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PACIFIC GAS AND ELECTRIC COMPANY

ELECTRIC PROGRAM INVESTMENT PLAN

NOVEMBER 1, 2012

ATTACHMENT 1

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EXECUTIVE SUMMARY

Executive Summary

Pacific Gas and Electric Company (PG&E) is pleased to present its 2012-2014 Triennial Electric Program Investment Charge (EPIC) 2012-2014 Investment Plan ("Investment Plan") to the California Public Utilities Commission (CPUC or Commission) for consideration and approval.

PG&E's 2012-2014 Investment Plan includes Technology Demonstration and Deployment projects in the following program categories:

- **Renewables and Distributed Energy Resource (DER) Integration** (Smart Energy Markets) – maps to grid operations/market design under EPIC
- **Grid Modernization and Optimization** (Smart Utility) – maps to transmission and distribution (T&D) under EPIC
- **Customer Service and Enablement** (Smart Customers) – maps to Demand-Side Management (DSM) under EPIC
- **Cross-Cutting/Foundational Strategies and Technologies** (Cross Cutting) – maps across the electric value chain as well as to technology evaluation, monitoring and standardization under EPIC and "Integrated and Cross Cutting" Smart Grid Annual Reporting decisions

Table 1-1 summarizes the 26 specific projects PG&E intends to pursue in its 2012-2014 EPIC Investment Plan. The table presents projects organized by key program objectives and identifies the primary benefits that PG&E believes the projects would achieve to increase safety, promote greater reliability and lower costs. Funding and development of each of these projects will be subject to further collaboration and consultation with the California Energy Commission (CEC), Southern California Edison Company (SCE), and San Diego Gas & Electric Company (SDG&E), in order to leverage the benefits of similar projects and to maximize the coordination of the various project scopes and administration.

TABLE 1-1
SUMMARY OF PG&E'S EPIC INVESTMENTS

PG&E's EPIC Investment Plan Project Portfolio			
Renewables and DER Integration Technology Demonstration and Deployment Projects			
Program Objective 1: Integrate DER, Generation, and Storage	**Safety**	**Reliability**	**Affordability**
1. Demonstrate energy storage end uses	✓	✓	✓
2. Demonstrate use of distributed energy storage for T&D cost reduction		✓	✓
3. Demonstrate priority scenarios from the Energy Storage Framework		✓	✓
4. Expand test lab and pilot facilities for new energy storage systems	✓	✓	✓
Program Objective 2: Improve Transparency of Resource Information	**Safety**	**Reliability**	**Affordability**
5. Demonstrate new resource forecast methods to better predict variable resource output		✓	✓
6. Demonstrate communication systems allowing the California Independent System Operator (CAISO) to utilize available renewable generation flexibility		✓	✓
Program Objective 3: Increase Generation Flexibility	**Safety**	**Reliability**	**Affordability**
7. Demonstrate systems to ramp existing gas-fired generation more quickly to adapt to changes in variable energy resources output		✓	✓
Grid Modernization and Optimization Technology Demonstration and Deployment Projects			
Program Objective 1: Optimize Existing Grid Assets	**Safety**	**Reliability**	**Affordability**
8. Improve distribution system safety and reliability through new data analytics techniques	✓	✓	✓
9. Test new remote monitoring and control systems for existing T&D Assets	✓	✓	✓
10. Demonstrate automated asset notification and management systems	✓	✓	✓
11. Demonstrate self-correcting tools to improve system records and operations	✓	✓	✓
12. Demonstrate new technologies that improve wildlife safety and protect assets from weather-related degradation	✓	✓	✓
Program Objective 2: Prepare for Emerging Technologies	**Safety**	**Reliability**	**Affordability**
13. Demonstrate new communication systems to improve substation automation and interoperability	✓	✓	✓
14. Demonstrate "Next generation" SmartMeter™ telecom network functionalities	✓	✓	✓
Program Objective 3: Design and Demonstrate Grid Operations of the Future	**Safety**	**Reliability**	**Affordability**
15. Demonstrate new technologies and strategies that support integrated "customer-to-market-to-grid" operations of the future	✓	✓	✓
16. Demonstrate Electric Vehicle as a resource to improve grid power quality and reduce customer outages	✓	✓	✓
17. Leverage EPIC funds by participating in multi-utility, industry wide Research, Development and Demonstration (RD&D) programs such as Electric Power Research Institute (EPRI)		✓	✓
Customer Service and Enablement Technology Demonstration and Deployment Projects			
Program Objective 1: Drive Customer Service Excellence by Leveraging PG&E's SmartMeter™ Platform	**Safety**	**Reliability**	**Affordability**
18. Demonstrate SmartMeter™-enabled data analytics to provide customers with appliance-level energy use information			✓
19. Pilot enhanced data techniques and capabilities via the SmartMeter™ platform			✓

TABLE 1-1
SUMMARY OF PG&E'S EPIC INVESTMENTS
(CONTINUED)

20. Demonstrate the benefits of providing the competitive, open market with automated access to customer-authorized SmartMeter™ data to drive innovation			✓
21. Pilot methods for automatic identification of distributed energy resources (such as solar PV) as they interconnect to the grid to improve safety & reliability	✓	✓	
Program Objective 2: Drive Customer Service Excellence by Offering Greater Billing Flexibility	**Safety**	**Reliability**	**Affordability**
22. Demonstrate Subtractive Billing with Submetering for Electric Vehicles (EV) to increase customer billing flexibility		✓	✓
23. Demonstrate Additive Billing with Submetering for PVs to increase customer billing flexibility		✓	✓
Program Objective 3: Integrate DSM for Grid Optimization	**Safety**	**Reliability**	**Affordability**
24. Demonstrate DSM for T&D cost reduction		✓	✓
25. Develop a tool to map the preferred locations for direct charge (DC) fast charging, based on traffic patterns and PG&E's distribution system, to address EV drivers' needs while reducing the impact on PG&E's distribution grid			✓
26. Pilot measurement and telemetry strategies and technologies that enable the cost-effective integration of mass market Demand Response (DR) resources into the CAISO wholesale market		✓	✓
Note: Cross-Cutting /Foundational activities are implicit within each of the above three program categories.			

PG&E intends to follow a project portfolio approach to manage its EPIC Technology Demonstration and Deployment (TD&D) investments utilizing portfolio governance best practices. A portfolio management approach entails a common framework and approach to track, prioritize, allocate resources and manage between projects. Distinct from managing individual projects based on differing criteria, a project portfolio approach provides stakeholders with a consistent and holistic view across all projects, and the portfolio's ability to meet the overarching goals of the EPIC program. This is especially important in research and development initiatives to maintain focus on the appropriate "project mix" that balances both short term projects that address immediate utility needs with longer term technology demonstration investments necessary to support the grids' development in future years.

PG&E has been at the forefront of multiple industry-leading innovations including establishing one of the first and largest deployments of SmartMeters™ in the United States (U.S.), integrating large amounts of rooftop solar Photovoltaics (PV) into its electric system, and spearheading the nationwide "Green Button" initiative to provide customers with SmartMeter™-enabled energy usage data. PG&E is also an industry

leader in demonstrating a commitment to diverse suppliers with approximately $1.6 billion in diverse spending in 2011 through internal sourcing policies, active community outreach programs, technical assistance programs, business workshops, and community sponsorships. This commitment will continue throughout the EPIC Program.

PG&E recognizes that the rapid rate of change in the electric industry and the need to meet societal, environmental and customer needs in the 21st century requires an even greater pace of innovation as well as collaboration across the State to maintain California's leadership in new, innovative energy related strategies and technologies.

In addition to developing and pursuing the 26 projects summarized above, PG&E's EPIC Investment Plan also includes a commitment to a formal and ongoing statewide RD&D collaboration process among PG&E, SCE, SDG&E and the Energy Commission to coordinate and leverage California's energy RD&D efforts under the overall EPIC program. In preparing its EPIC Investment Plan, PG&E has begun an open and collaborative process with the three program administrators that will continue throughout the review, approval and execution of PG&E's Investment Plan. PG&E and the other utilities have made substantial progress in developing a project portfolio, and will continue to work together throughout the portfolio management process to prioritize and balance the project portfolio taking into consideration each other's TD&D activities. PG&E intends to continue to work with the three program administrators to refine the projects to maximize synergies and collaboration between the parties leading up to the Commission's decision in May 2013. The 26 identified projects represent PG&E's proposed activities in its EPIC program. However, further development and evaluation of these projects will occur and may change the timing, scope and value of the projects.

PG&E's Investment Plan is organized and presented consistent with the Ordering Paragraph (OP) 12 requirements and other provisions in Decision 12-05-037 as follows:

- **Chapter 2** describes the approach and framework PG&E developed to align EPIC investments in the technology demonstration and deployment funding area to achieve the EPIC objectives and support California energy policies such as the 33 percent Renewable Portfolio Standard, Global Warming Solutions Act – Assembly Bill (AB) 32, the CPUC's Energy Storage Order

Instituting Rulemaking (OIR), Senate Bill (SB) 17 and the Governor's Distributed Generation (DG) goals. This chapter also describes the collaboration efforts with the other EPIC Program Administrators, and consultation with interested stakeholders and CPUC Staff.

- **Chapter 3** describes PG&E's EPIC RD&D Vision and Strategy to provide customers with safe, reliable and affordable energy services through strategic investments in its core electric transmission, distribution, customer service and electricity procurement operations. Foundational to PG&E's vision and strategy are investments that align with EPIC's guiding and complementary principles, map to the electricity value chain, and are consistent with Public Utilities Code (Pub. Util. Code) Sections 740.1 and 8360.
- **Chapter 4** describes PG&E's 2012-2014 EPIC Investment Plan Portfolio comprised of three program areas for investment in the technology demonstration and deployment funding category: (1) Renewable Distributed Energy Resources Integration, (2) Grid Modernization and Optimization; and (3) Customer Service and Enablement. The plan further describes strategic project objectives within these program areas and outlines the 26 projects planned as part of PG&E's EPIC Plan.
- **Chapter 5** describes Administration and Governance of PG&E's EPIC Investment Plan including ongoing collaboration and coordination efforts with the other EPIC program administrators, PG&E's governance process for managing the EPIC Portfolio, and the EPIC 2012-2014 Program budget and funding allocation for PG&E's portion of the EPIC budget.
- **Chapter 6** describes the Metrics, Measurement and Evaluation of PG&E's EPIC Investment Plan to evaluate potential benefits and results of each investment consistent with the primary principles of safety, reliability and affordability as well as the complementary principles of societal benefits, greenhouse gas (GHG) emissions mitigation and adaptation in the electricity sector at the lowest possible cost, the loading order, low emission vehicles and transportation, economic development, and efficient use of ratepayer monies as defined by the specific project and reported out annually to the Commission each February commencing with the first report on February 28, 2014.

- **Chapter 7** describes a Recommended Approach to EPIC Funded Intellectual Property consistent with the overall principles established by the Commission and for the benefit of electric customers.

PG&E would like to acknowledge the contributions of interested stakeholders throughout the development of the EPIC Investment Portfolio and provides a summary of stakeholder feedback in Appendix A.[1] To confirm EPIC investments are innovative and non-duplicative of other research and development efforts, PG&E provides a summary of Commission approved and pending R&D projects and identifies possible opportunities for further leveraging of customer funds in Appendix B.

Conclusion

PG&E's 2012-2104 EPIC Investment Plan is designed to advance California's energy policies and presents a unique opportunity to address unmet technology demonstration, development and deployment investment needs for the electric grid of the 21st century. The plan is premised on collaboration and coordination between the EPIC administrators and other industry leaders to avoid duplication of effort while providing a viable path and inclusive path to commercialization for promising new technologies.

PG&E looks forward to continuing to work closely with the Commission and the other program administrators to continue this collaboration both prior to and after the final CPUC decision in May 2013. As part of this collaboration effort, PG&E will continue to refine the proposed projects to confirm that they are synergistic and non-duplicative of other EPIC program administrator efforts and that they also remain aligned to California's evolving needs and energy policy landscape.

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1 D. 12-5-037, OP 12(b)(viii).

CHAPTER 2
PG&E'S FRAMEWORK FOR DEVELOPING ITS EPIC INVESTMENT PLAN

2. PG&E'S Framework for Developing Its EPIC Investment Plan

PG&E's Investment Plan is based on significant Investor-Owned Utilities (IOU) collaboration and stakeholder engagement to create a program that highlights specific areas within the technology demonstration and development funding category[2] that are important to the long term development of the 21st century electric grid. PG&E and the other IOUs developed a working framework to view proposed EPIC investments in the technology demonstration and deployment investment area and identify high priority needs that are common across all three IOUs. This framework does the following:

1. Captures the overarching EPIC Guiding Principles of safety, reliability and affordability to pursue TD&D projects and advance California energy policies in a cost-effective manner.
2. Demonstrates the direct linkage between the Utilities' proposed investment areas and key policy requirements such as achieving the 33 percent Renewable Portfolio Standard (RPS) and other "mega-trends" such as aging infrastructure, and/or workforce development needs that will significantly impact the 21st century grid.
3. Outlines the three primary investment areas and one Foundational, or "Cross-Cutting" category which the IOUs have identified as critical areas for focused, sustained, and collaborative TD&D investment in order to modernize the grid and provide long-term benefits to Californians.

Using this common approach, PG&E then used the criteria set forth in Decision 12-05-037 to arrive at the specific and priority objectives most suited to PG&E's customers' needs and that could leverage the specific assets, programs and technology infrastructure unique to PG&E.

Additionally, the framework illustrates how these investment areas will meet key EPIC criteria and other complementary investment principles. Decision 12-05-037 states "any projects funded through EPIC must demonstrate the potential to produce electricity

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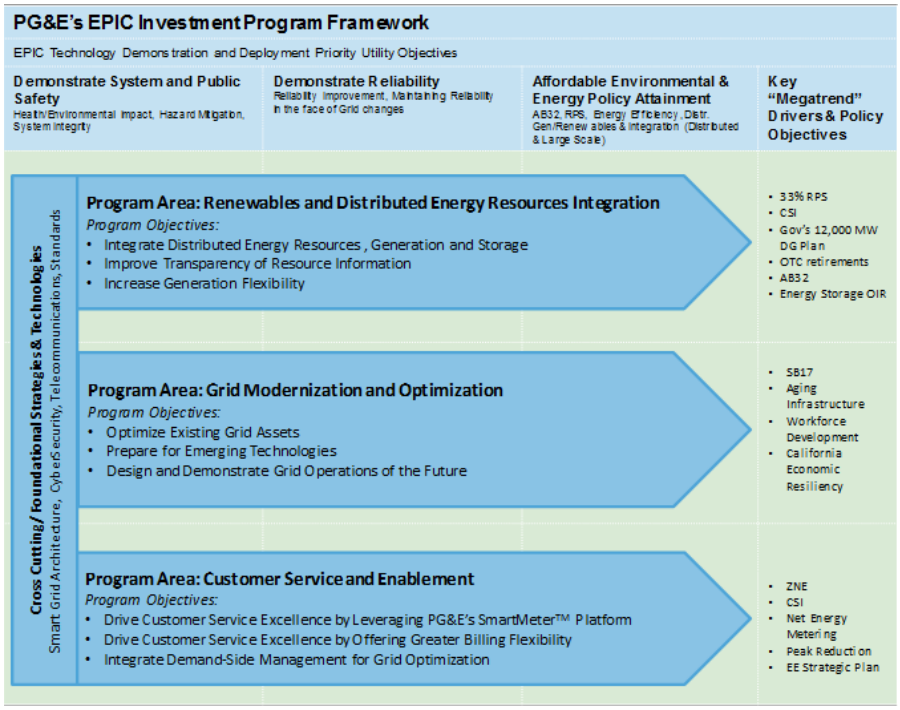
2 IOU program administrators met at least weekly and also coordinated with the CEC throughout the development of each program administrator's EPIC Plan.

ratepayer benefits, defined as promoting greater reliability, lower costs, and increased safety."[3] In addition, EPIC investments should further be guided by complementary principles of societal benefits, GHG emissions mitigation and adaptation reductions in the electricity sector at the lowest possible cost, the loading order,[4] low-emission vehicles and transportation, economic development, and efficient use of ratepayer monies. Lastly, EPIC expenditures must follow the statutory guidance provided by California Pub. Util. Code Sections 740.1 and 8360.[5]

This framework, discussed with the CEC and presented to interested stakeholders, provides greater clarity and awareness of PG&E's focus within the technology demonstration and deployment investment area. Figure 1 depicts the proposed EPIC program investment framework adapted from the joint IOU working framework, and is described further in this investment plan.

FIGURE 1



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3 D.12-05-037 at Finding of Fact (FOF) 1.

4 Since 2003, Commission-regulated utilities have had to procure resources to serve demand according to the "Loading Order," which is: (1) Conservation and Energy Efficiency; (2) Demand Response; (3) Renewable Resources & Distributed Generation; and (4) Clean Conventional (Fossil) Generation, if necessary.

5 D.12-05-037 at 18, Conclusion of Law (COL) 1, OP 12(e).

2.1 Collaboration With Other Program Administrators

The EPIC decision creates a statewide, coordinated energy research program.[6] The Program Administrators conducted joint working sessions as well as held various public workshops jointly hosted by the utilities and the CEC in northern and southern California with representatives from all Program Administrator participating in these forums to ensure consistency in approach, and provide input in the development of each other's respective plans. This process also provided common vehicles for stakeholders to provide feedback to the Program Administrators. This process and the resulting jointly developed working framework is an example of an effective, collaborative and holistic approach to RD&D investments. The IOU EPIC Program Administrators have met at least weekly and have hosted a number of working sessions with the CEC to foster an open exchange of ideas for leveraging investment opportunities. Industry knowledge was exchanged and opportunities for effective collaboration discussed and agreed upon.

2.2 Consultation With Interested Stakeholders

PG&E consulted with interested stakeholders throughout the development of its Investment Plan.[7] Representatives from the following stakeholders groups were invited to participate in the utility- hosted workshops on August 16 and 17 and a joint IOU webinar on September 28, and to provide written feedback. Stakeholders from the following groups were invited to participate on panel discussions and/or participate in the workshops.

- Members of the Legislature
- Government
- Utilities
- Investors
- The CAISO

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6 CPUC Decision 12-05-037, FOF 9.

7 *Id.*, Ordering Paragraph 15. PG&E participated in EPIC stakeholder sessions on August 8-9,16-17 and on September 27-28.

- Consumer Groups
- Environmental Organizations
- Agricultural Organizations
- Academia
- The Business Community
- The Energy Efficiency (EE) Community
- The Clean Energy Industry and/or Associations
- Other Industry Associations

Valuable stakeholder feedback was received during the development of this plan and is incorporated throughout PG&E's Investment Plan. A summary of stakeholder comments received during the development of this plan is included in Appendix A. A common concern expressed by interested stakeholders is the need for collaboration and coordination across Program Administrators to identify synergies and avoid unnecessary duplication. PG&E addresses this concern further in Chapter 5 Program Administration and Governance.

CHAPTER 3

PG&E'S EPIC INVESTMENT PLAN RD&D VISION AND STRATEGY

3. PG&E's EPIC Investment Plan RD&D Vision and Strategy

PG&E's energy RD&D vision is to provide customers with safe, reliable and affordable energy services through the analysis, testing and piloting of new energy technologies that support its core utility electric transmission, distribution, customer service and electricity procurement operations.

Informed by the Commission's recent guidance, as well as activities occurring within California and across the industry, PG&E's EPIC Investment Plan maps directly to the electricity value chain, namely: (1) grid operations/market design; (2) T&D; and (3) DSM.[8]

3. 1 EPIC Investments Are Consistent With PU Code Sections 740.1 and 8360

PG&E's investment plan also builds on PG&E's existing and planned RD&D programs consistent with the goals for utility-funded RD&D and pilot projects in Pub. Util. Code Sections 740.1 (utility RD&D) and 8360 (Smart Grid).[9] In particular, as part of its EPIC investment plan, PG&E has reflected the goals and strategy of its Smart Grid Deployment Plan, filed with the Commission in June 2011, as well as the Smart Grid metrics adopted by the Commission in April 2012. The vision and strategy of PG&E's EPIC investment plan and Smart Grid Deployment Plan are aligned and consistent.

PG&E has incorporated into its EPIC plan and project portfolio governance approach the energy RD&D criteria and methodology used in the solicitation, development and implementation of pilot technology demonstration and deployment projects in its energy efficiency and DR portfolio programs. These criteria include the following "business case" criteria for approving RD&D pilot projects

- The project must be new or innovative, and demonstrate a technology that has not yet been tested or employed.

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8 D.12-05-037, 12a. Planned investments are mapped to the electricity value chain. Per the Commission's direction, PG&E's EPIC investment plan does not include direct investments in generation-related RD&D projects or programs.

9 *Id.*, OP 12e.

- The project must address a concern, gap or problem, and assess the likelihood that it can be solved through utility RD&D.
- The project must match the characteristics for RD&D under Pub. Util. Code Section 740.1 (energy RD&D), Pub. Util. Code Section 8360 (Smart Grid), the EPIC decision, and/or the Commission's California Solar Initiative (CSI) RD&D decision (D.07-09-042).
- The project must have specific goals and objectives, and a clear budget and timeframe.
- The project must have standards or metrics (including an evaluation, measurement and verification plan as appropriate) by which the results of the project can be measured, including potential energy and cost savings; cost-effectiveness; job creation; economic benefits; environmental benefits; and other benefits.
- The project must have a plan for disseminating the information and results of the project widely to other California utilities and stakeholders, including a plan for system deployment of the technology as appropriate.

3. 2 Development of PG&E's EPIC Investment Plan

The focus of the EPIC Technology Demonstration and Deployment funding category is to test pre-commercial technologies and guide them through to commercial deployment for the benefit of electricity customers. An essential element of PG&E's EPIC Investment Plan is that each EPIC program administrator and other California energy research institutions share lessons learned within the industry to efficiently utilize and leverage customer and other funds for the advancement of California's energy and environmental policies and economic well-being. With the ever-increasing complexity of the utility infrastructure, there is a significant need to test and pilot systems and equipment on a transparent, "open access" basis in an "end-to-end" fashion to reduce risk, ensure benefits and manage costs.

To meet the EPIC program objectives, PG&E intends to leverage its existing facilities to perform technology demonstration and deployment whenever possible as well as monitor, benchmark, investigate and test new devices, equipment, communications, applications, and systems in an integrated manner, to inform and shape the industry

standards necessary to promote technology adoption and commercialization. Using existing infrastructure as a baseline, PG&E will support economic development by enhancing its technology evaluation capabilities to test new types of equipment, work processes and integrated systems developed by third-parties and other utilities. PG&E believes this will be of substantial benefit to the California economy, its customers and numerous pre-commercial vendors who contact PG&E on a regular basis, allowing PG&E to demonstrate new innovative ways of providing safe, reliable and affordable utility services.

PG&E's EPIC investment plan includes TD&D activities in the "Cross-Cutting/ Foundational Strategies and Technologies" category by integrating them into each program area and project. Although not explicitly included in the EPIC decision's electric value chain, activities common across the value chain have an effect on supporting systems, processes and technologies and must be viewed holistically as part of any integrated and successful TD&D program. In order to fully reflect the Commission's and California's priority for technology benchmarking, testing, integration and standardization in the global energy marketplace, cross-cutting strategies and technologies must be tested and evaluated and may not fit neatly within a particular category of the energy value chain. These activities include evaluating the impact of the new technologies on cybersecurity, telecommunications, information system architecture, standards, and workforce development.

PG&E's EPIC Investment Plan is based on an assessment of the ability for PG&E's existing systems to meet policy objectives and identification of potential gaps not currently met by other utility initiatives or California RD&D programs. The first part of the assessment surveyed PG&E-specific RD&D activities including current energy efficiency and DR emerging technology programs, California Solar Initiative (CSI) program contracts, Smart Grid Pilot Deployment Program, and Lawrence Livermore National Lab 21st Century Energy Systems (LNL CES-21) activities.[10] The second part of the assessment identified broader RD&D activities in the utility industry, including other California IOUs, other R&D institutions in California such as the CEC and

[10] Appendix B provides a summary of PG&E's RD&D related activities.

Universities, and a broader look at the utility industry in general. PG&E leveraged research from groups such as the Electric Power Research Institute (EPRI) and Det Norske Veritas (DNV) KEMA subject matter experts, who consult with electricity companies, agencies, and stakeholders throughout the United States and globally.

PG&E performed this internal and external assessment to identify both the short-term and long-term priority projects necessary for utility operations and services will continue to evolve to meet technological changes, and environmental and societal needs. Specific projects were evaluated and identified in the three program areas described in this plan: (1) Renewables and Distributed Energy Resources Integration; (2) Grid Modernization and Optimization; and (3) Customer Service and Enablement and reviewed for consistency and adherence to advancing EPIC's guiding principles of safety, reliability, and cost-effectiveness.

Each identified investment opportunity was then further evaluated based on the potential for meeting EPIC's complementary principles. As a result of this process, PG&E has included 26 projects in its EPIC Investment Plan as described in Chapter 4. Using a project portfolio governance approach, further analysis and ongoing coordination with the other program administrators expected to occur prior to and after May 2013 to ensure leveraging and collaboration on the scope and funding of each project. Final selection of EPIC projects will occur from this list of candidate projects once the EPIC program is approved in May 2013. The actual scope, timeline and budgets for each project will then be finalized based on information obtained through competitive solicitation processes as appropriate. Projects will be structured to follow a consistent pilot lifecycle process—including plan, design, analyze, deploy and evaluate phases for each approved project. Metrics will be developed, reported and shared widely for each project once completed.

3. 3 Summary of PG&E's Existing RD&D Projects

The EPIC Program should be the primary vehicle for consideration of utility electric RD&D proposals other than the proposals submitted by the utilities for DR and energy

efficiency emerging technology projects[11]. In its Phase 2 Decision, the Commission clearly articulated that energy efficiency and DR emerging technologies would continue to be separately funded within each of these respective proceedings Post 2008 EE Rulemaking 09-11-014 and DR Rulemaking 07-01-041 and their successor rulemakings. The Commission requested an informational summary of the RD&D activities undertaken by PG&E as part of approved DR and energy efficiency portfolios be included in this application and the summary is included in Appendix B.[12]

Additionally, PG&E assessed other RD&D efforts underway or proposed as part of its assessment to identify and leverage EPIC investments. Each proposed EPIC project has been determined to be unique to PG&E and independent of other PG&E RD&D projects underway or proposed.

In Chapter 4, PG&E describes its EPIC Technology Demonstration and Deployment Project Portfolio and the 26 high priority projects selected for the 2012-2014 EPIC investment cycle in more detail.

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11 D.12-05-037, OP 15.

12 *Id.*, OP 12b iii.

CHAPTER 4

PG&E'S EPIC INVESTMENT PLAN PROJECT PORTFOLIO

4. PG&E'S EPIC Investment Plan Project Portfolio

The IOU-administered portion of the EPIC Program is limited to the TD&D funding category.[13] Within this category, as described earlier, PG&E identified the following investment areas that map to the Electric Value Chain: (1) Renewables and Distributed Energy Resources Integration, (2) Grid Modernization and Optimization, and (3) Customer Service and Enablement. A fourth "Foundational" category is cross-cutting and maps across the entire Electric Value Chain. Foundational issues include cybersecurity, telecommunications, information system architecture, standards, and workforce development.

The TD&D funding category is designed to result in ratepayer benefits of greater reliability, lower costs, and increased safety while also providing important complementary benefits including societal benefits, GHG emissions mitigation and adaptation in the electricity sector at the lowest possible cost, the loading order, low-emission vehicles and transportation, economic development, and efficient use of ratepayer monies.

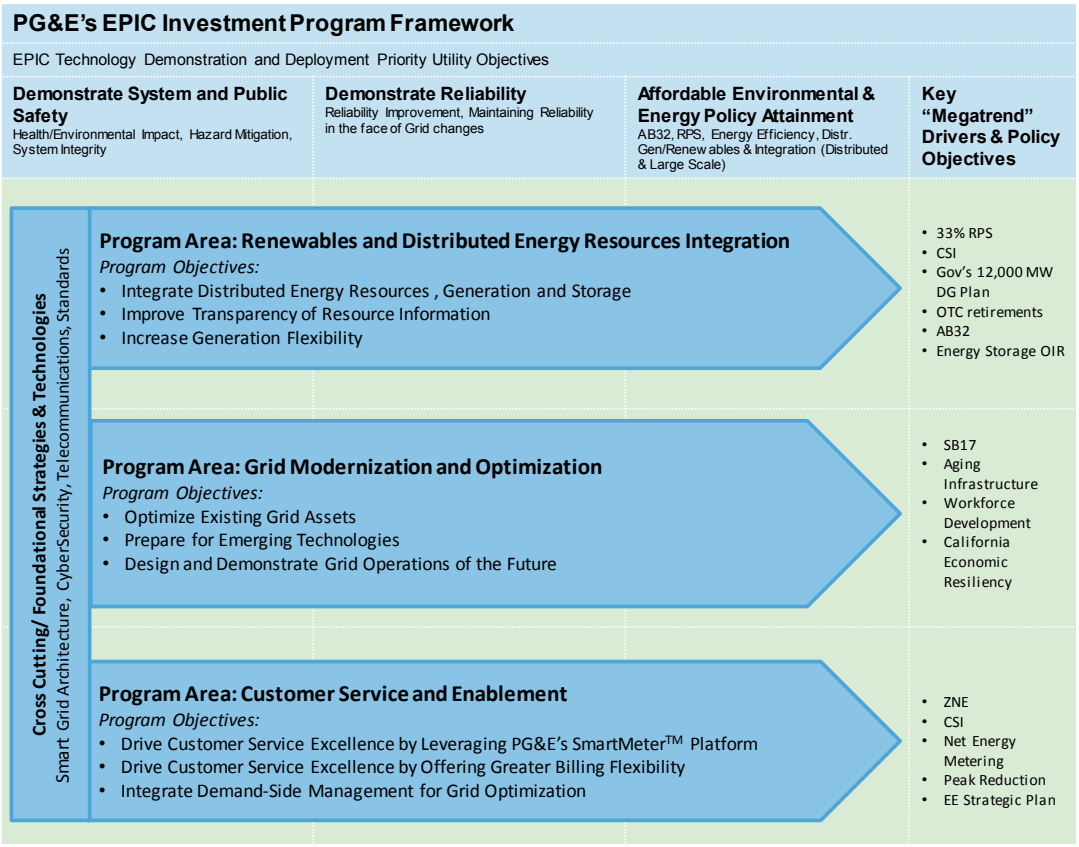
Technology Demonstration and Deployment Investments

The EPIC program provides vital investments in new and emerging technologies that will increase public and employee safety, enhance the reliability of PG&E's electricity delivery system, and lower costs for customers. The EPIC program will address key gaps by providing a pathway for pre-commercial technologies to commercialization by providing the utility scale demonstration required to vet and test the technologies necessary for full scale deployment.

This chapter presents each of the three program areas of investment – (1) Renewables and Distributed Energy Resources; (2) Grid Modernization and Optimization; and (3) Customer Service and Enablement as described earlier. A description of each program background and key program objectives is then followed by a summary of the

[13] D.12-05-037, OP 3.

current challenges and solutions to overcome barriers.[14] The proposed projects in support of these investment areas are mapped to the electricity value chain and are then presented in more detail. As described earlier, the projects presented here will be further developed, refined and augmented throughout the regulatory proceeding prior to the final decision on this application in May 2013. The final project selection will be made after Commission approval of the EPIC program.



4.1 Renewables and Distributed Energy Resources Integration

4.1.A Program Area Background

California has the most ambitious clean energy goals in the U.S. Specifically, by 2020, California energy policies call for utilities to: (1) contribute to reducing statewide greenhouse gas emissions to 1990 levels by 2020; (2) purchase or produce enough California-eligible renewable energy to meet 33 percent of customer needs;

[14] D.12-05-37, OP 12(c)(ii).

(3) interconnect 12,000 megawatt (MW) of locally-produced renewable generation; (4) retire 12,000 MW of once-through-cooling power plants; and (5) serve new residential dwellings that operate on a Zero Net Energy (ZNE) basis. All of these factors imply significant increases in the amount of renewable energy moving on California utility grids at the T&D levels.

Some forms of renewable generation (e.g., geothermal and biomass) act much like current central station power plants, presenting no significant new technological challenges. However, most of the utility-scale renewable energy generation connecting to the utility grid have very different operating characteristics. The most common type will be resources defined by the Federal Energy Regulatory Commission (FERC) as a "Variable Energy Resource" or VER. FERC defines a VER as an energy source that: (1) is renewable; (2) cannot be stored by the facility owner or operator; and (3) has variability that is beyond the control of the facility owner or operator. VERs generate electricity when natural conditions such as wind and sunshine allow it, presenting new challenges across the generating and load balancing time spectrum of seconds, minutes, hours, days, and months.

In addition to an increasing level of VERs, California expects to add other variable resources that will operate outside of utility or the CAISO control, such as more Combined Heat and Power (CHP), self-optimizing customer micro-grids, customer energy storage, and/or fuel cells installed behind customer meters. The principal need in this program area is to facilitate the integration of variable resources into the grid and coordinate with CAISO wholesale markets, such that the resources can be deployed reliably within the timeframes required to meet the policy goals noted above.

The operating characteristics of variable resources add complexities to managing the grid and makes it more difficult for the CAISO to maintain required balancing area standards for frequency, voltage, imbalances, and other requirements. At the same time, distribution-connected variable resources present a challenge for utilities to maintain distribution grid operating standards for voltage, harmonics and overall reliability.

Investment in this program area is needed to facilitate the reliable integration of variable resources into the PG&E grid. Key needs include identifying strategies and technologies to minimize grid disruptions, identifying cost-efficient methods to deal with intrinsically variable renewable resources output, and improving forecasting of VER generation and load. The electric industry has seen many recent technological advances in these areas, and these new emerging technologies must be further assessed, evaluated and provided a path towards viable large scale implementation if California is be successful in reaching its energy policy goals.

In developing the project portfolio for this program area, PG&E evaluated the findings from the CEC's 2011 Integrated Energy Policy Report (IEPR)[15] that identified the following grid integration issues:

- Need for regulation, ramping, spinning reserves, replacement power.
- Need to address potential overgeneration issues and improve forecasting of intermittent resources
- Use complementary technologies (natural gas plants, energy storage, DR) to provide integration services

4.1.B Key Program Objectives That Support Policy and Meet Industry Needs

PG&E has identified three key program objectives in the Renewable and Distributed Resources Program Area:

Program Objective 1	**Integrate Distributed Energy Resources (DER), Generation and Storage**
Program Objective 2	**Improve Transparency of Resource Information**
Program Objective 3	**Increase Generation Flexibility**

These three program objectives, current challenges and solutions to overcome barriers are discussed in more detail below.

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15 "Renewable Power Status and Issues," 2011 Integrated Energy Policy Report Proceeding, September 14, 2011.

4.1.B.1 Program Objective One: Integrate Distributed Energy Resources, Generation and Storage

Current Challenges

There are many changes to the grid that are needed to accommodate more variable resources. Utility distribution systems were designed to receive power from transmission systems, which were connected to large, central generating stations in a "one way flow of energy." Distributed resources that generate power behind the meter and flow back across the transformer and into the distribution feeder create the potential for new issues such as voltage spikes and dips, harmonics, and other issues. There is also the potential risk to put power onto the grid at a time when it is not needed. The variable nature of the new resources requires that the grid be able to respond to sudden changes in output by using flexible resources on the grid to provide Ancillary Services (A/S) such as frequency regulation, voltage control, load following and reserves.

The changes to the grid needed to accept increasing amounts of variable resources have been studied at the national and state level. The North American Electric Reliability Corporation (NERC) issued its report "Accommodating High Levels of Variable Generation" in April 2009. The CAISO has conducted many studies on renewable integration since 2007[16] and is currently working on additional analyses. The studies all discuss the types of services and attributes that will be necessary to manage the grid of the future. The key operating characteristic of the grid of the future is "flexibility." Resources will need to be able to ramp up and down faster to complement the variability of the new renewable resources. One of the more recent CAISO studies[17] identified the potential for a capacity shortage in 2020 of up to 4,600 MW of upward ramping and 500-800 MW of downward ramping resources. The study also stated that the required 800 MW of downward balancing flexibility may be satisfied using curtailment and/or additional energy storage.

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16 Beginning with "Integration of Renewable Resources, transmission and operating issues and recommendations for integrating renewable resources on the California ISO-controlled Grid," CAISO, November 2007.

17 "Briefing on Renewable Integration" memorandum to the CAISO Board of Governors from Keith Casey, Vice President, Market and Infrastructure Development, August 18, 2011.

Energy storage has been justifiably receiving much attention as a means to facilitate the integration of renewable energy as well as serve several other purposes on the electrical grid. The Department of Energy (DOE) has provided funding for more mature technologies through grants under the American Recovery and Reinvestment Act (ARRA).[18] DOE has also provided grants to developing technologies in California through its Advanced Research Projects Agency-Energy (ARPA-E) program. The CEC has also supported storage for many years through the Public Interest Energy Research (PIER) program.

AB 2514 was signed into law in California in 2010. It requires the CPUC to determine appropriate targets, if any, for utilities and other load-serving entities to procure viable and cost-effective energy storage systems. The Commission opened OIR Rulemaking 10-12-007 in response to AB 2514 and issued Decision 12-08-016 approving the Staff's "Final Proposal" on energy storage. The Staff report identified several barriers to entry for Energy Storage Systems (ESS). One of the barriers was "Lack of Commercial Operating Experience." Staff also identified four basic "scenarios" utilizing ESS to advance California energy policy objectives": Renewables Support/Dispatchability, Distributed Storage, DSM, and A/S.

Solutions

PG&E supports additional demonstration activities and proposes to use EPIC in this program area to further efforts in three of the four energy storage scenarios identified by the staff report. Specifically, PG&E proposes to include projects in EPIC for Renewables Support/ Dispatchability, Distributed Storage, and A/S. Consideration of the fourth scenario, DSM using "behind-the-meter" storage, will be in conjunction with other EPIC demand-side projects in Section 4.3, "Customer Service and Enablement." As part of EPIC Investment Plan, PG&E will evaluate the potential for energy storage to provide the services required to integrate more variable resources at the transmission and, especially, the distribution level. For example, wholesale energy storage or

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[18] PG&E received $25 million for Phase 1 of its Advanced Underground Compressed Energy Storage Project. SCE received $25 million for its Tehachapi Wind Energy Storage Project using utility-scale lithium-ion battery technology. Both projects are intended to integrate wind generation into the electric grid.

aggregated distribution-level energy storage can provide ancillary services to the CAISO, or it can be used to improve reliability of distribution systems by providing balancing and voltage smoothing to mitigate the impacts of distributed renewable generation. To mitigate risks to the electric grid, PG&E intends to demonstrate these technologies in the field at sufficient scale before further consideration for commercial deployment.

PG&E's TD&D approach includes conducting modeling and analysis to determine where to site distributed energy storage and to analyze how it would perform under various system conditions. Control systems and software may be developed to aggregate distributed energy storage and support T&D operations and the CAISO. TD&D projects in this program area may test a variety of use cases to demonstrate storage applications described in the CPUC Storage OIR, including: Distribution Reliability Improvements; Fast Response in A/S Markets; Energy Arbitrage; Renewable Intermittency Smoothing; Operating in CAISO Markets; and Resource Adequacy, all with a focus on demonstrating the value, technical performance and cost of the various use cases.

PG&E's Specific Projects to Meet Program Objective

Table 4-1 below outlines PG&E's proposed projects to successfully DER, Generation, and Storage:

TABLE 4-1
SUMMARY OF PROGRAM OBJECTIVES BY PROJECT

Program Objective 1: Integrate Distributed Energy Resources, Generation, and Storage	Safety	Reliability	Affordability
1. Demonstrate energy storage end uses Leveraging PG&E's two existing storage systems, use commercially available energy storage technology to test multiple end use storage applications and assess their economic feasibility. Develop and demonstrate automated controls via existing System Control and Data Acquisition (SCADA) systems to test multiple applications for cost effectiveness and expand the use of control algorithms to allow for response to changing requirements.	✓	✓	✓
2. Demonstrate use of distributed energy storage for T&D cost reduction Assess costs/benefits of using distributed energy storage to reduce T&D costs. PG&E will identify locations on the grid where T&D investments are needed, Evaluate the ability of energy storage to provide cost-effective services to the system (e.g., deferring T&D investment, providing power quality, providing reliability or otherwise reducing T&D costs).		✓	✓
3. Demonstrate priority energy storage scenarios from the Energy Storage Framework Demonstrate priority test scenarios developed as part of the Energy Division's Energy Storage Framework in the Energy Storage OIR (R.10-12-007). This project would analyze the business cases to create software, and systems for dispatch, bidding, and integration as a prelude to a future demonstration or deployment project.		✓	✓
4. Expand lab test and pilot facilities for new energy storage systems Working collaboratively with partners and vendors, enhance PG&E's existing test lab facilities to test "next generation" technologies that have the potential to make game changing breakthroughs and which have not previously been tested.	✓	✓	✓

PG&E has identified these projects to be of high priority in consideration of the need for increased emphasis on integrating variable resources in California. As noted previously, the CAISO has issued multiple reports on the subject, and achievement of California's energy policy goals depends on the successful integration of DER, Generation and Storage.

PG&E has a record of close coordination on Energy Storage initiatives, and continued IOU-CEC coordination is essential to achieving objectives in this program area. The CEC has also proposed EPIC projects in the same program area and both the CEC and the IOUs will work closely in this area to create synergies and prevent duplication. PG&E's lead proposal in this area will utilize assets that were the recipients of previous CEC awards. As such, there is already a strong level of communication, information sharing and collaboration.

PG&Es approach to TD&D efforts in this area are focused on obtaining the greatest level of understanding at the lowest levels of incremental investment. For example. PG&E already owns assets that will be used to demonstrate the new energy storage scenarios. By leveraging existing assets as much as possible, PG&E's EPIC proposal would provide the greatest return on previous and new ratepayer investments.

More detail about each of the projects included in Table 4-1 is provided in the following section.

Project Number: 1

Project Title: Energy Storage End Uses

Description of Technology or Strategy to Be Demonstrated[19]

Using an established, commercially-available energy storage technology to test end-use applications minimizes start-up challenges so the focus can be on the applications. Developing and demonstrating automated controls via PG&E's existing SCADA system

[19] Ordering Paragraph 3.b. TD&D. The installation and operation of pre-commercial technologies or strategies at a scale sufficiently large and in conditions sufficiently reflective of anticipated actual operating environments to enable appraisal of the operational and performance characteristics and the financial risks.

will allow energy storage to test the multiple applications that are frequently advocated as a way to make storage more economical. Expanding the use of control algorithms will allow responses to changing requirements of multiple applications.

PG&E currently owns two energy storage installations using sodium sulfur (NaS) batteries. One installation is 2 MW sited on a distribution line that hosts a 2 MW PV system also owned by PG&E. The other system is 4 MW sited on a distribution line that serves a high tech customer that needs the highest power quality and reliability available. The projects are being installed mainly using PG&E funds, but CEC grants also provided important contributions. The project intents to test more energy storage capabilities by expanding into additional end uses beyond their original funding commitments (e.g., new end uses could include bidding into the upcoming Non-Generator Resources (NGR) CAISO market and testing against Resource Adequacy (RA) requirements).

Applicable Electricity Value Chain Elements	
☒ Grid operations/market design	☐ Distribution
☐ Generation	☐ Demand-side management
☐ Transmission	

Concern, Gap, or Problem to be Addressed

Decision 12-08-016 identified "Lack of Commercial Operating Experience" as one of the barriers to entry for energy storage. The Energy Storage Framework approved by Decision 12-08-016 listed 20 end uses in four basic scenarios. Many of the applications have been conceptual to date with few, if any, of them demonstrated in combinations.

Potential Benefits at Full Deployment

If successful, the proposed project will demonstrate the ability to use energy storage to perform multiple applications by the same storage system. This could maintain or improve reliability, reduce pressures on customer rates, and provide services into new or expanded CAISO and utility markets. It would also demonstrate a new market for energy storage systems and would support the economic development of new storage companies in California.

Project Number: 2

Project Title: Demonstrate the Use of Distributed Energy Storage for T&D Cost Reduction

Description of Technology or Strategy To Be Demonstrated

This proposed project leverages other projects included in PG&E's proposed EPIC Investment Plan and is comprised of multiple steps. Steps 1, 2, 5 and 6 will be performed in conjunction with Project 24 DSM for T&D Cost Reduction.

1. Coordinate with distribution planners and operators to identify substations or feeders where capacity expansions are planned to address a forecasted overload or a projected growth of significant DG, EVs or ZNE buildings.
2. Identify or develop an economic modeling tool to compare the planned traditional utility investment with alternatives using distributed resources or demand-side investments.
3. Conduct a Request for Information with energy storage vendors to determine what energy storage technologies are available at what cost to meet the identified needs.
4. Determine how to aggregate excess energy storage capacity to bid into CAISO market(s) or meet utility Resource Adequacy needs.
5. Determine whether a planned conventional utility investment or a combination of alternative distributed or demand-side investments is the most cost effective while providing a comparable level of reliability.
6. Identify the most appropriate investment considering economics and reliability.

Applicable Electricity Value Chain Elements	
☒ Grid operations/market design	☒ Distribution
☐ Generation	☐ Demand-side management
☐ Transmission	

Concern, Gap, or Problem To Be Addressed

The effective use of the multiple capabilities of energy storage has the theoretical potential to reduce the cost of serving electric customers by delaying or postponing the

need for T&D capacity expansions and the acquisition of other services. This project would look at real-world needs and attempt to demonstrate how energy storage alone or in combination with other resources could fill those needs.

Potential Benefits at Full Deployment

If successful, the proposed project will demonstrate the ability to use energy storage more broadly to delay capacity expansions while maintaining or improving reliability, reducing pressures on customer rates, and while providing services into new or expanded CAISO and utility markets. It would also demonstrate a new market for energy storage systems and would support the economic development of new storage companies in California.

This project is not duplicative of any other known initiatives in California. This project would be synergistic with the Energy Storage OIR at the Commission by evaluating and potentially demonstrating a set of future uses and supports the EPIC guiding principle of lowering consumer costs while maintaining or improving reliability

Project Number: 3

Project Title: Demonstrate Priority Energy Storage Scenarios from the Energy Storage Framework

Description of Technology or Strategy to Be Demonstrated

The precise activities to be performed in this project have not been identified yet due to timing of Rulemaking 10-12-007. This project would fund work in support of future demonstration project(s) as needed to test priority scenarios developed in Rulemaking 10-12-007. The Commission issued Decision 12-08-016 in the Energy Storage OIR. The decision adopted the staff's Energy Storage Framework, but the proceeding remained open so that a second phase could be initiated to analyze the priority scenarios contained in the Framework. This project is intended to be responsive to the needs of the second phase of the storage OIR.

Applicable Electricity Value Chain Elements	
☒ Grid operations/market design	☐ Distribution
☐ Generation	☐ Demand-side management
☐ Transmission	

Concern, Gap, or Problem To Be Addressed

Energy storage has the potential to maintain or improve reliability on an affordable basis, however, there are currently many barriers to widespread use of energy storage. CPUC Staff developed the "Final Energy Storage Framework" to provide a roadmap to addressing those barriers. The next phase of the energy storage OIR will analyze the priority scenarios contained in the Staff's Energy Storage Framework. This proposed project will analyze those priority scenarios in support of a future demonstration project that will address observed barriers.

Potential Benefits at Full Deployment

If successful, the proposed project will lead to the demonstration of ways to remove existing barriers to deployment of energy storage systems. Full deployment of energy storage has the potential to maintain or improve reliability, reduce pressures on customer rates, and provide services into new or expanded CAISO and utility markets. It would also demonstrate a new market for energy storage systems and would support the economic development of new storage companies in California.

Project Number: 4

Project Title: Expand lab to test and pilot facilities for new energy storage systems

Description of Technology or Strategy to Be Demonstrated

This project would identify ways to enhance the existing test lab facilities at PG&E's Applied Technology Services (ATS) center to provide lab test and pilot facilities for new energy storage systems not previously lab tested. PG&E's ATS lab will be particularly helpful in working with the CEC and industry to test "next generation" technologies that have the potential to make breakthroughs in cost, performance targets, and other important parameters, in a test grid environment. This testing would be a critical step in accelerating commercialization of potential "game changing" technology. New types of technology that may be tested at ATS include, but are not limited to, advanced lithium

devices, new sodium-based systems, zinc-air systems and new flow battery chemistries and formats. The funding required to add full capabilities to ATS is minimal. The costs to perform the tests will be paid by the industry or by entities that have received research grants from agencies such as the CEC or Department of Energy (DOE).

The ATS center has successfully tested energy storage systems in the past, including CEC-funded flow battery and flywheel tests in the 2005-2008 timeframe. The flywheel test was a successful pilot conducted with the CAISO that demonstrated the capabilities of flywheels for frequency stabilization. Test technologies have improved since that time, which is why some EPIC funds are needed to upgrade and update some internal testing hardware.

Among the collaborations under consideration for the ATS facility is CalCharge, a public-private partnership created by the Lawrence Berkeley National Laboratory (LBNL) and the California Clean Energy Fund (CalCEF) to accelerate energy storage commercialization and market adoption through technology assistance, workforce training and market education. CalCharge intends to work with the more than 30 emerging Bay Area energy storage companies.

Applicable Electricity Value Chain Elements	
☒ Grid operations/market design	☐ Distribution
☐ Generation	☐ Demand-side management
☐ Transmission	

Concern, Gap, or Problem To Be Addressed

Energy storage has the potential to maintain or improve reliability on an affordable basis, however, there are currently many barriers to widespread use of energy storage, including cost and technology maturity. ATS is able to test and demonstrate new energy storage systems that may be able to break through the existing cost and technology barriers.

Potential Benefits at Full Deployment

If successful, the proposed project will lead to the demonstration of new technologies with lower costs and improved operating characteristics that have the potential to be "game changers" in the use of energy storage. Full deployment of energy storage has

the potential to maintain or improve reliability, reduce pressures on customer rates, and provide services into new or expanded CAISO and utility markets. It would also demonstrate a new market for energy storage systems and would support the economic development of new storage companies in California. There are other energy storage test facilities in California, but the ATS facility has unique capabilities when it comes to testing energy storage in a simulated utility operating environment.

The CEC has proposed EPIC initiatives in the same general area and can utilize the enhanced facility proposed in this project to advance those initiatives. The CEC and IOUs will continue to work closely in this area to assure synergies and prevent duplication.

Demonstrations of strategies and technologies facilitating integration of variable renewables likely will take place throughout the duration of the EPIC program, since continual development of new approaches are expected to continue well into the future. PG&E has a record of close coordination with the CEC on energy storage initiatives, both with the existing projects and in using PG&E ATS test facilities for past CEC projects.

4.1.B.2 Program Objective Two: Improve Transparency of Generating Resource Information

Current Challenges

Generating Resource visibility or transparency is necessary to assist the CAISO as well as Utilities with managing the grid. This Transparency includes better forecasting of renewable and distributed energy resources and also improved control of resources when needed, to maintain grid reliability.

The CAISO has stated that it believes that it is imperative that the operational and market impacts of DER are fully understood, especially since the administration has announced a goal of 12,000 MW of distributed generation by 2020. With that in mind,

the CAISO commissioned a study[20] to address possible impacts of DER, especially regarding the CAISO requirements for regulation and load following. The study noted the following conclusions:

- High DER penetrations can triple projected 2020 load following reserve requirements over a 2011 baseline.
- Increased visibility of behind-the-meter generation leads to more efficient procurement of regulating and load following requirements, more efficient database of planned and existing DER projects and grid response programs, more efficient loading of DER and existing grid components, and more efficient voltage management.
- Increased visibility to DER conditions can improve forecasting and reduce load following reserve requirements purchases by 8-12 percent in the three cases that the study modeled.
- The study found that even small reductions in forecast error of DER show benefits ranging from $90 million to $391 million per year in reduced load following and regulation reserve requirements in 2020 for CAISO members, depending upon the penetration of DER expected.
- The greatest benefit of improved visibility is with PV ($176 million), followed by DR ($149 million) and Distributed Storage ($63 million).

The need for transparency of resource information is well understood and is applicable to larger resources. As discussed in the energy storage section above, other CAISO studies have concluded that there is a need to increase grid capabilities for downward ramping of 500-800 MW that may be satisfied using curtailment and/or additional storage.[21] The CAISO study concluded that "(w)hile the magnitude and frequency of downward capacity shortfalls were limited, significant system costs can be incurred by maintaining downward flexibility when loading internal flexible gas resources and

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20 "Final Report for Assessment of Visibility and Control Options for Distributed Energy Resources," June 21, 2012, DNV KEMA (with support from National Renewable Energy Laboratory (NREL)) and Energy Exemplar, LLC.

21 "Briefing on Renewable Integration" memorandum to the CAISO Board of Governors from Keith Casey, Vice President, Market and Infrastructure Development, August 18, 2011.

reducing more economic imports. As a result, PG&E believes price responsive curtailment of renewable resource may be a more efficient solution to meet downward flexibility requirements."

There are also events where curtailments of renewable resources may become necessary due to concerns about overgeneration. Overgeneration events occur occasionally under current conditions, but these events are expected to occur more frequently as more variable resources become operational. A joint press release from the CAISO and CEC on Earth Day, 2011 contained the following statement:

"Record-high level of wind comes as the California snowpack reaches 160% of historical average. The heavy snow inventory, combined with warm temperatures, could lead to fast stream flows that fuel a glut in hydroelectricity. These "over generation" conditions in off-peak hours can affect reliability and require the ISO to send quick signals for power plants to "back down" - sometimes even paying generators last minute to reduce output. Flexible on/off ramping capability is critical in making sure megawatts do not overload the grid."

Preliminary observations and next steps recommended by the CAISO in "Summary of Preliminary Results of 33% Renewable Integration Study –2010 CPUC LTPP Docket No. R.10-05-006" (May 10, 2011) are that "(a)ssuming CA achieves demand side objectives, preliminary results indicate most operational requirements can be satisfied with potential need for measures to address some over-generation conditions." (Emphasis added.)

Curtailment of resources for reliability purposes such as the above scenario is allowed under many commercial contracts, but is rarely used with renewable resources because of the slow and sometimes uncertain process of calling plant operators to affect a curtailment.

Solutions

PG&E supports Technology Demonstration and Deployment projects that improve the CAISO's ability to manage the grid by improving the visibility of generation conditions both on a distributed basis and for large-scale resources. Implementing the TD&D

projects in PG&E's operating utility environment using real data and equipment will be of significant value to advance the body of existing conceptual level applied research.

PG&E's Specific Projects to Meet Program Objectives

Table 4-2 below outlines PG&E's specific projects to improve transparency of resource information.

TABLE 4-2
SUMMARY OF PROJECT OBJECTIVES

Program Objective 2: Improve Transparency of Resource Information	Safety	Reliability	Affordability
5. Demonstrate new resource forecast methods to better predict variable output Develop, deploy and demonstrate a mesoscale meteorological model to predict near surface wind speeds, solar radiation and other parameters to support forecasting for hour and day ahead energy markets; Provides increased visibility of meteorological conditions driving behind the meter generation to improve forecasting, reduce load following and reserve regulation.		✓	✓
6. Demonstrate communication systems allowing the CAISO to utilize renewable generation flexibility Demonstrate accepted communication protocols to allow CAISO to send operating signals to reduce renewable generation output under specified conditions to allow more flexible uses of renewable generation.		✓	✓

The first project in this area, leverages existing studies and is intended to demonstrate new, innovative technologies that improve accuracy of forecasting the CAISO's ancillary services needs in the face of higher levels of distributed resources on the grid. Since PG&E customers account for more than half of the statewide total installations of customer-sited PV systems, PG&E is in an optimal position to work with the CAISO on this issue.[22] Furthermore, the second project pertains to the important issue of communicating with both new and existing generation resources, and can be

[22] As of October 10, 2012, California had 128,489 solar projects installed with a total nameplate rating of 1,342 MW. PG&E customers account for half of this total at 692 MW.

demonstrated on existing generation assets as well as inform early stage applied research and market facilitation projects pursued by the CEC.[23]

More detail about each of the projects included in Table 4-2 is provided in the following section.

Project Number: 5

Project Title: Demonstrate New Resource Forecast Methods to Better Predict Variable Output

Description of Technology or Strategy To Be Demonstrated

This project type would develop, deploy, and operate a mesoscale meteorological modeling system that would improve the accuracy of wind and solar forecasts for forward energy markets (hour-ahead, day-ahead, and earlier). Mesoscale meteorological models are intermediate in size and address weather systems that range from 5 kilometers to several hundred kilometers. The outputs from a mesoscale model can be used to better forecast distributed or utility-scale renewable generation.

Applicable Electricity Value Chain Elements	
☒ Grid operations/market design	☐ Distribution
☐ Generation	☐ Demand-side management
☐ Transmission	

Concern, Gap, or Problem to Be Addressed

A CAISO study found that increased visibility of behind-the-meter generation can improve forecasting and reduce load following and regulation reserve requirements purchases by 8-12 percent. The study found that even small reductions in forecast error of DER show benefits ranging from $90 million to $391 million per year in reduced load following and regulation reserve requirements in 2020 for CAISO members, with the greatest benefit of improved visibility coming from PV ($176 million). Improved

[23] Utilities are prohibited in investing in generation-only projects and hence this project focuses on the communication to existing generation resources only. PG&E believes that the deployment of standard communication methods would be an important benefit for all new generation technologies and vendors.

visibility includes both data acquisition and solar forecasting. This project would improve the accuracy of solar and wind forecasting.

The California Solar Initiative RD&D program has funded three research projects that have elements of forecasting embedded in them. PG&E is monitoring those projects to prevent duplication.

The CEC's proposed Applied Research initiatives include S7.2 – "Improve Operator Dispatch and Visibility of Distributed Energy Resources." S7.2 would catalog characteristics of distributed energy resources in California to allow utilities and the CAISO to operate with far more visibility. This requires cataloguing the location, size, and type of distributed generation equipment and developing new tools using the database. The CEC's Applied Research initiative would be synergistic with this TD&D project and the experience from the demonstration could inform future efforts under the research activity.

PG&E also will need to coordinate closely with related projects conducted by Lawrence Livermore National Laboratory (LLNL) as part of the 21st Century Energy Systems initiative in order to ensure there is no duplication of effort. That initiative proposes ways to facilitate more accurate estimates of load following requirements and resource need based on computationally-intensive weather models.

Potential Benefits at Full Deployment

Full deployment of increased visibility of DER could show benefits of $90 million to $391 million per year, per a recent CAISO study. Full deployment of this meteorological model would also improve forward market forecasts of utility-scale solar and wind generation.

Improved visibility into DER output involves both data acquisition and solar forecasting. This project would improve the accuracy of solar forecasting. PG&E's Smart Grid Pilot Projects include a project for "Short-Term Demand Forecasting," which is focused on improved forecasting of demand based on data acquisition. Data acquisition will improve Hour Ahead and Real Time forecasts. This meteorological modeling system would also add the ability to improve Day Ahead and earlier forecasts.

Project Number: 6

Project Title: Demonstrate Communication Systems Allowing the CAISO to Utilize Renewable Generation Flexibility

Description of Technology or Strategy To Be Demonstrated

Wind turbines already have controls installed to provide "turndown" capabilities by allowing the blade pitch to be adjusted to reduce power output levels when necessary. Other technologies also have turndown capabilities. This project would demonstrate the use of accepted communications protocols to allow the CAISO to send an operating signal to reduce output under specified conditions, as allowed by contracts.

Applicable Electricity Value Chain Elements	
☒ Grid operations/market design	☐ Distribution
☐ Generation	☐ Demand-side management
☐ Transmission	

Concern, Gap, or Problem To Be Addressed

CAISO studies have concluded that there is a need to increase grid capabilities for downward ramping of 500-800 MW that may be satisfied using curtailment. Lack of that flexibility could cause reliability issues or require payments to reduce overgeneration occurrences. There are no other similar initiatives known at this time.

Potential Benefits at Full Deployment

The greatest benefits from this project would be preventing future reliability issues and reducing costs of projected overgeneration events.

Program Objective 3: Increase Generation Flexibility

B. 3 Program Objective 3 Increase Generation Flexibility

Current Challenges

As noted earlier in PG&E's proposed EPIC Investment Plan and discussed in the energy storage objective area, there is a need for fast ramping capabilities to respond to variability in resource output.

Natural gas-fueled power plants have operating characteristics that make them able to serve customer load by responding to forecast or unexpected changes in the output of

variable resources. However, as carbon levels are reduced, many natural gas-fueled power plants will need to be retired. Whatever natural gas-fueled plants remain or are added to the portfolio will need to be extremely flexible to provide the required response to accommodate the changes in grid operating patterns due to the growing amounts of variable resources.

Solutions

As noted in a recent CAISO study, the "Need for ramping capability is not the same thing as need for new resources. Conversion of existing resources to something more flexible could solve a ramping problem without changing the Planning Reserve Margin."[24]

PG&E intends to demonstrate ways that existing gas-fired power plants could be made more flexible to allow them to increase ramp rates to come up more quickly to maximum output. Vendors in the utility space have developed new, advanced control technologies to allow for faster ramp rates, however these have not been widely operationalized or tested. PG&E intents to evaluate and demonstrate use of these advanced capabilities to inform emerging technology in this space and support larger commercial scale deployment.

PG&E's Specific Project to Meet Program Objectives

Table 4-3 below outlines PG&E's specific project to increase generation flexibility

TABLE 4-3
SUMMARY OF PROJECT OBJECTIVES

Program Objective 3: Increase Generation Flexibility	Safety	Reliability	Affordability
7. Demonstrate systems to ramp existing gas-fired generation more quickly to adapt to changes in variable energy resources output Demonstrate improved ramp rate capabilities on existing gas turbines by utilizing advanced control technologies. This project is responsive to recent CAISO studies on potential for capacity shortage in 2020 if sufficient ramping capabilities are not available.		✓	✓

24 Renewables Integration Study Update, CAISO, February 10, 2012.

While this project would use EPIC funds to retrofit a generator, it is consistent with the Commission's mandate that "EPIC funds should not be used by utility administrators to fund electricity generation-only demonstration or deployment projects." (COL 13.) Decision 12-05-037 states: "The prohibition was designed to address two separate competitiveness concerns…the funds should not be used to advantage only IOU development of generation options…(t)he second concern is related to competition in the development of new generation itself …." PG&E's proposed project does not pertain to the development of new generation.

More detail about the project included in Table 4-3 is provided in the following section.

Project Number: 7

Project Title: Demonstrate Systems to Ramp Existing Gas-fired Generation More Quickly to Adapt to Changes in Variable Energy Resources Output

Description of Technology or Strategy To Be Demonstrated

There are 33 General Electric 7FA gas turbines installed in combined cycle configurations in California, which is considerably more than any other turbine model. GE offers a product marketed as "OpFlex Balance" that uses advanced controls technology to improve ramp rates to as high as 40 MW per minute (or higher in some cases). As of October 2012, none of the 7FAs in California were using this product. This project proposes to demonstrate improved ramp rate capabilities on one 7FA so that it can serve as a model for the rest of the 7FA fleet. It is assumed that there would be cost share with the vendor and the selected plant owner.

Applicable Electricity Value Chain Elements	
☒ Grid operations/market design	☐ Distribution
☐ Generation	☐ Demand-side management
☐ Transmission	

Concern, Gap, or Problem To Be Addressed

Recent CAISO studies have identified the potential for a capacity shortage in 2020 of up to 4,600 MW of upward ramping capability necessary to provide system reliability while

integrating renewable energy. There are no other active initiatives similar to this in California.[25]

Potential Benefits at Full Deployment

The greatest benefits from this project would be preventing future reliability issues that would occur if sufficient ramping capabilities are not available. Rates would also be lower than they would be if new generation was necessary to provide this capability.

4.2 Grid Modernization and Optimization

A. Program Area Background

Today's electric grid is a complex integration of electrical equipment components including meters, wires, structures, transformers, reclosers and switches, capacitor banks, substations, operations control centers, generation assets, communications networks, and measurement and monitoring systems (both equipment and software systems). This equipment and these systems must work together in perfect harmony to deliver electricity safely, reliably, and efficiently. PG&E's grid is extensive, covering 70,000 square miles and serving a population of 15 million people. PG&E's transmission system is one part of a much larger interconnect system serving the western U.S., two Canadian Provinces and Northern Mexico.

PG&E's grid includes:

- 141,215 circuit miles of distribution lines with 20 percent of the lines located underground
- 18,616 circuit miles of transmission lines
- 864 substations that include circuit breakers, transformers, voltage regulation equipment, and capacitor banks
- 2,190 substation transformers
- 3,124 distribution circuits

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25 PG&E discussed the importance of this initiative with the CEC on October 9 and 12 and as a result the CEC revised its draft Investment Plan to include this initiative. PG&E proposes to collaborate with the CEC on this project to demonstrate it on PG&E's grid and meet both CEC and utility objectives.

- 2.2 million wood poles

The expansion of PG&E's electric grid mirrors the post-World War II California population growth. Much of this grid infrastructure has been in place for more than 40 years and is considered outdated when compared to today's modern digital technology devices. This is a significant challenge faced by the vast majority of U.S. utilities. In 2011, EPRI estimated that the costs to modernize the grid in the United States would be in the range of $338-$476 billion over a 20-year period.[26] Yet, this modernization is imperative in order to continue to improve employee and public safety, provide reliable electric service in the face of changing needs, and improve the efficiency of electric operations to maintain electric service affordability. Managing this tremendous "grid overhaul" process in a well-planned manner is a major initiative for California utilities and imperative to meet California energy policy goals.[27]

While asset age is one driver for grid modernization, the application of improved technologies to managing the grid is another important driver. Utilities currently lack equipment monitoring, measuring, and communicating systems available in other industries that could drive more efficient asset management programs and reduce the labor-intensive efforts to inspect, test and maintain each of the millions of infrastructure components that comprise the grid. While these technologies are increasingly becoming available, they are not sufficiently tested and at scale to be considered fully vetted commercial technologies that adhere to industry standards, critical cybersecurity requirements or data protocols. Without utility scale demonstration, operators are wary to introduce unknown technologies into the grid environment that could potentially compromise system and public safety and reliability.

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26 EPRI, "Estimating the Costs and Benefits of the Smart Grid, A Preliminary Estimate of the Investment Requirements and the Resultant Benefits of a Fully Functioning Smart Grid," March 2011.

27 SB 17, AB 32, RPS, Executive Order S-3-05, Loading Order (Energy Action Plan), SB 626 (Low Emission Vehicles/Transportation), rely on the electric grid for implementation.

B. Key Program Objectives That Support Policy and Meet Industry Needs

PG&E has identified three key program objectives in the Grid Modernization and Optimization Program Area:

Program Objective 1	**Optimize Existing Grid Assets**
Program Objective 2	**Prepare for Emerging Technologies**
Program Objective 3	**Design and Demonstrate Grid Operations of the Future**

These three program objectives, current challenges and solutions to overcome barriers are discussed in more detail below.

B. 1 Program Objective One: Optimize Existing Grid Assets

Current Challenges

As noted earlier, utilities are facing the daunting task of performing grid "overhauls" while continuing to safely and reliably operate a complex electrical system containing millions of legacy components. Modernizing these assets presents a daunting and expensive task considering that PG&E owns and operates over $16.2 billion worth of distribution and transmission assets[28] that cost over $800 million annually to operate and maintain.[29] Consequently, a large scale overhaul is cost prohibitive, whereas incremental advances in asset management can yield long term cost benefits.

To keep costs low, utilities have focused on optimizing and extending the life of existing assets as well as implementing new remote monitoring and evaluation techniques. Advances in data analytics have also begun to move the industry from a forensic, "what happened" approach to a more proactive, "predict what will happen" approach. Optimizing existing assets will increase the cost-effectiveness of grid modernization, especially when existing infrastructure can be shown to successfully integrate with new

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28 PG&E FERC Form 1, April 18, 2012: Transmission: Total Plant - $6.7 billion, Accumulated Depreciation - $2.1 billion, Net Utility Plant - $4.6 billion; Distribution: Total Plant - $20.2 billion, Accumulated Depreciation - $8.6 billion, Net Utility Plant - $11.6 billion.

29 PG&E FERC Form 1, April 18, 2012: Transmission: Operations Expenses - $135.7 million, Maintenance Expenses - $69.1 million, Total Operations and Maintenance (O&M) - $204.8 million; Distribution: Operations Expenses - $186.8 million, Maintenance Expenses - $414.0 million, Total O&M - $600.8 million.

players that are increasingly on the grid, including distributed generating resources, electric vehicles, and new customer-oriented products and services.

Solutions

PG&E intends to pursue technology demonstration and deployment projects that leverage and optimize existing assets while advancing California policy objectives and maintaining affordable rates for customers. PG&E has identified various emerging technologies in the utility industry, that offer complementary and/or "bolt on" technologies that improve the underlying assets in service. These include new or improved "self-serve" data analysis engines and techniques to access existing utility and other sources of data, analyze it quickly, and efficiently develop actionable results. These technologies appear to offer significant benefits, however they have not progressed to wide spread, commercial-scale utility use. Utility-specific demonstration is necessary employing the unique characteristics of each utilities' processes, systems and technologies to prove a viable business case.

PG&E's Specific Projects to Meet Program Objectives

Table 4-4 below outlines PG&E's specific project to optimize existing assets.

TABLE 4-4
SUMMARY OF PROJECT OBJECTIVES

Program Objective 1: Optimize Existing Grid Assets	Safety	Reliability	Affordability
8. Improve distribution system safety and reliability through new data analytics techniques Utilize data analytics advances to improve grid safety and reliability. Demonstrate that the ever-increasing amounts of data can be mined and combined for targeted, cost-effective use. Potential scenarios include risk-based asset management, safety hazard mitigation and proactive outage prediction using "self serve" and virtual integration environments.	✓	✓	✓

TABLE 4-4
SUMMARY OF PROJECT OBJECTIVES
(CONTINUED)

Program Objective 1: Optimize Existing Grid Assets	Safety	Reliability	Affordability
9. Test new remote monitoring and control systems for T&D Assets Demonstrate emerging monitoring and control technologies that proactively identify "precursors" to safety or reliability issues in high priority areas and prevent system overload or failure. Priority areas include Discrete Series Reactors (DSR), that can optimize power flows, remote operations of underground vaults, and solid state transformers and dynamic voltage control equipment specifically aimed at supporting EV and PV integration.	✓	✓	✓
10. Demonstrate new strategies and technologies to improve the efficacy of existing maintenance and replacement programs Leverage on line monitoring tools for installed equipment (substation, transformers, underground cable, etc.) already deployed and expand their usage to replace currently manually intensive asset inspection efforts with automated, technologies. Demonstrate tools that integrate trend analysis, asset health indices, and simulation/visualization technologies to proactively create and inform asset maintenance activities.	✓	✓	✓
11. Demonstrate self-correcting tools to improve system records and operations Demonstrate tools that identify and "register" existing assets to improve the integration between utility planning and operations. As part of the demonstration, implement "self-correcting" technologies that identifies plan vs. actual discrepancies and updates system records automatically. High priority use cases include: (1) Mapping of transformers to primary phases, (2) Mapping of customers to transformers and (3) Precision mapping of PG&Es overhead and underground network.	✓	✓	✓
12. Demonstrate new technologies that improve wildlife safety and protect assets from weather-related degradation Demonstrate new strategies and technologies to improve animal and bird protection, reduce outages caused by animals and birds, and protect assets from expensive weather-related degradation such as fog related corrosion.	✓	✓	✓

PG&E deems these projects to be high priority due to their potential to leverage promising new technology to improve safety, reliability and reduce current program costs for customers. The overarching theme for this program area is "Integration."

These projects will provide PG&E with more useful, multi-faceted and cross-operations information where there is currently siloed operations or non-existent data due to the lack of interoperability between traditional utility systems.

More detail about each of the projects included in Table 4-4 is provided in the following section.

Project Number: 8

Project Title: Improve Distribution System Safety and Reliability through New Data Analytics Techniques

Description of Technology or Strategy To Be Demonstrated

This project proposes to demonstrate innovative technologies related to data analytics including instant data ad-hoc search and correlation, “mash-ups,” visualization, data recognition and other data analytics solutions. These solutions, developed as part of Internet technologies but not yet applied to the utility industry, will be looked at to demonstrate cost-efficient, scalable methods to improve key areas within grid operations. Potential demonstration scenarios include the following:

- A customer photographs a fallen tree on an electric line and uploads the picture. The utility tags it, automatically accesses records, identifies the line and sends a response crew with directions while auto-notifying impacted customers of the outage and potential safety hazard.
- Utility operators combine data such as weather forecasts, high fire danger areas, historical asset performance data, and vegetation management to significantly improve fire prediction, prevention and response capabilities, and share this information real time with first responders.
- Engineers and crews utilize millions of SCADA measurements, protective relay data, maintenance history, equipment test records, and other sources to optimize maintenance and replacement of costly equipment such as substation transformers and circuit breakers.

Applicable Electricity Value Chain Elements (check all that apply)	
☐ Grid operations/market design	☒ Distribution
☐ Generation	☐ Demand-side management
☒ Transmission	

Concern, Gap, or Problem To Be Addressed

Current processes are time-consuming, manually-intensive data collection efforts that result in large data extracts that preclude timely or meaningful analysis. Existing siloed Information Technology (IT) infrastructure is another limitation. Legacy hardware and traditional software is not sufficiently scalable and would require costly integration to meet future analytics and reporting needs. Existing processes are labor intensive and disruptive to ongoing operations. Meanwhile, the amount of data inside the utility continues to grow exponentially.

The concept of data analytics or "Big Data" has emerged as a potential solution to the problems noted above; however, the actual application of analytics has yet to be proven. PG&E has seen numerous promising presentations from service providers, but the service providers need access to utility systems, operations and data to demonstrate a concrete business case. As part of this project, PG&E would work with vendors using utility-specific processes, systems and data to demonstrate high-priority scenarios that show potential benefits, evaluate the business case for "Big Data" applications within utilities, and help inform vendor product development in the utility space.

Potential Benefits at Full Deployment

If the data analytic tools developed in this project were fully deployed at PG&E, benefits would include: improved maintenance procedures and effectiveness, more effective control of disparate resources, prevention of hazardous conditions and equipment failures, improved system safety, improved system reliability, and potentially lower operating costs in the future.

Project Number: 9

Project Title: Test New Remote Monitoring and Control Systems for T&D Assets

Description of Technology or Strategy To Be Demonstrated

This project proposes to demonstrate the use of developing technologies to enhance the capability of utilities to monitor equipment, detect anomalies in operating characteristics, and control equipment, all from remote locations, to prevent failures or limit the impact of failures. Currently, PG&E is deploying equipment and devices for remote monitoring and control, including traditional SCADA equipment and underground network sensor equipment. This project does not cover the same ground, as it looks to expand this process as new technology is developed and made available for utilities and as applications used in other industries and environments are looked at for utility use. Specific technologies and equipment presenting potential opportunities include:

- Discrete Series Reactors (DSR) – Through the developing concept of "Smart Wiring," DSRs, typically installed on fixed pads in substations, could be deployed directly onto conductors to detect the location of potential overload situations much more precisely than available today. As a conductor approaches the overload point, the DSR would inject a magnetic inductance into the line, increasing line impedance. As load increases, additional inductance increases impedance and the load would be shifted to a lower load conductor. These DSRs, installed at optimum locations and controlled remotely or pre-programmed with various algorithms, could vary their impact based on observed or analyzed operating conditions, ultimately allowing the utility to optimize generation resources, optimize line flows, mitigate normal overloads, and delay costly re-conductoring projects.
- Remote Security and Operations in Underground Vaults – Underground vaults for electric equipment are an environment that present additional safety concerns for the public and utility employees while presenting a less protected area (no fences like substations) for thieves or vandals. New security applications, alerting operators more quickly to unauthorized entry or preventing the entry altogether, would decrease the costs associated with theft or vandalism and reduce the potential for intruder injuries. On the

control side, with new applications of remote switching, an employee accessing the underground vault is able to remain at a safer operating distance while continuing to operate equipment in both daily and emergency situations.

- Solid State Distribution Transformers and Low Voltage Dynamic Voltage Control devices that can be installed independently to manage the voltage and reactive power intermittency of a large number of photovoltaic panels or charging electric vehicles downstream of the device. The devices could be set and manage themselves or be controlled via a central computer system. This project looks to test new equipment to support solar PV integration, EV integration and grid operating efficiency. These are new devices that could be used in a stand alone mode or in conjunction with a voltage and reactive power optimization system where a central computer manages existing equipment.

Applicable Electricity Value Chain Elements	
☐ Grid operations/market design	☒ Distribution
☐ Generation	☐ Demand-side management
☒ Transmission	

Concern, Gap, or Problem To Be Addressed

In order to increase operational effectiveness in an environment characterized by aging equipment and increased complexities of generation resources, while not replacing the underlying assets, utilities are looking to gather more data about their deployed assets in as close to real-time as possible and take actions to prevent failures and outages. While already deploying remote monitoring and control devices on equipment such as line reclosers and circuit breakers, utilities wish to expand this functionality out from the substations and onto the conductors at specific locations where other problems can be managed.

In the case of underground equipment, the vault itself is difficult to secure due to the inability to use fencing and other typical asset protection strategies; e.g., in terms of cameras there is no utility asset outside the vault on which to mount a camera and the darkness inside the vault precludes the installation of regular cameras. Inside the vault,

much of the equipment is difficult to access and existing communications for control devices is less effective in the underground environment. PG&E looks to address these issues through the application of technologies from non-utility, but similar, environments (possibly mines, subways, water utilities), while also working with equipment and security vendors to develop utility-specific solutions.

The forecasted amount of renewable generation and electric vehicle charging is expected to continue growing at an increasing rate impacting the utilities distribution system power quality and reliability. PG&E looks to address these issues through new devices that can manage the intermittency of the voltage and var fluctuations close to the source of the facilities causing the intermittency issue.

Potential Benefits at Full Deployment

The deployment of the remote monitoring and control equipment developed in this project were fully deployed across the PG&E system, the major benefits would be the remote and timely identification of abnormal situations, an increase in system reliability through decreased outages, and an increase in safety and security of PG&E assets through off-site equipment monitoring and control. Other benefits would include the remote and timely identification of maintenance issues and impending equipment failures, an increase in system operating efficiency through both the optimization of line flow and mitigation of overload situations through improved distributed resource integration, and a decrease in operating costs.

Project Number: 10

Project Title: Demonstrate New Strategies and Technologies to Improve the Efficacy of Existing Maintenance and Replacement Programs

Description of Technology or Strategy To Be Demonstrated

This project looks to advance the use of online monitoring tools to simplify the manual inspection process, both in terms of reducing the number of manual steps and replacing manual inspections with automated processes, as well as alert the operator of impending issues with equipment in near real time. In terms of specific tools, PG&E looks to investigate developing monitoring and analytics tools that provide trend

analysis, visualization, and asset health indexing of substation, underground cable and other equipment. Potential online monitoring tools could include:

- Underground Cable Analysis – Tools and algorithms that analyze load and operating characteristic data from underground cables in order to develop an understanding of potential failure points, cable maintenance needs, and cable life expectancy. This type of tool could also reduce the number of costly and time-consuming manual inspections associated with underground cables.
- Dissolved Gas Analysis – Tools and algorithms that analyze data from monitoring equipment installed on substation equipment (distribution and transmission) that tests for dissolved gasses or other precursor data that would assist in understanding the condition of the equipment. This detailed understanding would assist in establishing a condition-based maintenance program as well as enable maintenance personnel to reduce on-site inspection times by using remotely gathered and analyzed data. This analysis would also assist in preventing outages and increase the reliability of the electric service.
- Partial Discharge Analysis – Tools and algorithms that analyze data from monitoring equipment in order to identify cable (distribution and transmission) discharge that indicates an impending issue with the equipment. This analysis would assist in preventing outages and increase the reliability of the electric service.

Applicable Electricity Value Chain Elements	
☐ Grid operations/market design	☒ Distribution
☐ Generation	☐ Demand-side management
☒ Transmission	

Concern, Gap, or Problem To Be Addressed

Currently, the majority of transformer, underground cable and other equipment issues are identified upon the failure of the equipment, which typically results in an outage. Additional issues are identified through maintenance inspections, a relatively labor intensive effort. This reactive and time-consuming maintenance program does little to proactively manage the equipment assets and their health. With the online monitoring

in development today, PG&E would be able to improve the efficacy of maintenance and replacement programs, by more quickly identifying impending issues and prioritizing maintenance activities, and, ultimately, avoid the impact of failures. Unlike existing labor-intensive efforts to identify incipient problems, the equipment would identify itself when it needs maintenance or replacement.

Potential Benefits at Full Deployment

If, successfully demonstrated, these analysis and online monitoring tools would improve maintenance procedures and their effectiveness by remotely identifying maintenance issues and enabling the establishment of more condition-based maintenance principles. Additionally, through the remote identification of specific failure points or conditions, maintenance efforts could be rationalized and focused, while maintenance inspections could be redesigned with an automated component to shorten or do away with the manual components. Ultimately, these types of tools would lead to improved system reliability, improved system safety, and lower operating costs.

Project Number: 11

Project Title: Demonstrate Self-Correcting Tools to Improve System Records and Operations

Description of Technology or Strategy To Be Demonstrated

Utilities' data systems and models contain a level of inaccurate data, including data such as customer to transformer assignments, transformer to primary conductor phasing, and underground cable mapping. This project is focused on improving inaccuracies in these utility systems and models through automated methods in order to reduce the high costs associated with site visits to observe and analyze the equipment in order to correct the data manually. These automated methods do not yet exist commercially, but development has started as more data flows into the utility and utilities learn what they can do with all of that data. More accurate data increases the efficiency of utility field operations and overall system reliability through better maintenance planning, outage response and system analysis. Examples of targeted improvements include:

- Transformer Phasing and Customer Assignments – Transformer phasing and customer misassignment are a long-existing industry issue. For example, PG&E's existing transformer management system estimates that approximately 50,000 transformers[30] may be overloaded while another 50,000 transformers[31] may be idle largely due to inaccurate customer assignment to transformers. This situation can lead to unanticipated customer impacts and less effective system planning and design. Currently, utilities correct the data by on-site verification and manual entries in the asset data systems. This project looks to develop automated tools to analyze operational and performance data and self-correct or auto-correct existing data in the systems.
- Conductor Field Locations – Physical marking and tagging inaccuracies that occur for a variety of reasons over time in overhead and underground systems can lead to inadvertent customer power outages or worker safety hazards. All utilities, including PG&E, take a number of precautions to avoid these outcomes, but incidents do occur because equipment is often hidden from view or difficult to trace. This project looks to develop a network mapping "self-correction" tool that collects operating and performance data from a variety of operating devices such as SmartMeters™ and operating systems such as SCADA or outage management systems to identify the location of conductors and auto-update asset databases. Having more accurate information about overhead and underground conductors in a utility system is essential to conducting safe field operations, avoiding preventable outages, and improving operational efficiency.

Applicable Electricity Value Chain Elements	
☐ Grid operations/market design	☒ Distribution
☐ Generation	☐ Demand-side management
☒ Transmission	

30 An approximate number plus/minus 25 percent.

31 *Id.*

Concern, Gap, or Problem To Be Addressed

Inaccuracies exist in utility databases regarding specific asset characteristics, including customer to transformer assignments, transformer to primary conductor phasing, and underground cable mapping. These inaccuracies become an issue when unexpected customer outages occur or when making planning, design and asset management decisions that utilize customer to transformer assignment or when performing maintenance that requires one to know the exact location of underground or overhead assets. Utilities consistently verify and/or update this information as a result of site visits or maintenance activities, but this process is more reactive than proactive and only results in limited updates to an extensive asset database. The ability to analyze existing operating and performance data, identify inaccuracies in the current databases, and auto-correct these database inaccuracies would be instrumental in improving, cost effectively, planning and operating processes.

After reviewing all other ongoing and proposed initiatives, PG&E does not believe there are duplicative projects in California.

Potential Benefits at Full Deployment

Successfully demonstrating the capability to auto-correct or self-correct databases and data models would provide the benefits of improving maintenance procedures and effectiveness, preventing hazardous conditions, and avoiding preventable outages; i.e., those caused by inaccurate data or misassigned assets. Additionally, in replacing a highly manual process with an automated process, PG&E could lower operating costs.

Project Number: 12

Project Title: Demonstrate New Technologies that Improve Wildlife Safety and Protect Assets from Weather-Related Degradation

Description of Technology or Strategy To Be Demonstrated

Due to a utility's operating environment, there are many outages that result from animal and bird contact with electric system assets. Additionally, the weather impact on asset conditions, especially from moisture and fog in PG&E's case, is considerable. This project looks to identify, develop, and demonstrate devices, equipment, and strategies to lessen these impacts for the utility industry, either through avoidance technologies

(causing animals and birds to avoid equipment) or through mitigation technologies (enabling electric system equipment to withstand contact by animals or birds with no ill effects on the system or animal/bird; making electric system equipment impervious to fog-based moisture). Though animal contact prevention technology exists in other industries, such as bird deterrents for airports and buildings, most of these technologies are not immediately transferrable to a utility's system due to the location of power lines and substations in neighborhoods and crowded areas. For this reason, the utility industry is looking at developing new technology or adapting existing technology. On a higher-level, this project looks to identify tools and technologies to identify the most susceptible areas of the PG&E operating system with regards to these environmental factors. These technologies would improve environmental compatibility of electric facilities, decrease the number of animal/bird deaths resulting from electric system contact, improve safety and reliability, and reduce associated construction, operations, and maintenance costs.

Applicable Electricity Value Chain Elements	
☐ Grid operations/market design	☒ Distribution
☐ Generation	☐ Demand-side management
☒ Transmission	

Concern, Gap, or Problem To Be Addressed

The utility industry has always had the problem of animals and birds, some endangered species, coming in contact with the electrical system to the detriment of both the animal or bird and the reliable operations of the system. Additionally, utilities have to deal with fog (especially prevalent in PG&E's case) and other weather-related phenomena that cause corrosion of electric system equipment. These issues are further described:

- Animal-Caused Outages – Most utilities' operating environment contains a wide variety of animal and bird species, some of which are endangered or protected species. These birds and animals contact energized lines resulting in animal and bird deaths, power outages and wildfires. For example, in 2011, out of nearly 45,000 outages, PG&E had approximately 2,400 known animal or bird related outages and approximately 7,300 unknown outages, some of which were likely due to animals or birds. Consistent with agreements between PG&E and state and federal wildlife management

agencies, PG&E takes action to avoid bird-related power line contacts after events are confirmed, but PG&E is seeking a more proactive way to avoid these contacts. Demonstration of devices and technologies to identify areas most susceptible to animal or bird contacts and demonstrating new deterrents would improve the environmental compatibility and safety of PG&E's power system, reduce the number of power outages and reduce the associated maintenance and operating costs.

- Other Environmental Impacts and Equipment Failures – Utilities' equipment is exposed to a variety of environmental and weather conditions that can impact equipment life and operability. For example, in 2011, at PG&E, there were approximately 12,000 outages due to equipment failures and PG&E spent $1.6 million dollars washing T&D system insulators to prevent power outages, equipment damage and other impacts caused by environmental conditions adverse to the current electric system. Demonstration of devices and technologies to improve environmental compatibility and reduce the number of equipment failures would assist in reducing utility and customer outage costs and increase reliability.

PG&E is not aware of other utilities currently looking at these types of technologies and strategies, especially outside of California where the consideration of the impact on wildlife is much less of a priority. PG&E will ensure collaboration with other California utilities to ensure there is no duplication of technology evaluation in this specific arena.

Potential Benefits at Full Deployment

If PG&E is able to successfully demonstrate technology that reduces wildlife and fog/weather impacts on the electrical system, potential benefits to utilities would include: reduced equipment failures, reduced maintenance and operating costs, improved reliability through a reduction in outages, increased safety of the public and employees, increased safety of wildlife with a corresponding decrease in animal deaths, and a reduced impact on endangered species.

4.2.B.2 Program Area 2: Prepare for Emerging Technologies

Current Challenges

Utilities have a fundamental challenge of adapting to the rate of change of technology which is exponentially faster than the typical lifecycle of traditional electric assets. For example, a substation may be planned five years in advance, built in one to two years (taking into account siting, permitting, construction, and other factors), and last more than 30 years. New technology device lifecycle estimates range from 12 to18 months, marking a profound difference, in fact one tenth of the lifespan, of traditional energy infrastructure. Utilities must have a formal program to identify technologies on the near-term horizon to successfully integrate them into utility planning cycles. New technologies that do not have 20 years of “in the field” utility deployment are at a significant disadvantage. In addition, even if these technologies have been demonstrated in limited deployment, operators are often reluctant to “turn them on” or integrate them with existing, “tried and true” assets that have years of safety, reliability and operating data.

Solutions

PG&E intends to enable the rapid deployment and integration of developing technologies that are nearing commercialization. Projects in this area will increase the utilization and functionality of equipment already deployed, but whose advanced technology options have not been enabled or “turned on” due to a lack of industry experience with the new component. This includes various substation protection and control equipment, SCADA functionality, and communications network functionality that has not been not fully utilized across many utilities, yet has significant potential if it can be first demonstrated at sufficient scale.

PG&E's Specific Projects to Meet Program Objectives

Table 4-5 below outlines PG&E's specific project to prepare for emerging technologies.

TABLE 4-5
SUMMARY OF PROJECT OBJECTIVES

Program Objective 2: Prepare for Emerging Technologies	Safety	Reliability	Affordability
13. Demonstrate new systems to improve substation automation and interoperability Demonstrate new strategies and technologies to convert and integrate multiple existing proprietary technologies within the substation environment for more effective operations. Substations are key operational hubs and represent significant investments, which must be further leveraged by engaging with vendors to create the next generation of interoperable substation services and products.	✓	✓	✓
14. Demonstrate "next generation" SmartMeter™ telecommunications network functionalities Demonstrate and deploy strategies and technologies that leverage and improve the SmartMeter™ network. New technologies on the horizon run the gamut from new safety and operational monitoring equipment, to new customer-focused technologies, to new meter functionalities not yet commercially deployed. Explore technologies that improve or extend the SmartMeter™ telecommunications network and have the potential to improve meter performance, and decrease future upgrade, maintenance or operational costs.	✓	✓	✓

These projects also build on applied research proposed by the CEC in their EPIC plan to "develop automation and operational practices, including those for outage management, congestion mitigation, and infrastructure protection to make use of smart grid equipment."

More detail about each of the projects included in Table 4-5 is provided in the following section.

Project Number: 13

Project Title: Demonstrate New Systems to Improve Substation Automation and Interoperability

Description of Technology or Strategy To Be Demonstrated

Substations are key hubs for system operations and corresponding performance data. In addition, equipment located in substations represents a significant investment that needs to work in close coordination for safe and reliable operation. Since many utilities, including PG&E, use multiple vendor products for protection and control equipment, this project focuses on engaging manufacturers to develop digital interfacing devices that are interchangeable and functional with different vendor products, develop prototypes for testing and evaluation, and perform field evaluations. These interfacing devices, combined with digital equipment already installed in the substation through other projects, will significantly reduce design, installation, material, and testing costs over current analog equipment. In addition, though fiber optic cable has been used inside control structures within a substation, it has not widely been utilized outside these structures to establish connections and communication between all of the different pieces of equipment inside the substation footprint. By using fiber optic cable in this way, this project looks to demonstrate that a utility can establish a more reliable and secure communications network within the substation to improve equipment operation coordination. Overall, this project proposes to transform the substation protection, automation and control functions from analog to digital by using digital devices and fiber optic cable. This project will use International Electrotechnical Commission (IEC) standard 61850 to guide the installation design and deployment and leverage new communication technology available for substation environments. By virtue of less equipment with potential wiring and testing risks, PG&E expects to improve system reliability and establish the backbone to provide and analyze advanced data and allow for future equipment and technology enhancements.

Applicable Electricity Value Chain Elements	
☐ Grid operations/market design	☒ Distribution
☐ Generation	☐ Demand-side management
☒ Transmission	

Concern, Gap, or Problem To Be Addressed

Equipment in substations is critically important to the efficient operation of the electric system as well as being the source for a great deal of the operational and performance data that flows back to the utility back office and control centers for both system operations and equipment monitoring. As the majority of substations were built many years ago, utilities, including PG&E, have upgraded various components over the years and continue to upgrade components as new technology is developed, new systems are put in place, and new functionality is required. In upgrading various pieces of equipment and technology, especially in the areas of protection and control, market characteristics drive the use of multiple vendors. While many vendors have already adopted standards such as IEC 61850, their products are not necessarily interoperable with other vendors' products. This lack of interoperability creates a problem in terms of system operating efficiency, the problem being magnified as more digital equipment, with its added functionality, control, and communications capabilities, is added to the substation environment. To increase the substation interoperability, PG&E is looking to develop digital interfacing devices that are interchangeable and functional with different vendor products. These interfacing devices will significantly reduce design, installation, material, and testing costs over current analog equipment.

In addition to the interface issues, substations typically use traditional copper cable for indoor and outdoor applications. With digital devices and digital interfacing devices, a more robust communications network is required. The use of fiber optic cable could provide this more robust network, mitigating a portion of the risk associated with wiring issues associated with copper wires.

Potential Benefits at Full Deployment

If the substation automation and interoperability upgrades developed in this project were fully deployed at PG&E, potential benefits would include: improved operational efficiency (through interoperability and communications improvements), reduced capital and expense costs through reduced design, installation, material, and testing costs, improved system safety, and improved system reliability.

Project Number: 14

Project Title: Demonstrate "Next Generation" SmartMeter™ Telecommunications Network Functionalities

Description of Technology or Strategy To Be Demonstrated

PG&E has installed a telecommunications network to transfer data from SmartMeters™ to PG&E's back office. As PG&E's Smart Grid, (and smart grid technology in general), evolves, the SmartMeter™ telecommunications network must evolve as well. This project would demonstrate and deploy technologies that leverage and improve upon the existing PG&E SmartMeter™ telecommunications network. Emerging technologies that could potentially enhance the existing SmartMeter™ telecommunications network are extensive, and include safety and operational monitoring equipment, specific customer technologies (not already being considered as part of other projects), and additional meter functionality. PG&E anticipates that emerging technologies to improve or extend the SmartMeter™ telecommunications network's operational capabilities would include technologies designed to improve system reliability, enhance telecommunications network connectivity, increase message rates, and decrease ongoing maintenance and operational costs. Next generation technology to advance such capability warrants demonstration and deployment as part of this project.

Applicable Electricity Value Chain Elements	
☐ Grid operations/market design	☒ Distribution
☐ Generation	☐ Demand-side management
☒ Transmission	

Concern, Gap, or Problem To Be Addressed

The SmartMeter™ telecommunications network that has been deployed as part of PG&E's Smart Grid is working as designed and delivering substantial benefits in many areas including meter- reading savings, outage notification, faster restoration following outages, power theft identification, and more. The Smart Grid though continues to evolve and develop as utilities deploy different components, and develop new technologies and capabilities. As data analysis techniques develop, utilities have identified and will continue to identify, additional useful data. The generation of these

data results in additional functions for the existing SmartMeter™ telecommunications network that were not envisioned when the initial system was designed.

As the SmartMeter™ telecommunications network matures, in conjunction with the aforementioned evolution, the operating characteristics of the existing network will require “tweaking” to enable peak efficiency and added capability. This is not routine maintenance or routine upgrading of telecommunications network software that would be covered as part of the Smart Grid Deployment, but rather improvements to the system to support those capabilities not earlier envisioned and to improve operating functionality in areas such as network connectivity, availability, and speed. Additionally, this project could examine and potentially improve network characteristics and/or functionality as they relate to maintenance processes in order to drive down current maintenance costs.

Many utilities across the country are deploying Advanced Metering Infrastructure (AMI) and Smart Grid systems in their service territories, many with the same telecommunications network as PG&E’s program. As PG&E develops the details for the specific functionality extensions or operational improvements, PG&E will coordinate (direct contact or literature/information review) with many of these utilities to identify like projects that have already been conducted and determine whether a PG&E-specific project is warranted or whether PG&E can gain access to pilot/project results to use in lieu of a demonstration of their own.

Potential Benefits at Full Deployment

Depending on the technologies and functionality ultimately developed for the SmartMeter™ telecommunications network as part of this project, potential benefits would include: improved network reliability and connectivity, improved telecommunications network maintenance procedures, and lower operating and maintenance costs.

4.2.B.3 Program Objective 3: Design and Demonstrate Grid Operations of the Future – Current Challenges and Solutions

Current Challenges

The electric industry must continue to undertake significant transformation to achieve the vision of the 21st Century grid, and ongoing TD&D is a critical element of implementing the vision. The grid must support the increasing presence of renewable and distributed generation, continue to adapt to meet societal and environmental needs, and improve flexibility to attain evolving energy policy objectives.

Utilities face the challenge of managing long-term technology identification and development across a wide-ranging set of domains including power engineering, automation, telecommunications, information systems, and various other T&D operational areas. Many future technologies are in a very early, proof-of-concept stage, have had little standardized testing, and have not been widely deployed under accepted global or national standards. Yet, it is essential that these technologies also become a part of the utility technology demonstration pipeline to understand the technology, the potential interactions with existing technologies, the impact on existing processes and standards, and help inform product development to drive utility application and benefits. Combined with the issues of a transitional workforce where nearly half of PG&E's workforce will be eligible for retirement over the next five years, PG&E recognizes that there is an urgent need to create a new, streamlined set of tools that can support the grid and can be learned, implemented and operated consistently by future generations.

Solutions

PG&E intends to pursue demonstration projects in this area that emphasize new, integrative technologies as well as focus on human situational awareness and interaction factors. Operators must already take into account an ever-increasing set of processes, systems and technologies, each with its own user interface, monitoring dashboards, and set of operating procedures. One example of a "futuristic" technology that promises potential benefits, but that also faces "situational awareness" barriers is the PG&E/Western Electricity Coordinating Council collaborative project to test transmission system synchrophasor technology. While conceptually synchrophasor technology may yield significant benefits, more work is needed to understand the

practical applications of the technology, how it would integrate with existing control center operations and procedures, and how operators would use the information to improve system safety and reliability.

By working collaboratively with the CEC and the other IOUs, PG&E can advance early – stage technologies that have the potential to transform control center processes and ensure that they are fully tested, and "business case" ready for full-scale future implementation.

PG&E's Specific Projects to Meet Program Objectives

Table 4-6 below outlines PG&E's specific projects to design and demonstrate gird operations of the future.

TABLE 4-6
SUMMARY OF PROJECT OBJECTIVES

Program Objective 3: Prepare for Emerging Technologies	Safety	Reliability	Affordability
15. Demonstrate new technologies and strategies that support integrated "customer-to-market-to-grid" operations of the future Design and demonstrate the integration of distribution operations software tools, from siloed operating systems into an integrated and efficient combination of tools. Priority demonstration and integration areas include DG and Localized Load Monitoring, Integrated Telecommunications Network Management, and "next generation" operator consoles.	✓	✓	✓
16. Demonstrate electric vehicles as a resource to improve grid power quality and reduce customer outages Demonstrate electric vehicles as a resource that could provide the capability to connect to the distribution grid to improve power quality, reduce the length of customer planned or unplanned outages, reduce feeder congestion, and manage costs associated with increased demand and reliability. A priory demonstration includes using PG&E's electric vehicle fleet to supply power to individual customers during distribution system repairs.	✓	✓	✓
17. Leverage EPIC funds by participating in multi-utility, industry-wide RD&D programs such those Conducted by EPRI Leverage and advance existing industry collaboration efforts to attain California policy objectives and inform specific utility TD&D pilots. Potential programs include EPRI's *Intelligrid*, *Integration of Distributed Renewables*, *Energy Storage*, *Risk Mitigation Strategies*, and *Distribution Grid Modernization* programs.		✓	✓

These projects seek to address a wide variety of future anticipated needs, but do not yet have an established business case or definitive solution. Therefore, PG&E will emphasize collaboration in this area with partners such as the CEC to build on the CEC's applied research activities. In particular, PG&E envisions that these demonstrations outlined above would be synergistic to CEC objectives S6.1 Develop Equipment and Technologies to Enable Power Flow Control and Bi-Directional Power Flow Through the Transmission and Distribution System; S6.2 Develop Controls and

Equipment to Expand Distribution Automation Capabilities; S6.3 Develop Automation and Operational Practices to Make Use of Smart Grid Equipment; S6.4 Develop Grid Operation Practices and Applications that Use Renewable Availability Data; S7.3 (AR): Develop and run real-time scenarios to support operations, including energy storage utilization; and S14.3 (TD&D): Demonstrate advanced vehicle-to-grid storage technologies and second-use vehicle battery applications.

More detail about each of the projects included in Table 4-6 is provided in the following section.

Project Number: 15

Project Title: Demonstrate New Technologies and Strategies That Support Integrated "Customer-to-Market-to-Grid" Operations of the Future

Description of Technology or Strategy To Be Demonstrated

In the near future, PG&E will need to integrate significantly more data and information into both existing and future operational systems to assist in running the system safely, efficiently, and reliably. Data concerning EVs and PVs will grow exponentially and needs to be tightly integrated into control and planning operations. Data from customers concerning service, outages, and safety issues with existing assets will also need to be tied into analysis tools in order for it to be used effectively. System operators will need timely and simple access to this data and resulting analyses in order to manage the system and the resources effectively. Examples include:

- Distributed Generation and Localized Load Monitoring – This area seeks to develop tools to understand PG&E loads, generation including renewables, energy efficiency and demand response resources, and EVs by circuit, distribution planning area, sub-load aggregation point (CAISO Sub-LAPs), and systemwide in order to improve forecasting capabilities, operations, and situational awareness. This would allow PG&E to maintain or improve reliability in the face of new demands on the distribution system. The tool would show the current situation including system loading, distributed outputs and impacts, customer-managed energy efficiency, and DR resources all in a single consolidated operating environment. This consolidated operating

environment would be required to support the dramatically more complicated operating conditions of the near future and go beyond any technologies currently available in the Distribution Management System market. Today, these tools are not available, but they need to be developed quickly as the interconnection of distributed resources grows. For example, in PG&E's territory there are approximately 72,500 DG sites totaling 1,300 MWs[32] of nameplate capacity. Of the 72,500 sites, approximately 71,000 are photovoltaic sites and the number and capacity associated with type of generation is expected to double within five years. While proposed projects elsewhere in PG&E's EPIC program and other PG&E applications seek to measure and gather data about actual distributed generation information, this project creates a consolidated and more complete view that would enable system operators to utilize these new resources to more effectively operate the PG&E T&D grid.

- Operator Consoles – PG&E will develop and demonstrate initial versions of a new integrated operator's console that takes into account the anticipated change in demographics of the operators over the next decade. The "video game" generation will demand a more interactive user interface and higher quality graphics. The operators will receive trouble reports in many different channels: Facebook, Twitter, utility-specific apps, SmartMeter™, interactive voice response systems, and the customer information system. Photographs and video clips of the damaged equipment will become more available, enabling operators to determine accurately the correct crew to send to expedite repairs. The critical design aspect of the new systems will be how to integrate all the information received from a multitude of systems into a single user interface with the same look and feel.

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32 1,300 megawatts includes all Distributed Generation (photovoltaic, Biogas, Microturbines, Fuel Cells, Wind Turbines, Steam Turbines, etc.)

Applicable Electricity Value Chain Elements	
☐ Grid operations/market design	☒ Distribution
☐ Generation	☐ Demand-side management
☒ Transmission	

Concern, Gap, or Problem To Be Addressed

In addition to the data and information that flows to PG&E's system operations software today; in the operations of the near future, data and information will come from additional sources such as distributed generation resources and renewable resources, electric vehicles, SmartMeters™, social media, advance automation on the distribution and transmission system. Without changes, this data will flow into siloed systems and will not be used effectively or efficiently to run the PG&E electric system. To efficiently run the grid operations of the future, this data will need to be integrated, quickly analyzed as part of daily system operations, and presented to the system operators in a simple format by which they can make real-time decisions.

Potential Benefits at Full Deployment

If each of the described sub-projects to support grid operations of the future were fully deployed at PG&E, potential benefits could include: increased efficiency of system operations, expansion and simplification of the operator's console, improved outage response, improved system reliability, and reduced operating costs.

Project Number: 16

Project Title: Demonstrate Electric Vehicles as a Resource to Improve Grid Power Quality and Reduce Customer Outages

Description of Technology or Strategy To Be Demonstrated

This project looks at electric vehicles from the perspective of using the energy storage capabilities to improve utility grid operations, initially using utility fleets (primarily the fleet's larger trucks) to demonstrate vehicle battery technology potential in minimizing the duration and scope of localized outages. As an example, PG&E could use utility vehicles to supply power to individual customers during related transformer repairs (whether planned or unplanned). During planned outages, this technology use would move from using diesel- or gas-fired generation mobile supplies to battery storage

mobile supplies, thereby reducing GHG emissions and noise. During unplanned outages, this technology would allow customers to use the mobile electricity supply to meet their reliability needs.

Applicable Electricity Value Chain Elements	
☐ Grid operations/market design	☒ Distribution
☐ Generation	☐ Demand-side management
☒ Transmission	

Concern, Gap, or Problem To Be Addressed

During planned outages, mobile supplies, powered by diesel-fired or gas-fired generation, are sometimes used to supply power to affected customers. This is not only a noisy and GHG-producing solution, but it involves using an additional vehicle to supply the back-up power. During unplanned outages, especially on the smaller scale outages of a single transformer or a single line, customers are without power until the transformer or line is fixed; a negative consequence for the customer and the utility. Both of these issues may be addressed by the battery storage capabilities inherent in the large battery-powered vehicles/trucks operated by PG&E. These trucks, already present at outage events, could be connected to the affected circuit and provide power to customers on a limited basis, in terms of both scope and duration of the outage.

Current projects and initiatives at PG&E related to electric vehicles are focused on the customer-side of the issue, primarily enabling customers to charge vehicles efficiently to avoid adverse impacts on the grid. This project does not duplicate other PG&E efforts related to EVs. Many utilities across the country are preparing their systems for the expansion of the use of electric vehicles by customers and piloting projects on how best to integrate those vehicles into the grid. PG&E is not aware of any utilities looking at the use of utility fleet vehicle to improve reliability and reduce the impact of outages. PG&E will continue to monitor advances in these areas by other utilities in order to identify pilots or studies that they can use to support or shorten their own projects.

Potential Benefits at Full Deployment

This use of utility fleet electric vehicles, if fully utilized by PG&E, could benefit PG&E's customers in the following ways: decrease the scope and duration of outages, increase reliability, increase customer satisfaction, and lower operating costs.

Project Number: 17

Project Title: Leverage EPIC Funds by Participating in Multi-Utility, Industry-Wide RD&D Programs Such as Those Conducted by EPRI

Description of Technology or Strategy To Be Demonstrated

PG&E can leverage EPIC dollars by participating and collaborating in multi-utility industry-wide research initiatives conducted by third party organizations experienced in the RD&D area. These programs would allow PG&E to cost effectively develop a deeper awareness of industry trends, access real world experience through pilot programs, and identify the gaps that utilities will fill or close with technology. For example, through participation in existing EPRI programs, PG&E would participate in and gain access to demonstrations, analyses, and results of the testing and study of distribution equipment and strategies. High Value EPRI programs include: *IntelliGrid*, *Integration of Distributed Renewables*, *Energy Storage*, *Risk Mitigation Strategies*, and *Distribution Grid Modernization* programs.

Applicable Electricity Value Chain Elements	
☐ Grid operations/market design	☒ Distribution
☐ Generation	☐ Demand-side management
☒ Transmission	

Concern, Gap, or Problem To Be Addressed

As the electric grid rapidly evolves in today's environment, PG&E need to investigate new functionalities and capabilities, as well as resolve both existing and developing issues. The scope of these investigations is extensive and far exceeds both the personnel and funding resource capabilities of PG&E, even including EPIC funding. To expand the list of issues and technologies PG&E can undertake, PG&E will participate in third-party, industry-wide research efforts that specifically target areas of interest for PG&E and its operating environment.

In choosing third-party, industry-wide research programs in which to participate, PG&E will select specific initiatives which avoid duplication with pilots and projects already being conducted or proposed by PG&E. This project explicitly entails collaboration with other organizations including EPRI, CEC, LLNL and other utilities.

Potential Benefits at Full Deployment

Depending on the results of specific third-party research initiatives, potential benefits could include: increased efficiency of system operations, reduced operating costs, increased energy savings, low emission vehicle integration, improved system reliability, increased efficiency in maintenance processes, increased efficiency in data analysis, and increased automation of the grid.

4.3 Customer Service and Enablement

4.3.A Program Area Background

Driven by State energy policies and enabled by the emergence of new or newly cost-effective technologies, opportunities for California energy customers to be more than just consumers of electricity are increasing. PG&E customers can now adopt energy efficient technologies and processes, buy electric vehicles or demand response automation equipment, install distributed generation or energy storage, and also leverage SmartMeter™ data and energy management devices to monitor, control, and operate their energy usage at home and in business in a more optimal manner.

To support California's ambitious goals for energy efficiency and reduced GHG emissions, the challenge is to find compelling ways to inform, serve and engage customers so they choose to embrace these opportunities. The "Customer Service and Enablement" program area is designed to support projects that allow customers to actively manage their bills and reduce their environmental footprint.

4.3.B Key Program Objectives That Support Policy and Meet Industry Needs

PG&E has identified three key program objectives in the Customer Service and Enablement Program Area:

Program Objective 1	**Drive Customer Service Excellence by Leveraging PG&E's SmartMeter™ Platform**
Program Objective 2	**Drive Customer Service Excellence by Offering Greater Billing Flexibility**
Program Objective 3	**Integrate Demand-Side Management (DSM) for Grid Optimization**

These three program objectives, current challenges and solutions to overcome barriers and proposed projects are discussed in more detail below.

4.3.B.1 Program Objective One: Drive Customer Service Excellence by Leveraging PG&E's SmartMeter™ Platform

Current Challenges

PG&E has nearly fully deployed SmartMeter™ technology throughout its service territory, establishing a critical framework and foundational platform for further innovation in DR, EE and customer services.

In order to maximize the value of PG&E's prior investments in SmartMeters™ and the supporting communications network, PG&E proposes to build new and improved data collection techniques and capabilities that will substantially expand upon the promise of the SmartMeter™ system. In addition to providing PG&E with critical information to allow it to more effectively and efficiently monitor and manage the grid, enhanced data could support new information-based services, aimed at further enhancing customers' energy management services.

PG&E expects that EPIC funded projects in this area also will expand the competitive market place for consumer-oriented tools and products that use the SmartMeter™ platform.

Solutions

PG&E proposes TD&D projects that will leverage the SmartMeter™ platform to advance customer service excellence by:

- Enabling customers to make informed decisions about their energy consumption by, for example, combining data from multiple sources and presenting customers with engaging and actionable information to lower energy costs;
- Proactively providing both PG&E and customers access to simple, accurate and timely energy information extracted from the SmartMeter™ network and data.

PG&E's Specific Projects to Meet Program Objectives

Table 4-7 below outlines specific projects that would potentially Drive Customer Service Excellence by Leveraging PG&E's SmartMeter™ Platform.

TABLE 4-7
SUMMARY OF PROJECT OBJECTIVES

Program Objective 1: Drive Customer Service Excellence by Leveraging PG&E's SmartMeter™ Platform	Safety	Reliability	Affordability
18. Demonstrate SmartMeter™-enabled data analytics to provide customers with appliance-level energy use information Demonstrate the data analytics capabilities of the SmartMeter™ platform to perform appliance-level load disaggregation of the bill and thereby provide an enhanced billing experience to customers with highly personalized energy savings tips.			✓
19. Pilot enhanced data techniques and capabilities via the SmartMeter™ platform Demonstrate the type of additional data that can be collected via the SmartMeter™ platform. Evaluate the frequency of data collection for each data type and assess the impact of the increased data traffic on the SmartMeter™ network. Focus on data that will allow customers to make more informed decisions about their energy consumption.			✓
20. Demonstrate the benefits of providing the competitive market with automated access to customer-authorized SmartMeter™ data to drive innovation The information from the demonstration will be used to understand the requirements of third party application developers and customers, in order to help inform the development of broader customer services enabling systems.			✓

TABLE 4-7
SUMMARY OF PROJECT OBJECTIVES
(CONTINUED)

Program Objective 1: Drive Customer Service Excellence by Leveraging PG&E's SmartMeter™ Platform	Safety	Reliability	Affordability
21. Pilot methods for automatic identification of distributed energy resources (such as solar PV) as they interconnect to the grid to improve safety & reliability Demonstrate the use of SmartMeter™ analytics or other technologies to automatically identify otherwise undetected grid interconnections to manage the impact on the grid and increase public and employee safety.	✓	✓	

PG&E does not believe that its proposal overlaps with the CEC's investment plan regarding customer behavior. PG&E believes this is a high-priority objective and that the proposed projects deliver customer benefits.

More detail about each of the projects included in Table 4-7 is provided in the following section.

Project Number: 18

Project Title: Demonstrate SmartMeter™-enabled data analytics to provide customers with appliance-level energy use information

Description of Technology or Strategy To Be Demonstrated

Using the data analytics capabilities enabled by the SmartMeter™ platform, PG&E would demonstrate appliance-level itemization of monthly bill charges: customers, without completing any audit or subscribing to any new service, would receive a summary of their monthly electric bill, as well as energy usage itemized by appliance.

This technology would also enable customers to receive highly personalized energy saving tips in addition to the itemized billing summary. PG&E proposes to launch a pilot which would be based on weather zones, size of homes and / or other demographic information.

Applicable Electricity Value Chain Elements	
☐ Grid operations/market design	☐ Distribution
☐ Generation	☒ Demand-side management
☐ Transmission	

Concern, Gap, or Problem To Be Addressed

Without a complete Energy audit, it is challenging for customers to determine how their monthly energy bills reflect actual in-home usage and therefore the necessary actions and behavioral changes to reduce their energy bill. There is a nascent market of solutions that disaggregate load at an individual premise and help identify which appliances or usage patterns use the most electricity.

PG&E conducted research in 2012 with residential, small and medium business (SMB) and agricultural customers to learn how to best engage customers with rate plans and energy management strategies. Through both focus groups and quantitative surveys, customers were asked to rate a sample set of energy management tools, which included back-up power services, energy efficiency upgrades, energy audits, itemized billing and in-home displays. The research indicated that the most valuable energy management tools are those that help raise awareness around energy use, including itemized billing. In fact, itemized billing was the most highly rated tool with 71 percent of surveyed residential and 55 percent of surveyed SMB customers rating it as the most valuable of the options. SMB customers in particular indicated that they would benefit from the resulting information by making strategic decisions about the electricity usage at their facilities.

Potential Benefits at Full Deployment

By providing an enhanced billing experience to customers and highly personalized energy saving tips, this proposed project type meets the EPIC guiding complementary principles of supporting GHG emissions mitigation, the loading order and efficient use of customer funds.

As the project could also result in development of partnerships and/or new services with the nascent market of solutions providers that disaggregate load at an individual premises, PG&E also believes that this project supports the EPIC guiding complementary principles of economic development.

Project Number: 19

Project Title: Pilot enhanced data techniques and capabilities via the SmartMeter™ platform

Description of Technology or Strategy To Be Demonstrated

In order to maximize the value of SmartMeters™ for customers, PG&E proposes to demonstrate new and improved data collection techniques and capabilities that could greatly expand the type of data collected via the SmartMeter™ system. Project activities may include:

- Demonstrating the type of additional data that can be collected via the SmartMeter™ platform.
- Establishing the frequency (e.g., real time vs. processed with read-data) with which the possible data types can be provided to customers.
- Analyzing the system capability to determine where additional customer-side data may be collected (e.g., smaller interval size data or more data channels).
- Analyzing the system capability to support unscheduled endpoint data requests (e.g., instantaneous loading, voltage, sag-swell triggers).
- Piloting various data collection network improvement or endpoint devices with longer range or enhanced data rates or other data collection improvements.
- Calculating the impact of the increased data traffic on the SmartMeter™ network and, as necessary, demonstrating and deploying technologies to improve data throughput and network robustness.

Items that may warrant consideration as part of the project include:

- Collect and use intervals smaller than 15 minutes.
- Gather enhanced data fields, real-time triggers and system warning information generated at the meter location.
- Demonstrate and deploy new technologies that improve network-connectivity and further enhance customer data collection.

- Improve meter data transmission where the endpoint is in a location with constrained connectivity, often due to distance to next device or other elements constraining messages.

Applicable Electricity Value Chain Elements	
☒ Grid operations/market design	☐ Distribution
☐ Generation	☒ Demand-side management
☐ Transmission	

Concern, Gap, or Problem To Be Addressed

In addition to providing PG&E with critical information to allow it to more effectively and efficiently monitor and manage the grid, enhanced data could support new information-based services aimed at better addressing customer energy management needs. This, for example, could allow customers to understand and react to their consumption, and provide them with the opportunity to more closely manage costs and respond to alerts and grid conditions, should they choose to do so. The drive for new services also may include demonstrating and deploying new technologies that improve network connectivity in order to further enhance the customer experience.

This initiative focuses on activities that were not included as part of PG&E's SmartMeter™ project filings. Rather this initiative builds on the SmartMeter™ platform to demonstrate and evaluate new data types and techniques that can leverage the platform to drive customer service excellence.

Many utilities across the country are deploying AMI systems in their service territories, many with the same SmartMeter™ platform as PG&E's program. As PG&E builds out this initiative, it will coordinate(e.g., direct contact or literature/information review) with some of these utilities to identify similar projects and determine whether a PG&E-specific project is warranted or whether PG&E can gain access to project results to use in lieu of an additional demonstration of its own. Additionally, PG&E does not believe any overlap or duplication exists with the CEC investment plan. However, to be certain, the cooperation and collaboration principles described in the Investment Plan will ensure activities are coordinated and not duplicative.

Potential Benefits at Full Deployment

- Lower Consumer Costs and Environmental Benefits: Enhanced data may help customers understand their energy consumption and make more informed energy management decisions. Armed with timely, relevant and actionable data, customers may reduce overall consumption or shift usage from peak to non-peak periods.
- Economic Development: Customers increasingly want to provide their data to third party companies for analysis and presentment. Capturing, collecting and sharing new data types may help expand the marketplace for consumer-oriented tools and products that use SmartMeter™ platform data.
- Efficient Use of Ratepayer Monies: This project leverages the customers significant investment in the SmartMeter™ platform by demonstrating enhanced data techniques and capabilities which further enhance the customer experience. Additionally, enhanced data will provide PG&E with critical information to allow it to more effectively and efficiently monitor and manage data collection and may translate to lower overall operating and maintenance costs.

Project Number: 20

Project Title: Demonstrate the benefits of providing the competitive market with automated access to customer-authorized SmartMeter™ data to drive innovation

Description of Technology or Strategy To Be Demonstrated

This project will fund continued support of Green Button Connect (GBC). GBC provides a small number of vendors in the competitive market with automated access to recurring, machine-to-machine, programmatic data access to customer-authorized SmartMeter™ data in order to develop new, innovative and creative ways for customers to manage their energy consumption. GBC is a small demonstration, not scalable to support the larger customer base and wider vendor audience. PG&E is planning on implementing a robust, broader scale offering as part of its Customer Data Access (CDA) project.

The information gathered in this project will be used to further understand the requirements of third-party application developers and customers: e.g., latency requirements, how much processing capacity is needed per vendor, how to make Application Programming Interface (API) more accessible to vendors, how much vendor data is requested in batch versus on-demand, how best to implement secure solutions, and other information. These learnings will help inform the development of systems and business processes to support such an offering at a broader scale, which may lead to lower CDA implementation costs.

Applicable Electricity Value Chain Elements	
☐ Grid operations/market design	☐ Distribution
☐ Generation	☒ Demand-side management
☐ Transmission	

Concern, Gap, or Problem To Be Addressed

Over the last few years, PG&E has received an increasing number of requests from customers to access their data so that they can take advantage of third-party services. This trend is expected to continue for the foreseeable future, as third-parties develop new solutions to address customers' desire to make more informed energy usage decisions in a world of escalating energy prices and heightened environmental consciousness.

PG&E is executing on a strategic roadmap that combines a number of business and regulatory drivers[33] to provide access to customer data. However, increasing dependence on renewable energy resources, evolving CAISO markets, Smart Grid technologies, and the introduction of electric vehicles, are increasing opportunities to maximize the use and benefit of the programs. Customers will need to have access to a broad, complementary range of products and services to increase available demand-side resources and provide the necessary tools to make more informed energy consumption decisions. These products and services will be driven by the customer usage data.

33 D.11-07-056 Rules for Data Privacy and Security.

PG&E's CDA project referenced earlier is in direct response to the CPUC Decision 11-07-056 Rules for Data Privacy and Security. The CPUC outlined specific guidelines for PG&E to follow during the implementation of the CDA platform; including a rigorous third party registration and authorization process, and adherence to on-going nationally accepted data exchange standards; e.g., OpenADE. PG&E specified additional requirements in order to enhance the customer experience, and to ensure the solution was scalable to protect the customer investment in the platform.

The initial implementation of GBC was intended as a first step and does not address all these requirements but it puts in place a demonstration platform to facilitate a business operations learning experience and to validate potential technical implementation approaches. This proposed project would focus on identifying the learnings from the GBC around the technical implementation of sharing customer- authorized data with the goal to potentially lower CDA implementation costs when the specific implementation requirements are developed.

Potential Benefits at Full Deployment

PG&E is providing the competitive market with automated access to customer-authorized SmartMeter™ data to enable innovative new products and services for consumers to better manage their energy consumption. This proposed project meets the primary EPIC guiding principles of supporting lower energy costs, and the complimentary principles of GHG emissions mitigation and adaption in the electricity sector at the lowest possible cost, and efficient use of customer funds.

As the project's primary goal is to foster a competitive market where new startups and providers can emerge to address unanswered market needs, PG&E believes that it supports the EPIC guiding principles of economic development.

Project Number: 21

Project Title: Pilot methods for automatic identification of distributed energy resources (such as solar PV) as they interconnect to the grid to improve safety & reliability

Description of Technology or Strategy To Be Demonstrated

Analytics on SmartMeter™ data is one potential method to explore to automatically detect the resources. A demonstration, leveraging the SmartMeter™ data collected, could test the efficiency of this method to automatically identify distributed generation systems.

Applicable Electricity Value Chain Elements	
☐ Grid operations/market design	☒ Distribution
☐ Generation	☒ Demand-side management
☐ Transmission	

Concern, Gap, or Problem To Be Addressed

DER that generate power behind the meter which can flow back into the distribution feeder create potentially new issues for the grid. In addition, as small "do-it-yourself" PV systems are increasingly available at retail stores and installed without notification to PG&E, there is a growing safety concern, with significant potential risks to PG&E field employees and to the public. Specifically, there is a concern that in situations of a power outage, non-standard inverters may trip, thus introducing the risk that generation will energize lines that are assumed to be de-energized.

The automatic identification of distributed energy resources, as they interconnect to PG&E's grid, would limit the safety risks associated with otherwise undetected installations.

There is substantial uncertainty as to the current and potential size of the problem of undetected or unauthorized interconnections and the effectiveness of potential technological solutions. As a preliminary phase in this pilot, PG&E would propose to complete an assessment of the size of the problem along with a preliminary evaluation of potential mitigating policies and technologies. Results of this first phase would inform whether and how to proceed with further technological demonstrations. Analytics on SmartMeter™ data is one potential method to be explored.

Other approaches, possibly with third-party services and partnerships, could also be tested, possibly expanding on the results provided by SmartMeter™ data analytics. Examples include image processing in partnership with Google StreetView, or hardware

technologies like communication chips embedded in the DER systems, which the CEC proposes to research, as described in their S3.3 Proposed Funding Initiative "Develop Advanced Distributed Photovoltaic Systems to Reduce the Cost of Energy, Increase Interoperability, and Advance Plug-and-Play Capabilities." An "auto-registration" pilot for purchasers of DER to identify themselves to PG&E and get "authorized" would support the adoption of distributed generation by customers.

Potential Benefits at Full Deployment

By looking at solutions to manage the impact on the grid and limit the safety risks associated with otherwise undetected distributed PV installations, this proposed project type meets the EPIC guiding complementary principles of increasing safety and reliability. It also supports societal benefits, GHG emissions mitigation, and economic development because it supports the adoption of distributed generation by customers with the potential for local job creation.

4.3.B.2 Program Objective 2: Drive Customer Service Excellence by Offering Greater Billing Flexibility

Current Challenges

The sale of EV's by startups and major auto manufacturers is a stepping-stone to diversifying transportation fuel sources. California consumers are leading the way in expanding this market. In addition, the California Solar Initiative (SB1) expanded the use of rebates to subsidize the cost of PV distributed generation and has successfully promoted deployment of PV systems on the customer site.

California has not yet demonstrated commercial scale EV and PV sub-metering, yet sub-metering has been noted as a method to offer greater billing flexibility for EV drivers as well as owners of distributed PV. Determining a cost-effective implementation of sub-metering technologies may engender further adoption of EVs and PV deployment at customer sites.

Solutions

The integration of EVs and distributed generation to the electric grid is a key objective that supports California's AB32 goal of reducing greenhouse gas emissions to 1990 levels by 2020. PG&E intends to evaluate and demonstrate the viability of these two

technologies in support of California energy policies. In addition, demonstrations in this areas will offer increased billing flexibility to customers, an option that does not currently exist.

PG&E's Specific Projects to Meet Program Objectives

Table 4-8 below outlines PG&E's specific projects to Drive Customer Service Excellence by Offering Greater Billing Flexibility.

TABLE 4-8
SUMMARY OF PROJECT OBJECTIVES

Program Objective 2: Drive Customer Service Excellence by Offering Greater Billing Flexibility	Safety	Reliability	Affordability
22. Demonstrate Subtractive Billing with Submetering for EVs to increase customer billing flexibility Demonstrate potential for subtractive billing with submetering for EVs, as a potentially low-cost method to offer customers increased flexibility in choosing beneficial rates for their EV electricity usage.		✓	✓
23. Demonstrate Additive Billing with Submetering for PVs to increase customer billing flexibility Demonstrate potential for additive billing with submetering for PV, as a potentially low-cost method to provide homeowners with PV the opportunity to understand the gross energy characteristics of their entire house and as a platform to provide an expanded range of potential alternative DG compensation structures.		✓	✓

Many of the internal processes for additive (PV) and subtractive (EV) billing with sub meters are similar or identical in nature and it is reasonable to take advantage of potential synergies on these aspects. PG&E intends to collaborate with the other IOUs for specific sub-metering protocol development. Leveraging these collaborative efforts, PG&E would then execute demonstration specific to PG&E's own billing environment and unique system characteristics.

More detail about each of the projects included in Table 4-8 is provided in the following section.

Project Number: 22

Project Title: Demonstrate Subtractive Billing with Submetering for EVs to increase customer billing flexibility

Description of Technology or Strategy To Be Demonstrated

The intention of the pilot is to engage a sample of PG&E customers and provide a subtractive billing and submetering solution. The pilot would begin with the simpler use case, such as one primary meter associated with one stationary submeter, outlined in the January 3, 2012 EV submetering report and proceed to the more complicated use cases, such as net energy metering, as the more basic cases becomes well understood. This pilot would also help demonstrate the level of demand for subtractive billing with submetering for EVs.

Applicable Electricity Value Chain Elements	
☐ Grid operations/market design	☒ Distribution
☐ Generation	☒ Demand-side management
☐ Transmission	

Concern, Gap, or Problem To Be Addressed

The CPUC ordered the IOUs to develop subtractive billing with non-IOU submeters protocol. The IOUs have worked diligently to develop strawman tariffs for review by external stakeholders, but there has been no pilots to inform the development of these tariffs and gauge the customer demand for this type of service. This pilot work is needed to help develop the tariffs and gauge customer demand.

The current strawman tariffs only address the simpler use cases at this time. The IOUs and external stakeholders need time to work through the complexities of the more sophisticated use cases and with actual customers. Comments were received, after the stakeholders' webinar held by the IOUs on September 28, offering support for this initiative. PG&E also views this proposed project as high-priority.

Potential Benefits at Full Deployment

Assuming that the billing and metering complexities are resolved, subtractive billing using submeters for EVs provide increased rate option flexibility for customers, allowing a separate meter rate without the need for a new service.

Project Number: 23

Project Title: Demonstrate Additive Billing with Submetering for PVs to increase customer billing flexibility

Description of Technology or Strategy To Be Demonstrated

The intention of the pilot is to engage actual customers and provide an additive billing and submetering solution. This pilot would also help demonstrate the level of demand for additive billing with submetering for PVs and how it helps drive energy conservation and efficiency.

Applicable Electricity Value Chain Elements	
☐ Grid operations/market design	☒ Distribution
☐ Generation	☒ Demand-side management
☐ Transmission	

Concern, Gap, or Problem To Be Addressed

Customers with DG projects serving onsite load, and possibly exporting power under Net Energy Metering (NEM) typically only receive information regarding their net usage, i.e., their home's consumption minus the output of their onsite DG system. As a result, the more granular information needed for customers to make informed decisions to achieve energy conservation and efficiency is often lacking. A platform providing the gross generation output would help address this challenge. Furthermore, it could also provide the platform for an expanded range of potential alternative DG compensation structures. This initiative could be a statewide program involving the other IOUs for collaboration on protocol development. However, each IOU's billing system is unique and as such each IOU would need to work on its own systems and unique challenges.

Potential Benefits at Full Deployment

By providing the more granular information needed for customers to make informed decisions to achieve energy conservation and efficiency and providing the platform for an expanded range of potential alternative DG compensation structures, this proposed project type meets the primary EPIC objectives of reliability and reduced costs and complementary objectives of supporting societal benefits, GHG emissions mitigation, the loading order and efficient use of customer funds.

4.3.B.3 Program Objective 3: Integrate Demand-Side Management for Grid Optimization

Current Challenges

The emergence and expected growth of EVs, distributed PV and ZNE buildings present both a potential source of stress on local areas of the electric grid as well as the opportunity for optimized value between customers (buildings) and the grid. When considering load growth, system planners will need to account for the impact of these technologies when planning for local peak loads. At the same time, customers expect to receive value from adopting new technologies. Adopting innovative and holistic approaches to incorporating these technologies and considering them in an integrative manner that includes EE, DR, rate design and price signals, SmartMeter™ usage data, and distributed energy storage, can be effective in mitigating their individual impact on the grid, reduce overall customer costs and create customer value.

Solutions

PG&E intends to pursue demonstrations and deployments that address reliability, improve customer value and optimize T&D expenditures by using SmartMeter™ data—as a planning tool to optimize the use of integrated demand side capabilities—and by including new load management and direct load control technologies, targeted EE and DR tools, pricing options, and distributed energy storage in a coordinated fashion. Projects will further provide visibility into how to optimally integrate EVs and distributed PV as well as support the expansion of ZNE homes and buildings.

While evaluating each of the following elements *on their own* has value, this initiative will also assess the integrated value of the solutions used *in concert* to improve reliability, improve customer value, and reduce cost:

- The integration of EVs to the electric grid is a key policy objective, supporting California's AB 32 goal of reducing GHG emissions to 1990 levels by 2020.
- Increasing penetration of distributed generation potentially puts the safe and reliable operation of the grid at risk. Nevertheless, it also can represent opportunities for the development of a "smart" grid that can both accommodate and benefit from the presence of DG.

- The state's ZNE policy goals, consistent with the California Energy Efficiency Strategic Plan and the Energy Commission's Integrated Energy Policy Report, have established goals to achieve zero net energy new residential homes by 2020 and ZNE use for new commercial buildings by 2030.
- The use of SmartMeter™ data, the strategic deployment of EE and advanced and automated forms of DR in a targeted manner can achieve specific demand reductions during local peak periods to react to local grid conditions, or slow or postpone distribution system capacity expansions.

PG&E's Specific Projects to Meet Program Objectives

Table 4-9 below outlines PG&E's specific projects to Integrate DSM for Grid Optimization.

TABLE 4-9
SUMMARY OF PROJECT OBJECTIVES

Program Objective 3: Integrate Demand Side Management (DSM) for Grid Optimization	Safety	Reliability	Affordability
24. Demonstrate DSM for T&D cost reduction Demonstrate that multiple DSM resources can be combined, integrated and delivered in a targeted manner to provide reliable and sustained demand reductions to postpone T&D capacity expansions. This demonstration project would be integrated with PG&E's existing DR – T&D Integration Pilot described in PG&E's Smart Grid Annual Report.		✓	✓
25. Develop a tool to map the preferred locations for DC fast charging, based on traffic patterns and PG&E's distribution system, to address EV drivers' needs while reducing the impact on PG&E's distribution grid Develop, pilot and validate strategies that help determine the optimal location for DC fast charging based on traffic patterns and distribution grid infrastructure. Current maps have not been linked with PG&E's distribution system to determine the optimal placement of DC fast chargers, both in terms of traffic patterns *and* electric system capabilities. Work with market providers of DC chargers to optimize the selection of sites for demonstration projects.			✓
26. Pilot measurement and telemetry strategies and technologies that enable the cost-effective integration of mass market DR resources into the CAISO wholesale market Develop, pilot and validate approaches and technologies that enable the cost-effective integration (specifically, the measurement and telemetry) of mass market DR resources into the CAISO wholesale market. While other DR projects focus on integration of DR resources into various utility and future ISO operational needs, this project intends to test alternative telemetry solutions and technologies to satisfy CAISO operational visibility requirements.		✓	✓

More detail about each of the projects included in Table 4-9 is provided in the following section.

Project Number: 24

Project Title: Demonstrate DSM for T&D Cost Reduction

Description of Technology or Strategy To Be Demonstrated

This proposed project will utilize an integrated approach to package DSM resources to create customer- and location-specific solutions to reduce local peak loads. Growth of these local peak loads will have been forecasted to precipitate the need for capacity expansions to maintain local system reliability. There are multiple steps to this project, coordinating with distribution planners and operators to:

1. Identify specific targeted substations or feeders where capacity expansions are planned to address a forecasted overload or anticipate significant growth of DG, EVs or ZNE buildings.
2. Develop economic modeling to compare the planned traditional utility investment with alternatives using selected distributed or demand-side investments.
3. Identify strategic customers, using SmartMeter™ data, to target for demand reduction, and test new technologies that combine and integrate multiple DSM tools (EE, DR, distributed energy storage, consumer-oriented SmartMeter™ tools) to achieve a sufficient amount of demand reduction to delay the need for the capacity expansion.
4, Implement the most appropriate investment and while preserving reliability.
5. Evaluate the demand reduction delivered, while attributing to each technology/DSM tool used, the value and contribution to the reduction, and customer satisfaction with the solution.
6. Determine whether the planned utility investment or a combination of alternative distributed or demand-side investments is the most cost effective, while providing a comparable level of reliability.

This project will be performed in conjunction, to the extent possible, with Project 2 - Demonstrate the use of distributed energy storage for T&D cost reduction.

Supported by new load management technologies for direct control of specific appliances and processes to achieve a desired net demand level, these DSM offerings would enable system operators to limit the net peak load on a customer or feeder in local areas, even if customers are using distributed PV, thus mitigating the impact of PV on the distribution system

Applicable Electricity Value Chain Elements	
☒ Grid operations/market design	☒ Distribution
☐ Generation	☒ Demand-side management
☒ Transmission	

Concern, Gap, or Problem To Be Addressed

The targeting and combination of multiple DSM resources (rate design, price signals, consumer-oriented SmartMeter™ tools, distributed energy storage for DG or ZNE buildings, EE and DR tools) to specific local areas, where T&D upgrades are forecasted to be needed, have the potential to slow local load growth. Effectively doing so would delay or postpone the need for T&D capacity expansions.

This can be implemented by identifying specific customers within a local area who can most effectively reduce net load during the local peak. The proposed project complements and would be integrated with PG&E's DR-T&D Integration Pilot, as described in PG&E's Smart Grid Annual Report. The DR-T&D Integration Pilot is a study and demonstration to determine the needs of T&D operators and planners to integrate DR into their processes. The results of the DR-T&D Integration Pilot will inform how targeted DR is utilized and so will complement the proposed EPIC project.

The proposed project will also integrate, where practical, with Project 2 - Demonstrate the use of distributed energy storage for T&D cost reduction. Project 2 focuses on distributed energy storage connected directly to the distribution system. However, behind-the-meter distributed energy storage may also be appropriate when coordinating dispatch with other dispatchable DSM resources.

The proposed project 24 is not duplicative of the Emerging Technologies programs in the EE and DR portfolios because the load management technology to be evaluated does not fall within the scope of either the EE or DR program. The EE Emerging

Technologies program is meant to lead to new measures, whereas the proposed EPIC project primarily focuses on utilizing EE measures in a new way. The DR Emerging Technologies program focuses on technologies that customers would directly buy and install, whereas the new technologies envisioned in this EPIC project would be used by PG&E to ensure local system reliability.

The incremental funding required for this project will be primarily for: (1) new load management technologies, (2) incremental resources to work directly with strategic customers including possible incremental incentives, and (3) detailed economic evaluation of the effectiveness of the DSM application.

PG&E is uniquely positioned to implement this demonstration project because this effort will entail integration with the planning processes of its transmission and/or distribution system, and rely on confidential customer data.

Potential Benefits at Full Deployment

This proposed project meets the primary EPIC objectives of reliability and reduced costs and complementary objectives of supporting GHG emissions mitigation, the loading order and efficient use of customer funds.

The proposed project is not meant to result in greater energy or demand savings than would typically be realized through DSM resources but rather, a more strategic targeting of those savings to unlock their locational value. If successful, the proposed project will demonstrate the ability of DSM resources to delay the capacity expansions, thus allowing system planners to devote resources to other projects and maintain the reliability of the electric grid. This approach will improve customer satisfaction by temporarily avoiding any service disruptions that could occur during a capacity expansion while providing added value to those customers targeted for demand reduction measures.

Project Number: 25

Project Title: Develop a tool to map the preferred locations for DC fast charging, based on traffic patterns and PG&E's distribution system, to address EV drivers' needs while reducing the impact on PG&E's distribution grid

Description of Technology or Strategy to be Demonstrated

A sufficient quantity of Direct Current (DC) fast chargers is needed to increase the vehicle miles travelled using electricity. UC Davis researchers have created maps for the best locations to install DC fast chargers in California based on existing traffic patterns. However, these maps have not been linked with PG&E's distribution system to determine the optimal placement of DC fast chargers, both in terms of traffic patterns *and* electric system capabilities. Linking the traffic maps with the distribution grid would allow for better planning and reduced cost for all parties. This project will develop and pilot the process and analysis necessary to determine these optimal locations and update them on a periodic basis.

Applicable Electricity Value Chain Elements	
☐ Grid operations/market design	☒ Distribution
☐ Generation	☒ Demand-side management
☐ Transmission	

Concern, Gap, or Problem To Be Addressed

Currently, there is no process to determine where the optimal siting for DC fast chargers, although the DC fast chargers can impose significant load on the grid. Suboptimal siting of DC fast chargers could impose additional unneeded costs for the DC fast charger customer and ratepayers.

Potential Benefits at Full Deployment

- It is expected that this will provide reduced costs to install DC fast chargers and help site them where they will have the highest amount of usage and benefit to EV customers
- Increased electric miles driven would provide direct environmental benefits, as the electricity that PG&E provides for use in electric vehicles as a transportation fuel is much cleaner than using fossil fuels as a transportation fuel

Project Number: 26

Project Title: Pilot measurement and telemetry strategies and technologies that enable the cost-effective integration of mass-market DR resources into the CAISO wholesale market

Description of Technology or Strategy To Be Demonstrated

While other DR projects focus on integration of DR resources into various utility and future ISO operational needs, this project intends to test alternative telemetry solutions and technologies to satisfy CAISO operational visibility requirements. Adoption of new telemetry solutions and technologies by the CAISO may reduce the overhead burden associated with bidding resources consisting of thousands of mass market customers and the cost associated to fulfill CAISO's telemetry requirements.

Applicable Electricity Value Chain Elements	
☒ Grid operations/market design	☐ Distribution
☐ Generation	☒ Demand-side management
☐ Transmission	

Concern, Gap, or Problem To Be Addressed

The potential amount of demand response resources from mass-market customers is increasing. However, the CAISO has requirements for financial settlements and telemetry that were developed for large central generation facilities. Because telemetry is currently required at each customer site to ensure adequate visibility and transparency, it is prohibitively complex and expensive to bid mass-market DR resources into the CAISO market.

PG&E is working with the CAISO and other stakeholders in an effort to evaluate existing telemetry and metering requirements and assess whether changes need to occur. To date as part of this working group, no formal technology demonstration to evaluate cost effective telemetry and metering technology and solution has been conducted. PG&E believes that this demonstration will help the working group and the CAISO with modifying existing telemetry and metering requirements. This project is related, but separate, from the project (S2.1) proposed by the CEC, as PG&E will undertake the actual implementation of different telemetry solutions, while the CEC will concentrate on

the development of new theoretical frameworks to accomplish the goal of providing the CAISO operational visibility for mass market DR resources. There is a natural interaction between these projects, as PG&E's implementation will provide new insight to inform the development or refinement of CEC's theoretical frameworks.

Potential Benefits at Full Deployment

- Providing alternative cost-effective technology solution that meets CAISO operational visibility requirements would allow PG&E to construct resources that can be bid in the CAISO wholesale market. These resources will presumably compete against traditional supply side resources.
- There are cost savings elements for adopting and certifying new technologies that meet CAISO operational requirements. Existing technology and requirements for telemetry is cost prohibitive which discourages non-generation owners from constructing resources that can be bid in to the CAISO market.

CHAPTER 5
ADMINISTRATION AND GOVERNANCE OF PG&E'S EPIC INVESTMENT PLAN

5. Administration and Governance of PG&E's EPIC Investment Plan

5.1 Collaboration With Program Administrators and Industry Leaders

As one of four EPIC program administrators, PG&E is committed to coordination and collaboration among the program administrators to avoid duplication of effort while providing the essential flexibility necessary to each RD&D program administrator. Effective collaboration will enable the program administrators to respond to changing needs in the market place and provide the opportunity for efficient use of customer funds by effectively leveraging efforts across the state.[34] PG&E will explore and leverage both existing and new formal collaboration and cooperation mechanisms among EPIC Program Administrators and California's energy and environmental RD&D leaders. Similar to California Energy Systems for the 21st Century Project, PG&E proposes an open and collaborative process, under which PG&E will solicit a broad representation of California RD&D leaders such as EPRI and stakeholders to directly participate in advising PG&E on specific EPIC-funded projects and priorities.

Additionally, in furtherance of the guiding principles and goals of the EPIC energy RD&D program as set out by the CPUC, and in order to maximize the benefits of the program to utility customers and the public, the EPIC Administrators have agreed to pursue the following principles for cooperating and collaborating for EPIC-funded energy RD&D programs:

> **Information Sharing and Coordinated Planning**. The EPIC Administrators will work together to address common goals, consistent with the State's energy and environmental policies and the guiding principles for energy RD&D as stated in the CPUC's EPIC decision. To this end, the EPIC Administrators will share information regarding their EPIC investment plans, programs and projects as much as practicable in order to maximize the efficient use of the funds and facilitate the dissemination of the results of the program efforts for the benefit of utility customers and the state.

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34 D.12-05-037, OP 12(c)(v).

Leveraging Funding and Avoiding Duplication of Projects. To the extent legally permissible, the EPIC Administrators will work together to avoid unnecessary duplication of efforts, consistent with Pub. Util. Code Section 740.1, and to leverage the EPIC funding for the benefit of electric utility ratepayers and the state.

Consistent Evaluation, Measurement and Verification of RD&D Results. The EPIC Administrators will work together to establish consistent and common evaluation, measurement and verification protocols for developing and reporting to the CPUC and stakeholders the performance and results of EPIC funded projects..

Coordinated Input and Advice from Stakeholders. The EPIC Administrators will continue working together to schedule, solicit and respond to comments and advice from stakeholders on their respective proposed and on-going EPIC Plans and programs.

Intellectual Property. The EPIC Administrators will work together and use best efforts to agree on common approaches to intellectual property rights to facilitate the dissemination and sharing of EPIC funded RD&D results for the benefit of electric utility ratepayers and the state.

5.2 Proposed Project Portfolio Governance Process to Leverage EPIC Investments

Given the dynamic nature of RD&D efforts and the rapidly evolving electric industry, EPIC program administrators must follow a RD&D project portfolio approach to identify, categorize, evaluate, select and prioritize projects in an efficient manner that leverages best practice governance processes. The EPIC program extends through 2020 and therefore ongoing program management will be required to ensure projects continue to meet energy policies, the industry environment, and customer needs.

PG&E has identified a four-step process it will follow at the beginning of the 2012-2014 Investment Plan cycle and ongoing throughout the investment plan cycle before proceeding on specific projects:

Step 1: Perform a refresh of its internal gap analysis performed for the November 1, 2012 filing with respect to the policy landscape to identify specific priority needs for PG&E's grid infrastructure, or where technology demonstrations are necessary to advance policy objectives. Projects will be prioritized based on the EPIC guiding principles to improve safety, reliability and achieve state energy policies cost-effectively.

Step 2: Review the RD&D landscape to ensure alignment of proposed initiatives with broader industry direction and ensure alignment with California-specific needs. PG&E intends this process to be collaborative with the other Program Administrators and RD&D organizations with broad visibility into this landscape.

Step 3: Collaborate with the other EPIC program administrators to review its proposed list of projects, identify synergies and opportunities for greater collaboration to leverage EPIC funding. This process will also be used to confirm that RD&D initiatives are not duplicative.

Step 4: Following the steps noted above, PG&E's proposed projects will undergo established PG&E program governance procedures and supplier contracting processes to approve, initiate and manage individual projects against established project goals and metrics.

The four steps outlined above are vital to the success of each EPIC program administrator program and will ensure efficient utilization of EPIC funds. The identified steps above reaffirm the importance of collaboration across the program administrators, consider existing electric industry RD&D work, and seek to leverage existing PG&E program management governance processes and controls. These are all important to maximizing the use of limited EPIC funds on the highest priority projects.

PG&E intends to execute EPIC projects in a manner consistent with its RD&D vision described in Chapter 3. PG&E will follow a project portfolio governance approach that leverages best practices to holistically identify, prioritize, select projects, allocate resources and manage between projects. This approach is essential to ensure that the

overaching goals of the EPIC program are met and also that the appropriate RD&D investments are made to support grid needs in both the near term as well as the future.

PG&E and the other utilities have made substantial progress in developing a project portfolio, and will continue to work together throughout the portfolio management process to prioritize and balance the project portfolio taking into consideration each other's TD&D activities. PG&E intends to continue to work with the three other program administrators to continue to refine the projects to maximize synergies and collaboration between the parties leading up to the Commission's decision in May 2013.

5.3 Proposed 2012-2014 EPIC Budget and Funding Allocation

2012 EPIC funding levels were first authorized in Decision 11-12-037 at the level then currently in 2011 rates for the expired Renewables and Research and Development portion of the Public Goods Charge.[35] In establishing a 3-year investment program cycle and authorizing new funding levels for 2013 and beyond, the Commission directed that funds for the first triennial investment plan should be allocated to the 2012-2014 EPIC program cycle in the same proportion as the funding for 2013-2020.[36] The CEC is designated as administrator for 80 percent of the EPIC funds with 20 percent of program funding administered by the utilities based on their funding allocation of which the EPIC Decision allocated 50.1 percent in forecast EPIC Program funds collected from customers.[37] The 2012-2014 program budget for PG&E's portion of TD&D activities is approximately $43.2 million. In addition, the EPIC decision provides approximately $4.9 million for general PG&E administration of EPIC program. [38]

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35 On October 29, Energy Division issued a revised Program Oversight Budget based on 2011 Public Goods Charge funding levels approved for each utility exclusive of franchise fees and uncollectibles.

36 D.12-05-037, OP 8.

37 *Id.*, OP 5.

38 *Id.*, OP 12(b)(i).

TABLE 5-1
PG&E'S 2012-2014
TRIENNIAL INVESTMENT PLAN
PROGRAM BUDGET (MILLIONS)

	CEC	PG&E	SCE	SDG&E	Total
Utility Funding Allocation		50.1%	41.1%	8.8%	100.0%
Authorized EPIC Funding Budget		233.637	191.651	41.242	466.530
Program Administrator Budget					
Applied Research	$158.391				$158.391
Technology Demonstration and Deployment	129.623	$43.268	$35.495	$7.600	215.986
Market Facilitation	43.197	–	–	–	43.197
Program Administration	36.859	4.905	4.024	861	46.649
Program Oversight	–	1.155	947	203	2.304
Total	$368.071	$49.328	$40.467	$8.664	$466.530

As described in Table 5-2 below, PG&E proposes to allocate funding across the three investment areas within the TD&D area as follows:

TABLE 5-2
EPIC INVESTMENT AREAS
AND FUNDING ALLOCATION

PG&E EPIC Investment Areas	Technology Demonstration and Deployment Program Areas	Funds Allocation
Renewables and Distributed Energy Resources Integration	• Integrate Distributed Energy Resources, Generation and Storage • Improve Transparency of Resource Information • Increase Generation Flexibility	18%
Grid Modernization and Optimization	• Optimize Existing Assets • Prepare for Emerging Technologies • Design and Demonstrate Grid Operations of the Future	49%
Customer Service and Enablement	• Drive Customer Service Excellence by Leveraging the SmartMeter™ Platform • Drive Customer Service Excellence by Offering Greater Billing Flexibility • Integrate Demand-Side Management for Grid Optimization and cost reduction	23%
Program Administration		10%
Total		100%

The allocation shown in Table 5-2 may change as the proceeding to consider EPIC applications progresses and as PG&E refines, develops and approves projects. These funding levels are estimates and reflect PG&E's best judgement as of the filing of its Investment Plan. PG&E anticipates that allocations may change based on information

obtained through the RFI and RFP process as well as understanding the amount of leveraging of EPIC or other funds available.

The procedural schedule established by the Commission in Decision 12-05-037 contemplated proposed a Commission Decision by May 2013. As the Commission is unlikely to approve the first triennial EPIC investment plans before May 2013, halfway through the first triennial period, PG&E expects that expenditures for individual projects will likely extend beyond the end of the first triennial period December 31, 2014. For those projects that expand beyond the first investment cycle, PG&E proposes to ensure EPIC funds are committed in order to successfully complete approved pilots.

Consistent with the Phase 2 Decision, PG&E's EPIC Investment Plan will operate within the 10 percent program administration cap and will focus primarily on TD&D pilots and does not propose to allocate funding to other categories such as applied research and development, market facilitation or market support.[39] The decision also provided authorization to the program administrators to shift up to 5 percent of funds between funding categories (i.e., program administration, applied research, TD&D and market facilitation.) PG&E will submit a advice letter (Tier 2) seeking Energy Division approval to shift funds between program administration and TD&D funding categories if additional funding shifting beyond the 5 percent or to a new category is required.[40]

5.4 Procedures for Competitive Solicitation of Projects and Outreach to Stakeholders and Third-Parties

PG&E intends to consult extensively with other California energy RD&D stakeholders and subject matter experts before, during and after solicitation and selection of specific projects within the program categories in its EPIC investment plan. This consultation will include a variety of informal and formal mechanisms, including the twice-a-year meetings with stakeholders and annual reports required by the EPIC decision. PG&E regards this EPIC Investment Plan as an additional avenue to foster engagement with stakeholders and diverse businesses within California. RD&D is disruptive in nature,

39 D.12-05-037, OP 4 and 5.

40 *Id.*, OP 15.

and success by diverse businesses in EPIC may enable greater participation in later phase deployments. As described earlier, PG&E will continue its collaboration efforts with the other EPIC administrators in addition to other leading California energy RD&D institutions and funders, such as LLNL, LBNL, the University of California, Stanford University, the California State University system, and leading "green tech/clean tech" entrepreneurs and researchers in Silicon Valley and elsewhere in the State.

PG&E's selection of individual projects and project sponsors will employ a public and transparent competitive solicitation process when appropriate, such as "Requests for Information" (RFIs) and "Requests for Proposal" (RFPs), in order to draw on a broad array of expertise and innovation in the State, and to make clear to potential project sponsors what eligibility criteria and qualifications are required for a grant of EPIC funding. In this regard, PG&E will draw on the public solicitation and selection process used in the CPUC's CSI RD&D program as a model to inform for its EPIC RD&D solicitation process. Where a unique or specific expertise or capability is required for an individual project, PG&E may employ "sole source" procurement procedures, with documentation available to the CPUC and the public on its reasons for the sole source approach.

As EPIC projects move through the procurement process from concept to Request for Information, Request for Proposal and contracting, PG&E will use existing PG&E Sourcing policies, processes, tools and goals to evaluate product and service offerings included in the Investment Plan.

Portfolio and project opportunities will have clearly defined work scope, schedule and budget requirements established, along with any eligibility criteria and qualifications, prior to external posting. These opportunities may be made available to interested parties through multiple channels.

Before a supplier is presented to PG&E Sourcing for inclusion in a project bid opportunity, suppliers will have been vetted by a technical cross-functional team to ensure they satisfy EPIC's technical merits and benefits criteria, team qualifications, funding structure, and other technical, financial or policy requirements.

Qualified suppliers will be evaluated and scored by a second cross-functional team of sourcing, business and technical experts on multiple quality, safety, value and supplier diversity factors pertaining to a particular TD&D initiative. Contract type (Time & Material, Fixed, Incentive-based, etc.) may vary according to the needs of the specific project. Additional criteria may be used, as necessary, according to the needs of an individual project or PG&E's sourcing policies.[41]

Where a unique or specific expertise or capability is required for an individual project, PG&E may employ "sole source" procurement procedures, with documentation available to the CPUC and the public on its reasons for the sole source approach.

PG&E generally will use standard contractual provisions for each project, including as appropriate, both master agreements and specific scopes of work, based on standard time-and-materials contracts it has used in the past for similar RD&D projects. In addition, for each project, PG&E will require the applicant or third-party to provide PG&E with an assessment of: (1) funding available from other sources that could be leveraged with EPIC funding; (2) previous or existing RD&D projects or programs that overlap or duplicate the EPIC project or program category for which funds are requested; and (3) a proposed method for quantifying the estimated benefits of the project to ratepayers and the State.

PG&E does not expect to utilize loans or "pay-for-performance" types of contracts for EPIC projects, but does not rule out including other types of "performance-based" incentives in its RD&D grants and contracts, such demonstrating a minimum level of operating performance when piloting a particular technology, facility or process in the field. As is usual for utility contracts in general, PG&E's EPIC contracts will retain audit rights for both PG&E and the CPUC.

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41 OP 12 (b)(iv).

CHAPTER 6
METRICS, MEASUREMENT AND EVALUATION OF PG&E'S EPIC INVESTMENT PLAN

6. Metrics, Measurement and Evaluation of PG&E's EPIC Investment Plan

PG&E expects to use a combination of quantitative metrics and qualitative criteria, in evaluating the potential benefits and actual results of its EPIC-funded projects. Each project funded through the investment plan will delineate how it conforms to the EPIC primary and secondary guiding principles including societal benefits, GHG emissions mitigation and adaptation in the electricity sector at the lowest possible cost, the loading order, low emission vehicles and transportation, economic development and efficient use of customer funds.[42] PG&E intends to use these criteria to evaluate and report out against individual projects.

PG&E intends to work with the other EPIC administrators and the CPUC staff to develop a common methodology and format for documenting and reporting the results and metrics of individual EPIC-funded projects. As discussed in detail in PG&E's Smart Grid Deployment Plan and Smart Grid Pilot Deployment Project, PG&E uses four key metrics to evaluate the potential benefits and cost-effectiveness of various TD&D projects:

- Savings in Operation and Maintenance costs;
- Energy savings;
- Reliability improvement;[43] and
- Reduced GHG emissions.

To the extent that each project identifies proposed benefits to be evaluated during the pilot, a summary of results from each EPIC project se will be included as part of the annual report to the Commission.

Using the EPIC primary and complementary principles as a baseline, Table 6-1 outlines the potential benefit areas for each of the 26 projects.

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[42] D.12-05-037, OP 2.

[43] Reliability Improvement as measured by System Average Interruption Duration Index (SAIDI), System Average Interruption Frequency Index (SAIFI) and Customer Average Interruption Duration Index (CAIDI).

TABLE 6-1
SUMMARY OF EPIC INVESTMENT PORTFOLIO

PG&E's EPIC Investment Plan Project Portfolio									
	Primary EPIC Guiding Principles			Complementary EPIC Guiding Principles					
Program Area: Renewables and Distributed Energy Resources Integration Technology Demonstration and Deployment Projects									
Program Objective 1: Integrate Distributed Energy Resources, Generation and Storage	**Safety**	**Reliability**	**Affordability**	**Societal Benefits**	**GHG Emissions Mitigation / Adaptation**	**Loading Order**	**Low-Emission Vehicles/ Transportation**	**Economic Development**	**Efficient Use of Ratepayer Monies**
1. Demonstrate energy storage end uses	✓	✓	✓	✓	✓	✓	✓	✓	✓
2. Demonstrate the use of distributed energy storage for T&D cost reduction		✓	✓	✓	✓	✓	✓	✓	✓
3. Demonstrate priority energy storage scenarios from the Energy Storage Framework		✓	✓	✓	✓	✓	✓	✓	✓
4. Expand lab test and pilot facilities for new energy storage systems	✓	✓	✓	✓	✓	✓	✓	✓	✓
Program Objective 2: Improve Transparency of Resource Information	**Safety**	**Reliability**	**Affordability**	**Societal Benefits**	**GHG Emissions Mitigation / Adaptation**	**Loading Order**	**Low-Emission Vehicles/ Transportation**	**Economic Development**	**Efficient Use of Ratepayer Monies**
5. Demonstrate new resource forecast methods to better predict variable resource output		✓	✓	✓	✓	✓		✓	✓
6. Demonstrate communication systems allowing the CAISO to utilize available renewable generation flexibly		✓	✓	✓	✓	✓		✓	✓
Program Objective 3: Increase Generation Flexibility	**Safety**	**Reliability**	**Affordability**	**Societal Benefits**	**GHG Emissions Mitigation / Adaptation**	**Loading Order**	**Low-Emission Vehicles/ Transportation**	**Economic Development**	**Efficient Use of Ratepayer Monies**
7. Demonstrate systems to ramp existing gas-fired generation more quickly to adapt to changes in variable energy resources output		✓	✓	✓	✓	✓			✓
Program Area: Grid Modernization and Optimization Technology Demonstration and Deployment Projects									
Program Objective 1: Optimize Existing Grid Assets	**Safety**	**Reliability**	**Affordability**	**Societal Benefits**	**GHG Emissions Mitigation / Adaptation**	**Loading Order**	**Low-Emission Vehicles/ Transportation**	**Economic Development**	**Efficient Use of Ratepayer Monies**
8. Improve distribution system safety and reliability through new data analytics techniques	✓	✓	✓	✓				✓	✓
9. Test new remote monitoring and control systems for T&D Assets	✓	✓	✓						✓
10. Demonstrate new strategies and technologies to improve the efficacy of existing maintenance and replacement programs	✓	✓	✓	✓					✓
11. Demonstrate self-correcting tools to improve system records and operations	✓	✓	✓						✓

TABLE 6-1
SUMMARY OF EPIC INVESTMENT PORTFOLIO
(CONTINUED)

PG&E's EPIC Investment Plan Project Portfolio									
	Primary EPIC Guiding Principles			Complementary EPIC Guiding Principles					
12. Demonstrate new technologies that improve wildlife safety and protect assets from weather-related degradation	✓	✓	✓	✓				✓	✓
Program Objective 2: Prepare for Emerging Technologies	**Safety**	**Reliability**	**Affordability**	**Societal Benefits**	**GHG Emissions Mitigation / Adaptation**	**Loading Order**	**Low-Emission Vehicles/ Transportation**	**Economic Development**	**Efficient Use of Ratepayer Monies**
13. Demonstrate new systems to improve substation automation and interoperability	✓	✓	✓						✓
14. Demonstrate "next generation" SmartMeter™ telecommunications network functionalities	✓	✓	✓	✓			✓	✓	✓
Program Objective 3: Design and Demonstrate Grid Operations of the Future	**Safety**	**Reliability**	**Affordability**	**Societal Benefits**	**GHG Emissions Mitigation / Adaptation**	**Loading Order**	**Low-Emission Vehicles/ Transportation**	**Economic Development**	**Efficient Use of Ratepayer Monies**
15. Demonstrate new technologies and strategies that support integrated "customer-to-market-to-grid" operations of the future	✓	✓	✓	✓			✓		✓
16. Demonstrate electric vehicles as a resource to improve grid power quality and reduce customer outages	✓	✓	✓	✓	✓		✓	✓	✓
17. Leverage EPIC funds by participating in multi-utility, industry-wide RD&D programs such as those conducted by EPRI		✓	✓	✓	✓		✓		✓
Program Area: Customer Services and Enablement Technology Demonstration and Deployment Projects									
Program Objective 1: Drive Customer Service Excellence by Leveraging PG&E's SmartMeter™ Platform	**Safety**	**Reliability**	**Affordability**	**Societal Benefits**	**GHG Emissions Mitigation / Adaptation**	**Loading Order**	**Low-Emission Vehicles/ Transportation**	**Economic Development**	**Efficient Use of Ratepayer Monies**
18. Demonstrate SmartMeter™-enabled data analytics to provide customers with appliance-level energy use information			✓	✓	✓	✓		✓	✓
19. Pilot enhanced data techniques and capabilities via the SmartMeter™ platform			✓	✓	✓	✓		✓	✓
20. Demonstrate the benefits of providing the competitive, open market with automated access to customer-authorized SmartMeter™ data			✓	✓			✓	✓	✓
21. Pilot methods for automatic identification of distributed energy resources (such as solar PV) as they interconnect to the grid to improve safety & reliability	✓	✓		✓	✓	✓	✓	✓	✓

TABLE 6-1
SUMMARY OF EPIC INVESTMENT PORTFOLIO
(CONTINUED)

PG&E's EPIC Investment Plan Project Portfolio									
	Primary EPIC Guiding Principles			Complementary EPIC Guiding Principles					
Program Objective 2: Drive Customer Service Excellence by Offering Greater Billing Flexibility	**Safety**	**Reliability**	**Affordability**	**Societal Benefits**	**GHG Emissions Mitigation / Adaptation**	**Loading Order**	**Low-Emission Vehicles/ Transportation**	**Economic Development**	**Efficient Use of Ratepayer Monies**
22. Demonstrate subtractive billing with submetering for EVs to increase customer billing flexibility		✓	✓	✓	✓	✓	✓		✓
23. Demonstrate additive billing with submetering for PVs to increase customer billing flexibility		✓	✓	✓	✓	✓		✓	✓
Program Objective 3: Integrate Demand-Side Management (DSM) for Grid Optimization	**Safety**	**Reliability**	**Affordability**	**Societal Benefits**	**GHG Emissions Mitigation / Adaptation**	**Loading Order**	**Low-Emission Vehicles/ Transportation**	**Economic Development**	**Efficient Use of Ratepayer Monies**
24. Demonstrate DSM for T&D cost reduction		✓	✓	✓	✓	✓	✓	✓	✓
25. Develop a tool to map the preferred locations for DC fast charging, based on traffic patterns and PG&E's distribution system to address EV drivers' needs while reducing the impact on PG&E's distribution grid			✓	✓	✓		✓	✓	✓
26. Pilot measurement and telemetry strategies and technologies that enable the cost-effective integration of mass-market DR resources into the CAISO wholesale market		✓	✓	✓	✓	✓	✓		✓

6.1 Plan for Disseminating Information and Results of EPIC Programs and Projects to Stakeholders and the Public

PG&E intends to use formal and informal means for widely disseminating EPIC program and project information and results to stakeholders and the public.[44] On a formal basis, PG&E will provide updates on its EPIC program and specific projects in the twice-yearly meetings with stakeholders and the annual reports required by the EPIC decision. On a more informal basis, PG&E will seek to establish informal working groups and clearinghouses for exchange of information and RD&D results among the four EPIC administrators as well as with other leading California RD&D institutions and

44 D.12-05-37, OP12(c)(iii).

stakeholders. The goals of these information dissemination protocols will be to maximize the sharing of RD&D insights, innovations and results so that the “know how” and benefits of the EPIC program can be leveraged for the benefit of all utility customers and the public as quickly, efficiently and cost-effectively as possible. An additional goal of such information sharing is to enhance the ability of PG&E and other RD&D leaders in the State to “benchmark” RD&D goals, ideas and results on a national as well as global scale.

CHAPTER 7
RECOMMENDED APPROACH TO EPIC-FUNDED INTELLECTUAL PROPERTY

7. Recommended Approach to EPIC-Funded Intellectual Property

PG&E will work with the other EPIC administrators, stakeholders and potential EPIC recipients to determine an appropriate sharing of intellectual property on a project-by-project basis, as recommended in the EPIC decision. As a general principle, PG&E expects that intellectual property that it brings to EPIC projects will remain the property of PG&E,[45] and that intellectual property developed using ratepayer funds will also remain a utility asset, to be used for the benefit of the ratepayers who funded the project. Intellectual property that is jointly developed using the know-how and facilities of both PG&E and third parties, such as EPIC grant recipients, will be shared based on mutual agreement between PG&E and the third party. In all cases involving intellectual property used or developed with EPIC funds, PG&E will use and license the intellectual property consistent with the overall principles established by the CPUC in its EPIC decision, i.e., for the purposes of greater reliability, lower costs and increased safety for ratepayers, as well as for broader societal benefits as identified by the CPUC.[46]

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45 Publ. Util. Code Section 851.

46 OP 12(d).

APPENDIX A

ELECTRIC PROGRAM INVESTMENT CHARGE

STAKEHOLDER FEEDBACK

Electric Program Investment Charge Stakeholder Feedback

Date	Stakeholder	Description	EPIC Investment Plan Reference
24-Aug-12	Agricultural Energy Consumers Association	The CEC is required to fund 20% of their allocation to Technology Demonstration and Deployment (TD&D) funding on bioenergy projects, the IOUs should fund projects to help deploy bioenergy projects. Two primary recommendations for the IOUs as they develop their initial investment plan: 1. Establish programs to better deploy bioenergy projects in California 2. Fund energy efficiency and clean energy technologies for agricultural and waste water practices	The California Energy Commission's EPIC Investment Plan will address bioenergy projects.
22-Aug-12	Mehta Associates	Energy efficiency improvement incentive programs for industrial facilities are available through IOU energy efficiency programs such as EPIC. Most of the IOUs energy efficiency programs have focused on energy efficiency improvements and have not looked at the impact of these actions on criteria pollutant and toxic air contaminant emissions. Strongly recommend that CPUC, CEC, Air Resources Board and the IOUs to make this integration of EPIC program with AB 32 goals using the implementation funds and incentives.	EPIC Investments will align with the primary and complementary guiding principles.
24-Aug-12	Energy Initiatives	If EPIC is executed in a cohesive, coordinated and results-orientated framework, EPIC will advance the development and deployments of next generation clean technologies while ensuring the best possible use of ratepayer funds. EPIC funds should leverage ongoing efforts and coordinated with statewide efforts. California Energy Efficiency Strategic Plan must play a central role in EPIC's plan across the investment areas. Advancing the Strategic Plan will require implementing technologies, demonstrations and other market facilitation activities that require higher up front costs and fall outside traditional definitions of cost effectiveness. EPIC can and should "fill in the gaps" in support of the Strategic Plan by enabling programs to drive substantial savings in the future. (i.e. Zero Net Energy pilots)	PG&E's EPIC Investments plan is aligned with the CA Energy Efficiency Strategic Plan. PG&E has identified investment opportunities to demonstrate how to integrate DSM for Grid Optimization as well as support ZNE.
17-Aug-12	Michelle Rodriquez	Recommends developing smart grid and technology pilots with specific industries to develop smart grid best management practices, protocols, and information which might help reliability and sustainability. Pilots recommended in education, healthcare, media and entertainment, tourism/hospitality, manufacturing and government. Pilots should be geographically targeted in various areas such as along transit corridors and low income and underserved neighborhoods, technology districts, and in different population densities to get a sense of how geography changes the smart grid and technology. Pilots should address cross cutting issues of economic cost benefit and workforce/job creation and aligned with the Smart Grid Stakeholder Vision.	Pilots will be deployed geographically to test various conditions throughout PG&E"s service territory. PG&E's EPIC Investment Plan is aligned with its Smart Grid Strategy and Vision.

17-Aug-12	Electric Power Research Institute (EPRI)	Requests CEC and IOU engagement in EPRI's Annual Research Portfolio programs be considered as a distinct, non-competitive funding item included in the CEC Applied R&D investment plan. EPRI considers the research work to be an integral part of the technology demonstration pilots. Early involvement by the IOUs will reduce technology development timelines, enhance product features (i.e interoperability) and move technologies into the broader market. Requests the IOUs to consider EPRI programs in their investment plans to ensure investments are leverages, shared lessons learned both within California and industrywide in order to realize substantial value to ratepayers. Areas of value include: Collaborative financial leverage resulting in shared costs and lower financial risks. Minimizes duplication of efforts within and outside of California. Ensuring ideas, results and progress from RD&D outside of California are brought into California; collaborating with a research institute with strong history of public benefit and alignment with EPIC program principles.	PG&E, SCE, SDG&E and Energy Division attended a one day workshop hosted by EPRI. EPRI and the Program Administrators exchanged information on R&D roadmaps and validated the IOU's framework for approaching investments in R&D technology demonstration projects. PG&E has included funding within its EPIC Investment Plan to leverage efforts and avoid duplication of effort.
27-Aug-12	Waste Management Wheelabrator Technologies, Inc.	The IOUs should commit EPIC funds in support of the priorities and objectives of the Governor's BioEnergy Action Plan. (Action 2.2a and Action 4.1) EPIC funds should be used to advance development and deployment of biogas and biomethane. The technology to commercialize biomethane and biogas to energy is available, but currently too expensive to be competitive in the market. More efficient methods to use landfill gas to generate power will lead to cleaner energy and lower greenhouse gas emissions from both energy generation and waste disposal sectors. Technology exists to safely treat and monitor landfill gas for pipeline distribution, as demonstrated in 30 projects outside of California. EPIC funds should be used to demonstrate the acceptability and feasibility of further developing this renewable resource. EPIC funds should be available for demonstration of anaerobic digestion, gasification and other types of energy conversion technologies as well as to produce energy. Requests for Information and requirements of an EPIC proposal for funding should respect intellectual property rights and trade secrets to encourage participation by innovative technologies.	The California Energy Commission's EPIC Investment Plan will address bioenergy projects.

		Utilities should give special consideration to proposals that aggregate clean technologies to produce electricity. In addition to clean energy generation, management of municipal solid waste streams would be an integral part of such a project. It would be helpful for the utilities to provide comments on its specific requirements for information expected to be submitted in the grant process prior to release of a grant announcement so that disclosure requirements could be settled in advance to ensure participation by potential respondents.	
4-Oct-12	BirdsVision	Supports EPIC objective "Demonstrate System and Public Safety"- Health Environmental Impact, Hazard Mitigation, System Integrity" and proposes an emphasis to the Grid Modernization and Optimization Section - Demonstrate Strategies and technologies for the prevention of animal hazards to power line and other energy infrastructure. Types of demonstration and deployment projects that the IOUs are asked to consider include radars, algorithms to analyze data from different sources (cameras, radars, RF transmitters) deterrence technologies such as sonic, ultrasonic, visual etc. and risk management software that enables highly efficient operation of the deterrence components according to risk prioritization. Provides value to grid operations, transmission and distribution given the direct and indirect damages due to animal caused outages in energy infrastructure that are upwards of $1Billion annually in California alone.	PG&E is aware of BirdVisions technology and has met with them to understand its capabilities. PG&E will evaluate and pilot various technologies as part of its EPIC project in this area.
4-Oct-12	GridX	Supports PG&E's illustrative project "Pilot Subtractive Billing with submetering for EV's." Urges the program administrators to budget for and solicit proposals that will enable more rapid adoption of EV's in California. One critical piece of missing technology is key back office IT infrastructure for utilities to support the EV charging business models, including subtractive billing needed to facilitate submeteriing for EV's. This technology would provide ratepayer benefits through the use of a common platform to exchange data between parties, promote EV adoption, and could eliminate redundant investment by the utilities.	Comments were received, after the stakeholders' webinar held by the IOUs on September 28th, offering support for this initiative. PG&E also views this project as a high-priority.

4-Oct-12	Natural Resources Defense Council (NRDC)	In general, believes the proposed framework presents a solid approach to implementing the Commission's EPIC guidance and to making progress on the state's broader policy goals. Comments are provided to clarify NRDC's perspective on the EPIC Program. Urges the IOUs to consider the opportunity for additional RD&D in a couple of specific areas including expansion of energy efficiency technologies and policies that could benefit through focused RD&D efforts beyond the CEC's EPIC program, participation in joint research programs such as EPRI and if needed to request additional funding to support that participation from the Commission.	PG&E concurs that participation in Joint Research programs such as EPRI would inform EPIC Program Administrator's efforts. Funding is included within PG&E's EPIC Investment Plan.

APPENDIX B

PG&E'S ELECTRIC PROGRAM INVESTMENT PLAN

PG&E'S CURRENT AND PROPOSED TECHNOLOGY DEMONSTRATION & DEPLOYMENT (TD&D) INITIATIVES

APPENDIX B
Electric Program Investment Plan
PG&E's Current and Proposed Technology Demonstration & Deployment (TD&D) Initiatives

			Funding Source / Coordinating Activity (a)							
			Applied Research (b)		Technology Demonstration & Deployment (c)					
Item No.	EPIC Project No.	**Candidate Projects Sorted by EPIC Program Investment Area**	Distributed Generation (d)	LLNL CES-21 (e)	EPIC	Energy Efficiency	Demand Response	Smart Grid Pilot Deployment Application	Direct Links with EPIC Candidate Projects (f)	Notes
		Renewables and Distributed Energy Resources Integration								
R1		Development and analysis of a progressively smarter distribution system	X							
R2		Advanced grid-interactive distributed PV and storage	X							Scope includes customer-side storage, not grid-side storage.
R3		PV and advanced energy storage for demand reduction	X							Scope includes customer-side storage, not grid-side storage.
R4		Beopt-CA (EX): A tool for optimal integration of EE/DR/ES+PV for California homes	X							
R5		Quanta study #1 - Impacts of "mid-size" (i.e., 1-20 MW) PV on PG&E feeders	X							
R6		Quanta study #2 - Impacts of "small" PV (e.g., residential) PV on PG&E feeders	X							
R7		SmartGrid-Ready PV inverter with utility communication	X							
R8		Solar3.0: Comprehensive online tools for solar market acceleration	X							
R9		Screening distribution feeders - alternatives to 15% rule	X							Aims to improve distribution asset management practices through modeling and simulation.
R10		Quantification of risk of unintended islanding and reassessment of interconnection requirements in high penetration of customer-sited distributed PV generation	X							Inverter testing at PG&E's ATS labs - Testing if multiple inverters behind a meter shut off during grid disturbances
R11		Tools development for grid integration of high PV penetration	X							Aims to improve PV forecasting through modeling and simulation.
R12		Integrating PV into utility planning and operating tools	X						5	Aims to improve PV forecasting through modeling and simulation. Uses similar meteorological forecasting methods as Demonstrate new resource forecast methods to better predict variable output EPIC candidate project.
R13		Solar Energy & Economic Development Fund (SEED Fund) initiative	X							
R14		DOE Rooftop Challenge: streamlining and standardizing permitting, interconnection, and financing of rooftop PV to accelerate maturation of local solar PV markets	X							
R15	1	Demonstrate energy storage end uses			X					
R16	2	Demonstrate use of distributed energy storage for T&D cost reduction			X					
R17	3	Demonstrate priority scenarios from the Energy Storage Framework			X					
R18	4	Expand test lab and pilot facilities for new energy storage systems			X					
R19	5	Demonstrate new resource forecast methods to better predict variable output			X					Similar meteorological forecasting methods to Integrating PV forecasting project (ref. R12)
R20	6	Demonstrate communication systems allowing the CAISO to utilize renewable generation flexibly			X					
R21	7	Demonstrate systems to ramp existing gas-fired generation more quickly to adapt to changes in variable energy resources output			X					
R22		Short-Term Demand Forecasting Smart Grid Pilot						X		Uses more granular data (SmartMeter and SCADA) to improve short-term forecasts for participation in CAISO markets.
		Grid Modernization and Optimization								
G1		Smart Grid Line Sensor Pilot						X		
G2		Voltage and Reactive Power (Volt/Var) Optimization Pilot						X		
G3		Detect and Locate Distribution Line Outages and Faulted Circuit Conditions Pilot						X		
G4	8	Improve distribution system safety and reliability through new data analytics techniques			X					

APPENDIX B
Electric Program Investment Plan
PG&E's Current and Proposed Technology Demonstration & Deployment (TD&D) Initiatives

G5	9	Test new remote monitoring and control systems for existing T&D assets			X					
G6	10	Demonstrate automated asset notification and management systems			X					
G7	11	Demonstrate self-correcting tools to improve system records and operations			X					
G8	12	Demonstrate new technologies that improve wildlife safety and protect assets from weather-related degradation								
G9	13	Demonstrate new communication systems to improve substation automation and interoperability			X					Referenced in PG&E's Smart Grid Annual Report, but currently unfunded.
G10	14	Demonstrate "next generation" SmartMeterTM telecom network functionalities			X					
G11	15	Demonstrate new strategies and technologies that support integrated "Customer-to-Market-to-Grid" operations of the future			X					
G12	16	Demonstrate Electric Vehicles as a resource to improve grid power quality and reduce customer outages			X					The second phase of this project may be impacted by the DR EV pilot projects (ref. projects C2 and C7)
G13	17	Leverage EPIC funds by participating in multi-utility, industry wide RD&D programs such as EPRI			X					
G14		Electric Resource Planning - Analyze existing electric resource planning methods and develop improved models & tools.		X						
G15		Electric Resource Planning - Develop flexibility metrics and standards to provide input into planning and operating a grid with limited operating flexibility		X						
G16		Electric System Monitoring and Control: Adaptive protection, dynamic transmission path capability, and improved modeling and analytics for dynamic stability studies		X						
		Customer Service and Enablement								
C1		Auto DR/Technology Incentives					X			
C2		Emerging Technology - Auto DR Plug-in Electric Vehicle Charging Systems, Real-Time Feedback of DR Resources, Technologies & Controls that Facilitate new DR Capabilities (Including Ancillary Services)					X		16	Project may impact the second phase of the Demonstrate EVs as a resource EPIC candidate project.
C3		Permanent Load Shifting					X			
C4		DR Home Area Network Integration					X			
C5		Commercial and Industrial Based Intermittent Resource Management Pilot 2					X			
C6		Transmission & Distribution Pilot					X			
C7		Plug-In Electric Vehicle Pilot					X		16	Later stages of this pilot may impact the second phase of the Demonstrate EVs as a resource EPIC candidate project.
C8		Energy Efficiency - Food Services				X				
C9		Energy Efficiency - Appliances				X				
C10		Energy Efficiency - Commercial HVAC & General Purpose Motors				X				
C11		Energy Efficiency - Residential HVAC Systems				X				
C12		Energy Efficiency - Whole House Energy Upgrade California				X				
C13		Energy Efficiency - Building Shell				X				
C14		Energy Efficiency - Lighting Products (Residential, Multifamily, Commercial)				X				
C15		Energy Efficiency - Residential Audits				X				
C16		Energy Efficiency - Non-Residential Audits				X				
C17		Energy Efficiency - Industrial Products				X				
C18		Energy Efficiency - IT Products & Customized Solutions				X				
C19		Emerging Technology - Smart Thermostat (Residential)				X				
C20		Emerging Technology - Smart Appliances				X				
C21		Emerging Technology - Whole Home Connected Platform				X				
C22		Emerging Technology - HAN Platform Enabled				X				
C23	18	Demonstrate SmartMeter™-enabled data analytics to provide customers with appliance-level energy use information			X					
C24	19	Pilot enhanced data techniques and capabilities via the SmartMeter™ platform			X					
C25	20	Demonstrate the benefits of providing the competitive, open market with automated access to customer-authorized SmartMeter™ data to drive innovation			X					
C26	21	Pilot methods for automatic identification of distributed energy resources (such as solar PV) as they interconnect to the grid to improve safety & reliability			X					

APPENDIX B
Electric Program Investment Plan
PG&E's Current and Proposed Technology Demonstration & Deployment (TD&D) Initiatives

C27	22	Demonstrate Subtractive Billing with Submetering for EVs to increase customer billing flexibility			X					
C28	23	Demonstrate Additive Billing with Submetering for PV to increase customer billing flexibility			X					
C29	24	Demonstrate demand side management for T&D cost reduction			X					
C30	25	Develop a tool to map the preferred locations for DC fast charging, based on traffic patterns and PG&E's distribution system, to address EV drivers' needs while reducing the impact on PG&E's distribution grid			X					
C31	26	Pilot measurement and telemetry strategies and technologies that enable the cost-effective integration of mass market DR resources into the CAISO wholesale market			X					Links to applied research the CAISO is undertaking to fully develop the concept of this innovation.
Cross Cutting / Foundational Strategies & Technologies										
F1		Technology Evaluation, Standards, and Testing						X		
F2		Smart Grid Customer Outreach and Education Pilot						X		
F3		Cyber Security - Develop situational awareness, analyze threat environment and threat actors, simulate cyber attacks, and identify protective tools, processes, and standards		X						

Notes:
(a) "Funding Source / Coordinating Activity" reflects the actual or likely application funding a project, or points to the group within PG&E overseeing the project.
(b) "Applied Research" in the context of this document is research, analysis, modeling, simulation, and lab testing, that informs demonstration and deployment of pre-commercial technology.
(c) "Technology Demonstration & Deployment" in the context of this document is using PG&E's systems to test pre-commercial technology, either through demonstrations or limited deployments.
(d) Distributed Generation projects include projects funded by the California Solar Initiative (CSI) and various Department of Energy Funding Opportunity Announcements (FOA).
(e) Projects included in the Joint IOU and LLNL 21st Century Energy Systems filing are considered *Applied Research,* not Technology Demonstration & Deployment.
(f) "Direct" in the context of this document means that the work of one project has immediate material effect on another project.