups have expressed concern that Smart Grid technologies could place some customers at a disadvantage, for reasons including lack of Internet access and experience or language barriers.

**PG&E’s Outreach and Education Activities Are Envisioned to:**

1. Create awareness and understanding of the Smart Grid and its benefits for approximately 6 million residential, commercial and agriculture customers across 70,000 square miles of service area. All PG&E customers will be impacted by the Smart Grid and therefore must be educated broadly.

2. Drive deeper awareness of Smart Grid, SmartMeter™ and time-varying pricing information so that customers will understand how the concepts are related and mutually supportive.
3. Support broad, high-touch consumer outreach and customer communications through a multi-year outreach campaign layered into existing customer communications. Since Smart Grid development is a process and not a destination with a fixed “end date,” education efforts will be continuous.
4. Provide geographic- and demographic-specific outreach through multiple channels to deliver tailored, customized information to customers of various ethnicities, demographics, income levels, etc.
5. Communicate environmental and public health benefits of Smart Grid. Customers and policymakers have a stake in understanding holistic benefits, such as cleaner air and energy independence, and linkages among the concepts must be made clearly when they are not readily apparent. When possible, we will seek to quantify these benefits and provide substantive information to customers about public health and ecological benefits.

**PG&E Defines Successful Customer Outreach as Achieving the Following Objectives:**

1. Prepare all PG&E employees, with a particular initial focus on Contact Center Representatives and all customer-facing employees, for inquiries about the Smart Grid and Smart Grid projects and initiatives included in PG&E’s Smart Grid Deployment Plan.
2. Create awareness of the Smart Grid and its benefits among all customers.
3. Mitigate concerns of the Smart Grid’s impact for all customers.
4. Forge effective partnerships with consumer advocacy groups, vendors, contractors and other third parties to help educate customers with focused interests, affiliations and concerns.

5. Design specific outreach programs in conjunction with elected officials and municipalities who represent their constituents' interests, questions and concerns.

### **8.3 Overview of PG&E's Customer Audience**

PG&E provides electric and natural gas service to approximately 6 million residential, commercial and agriculture customers. The energy needs of these customer segments are uniquely defined by characteristics such as: geographic location and corresponding weather patterns, personal comfort and usage behaviors, business needs and energy demands, income level, and whether they own or rent their homes. Demographics of PG&E's customer base vary broadly and include ethnically diverse customers with specific language preferences, disabilities, varying levels of education and employment status, different ages and customers with and without Internet access.

Due to the enormous diversity of customers served by PG&E, and the complex nature of Smart Grid subject matter, the messaging challenges will be significant. Adding to the complexity are harder to reach populations such as low-income customers and the elderly. These factors reinforce the requirement for up-front research to understand consumers' knowledge states and ongoing "pulse checks" through various channels to test the effectiveness of outreach efforts and enable PG&E to iterate as necessary for maximum impact. Key to this adaptive learning process will be to learn how to empower customers, and go beyond merely providing information. When PG&E conducts further research of its customer base to understand their needs, we intend to use that information to design specific programs based on the latest science and scholarship on how to engage customers in the pursuit of Smart Grid benefits.

### **8.4 PG&E-Specific Customer Research**

The deployment of education and awareness efforts about the Smart Grid and customer-facing Smart Grid projects requires a significant customer research

undertaking. PG&E recognizes that its customers have opinions and experiences that may diverge from findings that national research studies may provide. Local and regional research must be completed prior to launching any Smart Grid outreach efforts. First and foremost, PG&E's research objective will be to verify assumptions made by nationwide studies and identify specific customer needs as they relate to the Smart Grid.

In order to place customers at the center of our Smart Grid vision and strategy, PG&E completed territory-specific customer research to understand customers' level of Smart Grid awareness. While the majority of PG&E's proposed Smart Grid projects are not directly customer facing, they will serve as important foundational elements, creating the need for customer communications.

The initial research identified the following:

- *The Smart Grid is largely unknown to residential customers, but favorability increases with information.*

When provided with basic information about the role of Smart Grid, customers view the technology favorably by a 4-to-1 margin (67% Favorable vs. 16% Unfavorable). Also, customers believe that their utility should begin working now to implement the Smart Grid, again by a wide margin (62% Support, 19% Oppose).

Prior to receiving any information about the Smart Grid, the majority of PG&E customers report they have little knowledge about this technology. In fact, 29 percent of customers say that they had never heard the term "Smart Grid" prior to participating in the survey and an additional 36 percent report that while they have heard the term before, they have very little knowledge about what it means.

Combined, these figures yield well over half (65%) of the PG&E customer-base that is almost totally uneducated on the topic of Smart Grid. While slightly more than one-quarter (27%) of customers report a “basic” understanding of the Smart Grid and what it does, less than 1-in-10 (8%) believe they have a fairly complete understanding.

- *There is a high level of interest in Smart Grid.*

Customers express a high level of interest (76% Very/Somewhat Interested) in getting more information on the Smart Grid. The areas with the greatest levels of desired information are how it will impact customers’ bills and what it will cost. The most credible sources cited by customers are the CPUC (80% Very/Somewhat) and PG&E (77% Very/Somewhat).

There are solid beliefs (69% – 77% Agree) that PG&E’s efforts to implement Smart Grid technology will result in more and better information about their household’s energy use, demonstrates that PG&E is focused on bringing innovative energy solutions to its customers and demonstrates a clear vision for addressing California’s future energy needs.

Over one-half of PG&E customers assume that the cost of Smart Grid implementation will be fully covered by PG&E without rate impacts on customers. One-third (31%) believes that customers will fund Smart Grid development through rate adjustments.

These results provide a solid foundation to begin answering additional questions.

Further areas of research include:

- *Which industries, business sizes and customer attributes are most receptive to the Smart Grid, and which ones are not?*

- *What are barriers to customers getting more engaged in Smart Grid deployment?*
- *What benefits can customers identify about the Smart Grid?*
- *What will motivate the customer to take a greater interest in the Smart Grid?*

As PG&E better understands the Smart Grid needs and interests of its customers, particularly in connection with customer-facing Smart Grid projects and initiatives, it will be able to tailor its outreach, education and awareness strategies and tactics to meet the specific needs of its customers.

The initial phase of content development will be driven by understanding the needs of PG&E customers. Through data and focus group information gathered directly from customers from all segments, PG&E will develop the key messages, information and customer benefits they seek and expect from energy advisors. This education content will then be customized for each of the various stakeholder groups to best fit with the expectations customers have when they communicate with PG&E. All customer messaging, whether through customer contact employees or the mass media, will be consistent and relevant. Once an outreach effort is underway, customer feedback will be gathered and analyzed in order to refine outreach to ensure the most effective and relevant education and advice is provided by customer contact employees, third-party partners and media channels.

## **8.5 Lessons Learned From Past Outreach and Education Efforts**

California's investor-owned utilities (IOU) have been among the first utilities nationwide to embark on a wide-scale deployment of advanced metering technology, and have led the nation in implementing an extensive, default-driven dynamic pricing program for customers. These groundbreaking experiences have highlighted both a number of challenges as well as several opportunities to improve. In order to maximize the

effectiveness of the Smart Grid education and awareness efforts, PG&E finds it is important to highlight the following lessons learned from its experience with SmartMeter™ deployment as well as large commercial and industrial (C&I) customer Peak Day Pricing (PDP) rollout.

**Lesson 1: Successful Smart Grid Deployment and Customer Education on Benefits, Tools and Pricing Options Is a Critical First Step to the Success of Customer- Facing Smart Grid Projects**

Many of the high bill complaints that customers attributed to their SmartMeter™ devices were not caused by the SmartMeter™ devices. Instead, the high bills were caused by rate increases and the effects of residential rate design—along with additional weather-related usage—that occurred contemporaneously with the installation of SmartMeter™ devices. The contemporaneous nature of these changes led to significant numbers of customer complaints, confusion, and dissatisfaction with the SmartMeter™ devices, including misplaced concern about the accuracy of the meters. In contrast with the dissatisfaction encountered when mandatory rate changes coincided with the installation of the SmartMeter™ devices, when voluntary time-varying pricing (e.g., SmartRate™) has been introduced and presented as an option only available when accompanied by a SmartMeter™ device, customer satisfaction with the rate option has been high. According to a 2010 survey, 81 percent of SmartRate customers report being very satisfied with SmartRate.

***Implication for Smart Grid Customer Outreach***

The introduction of new concepts about technology and benefits require customer education. Since different customers absorb this kind of education at different rates, Smart Grid education deployment requires significant and comprehensive education to help customers understand the benefits of such a system. This can be layered into existing channels and in coordination with products and programs that enable customers to reap the benefits of using a Smart Grid. For customers who are ready to absorb and embrace the technology and the required behavior changes, program or

product participation enhances customer engagement in understanding energy usage as it transmits along the Smart Grid.

**Lesson 2: For Customers Not on Any Form of Time-Varying Rates, Allocating Time to Carefully Convey the Additional Context for the Purpose and Benefits the Program or Project Is Critical**

Research shows that when customers first hear about the change to time-varying pricing, many feel they will be hurt by its introduction because they assume that any rate structure change will translate automatically into a bill increase. Many customers initially assume this change is driven by PG&E as a means to increase electric revenues. Furthermore, when customers first hear about the PDP rate, most do not immediately grasp that PDP reflects California's statewide energy policy and that PG&E does not make money from executing this policy. The research also shows that many small and medium C&I and small agricultural customers feel they are being singled out, and are bearing the burden of the "rate increase."

***Implication for Smart Grid Customer Education***

Customers need to understand the purpose of the Smart Grid and California's policy to address system reliability, responsiveness and environmental impacts. The first phase could begin with educating customers on the "what," the "why," and "who" of the Smart Grid. That is, customers need to be taught what the Smart Grid is, why it is necessary and mandatory (to achieve California's energy goals), who is requiring it (the state of California) and who it impacts (all of California). Given the complexity and novelty of the concept, this phase requires a great deal of outreach via multiple channels that are proposed later in this chapter. It also requires time to execute thoroughly and properly.

The initial awareness and education phase is further challenged by the need to overcome some initial misconceptions and resistance. Customers need to understand



the foundational drivers for the Smart Grid. Once they understand this, they will be more inclined to focus on how they are personally impacted.

PG&E believes that alignment of the timing for educating customers about the Smart Grid across California can lay the groundwork for a common message. If all of the IOUs are educating customers about the Smart Grid, customers will receive consistent information. A coordination of timing will enable customers to hear similar outreach messages from many locations across California. This is especially true for commercial customers who have multiple service accounts across California.

## **8.6 Smart Grid in the Context of Other Customer Awareness and Education Efforts**

PG&E customers are in the process of being educated on a variety of tools, rates, programs and products that are implemented to save energy and money, preserve energy resources and protect the environment. A typical PG&E customer can be simultaneously educated on time-varying pricing, conserving energy, EE programs, DR and technologies that optimize performance on new rates. As such, PG&E recognizes that it must be strategic and deliberate in providing the right information to a customer at the right time. Most importantly, careful concurrent campaign planning and layering some aspects of Smart Grid into existing media efforts and channels can avoid overwhelming customers and thereby making them indifferent or unresponsive to outreach efforts.

A key component of the strategic customer outreach and communication approach for new concept implementation, such as the Smart Grid, is to combine strategies that involve community based social marketing principles that deliver sustained behavior change modeled by key community figures. This is the key strategy behind the statewide Engage 360 campaign, which is designed to deliver a concept movement about EE, in which a groundswell is developed by utilizing both grassroots and social

networking efforts that rely on influencers who are public figures and high profile community leaders to personally carry its message. Use of such a strategy, among others, is provided in further detail in the Planned Outreach and Education Activities section below.

As a baseline concept of outreach and education, PG&E believes it is important to effectively connect Smart Grid, time-varying pricing and SmartMeters™ to give customers a holistic view of how they can manage their energy usage. PG&E has a number of outreach mechanisms in place that can be expanded and tailored to include Smart Grid messaging. By implementing this approach, PG&E can streamline customer communications and lessen the risk of confusion among the customer base.

## **8.7 Planned Outreach and Education Activities**

This section describes the media, third-party and outreach channels that PG&E may utilize to address the challenges associated with communicating the impact of the Smart Grid to its large and diverse audience. PG&E believes the outreach tactics proposed in this section hinge largely on the outcomes of PG&E-specific customer research plans described above.

Subject to the availability of future funding, PG&E will look for ways to leverage strategies that prove successful in existing or past outreach activities, and plans to implement a broad-reaching set of activities that continue through subsequent years. Prior to launching Smart Grid outreach and awareness efforts, PG&E will engage in foundational activities to prepare PG&E systems and employees for the changes and communications associated with the Smart Grid, particularly those relating to customer-facing Smart Grid projects and initiatives.

PG&E would use its current “Information is Power” campaign as a potential model to build from, for mass media efforts. The Information is Power series highlights the diverse support for California’s effort to move toward a Smart Grid. This campaign has successfully aired in broadcast and online.

“Information is Power” features leaders in the renewable energy industry, community organizations, business groups, academics and elected officials. It illustrates how regulators and policy makers and others recognize the critical role that the Smart Grid will play in improving reliability, efficiency and the development of renewable power.

The Smart Grid approach would be regionally redesigned to address the demographics of specific areas and to address questions or concerns that are prevalent among certain populations. For example, if customer research shows that privacy is a major Smart Grid concern in a specific region, the campaign running there would address those questions directly with third-party privacy advocates or thought leaders. Additionally, this campaign would be produced in English, Spanish, Chinese and Vietnamese.

## **8.8 Customer Inquiry**

PG&E recognizes the critical role that contact center and other customer operations customer contact teams’ readiness will play in the success of the Smart Grid. Customer concerns and questions will first be directed to various customer contact employees, including those employees in contact centers and local offices, and they must be prepared to assist customers in understanding the opportunities inherent with the implementation of the Smart Grid. As Smart Grid awareness increases and mass media and/or earned media begin to communicate the concept more frequently, this is likely to prompt customer inquiries. PG&E intends to systematically prepare all customer contact personnel to effectively manage these customer contacts with a focus on education and customer benefits. PG&E believes there is an excellent opportunity to engage and educate customers through these critical channels.

One key element of PG&E’s preparation will be to enable contact center personnel to provide detailed Smart Grid information without having to transfer the customer to multiple personnel, which can cause frustration. Additionally, all customer contact personnel should have access to simple, easy to explain information that customers can

pursue or receive about the Smart Grid. For example, for those customers with Internet access, simple website links with further resources can be provided. For those customers without Internet access, full hard copy information packets, in multiple languages, should be easily available for use in community forums, by mail or available in PG&E local offices.

Historically, PG&E's contact centers and local offices have been primarily transaction based. Customers typically use these channels because they have specific questions regarding their bill, energy usage or other items unique to them. With the advent of the Smart Grid, customer calls will change to more of a consultative/educational-type conversation to explain the concepts, drivers and customer opportunities represented by the Smart Grid. These new customer inquiries will require longer conversations with customers both on the phone and in person than traditional inquiries, which in turn will require additional staffing, training and education to maintain service levels. In addition, an extensive education and training program will be necessary to ensure that all PG&E's 1,500+ customer contact employees in the contact centers, local offices and other work teams have the necessary information and expertise to successfully address customer questions on the Smart Grid.

## **8.9 Customer Contact Employee Education and Training**

In order to prepare all customer contact employees to advise and inform customers in an effective manner, a targeted Smart Grid Education and Training Program will be developed. This program will focus on four key areas: (1) stakeholder needs assessment; (2) content development; (3) customization; and (4) training delivery. A thorough stakeholder needs assessment will be conducted in order to determine the specific needs of various customer facing employee groups in the company. This includes not only contact center and local office employees, but also the various office-based and field employees that engage with customers. This critical first step in the plan is to determine what information the various employee groups will require to

best educate customers and the most effective delivery methods to provide training and education. A consideration will be made for general education for all company employees, as all employees' roles evolve into company ambassadors.

### **8.10 External Organizations and Partnership Outreach**

PG&E plans to engage and partner with third parties to address consumer questions and concerns and connect with hard to reach audiences.

PG&E plans to partner with retailers, vendors, contractors and other third-party businesses and organizations that will help transmit positive and engaging messages about the Smart Grid, particularly customer-facing Smart Grid programs and projects, to their personal network of consumers. PG&E recognizes that it will be critical to partner with such third parties, who have a personal and financial investment in the success and widespread acceptance of the Smart Grid. Third-party partnerships will play a critical role in carrying Smart Grid education and awareness messages forward. PG&E also plans to incorporate additional EE third-party partnerships to reinforce the effort to reach customers through a variety of channels and strategies.

Local community organizations and advocacy groups will be critical avenues to communicate the broad Smart Grid message and to provide trusted third parties as additional voices. PG&E proposes partnership with key organizations that include, but are not limited to, the American Association for Retired Persons, Center for Democracy and Technology and Electronic Frontiers Foundation. In addition to participating in events or venues driven by these organizations, PG&E would include residential canvassing efforts, meetings and presentation materials and displays.

PG&E will also engage with third parties that work with specific ethnic groups that will have distinct needs and methods of preferred communication.

## **Policy Makers**

Public policymakers will have their own unique needs with respect to Smart Grid outreach and education. For example, during the SmartMeter™ rollout, the majority of the concerns that were expressed by elected officials and their communities in the North Bay or Central Coast were not the same concerns that North and Central Valley customers had voiced. Coastal areas like Marin and Santa Cruz had a variety of concerns about the SmartMeter™ program, most notably the potential impact of radio frequency on health, while the North and Central Valley's major concerns were related to accuracy and the potential for higher bills.

Initial Smart Grid outreach will entail engaging directly with state and local officials to give them a general overview, discuss potential constituent issues and help tailor local solutions to best serve the community.

## **Stakeholder Outreach and Engagement**

A key component of outreach activities will be tapping into PG&E's Local Community Advisory Groups (CAG) which are based in various regions throughout the service territory. CAGs serve as critical connections between PG&E and its local community leaders and provide a forum for candid and region-specific feedback and recommendations regarding PG&E service and programs. Identified leaders are from various sectors of the community including, but not limited to, education, government, labor, non-profit, and small, medium and large business.

For purposes of Smart Grid outreach, these CAGs provide a venue for community leaders to receive additional information, understand the technology and potentially become advocates, spreading the message to others within the community. As third-party validators, the feedback PG&E receives from CAGs is critical, as these leaders can help convey information to their respective organizations and help correct any misinformation that community members may receive.

## **Community Relations**

PG&E's goal is to engage, support and improve the neighborhoods where its customers and employees live and work. Activities include helping local communities launch new school programs for students interested in the energy industry and providing employee volunteers to support neighborhood improvement projects.

Through support of hundreds of community and volunteer events annually across the service area, PG&E has the opportunity to directly interact with customers in their neighborhoods and share information on topics of interest, including the Smart Grid. And as part of PG&E's charitable focus on supporting education, PG&E will partner with several non-profit organizations to develop Smart Grid-related curriculum initiatives that are aligned with the state of California's educational requirements for youth.

## **Customer Advisory Panels**

PG&E has a network of Customer Advisory Panels in place throughout our service territory to directly engage with our customers on a variety of topics that are important to them. These panels serve as an informal setting in which to learn about our customers' energy needs, concerns and opinions. By leveraging these groups, PG&E can gain further insight about customers and the Smart Grid, and apply those learnings to improve customer education and awareness.

## **8.11 Awareness and Education Outreach – Mass Media**

In addition to third-party partnerships and learning directly from customer feedback, PG&E believes that mass media will be an important tool to communicate Smart Grid information and benefits. The campaign's intent would be to feature regional and local third parties to provide context and insight on the reasons for Smart Grid development. The campaign would include TV, radio, print and online media and would be implemented throughout the PG&E service territory.

## **8.12 Earned Media Outreach**

PG&E will help raise awareness of the Smart Grid through an external communications campaign using newspapers, magazines, radio talk shows, local news programs, community events, digital content, and other non-paid opportunities that will raise awareness.

The goal is to help shift the existing conversation in the media from SmartMeter™ as a device to a more advanced story of how the Smart Grid can offer an array of cost- and energy-saving options and choices for customers.

To do so, the communications would begin through education of the media—telling reporters, editors and publishers about the current state of California’s energy grid and what the transition to a Smart Grid looks like. Given PG&E’s completion of nearly 10 million SmartMeter™ upgrades in 2012, the conversation will shift from meter deployments to the larger capabilities of the Smart Grid for customers.

## **8.13 Online and Social Media**

The Internet and social media will be critical communications channels for Smart Grid outreach efforts. For certain demographics, the web is the first and sometimes only platform for information. PG&E will leverage existing digital properties as well as social media platforms including Facebook and Twitter. Ultimately, online channels need to provide a complete picture of the Smart Grid.

Online channels serve as an excellent opportunity to provide rich, interactive customer experiences that educate through animation, video and audio as well as in-depth information. The online channel in general provides opportunities for customers to dig deeper and learn the details of a topic. In fact, the online experience will not tell, but show the customer the whole story of the Smart Grid. PG&E will leverage existing digital platforms such as [www.pge.com](http://www.pge.com), [www.pgecurrents.com](http://www.pgecurrents.com), e-mail, social media



platforms including Facebook, Twitter, and PG&E blogs such as Next100 and See Your Power.

To better understand the baseline of customer's knowledge and interest in the Smart Grid, online polls and user response mechanisms will be used. An initial set of tools on the site will establish the basic awareness level of the Smart Grid among users and identify candidates interested in giving further feedback. A second in-depth survey will be presented at a later time to customers with some knowledge about the Smart Grid in the effort to learn specific issues that are top of mind to customers and how best to present the Smart Grid within a learning tool. The results of these surveys will allow online and offline Smart Grid educational materials to be best designed to meet customer needs.

Beginning in 2010, PG&E rolled out Customer Education Centers and Open Houses. These centers are held in a variety of locations driven by customer needs, including PG&E Payment Centers, rented space in specific neighborhoods and public spaces such as libraries. The Education Centers are staffed by trained personnel from the Customer Impact Team to provide person-to-person support and response to customer inquiries. By leveraging this existing group, PG&E can personally address Smart Grid questions in conjunction with other activities such as providing information on billing questions, EE, financial programs and more.

## **Chapter 9 – Grid Security and Cyber Security Strategy**

## 9.1 Background

The term “cyber security” is used to describe a wide variety of protection mechanisms against security risks associated with the use of technology, such as theft of customer information, disruption caused by an Internet virus, or sabotage of control systems used to remotely manage or monitor operations. As the evolution of the Smart Grid has significant ramifications for security and privacy, PG&E must be prepared to evolve its security program, technology, and processes to meet these challenges as well as meet the multiple strategic objectives—including safety, reliability, customer empowerment, flourishing and efficient energy markets, environmental sustainability, and consumer and technological advancement—envisioned for the Smart Grid. Enhancing PG&E’s cyber security foundation is a critical, cross-cutting initiative that impacts customer trust, workforce safety, service, reliability, demand management effectiveness, and security of energy supply. Without this holistic, enterprise level focus on cyber security, the individual Smart Grid systems could introduce unacceptable levels of risks into the electric grid system and instead become obstacles to achieving the strategic objectives envisioned for the Smart Grid deployment plan.

As part of its Smart Grid initiatives, PG&E is rapidly increasing its utilization of technology to meet changing business needs and to achieve enhanced benefits with respect to operations, utility customers, and integrated energy markets. These changes will largely be enabled through increased automation and integration of PG&E’s key business functions in the areas of bulk generation, storage, distribution, transmission, and metering over a large geographical area. Networks of automated, interconnected electronic devices will be used to monitor and control energy production and its distribution on the electric grid. Customer owned assets such as home area energy management networks and Plug-in Electric Vehicles (PEV) will also become integral components that will be able to communicate with the Smart Grid.

In parallel with the increased automation, integration, and use of new technology, it is also widely understood that new risks, including cyber threats, can potentially be introduced into the operation environment. The incidences of cyber attacks, including the level of sophistication displayed by cyber attackers have also significantly increased. In tandem, and the level of knowledge and effort required to collect information to carry out a cyber attack has decreased, leading to constantly evolving and newly emerging sources and methods of attack.

Threats in the Smart Grid environment must be well assessed, understood, and addressed. Previously isolated operational technologies will emerge into complex Information Technology (IT) systems, creating the need for a converged level of security control sophistication across logical and physical boundaries in the Smart Grid. Utilities must be prepared to evolve their cyber and physical security programs, enhance the control technology foundation, and evolve security processes to meet these needs. This includes evaluating security controls across a people, process, and technology perspective, methodically surfacing risks, designing those controls up-front and early as an integral part of the systems engineering lifecycle, and leveraging industry standards and collaborative research. This program evolution is critical to mitigate risks that could threaten safe and reliable operations, endanger customer privacy and impact energy market efficiency. Therefore, PG&E views cyber security as an essential, fundamental and embedded tenet to the evolution of the Smart Grid.

This chapter describes PG&E's approach to security, including physical and cyber security, as well as the privacy framework to demonstrate its overall programmatic approach to securing the Smart Grid, Smart Grid technologies and sensitive data.

## **9.2 Strategy and Approach Framework**

While security principles, operational processes, and supporting architectures used by PG&E today will be leveraged to continue to mitigate risks, PG&E recognizes that the

Smart Grid poses new security challenges and risks that must be addressed. For example, real-time data collected across a host of new field devices in physically unprotected areas, and communicated across networks from the customer premise to distribution systems and to wholesale markets creates an absolute need for end-to-end security. Protecting sensitive data, including customer energy use, critical infrastructure data, and other sensitive information requires utilities, consumer groups, and vendors to collaborate and develop secure software, hardware, security tools and new standards that are appropriate to the Smart Grid environment. The changing regulatory landscape in the context of the Smart Grid is also an important factor. PG&E anticipates that security and privacy requirements already in place for today's transmission and customer systems will be extended in more depth to customer and distribution systems as part of regulatory changes.

While PG&E cannot predict all of the changes, PG&E is following a best practices approach to build in security in anticipating of future requirements. Many of the security and privacy challenges are being addressed through utility, vendors, and government participation in collaborative associations and research forums. PG&E continues to take both a leadership and contributor role in many of those organizations such as the Open Smart Grid (OpenSG) and the National Institute of Standards and Technology (NIST) Cyber Security Working Group (CSWG). PG&E actively uses the working content from those and other key organizations to inform its current security processes and future architecture.

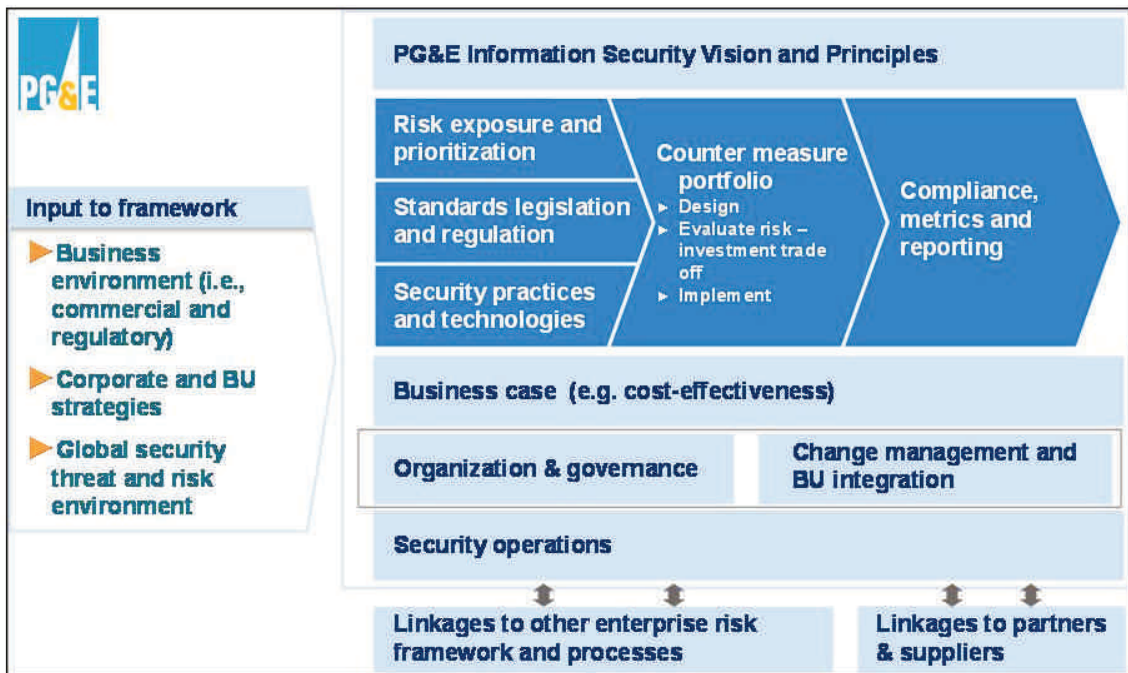
PG&E recognizes that the Smart Grid environment will be more dynamic and require more agile security processes. For example, previously isolated systems deemed "low" risk may require increased connectivity to new, external systems with increased communications capability, thus resulting in a "high" risk security rating given the new exposures and new system boundary definition. PG&E intends to re-aligns its overall risk assessment process, along with risk assessment frequency and agility to meet the

demands associated to these types of changing conditions brought forward by the Smart Grid.

### 9.3 Cyber Security: A Governing Process

PG&E’s cyber security program is one component of PG&E’s overarching enterprise risk framework which seeks to minimize operating risk, provide for a safe and reliable grid, and protect customer privacy. As part of its cyber security program, PG&E seeks to strike the appropriate balance that reduces risk to an acceptable level and is informed by industry best practices, regulatory frameworks, customer and other stakeholder needs, and other environmental factors. PG&E applies security controls and processes in the functional areas of architecture, engineering, operations, and audit activities to achieve these objectives. The graphic below depicts PG&E’s security program and framework.

**Figure 9-1: PG&E Information and Security Framework**



PG&E's existing information security and cyber security policies and standards will be leveraged for securing the Smart Grid. Prevention, detection, response, and recovery are elements encompassed by the policies and standards which also align with other industry requirements, guidelines, and practices such as North American Energy Reliability Council (NERC) Critical Infrastructure Protection (CIP), Sarbanes Oxley, California Senate Bill 1386, NIST, International Organization for Standardization (ISO)/ International Electrotechnical Commission (IEC) 27002. They are then periodically reviewed for alignment with emerging industry cyber security standards and regulations governing the Smart Grid environment. Updates are made to the PG&E standards as needed in response to this rapidly changing environment. Specific standards heavily leveraged for the Smart Grid include both process and technology controls as described by the following documents:

- NIST Interagency Report (IR) 7628
- Advanced Security Acceleration Project for the Smart Grid (ASAP-SG) security profiles:
  - Distribution Management Security Profile
  - Third Party Data Access Security Profile
  - Wide-Area Monitoring, Protection, and Control (Synchrophasor) Security Profile
  - Advanced Metering Infrastructure (AMI) Security Profile
- Department of Homeland Security (DHS) Catalog of Control Systems Security: Recommendations for Standards Developers
- DHS: Cyber Security Procurement Language for Control Systems

These interrelated standards heavily inform PG&E's Smart Grid deployment cyber security program, and are referenced throughout this document. Use of appropriate, industry best practice, common standards is critical to system interoperability as well as building the secure and strong Smart Grid foundation that provides customers assurance over their data and energy reliability.

From a process perspective, PG&E performs project specific security reviews for IT related projects throughout the lifecycle of the system development, establishing risk levels against a baseline set of controls defined by the architecture and technology standards process. IT projects are controlled by a structured project management process that aligns with IT Infrastructure Library practices. Security reviews are a condition prescribed by this process. All of the projects that are described in the Smart Grid deployment plan will follow a governing cyber security strategy, framework and plan, together with project-specific cyber security reviews to ensure that appropriate security measures are established in the design. This review will establish the levels of sensitivity for data confidentiality, integrity, and availability during transmission and in storage. Privacy is also considered in this review and leverages the Fair Information Practices Principles (FIP) based privacy framework. Privacy is addressed in more detail later in this document. Each project is then reviewed for alignment with the enterprise Smart Grid security architecture and mitigating security controls are prescribed for each project based upon derived risk levels. Recognized industry resources such as NISTIR 7628 as well as the other documents previously outlined are then used as a baseline reference during the performance of the cyber security review.

Like any other utility, there remains a level of residual risk to be managed on a daily basis. PG&E's incident response process supports containment and recovery activities associated with information security incidents. A company wide emergency operations plan has been established to enable response and recovery capabilities for operational events. The incident response process for cyber security incidents has been integrated within this company wide emergency operations plan. PG&E's incident response program is one of many cyber and information security capabilities that will be enhanced and extended to encompass new risks introduced via Smart Grid technologies. Using the previously cited example of new field devices or "edge" devices that could require enhanced automated monitoring and control due to their physical



accessibility, PG&E's incident response process would be enhanced to identify events associated to an edge device, provide rapid asset identification, identity certainty, and possible quarantine capability to prevent widespread upstream impacts to the Smart Grid.

An essential foundational element of an effective security program is security awareness and training. PG&E is reliant upon a security-informed workforce to design and operate the Smart Grid environment. PG&E has a dedicated team focused on providing personnel security awareness and training. Multiple types of training are developed which encompass general security employee training as well as specialized training focused on advanced areas of IT. Smart Grid specific, specialized security training will be incorporated into the overall Smart Grid workforce development strategy.

PG&E and other utilities are reliant upon the supply chain for components and services that enable a smart grid environment. In the case of third party equipment procurement, such as edge devices or third party software, PG&E will use language recommended in the DHS Cyber Security Procurement Language for Control Systems and the Catalog of Control Systems Security: Recommendations for Standards Developers which delineates specific language that can be used for vendor procurement, as well as detailed guidance on areas such as secure coding practices and malware detection. These can be used as part of the control baseline for both procurement and roll out of new systems. This alignment to standards will help ensure vendor technologies are developed and procured in alignment to the security requirements set forth for each system. PG&E will also continue to monitor the development of the NIST certification programs for securing the Smart Grid and incorporate any certifications and/or vendor directional adoption draft certifications into the evaluation criteria. Solutions will also consider the lifetime of the solution being implemented. This is especially important given the longer lifecycle considerations for field devices. Vendors providing security specific solutions will be

scrutinized as well as their associated security products. When a vendor is selected for services, knowledge of the industry, standards, and its cyber security requirements becomes mandatory criteria for selection. Vendors are also reviewed by PG&E information security staff to ensure adherence to PG&E internal policies and standards.

PG&E has established risk assessment and compliance functions dedicated to the performance of systematic assessments for the organization's IT environments. The assessments may be performed during the lifecycle of an IT project as a condition for placement into production or a recurring post operational assessment. Risk assessments include a review of industry best practices as applicable to PG&E's environment. Compliance assessments focus on the implementation of PG&E standards and regulations. Assessments encompass all Utility system environments such as the operational environment, Smart Grid edge points, and customer care systems. As previously mentioned, assessments may also extend to supply chain partners and third party service providers to ensure risks are identified and appropriately mitigated. Since risk assessment is the foundational element which influences all design practices, a more detail description of the risk assessment engagement and applicability to the Smart Grid environment follows.

#### **9.4 Cyber Security: Risk Assessment**

The Utility has a risk assessment program that continuously monitors and manages the cyber security risks posed to the company. The risks are assessed early and often by and follow an engagement process governed by multiple coordinated security functions with clear lines of accountability. This program characterizes risk as a function of three contributing factors:

- (1) Potential threats facing PG&E systems
- (2) Potential vulnerabilities relevant to PG&E's environment

- (3) Level of potential impact to the Utility, its customers or other stakeholders based on vulnerability exploitation

Baseline vulnerability exposure and risk levels are measured as a function of loss of information confidentiality, integrity, and availability. The risk levels are then mitigated through investments in countermeasures used to protect the systems and bring them to an acceptable level of operating risk as defined by the risk assessment process. Once quantified, risk reduction metrics demonstrate non-monetary benefits directly tied to ensuring the safe and reliable operation of the Smart Grid systems. This is based on the threats, the likelihood, and the anticipated impact a security breach would have on system operation. Less risk means better resiliency, system sustainability and enhanced levels of system health. For the Smart Grid, PG&E will leverage and extend the existing approach to risk management which is currently based on ISO/IEC 27005-series, Control Objectives for Information and Related Technology (COBIT), and NIST.

Extensions to PG&E's risk identification and management approach will use the work completed by NIST in the NISTIR 7628. For example, the NISTIR 7628 introduces a language of risk based on three areas of impact measure: "high," "medium," and "low." As this assessment approach becomes more prevalent and as PG&E monitors evolving NERC CIP guidance, PG&E will make enhancements to its existing methodology and framework as deemed necessary for alignment.

From a systems development perspective, cyber security risks exist at all stages of the system lifecycle. Therefore, security risk management and mitigation is aligned and integrated throughout each stage of the project lifecycle. Cyber security risks will be identified for each of the deployment lifecycle phases. These include: ideation, initiation, requirements gathering, design, development/integration, testing, deployment, and maintenance. Throughout all phases, ongoing detection and

mitigation work creates a continuous improvement security effort to reduce risks to the system.

The risk management approach also considers cross-functional impacts across different business units within PG&E, which is particularly important for Smart Grid systems which tend to operate across departments. As part of risk management system descriptions will provide for clear boundary definitions and interface handoff so that the security risks can be identified in the context of appropriate extended system boundaries and definition. This allows the Utility to clearly view how risks in one system affect the risks in another, and mitigate those risks with an end-to-end security mindset. This also enables an enterprise risk-based approach and prioritization, lending even more focus on the handoffs between discrete system components where vulnerabilities are inherently introduced.

The approach described above allows the Utility to make better decisions about risk from an enterprise, cross-business unit even before a system is deployed into a production setting. Once the system is finally introduced into the PG&E ecosystem, residual risk is continuously monitored to identify, detect and prevent potential new issues, to ensure ongoing situational awareness, and to execute risk response and recovery activities where appropriate.

## **9.5 Cyber Security: Smart Grid Design and Architectural Approach**

This section describes in detail PG&E's architectural processes as well as the approach for augmenting the existing architecture to securely enable the Smart Grid. The architectural approach to securing PG&E's Smart Grid systems incorporates existing methods, principles, and practices currently used within PG&E for designing secure systems. The process will then be extended to leverage the bodies work already completed or in progress by major organizations contributing to industry standards development for Smart Grid. These include NIST, Utilities Communication Architecture

International User Group (UCAiug), OpenSG, Industry Standard Architecture (ISA), IEC, DHS, as well as NERC regulatory requirements as mandated by the Federal Energy Regulatory Commission. Some of the design elements covered in the previous section in the context of the systems development lifecycle are also identified below as part of the overarching design process.

### 9.5.1 Design Principles

The existing PG&E security architecture is best described as a system-of-systems or enterprise security architecture. The architecture development is governed by principles and designed to protect against traditional threats as well as evolving and emerging threats in the Utility industry. The core principles leveraged in architecture design are as follows:

- **Defense in Depth:** Controls are layered such that if one layer of control fails, there is another, different type of control at the next layer to protect.
- **Segmentation and Compartmentalization:** Systems are grouped, categorized and logically separated according to their calculated risk rating. Additional security controls are applied between logical segments and access hierarchy may logically “stack” each segment depending on the risk rating. PG&E also specifically leverages industry research, such as the ASAP-SG Distribution Management Security Profile to enhance network segmentation design.
- **Open Standards-Based:** Interoperability is designed into the system to reduce reliance on proprietary solutions and instead adopt industry-vetted secure solutions.
- **Weakest Link:** Systems are designed to minimize single points of failure—the security of the system is only as effective as the least secure element of that system.

- **Resiliency:** Systems are designed and managed so that in the event of system interruption, outages are contained and result in least possible information security compromise.
- **Auditability and Accountability:** System and process events should be traceable to the initiator, tamperproof, and must be possible for an independent expert to verify their compliance to policy.
- **Secure Emergency Override:** Controls may be bypassed only in predetermined and secure methods.
- **Practicality:** Security controls need to be commensurate with the level of risk.
- **Simplicity:** Complexity creates more risk.
- **Least Privilege:** Users and system processes should be given the least authority and minimum access to resources required to accomplish a given task.
- **Centralized Policy:** Where possible, centrally coordinate system policy decisions and reduce dependency on policy fragmentation.

These principles seek to define and allow only trusted resource access, while defining and blocking untrusted resource access. These principles are woven throughout the fabric of system design, development and implementation at PG&E.

### **9.5.2 Technology Design: A Layered, Defense-In-Depth Approach**

The technology architecture, coupled with a discipline-focused organizational structure and mature processes together enable the secure ecosystem. Key components are: (1) the technology architecture itself (security enabling devices and systems); and (2) the architectural design process that begins with the conceptual security model and ends with the technology roadmap, along with the corresponding security plans and ongoing reviews that are part of the roadmap.

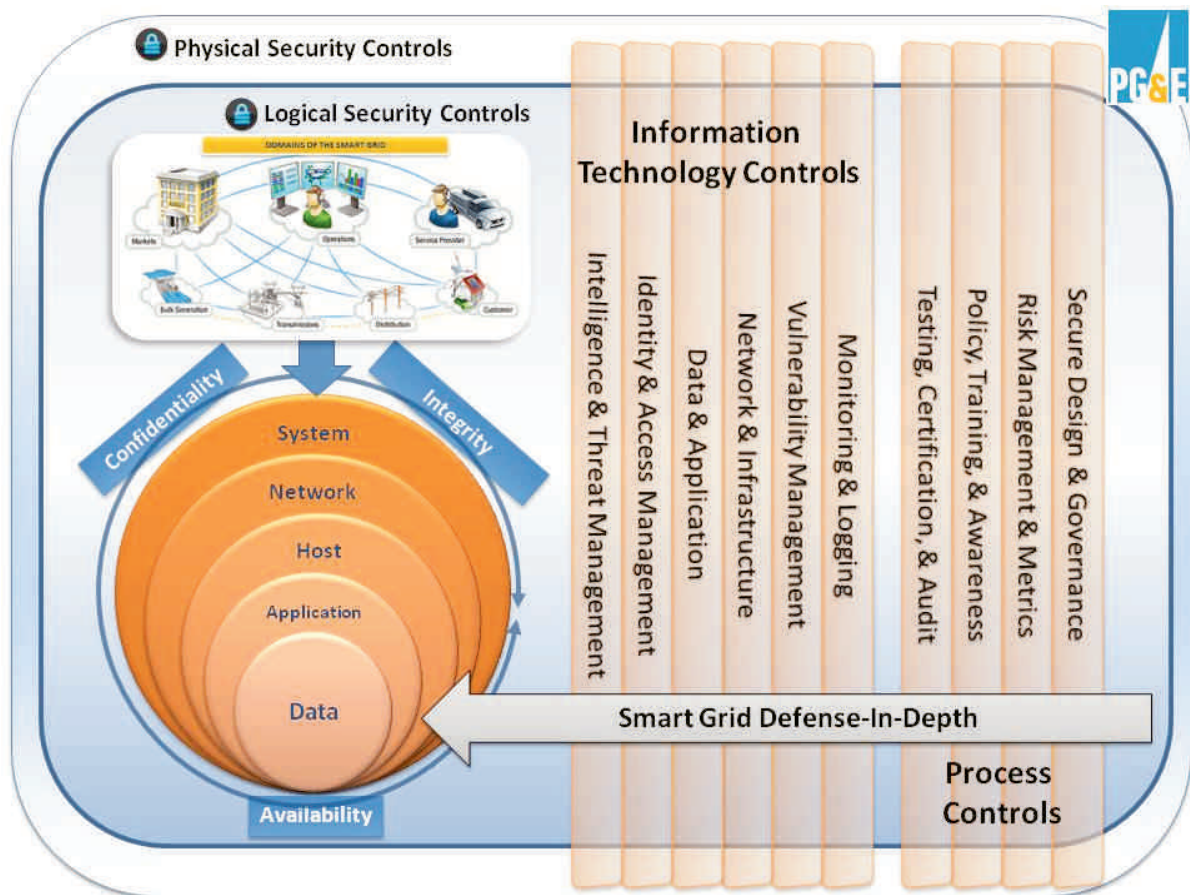
From a technology perspective, the existing architecture consists of the following security layers, each of which employs detective, preventative, and corrective control mechanisms:

- **Intelligence and threat management layer:** Provides an early-warning system through the use of information sharing and correlation tools and techniques. PG&E has established a security intelligence team to identify credible emerging threats and enable enhanced operational monitoring. Additional public/private partnerships have also been developed within this function to enhance information sharing.
- **Identity and access management layer:** Ensures only the right people have access to the right systems based on their level of need for their role through the use of multiple technology mechanisms. This includes techniques to ensure secure, authorized, and limited remote access to required resources.
- **Data and application protection layer:** Provides specific protection around sensitive company data and privacy protection for customer data. Control techniques include data encryption and data loss prevention.
- **Network and infrastructure protection layer:** Employs firewalls, Virtual Private Networks, intrusion detection and prevention, encrypted tunnels and network segmentation.
- **Vulnerability management layer:** Establishes tools and techniques for rapidly identifying, quarantining, and removing identified system vulnerabilities through technologies such as anti-malware and automated system patching.
- **Monitoring and logging layer:** Provides visibility into system activity using log aggregation and security information and event management tools and techniques. Technologies that support security event logging and real time intrusion monitoring are deployed throughout the environment, and events are monitored on a real time basis 24 hours day, 7 days a week.

All of these layers accompanied by the appropriate processes work together to minimize information security attacks, provide actionable information to respond to attacks, enable quick recovery, and adapt/learn from attacks to build new defenses.

It is also important to point out that, in alignment to the core principle discussed above, PG&E maintains a segmented network dedicated to the operation of energy control systems. That network is leveraged as the primary network to support the Smart Grid. Segmented security perimeters have been established within that network.

**Figure 9-2: Smart Grid Defense-In-Depth Architectural Approach**



### 9.5.3 Architectural Design Process

PG&E’s architectural approach designs security at the individual component level (project/initiative-based) as well as at the system-of-systems, or enterprise level.



Iterations of increasing design detail are applied through multiple layers of abstraction depicted as conceptual, logical, and physical designs. The approach also considers the levels of risk associated at each stage of the development lifecycle as previously noted. Best practice industry standards are incorporated, including significant use of the NISTIR 7628 which extends cyber security requirements to incorporate distribution system components, customer premise devices including AMI and Home Area Networks (HAN), and interactions with energy markets and third parties. Guidance from other evolving industry resources such as the ASAP-SG Security Profiles are also leveraged for cyber security architecture and design practices. The NISTIR 7628 document has outlined 22 logical interface categories across areas of the Smart Grid and defined security requirements across the enumerated interfaces. The ASAP-SG security profiles then provide more use-case driven detail surrounding the controls that will help specify application of the controls to the specific business use cases for the Smart Grid.

PG&E's existing architectural process begins with the development of a Security Plan that addresses each component level initiative. The Security Plan is currently based on the NIST special publication 800 series leveraging 800-18 for security plan and 800-53 for control families for all systems. This existing approach provides a well aligned foundation to incorporate the NISTIR 7628 guidance given the 800 series was also referenced in the NISTIR 7628 framework. The Security Plan outlines the system and data classification, the system security design specifications and architectural blueprints, and the standard controls leveraged to support that design. The Security Plan is then used as the basis for detailed (physical) design, independent control testing and verification, and residual risk mitigation plan of action and milestone management. Independent security testing may involve the use of penetration testing, application code reviews, third party or vendor testing, and other assessments prior to system commissioning.

#### **9.5.4 Individual Component Design Process Viewpoint**

For the Smart Grid component-level viewpoint, each specific business initiative design will be evaluated on its own merit and security design standards and controls will be embedded into those systems based on the risk commensurate to that component. Each specific component initiative will be assessed and aligned to the logical interface categories as proposed by the NISTIR 7628.

The risks of each interface will be assessed using the guidelines in the NISTIR 7628 as a basis for the measurement in conjunction with PG&E's own risk assessment process as described in the previous section. For example, if the logical interface for line sensors is rated as a "high" from a risk impact perspective, PG&E will use that rating as a starting point for the baseline set of controls to sketch out a conceptual design. Once the actual risks are determined, the security requirements will be applied to that component system design also in alignment to the baseline recommendations in the NISTIR 7628 and tailored based on the overall system integration, available control maturity, and compensating controls that exist as each component is implemented and integrated into the overall Smart Grid system. Other guidance and standards set forth by contributing organizations will also be used, such as the more detailed security profiles outlined by ASAP-SG, to iterate the designs from conceptual to a more detailed logical design.

#### **9.5.5 System-of-Systems Design Process Viewpoint**

The aggregate system-of-systems viewpoint provides a more broad perspective and focuses on the design of the enterprise security system itself. The aggregate system design provides a critical foundation that individual component level designs can leverage through standard integration use and inheritance. This design provides a common thread to ensure tighter control and better end-to-end security through common architecture and consolidated system management functions. This also helps to reduce complexity associated with fragmented architectures and non-standard

integration which is often characterized as one of the major cyber security risks facing companies today. At this aggregate level, the design risks and resulting requirements are analyzed and derived in the context of enterprise capability gaps and the system's ability to feed metrics and visibility into the overall enterprise risk dashboard (for reference, this aggregate system-of-systems is also defined as logical interface #22 in the NISTIR 7628).

### **9.5.6 Applying the Design Process to the Smart Grid Initiatives**

Architecturally, PG&E has concluded that advancing the Smart Grid begins with a foundational level of investment in a core set of IT security capabilities that will securely enable the Smart Grid initiatives while also providing the robust, adaptive platform to grow and scale in the face of evolving cyber threats to the utility industry. These security capabilities (bulleted below) were derived by first performing a high-level analysis on each of the Smart Grid initiatives and mapping them to one or more of the interface categories as defined in the NISTIR 7628. Based on that mapping, the interfaces were evaluated against the risk for loss or compromise of confidentiality, integrity, and availability using both internal analysis as well as the recommended impact levels in the NISTIR 7628. Additional analysis was performed on the individual initiatives as well as at the extended enterprise level based on interconnectivity that the Smart Grid will provide. Once those impact levels were derived, the recommended security requirements were then reviewed at the aggregate 'family' level to determine the additional investments required to meet the security control objectives for PG&E and the Smart Grid. The high-level security domains identified for investment are as follows:

- Identity and Access Management
- Cryptography and Key Management
- Network Security Design
- Threat Intelligence and Information Sharing

- Information & Event Monitoring, Log Management, and Wide Area Situational Awareness
- Device Management
- Configuration and Patch Management
- Risk Assessment
- Vulnerability Management and Incident Response
- Security Architecture, Design, Standards and Advanced Research
- Application Level Security, Web Services Security, and Policy Management
- Training and Awareness
- Layered Controls for Legacy Integration
- Audit, Accountability & Reporting and Analytics
- Device & Embedded System Forensics
- Advanced Vulnerability & Penetration Testing and Certification

These capabilities form the basis for the system-of-systems (enterprise) architecture conceptual design that will augment the existing enterprise architecture and will be used to secure the Smart Grid.

While capabilities currently exist in many of these areas, further investment will extend the Utility's capabilities to incorporate the fundamental design differences required for the evolving Smart Grid. Enhancements to the security foundation will leverage PG&E's existing system where applicable to arrive at incremental investment needs aligned to an already stable architectural foundation and supporting processes.

Security measures and specific investments will evolve based on the evolution of the Smart Grid. In addition, more detailed analysis of security needs will occur in line with the design and launch of each Smart Grid initiative. At this time, alignment to the NISTIR 7628 and other foundational standards that are relevant to the specific initiative will also re-assessed, including IEC 62351 Part 3—security profiles for Transmission

Control Protocol/Internet Protocol (TCP/IP), IEC 62351 Part 5, security profiles for IEC 60870-5, IEC 62351 part 6, security and network management, Zigbee Smart Energy 2.0 Application Profile, and the UCAiug Embedded Systems Security Task Force.

With both the individual component and aggregate system-of-systems approach, PG&E's architectural process promotes cross-functional and cross-organizational analysis of systems, better aligning the IT to the business and the business to IT. With better alignment comes better security given that risks and tradeoffs must be well understood.

PG&E actively tracks the NISTIR 7628 methodology as well as other standards to ensure that they will be appropriately applied in the Smart Grid environment. In addition to tracking and actively participating in the referenced standards, PG&E is involved in a host of non security related standards work including communications technology (UCAiug, OpenSG, Internet Engineering Task Force), PEV connectivity standards (Society of Automotive Engineers), NIST, North American Energy Standards Board, Institute of Electrical and Electronic Engineers, and Open Access Same-Time Information System. Although not directly related, the cross-cutting applicability of security in all of these standards and guideline issuing organizations helps to provide a comprehensive view of the complex security ecosystem for the Smart Grid.

## **9.6 Physical Security**

Both physical and cyber environments must be holistically addressed from a security perspective. Much like the cyber security strategy, PG&E's physical security strategy is based on a systematic risk assessment to identify and mitigate against potential security threats. Physical security audits based on industry best practices also play a critical role to ensure the Utility is appropriately prepared and protected against security threats. Finally incident response processes are utilized to help respond to, and recover from

security threats to the Utility's physical environment, including its advanced meter and communications infrastructure.

Corporate Security utilizes four layers of physical security that work to complement each other to provide for the security of the Smart Grid. These layers consist of environmental design, mechanical and electronic access control, intrusion detection, and video monitoring. The Corporate Security strategies for the physical security of the Smart Grid will model those that enhance the physical security of the Critical Cyber Assets outlined in the NERC Cyber Security Standards, CIP-006. The NISTIR 7628 will be leveraged for existing physical requirements per Section 3.18 (Physical and Environmental Security) and also tracked in future versions of the NISTIR by the NIST CSWG for dealing with combined cyber-physical attacks.

PG&E as well as the standards organizations recognize that an increase in physical security efforts is required due to the additional identification of and inclusion of critical Smart Grid assets. Requirements include enhancements to the physical security plan. The plan will follow and address maintaining physical protections to identified critical cyber assets, including the following protections:

- (1) Establishing physical perimeters
- (2) Identification and monitoring of all access and entry points
- (3) Management and credentialing of personnel who interact with critical systems or assets including background checks and training requirements
- (4) Processes for review, approval, and revocation of access
- (5) Enhanced processes for timely updating and review of the plan

Where design of physical security perimeters are not feasible given the distributed nature of edge devices, for example, PG&E plans to follow a rigorous information protection methodology incorporating standards that protect devices in the type of

environment with little physical protection such as line sensors or SmartMeters™. For these types of situations, PG&E designs the controls under the premise that devices will be compromised, and therefore the components must be tamper resistant and follow standards such as the assurance levels specified in NIST FIPS 140-2.

PG&E follows a layered approach to apply physical security controls. Critical IT equipment including PG&E's servers are housed in data centers with rigorous physical security controls, including alarm systems, secure badge readers with logging, and video recording. In order to gain physical access to critical cyber assets, employees must undergo background checks and complete regular Information Security awareness training. Physical access is allowed only as long as an employee's duties require it. PG&E is currently in the process of building and designing a new data center where both physical and cyber security requirements are being aligned in anticipation of the Smart Grid.

## **9.7 Privacy**

### **9.7.1 PG&E's Commitment to Customer Privacy Protection**

PG&E is committed to protecting customer privacy and has multiple standards, policies, and procedures which ensure compliance with federal and state laws and Commission orders aimed at protecting private customer information. As part of the Commission's Smart Grid Technologies Order Instituting Rulemaking (OIR) proceeding,<sup>10</sup> PG&E has worked with other stakeholders to propose a new privacy framework based on the nationally accepted FIPs principles.<sup>11</sup> These revised privacy rules were codified in the Commission's May 6, 2011, Proposed Decision Adopting Rules to Protect the Privacy and

---

<sup>10</sup> See Opening Responses of Pacific Gas and Electric Company (U 39 E) to Assigned Commissioner's Ruling on Customer Privacy and Security Issues, October 15, 2010; Reply Comments of Pacific Gas and Electric Company (U 39 E) on Customer Privacy and Security Issues, November 8, 2010.

<sup>11</sup> See, for example, NIST IR 7628, Guidelines for Smart Grid Cyber Security: Vol. 2, Privacy and the Smart Grid; Department of Homeland Security Memorandum 2008-01: The Fair Information Practice Principles: Framework for Privacy Policy at the Department of Homeland.

Security of the Electricity Usage Data of the Customers of Pacific Gas and Electric Company, Southern California Edison Company, and San Diego Gas & Electric Company (“Commission’s Proposed Decision”). As PG&E has described throughout the Commission’s Smart Grid OIR proceeding, PG&E is already protecting customer privacy and abiding by long-standing and recently revised privacy practices adopted by the Commission and other policymakers. The Commission’s Proposed Decision privacy framework is thus an attempt to codify myriad existing policies, laws, and orders.

### **9.7.2 Overview of Private Customer Data PG&E Collects**

PG&E collects customer information based on the business relationship between customers and their use of PG&E utility services and other products PG&E provides. Some examples include:

- Contact information that allows PG&E to communicate with the customer, including name, address, telephone number and email address
- Billing information related to customers’ financial relationship with PG&E, including payment data, credit history, and Social Security Number
- Electric and gas usage data gathered by PG&E’s metering systems
- Information gathered when a customer participates in utility programs such as those related to energy efficiency

PG&E collects customer information in a variety of ways including:

- When a customer sets up an account and interacts with PG&E regarding their account, their utility service, and their participation in utility programs
- When a customer uses electricity and natural gas service, usage data is collected via PG&E’s metering systems (including the SmartMeter™ system)
- When a customer chooses to engage with PG&E through pge.com (view our Website Privacy Policy and Terms of Use)



- When PG&E interacts with third parties such as credit agencies

PG&E uses this personal information to administer customers' account, inform customers about their energy usage, as well as to manage, provide, and improve services and business operations. As described more fully in the Commission's Proposed Decision, these are defined as Primary Purposes. Some examples include:

- To generate customer billing statement and otherwise in connection with billing and payment on a customer account
- To enable customers to see their energy usage data on a next day basis via secure access on the internet (available to residential customers on the SmartMeter™ system or commercial customers)
- To communicate with customers about their energy usage to help them select the best rate plan, or help customers take better advantage of certain pricing programs offered by PG&E, such as the SmartRate™ Program
- To communicate with customers about specific programs or opportunities offered by PG&E that may help to lower the customers' energy usage or realize other benefits
- To communicate with customers about energy saving tips and energy management tips tailored to their geographic area, climate, and daily energy usage

PG&E may also aggregate data about customers' electric and gas usage in various formats such that the data becomes anonymous and cannot be used to identify personal data associated with a particular customer. For instance, aggregated data could be a summary of total energy usage for all homes and businesses in a certain geographic area or climate. Aggregated data is not subject to privacy restrictions and is used by PG&E to manage, provide, and improve customer services and business operations. Some examples include:

- To analyze rates and rate structures
- To project usage demand patterns and plot growth in different geographic or other areas
- To improve energy supply planning and to better design and engineer our energy distribution systems

When using customer data, PG&E may share it with contractors and vendors for purposes of providing services to customers and operating the utility system. However, in that case, PG&E requires that the contractors or vendors agree to only use the data for utility operational purposes (i.e., Primary Purposes under the Commission's Proposed Decision) and to protect it under the same confidentiality and privacy standards as PG&E applies to its own employees and operations.

PG&E currently uses SmartMeter™ program data for meter reading, remote connect and disconnect purposes, and to improve outage restoration capabilities. Further, PG&E is evaluating use of the new 24/7 time-of-use data generated by our SmartMeter™ program for additional operational and management benefits, including exploring the potential uses of the data for targeting and enhancing customer services and programs, such as customer energy efficiency and demand response programs and rate designs. PG&E is also beginning to analyze the use of the SmartMeter™ generated data for energy procurement and capacity planning and procurement, including integration of distributed generation and renewable, as well as more precise procurement of shaped and peaking resources generally, such as electric vehicle load integration.

### **9.7.3 Protection of Private Customer Data; Customer Consent**

Per the Commission's Proposed Decision, PG&E does not release personal customer information to any other person or business entity without the customer's prior written consent.

There are, however, certain exceptions that have been authorized by the Commission or the California Legislature. PG&E may release personal information without a customers' prior written consent as follows:

- To law enforcement officers, pursuant to legal process (such as a warrant or subpoena approved by a judge)
- To contractors providing utility--related (Primary Purpose) services on behalf of PG&E—but only to the extent necessary to render the service and subject to confidentiality and security obligations
- To the Commission (or other governmental agencies with jurisdiction over PG&E), when those agencies require such information
- To others as required by court order or by applicable laws, rules, or regulations governing PG&E
- To credit reporting agencies, and to collection agencies (if a customer account is assigned for collection)
- On occasion, PG&E may share non-customer specific energy usage data with third parties where necessary or beneficial for utility business operations, such as academicians performing research that may help improve our Customer Energy Efficiency (CEE) or Demand Response (DR) Programs (see Commission's Proposed Decision, Appendix D, Section 6(g))

PG&E does not sell or provide personal customer information to third parties for its commercial benefit.

PG&E currently provides customer-specific energy usage data to third parties who are not PG&E's contractors or agents only with the affirmative consent of the individual customers, or where authorized by Commission rules, orders or statutes, such as under Community Choice Aggregation programmed authorized by Public Utilities Code 366.2. For purposes of its utility operations or authorized customer services or programs

(i.e., Primary Purposes per the Commission’s Proposed Decision), such as CEE or DR Programs, PG&E shares customer specific energy usage data with its contractors or agents, but only under specific commercial protections to ensure that the third party contractors and agents protect the customer usage data from disclosure to others under the Commission’s existing rules and orders on customer privacy. On occasion, PG&E may share non-customer specific energy usage data with third parties where necessary or beneficial for utility business operation, such as academics performing research that may help improved CEE or DR Programs, as authorized by Commission’s Proposed Decision, Appendix D, Section 6(g).

PG&E shares customer-specific energy usage data (available on the utility servers) with third parties only if the individual customer consents to such sharing or the data is shared for Commission-approved utility purposes in accordance with Commission orders and California law. Today, any PG&E customer can directly share their paper or electronic information, including historical energy usage data, with third parties, without the need for additional PG&E data collection or systems. However, direct third party access to customer data, as proposed in the Commission’s Proposed Decision, Ordering Paragraph 8 (p. 137), will require additional data systems and processing, at additional utility expense.

PG&E treats all requests from third parties for customer specific information under the same Commission-approved rules, orders and statutory requirements. This includes requests from law enforcement and governmental agencies as well as requests from private parties and civil litigants. The Commission’s Proposed Decision contains a list of Commission decisions and orders and identifies the various standards and protections applicable to specific categories of requests, including requests from law enforcement agencies. PG&E will continue to work with the Commission and privacy advocates to establish robust rules and policies for robust protections for customer data.

#### **9.7.4 Customer Access to Their Private Data**

Residential customers with installed and activated PG&E SmartMeters™ have internet-based access to their electricity usage data on an hourly, 24/7 interval basis. Non-residential customers with SmartMeters™ have access to this data on a 15 minute, 24/7 interval basis. Natural gas SmartMeter™ data is available on a daily basis. Per the Commission’s AMI decision, this energy usage data is available to a customer one day after actual usage.

Customers with SmartMeters™ also have secure access to their pricing information, including an estimate of their month-end bill and rates at peak and non-peak time. Customers further have an option to be notified when they move between rate tiers. Residential and non-residential customers with a SmartMeter™ device can download to their own computer system not only their interval usage data, but also the pricing associated with that particular interval. Large, medium, and small business as well as agricultural customers have access to a robust set of relatively sophisticated rate analysis tools; these will be made available for residential customers as dynamic rates become available for them as well.

Already, PG&E customers have significantly more informational about their energy usage and bills than just a few years ago. Today, nearly 2 million of PG&E’s residential customers with SmartMeters™ have internet-based access not only to their electricity and gas usage data on an hourly, 24/7 interval basis, but also to web-based tools for forecasting and calculating their energy usage and costs, using a cost calculator based on their trended usage. Customers are able to see their estimated month-end bill and compare that with usage in the prior year. Through PG&E’s “Energy Alerts” program, customers can also sign up to receive email, text or phone messages as they transition from one of the upper tiers into a higher tier.

Separately, PG&E's SmartMeter™-enabled HAN system, when complete, will provide customers with the ability to access their energy usage data on a "near-real-time" basis (i.e., every 10 seconds) using HAN-enabled devices, including third-party devices that are "registered" with their PG&E meter and meet national Smart Energy Protocol 2.0 (SEP 2.0) standards for access and customer security. The energy usage data on the HAN system will be provided directly to the customer, and in general will not be available on the utility servers.

Customers may authorize any third party to have access to their PG&E provided data via a direct authorization form submitted to PG&E. Further, customers may directly share their data, downloaded from the PG&E website, with anyone they choose. PG&E would have no knowledge of or information about those uses by customers of their own data.

#### **9.7.5 Maintaining Customer Data**

PG&E maintains customer-specific energy usage and billing information for seven years in accordance with Commission rules and standards.

Existing Commission rules and tariffs already specify the accuracy and completeness required for various types of utility information, including billing and metering information, program information, and information provided to regulators. (See Privacy PD, Appendix D, Section 7 and Appendix A to PG&E's Reply Comments filed November 8, 2010.)

PG&E understands that system and data security is a top priority for its customers. PG&E takes extensive measures to ensure the integrity of its systems and to secure and protect customers and customer data. PG&E safeguards customer information on secure systems with restricted and role-based access controls, and has implemented appropriate security controls to protect the information when it is stored or transmitted. PG&E contractors acting on behalf of the company are also required to

comply with the privacy policy. The security controls outlined in the previous section outline those measures that help to protect customer information in accordance with privacy policy.

See discussion earlier in this chapter for a description of the cyber and physical protections that PG&E employees against loss or misuse.

Existing Commission rules and processes already govern the resolution and redress of customer complaints regarding utility services, including customer privacy issues. The recently released Commission's Proposed Decision requires regular audits in conjunction with each Investor-Owned Utilities General Rate Case.

## **9.8 Conclusion**

PG&E is methodically evolving its cyber security, grid security, and privacy strategy in alignment with best practices, industry standards, customer and stakeholder input, environmental issues and public policies. Existing, in-flight and planned future efforts are all integral parts of PG&E's continuously evolving risk management program. Both physical and cyber security controls are used to ensure the PG&E program continues to meet the growing needs for safety, privacy, reliability and resiliency in the constantly evolving Smart Grid.

## **Chapter 10 – Smart Grid Metrics**



## 10.1 Introduction

The purpose of this chapter is to describe the interim Smart Grid metrics as proposed by PG&E, SCE, and SDG&E,<sup>12</sup> which are being presented in conjunction with this Smart Grid Deployment Plan. Quantitative metrics can be used to objectively measure progress towards the implementation of a Smart Grid. Metrics also can be used to evaluate the deployment of advanced technologies. In addition, metrics can be used to determine whether state and federal policies are being met.

## 10.2 Consensus Interim Smart Grid Metrics

The proposed interim Smart Grid metrics reflect the input of various parties in the Smart Grid Technologies OIR proceeding. In its “Report on Consensus and Non-Consensus Smart Grid Metrics” (Report), PG&E, SCE, and SDG&E, collectively, proposed 19 interim metrics. This Report was prepared at the direction of Commission staff and resulted from a workshop, opening comments, four “webinars” facilitated by Commission staff, and discussions with interested parties. As stated in Administrative Law Judge Sullivan’s December 29, 2010 ruling, these metrics “reflect the efforts of the IOUs to determine what information is or could be feasible to collect by IOUs in the near term.”<sup>13</sup>

PG&E fully supports the interim metrics as a useful starting point for initial development of the investor-owned utility’s (IOU) Smart Grid Deployment Plans. PG&E also believes that the interim metrics also provide the Commission with sufficient information to fulfill its obligation to report on Smart Grid plans to the Governor and Legislature on an annual basis. However, as PG&E suggested in its opening comments on the proposed metrics, some of the interim metrics are dependent on factors or funding that are outside the reasonable control of the IOUs, such as voluntary changes in customer behavior (e.g., DR) or technological developments (e.g., development of cost-effective

---

<sup>12</sup> “Report on Consensus and Non-Consensus Smart Grid Metrics,” submitted by Pacific Gas and Electric Company, Southern California Edison Company, and San Diego Gas & Electric Company, in consultation with Environmental Defense Fund, submitted to the Commission on October 22, 2010.

<sup>13</sup> As of June 30, 2011, the Commission has not issued a final decision formally adopting the interim Smart Grid metrics.

energy storage technologies).<sup>14</sup> PG&E intends to continue to work with stakeholders and the Commission to refine the interim metrics over time to address these and other issues as the Smart Grid evolves in California.

Although these interim metrics are included in PG&E's Smart Grid Deployment Plans, the value of these metrics may evolve over time to be more suitable for future Deployment Plans and updates. The exact nature of Smart Grid investments, projects, and programs are subject to revisions and modifications based on each IOUs' specific deployment experience, which may in fact differ significantly from current expectations. As such, future Smart Grid developments may require the Commission, the IOUs, and other stakeholders to revisit these proposed interim metrics.

Because Senate Bill 17 and the Commission define the term "smart grid" to include programs, projects, products and services that are directly utilized by utility customers as well as by utilities to serve those customers, the consensus metrics in this report significantly overlap with data that is already collected or reported under utility programs and projects governed by other CPUC proceedings and statutes, such as Advanced Metering Infrastructure (AMI), DR, Renewable Portfolio Standard, Long Term Procurement Plan, Alternative Fuel Vehicles and General Rate Case (GRC) proceedings.<sup>15</sup>

### **10.3 PG&E's Interim Smart Grid Metrics**

In the "Report on Consensus and Non-Consensus Smart Grid Metrics," the three IOUs proposed a set of interim Smart Grid metrics for the IOUs to include in its Smart Grid Deployment Plans and in subsequent utility Smart Grid annual reports. They are listed here along with the reported annual values as of December 31, 2010.

---

<sup>14</sup> PG&E Opening Comments on Proposed Interim Smart Grid Metrics, January 24, 2011, page 1.

<sup>15</sup> "Report on Consensus and Non-Consensus Smart Grid Metrics," page 2.

## 10.4 Customer/Advanced Metering Infrastructure Metrics

**Metric 1:** Number of advanced meter malfunctions where customer electric service is disrupted.

**Purpose/Policy Goal Supported:** To measure improvements in grid reliability at the customer level and to measure the ability of the Smart Grid to avoid and identify outages. § 8360(a)

### Definitions:

**Advanced Meter:** A meter that measures interval data and enables two-way communication between utilities and the meters located at customer premises.

- *Includes AMI meters, or smart meters approved by the CPUC under the AMI deployment programs.*
- *Excludes real time energy meter (RTEM) and legacy meters (electro-mechanical and non-AMI).*

**Meter Malfunction:** Malfunction that caused a smart meter to become inoperable.

- *Includes AMI meters with integrated service switch.*
- *Excludes AMI meters without service switch, RTEM, and legacy meters.*

**Service Disruption:** Outages caused by faulty AMI meters.

- *Excludes outages caused by service panel or weather head issues or house fires, outages caused by AMI meters without service switch, RTEM or legacy meters, AMI meters installed with service switch open by mistake, and AMI meter replacements.*

Number of PG&E Advanced Meter Malfunctions Where Service is Disrupted	
Metric	2010 Value
Number of meters (annually)	587 meters

Note: This number represents incidents of radio frequency interference with breakers; PG&E installed a low power meter to resolve the issue.

**Metric 2:** Load impact from Smart Grid-enabled, utility administered DR programs (in total and by customer class, to the extent available).

**Purpose/Policy Goal Supported:** To measure the achievement of EE and DR goals as listed in § 454.5 and § 454.55 – § 8366(d).

**Definitions:**

Smart Grid-Enabled DR Programs: DR programs that rely upon two-way communications, including meters that allow for Home Area Network (HAN) or internet enabled access of interval meter data and/or notifications.

- *Includes: Peak Time Rebate (PTR) (California Alternate Rates for Energy (CARE) and non-CARE DR impacts, to the extent available), Critical Peak Pricing (CPP), Programmable Communicating Thermostat (PCT), time-of-use (TOU), Air Conditioning Cycling (AC Cycling).*
- *Excludes: Energy information tools such as in-home displays (IHD), web presentment, budget assistant, and third party data access.*

Load Impact: DR megawatt (MW) reductions will be determined, measured by ex post load impact analysis, coincident with each utility's system peak (adjusted to account for the DR load reduction).

Customer Class: A group of customers with similar characteristics that have similar rate schedules or structures for electric service. For the purposes of this metric, customer classes shall be defined by existing tariff structures. For each utility, the customer classes shall be as follows:

- *for SCE: (1) Residential, (2) Commercial and Industrial (C&I) < 200 kilowatt (kW), (3) C&I > 200 kW, (4) Agriculture and Pumping.*
- *for PG&E: (1) Residential, (2) non-Residential < 200 kW, (3) non-Residential > 200 kW, (4) Other.*
- *for SDG&E: (1) Residential, (2) C&I < 500 kW, (3) C&I > 500 kW, (4) Other.*

<b>Load Impacts From Smart Grid-enabled, PG&amp;E Administered DR Programs</b>	
<b>Metric</b>	<b>2010 Value</b>
<b>Residential</b>	<b>0 MW</b>
<b>Non-Residential</b>	<b>0 MW</b>
<b>Other</b>	<b>0 MW</b>
<b>Total</b>	<b>0 MW</b>

Note: Given the definition in Metric 2, PG&E does not currently operate any Smart Grid-Enabled DR Programs. PG&E's current DR portfolio relies on legacy interval meters and to a lesser degree SmartMeters™ where deployed with eligible customers. PG&E uses several notification methods that are not necessarily dependent on two-way communication.

Even though PG&E does not yet have DR programs leveraging two-way communication systems, PG&E is still highly committed to DR. PG&E's total DR program numbers are reflected in the table below. These figures summarize the ex post load impacts that are reported, pursuant to CPUC Decision 08-04-050, in the annual load impact evaluations of PG&E's 2010 DR programs.

<b>Load Impacts From PG&amp;E Administered DR Programs</b>	
<b>Metric</b>	<b>2010 Value</b>
<b>Residential</b>	<b>50.1 MW</b>
<b>Non-Residential</b>	<b>411.5 MW</b>
<b>Other</b>	<b>0 MW</b>
<b>Total</b>	<b>461.6 MW</b>

**Metric 3:** Percentage of DR enabled by AutoDR (Automated Demand Response) by individual DR impact program.

**Purpose/Policy Goal Supported:** The Smart Grid seeks to promote the use of DR and is tied to § 8366(d) and § 8360(d).

**Definitions:**

AutoDR: DR that is enabled through a variety of technologies that are automatically activated upon receiving a DR event or price trigger from the DR provider. Examples of technologies include energy management systems and software, wired and wireless controls, thermostats and enabled appliances. For purposes of this metric, AutoDR is limited to utility administered programs for business customers.

Percentage: Verified kW load reductions (engineering analysis) available for DR, divided by total DR portfolio kW.

Enabled: Event triggered DR programs.

Percentage of PG&E DR enabled by AutoDR	
Metric	2010 Value
Percentage of DR enabled by AutoDR – Demand Bidding Program (DBP)	n/a
Percentage of DR enabled by AutoDR – Peak Day Pricing (PDP) program	n/a

Note: Given the definition in Metric 3, the DR load impact evaluations for program year 2010 do not calculate load impacts in such a way that PG&E can report the percentage of DR enabled by AutoDR by individual DR impact program.

**Metric 4:** The number of utility-owned advanced meters with consumer devices with HAN or comparable consumer energy monitoring or measurement devices registered with the utility (by customer class, CARE, and climate zone, to extent available).

**Purpose/Policy Goal Supported:** Some of the benefits of the Smart Grid are linked to customer usage of its capabilities, and this metric seeks to measure customer use of smart grid and advanced meter capabilities. Tied to §8360(f), (h) (i) and §8366(a).

**Definitions:**

Consumer Devices: Smart Grid-enabled tools used by consumers that communicate with the utility-owned meter or other gateway.

- *Includes HAN devices (e.g., IHDs, PCTs, PC USB devices); devices owned by the consumer, utility or third party; devices that are included as part of a utility program; devices that are not included in part of a utility program.*
- *Excludes PC-software applications, Internet portal applications (e.g., bill forecast, bill-to-date, SCE's budget assistant tool, PG&E/SDG&E's tier alerts, presentment of interval data), Plug-in Electric Vehicles (PEV), EE and solar-related devices, and AC Cycling devices.*

Register: The act or process of pairing a consumer device to a HAN. Used to ensure that devices are communicating with the intended recipient (e.g., AMI meter). Registering a device is a control to prevent cyber security issues.

Considerations:

- *All devices that communicate with the utility's HAN will need to be registered with the utility, regardless of where or how the device was purchased, or the ownership of such device. In addition, all devices that are part of a utility program will need to be registered with the utility.*
- *This metric is likely a cumulative metric and will therefore increase over time. That is, once a meter has a device registered to it, the customer is unlikely to deregister the device, even if the device is no longer in use.*

**Customer Class:** A group of customers with similar characteristics that have similar rate schedules or structures for electric service. For the purposes of this metric, customer classes shall be:

- *for SCE: (1) Residential, (2) C&I < 200 kW, (3) C&I > 200 kW, (4) Agriculture and Pumping.*
- *for PG&E: (1) Residential, (2) non-Residential < 200 kW, (3) non-Residential > 200 kW, (4) Other.*
- *for SDG&E: (1) Residential, (2) C&I < 500 kW, (3) C&I > 500 kW, (4) Other.*

**CARE:** CARE program. CARE offers income-qualified customers a discount of 20 percent or more off their monthly electric bill.

**Climate Zone:** An area that is distinguished by its climate so that utility customers within the territory have similar heating and cooling needs.

<b>PG&amp;E Owned Advanced Meters with HAN/Comparable Devices Registered</b>	
<b>Metric</b>	<b>2010 Value</b>
<b>Residential</b>	<b>20 meters</b>
<b>Non-Residential &lt; 200 kW</b>	<b>0 meters</b>
<b>Non-Residential &gt; 200 kW</b>	<b>0 meters</b>
<b>Other</b>	<b>0 meters</b>
<b>Total</b>	<b>20 meters</b>
<b>CARE</b>	<b>0 meters</b>
<b>Non-CARE</b>	<b>20 meters</b>
<b>Total by CARE/non-CARE</b>	<b>20 meters</b>
<b>Climate Zone S</b>	<b>1 meter</b>
<b>Climate Zone T</b>	<b>9 meters</b>
<b>Climate Zone X</b>	<b>10 meters</b>
<b>Total by Climate Zone</b>	<b>20 meters</b>

Note: These 20 meters are part of a pilot where the meters and devices are installed on a test network within 20 PG&E employee homes. These employees are participating in the evaluation of these technologies.



**Metric 5:** Number of customers that are on a time-variant or dynamic pricing tariff (by customer class, CARE, and climate zone, to the extent available).

**Purpose/Policy Goal Supported:** Some of the benefits of the Smart Grid are linked to customer usage of its capabilities, and this metric seeks to measure customer use of Smart Grid and advanced meter capabilities. § 8360(f), (h), (i) and § 8366(a)

**Definitions:**

Time Variant or Dynamic Pricing Tariff: A rate in which prices can be adjusted on short notice (typically an hour or day ahead) as a function of system conditions. A dynamic rate cannot be fully predetermined at the time the tariff goes into effect; either the price or the timing is unknown until real-time system conditions warrant a price adjustment.

- *Includes customers on CPP, TOU, Real-Time Pricing rates, customers enrolled in PTR notifications, and customers on separately metered PEV rates.*
- *Excludes AC Cycling programs, PCT programs, and customers with a PEV that are not on an EV time variant rates.*

Customer Class: Same as Metric 4. A group of customers with similar characteristics that have similar rate schedules or structures for electric service. For the purposes of this metric, customer classes shall be defined by existing tariff structures. For each utility, the customer classes shall be as follows:

- *for SCE: (1) Residential, (2) C&I < 200 kW, (3) C&I > 200 kW, (4) Agriculture and Pumping.*
- *for PG&E: (1) Residential, (2) non-Residential < 200 kW, (3) non-Residential > 200 kW, (4) Other.*
- *for SDG&E: (1) Residential, (2) C&I < 500 kW, (3) C&I > 500 kW, (4) Other.*

CARE: Same as Metric 4. Number of customers enrolled in the CARE program. CARE offers income-qualified customers a discount of 20 percent or more off their monthly electric bill.

Climate Zone: Same as Metric 4. An area that is distinguished by its climate so that utility customers within the territory have similar heating and cooling needs.

<b>Number of PG&amp;E Customers on a Time-Variant or Dynamic Pricing Tariff</b>	
<b>Metric</b>	<b>2010 Value</b>
<b>Residential</b>	<b>110,625 customers</b>
<b>Non-Residential</b>	<b>99,296 customers</b>
<b>Other</b>	<b>0 customers</b>
<b>Total by Customer Class</b>	<b>209,921 customers</b>
<b>CARE</b>	<b>0 customers</b>
<b>Non-CARE</b>	<b>209,921 customers</b>
<b>Total by CARE/non-CARE</b>	<b>209,921 customers</b>

Note: This metric is not available by climate zone.

**Metric 6:** Number of escalated customer complaints related to: (1) the accuracy, functioning, or installation of advanced meters or (2) or the functioning of a utility-administered HAN with registered consumer devices.

**Purpose/Policy Goal Supported:** Linked to cost-effectiveness and provision of information to customers. § 8360(a), (e), (h)

**Definitions:**

Escalated Complaint: Escalated customer complaints (written or telephone call) received by the utility’s Consumer Affairs Department (or equivalent) regarding the AMI meter or program, or regarding device registration and communication issues.

Advanced Meter: Same as Metric 1. A meter that enables two-way communication between utilities/customers with the advanced meter.

Consumer Device: Tools that: (1) provide electricity energy information to customers or provides control over energy usage, and (2) provides such information and/or control via a HAN.

- *Includes devices provided by a utility program and devices purchased by consumers.*
- *Excludes devices not registered with the utility and devices communicating with HANs provided by non-utilities.*

Home Area Network: A network of energy management devices, digital consumer electronics, signal-controlled or enabled appliances, and applications within a home environment that is on the home side of the electric meter.

- *Includes HANs provided by a utility.*
- *Excludes HAN provided by non-utilities (e.g., customers, device manufacturers).*

Considerations:

- *Complaints related to the interaction of consumer devices with HANs, is dependent on the availability of utility HAN consumer devices, which is expected in 2012 to 2013.*

<b>Number of Escalated PG&amp;E Customer Complaints Related to:</b>	
<b>1 - Accuracy, Functioning or Installation of Advanced Meters, or</b>	
<b>2 - Functioning of a PG&amp;E-administered HAN with Registered Consumer Devices</b>	
<b>Metric</b>	<b>2010 Value</b>
<b>Number of escalated customer complaints related to the accuracy, functioning or installation of advanced meters (annually)</b>	<b>1,470 complaints</b>
<b>Number of escalated customer complaints related to the functioning of a PG&amp;E-administered HAN with registered consumer devices</b>	<b>0 complaints (n/a)</b>

**Metric 7:** Number of utility-owned advanced meters replaced annually before the end of their expected useful life.

**Purpose/Policy Goal Supported:** Linked to cost-effectiveness and provision of information to customers. § 8360(a), (e), (h)

**Definitions:**

Advanced meters: A meter that enables two-way communication between utilities/customers with the advanced meter.

- *Includes AMI meters, or smart meters approved by the CPUC under the AMI deployment program.*
- *Excludes RTEM meters and legacy meters.*

Replaced: AMI meter that has been replaced due to a malfunction causing the AMI meter to become inoperable.

Consumer Device: Tools that: (1) provide electricity energy information to customers or provides control over energy usage, and (2) provides such information and/or control via a HAN.

- *Includes devices provided by a utility program and devices purchased by consumers.*
- *Excludes devices not registered with the utility and devices communicating with HANs provided by non-utilities.*

<b>Number of PG&amp;E-owned Advanced Meters Replaced in 2010 Before the End of Their Expected Useful Life</b>	
<b>Metric</b>	<b>2010 Value</b>
<b>Number of meters</b>	<b>4,739 meters</b>

Note: This number does not include meters replaced due to technology change, such as the replacements approved by the CPUC in Decision 09-03-026. During 2010, an additional 50,289 advanced electric meters were removed from the field to be

investigated under the meter vendor warranty process. Of these, approximately 22,000 had an indication that removal was due to a malfunction causing the meter to become inoperable. Investigation of these meters continues; thus, it is possible that these meters will be returned to service and not retired.

**Metric 8:** Number of advanced meter field tests performed at the request of customers pursuant to utility tariffs providing for such field tests.

**Purpose/Policy Goal Supported:** Linked to cost-effectiveness and provision of information to customers. § 8360(a), (e), (h)

**Definitions:**

Advanced meters: A meter that enables two-way communication between utilities/customers with the advanced meter.

- *Includes AMI meters, or smart meters approved by the CPUC under the AMI deployment program.*
- *Excludes RTEM meters, legacy meters, and AMI meters replaced when service panel is removed or upgraded, installed in wrong service type, customer changes rate (NEM) requiring a new meter with a different program.*

Field Test: A test requested by a customer and conducted personnel at the customers premise to determine if a meter is measuring usage correctly.

- *Includes customer-requested field tests performed by utilities.*

Excludes tests independently conducted (not customer-requested)

<b>Number of Advanced Meter Field Tests Performed at the Request of PG&amp;E Customers</b>	
<b>Metric</b>	<b>2010 Value</b>
<b>Number of meters (annually)</b>	<b>10,928 meters</b>

**Metric 9:** Number and percentage of customers with advanced meters using a utility-administered internet or web-based portal to access energy usage information or to enroll in utility energy information programs.

**Purpose/Policy Goal Supported:** Linked to cost-effectiveness and provision of information to customers. § 8360(a), (e), (h)

**Definitions:**

Customers: Number of unique customers that: (1) have interval usage data available to them, and (2) have accessed the energy usage information at least once during the preceding 12 months.

Internet or Other Web-Based Portal:

- *Includes mobile phone applications*
- *Excludes customers accessing energy usage information from non-utility portals or websites*

Enrollments in Energy Information Programs:

- *Includes enrollments in Tier Alert/Budget Assistant programs, phone applications*
- *Excludes enrollments in dynamic pricing and customers calls*

Energy Usage Information:

- *Includes interval usage data collected by the AMI meter, backhauled to utility back office systems, and presented on utility web sites.*
- *Excludes usage or other data presented on third-party websites or tools, near real-time usage data available or any other information that is not received/stored in the utility back office systems (i.e., information received directly from the HAN), and cumulative energy usage information.*



<b>Number/Percentage of PG&amp;E Customers with Advanced Meters Using PG&amp;E's Internet Portal to Access Energy Usage Information or to Enroll in Utility Energy Information Programs</b>	
<b>Metric</b>	<b>2010 Value</b>
<b>www.pge.com "My Account" Customers</b>	<b>1,592,345 / 21.3%</b>
<b>SmartMeter™ Online Usage Inquiries</b>	<b>403,807 / 5.4%</b>
<b>Energy Alert Participants</b>	<b>28,625 / 0.4%</b>
<b>eBill Customers</b>	<b>1,609,711 / 21.5%</b>

## 10.5 Plug-in Electric Vehicle Metrics

**Metric 1:** Number of customers enrolled in time-variant electric vehicles tariffs.

**Purpose/Policy Goal Supported:** Provides a view into the usage of plug in electric vehicles; consistent with § 8360(g).

### Definitions:

Time Variant Electric Vehicle Tariffs:

- *for SCE: TOU-EV-1, TOU-EV-2, TOU-EV-3, TOU-EV-4, and TOU-D-TEV;*
- *for PG&E: E9a and E9b;*
- *for SDG&E: EV-TOU, EV-TOU-2, EV-TOU-3, EPEV-L, EPEV-M and EPEV-H.*

Number of PG&E Customers Enrolled in a Time-Variant Electric Vehicle Tariff	
Metric	2010 Value
Number of E-9A Customers	179 customers
Number of E-9B Customers	16 customers

## 10.6 Energy Storage Metrics

**Metric 1:** MW and MWh of grid connected energy storage interconnected at the transmission or distribution system level.

**Purpose/Policy Goal Supported:** Determine the number of units providing storage services to the network and their capability. § 8360(g)

**Definitions:** None.

PG&E – MW and MWh of Grid Connected Energy Storage	
Metric	2010 Value
Grid connected energy storage	1,212 MW 584,000 MWh

## 10.7 Grid Operations Metrics

**Metric 1:** The system-wide total number of minutes per year of sustained outage per customer served as reflected by the System Average Interruption Duration Index (SAIDI), Major Events Included and Excluded.

**Purpose/Policy Goal Supported:** Meet reporting requirements of § 8366(e) and the policy goal of § 8360(a).

### Definitions:

IOUs will use information reported in Annual Reliability Reports to produced information required for this metric. Each IOU's Annual Reliability Report is available at: <http://www.cpuc.ca.gov/PUC/energy/ElectricSR/Reliability/annualreports/>

<b>PG&amp;E System Average Interruption Duration Index (SAIDI)</b>	
<b>Major Events Included/Major Events Excluded</b>	
<b>Metric</b>	<b>2010 Value</b>
<b>SAIDI – Major Events Included</b>	<b>246.2</b>
<b>SAIDI – Major Events Excluded</b>	<b>168.5</b>

**Metric 2:** How often the system-wide average customer was interrupted in the reporting year as reflected by the System Average Interruption Frequency Index (SAIFI), Major Events Included and Excluded.

**Purpose/Policy Goal Supported:** Meet reporting requirements of § 8366(e) and the policy goal of § 8360(a).

**Definitions:**

IOUs will use information reported in Annual Reliability Reports to produced information required for this metric. Each IOU's Annual Reliability Report is available at: <http://www.cpuc.ca.gov/PUC/energy/ElectricSR/Reliability/annualreports/>

<b>PG&amp;E System Average Interruption Frequency Index (SAIFI)</b>	
<b>Major Events Included / Major Events Excluded</b>	
<b>Metric</b>	<b>2010 Value</b>
<b>SAIFI – Major Events Included</b>	<b>1.384</b>
<b>SAIFI – Major Events Excluded</b>	<b>1.168</b>

**Metric 3:** The number of momentary outages per customer system-wide per year as reflected by the Momentary Average Interruption Frequency Index (MAIFI), Major Events Included and Excluded.

**Purpose/Policy Goal Supported:** Meet reporting requirements of § 8366(e) and the policy goal of § 8360(a).

**Definitions:**

IOUs will use information reported in Annual Reliability Reports to produced information required for this metric. Each IOU's Annual Reliability Report is available at: <http://www.cpuc.ca.gov/PUC/energy/ElectricSR/Reliability/annualreports/>

<b>PG&amp;E Momentary Average Interruption Frequency Index (MAIFI)</b>	
<b>Major Events Included / Major Events Excluded</b>	
<b>Metric</b>	<b>2010 Value</b>
<b>MAIFI – Major Events Included</b>	<b>1.480</b>
<b>MAIFI – Major Events Excluded</b>	<b>1.304</b>

**Metric 4:** Number of customers per year and circuits per year experiencing greater than 12 sustained outages.

**Purpose/Policy Goal Supported:** Meet reporting requirements of § 8366(e) and the policy goal of § 8360(a).

**Definitions:**

IOUs will use information reported in Annual Reliability Reports to produce information required for this metric. Each IOU's Annual Reliability Report is available at: <http://www.cpuc.ca.gov/PUC/energy/ElectricSR/Reliability/annualreports/>

<b>PG&amp;E Customers/Circuits Experiencing &gt;12 Sustained Outages</b>	
<b>Metric</b>	<b>2010 Value</b>
<b>Number of Customers</b>	<b>3,792</b>
<b>Number of Circuits</b>	<b>38</b>

**Metric 5:** System load factor and load factor by customer class.

**Purpose/Policy Goal Supported:** Meet reporting requirements of § 8366(e) and the policy goal of § 8360(a).

**Definitions:**

System: The distribution system owned and operated by a utility.

Load Factor: Calculated by dividing: (1) average load (total energy divided by number of hours) during the year by (2) peak load during the year. In the case of Load Factor by customer class, the average and peak load during the year shall both be measured for that customer class (as opposed to the system).

Customer Class: A group of customers with similar characteristics that have similar rate schedules or structures for electric service. For the purposes of this metric, customer classes shall be defined by existing tariff structures. For each utility, the customer classes shall be as follows:

- *for SCE: (1) Residential, (2) C&I < 200 kW, (3) C&I > 200 kW, (4) Agriculture and Pumping.*
- *for PG&E: (1) Residential, (2) non-Residential < 200 kW, (3) non-Residential > 200 kW, (4) Other.*
- *for SDG&E: (1) Residential, (2) C&I < 500 kW, (3) C&I > 500 kW, (4) Other.*

<b>PG&amp;E Load Factors</b>	
<b>Metric</b>	<b>2010 Value</b>
<b>System Load Factor</b>	<b>55%</b>
<b>Load Factor - Residential</b>	<b>39%</b>
<b>Load Factor - Non-Residential &lt; 200 kW</b>	<b>Small L&amp;P: 35%</b> <b>Medium L&amp;P: 49%</b>
<b>Load Factor - Non-Residential &gt; 200 kW</b>	<b>Large L&amp;P: 71%</b>
<b>Other (agriculture)</b>	<b>38%</b>

Note: Small L&P: < 20 kW; Medium L&P: 20-500 kW; Large L&P: > 500 kW



**Metric 6:** Number of and total nameplate capacity of customer-owned or operated, grid-connected distributed generation facilities.

**Purpose/Policy Goal Supported:** State policy seeks to promote both distributed generation and the use of renewables. The ability to integrate these resources is an expected benefit of the smart grid. This is tied to § 8366(b) renewable and § 8360(c) distributed generation.

**Definitions:**

Distributed Generation Facilities: Generating systems that are: (1) enrolled with a utility in the Self Generation Incentive Program (SGIP) or the California Solar Initiative (CSI) (2) part of each utility’s respective Solar Photovoltaic (PV) program or, (3) operating under a Feed-In Tariff (FIT).

Electricity Deliveries From Grid-Connected, Customer Owned Or Operated Distributed Generation: All electricity purchased by a utility under a Net Surplus Compensation Tariff or under a FIT, measured in kilowatt-hour (kWh).

<b>Number and Total Nameplate Capacity of PG&amp;E Customer-owned or operated Grid-connected Distributed Generation Facilities</b>	
<b>Metric</b>	<b>2010 Value</b>
<b>Number of distributed generation facilities (solar)</b>	<b>25,977 facilities</b>
<b>Number of distributed generation facilities (non-solar)</b>	<b>199 facilities</b>
<b>Total number of distributed generation facilities (solar and non-solar)</b>	<b>26,176 facilities</b>
<b>Capacity of units (solar)</b>	<b>339 MW</b>
<b>Capacity of units (non-solar)</b>	<b>92 MW</b>
<b>Total capacity of distributed generation facilities (solar and non-solar)</b>	<b>432 MW</b>

**Metric 7:** Total annual electricity deliveries from customer-owned or operated, grid-connected distributed generation facilities

**Purpose/Policy Goal Supported:** State policy seeks to promote both distributed generation and the use of renewables. The ability to integrate these resources is an expected benefit of the smart grid. This is tied to § 8366(b) renewable and § 8360(c) distributed generation.

**Definitions:**

Distributed Generation Facilities: Generating systems that are: (1) enrolled with a utility in the SGIP or the CSI (2) part of each utility’s respective Solar PV program or, (3) operating under a FIT.

Electricity Deliveries From Grid-Connected, Customer Owned Or Operated Distributed Generation: All electricity purchased by a utility under a Net Surplus Compensation Tariff or under a FIT, measured in KWh.

<b>Total Annual Electricity Deliveries from PG&amp;E Customer-owned or Operated Grid-connected Distributed Generation Facilities</b>	
<b>Metric</b>	<b>2010 Value</b>
<b>Total annual electricity deliveries from customer-owned DG</b>	<b>22.5 GWh</b>

**Metric 8:** Number and percentage of distribution circuits equipped with automation or control equipment, including Supervisory Control and Data Acquisition (SCADA) systems.

**Purpose/Policy Goal Supported:** Measure the extension/development of the smart grid.

**Definitions:** None.

<b>Number and Percentage of PG&amp;E Distributed Generation Circuits Equipped with Automation or Control Equipment Including SCADA</b>	
<b>Metric</b>	<b>2010 Value</b>
<b>Number of circuits</b>	<b>1,546</b>
<b>Percentage of circuits</b>	<b>49.6%</b>

## **10.8 Review of and Revisions to Interim Metrics**

After public technical working sessions on Smart Grid metrics (October 8 through October 15, 2010), the parties identified certain Smart Grid metrics and topics as being either non-consensus or for “further consideration.” While there are important benefits or capabilities of the Smart Grid, the IOUs have determined that they are not feasible to measure or attribute reliably to Smart Grid deployment at this time. These areas include Advanced Automation and Measurement Technologies, Environmental Metrics, Customer/AMI, PEVs, Cyber Security, and Energy Storage. As discussed in the webinar on October 15, 2010, the Environmental Defense Fund (EDF), PG&E, SCE and SDG&E committed to work together to develop useful and relevant environmental metrics for consideration for inclusion in the 2011 Smart Grid Deployment Plans. At this time, these parties have acknowledged that developing environmental metrics in the context of the Smart Grid would be duplicative of metrics already reported in other proceedings. PG&E will continue to work with EDF to determine if useful and relevant environmental metrics for the Smart Grid can be developed in the future. PG&E intends to report progress on this issue in its first Smart Grid Annual Report filing in October 2012.

Additionally, as the IOUs make progress in defining the exact nature of their Smart Grid investments—in their respective Smart Grid Deployment Plans and GRCs or separate applications—the Commission should direct further metric development in these areas. The three IOUs requested that the Commission hold a workshop and/or return to the current informal process (with notice to parties) as more information emerges about Smart Grid Deployments. While the IOUs report the proposed consensus metrics in their 2011 Smart Grid Deployment Plans, PG&E recommends that the Commission begin the process of re-evaluating the current list in advance of the October 2012 deadline for the first annual report following the initial Deployment Plan submission. During this process, the IOUs can share additional information with parties pertaining to data that can be collected and specific planned deployments. These workshops can help to identify specific metrics as they become feasible and further guide the IOUs as they

make smart grid investments, while deployment plans will give parties greater clarity on evaluative data available.

### **10.9 Appropriate Reporting Period**

As stated in the “Report on Consensus and non-Consensus Metrics,” the IOUs elected not to discuss the baseline and reporting periods for the consensus metrics. However, this aspect is an important parameter of the Smart Grid metrics reporting process. The three IOUs advocated that a June 30 reporting date for the initial metric reports is illogical. Instead, the IOUs proposed to report on the proposed interim metrics as December 31, 2010.<sup>16</sup>

As stated in Decision 10-06-046, the Commission envisions that, as part of its review of the first Smart Grid Deployment Plan for each utility, it will address when and how updates to the Deployment Plans should be filed. PG&E recommends that, as part of that proceeding, the Commission should review the timing of metrics report and consider requiring the IOUs to report its Smart Grid metrics on a calendar year basis (i.e., as of December 31).

### **10.10 Conclusion**

As required by Decision 10-06-047, PG&E reports its Smart Grid metrics based on the interim Smart Grid metrics proposed by PG&E, SCE, and SDG&E, in consultation with EDF. At the time of this Deployment Plan filing, the Commission has not yet issued a final decision adopting the interim Smart Grid metrics. To the extent that the final decision modifies these proposed interim metrics, PG&E will reflect any modifications in a subsequent report to the Commission.

PG&E is committed to work with EDF and other parties to develop relevant environmental metrics and will report progress on this issue in its first Smart Grid

---

<sup>16</sup> Report on Consensus and Non-Consensus Smart Grid Metrics, page 7.

Annual Report filing in October 2012. In addition, PG&E supports a process of reviewing and re-evaluating the proposed interim metrics in advance of its first Smart Grid annual report, which will be submitted by October 1, 2012, as more insight on the Smart Grid becomes available.

Finally, PG&E recommends that the Smart Grid metrics be reported on a calendar year basis (i.e., as of December 31) rather than as of June 30 as stated originally in Decision 10-06-047.

## **Chapter 11 – Conclusion**

PG&E greatly appreciates the guidance and advice it has received from the Commission, the California Legislature, customers, market participants, members of the public, policymakers and other parties and stakeholders over the last three years leading up to the submittal of its Smart Grid Deployment Plan.

PG&E's Smart Grid Plan fully meets and complies with Senate Bill 17 (Padilla) which states that “[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 the following specific objectives:<sup>17</sup>

1. Increased use of cost-effective digital information and control technology to improve reliability, security, and efficiency of the electric grid.
2. 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.
3. Deployment and integration of cost-effective distributed resources and generation, including renewable resources.
4. Development and incorporation of cost-effective DR, demand-side resources, and energy-efficient resources.
5. 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.
6. Integration of cost-effective smart appliances and consumer devices.
7. 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.

---

<sup>17</sup> California Public Utilities Code, Section 8360.



8. Provide consumers with timely information and control options.
9. Develop standards for communication and interoperability of appliances and equipment connected to the electric grid, including the infrastructure serving the grid.
10. Identification and lowering of unreasonable or unnecessary barriers to adoption of smart grid technologies, practices and services.

In addition, PG&E's Smart Grid Plan follows the guidance provided in the Commission's Smart Grid policy decisions, including Decisions 09-09-029 and 10-06-047. Pursuant to the Commission's guidance, PG&E's Smart Grid Plan includes its Smart Grid Vision; Smart Grid Strategy; Deployment Baseline; Grid Security and Cyber Security; Smart Grid Roadmap; Cost and Benefits Estimates; and Metrics.

PG&E's Smart Grid Plan also demonstrates how it protects customer privacy and security and how it promotes compliance with California's environmental laws and policies, including Assembly Bill 32. PG&E appreciates the guidance and recommendations provided by the Environmental Defense Fund (EDF) in the Commission proceeding, including its fundamental recommendations that Smart Grid Plans address the following three points:

1. Enable maximum access by third parties to the grid, creating a platform for innovation in technology and services.
2. Have the infrastructure and policies necessary to enable and support the sale of DR, EE, distributed generation, and storage into wholesale energy markets as a resource, on equal footing with traditional generation resources.
3. Significantly reduce the total environmental footprint of the current electric generation and delivery system in California.

PG&E's Smart Grid Plan is intended to meet and exceed these sustainability, customer empowerment and market efficiency goals described by EDF.

PG&E's Smart Grid Plan is part of PG&E's overall commitment to improve the safety and reliability of its utility services and operations, and to maintain and enhance the confidence and trust of its customers.

PG&E looks forward to continuing to collaborate with policymakers, customers and other stakeholders as its Smart Grid Plan is reviewed and continues to evolve.