

PG&E Advanced Metering Assessment Report

Commissioned by the
California Public Utilities Commission

Prepared and Presented by Structure Consulting Group, LLC.





12335 Kingside, #401
Houston, TX 77024
Voice: 713.783.0500
Fax: 832.482.0871

September 2, 2010

Ms. Julie Fitch, Director
Energy Division
California Public Utilities Commission

Dear Ms. Fitch:

We are pleased to present our final report, "PG&E Advanced Metering Assessment", focused on Smart Meter accuracy and Customer High Bill Complaints as contracted for by the California Public Utilities Commission on April 1, 2010, and completed on September 2, 2010.

Sincerely,

Stacey Wood
Principal
The Structure Group



Structure Consulting Group Overview

Structure Consulting Group, LLC ("Structure"), is a global consulting firm focused exclusively on the energy and utility industry, providing services and technology solutions in North America and Europe. Since opening the doors in 1998, Structure has served over 100 organizations through all stages of business transformation, from the beginning of wholesale energy markets to the Smart Grid revolution.

Structure focuses in providing a spectrum of services across business advisory, program management, solution delivery and implementation, and performance improvements and was recognized as the Advisory Firm of the Year 2010 by Energy Risk Magazine.

Structure assists companies in implementing their Smart Grid initiatives through comprehensive strategy development, business case creation and refinement, vendor and system selection, program management, process re-engineering, system implementation, legacy system integration, and testing of components and/or end-to-end solutions.

The Structure workforce is comprised of diverse utility and energy professionals with extensive experience in the energy industry, as well as regulatory program development with NERC, FERC, and other compliance standards.

Structure specializes in key energy industry areas including Smart Grid/Distribution Operations/Distribution Automation, SCADA & Energy Management Systems, Energy Trading & Risk Management, and Competitive Energy Market Solutions.



Limitations

In connection with preparing this Report, Structure Consulting Group (“Structure”) examined reproductions of documents provided by Pacific Gas & Electric (“PG&E”) and the California Public Utilities Commission (“CPUC”). Structure relied upon the completeness and accuracy of all documents and other information requested by and provided to Structure, as well as such other records, agreements, test results, and documents requested from the CPUC and PG&E and deemed necessary or relevant as the basis for our Report. In such examinations, Structure assumed (i) the genuineness of all documents reviewed by Structure, (ii) the conformity of the copies received by Structure to the original documents, and (iii) the authenticity of the original documents. Structure further assumed that each of the parties to the documents and agreements reviewed by Structure had the full power, authority, and legal right under its governing documents, corporate legislation, and applicable laws and regulations to execute and perform its obligations under all documents executed by it. Structure assumed that the documents reviewed by Structure were free from any fraud or misrepresentation and the truth, as were the accuracy of representations and warranties in our interviews with PG&E employees and other representatives. This Report was based solely upon the information received by Structure from the CPUC, PG&E employees, PG&E Customers, PG&E vendors and representatives. Structure assumed that the information received was accurate and complete information and documentation.

Subject to the foregoing, Structure has conducted an independent assessment of the matters that Structure believes to be reasonably necessary to produce this Report. Structure was limited in scope and was not requested nor performed an exhaustive review of all Smart Meter system deployment documentations, configurations, and meter installations. Structure has used its reasonable efforts and impartial assessment to ensure the independence and accuracy of the facts contained in this Report.



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Executive Summary

A. Introduction

Pursuant to California Public Utilities Commission (“CPUC”) decisions D.06-07-027 and D.09-03-026, Pacific Gas and Electric (“PG&E”) was given approval for full deployment of an Advanced Meter Infrastructure (AMI) Project that included upgrading both metering and communications networks as well as the related computerized systems and software for 5.1 million electric meters and 4.2 million gas meters within the PG&E territory. PG&E’s AMI Project, subsequently named the SmartMeter™ Program, initiated meter deployment in 2007. During the first half of 2010, PG&E actively deployed Smart Meters at an average rate of 176,000 gas and electric meters per month. As of June 2010, 3,146,000 electric and 3,101,000 gas Smart Meters had been installed throughout PG&E’s service territory.

By the fall of 2009, the CPUC had received over 600 Smart Meter consumer complaints about “unexpectedly high” bills and allegations that the new electric Smart Meters were not accurately recording electric usage, almost all of which were from PG&E’s service area. The initial CPUC complaints were supplemented by complaints provided by Senators Dean Florez (D-Shafter) and Roy Ashburn (R-Bakersfield), identified during town hall meetings in Bakersfield and Fresno. In response to these complaints, the CPUC committed to conduct an independent review to determine whether PG&E’s Smart Meter system was correctly measuring and billing electric usage.

On April 1, 2010, the CPUC contracted with Structure Consulting Group LLC (“Structure”) to provide an independent report related to testing and validating meter and billing accuracy of PG&E’s residential electric Smart Meters. The five month evaluation, labeled the PG&E Advanced Metering Assessment Report and hereafter referred to as “The Assessment”, culminated in the production of this report, issued on September 2, 2010.

The Assessment focused on addressing residential electric Customer concerns that Smart Meters caused higher energy bills. The Assessment’s scope and objective was to independently assess whether PG&E’s electric Smart Meter system and related billing system had been measuring and calculating electric usage accurately, and billing PG&E Customers appropriately for their usage. The Assessment included meter testing, end-to-end system testing, an evaluation of high bill complaints, and an evaluation of PG&E’s Smart Meter deployment as compared to industry best practices.

Structure segregated The Assessment’s scope into the following areas:

Structure’s PG&E AMI Assessment Scope	
Area	Focus
Laboratory Meter Testing	Conducted to establish whether the meters used by PG&E tested accurately at a functional level and under normal and extreme environmental conditions.
Field Meter Testing	Involved testing Customer meters at their premises to determine Registration Accuracy within an established tolerance range. Customers were selected to provide a representative cross-section of PG&E’s population base, as applicable to the field testing scenarios.
End-to-End System Testing	Comprised of a combination of laboratory and field tests, to determine the effectiveness of PG&E SmartMeter and billing systems’ efficacy to capture meter data information.



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Structure’s PG&E AMI Assessment Scope	
Area	Focus
High Bill Complaint Analysis	Performed on a subset of the Customers identified as part of the High Bill Complaint population to determine trends in high bills associated with meter type, usage patterns, and billing issues. The Customer base for this analysis was drawn from complaints received by the CPUC, town hall meetings organized by state senators, and PG&E. Customer interviews were conducted from the High Bill Complaint group to evaluate the circumstances related to the complaint, PG&E’s handling of the complaint, and any associated resolutions.
Best Practices Associated with Smart Meters	Assessed across the energy industry to provide insight into Smart Meter operations compared to PG&E’s Smart Meter program.
Security Assessment	Performed a review of PG&E’s cyber security framework focused on PG&E’s Smart Meter system as part of the evaluation. The review was limited and conducted with a focus on the smart grid system utilizing the applicable sections of the “AMI System Security Requirements” developed by the Smart Grid industry’s OpenSG AMI-SEC Task Force. The security assessment was performed to determine whether controls were established and documented around industry-standard criteria.

Figure 1: Structure’s PG&E AMI Assessment Scope

Structure performed an impartial and independent evaluation, employing reasonable efforts to complete the engagement work agreed to by the CPUC within a reasonable timeframe, and with the understanding that supporting documentation and information was provided by the CPUC and PG&E on a timely basis.

Throughout the duration of the Assessment, Structure did not share the results or findings of the Assessment with PG&E, with the exception of results for a limited number of field meter tests that showed an out of tolerance or unable to test condition. This limited disclosure to PG&E was done independently of this report to allow PG&E the opportunity to promptly investigate the situation and take any mitigation measure at their discretion to minimize the impact on the Customer. The findings from this study were developed independently of the CPUC and PG&E with regards to previous or current litigation and or regulatory actions. While this report may be utilized by the CPUC to determine future requirements related to Smart Meters and the impact of Smart Meters on Customers, Structure’s obligation associated with this evaluation should be considered complete upon delivery of this report to the CPUC. Dissemination of the report and its contents will be at the discretion of the CPUC in accordance with applicable State of California regulations.

This Executive Summary should not be taken stand alone from the entirety of the report, and should be considered a culmination of information, facts, tests, explanations, and limitations described throughout the entirety of the report.



B. Summary of Key Findings

From April 1, 2010, to August 25, 2010, Structure reviewed relevant documentation related to PG&E's SmartMeter™ equipment, systems, and processes and compared it to industry standards, independently-performed customer interviews, and PG&E-provided vendor specifications and internal documentation. This evaluation principally consisted of an assessment of PG&E's accuracy and conformity to meter standards, analytical procedures applied to customer data, business processes, and practices. Due to the number of systems and process within the PG&E framework, this Assessment reflects Structure's opinion on only the scope of work which Structure was requested to perform.

The CPUC tasked Structure with addressing three broad questions related to PG&E's SmartMeter™ system, focusing on residential electric Customers. Working independently and with the facilitation of the CPUC, Structure's Assessment yielded the following findings related to CPUC's inquiries involving PG&E's residential electric SmartMeters™:

1. Does PG&E's SmartMeter™ system measure and bill electric usage accurately, both now and since PG&E's Smart Meter deployment began?

PRESENT: While Structure cannot ensure that all issues related to the SmartMeter™ program have been identified or that future issues may not develop at a later date due to process, controls, or technical modifications instituted after the completion of The Assessment, Structure's evaluation provides the reasonable conclusion that PG&E's SmartMeters™ are accurately recording electric usage within acceptable CPUC tolerances, and are being accurately utilized in Customer billing.

SINCE DEPLOYMENT: Although Structure was unable to test electromechanical and Smart Meters since PG&E's program began, Structure reviewed PG&E's SmartMeter™ program documentation issue logs, incident reports, and analysis of historical customer complaints and did not identify systemic issues in the measuring and billing of electric usage within PG&E's SmartMeter™ system for the deployment period prior to our Assessment beyond those that had already been previously reported to the CPUC. Identified exceptions related to meter and billing issues appeared to have been limited and did not appear to have been prevalent in the overall deployed Smart Meter population.

2. What factors contributed to Smart Meter high bill complaints?

High bill Customer complaint analysis took the form of scrutinizing PG&E's internal meter data processing activities, reviewing historical data provided by PG&E, and performing Customer interviews related to high bill complaints. Structure's Assessment identified multiple factors that appeared to contribute to the escalation of Smart Meter high bill complaints during late 2009 and early 2010, including:

- *Customer Usage:*
 - *Meter deployment schedules coincided with increased energy usage caused by a heat wave.*
 - *Some Customers experienced load changes that were reflective of changes in personal circumstances. Examples included room additions, pool additions, and equipment malfunctions.*
 - *Electromechanical meter degradation that was also identified as part of Structure's field meter testing.*
- *Rates:*



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- *Rate increases compounded the financial impact of the additional weather-related usage, resulting in higher bills that occurred as Smart Meters were being installed.*
 - *Incorrectly applied rates that were based upon historical premise assumptions.*
 - *Rate-based inquires that increased as Customer bills escalated. Requests for new or renewed financial assistance through California Alternate Rates for Energy (CARE) were identified as potential reductions of financial impacts related to higher bills.*
 - **Customer Service:**
 - *PG&E processes did not address the Customer concerns associated with the new equipment and usage changes.*
 - *Customer skepticism regarding the new advanced meter technology was not effectively addressed by PG&E on a timely basis.*
 - *Customers interviewed during this assessment did not consider their complaint resolved, despite indications from PG&E and CPUC that the Customer agreed with the resolution*
 - *PG&E Customer complaint resolution did not provide of interval read information available with Smart Meters, which may have assisted Customers' understanding of hourly usage patterns.*
 - **Process Issues:**
 - *Customers indicated that communications/notifications surrounding physical meter installation were lacking, or that the Customer had issues with the installation personnel.*
 - *PG&E utilized field meter readers for an average of 131 days after Smart Meters were installed, resulting in similar meter reading errors as electromechanical meters. The transition to automate the Smart Meter data for use in billing was not clearly addressed with Customers.*
 - *PG&E's system tolerances related to billing quality control were not stringent enough, resulting in multiple bill cancelations and re-billings, which were confusing to Customers.*
3. *How does PG&E's SmartMeter™ Program's past and current operational and deployment compare against the framework of industry best practices?*

Structure found PG&E to have been historically in compliance, or have recently come into compliance, with the majority of Best Practices Associated with Smart Meters. Structure identified several items of partial or non-compliance related to industry best practices during The Assessment, which have been recognized by PG&E through their presentations of information as shortcomings to be addressed:

- a. *The lack of documentation verifying compliance with the Meter Deployment best practice to deploy WAN/LAN collectors prior to meter deployment.*
 - i. *By not deploying the communication backbone prior to meter deployment, the time to transition meter reading from manual to Advanced Metering Infrastructure (AMI) system readings is exacerbated, extending to an average of 131 days over the implementation period. This allows a continuation of the higher error rate associated with manual meter reading, and may contribute to the perception that the Smart Meters are inaccurate.*
- b. *The inability to verify compliance around:*



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- i. *The Meter Data Managements (MDMS) Interface best practice to correlate AMI meter events and alarms with Validation, Estimating and Editing (VEE) and Customer Information System (CIS) audits and checks for automated exception handling; and*
- ii. *The VEE Best Practice of MDMS must provide an on-line method, with workflow, resolving validation errors rather than reports.*

These lapses have created a situation where data required manual editing, causing cancel/re-bills and delayed processing of Customer data in a relatively small portion of the bills processed. The cancel/re-bills and delayed processing potentially increased the days within a billing cycle presented in Customer's bills, as reflected in a portion of the High Bill complaints, and furthered Customer perception that Smart Meters may not have been accurate.

Based upon Structure's review of requested PG&E documentation and Structure's associated testing, Structure determined that previously-identified issues brought to CPUC's attention were being appropriately addressed by PG&E. Structure's testing did not uncover issues that would challenge that PG&E's Smart Meters were accurately measuring and recording electric usage, or that PG&E's internal systems were accurately utilizing this data for billing purposes. Structure identified no relevant correlation between installed Smart Meters, impacts to billing on installed Smart Meters, and residential Customer Smart Meter high bill complaints. Structure did identify certain events and circumstances, including sub-optimal Customer service and variable implementations of industry best practices that contributed to the increase in Smart Meter high bill complaints. The concerns uncovered should be addressed, but did not appear to be related to the ability of PG&E's Smart Meter System to measure and bill electric usage correctly.

Overall, Structure found that the AMI technology deployed by PG&E appears to be 1) consistent with industry standards, based upon the goals of the AMI implementation and upgrades approved by the CPUC, and 2) accurate from a metering and billing perspective. Structure identified gaps in Customer services and processes related to high bill complaints, and determined certain PG&E practices to be partially non-compliant relative to industry best practices.

The following Figure provides a high-level summary of Structure's findings for each of the PG&E AMI Assessment's areas of focus.



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Structure's PG&E AMI Assessment Findings Summary	
Area	Finding
Laboratory Meter Testing	All of the Smart Meters tested in Structure's independent laboratory passed the accuracy testing. The Smart Meters subjected to environmental stress testing in a controlled temperature chamber at reference, high, and low temperatures all fell within the American National Standards Institute (ANSI) standards.
Field Meter Testing	<ul style="list-style-type: none"> • Structure's Pass/Fail Criteria was based upon the CPUC Standard of $\pm 2.0\%$ for electromechanical meters and Smart Meters. • Of the 613 Smart Meter field tests, 611 meters were successfully tested and 100% passed Average Registration Accuracy. One meter was found to have serious errors and be malfunctioning on arrival, and one was found to have serious event errors upon installation; these meters were therefore excluded from testing. • Of the 147 completed electromechanical meter field tests, 141 meters passed and 6 failed Average Registration Accuracy. One meter was found to be non-functional, registering zero on all tests, and was therefore excluded from testing.
End-to-End System Testing	By utilizing a representative, small sample size to confirm meter-to-bill system accuracy, Structure did not identify deviations during testing that indicated a systemic problem in the meter billing system's accuracy.
High Bill Complaint Analysis	After reviewing and analyzing over 1,378 High Bill complaints, Structure did not identify pervasive issues with meter data or billing systems. Results from 20 High Bill Complaint Customer interviews identified service issues around complaint management by PG&E and the CPUC.
Best Practices Associated with Smart Meters	Structure found PG&E to have been historically in compliance, or have recently come into compliance, with the majority of industry best practices associated with Smart Meters. Structure identified several items of some concern during the Assessment, which have been recognized by PG&E, through their presentation of information, as shortcomings to be addressed.
Security Assessment	Structure concluded that PG&E has developed a cyber security framework that meets the objectives established in the Smart Grid industry's OpenSG AMI-SEC Task Force "AMI System Security Requirements" that were reviewed as part of this evaluation.

Figure 2: Structure's PG&E AMI Assessment Findings Summary



C. Work Scope

Structure's evaluation focused primarily on evaluating meter accuracy and advanced metering system capabilities to accurately determine and bill Customer electric usage for PG&E's residential electric Smart Meter installations. Structure also evaluated PG&E's Smart Meter system deployment current and historical business practices against industry best practices and standards and assessed PG&E's AMI security framework. The Assessment also included addressing the influx of high bill complaints that were perceived by Customers as being Smart Meter-related. Historical meter accuracy and associated meter replacement firmware upgrades were not tested as part of the scope of this engagement, as Structure was not able to evaluate the meters at the time that those complaints were initiated.

During project planning and initiation, PG&E provided a system overview that included previous meter testing performed, meter reading and billing transition scheduling, and high bill complaints received. Based upon the overview provided, Structure consulted with the CPUC to increase the meter accuracy testing and associated Customer complaint analysis on PG&E's electric Customers as part of The Assessment. Structure worked with the CPUC to modify the project scope to better evaluate PG&E's AMI systems based upon data availability, budget constraints, and the available timeframe. Some scope modifications resulted from additional efforts required to complete the proposed work, as discussed in the Scope of Work section of this report.

During the course of The Assessment that spanned April to August of 2010, Structure independently tested over 750 Smart Meters and 147 electromechanical meters. Structure also reviewed the 1,378 electric Smart Meter Customer accounts from a PG&E provided list of 2,915 Smart Meter electric and gas high bill-based complaints. Structure requested that PG&E provide a detailed explanation of 73 accounts where Structure identified billing data anomalies that could not be attributed to the Customer's usage profile. Structure also attempted to contact over 100 of the high-bill complaint Customers, resulting in 20 high-bill complaint phone interviews. Structure reviewed the accounts of each of the interviews with PG&E's complaint resolution team for further analysis.

Throughout the evaluation, less than a 1,000 pages of double sided hard-copy sheets were transmitted in consideration of California's green initiatives. Approximately 6GB of zipped compressed data in the form of 1,600 documents was provided by PG&E, which contained approximately 27,000 pages or slides and 2,000 worksheets. Structure electronically pulled 2.4 million sample Customer stratifications from over 5.2 million Customer meter locations.

During the course of the project, Structure reviewed manufacturer specifications, procedures, and relevant data associated with meter manufacturers, communication network, and meter data management and billing systems. Structure also held interviews with PG&E vendors and performed site visits to PG&E and vendor facilities to observe processes and procedures. Detailed methodology, procedures, test results, and identified issues can be found in the appropriate sections of this Assessment.

Structure's work included meetings and interviews with PG&E resources and subject matter experts and Customers to obtain insight and information relevant to our evaluation. Structure also maintained a call center associated with the field meter testing that allowed Customers to address questions associated with the evaluation meter testing. In addition, a meeting was held with the TURN consumer advocacy group at their request. As part of the assessment, Structure reviewed documents and held over numerous interviews with PG&E personnel, focused on process and methodology. Additional time was spent with PG&E security personnel to conduct the security assessment.

The number of meter tests and customer interviews performed was based upon cost/benefit analysis conducted by Structure in conjunction with the CPUC at various points throughout the project. The sample



sizes selected were determined to provide a reasonable representation of the PG&E meter and high bill complaint populations based upon the CPUC-requested scope of work.

The project scope was divided into the following areas:

- Laboratory Meter Testing
- Field Meter Testing
- End-to-End System Testing
- High Bill Complaint Analysis
- Best Practices Associated with Smart Meters
- Security Assessment

From the initial RFP response throughout the project, Structure contracted for the services of Trimark Associates (“Trimark”). Trimark’s credentials included certification as a Meter Service Provider (MSP) in California by the CPUC. Trimark has provided metering and meter data management services for over nine years within California and throughout North America. The synergy between the two companies allowed Structure to utilize Trimark as a dedicated contractor to perform the meter-based field and laboratory testing defined throughout this report. As the sole contractor to Structure for this Assessment, further reference to Trimark work within this report may be included under the Structure reference.

The following sections provide scope overviews associated with each of the key project areas.

C.1 Laboratory Meter Testing

Laboratory meter testing was performed in a qualified, non-PG&E laboratory located within the PG&E territory and overseen by Structure resources. Structure verified meter accuracy and factory programming laboratory tests on a representative meter sample set obtained from PG&E’s warehouse facilities. Structure allocated a portion of the sample set meters for end-to-end and environmental testing, and the remainder for installation at residential Customer premises.

Structure utilized a subset of the PG&E warehouse randomly selected meters to perform environmental testing in the laboratory, where the meters were subjected to temperature-based stress tests. An additional set of meters were used for end-to-end system testing to monitor meter activity from installation through billing. The tests are highlighted in the following Figure, Summary of Structure’s Test Scenarios, Scenarios 1 and 2.

Summary of Structure’s Test Scenarios		
Location of Test	Scenario	Description
Laboratory	Scenario 1	Environmental and End-to-End Smart Meter Laboratory Test
Laboratory	Scenario 2	Warehouse Stock Smart Meter Accuracy Laboratory Test
Field	Scenario 3	Electromechanical Meter Test & Smart Meter Field Replacement
Field	Scenario 4	Non-High Bill Complaint Smart Meter Field Test
Field	Scenario 5	High Bill Complaint Smart Meter Field Test
Field	Scenario 6	High Bill Complaint Shadow Meter Field Test
Field	Scenario 7	Non-High Bill Complaint Electromechanical Meter Field Test
Field	Scenario 8	High Bill Complaint PG&E Installed Shadow Meter Test Verification

Figure 3: Summary of Structure’s Test Scenarios



The laboratory and field test scenarios were developed as a representative set of tests normally used by utility companies to determine compliance to Public Utility Commission accuracy standards based on ANSI Standard C12.20.

C.2 Field Meter Testing

The Assessment's field meter testing utilized the Standards for Meter Installation, Maintenance, Testing and Calibration as set forth in the Direct Access Standards for Metering and Meter Data (DASMMMD) and American National Standards Institute (ANSI) standards to verify the accuracy associated with PG&E's Smart Meters. Structure also performed field testing on a sample of electromechanical meters installed at electric residential Customer locations in order to confirm meter accuracy. The guidelines for testing were based on DASMMMD standards that were established in 1998, which provided for electromechanical meters and did not include updates applicable to Smart Meter systems. Meter accuracy was monitored based upon the DASMMMD requirements. Based upon discussion with CPUC, the DASMMMD standards were the established regulatory guidelines to be followed. The PG&E and manufacturer comparisons were utilized for reference purposes only.

Field meter testing was conducted using six scenarios that were identified by Structure to test both the electromechanical and Smart Meters in the field and evaluate both the accuracy of Customers' electromechanical and Smart Meters and the associated procedures. The conducted tests are summarized in Figure 3, Scenario 3 through Scenario 8. Customers whose meters were selected for testing were contacted by mail and/or by a Structure representative to describe the process and test coordination.

Each of the field testing scenarios was conducted by Structure and accompanied by PG&E's meter technicians, and followed industry-standard established procedures as described in this report and associated documentation. All meter testing was performed by Structure technicians for Scenarios 3-7; in Scenario 8, Structure observed PG&E's field processes for shadow meter tests. The field meter testing included:

- Site verification
- Meter type and form factor verification
- Proper installation
- Meter program and accuracy verification

Field-based testing focused on residential meters; thus, testing of commercial meters was excluded from the scope and the test scenarios.

C.3 End-to-End System Testing

End-to-End System Testing included both laboratory and field testing.

End-to-End laboratory testing was performed on five PG&E Smart meters, with five Elster™ digital meters used as "shadow" meters. Each of these meter pairs were subjected to a different amount of load, reflecting measurement at various rate tiers over the test period. In addition, the end-to-end "shadow" meters were also subjected to common exceptions to normal conditions, including power outages, voltage swells, voltage sags, and loss of Radio Frequency reception. Inclusion of common exceptions facilitated testing PG&E's capability to perform validation, editing, and estimation (VEE) processes in compliance with CPUC rules, and without introducing errors into Customer bills.

“Proxy” Customer accounts were created within PG&E’s billing system for each of the end-to-end meters, giving Structure the ability to determine PG&E’s application of billing determinants and rate assignments, as well as the accuracy and the timeliness of physical bill issuance to residential electric Customers. The end-to-end test process was designed for completion over the course of one PG&E billing cycle.

End-to-End field testing utilized the field testing shadow meter installations for selected High Bill Complaint Customers as part of field meter testing Scenario 6. The field testing shadow meter setup used the existing installed PG&E Smart Meter and an Elster digital shadow meter installed side-by-side to measure the Customer’s usage simultaneously through both meters. Structure also utilized these same installations to verify the flow of meter usage and event data from the Customer premise, through the AMI and Billing systems, to the Customer’s receipt of the printed bill.

A PG&E-provided representation of PG&E’s metering and billing system connectivity is found in the Figure below. The information tested in end-to-end system testing was processed through these systems.

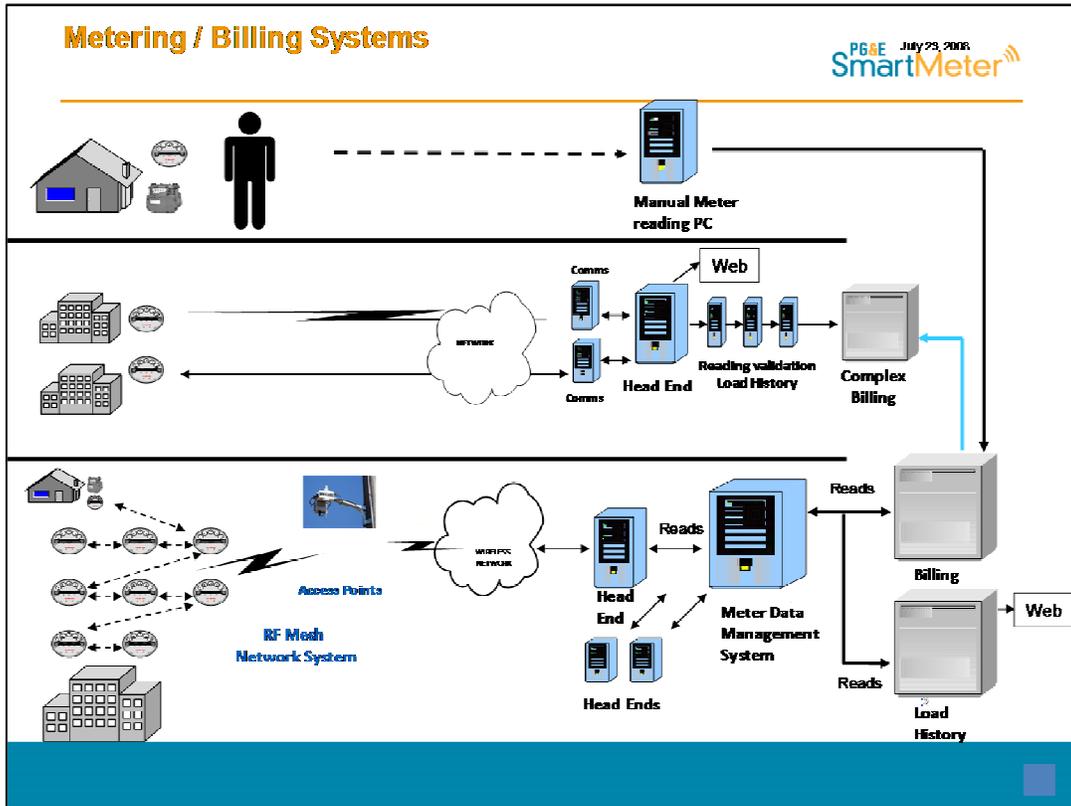


Figure 4: PG&E-Provided Representation of PG&E's Metering/Billing Systems Connectivity

C.4 High Bill Complaint Analysis

To perform the High Bill Complaint Analysis, Structure examined the entire population of 1,378 Smart Meter electric high bill complaints consisting of those officially filed with the CPUC, those provided by the office of Senate Majority Leader Dean Florez (D-Shafter), and Smart Meter High Bill Complaints specifically identified



and provided by PG&E for the period September 17, 2007 to April 30, 2010. Structure further refined the High Bill complaint list to focus on determining the underlying nature of the complaint by utilizing account information and reviewing detailed historical usage for 1,066 of the Customer complaint accounts with available historical usage data specifically related to residential electric Smart Meters. The detailed analysis of 1,066 accounts was done by evaluating the High Bill Complaint Customers' usage patterns and account specific information prior to and after Smart Meter installation to identify impacts of weather, extended bill cycles, cancel/re-bills, estimated meter reads, and usage spikes on Customer complaints.

A targeted selection of 73 Customer complaints was chosen based on account activity that suggested the potential for identifying underlying system or process issues, and was further analyzed to identify contributing factors for the complaints. The analysis on the 73 complaints included a detailed review of complaint resolution documentation, usage analysis, complaint history, account history, and Customer Service and Customer interaction notes. Structure utilized the 73 complaints reviewed and an additional 27 complaints with similar profiles to contact Customers for potential interviews. Of the 100 potential Customer interview participants, 20 agreed to participate in one-on-one interviews focused on documenting Customer rationale when initiating the complaint process, the Customer's experiences, premise conditions, energy usage, and the Customer's insight into the subsequent PG&E resolution process. Structure followed the 20 Customer interviews with an examination of each of their accounts with the PG&E Escalated Complaints team, to better understand the PG&E processes followed and the PG&E outcome of the Customer complaint.

Structure also specifically reviewed Customer usage and resolution status associated with 231 of 300 Bakersfield and Fresno electric Smart Meter town hall complaints, including the underlying analysis performed by PG&E and the associated resolution process for these accounts.

C.5 Best Practices Associated with Smart Meters

To evaluate Best Practices, Structure reviewed PG&E's documentation of past and current operational and deployment policies, processes, and procedures against a framework of industry best practices. The framework was developed by Structure subject matter experts with combined electric and gas field, operations, and billing experience of over 75 years, and presented to three independent Smart Meter industry experts for review and input. Structure compiled the contributions of these experts, applied it to the framework, and compared PG&E's policies, processes, and procedures against the established framework.

The Best Practices work included review of eight key areas associated with Smart Meters:

- Meter manufacturing quality control
- Meter installation standards
- Meter equipment safety
- Meter deployment
- Meter Data Management interfaces
- Validating, Estimating and Editing for monthly and interval data
- Account billing
- High bill complaint troubleshooting

The Best Practice analysis also identified business process improvements initiated by PG&E since January 2010 to enhance meter accuracy and increase customer satisfaction. Inclusion of the improvements was intended to document PG&E's efforts to align with industry Best Practices associated with Smart Meters.



Best Practices included in this report are reflective of the current industry environment for the areas addressed, as provided by Structure and industry experts retained by Structure. The views and opinions expressed in The Assessment may not reflect the views or opinions of all industry experts, and may change as Smart Meter systems continue to mature.

C.6 Security Assessment

Structure performed a review of PG&E's cyber security framework focused on the smart grid system as part of The Assessment. The review was limited based on priority, time, and budget, and was conducted with a focus on the smart grid system, utilizing the applicable sections of the "AMI System Security Requirements" developed by the Smart Grid industry's OpenSG AMI-SEC Task Force. The security assessment was performed to provide a confirmation that controls were established and documented around:

- Corporate Cyber Security Approach
- Confidentiality and Privacy
- Data and System Integrity
- System Availability
- Identification and Authentication of Users
- Authorization of Users
- Accounting and Non-Repudiation
- Anomaly Detection Services
- Boundary Services and Interfaces
- Cryptographic Services
- Resource Management Services
- Development Rigor
- Organization Rigor
- Handling and Operating Rigor
- Accountability

Per The Assessment's scope, Structure utilized several methods to perform the review, including interviews and documentation reviews of PG&E policies and procedures, referred to as a "paper" review of PG&E's security framework. The review included interviews with key PG&E personnel tasked with managing security, inspection of relevant PG&E documents, and review of third-party audit reports where applicable and available. The information obtained through these methods was then compared against the applicable sections of the "AMI System Security Requirements" standards developed by the Smart Grid industry's OpenSG AMI-SEC Task Force. A comparison to cyber security "best practices" was also performed.

An in-depth qualitative assessment of PG&E's framework implementation was beyond the scope of this Assessment. An evaluation of this nature would have taken several months to evaluate each major sub-system within the Smart Grid system, as well as additional time to evaluate the implementation within PG&E's security framework. An in-depth review would involve reviewing firewall rules, system configurations, user permissions, training, background checks, etc.



D. Detailed Summary of Observations and Findings

The following summary of Structure's findings reflects the results of The Assessment's testing and analysis. Structure found the summarized results to be representative of the overall PG&E AMI program; however, due to the accelerated nature of the engagement, Structure's Assessment was limited its ability to express an opinion on all of the AMI processes and procedures used at PG&E. Accordingly, the results should be taken in the context of the data reviewed.

D.1 Laboratory Meter Testing

D.1.1 Laboratory Meter Testing Findings Summary

Structure utilized a laboratory testing facility that was independent from PG&E to conduct tests for meter accuracy, environmental stresses, and end-to-end system functionality. Structure selected 174 Smart Meters from PG&E's warehouses using a randomized selection process based on representative vendor and meter type criteria, and then tested the meters for accuracy in the independent laboratory. All of the tested Smart Meters passed the accuracy testing. Structure then utilized a portion of the selected Smart Meters for environmental stress testing, and found all of the meters to fall within the American National Standards Institute (ANSI) standards when tested in a controlled temperature chamber at reference, high, and low temperatures.

D.1.2 Laboratory Meter Testing Findings Details

Structure set aside 18 of the 174 meters selected from the warehouses as "spares", and conducted laboratory-based accuracy tests on the remaining 156 stock PG&E Smart Meters selected from the five randomly selected PG&E warehouses. The sample set consisted of a range of meter types and meter manufacturers representing a representative sample of meters available in the PG&E in-stock inventory, which were procured using a random meter selection methodology.

The Results of the Laboratory Accuracy Tests were:

- 100% of the 156 PG&E stock Smart Meters tested were within an accuracy range of 99.81% to 100.15%, with an average accuracy of 100.01% and a standard deviation of 0.0408%.
- The meters passed the $\pm 0.2\%$ acceptable accuracy standard established by the meter manufacturer, which also satisfied the CPUC accuracy requirement of $\pm 2.0\%$.

Following an initial test to verify the accuracy of the meters at full load, light load, and with a 50% power factor in accordance with ANSI standards, a subset of these meters were used in Structure's laboratory and field test scenarios.

Environmental testing consisted of subjecting six of the PG&E Smart Meters to extreme hot and cold conditions in a controlled environmental chamber designed to accurately replicate these conditions in accordance with ANSI C12.20 specifications. The meters were placed into the environmental chamber for 24 hours and allowed to reach "equilibrium". The temperature was then adjusted, and the test performed.

The summary findings from the Environmental Laboratory Meter Tests were:

- When subjected to +50 degrees Celsius (+122 degrees Fahrenheit) for 24 hours, all of the meters tested within the $\pm 2\%$ CPUC standard; however, one out of the six meters did not conform to the ANSI C12.20 maximum deviation of $\pm 0.5\%$ from reference test temperature standard used by the meter



manufacturer. The non-conforming meter exceeded the allowed 0.5% deviation by 0.07% during the full load test. The non-conforming meter's deviation was slightly out of tolerance on the Full Load and Light Load test, but the meter passed the CPUC standard for accuracy when adjusted for Average Meter Registration Accuracy (Full Load Test + Light Load Test)/2.

- When subjected to -20 degrees Celsius (-4 degrees Fahrenheit) for 24 hours, all of the meters tested within the PG&E and CPUC criteria of $\pm 0.5\%$ and $\pm 2\%$, respectively. All of the meters passed the ANSI C12.20 maximum deviation of $\pm 0.5\%$ from the reference test temperature standard used by the meter manufacturer.

D.2 Field Meter Testing

D.2.1 Field Meter Testing Findings Summary

Structure conducted field tests on 797 meters using defined procedures and protocols for each of the following six scenarios:

- Scenario 3: Electromechanical Meter Test and Smart Meter Field Replacement
- Scenario 4: Non-High Bill Complaint Smart Meter Field Test
- Scenario 5: High Bill Complaint Smart Meter Field Test
- Scenario 6: High Bill Complaint Shadow Meter Field Test
- Scenario 7: Non-High Bill Complaint Electromechanical Meter Field Test
- Scenario 8: High Bill Complaint PG&E-Installed Shadow Meter Test Verification

Structure's field tests measured accuracy of the meters at full load, light load, and with an applied power factor. The results were tracked to acceptance levels for the CPUC ($\pm 2\%$ for both Smart Meters and electromechanical meters), PG&E ($\pm 0.5\%$ for Smart Meters, $\pm 2\%$ for electromechanical meters), and the manufacturer ($\pm 0.2\%$ for Smart Meters, $\pm 2\%$ for electromechanical meters). Structure's Pass/Fail criterion used in this report was based upon the CPUC standard of $\pm 2.0\%$ for electromechanical meters and Smart Meters.

Structure attempted 897 field meter tests and completed 797 field meter tests, including both Smart Meters and electromechanical meters. Structure was unable to complete the remaining 100 meters due to normal reasons, such as meter banks on apartment buildings preventing the installation of the dual socket required for testing and meters locations that required extension ladders for access. Overall, a statistically valid, randomized sample of Smart Meters representing the entire installed base of Smart Meters in the P&GE territory was found to pass accuracy reading. Using the CPUC pass/fail criterion of $\pm 2.0\%$, 611 of the 613 Smart Meter field tests were completed, with 100% passing CPUC registration accuracy readings. Two Smart Meters were found to have serious errors and be malfunctioning. One meter was found to have serious errors and be malfunctioning on arrival, and one was found to have serious event errors upon installation; these meters were therefore excluded from testing. The Average Registration Accuracy of the 611 meters tested was 100.067%, with a Standard Deviation of 0.271%. Of the 147 completed electromechanical meter field tests, 141 meters, or 95.92%, passed and 6, or 4.08%, failed accuracy readings.

Structure identified one meter that was registering a zero read during the field meter testing. After further examination of PG&E's issue logs, the error was identified as a "data storage" issue. These data storage issues had been identified by PG&E in 12,735 meters as of May 2010, potentially resulting in a subset of Customers receiving zero usage or lower estimated bills. Data storage issues are one type of exception disclosed by PG&E, and may include:

- Negative intervals



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- Large intervals
- Zero table
- Negative register readings
- Table resets

Structure noted that these data storage issues were identified in early October 2009, with replacements starting in May 2010. These errors were disclosed to the public and to the CPUC in May 2010. PG&E subsequently initiated processes to address these issues in a timely and effective manner. As of July 2010, the outstanding data storage issues had been reduced to 1,526 meters.

The following Figure illustrates the number of meters that passed and failed the accuracy test for all of the Structure Field Meter Testing Scenarios, delineated by electromechanical meter tests in blue, and Smart Meter tests in yellow. The field testing scenarios were referred to as “High Bill Complaint” and “Non-High Bill Complaint” populations. The High Bill Complaint population was derived from complaints received directly by the CPUC or PG&E and those received at the town hall meetings organized by state senators. Non-High Bill Complaint refers to Customers who had not filed a high bill complaint through one of these channels.

Pass/Fail Results of Structure Field Meter Accuracy Tests by Scenario			
Scenario	Total Meters	Pass	Fail
3: Replace Electromechanical Meter with Smart Meter – Electromechanical Meter Test	47	41	6
3: Replace Electromechanical Meter with Smart Meter – Smart Meter Test	44	44	0
4: Smart Meters (Non-Complaint)	531	531	0
5: Smart Meters (High Bill Complaint)	36	36	0
6: <i>Shadow Meters (High Bill Complaint, Structure)</i>	19	N/A-S	N/A-S
7: Test Electromechanical Meter	100	100	0
8: <i>Shadow Meters (High Bill Complaint, Structure-PG&E)</i>	18	N/A-S	N/A-S
Total of all Field-Tested Meters	795	752	6
Total - Smart Meters	611	611	0
Total - Electromechanical Meters	147	141	6
Percentage of Total Smart Meters Tested	-	100.00%	0.00%
Percentage of Total Electromechanical Meters Tested	-	95.92%	4.08%

Figure 5: Structure’s Field Meter Testing Pass/Fail Accuracy Results by Field Test Scenario

N/A–S: Not Applicable–Shadow Meter

Of the 613 completed Smart Meter field tests, 611 meters were successfully tested and 100% passed Average Registration Accuracy. One meter was found to have serious errors and be malfunctioning on arrival, and one was found to have serious event errors upon installation; these meters were therefore excluded from testing.



D.2.2 Field Meter Testing Findings Details

A description of Structure's field testing scenarios and summary of the scenario-based testing results are presented in the following Figure. The field testing scenarios were referred to as "High Bill Complaint" and "Non-High Bill Complaint" populations. The High Bill Complaint population was derived from complaints received directly by the CPUC or PG&E and those received at the town hall meetings organized by state senators. Non-High Bill Complaint refers to Customers who had not filed a high bill complaint through one of these channels. Average registration accuracy is calculated using the equation $(\text{Light Load Test} + \text{Full Load Test})/2$ and refers to the average accuracy of a "register," which maintains a measure of the total power consumption that passed through the meter over time.

Each of the following scenarios was performed independently of each other, and involved a unique Customer premise.



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Structure Field Testing Scenarios and Results			
Scenario	Description	Synopsis	Results
Scenario 3	Electromechanical Meter Test & Smart Meter Field Replacement	Structure used a representative sample of 50 Customers that were scheduled to have their electromechanical meter replaced by PG&E. The electromechanical meters were removed and accuracy tested in the field at full load, light load, and 50% power factor. A laboratory-tested Smart Meter was then accuracy-tested in the field before being installed in the Customer's premise. The results of each of these tests were recorded by the Structure contractor. 47 successful electromechanical meter tests and 44 successful Smart Meter tests were conducted for this Scenario. The difference in number of electromechanical tests and Smart Meter tests was due to 6 electromechanical meters that failed. These meters subsequently did not receive a Smart Meter installation at the time of the test; therefore, Structure did not conduct a Smart Meter test at that premise.	<ul style="list-style-type: none"> • One Smart Meter was found to have a serious event error and be malfunctioning upon installation, and was therefore excluded from testing. • 100% of the 44 tested Smart Meters used for this scenario passed CPUC's accuracy testing acceptance standard of $\pm 2.0\%$ in the field test. • Field test results of 44 of the previously laboratory-tested Smart Meters indicated an Average Registration Accuracy of 100.27% during the field tests with a standard deviation of 0.112%. • One electromechanical meter was not found to be functional, registering zero on all tests; and was therefore excluded from testing. • 41 of 47 tested electromechanical meters passed the CPUC's accuracy testing standard of $\pm 2.0\%$ in the field test. • Six of the 47 tested electromechanical meters failed the CPUC Accuracy Standard of $\pm 2.0\%$, with one failing the Full Load and Power Factor tests, one failing the Light Load test, one failing the Power Factor test, and three meters failing the Light Load and Power Factor standard tests. • Two of the six electromechanical meter failures failed the Average Registration Accuracy standard. All field-tested electromechanical meters that were replaced with Smart Meters were returned to PG&E with an indication of whether or not they passed the field test. • The 47 tested electromechanical meters had an Average Registration Accuracy of 99.556%, with a Standard Deviation of 1.343% for the successful tests.



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Structure Field Testing Scenarios and Results			
Scenario	Description	Synopsis	Results
Scenario 4	Non-High Bill Complaint Smart Meter Field Test	A representative sample of 532 Smart Meters was chosen from the population of PG&E Customers where a Smart Meter had previously been installed by PG&E and the Customers were not in the High Bill Complaint list. These meters were removed from the Customer's meter socket and placed in a calibrated field test set on-site at the Customer's premise, where the meters were then accuracy-tested at full load, light load and a 50% power factor. In addition, the existing internal meter program was verified to confirm proper functionality.	<ul style="list-style-type: none"> One Smart Meter (of the 532) was found to have a serious event error and was malfunctioning, and was thus excluded from testing. The communication module on this device was functional and had been reporting zero usage for almost six months. 100% of the 531 tested meters tested within the CPUC accuracy standard of $\pm 2.0\%$. Average Registration Accuracy ranged from 98.345 % to 100.78% with an average of 100.075% and a standard deviation of 0.275%.
Scenario 5	High Bill Complaint Smart Meter Field Test	Structure selected 50 Smart Meter installations from the High Bill Complaint population to verify that the meter was properly installed and to field test the registration accuracy of the installed Smart Meter. 36 Smart Meter tests were conducted for this Scenario. At each location, the Smart Meter was removed and installed in a calibrated field test set, where the meter was accuracy tested at full load, light load and a 50% power factor. In addition, the existing internal meter program was verified as functioning properly.	<ul style="list-style-type: none"> All 36 Smart Meters tested passed the CPUC acceptance standard of $\pm 2.0\%$. The Average Registration Accuracy for the Scenario 5 meters was 100.004%, with a Standard Deviation of 0.351%.
Scenario 6	High Bill Complaint Shadow Meter Field Test	Structure selected 20 locations from the High Bill Complaint population to install a Field Shadow Meter setup, and completed tests at 19 locations. The Field Shadow meter setup consisted of the existing installed PG&E Smart Meter and an Elster digital Shadow meter installed side-by-side to measure the Customer's usage simultaneously through both meters. These meters were used to establish the accuracy of the Customer meters already installed by performing a weekly accuracy check and comparing the readings from the two meters. In addition to verifying Smart Meter accuracy, these installations were also used to verify the end-to-end accuracy thru the PG&E AML system to the customer bill.	<ul style="list-style-type: none"> The results of the 19 shadow meter tests showed that the shadow meter reads were in concert with the Smart Meter reads. The bills from both the lab-tested shadow meters and the field-tested shadow meters matched the expected results from manual bill calculations. Structure encountered four unauthorized PG&E meter swaps/meter tests during the execution of this scenario, as noted in the "Unauthorized PG&E Meter Swaps" section of this report, and in Appendix F: Unauthorized Scenario 6 Meter Swaps Exhibitions. These meters were subsequently not tested by Structure in the field, but were retrieved from PG&E and evaluated in the laboratory with no noted issues. Structure selected additional accounts to test in lieu of the meters excluded from test sample due to the unauthorized meter swap.



Structure Field Testing Scenarios and Results			
Scenario	Description	Synopsis	Results
Scenario 7	Non-High Bill Complaint Electromechanical Meter Field Test	Structure used a representative sample of 100 installed PG&E electromechanical meters to verify the accuracy of these meters in the field. The meters were removed from the customer installation and placed in a calibrated field test set to verify their accuracy at full load, light load, and at a 50% power factor.	<ul style="list-style-type: none"> Scenario 7's test included 100 installed PG&E electromechanical meters, with no failures on the CPUC Standard of $\pm 2.0\%$. The 100 meters had an Average Meter Registration Accuracy of 99.798% with a Standard Deviation of 0.528%. The minimum Registration across all tests (Full Load, Power Factor, and Light Load) was 98.1%, and the maximum registration across all tests was 101.95%.
Scenario 8	High Bill Complaint PG&E Installed Shadow Meter Test Verification	Structure accompanied PG&E Meter personnel during the installation of 18 shadow meter tests performed by PG&E. These installations consisted of the installation of a side-by-side electromechanical meter and Smart Meter at the site of Structure-selected High Bill Complaint Customer's premises. Structure reviewed PG&E's installation practices to determine if they were in line with documented installation, testing and meter reading procedures and to determine if PG&E followed their documented practices and procedures.	<ul style="list-style-type: none"> Of the 27 meters selected for Scenario 8, 18 were successfully completed with no identified deviations, and nine were unable to be completed due to premise restrictions and meter installation routing schedules. In all test cases, PG&E complied with internally documented practices and procedures for the shadow test verification.

Figure 6: Structure's Field Meter Testing Summary of Results

D.3 End-to-End System Testing

D.3.1 End-to-End System Testing Findings Summary

End-to-end system testing was used to verify the accuracy of the PG&E Smart Meters, data communications and associated systems, estimation routines, and the customer billing system, including bill printing. A laboratory end-to-end test scenario was used to simulate system exception handling in a controlled environment, including the addition of a meter access point that served as the collection point for the meter information that was sent back to PG&E.

End-to-End laboratory testing was performed on five PG&E Smart Meters, with five Elster digital meters used as parallel, side-by-side measurement, referred to in this Assessment as "shadow" meters. These end-to-end laboratory tests involved creating a proxy Customer account, installing a Smart Meter for this account and an electronic meter side-by-side to shadow the account's usage, and conducting tests from the time of installation through to receiving a bill. Structure established shadow meter test boards and conditions in the independent laboratory for use in the end-to-end system testing, to determine whether the Smart Meters were accurately



measuring energy consumption as compared to an independent electronic Meter. A field end-to-end test scenario, Scenario 6, was used to test the actual performance at Customer-installed facilities.

Structure did not identify issues during the testing of the meter billing system accuracy. Structure encountered an issue with PG&E's set-up of the proxy accounts, wherein Structure specified a specific billing address and PG&E sent all of the proxy account bills to the wrong address. PG&E indicated that this occurred because they did not follow their standard practices.

D.3.2 End-to-End System Testing Findings Details

Twenty-six Elster digital meters procured from the Elster meter manufacturer were laboratory-tested for accuracy and utilized as an auxiliary/additional meter to record energy consumption on the secondary meters, hereby referred to as a "shadow" meters in both the laboratory end-to-end testing and the field end-to-end testing scenarios.

End-to-end laboratory testing was performed on five PG&E Smart Meters, with five Elster digital meters used as shadow meters. Each of these meter pairs was subjected to a different amount of load, reflecting measurement at various rate tiers over the test period. In addition, the meters were also subjected to common exceptions to normal conditions often found in the field, including power outages, voltage swells, voltage sags, and loss of Radio Frequency reception. Inclusion of the common exceptions facilitated testing PG&E's capability to perform validation, editing, and estimation (VEE) processes in compliance with CPUC rules, and without introducing errors into Customer bills. The referenced VEE standard was California Interval Data VEE Rules Revision 2.0.

"Proxy" Structure Customer accounts were created within PG&E's billing system for each of the laboratory-based end-to-end meters, giving Structure the ability to determine PG&E's application of billing determinants and rate assignments accuracy and the timeliness of physical bill issuance to residential electric Customers. The end-to-end test process was designed for completion over the course of one PG&E billing cycle.

Structure encountered an issue with PG&E's set-up of the proxy accounts, wherein Structure specified a specific billing address to be used instead of the premise address and PG&E sent all of the proxy account bills to the wrong address. Structure specifically requested use of the billing address instead of the premise address in order to accommodate a specific route and satisfy the specified bill cycle. The proxy bills were sent to the "premise address" that was created for the proxy accounts, which was a fictitious address created by PG&E for internal use for a premise that does not exist. Structure contacted PG&E when the bills were not received, and subsequently received the bills. PG&E indicated that the bills were sent to the incorrect address because they did not follow their standard practices for account setup. PG&E failed to note on the account that bills were to be sent to the billing address, instead of the premise address, and told Structure that the billing system defaulted to the premise address for bill delivery.

End-to-end field testing utilized four Scenario 6 field test shadow meter installations on selected High Bill Complaint Customers. The field test shadow meter setup used the existing installed PG&E Smart Meter and an Elster electronic shadow meter installed side-by-side to measure the Customer's usage simultaneously through both meters. The meter comparison results are discussed in the Field Meter Testing section. Structure also utilized these installations to verify the flow of meter usage and event data from the Customer premise, through the PG&E AMI and Billing systems, to the Customer's receipt of the printed bill.

Structure experienced initial laboratory testing setup challenges that were resolved within the first days of testing. The challenges identified during setup did not impact the overall scope or development of testing conclusions. The results of the end-to-end tests included:



- End-to-End laboratory system testing verified that the representative sample of five Smart Meters being billed through the PG&E systems had average accuracies compared to the reference Elster meters of 0.06% with a standard deviation of 0.001%. Meter Data Management System (MDMS) validation routines were verified to be working accurately under the tested conditions, and billing matched the expected results.
- Meter readings were verified as accurate between the Advanced Metering Infrastructure (AMI) head-end, the Meter Data Management System (MDMS), and the Customer Care and Billing (CC&B) systems.
- Application of billing determinants were verified as accurate, including the assignment of baseline allocations, transition of billing through seasons, and transition of billing through new tariffs.

D.4 High Bill Complaint Analysis

D.4.1 High Bill Complaint Analysis Findings Summary

Structure obtained the complaint register associated with the electric Smart Meter High Bill Complaints from both PG&E and the CPUC since the implementation of Smart Meters through June 10, 2010, for inclusion in our analysis which included usage history for 1,378 records. A detailed analysis was performed on 1,066 of these records. The records were analyzed for usage sensitivity to weather, unusual spikes, meter problems, manual or system based issues, meter reading issues, rate impacts, and service issues. Structure further analyzed a targeted sample of 73 complaints that were identified as having multiple issues and would likely provide the greatest insight into potential PG&E system or process issues. Structure contacted 100 High Bill Complaint including the 73 researched complaints, and conducted interviews with 20 Customers that had filed complaints during the period and exhibited excessively high bill periods, cancel/re-bills, or complaint resolution codes that reflected a potential problem. The 73 complaint accounts were also included in the field meter tests.

As a result of the high bill complaint analysis, Structure did not identify problems with the Smart Meter data utilized for billing. Structure identified the following factors that contributed to high bill complaints during late 2009 and early 2010:

- *Customer Usage:*
 - *Meter deployment schedules coincided with increased energy usage caused by a heat wave.*
 - *Some Customers experienced load changes that were reflective of changes in personal circumstances. Examples included room additions, pool additions, and equipment malfunctions.*
 - *Electromechanical meter degradation that was also identified as part of Structure's field meter testing.*
- *Rates:*
 - *Rate increases compounded the financial impact of the additional weather-related usage, resulting in higher bills that occurred as Smart Meters were being installed.*
 - *Incorrectly applied rates that were based upon historical premise assumptions.*
 - *Rate-based inquires that increased as Customer bills escalated. Requests for new or renewed financial assistance through California Alternate Rates for Energy (CARE) were identified as potential reductions of financial impacts related to higher bills.*
- *Customer Service:*



- *PG&E processes did not address the Customer concerns associated with the new equipment and usage changes.*
- *Customer skepticism regarding the new advanced meter technology was not effectively addressed by PG&E on a timely basis.*
- *Customers interviewed during this assessment did not consider their complaint resolved, despite indications from PG&E and CPUC that the Customer agreed with the resolution*
- *PG&E Customer complaint resolution did not provide of interval read information available with Smart Meters, which may have assisted Customers' understanding of hourly usage patterns.*
- *Process Issues:*
 - *Customers indicated that communications/notifications surrounding physical meter installation were lacking, or that the Customer had issues with the installation personnel.*
 - *PG&E utilized field meter readers for an average of 131 days after Smart Meters were installed, resulting in similar meter reading errors as electromechanical meters. The transition to automate the Smart Meter data for use in billing was not clearly addressed with Customers.*
 - *PG&E's system tolerances related to billing quality control were not stringent enough, resulting in multiple bill cancelations and re-billings, which were confusing to Customers.*

Additionally, Structure determined that the PG&E complaint resolution process was inefficient and ineffective in providing Customers with resolution details and education related to Smart Meters. Recent process changes adopted by PG&E created Customer Relations resources that were focused on Smart Meters, along with a group focused on resolving escalated complaints. Structure performed a complaint walkthrough with both the PG&E groups and was satisfied that additional focus was being placed on resolving Customer complaints.

D.4.2 High Bill Complaint Analysis Findings Details

D.4.2.1 Customer Complaint Process

The Customer complaint process followed multiple paths, including contacting the CPUC Consumer Affairs Branch (CAB) to file a complaint and filing directly with PG&E's Customer Relations Department. In some cases, Customers registered complaints with both the CPUC and PG&E. Typically, Customers had filed more than one complaint with PG&E. Included in the CPUC complaint list were complaints received during town halls hosted by Senators Dean Florez (D-Shafter) in October 2009. The complaint process is illustrated in the Findings section of this document.

All complaints filed with the CPUC were provided to PG&E for resolution and expected to either be resolved in 10 days or to provide a required \$30 credit to the Customer. CPUC was responsible for communicating results back to the Customer. Complaints filed with PG&E were handled through the Customer Relations call center and logged into the Customer's account profile.

The following Figure illustrates the number of Smart Meter high bill complaints received by PG&E on a monthly basis.



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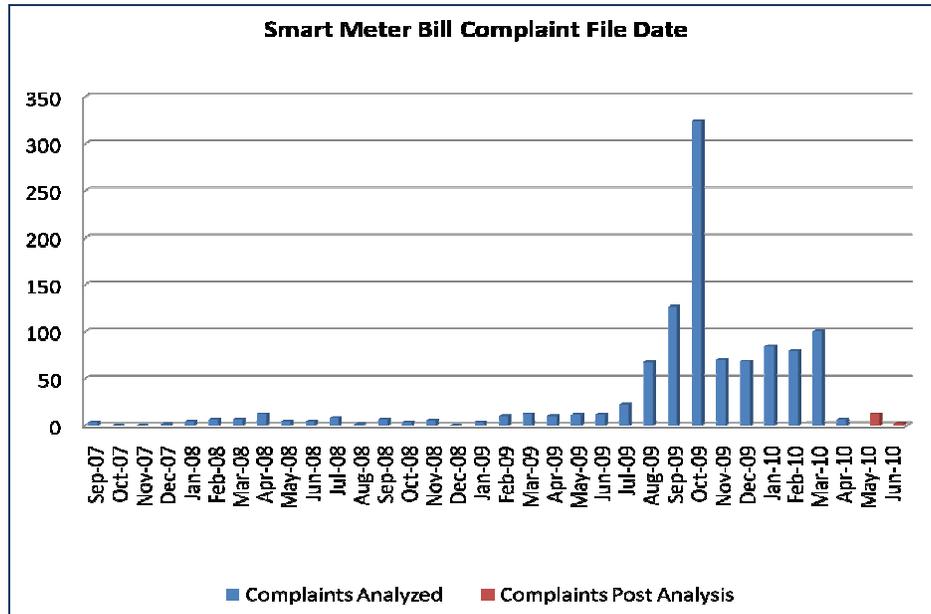


Figure 7: PG&E-Provided Smart Meter Electric Customer Account Complaints

Structure noted a disproportionate number of complaints filed with the CPUC than with PG&E, as indicated in the Figure below.

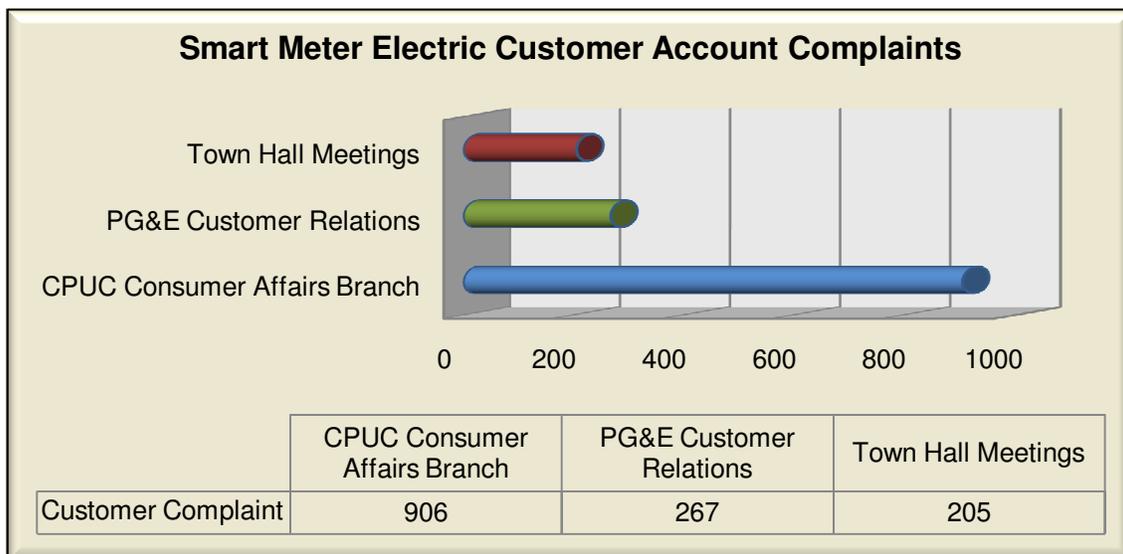


Figure 8: Structure-Identified Smart Meter Electric Customer Complaints

Structure was told by PG&E that a complaint was not marked as a Smart Meter complaint if the Customer did not mention that they had a Smart Meter. This approach may result in complaints not being accurately coded



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and reported as Smart Meter complaints. Some Customers interviewed indicated that complaints were registered with both the CPUC and PG&E, although only the CPUC record was identified.

Structure also performed a historical usage analysis utilizing an aggregated Smart Meter complaint inventory file provided by PG&E. The file included identification of the complaint source, relevant complaints, and related account detail. Structure conducted an analysis of the Smart Meter Complaint inventory to remove duplicate and non-Smart Meter billing data, and concluded that of the 2,915 Smart Meter complaints that were filed by PG&E Customers from September 2007 through April 2010, there were 1,378 distinct Customers that filed complaints related to residential electric accounts. Structure's evaluation included a further detailed review that evidenced 1,066 represented electric residential Smart Meter Customer accounts.

Subsequent to the conclusion of our analysis, Structure received additional high complaints from both PG&E and the CPUC. Structure reconciled the lists and determined that an additional 117 CPUC CAB Customer complaints had been excluded from the PG&E-provided consolidated list. Structure utilized the complaint lists and supplemental complaints as the basis for our testing selection, but did not include a complete analysis on these accounts.

As part of a follow-up to the Town Hall meeting complaint process, Structure reviewed the detailed Customer analysis performed by PG&E and the associated complaint resolutions. The PG&E analysis included a comparison of the Customer's average daily usage in kWh vs. the monthly average temperature for the region to demonstrate the trend in usage pre- and post- Smart Meter installation.

Structure reviewed the Town Hall Meeting historical usage profile for each complaint to determine accounts that were impacted by weather. Structure included the Town Hall complaints within the potential selection group for the Customer Interviews and in the Smart Meter High Bill meter tests for further validation.

Structure also performed an independent analysis on the high bill complaint Customer accounts by reviewing the historical usage for 1,378 accounts, and performing detailed analysis on 1,066 accounts. The analysis performed included:

- Weather impacts on average daily usage
- Average Daily Usage prior month prior year
- Extended billing cycles
- Unresolved complaints
- Cancel/re-bill review

Structure compared the historic average daily kilowatt hours (kWh) usage for each of the 1,066 Customer accounts with the objective of determining if the high bill complaint Customers experienced increased kilowatt hour (kWh) usage after installation of Smart Meters due to weather. The comparison utilized the 2006 and 2009 years with similar summer profiles and determined that in 86% of the 2009 complaints, the average daily usage was less than the 2006 summer although the 2006 summer months were hotter. Structure verified that the weather in the same July/August period for 2007 and 2008 was 2 to 3 degrees cooler than in 2009. The remaining 14% of accounts required additional analysis to determine the potential cause for the increased usage.

Structure also reviewed the average daily usage for the same period of the prior year for each Customer Complaint account history, and identified less than 6% of the records for the complaint Customers that exceeded 150% of the same period prior year. Structure utilized the 150% value to reflect the differential in weather between 2008 and 2009 and focus on identifying unusual spikes in energy usage.



Additional complaint analysis focused on the extent to which bills were included in an extended billing cycle, or delayed bills, outside of the typical (27-32 day) billing cycle. Structure's evaluation discovered that in 2009 and 2010, approximately 9% of the bills reflected a billing period beyond the standard cycle, although less than 0.4% extended past a 45 day window. Extended billing cycles that resulted in higher overall bills were identified as contributing to high bill complaints. Structure recalculated several bills and determined that the appropriate baseline adjustments were included in the bills and that the bills were accurately calculated.

Structure also noted that during late 2009 and early 2010, a significant portion of complaints were not resolved within the CPUC-required 10 day complaint resolution period. PG&E indicated that the resolution time period extended well beyond the 10-day timeframe due to the influx of complaints during the second half of 2009 and early 2010. Structure calculated that PG&E took more than 10 days to resolve complaints for more than 67% of the Customer accounts during this time period. Structure did not review all accounts to identify whether the CPUC credit for account resolution was provided, but did identify that in several cases where detailed review was performed, the adjustment was properly applied after Structure's additional review and discussion with PG&E.

The cancel/re-bills documented by PG&E represented 1% of the total high bill complaints. A portion of the cancel/re-bills related to overbilling from estimated meter reads identified by Customers subsequently required adjustments by PG&E. Billing adjustments were also made to compensate for meter installation issues.

D.4.2.2 Customer Interviews

Structure contacted 100 high-bill complaint Customers for potential in-depth interview participation related to their high bill complaint. Of the 100 Customers contacted, 20 Customers agreed to be interviewed. Some Customers permitted inclusion of their information in The Assessment, and permitted Structure to follow up with PG&E on their behalf. The Customer interviews focused on the nature of the complaint described to PG&E, PG&E's approach to resolving the Customer's complaint, and the current status of the complaint. The 20 Customers participating in interviews were also included in the field meter testing population.

Based upon Customer interviews, Structure identified gaps in PG&E's approach taken to resolve Customer complaints, including but not limited to:

- Some Customer complaints were not logged into the service history on Customer accounts.
- Follow-up with Customer was not performed on a timely basis.
- PG&E indicated that account was resolved did not align with Customer perception.
- Lack of resolution communication back to Customer.
- Customer lacked clear understanding of complaint resolution process.
- Customer consistently treated by PG&E as wrong, until the Customer proved to PG&E that they were right.
- Customer perception of Smart Meter functionality resulted in complaint escalation.
- PG&E front-line customer call representatives lacked professionalism while dealing with Customer complaints.
- Underlying cause of billing issue not discovered in most cases, even when monetary resolution was reached.

Recent process changes adapted by PG&E allocated Customer Relations resources focused on Smart Meters, along with a group focused on resolving escalated complaints. Structure performed a complaint walkthrough



with both of the PG&E groups and was satisfied that additional focus was being placed on effectively resolving Customer complaints.

In regards to the CPUC complaint resolution process, Structure noted that the Complaint closure letter Customers received from the CPUC provided no further information than had been provided by PG&E, and both were considered to be ineffective.

Structure followed-up on the Customer interviews by reviewing the Customer Complaints with PG&E. As an outcome of Structure's review with PG&E, two accounts were adjusted based upon the Customer's satisfaction of certain criteria, including low income CARE eligibility and major customer equipment malfunctions, which were subsequently repaired by the Customer.

During the interview process, Structure identified discrepancies in the retroactive application of the CARE eligibility for two Customers. These discrepancies were later resolved by PG&E, following Structure's inquiries, in favor of the Customer.

Of the 20 Customer interviews completed, Structure identified the following non-unique account issues:

- 9 Customers experienced unusually high bills in the initial months after the Smart Meter was installed
 - Explanations identified:
 - Estimated meter reads
 - Cancel/re-bill adjustments
 - Weather related
 - Usage pattern adjustments
- 9 Customers do not have an explanation, personally or from PG&E, for the spike in electricity usage.
 - Potential explanation identified:
 - Electromechanical degradation (similar to those found in field testing)
- 5 Customers were on the wrong rate structure, or PG&E changed their rate structure as a result of their complaint.
 - Explanations included:
 - Historical premise classified incorrectly, affecting the baseline applied to the premise
 - Lapse in CARE qualification, or not registered for lower income-based programs
- 1 Customer experienced a 500% increase in kWhs used after Smart Meter installation
 - Explanation included:
 - Correction of estimated meter reads.
 - Note: The lack of adequate PG&E exception and validation controls resulted in the bill being processed.
- 2 Customers interviewed experienced electrical problems due to Smart Meters causing "surges" or interruptions in timed electrical services such as security lights and hot tub pumps.
 - Explanations included:
 - There is a possibility for a meter in close proximity to FCC Part 15 Unlicensed Radio Frequency (RF) devices and transmitting data via a 1 watt radio transmitter to create operational interference (e.g., static, trip, or outage) when the RF signal passes through these devices. This is an issue that is prevalent with any RF device, such as walkie-talkies, garage door openers, etc. Electrical issues may be due to a matter of proximity to the transmitter, strength of the transmitter, frequency of the transmitter, and the impact on the neighboring device.
 - FCC Part 15 Unlicensed RF devices include:



- Motion sensors
- Garage door openers
- Baby monitors
- Wireless telephones
- Wireless speakers
- PG&E has determined that certain models of Ground Fault Interrupter (GFI) breakers (such as those used on hot tubs) may be impacted if they are in close proximity to the meter. PG&E has also engaged Smart Meter manufacturers to develop low power transmitter solutions to the GFI interference issue, and has trained the installation contractors to listen for GFI tripping upon installation of a new meter.

On average, Customers indicated a 4.5 month delay between complaint submission and ultimate resolution. The quickest resolution was reached in four days; however, the longest resolution took 12 months and significant effort on the part of the Customer.

While the Customer interviews and related detail account reviews provided significant insight into potential issues within the Smart Meter program, Structure did not identify recurrent issues that impacted the overall population of High Bill Complaints analyzed.

D.5 Best Practices Associated with Smart Meters

D.5.1 Best Practices Associated with Smart Meters Findings Summary

Structure found PG&E to have been either historically in compliance, or to have recently come into compliance, with the majority of industry best practices associated with Smart Meters. Recognizing that some of these practices have matured over PG&E's three year AMI deployment period, it is reasonable that they have recently come into compliance with standards associated with best practices. Some concerns were noted around PG&E's practices related to Meter Deployment, Meter Data Management Interfaces, and VEE.

The following Figure presents a pictorial representation of Structure's evaluation of PG&E's historical and current adherence to industry best practices.

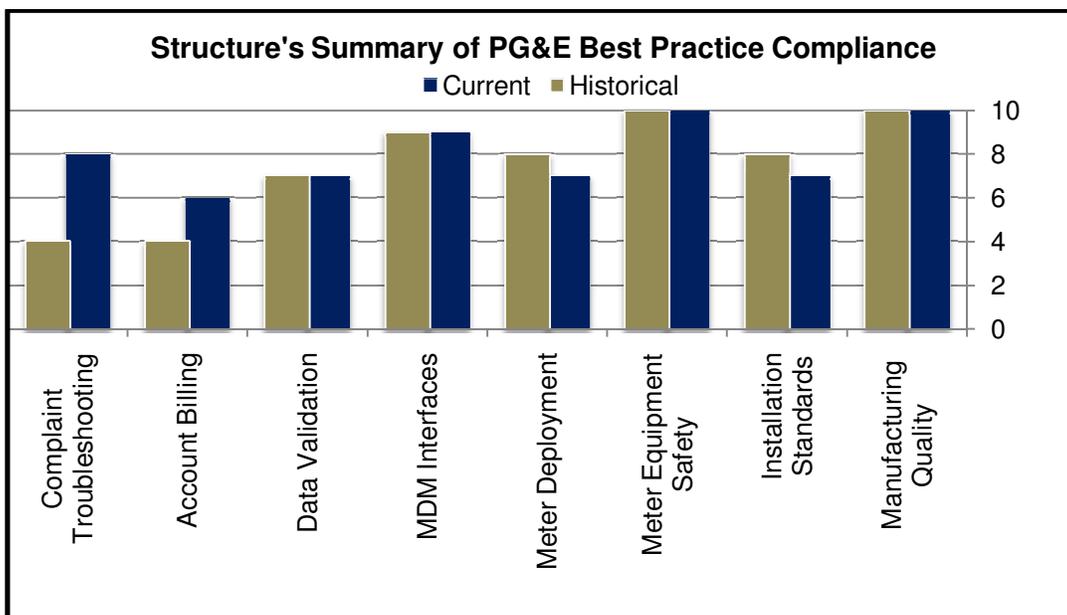


Figure 9: Structure's Summary of PG&E Best Practice Compliance

The Findings section of this report addresses the specific areas in which PG&E is historically and/or currently not compliant with best practices.

D.5.2 Best Practices Associated with Smart Meters Findings Details

Although PG&E was not in compliance with the recommendation to utilize IEC 61968-9 interoperability standards, PG&E provided documentation that it was employing a set of interoperability standards for MDM Interfaces.

Of some concern is the lack of documentation verifying compliance with the Meter Deployment best practice to deploy WAN/LAN collectors prior to meter deployment. By not deploying the communication backbone prior to meter deployment, the time to transition meter reading from manual to AMI system readings is exacerbated, extending to an average of 131 days over the implementation period. This allows a continuation of the higher error rate associated with meter reading and may contribute to the perception that the Smart Meters are inaccurate.

Additionally, the inability to verify compliance around the Meter Data Management Interface best practice to “Correlate AMI meter events and alarms with VEE and CIS audits and checks for automated exception handling” and the VEE Best Practice of “MDMS must provide an on-line method, with workflow, resolving validation errors rather than reports” has created a situation where there is manual editing of data causing numerous cancel/re-bills and delayed processing of Customer data. This, coupled with extensive manual, instead of automated, exception handling of issues has allowed many metering and billing errors to occur on a repetitive basis, over time, furthering the perception that the Smart Meters are not accurate.



PG&E has recognized, through the presentation of information, their shortcomings on these issues and has been actively pursuing remedies such as process improvements and the recent consolidation of the Billing, VEE, Smart Meter Engineering, and Troubleshooting operations into one Operation Center.

D.6 Security Assessment

D.6.1 Security Assessment Findings Summary

Structure concluded that PG&E has developed a cyber security framework that meets the objectives of the Smart Grid industry's OpenSG AMI-SEC Task Force "AMI System Security Requirements" that were reviewed as part of this evaluation.

D.6.2 Security Assessment Findings Details

Structure independently reviewed PG&E's cyber security framework as it applies to their Smart Meter system. Structure also evaluated PG&E's cyber security framework against industry best practice standards to identify deviations in current and historical business practices. Structure concluded that PG&E had developed a cyber security framework that met the objectives of the OpenSG AMI-SEC Task Force "AMI System Security Requirements" that were reviewed as part of this evaluation. An assessment of the implementation of the cyber security framework was not within Structure's agreed-upon scope of work.

D.7 Other Observations

Structure submitted data requests, using PG&E's standard request procedures as agreed to with PG&E and CPUC to obtain information used as the basis for this report. At PG&E's request, Structure assigned priorities to the data requests to facilitate response focus and expedition. While PG&E accommodated the requests, 28% of the requests were substantially delayed due to PG&E's internal processing and legal review. The delayed resulted in Structure requiring additional time and resources to process, integrate and reconcile information in an effective manner once received. While Structure does not feel that the delayed information impacted the results of the Assessment, the receipt of limited data and the differences in data presentation in the received data impacted the amount of time required to complete the planned analysis, and led to scope modifications and a revised project completion date of September 2, 2010.