PUBLIC UTILITIES COMMISSION
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January 20, 2015

Advice Letter 4538-E

Meredith Allen
Senior Director, Regulatory Relations
Pacific Gas and Electric Company
77 Beale Street, Mail Code B10C
P.O. Box 770000
San Francisco, California 94177

SUBJECT: Smart Grid Line Sensor Pilot Project - Phase 1 Status Report, Pursuant to D.13-03-032

Dear Ms. Allen:

Advice Letter 4538-E is effective as of December 21, 2014.

Sincerely,

Edward Randolph

Edward Randolph
Director, Energy Division

Pacific Gas and Electric Company

Meredith Allen
Senior Director
Regulatory Relations

Pacific Gas and Electric Company
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November 21, 2014

Advice 4538-E
(Pacific Gas and Electric Company ID U 39 E)

Public Utilities Commission of the State of California

Subject: Smart Grid Line Sensor Pilot Project - Phase 1 Status Report, Pursuant to Decision 13-03-032

Purpose

The purpose of this advice letter is to comply with Ordering Paragraph (OP) 9 of Decision (D.) 13-03-032, *Decision Granting, in Part, and Denying, in Part, Pacific Gas and Electric Company's Application for Smart Grid Pilot Deployment Project*, which directs Pacific Gas and Electric Company (PG&E) to submit a status report via a Tier 2 Advice Letter within 14 days of the completion of each phase of each approved Smart Grid pilot. The Smart Grid Line Sensor Pilot Project has completed the key objectives of Phase I as described in Advice Letter 4227-E.[1] Therefore, PG&E submits this status report for review and approval to commence Phase 2 of the Line Sensor Pilot.

Background

On November 21, 2011, PG&E filed Application (A.) 11-11-017 requesting authorization to recover costs for implementing six Smart Grid Deployment Pilot Projects over four years. The Smart Grid Deployment Pilot Projects seek to advance the modernization of PG&E's electric grid consistent with California's energy policies as described in Senate Bill (SB) 17 and PG&E's Smart Grid Deployment Plan which was filed on June 30, 2011, and approved on July 25, 2013.

On March 27, 2013, in D.13-03-032, the California Public Utilities Commission (Commission or CPUC) approved four of the Smart Grid Pilot projects proposed by PG&E in A.11-11-017: (1) the Smart Grid Line Sensor Pilot Project, (2) the Smart Grid Voltage and Reactive Power Optimization Pilot Project, (3) the Smart Grid Detect and Locate Distribution Line Outages and Faulted Circuit Conditions Pilot

[1] PG&E's Advice Letter 4227-E, *Smart Grid Pilot Deployment Projects Implementation Plan, Pursuant to D.13-03-032*, submitted for filing on May 22, 2013, and approved effective June 21, 2013, by the CPUC's Energy Division.

Project, and (4) the Smart Grid Short Term Demand Forecast Pilot Project. OP 9 of D.13-03-032 states:

> "Within 14 days of the completion of each phase of each approved pilot, PG&E shall submit a status report via a Tier 2 Advice Letter to Commission staff. Each status report must include a) details of the activities occurring in the phase; b) a detailed breakdown of the costs of those activities; c) the results of the phase including evaluation and measurements of pre-selected metrics to portray the success or failure of the pilot phase; and d) a recommendation and rationalization of whether the pilot should advance to its next phase. PG&E should ensure that status reports are detailed, both quantitatively and qualitatively. Funding for subsequent phases, although approved in this decision, may not be spent by PG&E until the Advice Letter for the current phase is submitted and approved."

Discussion

PG&E has achieved its key Line Sensor Pilot Phase 1 goals and objectives, as described below and in Attachment 1, and is ready to proceed to Phase 2. Specifically, PG&E has demonstrated viable line sensor solutions that are ready for field deployment. PG&E submits this Advice Letter upon completion of the key Phase 1 objectives in order to allow for timely CPUC evaluation of the Phase 1 work and transition of work to Phase 2 to ensure a timely ability to order, deploy, and install the equipment and systems necessary to capture Line Sensor Pilot results for the 2015 storm season. Based on lab testing, PG&E has determined that it is viable for line sensor equipment to enhance grid outage detection, problem isolation, and restoration, as well as enhance grid system safety, integration of distributed energy resources, monitoring, control, and analysis. PG&E believes the understanding of the benefits potential for line sensors will be achieved by having the system in place with measurement and evaluation fully engaged throughout the summer of 2015 for a benchmark and then the subsequent seasons for further study and potential advanced functionality.

Overview of the Smart Grid Line Sensor Pilot Project

Through its Line Sensor Pilot project, PG&E will determine how the deployment of line sensor equipment can support reduced outage times by enhancing grid outage detection, problem isolation and more timely restoration. An additional goal of the Line Sensor Pilot Project is to provide granular loading data to facilitate distribution system operations, planning decisions, and analysis. This loading data could provide additional grid reliability and could also support increased integration of distributed energy resources.

Line sensors offers two potential direct benefits:

1. Increased System Reliability – Line sensors will assist in reducing the duration of customer outages by more granularly helping locate outages. Additionally, broad line sensor deployment could potentially improve customer power quality due to future line sensor device technological advances, providing information to assist in mitigating power quality disturbances.

2. Reduced Cost of Outage Response – Line sensors seek to reduce costs associated with outage response. They assist in pinpointing outages to a smaller area on the distribution circuit therefore reducing overall patrol time. Line sensors potentially accomplish outage response better than existing solutions by complementing SmartMeter™ outage data. SmartMeter™ data is effective at scoping the extent of an outage, i.e. customers impacted, and verifies restoration to each customer. However, line sensor data has the potential to add information on where the fault location is within the outage area. The line sensors will communicate back to the distribution operations central authority for that distribution circuit to direct the field troubleshooter to a more defined area, reducing overall truck roll time. The field troubleshooter will be able to locate the problematic equipment sooner, thereby minimizing hazardous situations and reducing the time needed to complete the repairs. This will result in reducing the customers' outage duration.

   Additionally, the line sensors can potentially provide real time loading information upon request to assist in real time switching operations in support of balancing line loads, as well as provide information for planning engineers to use in future planning activities. If successful, this loading information may also provide additional visibility into the real time operations of distributed energy resources, thus allowing grid operators better integration of the distributed energy resources on the grid. It is also believed that this real time loading capability may reduce costs in operating the system as well as deferring capital upgrade costs by providing additional data about the performance of existing capital equipment.

PG&E is assessing line sensor capabilities in each of the above areas as part of the pilot evaluation of commercially available systems and components. The pilot evaluations will be used to establish feeder characteristics that support benefit realization and project benefits associated with a large scale deployment of line sensors.

Line Sensor Pilot Phase 1 – Analysis and Laboratory Test Results

The analysis and laboratory test phase involved: (1) assessing commercially available line sensor products, reviewing the manufacturer's specifications and capabilities relative to PG&E's performance requirements and integrating with existing systems as well as evaluating vendor performance and viability;

(2) benchmarking with other utilities to assess industry experience with the technology provided by various vendors to assess operating performance and benefits and new innovations developed through actual field usage; and (3) testing line sensors that have a high probability of successful integration into PG&E's system, providing accurate and necessary results and being used by operators and engineers to change system operations practices to achieve the targeted benefits.

As described in further detail in Attachment 1, PG&E has successfully completed the key objectives of Phase 1 and recommends moving to Phase 2. It is important that PG&E begin the Phase 2 activities no later than February 1, 2015, to ensure a timely ability to order, deploy, and install the equipment and systems necessary to capture Line Sensor Pilot results for the summer of 2015. Commencing Phase 2 activites after February 1, 2015, will impact the critical path of this pilot project, increasing the risk of missing these key schedule milestones. PG&E believes the authorized Phase 1 testing will be completed in January 2015.

Line Sensor Pilot Phase 2 – Field Trial

In Phase 2, PG&E will perform field trials of line sensor products on distribution feeders in a subset of PG&E's divisions and proceed to operate, evaluate, and demonstrate the project in a field trial. In addition to testing the field capabilities of line sensors, PG&E's Phase 2 deployment will attempt to leverage and complement SmartMeter™ technology by using outage detection meter data and potentially using the communications network. PG&E plans to make use of any Phase 1 under-spend for Phase 2.

Protests

Anyone wishing to protest this filing may do so by letter sent via U.S. mail, facsimile or E-mail, no later than **December 11, 2014**, which is 20 days after the date of this filing. Protests must be submitted to:

CPUC Energy Division
ED Tariff Unit
505 Van Ness Avenue, 4th Floor
San Francisco, California 94102

Facsimile: (415) 703-2200
E-mail: EDTariffUnit@cpuc.ca.gov

Copies of protests also should be mailed to the attention of the Director, Energy Division, Room 4004, at the address shown above.

The protest shall also be sent to PG&E either via E-mail or U.S. mail (and by facsimile, if possible) at the address shown below on the same date it is mailed or delivered to the Commission:

Meredith Allen
Senior Director, Regulatory Relations
Pacific Gas and Electric Company
77 Beale Street, Mail Code B10C
P.O. Box 770000
San Francisco, California 94177

Facsimile: (415) 973-7226
E-mail: PGETariffs@pge.com

Any person (including individuals, groups, or organizations) may protest or respond to an advice letter (General Order 96-B, Section 7.4). The protest shall contain the following information: specification of the advice letter protested; grounds for the protest; supporting factual information or legal argument; name, telephone number, postal address, and (where appropriate) e-mail address of the protestant; and statement that the protest was sent to the utility no later than the day on which the protest was submitted to the reviewing Industry Division (General Order 96-B, Section 3.11).

Effective Date

PG&E requests that this Tier 2 advice filing become effective on regular notice, **December 21, 2014**, which is 30 calendar days after the date of filing.

Notice

In accordance with General Order 96-B, Section IV, a copy of this advice letter is being sent electronically and via U.S. mail to parties shown on the attached list and the service list for A.11-11-017. Address changes to the General Order 96-B service list should be directed to PG&E at email address PGETariffs@pge.com. For changes to any other service list, please contact the Commission's Process Office at (415) 703-2021 or at Process_Office@cpuc.ca.gov. Send all electronic approvals to PGETariffs@pge.com. Advice letter filings can also be accessed electronically at: http://www.pge.com/tariffs

/S/
Meredith Allen
Senior Director, Regulatory Relations

Attachment

cc: Service List A.11-11-017

CALIFORNIA PUBLIC UTILITIES COMMISSION

ADVICE LETTER FILING SUMMARY
ENERGY UTILITY

MUST BE COMPLETED BY UTILITY (Attach additional pages as needed)

Company name/CPUC Utility No. **Pacific Gas and Electric Company (ID U39 E)**

Utility type:	Contact Person: **Shirley Wong**
☑ ELC ☐ GAS	Phone #: **(415) 972-5505**
☐ PLC ☐ HEAT ☐ WATER	E-mail: **slwb@pge.com and PGETariffs@pge.com**

EXPLANATION OF UTILITY TYPE

ELC = Electric GAS = Gas ☐
PLC = Pipeline HEAT = Heat WATER = Water

(Date Filed/ Received Stamp by CPUC)

Advice Letter (AL) #: **4538-E** **Tier: 2**

Subject of AL: **Smart Grid Line Sensor Pilot Project - Phase 1 Status Report, Pursuant to Decision 13-03-032**

Keywords (choose from CPUC listing): **Compliance**

AL filing type: ☐ Monthly ☐ Quarterly ☑ Annual ☐ One-Time ☐ Other _____

If AL filed in compliance with a Commission order, indicate relevant Decision/Resolution #: **Decision 13-03-032**

Does AL replace a withdrawn or rejected AL? If so, identify the prior AL: No

Summarize differences between the AL and the prior withdrawn or rejected AL:

Is AL requesting confidential treatment? If so, what information is the utility seeking confidential treatment for: No

Confidential information will be made available to those who have executed a nondisclosure agreement: N/A

Name(s) and contact information of the person(s) who will provide the nondisclosure agreement and access to the confidential information: _____

Resolution Required? ☐ Yes ☑No

Requested effective date: **December 21, 2014** No. of tariff sheets: N/A

Estimated system annual revenue effect (%): N/A

Estimated system average rate effect (%): N/A

When rates are affected by AL, include attachment in AL showing average rate effects on customer classes (residential, small commercial, large C/I, agricultural, lighting).

Tariff schedules affected: N/A

Service affected and changes proposed: N/A

Protests, dispositions, and all other correspondence regarding this AL are due no later than 20 days after the date of this filing, unless otherwise authorized by the Commission, and shall be sent to:

CPUC, Energy Division
ED Tariff Unit
505 Van Ness Ave., 4th Floor
San Francisco, CA 94102
E-mail: EDTariffUnit@cpuc.ca.gov

Pacific Gas and Electric Company
Attn: Meredith Allen, Senior Director, Regulatory Relations
77 Beale Street, Mail Code B10C
P.O. Box 770000
San Francisco, CA 94177
E-mail: PGETariffs@pge.com

ATTACHMENT 1

Pacific Gas and Electric Company

Smart Grid Line Sensor Pilot Project
Completion of Phase 1 Key Objectives Report

Advice 4538-E

November 21, 2014

Attachment 1

Pacific Gas and Electric Company

Smart Grid Line Sensor Pilot Project
Completion of Phase 1 Key Objectives Report

November 21, 2014

This status report summarizes the completion of Phase 1 Key Objectives of the Smart Grid Line Sensor Pilot Project. Details presented in this Report support the conclusion that, based on lab testing, it is viable for line sensor equipment to enhance grid outage detection, problem isolation, and restoration, as well as enhance grid system safety, integration of distributed energy resources, monitoring, control, and analysis.

Therefore, PG&E recommends and requests approval to proceed with the Phase 2 Field Demonstration as described in Advice Letter (AL) 4227-E.

Table of Contents:

1. Goals and Objectives

The goal of the Line Sensor Pilot Project is to evaluate the ability of line sensor equipment to support reduced outage times by enhancing grid outage detection, problem isolation and more timely restoration. An additional goal of the Line Sensor Pilot Project is to provide granular loading data to facilitate distribution system operations, planning decisions, and analysis. This loading data may provide additional grid reliability and could support increased integration of distributed energy resources. PG&E was authorized to perform tasks in Phase 1 to meet these Phase 1 objectives and goals:[1]

- PG&E will identify and assess line sensor technology commercially available in the industry and being used by other utilities.

[1] AL 4227-E, Page 8

- PG&E will analyze technology requirements to support line sensors deployment and use, including software analysis and visualization applications, cyber security, information architecture, equipment standards and telecommunications.
- In a laboratory environment, PG&E will test the selected line sensors and identify the specific line sensors and supporting technologies to use for the field trial.

PG&E has fulfilled the goals and objectives of Phase 1. Based on findings obtained in Phase 1, PG&E requests approval to proceed to Phase 2. In Phase 2, PG&E will perform field trials of line sensor products on distribution feeders in a subset of PG&E's divisions and proceed to operate, evaluate and demonstrate the project in a field trial.

In addition to testing the field capabilities of line sensors, PG&E's Phase 2 deployment will attempt to leverage and complement SmartMeter™ technology by using outage detection meter data and potentially using the communications network.

2. Benchmarking with Other Utilities

PG&E held benchmarking interviews with utilities including Florida Power & Light, Alabama Power, Baltimore Gas & Electric, and San Diego Gas & Electric to understand drivers for implementing line sensors, vendor selection processes and outcomes as experienced at other utilities.

PG&E's benchmarking sessions have identified lessons learned from these peer utilities. Some of the key learnings include:

- There is a general acceptance of line sensors as valuable to utility operations and PG&E has discovered a trend toward adoption of these products. However, these sensors still represent a new way of operating and vendor products continue to evolve.
- Significant benefit is derived from applying line sensors on feeders with characteristics that lead to lengthy patrol times.
- It is important to test sensor accuracy and the sensor's ability to operate under normal conditions as well as fault conditions.
- Test plans should include an evaluation of how sensors perform at the low end of minimum current requirement range to ensure sensors are available and function as expected during low current periods.

3. Prospective Vendors: Evaluation and Selection

PG&E pursued a two-stage vendor evaluation process. The process included: 1) an initial Request for Information (RFI) to clearly understand commercially available line sensor products and 2) a detailed investigation of vendors shortlisted based on the RFI. The two phases of the evaluation are described in the subsections below.

Request for Information (RFI)

PG&E issued an RFI in December 2013 to evaluate the capabilities of available line sensor products. PG&E engaged industry experts to ensure the RFI would provide information relevant for the selection of candidate vendors from whom additional information would be requested. The RFI focused on the following attributes of the vendor technologies:

- Overall Line Sensor Pilot Approach
- Solution Functionality
- Reporting, Analytics, and EM&V Capabilities
- System Maintenance and Support Requirements
- Application Architecture
- Network and Communications
- Security
- System Integration
- Existing Installations / Customers
- Total Cost of Ownership

Eighteen line sensor vendors responded to the RFIs and were evaluated by project stakeholders including PG&E Electric Operations, Asset Management and IT organizations. The vendor evaluation was aligned with the PG&E's sourcing policies and included consideration of supplier diversity, safety, and environmental responsibility, in addition to the technical evaluation of vendor responses.

Seven vendor offerings were selected for detailed investigation in the evaluation process.

Detailed Investigation

The detailed investigation included review and assessment of:

- Details of vendor hardware offering
- Vendor responses to specific PG&E requests and needs
- Ability to leverage PG&E's existing and planned infrastructure and systems, e.g. Silver Springs SmartMeter™ technology Network
- Vendor clients and confirmation of references
- Supporting products such as software-based analytics
- System integration options including interfaces to existing PG&E systems such as SCADA
- Vendor roadmap and future product enhancement potentials
- Vendor specific functionality
- Vendor product communications path options
- Vendor product cybersecurity features

Vendor Selection Lessons Learned Include:

- The Smart Grid line sensor marketplace is in transition, with vendors modifying their products to meet the requirements from different utility market segments.
- Available sensors fall into three general categories: 1) "low-end" products that have only faulted circuit blinking light (FCI) indicator and load current measurement capabilities, 2)

"mid-range" products that have advanced capabilities like data logging and electric current characteristic signature or 'waveform' capture as well as FCI and electric load current features, and 3) "high-end" products that include accurate voltage measurement capabilities or other advanced features. The pricing of these devices tracks their functionality, i.e. low-end devices tend to cost the least and high-end products are significantly more expensive than mid-range or low-end devices.

- Many of the line sensor products evaluated during the detailed investigation phase have the potential to meet the goals of grid outage detection, problem isolation, and restoration, as well as enhance grid system safety, integration of distributed energy resources, monitoring, control, and analysis.
- In addition, three of the four lab evaluated vendors have functionality that may support additional operational benefits including enhanced line loading and predictive fault detection.

Conclusion

Four vendors were selected for laboratory testing after passing the RFI product evaluation. These four vendors represent a cross-selection of vendor products after passing screening of the RFI review and customer reference due diligence. The products evaluated in the lab included a cross section of low-end to high-end features and communications path options. The selected vendors were evaluated in the Phase 1 testing and evaluation at the PG&E Applied Technology Services (ATS) laboratory in San Ramon: Cooper Power Systems (now Eaton), GE, Sentient, and Tollgrade.

4. Laboratory Test Environment

PG&E's Applied Technology Services (ATS) laboratory is a multidisciplinary team of 100 engineers, scientists, and technicians committed to delivering practical testing solutions to the electric and gas industry's challenging problems. The facility houses multiple laboratories supporting comprehensive and often simultaneous testing in power laboratory facilities, environmental chambers, IT and communications laboratories. In addition to leveraging the established test facilities, PG&E supplemented the test environments with specific test fixtures such as pressurized water chamber for simulating a 30 foot depth to evaluate long term product submergibility for underground electric facility applications.

5. Laboratory Testing

Laboratory Testing performed at the ATS facility focused on safety, installation, operation, accuracy, integration, and communications. Testing also provided information that will support development of design, operating instructions and training in support of the Phase 2 field pilot. PG&E requirements for line sensors are divided between "Core" and "Advanced" requirements. Core requirements are needed for the device to be safe and reliable and to provide the critical functions of fault detection and line load monitoring with the ability to deploy the products anywhere on a distribution circuit. Vendors must meet the core requirements in order to be recommended for field pilot. Advanced requirements support supplemental benefits and future product capability.

Table 1 below outlines the high level business requirements and corresponding product requirements tested within ATS.

Table 1: Business and Product Requirements

Type	Requirement	Testing Process
Core: Safe and reliable operation	Safe and practical for field installation and removal	Installation and removal with "hot" stick, device weight/impact to pole loading, ease and speed of installation
Core: Safe and reliable operation	Will operate across PG&E's service territory and in severe environments	Temperature, humidity, submergibility when applicable, voltage and current transients handling capability
Core: Safe and reliable operation	Reliable communications	Ability to manage settings and firmware over the air, general traffic, reliable cell and SmartMeter™ communications
Core: Safe and reliable operation	End device to headend reliable operation	Headend commands sent to device via vendor headend or SCADA headend function
Core: Supports fault detection	Overcurrent faults are detected reliably. No false indications	Simulation of high current faults including operating of distribution circuit switch reclosing devices and other real-world conditions
Core: Supports management of feeder	Line loading is accurate, ability to sense current direction	Base measurements of electric current. Flow direction indication
Advanced: Waveform capture	Waveform is captured based on vendor specified Parameters. Waveform has acceptable (minimum) distortion.	Vendor dependent. Vendor product waveform production are compared with standards established through lab devices
Advanced: e-field and other measurement types	Measurements meet vendor's claims	E-field, power factor, harmonic content produced by the vendor product are compared with standards established through lab devices

6. Analysis and Laboratory Test Results

The extensive laboratory testing of vendor products indicate that two vendor products have the necessary features and functions to demonstrate capabilities of grid outage detection, problem isolation and more timely restoration in a field pilot.

The two other vendor products that were evaluated in laboratory testing encountered issues during testing. The product issues have been discussed in detail with those vendors for remediation. Both of these products show promise of unique capabilities of Core line sensor functionality, or particular capabilities of Advanced line sensor functionality. If and when the vendors make product modifications and subsequent testing demonstrates the products are also ready for field pilots, PG&E will add these products to the field pilot.

In addition, PG&E expects to continue to lab test new firmware, system software, product, feature or functionality modifications to these line sensor products.

Significant Knowledge Gained:
PG&E has developed significant knowledge surrounding the line sensor products and the integration required to achieve successful line sensor operation. Major areas of knowledge improvement include:

Integration to current SCADA control mechanism

Understanding the vendor product capabilities and ways of functioning has provided significant knowledge. An item of particular importance is our better understanding of the communications and IT integration path. Rather than using a traditional SCADA polling to the end device, analysis and testing determined PG&E's systems will perform better if the SCADA polling is decoupled from the field device and field communications. PG&E's planned architecture places a gateway-type device between the PG&E systems and the field communications which optimizes the field communications for unsolicited messaging, maintenance messaging and other tools while allowing PG&E SCADA and other systems to operate in their normal fashion. The project determined implementation of a gateway or application headend between the line sensors and SCADA would meet the following requirements:

- Allows management of the communications channel
- Enhances data and performance management that is highly critical to distribution automation switch deployments
- Line sensors are part of the overall fault location solution with an operational goal of providing a single fault location indication to the Distribution Operator rather than the actual status of all devices
- Vendor headend or gateway products are needed for firmware management

Power requirements

PG&E laboratory testing indicated that sensors cannot support full functionality at low line current levels. For example some products were designed to put the radio into a "sleep" mode where it cannot hear a communications request from SCADA or other headend systems. Overall system design and operational expectations would need to be adjusted if units are deployed at low line current locations. This does not reduce the general value and applicability of line sensors since most important sensing locations are expected to have sufficient line current for full operation.

State of technology

The PG&E testing provided insight to the general state of the line sensor industry and technologies. These products are still evolving and vendors are still searching for the where the largest opportunity will be for their products. For example Cooper (Eaton), is evaluating to what degree it may introduce further advanced functionality into their product such as highly accurate GPS measurements.

No single vendor is able to support all communications options of interest to PG&E, while at the same time supporting all installation conditions, e.g. overhead, underground, and small conductor.

7. Recommendations for pilot program refinements

PG&E believes that funding is likely sufficient to make the following refinements to certain items mentioned in AL 4227-E:

- PG&E proposes installing line sensors on more than 30 feeders. Additional feeders will have the impact of significantly increasing the likelihood that the line sensors will encounter faults of various types and conditions
- PG&E proposes continuing to monitor the vendor product industry, and if a significant product is introduced or modified; PG&E would like the ability to run that product through Phase I lab testing and promote it to the field during Phase II if all testing is confirmed

PG&E will only fund and undertake activities to the extent there is funding available within the existing approvals.

8. Selection of Feeders for Phase 2 Field Trials

As part of Phase 1, PG&E identified feeder location selection criteria and rationale for the Phase 2 field pilot. For Phase 2, project stakeholders will be consulted during feeder selection to ensure that piloting line sensor technology would not adversely impact PG&E's ability to deliver

safe, reliable, and affordable electrical service to customers served by the pilot feeders. Factors considered in selection of test feeders will include:

- A history of lower reliability relative to the rest of the system
- A location where line faults result in significant patrol time
- Feeders that have sufficient interaction cross over with other feeders to support rapid circuit reconfiguration (where customers receive their electric service from a secondary source)
- Feeders that have significant distributed energy resources
- Feeders with a representative sample of urban, suburban, rural
- Feeders with a representative sample of communications environments, particularly for application of SmartMeter™ communications.

9. Benefits Assessment

Line sensor benefit high level estimates were provided in AL 4227-E. Phase 1 testing and analysis did not uncover material new issues, relevant to costs or benefits, for the core value applications of improved reliability and optimized operation of distribution lines. Line sensors continue to promise the following potential direct benefits to customers:

- Increased System Reliability – Line sensors will assist in reducing the duration of customer outages by more granularly helping locate outages. Additionally, broad line sensor deployment would potentially improve customer power quality due to future line sensor device technological advances, providing information to assist in mitigating power quality disturbances.
- Reduced Cost of Outage Response – Line sensors seek to reduce costs associated with outage response. They assist in pinpointing outages to a smaller area on the distribution circuit therefore reducing overall patrol time. Line sensors potentially accomplish outage response better than existing solutions by complementing SmartMeter™ outage data. SmartMeter™ data is effective at scoping the extent of an outage, i.e. customers impacted, and verifies restoration to each customer but line sensor data has the potential to add information on where, within the outage area is the fault location. The Line sensors will communicate back to the distribution operations central authority for that distribution circuit to direct the field troubleshooter to a more defined area, reducing overall truck roll time. The field troubleshooter will be able to locate the problematic equipment sooner reducing hazard situations as well as the time needed to complete repair reducing customer outage duration. Additionally, the Line sensors can potentially provide real time loading information upon request to assist in real time switching operations in support of balancing line loads, as well as provide information for planning engineers to use in future planning activities. If successful, this loading information may also provide additional visibility into the real time operations of distributed energy resources, thus allowing grid operators better integration of the distributed energy resources on the grid. It is also believed that this real time loading capability may reduce

costs in operating the system as well as deferring capital upgrade costs by providing additional data about the performance of existing capital equipment.

Based on engineering analysis performed in the lab during Phase 1, PG&E has prepared demonstrations that confirm that line sensors have the potential to offer these System Reliability and Outage Response benefits. As a lab study in Phase 1, the benefits can only be modeled by simulation of real events. Phase 2 pilot deployments will provide real operational data and inform PG&E regarding all benefit elements. Cost and benefit models will be enhanced during the deployment and operation stages to capture improved detail regarding cost and benefit elements.

Advanced applications such as identifying pre-failure devices are new and are technically uncertain. Phase 2 will determine if present technologies can actually provide value and if so, Phase 2 will quantify the benefits.

10. Line Sensor Pilot Project Milestones and Timeline by Phases

Table 2 provides updated project phases milestones and expected timelines for the Line Sensor Pilot. The forecasted timeline for Phase 2 is 2014 through 2016 with the expected major milestones and durations as shown in Table 2:

Table 2: Project Milestones by Phase

Description of the Phases and Key Milestones/Deliverables	Start Date*	Completion Date*
Phase 1: July 2013 – January 2015		
• **Plan/Analyze:** benchmark WLS implementations, assess and select vendors for testing, negotiate testing contract	8/13/2013	5/30/2014
• **Critical solution testing:** setup and test critical features four WLS solutions at PG&E's ATS facility in San Ramon. Phase 1critical solution testing has verified that vendor solutions are ready to proceed to Phase 2	6/1/2014	11/05/2014
• **Continued analysis and testing of additional WLS functionality:** Additional non-critical Phase 1 analysis of vendor products and Phase 2 planning	11/05/14	January 2015 (est.)
• **Obtain CPUC approval to move to Phase 2**	11/25/2014	January 2015 (est.)

Phase 2 January 2015–December 2016		
• **Field installation:** Install field equipment, setup and commission WLS	January 2015 (est.)	5/31/2015
• **WLS IT infrastructure and software:** setup infrastructure, install WLS software, and integrate IT systems	January 2015 (est.)	9/1/2015
• **Benefits Measurement and Verification (M&V):** measure pilot and forecast system-wide benefits	5/31/2015	12/31/2016
• **Project Analysis, Closure, CPUC Advice Letter**	10/31/2016	12/31/2016

* Forecasted Dates

11. Line Sensor Pilot Project Costs — Detailed Budget and Expenditures

The Phase 1 project costs to date and the forecasted costs to complete the testing required to promote vendors to the field and to develop detailed plans and designs for the field demonstration are detailed in Table 3 below.

Table 3: Phase 1 Actual and Forecast Costs (figures are in thousands of $)

	2013	2014				2015	**Total***
		Q1	Q2	Q3	Q4	Q1	
Capital - Actual	$186	$318	$432	$792	$319		**$2,047**
Capital - Forecast					$804	$342	**$1,146**
Capital - Totals	$186	$318	$432	$792	$1,123	$342	**$3,193**

* Forecast

Phase 1 costs were forecast to be approximately $3.5 million. Therefore, PG&E is presently forecasting a favorable under-spend of approximately $0.3 million. This favorable under-spend is largely a timing variance, primarily due to expected IT expenditures for integration testing that will occur as part of the Phase 2 field deployment process in early 2015. PG&E expects to spend any carryover from Phase 1 on additional line sensors for field deployment in Phase 2.

12. Summary and Recommendation to Proceed to Phase 2

In summary, Phase 1 testing has demonstrated viable line sensor solutions that are ready for field deployment, and therefore PG&E recommends the Smart Grid Line Sensor Pilot Project move into Phase 2.

The plan as described in PG&E's advice letter AL 4227-E has been completed for Phase 1 testing and analysis as follows:

- Assessed line sensor products available in the market
- Reviewed associated visualization and analysis software relative to function, cyber security, standards and telecommunications
- Laboratory tested line sensors at the San Ramon test facilities
- Analyzed that sensors will be effective in improving reliability and reducing patrol time when deployed
- Completed benchmarking with major Investor-Owned Utilities
- Tested and evaluated measurement accuracies, software and system performance
- Determined devices are appropriate safe and practical to install and are expected to operate reliably in PG&E's service environment
- Documented test results in PG&E standard test reports

PG&E believes the understanding of the benefits potential for line sensors will be achieved by having the system in place with measurement and evaluation fully engaged throughout the summer of 2015 for a benchmark and then the subsequent seasons for further study and potential advanced functionality. It is critical that PG&E begin the Phase 2 activities no later than February 1, 2015, to ensure a timely ability to order, deploy, and install the equipment and systems necessary to capture Line Sensor Pilot results for the summer of 2015.

PG&E Gas and Electric
Advice Filing List
General Order 96-B, Section IV

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Clean Power
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