BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF CALIFORNIA

In the Matter of the Application of Pacific Gas and Electric Company for Approval of its 2018-2020 Electric Program Investment Charge Investment Plan. (U39E).	Application 17-04-028
And Related Matters.	Application 17-05-003 Application 17-05-005 Application 17-05-009

COMPLIANCE FILING OF SAN DIEGO GAS & ELECTRIC COMPANY'S (U 902 E) 2017 ELECTRIC PROGRAM INVESTMENT CHARGE ANNUAL REPORT

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Attorneys for:
SAN DIEGO GAS & ELECTRIC COMPANY

February 28, 2018

BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF CALIFORNIA

In the Matter of the Application of Pacific Gas and Electric Company for Approval of its 2018-2020 Electric Program Investment Charge Investment Plan. (U39E).	Application 17-04-028
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COMPLIANCE FILING OF SAN DIEGO GAS & ELECTRIC COMPANY'S (U 902 E)
2017 ELECTRIC PROGRAM INVESTMENT CHARGE ANNUAL REPORT

Pursuant to Ordering Paragraph 16 of Decision (D.) 12-05-037 and in accordance with the Annual Report Outline provided in Attachment 5 of D.13-11-025, San Diego Gas & Electric Company (SDG&E) hereby submits its 2017 Annual Report for its Electric Program Investment Charge (EPIC) Program (Report), provided as Attachment A hereto. In addition, SDG&E provides the excel file titled "SDG&E 2017 EPIC Project Status Report" in accordance with D.13-11-025 as Attachment B,[1] and its EPIC Final Reports as Attachment C.[2] Together, these documents provide an overview of SDG&E's EPIC activities and program financial information during the 2017 calendar year.

[1] SDG&E, the California Energy Commission (CEC), Pacific Gas and Electric Company (PG&E), and Southern California Edison Company (SCE) (together, the EPIC Administrators) are required to provide with the annual report "electronically in spreadsheet format the information identified in Attachment 6 to report on projects described in Section 4.b of the EPIC annual report outline adopted by this decision." D.13-11-025 at 63. *Id*. at Attachment 5 and Attachment 6.

[2] The EPIC Administrators "must include with their [EPIC] annual report a final report on every project completed during the previous year." D.13-11-025 at 136, Ordering Paragraph 14. Due to size, Attachment C is being made available to all parties via Notice of Availability.

SDG&E and its fellow EPIC Administrators are required to each submit an annual report "detailing program activities."[3] The annual reports are designed "to facilitate consistent reporting by the [EPIC] Administrators on their investment plans and project results."[4] In accordance with D.12-05-037, SDG&E serves this Report on "all parties in the most recent EPIC proceeding, and all parties to the most recent general rate cases for [SDG&E, PG&E, and SCE], and each successful and unsuccessful applicant for an EPIC funding award" through December 31, 2017.[5]

Respectfully submitted,

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February 28, 2018

[3] D.12-05-037 at 8.
[4] D.13-11-025 at 4-5, 62.
[5] *Id*. at Ordering Paragraph 16.

ATTACHMENT A

SDG&E 2017 EPIC ANNUAL REPORT

San Diego Gas & Electric Company

2017 EPIC Annual Report

February 28, 2018

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APPENDICES

I. EXECUTIVE SUMMARY

Pursuant to Ordering Paragraph 16 of Decision (D.) 12-05-037 and in accordance with the Annual Report outline provided in Attachment 5 of D.13-11-025, San Diego Gas & Electric Company (SDG&E) hereby submits its 2017 EPIC Annual Report (Report). This Report provides an overview of SDG&E's EPIC activities during the 2017 calendar year. As required by D.13-11-025, SDG&E is providing additional information about SDG&E's EPIC activities in an excel file titled, "SDG&E 2017 EPIC Project Status Report" as Attachment B, and its EPIC Final Reports as Attachment C.[1]

SDG&E proposed and received approval for five projects that demonstrate smart grid system integration solutions in its first triennial application for years 2012-2014 (EPIC-1).[2] In addition, SDG&E proposed and received approval for six projects that demonstrate grid modernization and technology integration solutions in its second triennial application for years 2015-2017 (EPIC-2).[3] This Report summarizes SDG&E's progress and status for projects approved for both EPIC-1 and EPIC-2.

A. Overview of Programs/Plan Highlights

In A.12-11-002, SDG&E requested Commission approval of five programs that demonstrate smart grid system integration solutions. In November 2013, SDG&E's Application and First Triennial EPIC Plan was approved in full, with minor modifications, by the Commission in D.13-11-025. The total SDG&E budget for the first triennial cycle is $8,600k. Ten percent of this amount ($860k) is allotted to program administration. The remainder ($7,740k) is allotted to technical work in the Technology Demonstration and Deployment (TD&D) programs, which are limited to pre-commercial demonstrations.

In A.14-05-004, SDG&E requested Commission approval of its Second Triennial EPIC Plan which included five programs that have the potential to help modernize the electric grid to improve customer benefits, as well as a sixth project through which SDG&E will participate in industry RD&D consortia. In April 2015, SDG&E's Application and Second Triennial EPIC

[1] D.13-11-025 at 63 and 136.
[2] Application (A.) 12-11-002, which was approved by the California Public Utilities Commission (Commission) in D.13-11-025. SDG&E's Application (A.17-05-009) for its third triennial application for years 2018-2020 (EPIC-3) is still pending at the time of this filing.
[3] A.14-05-004, which was approved by D.15-04-020.

Plan was approved in full, with minor modifications, by the Commission in D.15-04-020. The total committed SDG&E budget for the second triennial cycle is $8,679k. Ten percent of the total authorized budget of $8,792 ($879k) is allotted to program administration. The remainder of the committed budget ($7,800) is allotted to technical work in TD&D programs, which are limited to pre-commercial demonstrations.

B. Status of EPIC-1 and EPIC-2 Projects

As discussed in further detail below, throughout 2017, SDG&E completed four of the five EPIC-1 projects. The final reports for the four completed projects are provided with this annual report (*see* Appendices 1 to 8). The unfinished project (EPIC-1, Project 2) was partially completed, and a final report for the completed part is delivered with this annual report (provided as Appendix 2). The remainder of this project will be performed in 2018, and a final report for that portion of the project will be provided upon completion.

In 2017, SDG&E continued the work on the six EPIC-2 projects and completed all six projects. The final reports for the six EPIC-2 projects are provided with this annual report (*see* Appendices 9 to 15).

SDG&E's updated portfolio for both EPIC-1 and EPIC-2 is provided in Table 1 below.

Table 1. SDG&E's EPIC-1 and EPIC-2 Portfolio as of December 31, 2017

EPIC-1 Projects (2012 – 2014)				
EPIC Project	**Incurred[4] Costs ($ thousands)**	**Encumbered[5] Costs ($ thousands)**	**Commitments[6] ($ thousands)**	**Project Status**
1. Smart Grid Architecture Demonstrations	1,402	1,406	1,406	Complete
2. Visualization and Situational Awareness Demonstrations	1,061	2,075	2,301	In Progress
3. Distributed Control for Smart Grids	1,386	1,392	1,392	Complete
4. Demonstration of Grid Support Functions of Distributed Energy Resources	1,095	1,200	1,200	Complete
5. Smart Distribution Circuits Demonstrations	1,433	1,441	1,441	Complete
6. SDG&E Program Administration	582	746	860	In Progress
Total	**$6,959**	**$8,260**	**$8,600**	

EPIC-2 Projects (2015 – 2017)				
EPIC Project	**Incurred Costs ($ thousands)**	**Encumbered Costs ($ thousands)**	**Commitments ($ thousands)**	**Project Status**
1. Modernization of Distribution System & Integration of Distributed Generation and Storage	1,971	2,009	2,009	Complete
2. Data Analytics in Support of Advanced Planning and System Operations	957	1,111	1,111	Complete
3. Monitoring, Communications, and Control Infrastructure for Power System Modernization	1,288	1,305	1,305	Complete
4. System Operations Development and Advancement	1,064	1,088	1,088	Complete
5. Integration of Customer Systems into Electric Utility Infrastructure	978	985	985	Complete
6. Collaborative Programs in RD&D Consortia	830	1,561	1,561	Complete
7. SDG&E Program Administration	372	510	620	In Progress
Total	**$7,460**	**$8,569**	**$8,679**	

[4] As used in this Report, incurred costs means actual booked expenditures.
[5] As used in this Report, encumbered costs are funds that are specified for contracts (D.13-11-025 at 101; Ordering Paragraph 45) or for in-house work necessary in collaboration with a contractor (D.13-11-025 at 53). They differ from commitments in that commitments are the identification of blocks of funds to be assigned to projects, whereas encumbrances specify how the commitments will be used in the projects.
[6] As used in this Report, commitment means assigned for anticipated work on a project, including anticipated contractual commitments, equipment purchases, software licenses, associated technical work by the SDG&E project team, and other expenses directly associated with the project work.

1. EPIC-1 Projects

Project 1: Smart Grid Architecture Demonstrations

All project activities were completed in 2017. IEC 61850 was identified as a principal component of the new architecture. A representative test system was constructed, and a total of eleven use cases were defined to demonstrate the use of IEC 61850 standards. The recommendation is that SDG&E plan for long-term migration to an architecture that incorporates IEC 61850 standards

Project 2: Visualization and Situational Awareness Demonstrations

In 2017, the project final report was completed. Funds were encumbered to continue work in 2018 on selected use cases, to gain additional value. With the solutions demonstrated in the project, the SDG&E project team has made significant improvements over the state-of-the-art approaches at SDG&E in each of the areas addressed by the eight use cases this project presented.

The project was presented at the following events: EPIC Symposium on February 2017 in Sacramento, Data Analytics Conference on September 2017 in San Diego, OSIsoft T&D User Group Meeting on September 2017 in New Orleans, and EPIC Fall Symposium in October 2017 in San Diego.

Project 3: Distributed Control for Smart Grids

In 2017, the project final report was completed. The project concluded with the final task, which involved conducting extensive tests on the system, beginning with factory acceptance testing and culminating with system acceptance testing, and a final pre-commercial demonstration of the operation and performance of the system at SDG&E's Integrated Test Facility (ITF). The results of those tests and the comparison between the different approaches were documented and used to formulate findings and conclusions.

The project was presented at the EPIC Symposium on February 2017 in Sacramento, and at the EPIC Fall Symposium in October 2017 in San Diego.

Project 4: Demonstration of Grid Support Functions of Distributed Energy Resources

This project's primary focus was on pre-commercial demonstrations to assess the value of distributed energy resources (DER) grid support functions in various alternative application situations. This project consists of three modules: value assessment of grid support functions of DER, communication standards for grid support functions of DER, and demonstration and comparison of the EPRI and SDG&E DER hosting capacity analysis tools. All three modules were completed in 2017 and comprehensive final reports (with project approach, results, findings, recommendations, metrics, and value proposition sections) were prepared for each of the modules individually. For Module 1 (which was a substantial part of this project), a prime contractor was selected by competitive procurement. Three bidders responded to the solicitation.

All bids passed the initial screening criterion of being responsive to the request for proposal, and they were all evaluated and scored in accordance with the evaluation criteria. Schweitzer Engineering Laboratories (SEL) was selected for the contract award. SEL was the highest scoring bidder. Modules 2 and 3 were smaller efforts for which the contractors were selected by sole source.

Project 5: Smart Distribution Circuit Demonstrations

The project concluded in 2017. The project was divided into 2 modules:

- Module 1: Demonstration of Advanced Circuit Concepts – SDG&E selected Schweitzer Engineering Laboratory (SEL) as the prime contractor for this module. The focus was to perform pilot demonstrations of smart distribution circuit features in a laboratory for a set of selected test circuits. Using simulations and hardware-in-the-loop (HIL) testing, the desired features and upgrades were tested in the selected circuits to assess their suitability for widespread adoption.
- Module 2: Pre-Commercial Demonstration of Methodologies and Tools for Energy Storage Integration into Smart Distribution Circuits – All project activities were completed in the year 2017. The test included identification, evaluation, selection, and demonstration of methodologies and tools for prospective use in planning future energy storage projects. Test results from the test system were documented and evaluated. Chosen tools, software programs and methodologies were recommended to stakeholders.

2. EPIC-2 Projects

Project 1: Modernization of Distribution System and Integration of Distributed Generation and Storage

The project focused on a pre-commercial demonstration of a substation communication network based on the IEC 61850 communication standards. Members of SDG&E's substations and protection sections were engaged in the project planning in both project team and project stakeholder (prospective user) roles. Intelligence was gathered on the status of the IEC standards and the vendor equipment options for the demonstration. A prime contractor was added to the project team. A test system was developed, and a pre-commercial demonstration performed for selected use cases. The demonstration showed clear advantages of IEC 61850 over legacy communication standards.

Project 2: Data Analytics in Support of Advanced Planning and System Operations
All project activities were completed in 2017. The pre-commercial demonstration included ingestion of several data sources into a data lake, test build of preliminary predictive models for major electric distribution asset management use cases, and visualization development using business intelligence tools to provide insight into the health of various assets on the utility distribution system. Based on the project findings, it is recommended that SDG&E and other utility stakeholders commercially adopt and implement advanced data analytics techniques for effective asset management.

Project 3: Monitoring, Communication, and Control Infrastructure for Power System Modernization

All project activities were completed in 2017. The project focus was on pre-commercial demonstration of an Open Field Messaging Bus (Open FMB) for interoperability, peer-to-peer communication, and multiple protocol conversion. A representative test system was constructed, and a total of thirteen use cases were defined to demonstrate the use of OpenFMB for monitoring and control. As a result of this demonstration, it is recommended that work be continued to further define the OpenFMB standard so that it can be successfully utilized in future utility distribution system projects and deployments.

Project 4: System Operations Development and Advancement

All project activities were completed in the year 2017. A PHIL (Power Hardware In the Loop) test system was developed to examine improvements of the distribution system containing modern system component by optimization, using the RAMCO (Regional Aggregation Monitoring and Circuit Optimizers) and LRAM (Local Resource Aggregation and Monitoring). Results from the test system were evaluated and concluded that, the system operated as intended and optimized the distribution system. The recommendation is that stakeholders pursue this system further and commercialize it.

Project 5: Integration of Customer Systems into Electric Utility Infrastructure

The primary objective of this project was to investigate and address the evolving gateway between customers and utilities to facilitate increase in reliable deployment of clean energy technologies to support distribution systems. All project activities were completed in 2017. The project focus was on performing pre-commercial demonstration of advanced monitoring schemes, root-cause analysis tools, and assessment methodologies for safe and reliable integration and interoperability of customer systems with the distribution system and thereby increasing ratepayer satisfaction and benefits.

Project 6: Collaborative Programs in RD&D Consortia

Project development on demonstrations through collaborative R&D consortia focused on two modules. All project activities were completed in 2017.

For the project module on forecasting customer adoption of photovoltaic (PV), the project team used machine learning to identify several important attributes driving adoption for disadvantaged communities (DAC) and other locations (non-DAC) at the zip code level. Owner occupancy emerged as a key attribute explaining the difference in PV market share. The percentage of owner occupied homes is 50% for DAC zip codes compared to 63% for non-DAC zip codes. It is recommended that SDG&E not commercially adopt these methods and tools at this juncture, without more foundational work being done first.

For the module on unmanned aerial systems (UAS) data lifecycle management and deep learning demonstration, the project demonstrated integration with existing and future SDG&E

infrastructure, software applications and legacy data sets with the ability to ingest, store, analyze and report on SDG&E assets derived from Geographic Information System (GIS), Power Line Systems – Computer Aided Draft and Design (PLS-CADD), unmanned aircraft system (UAS) collected data and other various sources. Three test cases were demonstrated including equipment identification, vegetation encroachment identification, and cataloging and remote asset management. It is recommended that SDG&E pursue additional evaluation of UAS technology for stakeholder groups within the company that will benefit from the aggregation of various sources of data into a data management platform that also provides advanced analytical capabilities.

II. INTRODUCTION AND OVERVIEW

A. Background on the EPIC Program

The EPIC program was established by the Commission in D.11-12-035 to provide public interest investments in applied research and development, technology demonstration and deployment, market support, and market facilitation of clean energy technologies and approaches for the benefit of ratepayers of California investor-owned utilities (IOUs). D.12-05-037 established the purposes and governance structure for the EPIC program and D.13-11-025 clarified many of the program's regulatory requirements.

The EPIC program is designed to provide funding for electric utility research, development, and demonstration (RD&D). Specific funding allotments are made to four EPIC program administrators, including SDG&E.[7] The EPIC program is intended to run until 2020 and is comprised of three triennial program cycles (*i.e.*, EPIC-1, EPIC-2, EPIC-3).

B. EPIC Program Components

The IOUs, including SDG&E, may only administer EPIC projects in the area of pre-commercial technology demonstration and deployment (TD&D). Post-commercial demonstrations and deployments are not allowed. Utility participation in the early stages of the research and development process, *i.e.*, basic research and applied research for new utility-related technology, is also not allowed.

C. EPIC Program Regulatory Process

Pursuant to D.12-05-037, SDG&E was required to submit an application seeking Commission approval of an EPIC plan every three years. SDG&E submitted its First Triennial

[7] The EPIC administrators are the California Energy Commission (CEC), SDG&E, Southern California Edison Company (SCE) and Pacific Gas and Electric Company (PG&E).

EPIC Plan for years 2012-2014 (A.12-11-002) on November 1, 2012 (EPIC-1) and received full Commission approval of its EPIC-1 Plan in D.13-11-025. No hearings were held. SDG&E submitted its Second Triennial EPIC Plan for years 2015-2017 (A.14-05-004) on May 1, 2014 (EPIC-2) and received Commission approval of its EPIC-2 Plan in D.15-04-020. No hearings were held. SDG&E submitted its Third Triennial EPIC Plan for years 2018-2020 (A.17-05-009) on May 1, 2017 (EPIC-3). As of the date of this Report, SDG&E is awaiting a decision from the Commission on its EPIC-3 Application.

In accordance with Ordering Paragraph 16 of D.12-05-037 and consistent with the Annual Report outline provided in Attachment 5 of D.13-11-025, SDG&E and the other EPIC Administrators are required to submit an annual report annually on February 28, 2013 through February 28, 2020. This is the sixth annual report submitted by SDG&E for its EPIC program.

D. Coordination among EPIC Administrators

The four EPIC Administrators have regular teleconferences and face-to-face meetings as needed to coordinate EPIC activities.

E. Transparent and Public Process

SDG&E is committed to conducting competitive procurements for those parts of the project work that require contracted services or major purchases of equipment or software. Development and issuance of request for proposals (RFPs) for two EPIC-1 projects were initiated in late 2014 and for a third EPIC-1 project in 2015. Competitive procurements for four additional EPIC projects were initiated in 2016 (including one for an EPIC-1 project and three for EPIC-2 projects). One informal competitive procurement was performed for an EPIC-2 project in 2017.

SDG&E and the other EPIC Administrators are required to host at least two stakeholder meetings annually to discuss their EPIC programs, proposals, and progress.[8] On January 30, 2017, SDG&E hosted a one-day workshop with EPRI and the other EPIC Administrators, the purpose of which was to conduct a gaps analysis on the proposed content of the Administrators' EPIC plans to assure the projects were filing key gaps in RD&D in a global context. In addition, SDG&E, together with the IOU Administrators, hosted two EPIC public stakeholder workshops

[8] D.12-05-037 at 74.

(March 9, 2017 and March 24, 2017), where the planning and coordination process was summarized, and the IOU Administrators presented examples of projects under consideration for their respective EPIC-3 Applications. SDG&E also participated in the EPIC Fall Symposium (October 18, 2017).

SDG&E established and maintains an EPIC website accessible to the public: https://www.sdge.com/epic. This website provides EPIC program information and updates, as well as SDG&E's EPIC annual reports and EPIC projects' final reports.

III. SDG&E'S EPIC BUDGET AND RELATED COSTS

A. SDG&E Authorized Budget and Incurred Costs for EPIC-1 (2012 – 2014) and EPIC-2 (2015 -2017)

Table 2 below, sets forth SDG&E's Commission-authorized EPIC budget incurred costs for EPIC-1 and EPIC-2 as of December 31, 2017.

Table 2. SDG&E Budget and Incurred Costs for EPIC-1 and EPIC-2 as of December 31, 2017 (in $ thousands)

	EPIC Triennial 1 (2012 – 2014)		EPIC Triennial 2 (2015 – 2017)	
	Technology Demonstration & Deployment	**Program Administrative**	**Technology Demonstration & Deployment**	**Program Administrative**
SDG&E Commission-Authorized Budget[9]	7,740	860	7,800	879
SDG&E Incurred Costs[10] as of December 31, 2017	6,376	582	7,088	372

Table 3 below, sets forth SDG&E's disbursements to the CEC and Commission for EPIC-1 and EPIC-2 as of December 31, 2017.

[9] D.13-11-025 for EPIC-1 and D.15-04-020 for EPIC-2.
[10] Incurred costs mean actual booked expenditures.

Table 3. SDG&E's Disbursements to the CEC and Commission for EPIC-1 and EPIC-2 as of December 31, 2017 (in $ thousands)

	EPIC Triennial 1 (2012 – 2014)		EPIC Triennial 2 (2015 – 2017)	
	Technology Demonstration & Deployment	**Program Administrative**	**Technology Demonstration & Deployment**	**Program Administrative**
SDG&E Disbursements to CEC	16,127	3,024	30,674	2,991
SDG&E Disbursements to Commission for Regulatory Oversight	N/A	273	N/A	224

B. Commitments/Encumbrances[11,12] for TD&D Projects

SDG&E has committed $7,740k of its TD&D budget for the EPIC-1 cycle to the five projects in its approved First Triennial Plan. As of December 31, 2017, SDG&E has encumbered $7,514k of EPIC-1 funds for contracted activities and in-house work in collaboration with a contractor. As of December 31, 2017, SDG&E has expended $5,698k on contracted work. SDG&E has spent $678k on internal project work. The total expenditures through December 31, 2017 on EPIC-1 TD&D project work is therefore $6,377k. Further detail is provided in Attachment B.

SDG&E has committed $8,059k of its EPIC-2 TD&D budget to the six projects in its approved EPIC-2 plan. This constitutes full commitment of the ***approved*** EPIC-2 TD&D funds. As of December 31, 2017, SDG&E has encumbered $8,059k of EPIC-2 funds for contracted

[11] Commitment means assigned for anticipated work on a project, including anticipated contractual commitments, equipment purchases, software licenses, associated technical work by the SDG&E project team, and other expenses directly associated with the project work.

[12] Encumbrances are funds that are specified for contracts (D.13-11-025 at 101; Ordering Paragraph 45) or for in-house work necessary in collaboration with a contractor (D.13-11-025 at 53). They differ from commitments in that commitments are the identification of blocks of funds to be assigned to projects, whereas encumbrances specify how the commitments will be used in the projects.

activities and in-house work in collaboration with a contractor. As of December 31, 2017, SDG&E has expended $6,649k on contracted work. SDG&E has spent $438k on internal project work. The total expenditures through December 31, 2017 on EPIC-2 TD&D project work is therefore $7,088k. Further detail is provided in Appendix A.

C. Commitments/Encumbrances for Program Administration

As of December 31, 2017, SDG&E has made the following commitments for its program administration budgets: $860k for EPIC-1 and $620k for EPIC-2. SDG&E has spent a cumulative $954k for overall program administration expenses through 2017, which includes both EPIC-1 and EPIC-2 costs. Of this amount, $582k is attributed to EPIC-1 and $372k is attributed to EPIC-2.

D. Fund Shifting Above 5% between Program Areas

SDG&E has done no fund shifting to date.

E. Uncommitted/Unencumbered Program Funds

SDG&E does not have any ***approved*** program TD&D funds that are uncommitted as of December 31, 2017. However, there is a small difference ($68.6k) between the $7,868.6k that was authorized for EPIC-2 and the $7,800k that is committed for TD&D. The difference exists because SDG&E did not propose to invest this amount in SDG&E's Application for EPIC-2. Therefore, SDG&E's approved budget in D.15-04-020 reflects the amount proposed in its EPIC-2 Application. Should SDG&E decide to commit the $68.6k (which is currently uncommitted/unencumbered), the Commission in D.15-04-020 advised SDG&E that they may submit a subsequent regulatory filing seeking approval to invest these funds.[13]

IV. SDG&E EPIC-1 PROJECTS

The following is a high-level summary and status report of EPIC-1 projects.

Project 1: Smart Grid Architecture Demonstrations

i. Investment Plan Period
2012-2014 (EPIC-1)

[13] D.15-04-020 at 34-35.

ii. Assignment to Value Chain
Distribution

iii. Objective
The specific objectives of the project were to: perform pilot demonstration of key candidate prototype building blocks of the SDG&E smart grid architecture to determine their suitability for adoption in the architecture; document the results and make recommendations of whether specific building blocks should be adopted; and, provide demonstration results to the SDG&E interdepartmental smart grid architecture team to support the implementation phase for any building blocks adopted.

iv. Scope
The distribution system architecture building blocks were created after reviewing the existing architecture, identifying next generation architecture principles, and evaluating standards and protocols for the various architectural constructs. IEC 61850 was identified as the priority building block for demonstration. A test plan was written, and testing undertaken at SDG&E's ITF. The pre-commercial demonstration for IEC 61850 included modeling and simulation of a distribution substation and two feeders that included multiple Intelligent Electronic Devices (IED) and distributed energy resources (DERs) on the circuits. Additional demonstrations also included the comparison using IEC 61850 as a communication path and Open Field Message Bus (OpenFMB) as an alternative communication path to communicate between a simulated control center and devices in the modeled substation and distribution feeders. An analysis was performed, and recommendations were made relative to adoption of IEC 61850.

v. Deliverables
A comprehensive final report was developed describing the work and results of the project.

vi. Metrics
The following metrics were identified for this project and evaluated during the pre-commercial demonstration. These metrics are not exhaustive given the pre-commercial demonstration approach for this project.

- Identification of barriers or issues resolved that prevented widespread deployment of technology or strategy
    - Identification and lowering of unreasonable or unnecessary barriers to adoption of smart grid technologies, practices, and services (P.U. Code § 8360) – Use of configuration inheritance and descriptive data point naming supported by IEC 61850 makes the task of configuring devices in substation and feeders considerably easier when contrasted to the conventional approach. Digitization of devices using IEC 61850 can potentially lower the barriers of adoption of newer technologies within the electric infrastructure.

    - Develop standards for communication and interoperability of appliances and equipment connected to the electric grid, including the infrastructure serving the grid (P.U. Code § 8360) – The industry has many standards that exist among several standards development organizations that may be applicable to multiple layers of the power systems architecture. A key standard is the IEC 61850 protocol suite. The extent of harmonization efforts that have included IEC 61850 show that the suite has the potential of becoming a key building block in the future smart grid architecture that enable effective communication and interoperability of equipment connected to the electric grid.
- Safety, Power Quality, and Reliability (Equipment, Electricity System) – The use of IEC 61850 in the field could enable interoperability, improve protection coordination and provide effective information sharing between field devices and backend systems. The following sub-factors could be enhanced with the use of IEC 61850:
    - Increase in the number if nodes in the power system at monitoring points
    - Reduction in outage numbers, frequency, and duration.
    - Reduction in system harmonics

vii. Schedule
February 10, 2016 to December 31, 2017

viii. EPIC Funds Encumbered as of December 31, 2017
$1,406k

ix. EPIC Funds Spent as of December 31, 2017
$1,402k

x. Partners (if applicable)
n/a

xi. Match Funding (if applicable)
n/a

xii. Match Funding Split (if applicable)
n/a

xiii. Funding Mechanism (if applicable)
A combination of in-house work and pay-for-performance contracts was used. A Request for Proposal (RFP) was released in third quarter of 2016, with contractor selection completed in 2017.

xiv. Treatment of Intellectual Property (if applicable)
No IP developed.

xv. Status Update

Project activities completed in 2017.

- The project was implemented in four phases:
  - Phase 1 – SDG&E Internal Project Work Prior to contractor procurement
  - Phase 2 – Architecture Baseline and Development
  - Phase 3 – Pre-Commercial Demonstration of IEC 61850
  - Phase 4 – SDG&E Internal Project Work prior to project conclusion
- As part of architecture development in Phase 2, Smart Grid Architecture Model (SGAM) framework was identified as best suited to document the current and proposed architecture necessary to adapt to the changing demands on the system. IEC 61850 is a principal component of the platform that warranted further investigation in the third phase of the project.
- In the third phase, a representative test system was constructed, and a total of eleven use cases were defined to demonstrate the use of IEC 61850 standards. The uses cases included tests of the ability of IEC 61850 to integrate substation and feeder devices and perform some of the advanced communications and automation necessary to optimize the use of DER and other IEDs. Other tests were defined to examine the process and organizational impact of utilizing IEC 61850, while others were used to compare IEC 61850 with other protocols, such as DNP 3.0 and OpenFMB. The demonstration showed that IEC 61850 has some unique abilities that offered tangible benefits over current approaches.
- The various use cases documented in the final report (in Phase 4) comprehensively demonstrate that IEC 61850 is a robust standards platform that offers numerous advantages over conventional approaches. The recommendation is that SDG&E plan for long-term migration to an architecture that incorporates IEC 61850 standards.

Project 2: Visualization and Situational Awareness Demonstrations

i. Investment Plan Period

2012-2014 (EPIC-1)

ii. Assignment to Value Chain

Distribution

iii. Objective

The objective of this demonstration project is to explore how data collected from sensors and devices can be processed, combined, and presented to system operators in a way that enhances grid monitoring and situational awareness. This project will look at how data currently unexploited and separately processed can be integrated and visually presented for strategic use by system operators. When transformed and presented in a visually integrated manner, this data can be invaluable for utilities to optimize grid operations as well as provide insights in the performance of the overall utility system. This visual framework also provides

insights into customers' energy consumption behavior to serve them more effectively, foster energy conservation, and reduce peak demand. The demonstration of specific visualization and situational awareness concepts will be used to help SDG&E make choices on which options should be adopted into a future visualization and situational awareness system.

iv. Scope

The work will include requirements definition for the visualization and situational awareness based on where data could yield significant value, prototyping the data integration schemes, displays and algorithms, and implementing a testing plan. A roadmap will be developed for integrating project results deemed suitable for commercial adoption into SDG&E's power system.

The following eight use cases, addressing a wide range of SDG&E business needs within the smart grid visualization area, were selected for the project: (1) Transmission Fault Location Visualization, (2) Load Curtailment Visualization, (3) Automation of Quarterly Electric Utility Reports, (4) Visualization of Outage History Playback, (5) AMI for Operations Visualization, (6) Customer-owned DER Visualization, (7) Imagery Management, and (8) GIS Visualization infrastructure modernization.

v. Deliverables

A comprehensive final project report describing the work and results of the project.

vi. Metrics

The project tracking metrics will be the milestones in the project plan. Technical project metrics will include the completion of the initial specification for a visualization and situational awareness system, the demonstration of a system display mock-up, and the specifications and recommendations regarding adoption by SDG&E.

Also, major project results will be submitted in technical papers and presentations for consideration by major technical conferences and publications.

The following metrics were identified for this project and further explained in the final report:

- Safety, Power Quality, and Reliability (Equipment, Electricity System).
- Identification of barriers or issues resolved that prevented widespread deployment of technology or strategy.
- Adoption of EPIC technology, strategy, and research data/results by others.

vii. Schedule

February 10, 2016 to August 31, 2018

viii. EPIC Funds Encumbered as of December 31, 2017
$2,075k

ix. EPIC Funds Spent as of December 31, 2017
$1,061k

x. Partners (if applicable)
n/a

xi. Match Funding (if applicable)
n/a

xii. Match Funding Split (if applicable)
n/a

xiii. Funding Mechanism (if applicable)
SDG&E EPIC funding used for work performed by the internal SDG&E project team.

xiv. Treatment of Intellectual Property (if applicable)
No IP developed.

xv. Status Update
Major project activities completed in 2017. Based on the feedback from early users of the project results – which has been uniformly positive – this project has successfully achieved all its key objectives. Through the performed work, SDG&E has demonstrated novel solutions to the selected use cases, and, in the process, has also gained reusable software artifacts and substantial experience in integrating GIS, historical, asset management, and other major SDG&E computer systems. Both aspects will provide usability well beyond the direct utility of the software components produced by the project.

The project committed additional funds by the end of 2017 to perform additional work on selected use cases to give them greater value and further development.

Project 3: Distributed Control for Smart Grids

i. Investment Plan Period
2012-2014 (EPIC-1)

ii. Assignment to Value Chain
Distribution

iii. Objective
The objective of this project was to test alternatives for communication and control across distribution system resources to ensure that devices operate in a complementary manner and ensure optimum distribution system performance,

reliability, and stability. The project tested distributed control methods and approaches to control distribution circuit resources and integrate them as part of a unified control scheme with other higher-level control systems, such as the distribution management system (DMS). The project assessed the scalability and performance of alternative control schemes.

iv. Scope

Phase 1 – Design and Development of Technical Solution: This phase will include requirements definition for the distributed control concepts to be demonstrated. The requirements definition will consider the functions, specifications, control interface, control algorithms, data models, data exchange, and security requirements for using distributed (less centralized) control in future electric utility power distribution systems. It will build on existing infrastructure in the SDG&E system.

Phase 2 – System Installation and laboratory testing at SDG&E's Integrated Test Facility (ITF): This phase will involve the installation of the test system, modeling and verification of RTDS circuit models, integration of hardware, development of control and operational schemes, development of the test plan for evaluation of the proposed distributed control concepts, and the execution of the test plan.

Phase 3 – Data Collection and Analysis for the Pre-Commercial Demonstration: This phase will include detailed analysis of the data collected, including functions of the proposed system, control methodologies of the system (including updates to existing strategies), results of testing and effect on the existing SDG&E control system, benefits, costs, challenges, and impact on the overall SDG&E distribution system and equipment, particularly with respect to operational situations.

v. Deliverables

A comprehensive final project report was developed describing the work and results of the project.

vi. Metrics

The project tracking metrics will be the milestones in the project plan. Technical metrics for this project will be based on comparing the performance of distribution system operations when various new control schemes are in place with the performance of the same operations when the control schemes are not in place. These performance metrics will include measures of power quality, electrical loss reductions, asset health maintenance, and adaptability to new device types in the distribution system.

Also, major project results will be submitted as technical papers and presentations for consideration by major technical conferences and publications.

The following metrics were identified for this project and further explained in the final report:

- Economic Benefits.
- Safety, Power Quality, and Reliability (Equipment, Electricity System).
- Identification of barriers or issues resolved that prevented widespread deployment of technology or strategy.
- Effectiveness of information dissemination.
- Adoption of EPIC technology, strategy, and research data/results by others.

vii. Schedule
January 12, 2015 to December 31, 2017

viii. EPIC Funds Encumbered as of December 31, 2017
$1,392k

ix. EPIC Funds Spent as of December 31, 2017
$1,386k

x. Partners (if applicable)
n/a

xi. Match Funding (if applicable)
n/a

xii. Match Funding Split (if applicable)
n/a

xiii. Funding Mechanism (if applicable)
SDG&E EPIC funds were applied to a combination of in-house work and a pay-for-performance contract. A prime contractor was selected by competitive procurement in the second quarter of 2016. Five bidders responded to the solicitation. All bids passed the initial screening criterion of being responsive the request for proposal, and they were all evaluated and scored in accordance with the evaluation criteria. Quanta Technology, LLC was selected for the contract award. Quanta was the highest scoring bidder.

xiv. Treatment of Intellectual Property (if applicable)
No IP developed.

xv. Status Update

2017 saw the completion of the project. The results provided quantifiable evidence that the distributed control of system resources could achieve benefits when compared to a conventional approach. Major benefits identified included:

- Increase the utilization and contribution of DERs

- Reduce and even prevent unintentional reverse power flow
- Produce a flatter voltage profile over the length of a circuit
- Bring voltage profiles back inside the permissible range after a system event
- Reduce system electrical losses
- Improve the power factor of a circuit
- Reduce the number of operations of controllable assets like capacitor banks, voltage regulators and load tap changers
- Dynamically adjust protection settings to increase system reliability

The tests demonstrated that the greatest benefits were obtained when the control system was able to coordinate the control of two adjacent substations and when the regionally-based master controller was controlling the system, because it provided more possibilities for system optimization.

Additional tests demonstrated that a purely substation-based control scheme was still able to provide benefit, although not to the same extent as when the master controller was present, due to the inability to coordinate and therefore optimize between the two substations.

The demonstrated benefits of the distributed control approach in the areas of DER integration, improved grid stability, reliability and power quality and better utilization of controllable assets certainly warrants additional research, as well as inclusion into the technology roadmap of any utility facing an expansion in DER and IED devices on the distribution system.

Project 4: Demonstration of Grid Support Functions of Distributed Energy Resources

i. Investment Plan Period
2012-2014 (EPIC-1)

ii. Assignment to Value Chain
Distribution

iii. Objective
The objective of EPIC-1, Project 4, Demonstration of Grid Support Functions of Distributed Energy Resources (DER) was to demonstrate grid support functions of DER, which can improve distribution system operations. In other words, the objective was to assess the viability of using DER to provide non-traditional functions, such as volt/VAr optimization, fast-response peaking or emergency power, peak shaving, and distribution system status information. The chosen sub-projects and modules quantified the value of specific grid support functions in specific application situations and provided a basis for SDG&E to determine which functions it wants to pursue commercially in the development of its smart grid. This project consisted of three modules: value assessment of grid support functions of DER, communication standards for grid support functions of DER, and

demonstration and comparison of the EPRI and SDG&E DER hosting capacity analysis tools.

iv. Scope

As previously mentioned, this project was broken into three modules: value assessment of grid support functions of DER, communication standards for grid support functions of DER, and demonstration and comparison of the EPRI and SDG&E DER hosting capacity analysis tools. The scope of each module is described individually below:

Module 1: This module addresses value assessment of grid support functions of DER, to demonstrate and determine the viability of specific DER functions and to identify which, if any, grid support functions of DER and application situations (use cases) should be pursued in advanced distribution system automation.

Module 2: This module addresses pre-commercial demonstration of communication standards for grid support functions of DER. Furthermore, it investigates how the choice of communication standards may affect functionality of DER in the distribution systems.

Module 3: This module addresses pre-commercial demonstration of EPRI's Distribution Resource Integration and Value Estimation (DRIVE) tool. Moreover, it compares SDG&E's Iterative Integration Capacity Analysis (ICA) tool with DRIVE tool and defines the pros and cons of each method. A set of recommendations was made for enhancement of hosting capacity estimation techniques at SDG&E.

v. Deliverables

The key deliverable for each module of this project was a comprehensive final report on the procedure, findings, and results. A section on conclusions and recommendations, and a separate section on metrics and value proposition completed each report. Collectively, these module final reports provide:

- Descriptions of DER functions demonstrated, application situations, testing performed, and test and analysis results.
- Recommendations regarding DER functions (or communication standard or hosting capacity tool) which should be pursued commercially and adopted by SDG&E.
- Recommendations for technology transfer of knowledge gained (on function viability and interoperability system requirements to support functions) into commercial practice and/or to standards working groups, as may be appropriate.
- Recommendations for integration systems to encourage "plug and play" capabilities in the inverters (power conditioning systems) and other integration components.
- Analysis of the metrics and value proposition.

vi. Metrics
Technical metrics for the pre-commercial demonstration were determined during the demonstration planning phase.

One measure of success for Module 1 of this project was whether it provided a basis for deciding which DER functions warrant commercial pursuit in future distribution system development. Metrics for this module also included the identification of suitable interoperability requirements, interconnection systems, and communication protocols that support the functions.

In Module 2, the metrics included a determination of which communication standards are preferred to support the adoption of viable grid support functions.

In Module 3 of this project, the metrics addressed the pros and cons of the SDG&E hosting capacity tool in comparison with the EPRI DRIVE DER hosting capacity tool.

vii. Schedule
April 1, 2014 to December 31, 2017

viii. EPIC Funds Encumbered as of December 31, 2017
$1,200K

ix. EPIC Funds Spent as of December 31, 2017
$1,095K

x. Partners (if applicable)
n/a

xi. Match Funding (if applicable)
n/a

xii. Match Funding Split (if applicable)
n/a

xiii. Funding Mechanism (if applicable)
EPIC funding of an internal SDG&E project team working with a pay-for-performance prime contractor. For Module 1 (which was a substantial part of this project), a prime contractor was selected by competitive procurement. Three bidders responded to the solicitation. All bids passed the initial screening criterion of being responsive to the request for proposal, and they were all evaluated and scored in accordance with the evaluation criteria. Schweitzer Engineering Laboratories (SEL) was selected for the contract award. SEL was the highest scoring bidder. Modules 2 and 3 were smaller efforts for which the contractors were selected by sole source.

xiv. Treatment of Intellectual Property (if applicable)
No IP developed.

xv. Status Update
The three modules of this project were successfully accomplished with collaboration of the SDG&E internal team and the contractors' team. Final reports were completed individually for each module. They were carefully reviewed by the internal stakeholders, the SDG&E internal team, and the contractors' team.

Project 5: Smart Distribution Circuit Demonstrations

i. Investment Plan Period
2012-2014 (EPIC-1)

ii. Assignment to Value Chain
Distribution

iii. Objective
The objective of this project was to perform pilot demonstrations of smart distribution circuit features and associated simulation work to identify best practices for integrating new and existing distribution equipment in these circuits. Simulations took advantage of hardware-in-loop testing with a real-time digital simulator currently available at SDG&E. Using simulations to optimize one particular circuit, desired features were tested in that circuit to assess their suitability for widespread commercial adoption.

iv. Scope
The project included laboratory testing of alternative distribution circuit components and designs, and it included detailed examination of evaluation tools for integration of energy storage. Tests were staged, and data was taken. Data analysis was performed, and recommendations were made on best practices for robust distribution circuit practices in the future.

The project was broken into two modules:

- Module 1: Demonstration of Advanced Circuit Concepts: The focus of this module was to perform pilot demonstrations of smart distribution circuit features in a laboratory for a set of selected test circuits. Using simulations and hardware-in-the-loop (HIL) testing, the desired features and upgrades were tested in the selected circuits to assess their suitability for widespread adoption.
- Module 2: Pre-Commercial Demonstration of Methodologies and Tools for Energy Storage Integration into Smart Distribution Circuit: The chosen focus of this specific project module was on pre-commercial demonstration of methodologies and tools for energy storage integration into smart distribution circuits. The work included identification, evaluation, selection and

demonstration of methodologies and tools for prospective use in planning future energy storage projects.

v. Deliverables

Comprehensive final project reports were developed for both modules describing the work and results.

vi. Metrics

The project tracking metrics included the milestones in the project plan. Technical metrics were developed to guide the actual demonstration work. In general, the ultimate measure of success was having a benchmark future distribution circuit design concept that helps advance future distribution system development. The circuit design can assimilate a wide variety of existing and emerging device types and has a protection system that allows this assimilation to be done without compromising reliability or safety.

The following metrics were identified for Module 1 and further explained in the final report:

- Economic Benefits.
- Safety, Power Quality, and Reliability (Equipment, Electricity System).
- Identification of barriers or issues resolved that prevented widespread deployment of technology or strategy.
- Effectiveness of information dissemination.
- Adoption of EPIC technology, strategy, and research data/results by others.

The following metrics were identified for Module 2 and further explained in the final report.

- **Potential energy and cost savings**
  - Avoided procurement and generation costs
  - Nameplate capacity (MW) of grid-connected energy storage – use methodology and tools to target ESS size for each application
- **Economic benefits**
  - Maintain/reduce capital costs (by proper sizing and increase in utilization factor)
  - Non-energy economic benefits
- **Safety, Power Quality, and Reliability (Equipment, Electricity System)**
  - Outage number, frequency and duration reductions
  - Electric system power flow congestion reduction
  - Forecast accuracy improvement
  - Public safety improvement and hazard exposure reduction
  - Reduced flicker and other power quality differences

- **Effectiveness of information dissemination**
  - A technology transfer plan was presented in the final report.

vii. Schedule
July 7, 2014 to December 31, 2017

viii. EPIC Funds Encumbered as of December 31, 2017
$1,441k

ix. EPIC Funds Spent as of December 31, 2017
$1,433k

x. Partners (if applicable)
n/a

xi. Match Funding (if applicable)
n/a

xii. Match Funding Split (if applicable)
n/a

xiii. Funding Mechanism (if applicable)
For both Module 1 and Module 2, SDG&E EPIC funds were applied to support a team of internal technical staff and pay-for-performance contractors. The contractors were selected as per SDG&E procurement policy.

xiv. Treatment of Intellectual Property (if applicable)
No IP developed.

xv. Status Update
The project was concluded in 2017. As previously mentioned, the project was broken into two modules:

- Module 1: Demonstration of Advanced Circuit Concepts: Developed with the assistance of Schweitzer Engineering Laboratories, Inc. This module was developed in 3 phases:
  - Phase 1 of the project covered the evaluation and documentation of products and technologies currently available for improved distribution circuit design, system operation, and protection.
  - Phase 2 of the project included selection and modeling of three diverse SDG&E distribution circuits viz., coastal-residential, urban, and desert-rural in a modeled environment for demonstration of advanced circuit concepts. The observations and results captured were analyzed and the findings from stand-alone device testing provided inputs on how to modify the existing circuits for improved reliability and performance.

- Phase 3 of the project included findings and recommendations from the demonstration in Phase 2. The recommended system architecture for commercial implementation of voltage support coordination scheme is provided.

- Module 2: Pre-Commercial Demonstration of Methodologies and Tools for Energy Storage Integration into Smart Distribution Circuits: All project activities were completed in the year 2017. The project team held working sessions to define the use cases and technical details. Simulation systems, different tools and methodologies were selected to be evaluated based on input from project stakeholders. The pre-commercial demonstration was carried out at SDG&E's ITF and/or at the contractor's site. A comprehensive final report was developed, including the pre-commercial demonstration approach, test result analysis, findings, recommendations, metrics, value proposition and conclusions.

V. SDG&E EPIC-2 PROJECTS

The following is a high-level summary and status report of EPIC-2 projects.

Project 1: Modernization of Distribution System and Integration of Distributed Generation and Storage

i. Investment Plan Period
2015-2017 (EPIC-2)

ii. Assignment to Value Chain
Distribution

iii. Objective
The objective of this project was to demonstrate distribution system infrastructure modernization solutions, including advances in distribution system design to enable use of new technologies, such as power electronic components, new protection systems, distributed generation and alternative storage technologies. The work built on the current state of the art for these devices and any track record that was available from the industry.

iv. Scope
This project has been focused on the pre-commercial demonstration of the international standard, IEC 61850, in a substation network. Investigating the application and usefulness of IEC 61850 will help SDG&E to assess the benefits and challenges of implementing this standard in substations. This pre-commercial demonstration will also investigate the interoperability of multiple vendor products.

This project will create knowledge to help SDG&E assess whether IEC 61850 should be adopted commercially and what the adoption requirements and processes would be. The knowledge may help other utilities with similar decision processes.

v. Deliverables
A comprehensive final report on the work and results of the project.

vi. Metrics
The following metrics were identified for this project. Given the proof of concept nature of this EPIC project, these metrics are forward looking to prospective adoption of IEC 61850 standards.

The main protection concerns that were identified in this project were speed and reliability. The following metrics address these concerns.

- Potential energy and cost savings:
  Due to reduced engineering efforts in the design process using IEC 61850 equipment, cost savings flow through to ratepayers. The integrated engineering tools make it easier to design the substation and test the equipment before deployment, which is hard to achieve now and is more time consuming with current legacy systems.

- Economic benefits:
  - Maintain/reduce operation and maintenance costs:
    - IEC 61850 digital equipment allows easier maintenance and debugging of the equipment using advanced embedded software tools.
    - The labor costs associated with the process bus implementation are reduced significantly. This is primarily due to the reduction in wiring.
  - Improvements in system operation efficiency and adding automation features:
    - Operation efficiency can be improved using IEC 61850 equipment especially with the new peer-to-peer communication feature, which allows major improvements of operations. More equipment can be monitored and operated to reduce the causes of outages and improve the reliability. Peer-to-peer communication also allows increased functional capabilities in the protection scheme.

vii. Schedule
January 4, 2016 to December 31, 2017

viii. EPIC Funds Encumbered as of December 31, 2017
$2,009k

ix. EPIC Funds Spent as of December 31, 2017
$1,971k

x. Partners (if applicable)
n/a

xi. Match Funding (if applicable)
n/a

xii. Match Funding Split (if applicable)
n/a

xiii. Funding Mechanism (if applicable)
A combination of in-house work and a pay-per-performance contract were used.

xiv. Treatment of Intellectual Property (if applicable)
No IP developed.

xv. Status Update
The project was completed in 2017. Stakeholders from SDG&E's substations and protection sections worked with the internal project team and contractor to plan and review the task work in this project. Options for performing the demonstration were explored, including at an actual substation or in a laboratory. Due to cost and risk considerations, it was decided to perform the demonstration in a laboratory using a substation mock-up. Intelligence was gathered on the status of the IEC standards and the vendor equipment options for the demonstration.

The project team finished a successful laboratory demonstration for several substation-protection use cases. A key recommendation coming from the project was for SDG&E to further explore commercial adoption of IEC 61850. Internal stakeholders are doing so.

Other technology transfer activities have included presentations at various conferences. Included were a presentation at the IEC 61850 Europe 2017 Conference in September 2017 and acceptance for presentation at DistribuTECH 2018 (presented in January 2018). The project was also presented at EPIC Symposiums on December 1, 2016 in Sacramento and on October 18, 2017 in San Diego.

Project 2: Data Analytics in Support of Advanced Planning and System Operations

i. Investment Plan Period
2015-2017 (EPIC-2)

ii. Assignment to Value Chain
Distribution

iii. Objective

This project was designed to address the anticipated "data tsunami" associated with more widespread system monitoring and more widespread use of controllable devices in the power system. It helped to create better data management. It also demonstrated solutions for the data management issues and challenges expected to accompany the extensive amount of real-time and stored data being archived from field devices and identify the data mining procedures and the data-archiving methods, utilizing this data to improve power system operations. Solutions that are deemed to be best practices were documented for use in improving the data management systems that support power system operations. The project results are expected to benefit SDG&E and other utilities.

iv. Scope

This demonstration project determined the quantity and location of data-generating devices in the power system, the generation capabilities of these devices, and how the resulting data was being stored and archived. The project determined how the use of vast amounts of data to support the power system operations, such as pot event analysis, predictive maintenance, and asset management. The project identified and performed advanced analytics for various types of distribution system asset failures. The project demonstrated integration of multiple data sources into a data lake, creation of test models to perform predictive, and created visualizations for business user engagement. The pre-commercial demonstration system was used to demonstrate specific use cases from the roster of use cases developed by SDG&E's Electric Distribution Engineering (EDE) team.

v. Deliverables

A comprehensive final report was developed describing the work and results of the project.

vi. Metrics

The following metrics were identified for this project and evaluated during the course of the pre-commercial demonstration. These metrics are not exhaustive given the pre-commercial demonstration approach for this project.

- Safety, Power Quality, and Reliability (Equipment, Electricity System) – The use of machine learning and advanced data analytics can help stakeholders predict the failure of equipment based on current and historical operational data and other data. The following sub-factors could be analyzed with advanced data analytics:
    - Number of outages, frequency and duration reductions
    - Forecast accuracy improvement
    - Public safety improvement
    - Utility worker safety improvement
- Economic Benefits – Advanced data analytics can provide significant economic benefits by helping the identification of failing or aging equipment, before they fail, thereby reducing operational expenditures

and planning capital expenditures effectively. The following sub-factors could be affected with advanced data analytics:
    - Maintain/reduce operations and maintenance costs
    - Maintain/reduce capital costs
    - Improvement in system operation efficiencies

vii. Schedule
October 16, 2015 to December 31, 2017

viii. EPIC Funds Encumbered as of December 31, 2017
$1,111k

ix. EPIC Funds Spent as of December 31, 2017
$957k

x. Partners (if applicable)
n/a

xi. Match Funding (if applicable)
n/a

xii. Match Funding Split (if applicable)
n/a

xiii. Funding Mechanism (if applicable)
Combination of in-house work and pay-for-performance contracts. A Request for Proposal (RFP) was released in third quarter of 2016, with contractor selection completed in 2017.

xiv. Treatment of Intellectual Property (if applicable)
No IP developed.

xv. Status Update
Project activities completed in 2017:
- The project was implemented in three phases:
    - Phase 1 – SDG&E Internal Project Work Prior to contractor procurement
    - Phase 2 – Project Development Activities
    - Phase 3 – SDG&E Internal Project Work prior to project conclusion
- Phase 2 included the significant technical demonstration of the project:
    - Ingestion of several data sources into the data lake
    - Test build of preliminary predictive models for major electric distribution asset management use cases, and
    - Visualization development using business intelligence tools to provide insight into the health of various assets on the grid

- Four use cases successfully demonstrated the ability to predict equipment failure using machine learning techniques on vast amount of data for:
    - Underground electric distribution cable,
    - 600-amp tee Connectors,
    - Padmount service transformers, and
    - Overhead distribution wire failures (i.e. wire down)
- It is recommended that SDG&E and other utility stakeholders commercially adopt and implement advanced data analytics techniques for effective asset management.

Project 3: Monitoring, Communication, and Control Infrastructure for Power System Modernization

i. Investment Plan Period
2015-2017 (EPIC-2)

ii. Assignment to Value Chain
Distribution

iii. Objective
The objective of this project was to demonstrate advanced monitoring, communication and control infrastructure needed to operate an increasingly complex power system infrastructure. In other words, to test system controls to "sort" data and use what is helpful and useful.

iv. Scope
To achieve this objective, the project undertook a demonstration to evaluate an Open Field Message Bus (OpenFMB) with respect to SDG&E's existing architecture and vision for the future. The project demonstrated interoperability through secure, peer-to-peer control and communication between multiple distribution system equipment types based on existing standards. The approach included development of a test system for use in a pre-commercial demonstration to evaluate and demonstrate OpenFMB in a controlled environment within SDG&E's laboratory. The test system consisted of several controllable utility distribution system devices networked to mimic two feeders on SDG&E's distribution network. These devices were networked using differing network technologies designed to reproduce field conditions. The project also demonstrated communications interoperability among different vendor products through the use of adapters which converted those products' legacy communications technologies to OpenFMB. The OpenFMB network used multiple communications protocols, including MQTT, DDS, and R-GOOSE, to accomplish 13 use cases developed for this project. The pre-commercial demonstration system was subjected to a number of test cases to verify its correct operation and validate the use cases.

v. Deliverables

A comprehensive final report was developed describing the work and results of the project.

vi. Metrics

The following metrics were identified for this project and evaluated during the course of the pre-commercial demonstration. These metrics are not exhaustive given the pre-commercial demonstration approach for this project.

- Identification of barriers or issues resolved that prevented widespread deployment of technology or strategy
  - Develop standards for communication and interoperability of appliances and equipment connected to the electric grid, including the infrastructure serving the grid (P.U. Code § 8360) – The EPIC project demonstrated the potential value of OpenFMB in addressing interoperability issues that exist in the electric system today, with multiple vendor technologies/systems unable to interface or interact with each other in a seamless manner. OpenFMB could provide a framework that enables the coexistence of traditional IEDs or devices that operate in a centralized manner with new IEDs or devices (especially DERs) that have the capability to operate in a decentralized manner.
  - Identification and lowering of unreasonable or unnecessary barriers to adoption of smart grid technologies, practices, and services (P.U. Code § 8360) – This EPIC project established a potential OpenFMB framework that could be implemented in the secondary layer that sits between the enterprise layer in a utility control center, and the primary layer that sits on multiple devices or equipment in the field. Next generation of IEDs or DERs may provide the necessary communication technology and application framework that enable peer to peer communication between devices and routes the information through the OpenFMB framework to disparate systems in the backend.
- Safety, Power Quality, and Reliability (Equipment, Electricity System) The use of OpenFMB framework to deploy decentralized applications could enable interoperability and improve information sharing between field devices and backend systems. The following sub-factors could be enhanced with the use of OpenFMB:
  - Reduction in outage numbers, frequency, and duration.
  - Reduction in system harmonics
  - Increase in the number if nodes in the power system at monitoring points
  - Public safety improvement and hazard exposure reduction

vii. Schedule

November 1, 2015 to December 31, 2017

viii. EPIC Funds Encumbered as of December 31, 2017
$1,305k

ix. EPIC Funds Spent as of December 31, 2017
$1,288k

x. Partners (if applicable)
n/a

xi. Match Funding (if applicable)
n/a

xii. Match Funding Split (if applicable)
n/a

xiii. Funding Mechanism (if applicable)
SDG&E EPIC funds applied to a combination of in-house work and a pay-for-performance contract. An RFP was released in third quarter of 2016, with contractor selection completed in 2017.

xiv. Treatment of Intellectual Property (if applicable)
No IP developed.

xv. Status Update
Project activities completed in 2017

- The project was implemented in three phases:
  - Phase 1 – SDG&E Internal Project Work Prior to contractor procurement
  - Phase 2 – Project Development Activities
  - Phase 3 – SDG&E Internal Project Work prior to project conclusion
- In the second phase, a representative test system was constructed, and a total of thirteen use cases were defined to demonstrate the use of OpenFMB for monitoring and control.
- The primary objectives for evaluation of OpenFMB was to demonstrate its use for:
  - Interoperability
  - Peer-to-peer communication, and
  - Multiple protocol conversion
- Use cases that were demonstrated address the following applications:
  - Volt/VAr control
  - Autonomous DER control
  - Enhanced feeder redeployment
  - Dynamic subscription
  - Provisioning and administration

- As a result of this demonstration, it was found that OpenFMB is not yet a standard for peer-to-peer interoperability. Gaps and options in OpenFMB's definitions are hindrances to achieving interoperability.
- It is recommended that work be continued to further define the OpenFMB standard so that it can be successfully utilized in future utility distribution system projects and deployments.

Project 4: System Operations Development and Advancement

i. Investment Plan Period
2015-2017 (EPIC-2)

ii. Assignment to Value Chain
Distribution

iii. Objective
The objective of this project was to support continued modernization of SDG&E's power system via demonstrations of improved capabilities in system operations. The project demonstrated a systematic process for the realignment of operating practices with advances in technology, software and standards used in the power system. The realignment is broad and addresses system integration issues and technology transfer.

iv. Scope
This project was focused on a distributed, autonomous, and scalable architecture, which included robust communication architecture and a hardware and software platform for aggregating and dispatching coordinated net-load resources (the difference between the load and power from Distributed Energy Resources (DER) in localized regions of the distribution system). The architecture included a concept of Localized Residential Aggregation and Monitoring (LRAMs) and Regional Aggregation, Monitoring & Circuit Optimizer (RAMCOs) for control and aggregation of customer-owned distributed generation and controllable loads on distribution systems. The project work was performed by a team comprised of SDG&E technical staff and the contractor.

v. Deliverables
A comprehensive final report on the project.

vi. Metrics
The following metrics were used to evaluate the project from different perspectives including Project Success Factors, Project Implementation Milestones, and Technical Achievements.

- **Potential energy and cost savings**
  - Number and total nameplate capacity of distributed generation facilities – 15 sites were included in the demonstration.

- Peak load reduction (MW) from summer and winter programs-- One of the implemented use cases was focused on circuit level load management and emergency dispatch. Based on aggregated resources, up to 20% load reduction was achieved.

- **Economic benefits**
  - Reduction in electrical losses in the transmission and distribution system – The demonstrated method incorporated Volt/VAr management at the primary and secondary levels, to reduce kVA and losses (up to 3% in the tested case).
  - Number of operations of various existing equipment types (such as voltage regulators) before and after adoption of a new smart grid component, as an indicator of possible equipment life extensions from reduced wear and tear – The propose method utilized fast action of DERs and secondary resources to reduce voltage and load fluctuations and enhance life cycle. Unnecessary tap operations were eliminated. Capacitor switching was prevented.
- **Safety, Power Quality, and Reliability (Equipment, Electricity System**
  - Electric system power flow congestion reduction – In the emergency mode of the control platform, the circuit level power flow and demand were managed through control of aggregated resources to prevent congestion.
  - Increase in the number of nodes in the power system with monitoring capability – Real time monitoring and 5-minute or 10-minute system prediction were included as an integral part of the platform design. A phasor measurement unit system also provided high-resolution data for enhanced visualization.
- **Identification of barriers or issues resolved that prevented widespread deployment of technology or strategy**
  - Increased use of cost-effective digital information and control technology to improve reliability, security, and efficiency of the electric grid (P.U. Code § 8360) – Integration between SCADA/DMS and the DER aggregation platform was identified as a cost-effective solution to ensure integrity of the system.
- **Effectiveness of information dissemination**
  - Stakeholder participation in workshops – Project stakeholders within SDG&E were selected and invited to workshops.
  - Technology transfer – A plan was made for knowledge transfer through journals and conferences. A panel presentation was accepted for DistribuTECH 2018, in San Antonio (presented in January 2018).

vii. Schedule
November 11, 2015 to December 31, 2017

viii. EPIC Funds Encumbered as of December 31, 2017
$1,088k

ix. EPIC Funds Spent as of December 31, 2017
$1,064k

x. Partners (if applicable)
n/a

xi. Match Funding (if applicable)
n/a

xii. Match Funding Split (if applicable)
n/a

xiii. Funding Mechanism (if applicable)
A combination of in-house work and a pay-for-performance contract was used.

xiv. Treatment of Intellectual Property (if applicable)
No IP developed.

xv. Status Update
All project activities were completed in the year 2017. The project team held working sessions to define the baseline evaluation, concept of operations, use cases, other technical details, project schedule and resource management. Based on use cases, engineering and design, the test plan and test system were developed. The pre-commercial demonstration was carried out at the ITF, after successful factory acceptance and site acceptance tests. A comprehensive final report was developed, including the pre-commercial demonstration description, test result analysis, findings, recommendations, metrics, value proposition and conclusions.

Project 5: Integration of Customer Systems into Electric Utility Infrastructure

i. Investment Plan Period
2015-2017 (EPIC-2)

ii. Assignment to Value Chain
Distribution

iii. Objective
The project addressed the evolving gateway between customers and utilities. Specifically, it demonstrated the safe and reliable interoperability of customer systems with the distribution and transmission system and California Independent System Operator (CAISO) operations to improve grid operations and thereby increase ratepayer satisfaction and benefits.

iv. Scope
Alternative solutions for successful customer interoperability with utility systems were identified. Requirements for integration of these solutions with utility

systems were specified. Promising interoperability systems were demonstrated to create a knowledge base to support decisions on prospective commercial deployment of the systems. The work was performed by a team comprised of SDG&E technical staff and a contractor.

v. Deliverables

A comprehensive final report on the work and the results of the project were delivered after project completion.

vi. Metrics

Project tracking metrics included whether the SDG&E/contactor project team met milestones in the project plan. Technical metrics for the demonstration work were identified during performance of the demonstration. Metrics for this project are based on comparing the performance of power system operations when various interoperability solutions are in place with the performance of operations when they are not in place. The commercial adoption of this project will be impacted by the following metrics:

- Potential energy and cost savings
  - The project demonstrated new technologies and analysis methods for monitoring, visualization, and root-cause analysis of distribution systems by using various measurement techniques and data sources and integrating them in one platform to provide a unique monitoring and visualization user experience. This will create significant cost savings through reducing the required nameplate capacity of energy storage and distribution generation facilities due to the enhancement of the operations by providing additional means of awareness about the system behavior.
  - Avoided procurement and generation costs – Accurate monitoring enables utilities to predict generation costs especially through predicting dynamic events caused by varying characteristics of DER energy productions, loading effect of electric vehicle charging stations, and power electronic apparatus.

- Economic Benefits
  - Operation costs of the system can be significantly reduced by increased awareness and monitoring capability of the system.
- Safety, Power Quality, and Reliability
  - Electric system power flow congestion reduction – Any possible congestion might be diminished due to the improved monitoring, and visibility of the system. Any probable failure, or transient behavior can be properly predicted to avoid possible damage to the personnel, or equipment.
  - Forecast accuracy improvement – With improved visibility of the system, better forecasting capability is provided for the system, and any undesired behavior can be avoided by properly designing protection systems.

- Utility worker safety improvement and hazard exposure reduction– Utility workers safety can be considerably improved by enhanced awareness of distribution assets in the real-time mode. Other obtained safety related improvements include facilitated root cause analysis, operator and engineers training, and assessment of operation and design procedures for new technologies and approaches.
- Increase in the number of nodes in the power system with monitoring capability–This project provided more visibility, and situational awareness through increasing number of devices which monitor the system performance.

o Identification of barriers or issues resolved that prevented widespread deployment of technology or strategy

This project was successful in completing demonstrations of candidate interoperability solutions to create knowledge that will support SDG&E decisions regarding commercial adoption.

In addition, key results are presented in the final report are being submitted for consideration for publication or presentation in relevant technical journals and conferences.

vii. Schedule
October 16, 2015 to December 31, 2017

viii. EPIC Funds Encumbered as of December 31, 2017
$985k

ix. EPIC Funds Spent as of December 31, 2017
$978k

x. Partners (if applicable)
n/a

xi. Match Funding (if applicable)
n/a

xii. Match Funding Split (if applicable)
n/a

xiii. Funding Mechanism (if applicable)
SDG&E EPIC funding applied to internal project team work and a pay-for-performance contract.

xiv. Treatment of Intellectual Property (if applicable)
No IP developed.

xv. Status Update

All project activities were completed in 2017. The key system capabilities that were successfully demonstrated and validated were:

- Monitoring distribution assets in the field (outside of substations) in real-time, based on measurements received from monitoring devices.
- Tapping into historical data collected to playback and investigate events over extended periods as selected and required by an operator or an engineer. This approach resolved major issues in previous systems due to lack of proper time synchronization and difficulty of alignment of the data points from various devices.
- Providing a set of tools for pre/post event analysis based on various data types and sources; this feature was shown to be very effective for root cause analysis, training of operators and engineers, and assessment of operation and design procedures for new technologies and approaches.

Project 6: Collaborative Programs in RD&D Consortia

i. Investment Plan Period

2015-2017 (EPIC-2)

ii. Assignment to Value Chain

Distribution

iii. Objective

The objective of this project was to accomplish highly leveraged demonstration work through collaborative projects in industry R&D consortia. This included information and intelligence leveraging by better informing the project content in EPIC activities with the knowledge of relevant activities occurring in a worldwide sense.

iv. Scope

The project team worked with R&D consortia to organize pre-commercial demonstration projects that focused on two modules:

- Demonstration of methodology and tools for estimating propensity for customer adoption of photovoltaics – The focus of this project module was to identify methodologies and tools for determining the primary drivers for residential photovoltaic (PV) adoption, predict residential PV adoption over time, and to demonstrate selected methods on a use case (*e.g.*, propensity to adopt PV on the zip code level). The effort also developed recommendations about whether to adopt all or some of the methods and tools on a commercial basis. The project team focused specifically on residential sector PV market adoption. Additionally, the project team conducted machine learning (ML) analytics on disadvantaged communities (DAC) zip codes and evaluated the difference in propensity to adopt solar PV between DAC and other zip codes.

- Unmanned aerial systems data lifecycle management and deep learning demonstration – The focus of this project module was to demonstrate tools that ingested and analyzed data collected by means of unmanned aircraft systems (UAS), existing red, green & blue (RGB) imagery, geographic information systems (GIS), power line systems – computer aided design and drafting (PLS-CADD) and other various inspection data types. The project module demonstrated the tools' ability to automatically identify and tag assets shown in RGB imagery, specifically avian covers, in real-world locations through machine learning. Additional identification of vegetation modeled using light imaging detection and ranging (LiDAR) data that encroached into pre-determined zone(s) around electrical wires provided a road map for future proactive vegetation maintenance efforts.

v. Deliverables

Two comprehensive final reports for the two project modules were developed describing the work and results of the project modules.

vi. Metrics

The commercial adoption methodologies and tools for estimating propensity for customer adoption of photovoltaics will be impacted by the following metrics.

- Potential energy and cost savings
  - Avoided customer energy use (kWh saved) – The use of tools to estimate customer adoption of PV would lead to understanding the contribution of electric load from PV systems, which in turn will provide the customers with reduced energy usage and economic savings.
  - Avoided procurement and generation costs – Accurate estimation of customer PV adoption rates would enable utilities to estimate the avoided cost to procure energy from sources that might be inefficient or contribute to environmental pollution.

- Environmental benefits
  - Greenhouse Gas (GHG) emissions reductions – Adoption of PV would lead to reduced emissions from fossil fuel-based sources which would have to be used in absence of renewable resources like PV.

The project metrics used to evaluate and test UAS technology and machine learning tools include:

- Habitat area disturbance reductions – UAS technologies allow for a remotely operate vehicle to access sensitive habits without impacting the land through vehicular are personnel incursions. The use cases demonstrated a process to capture and analyze electrical facilities, surrounding vegetation and terrain features from an aerial drone. The UAS

technology can reduce habitat area disturbance by replacing some required physical inspections with UAS derived inspections.

- Wildlife fatality reductions (electrocutions, collisions) – This project module studied the feasibility of combining UAS derived imagery with deep learning analytics to determine the location and condition of avian covers on electrical facilities. The avian covers provide a level of protection against electrocution for birds with large wing spans resting on electrical distribution and transmission poles. Currently the avian covers are assessed by physical inspection taken from ground observation on scheduled maintenance intervals. UAS data capture and associated deep learning analytics could provide increase inspections, improved evaluation of the presence and condition of avian covers resulting in reducing the risk to wildlife.
- Utility work safety improvement and hazardous exposure reduction – This project module studied several uses case for utilizing UAS technology and machine learning analytics to remotely observe, measure and catalog electrical facilities and surrounding terrain. The technology and process remove utility workers from making physical inspection where in many cases required access through hazardous terrain and complete inspections in close proximity to energized facilities and equipment.

vii. Schedule
March 1, 2016 to December 31, 2017

viii. EPIC Funds Encumbered as of December 31, 2017
$1,561k

ix. EPIC Funds Spent as of December 31, 2017
$830k

x. Partners (if applicable)
n/a

xi. Match Funding (if applicable)
n/a

xii. Match Funding Split (if applicable)
n/a

xiii. Funding Mechanism (if applicable)
SDG&E EPIC funds applied to an internal team and collaborative consortium to define, set up, and execute two collaborative pre-commercial demonstration project modules.

xiv. Treatment of Intellectual Property (if applicable)
No IP developed.

xv. Status Update

The two project module activities were completed in 2017

- Module on demonstration of methodology and tools for estimating propensity for customer adoption of photovoltaics
    - The project to demonstrated methodologies and tools for forecasting the propensity for residential customer solar PV adoption in California and SDG&E zip codes included the following major tasks:
        - Literature Review and Methodology Justification
        - Methodology Framework Development
        - Demonstration Plan
        - Disadvantaged Communities Analysis
    - Using machine learning, the project identified the several important attributes driving adoption at the non-DAC and DAC zip code level. Comparing adoption in DAC and non-DAC zip codes, owner occupancy emerged as a key attribute explaining the difference in PV market share. The percentage of owner occupied homes is 63% for non-DAC zip codes, compared to 50% for DAC zip codes.
    - The strength of aggregate and zip code-level back-casts suggest that causal models can be used to forecast residential rooftop PV adoption moving forward with a reasonable degree of accuracy, even when the analysis is spatially disaggregated. Such methods could support integrated resource planning and a better understanding of likely solar PV installation location.
    - The project recommends that SDG&E not commercially adopt these methods and tools at this juncture, without more foundational work being done first.
    - Based on the pre-commercial demonstration results and findings of this project, the following actions by SDG&E or other stakeholders are recommended as steps toward prospective commercial adoption of the demonstrated methods and tools:
        - Improve SDG&E's existing zip-code-based bass diffusion technique with refinements for the long-run market share parameters based on significant customer attributes.
        - Improve certain model input parameters (*e.g.*, historical PPA prices, kilowatt-hour production, technical suitability due to shading and orientation, price sensitivity, and correlation between homeownership and credit scores.
        - Leverage the same or equivalent methodology to evaluate solar PV adoption for other specific segments of interest and potentially individual customer analysis, including but not limited to: commercial and industrial customers, low-income customers, and customers on distribution feeders that are capacity constrained or at risk for reverse power flow.
        - Adapt the methodology for use in forecasting adoption of other DER types.

        - Consider utilizing a customer discrete choice survey approach to facilitate independent estimation of both the long-run market share parameters and the Bass diffusion coefficients
- Module on unmanned aerial systems data lifecycle management and deep learning demonstration
    - Unmanned Aerial Systems (UAS) have provided a unique opportunity for SDG&E and other utilities to obtain, disseminate and use aerial sensor data that provides benefits such as cost savings to its ratepayers and lower physical risks to SDG&E personnel while increasing public safety.
    - The project module was able to demonstrate integration with existing and future SDG&E infrastructure, software applications and legacy data sets with the ability to ingest, store, analyze and report on SDG&E assets derived from GIS, PLS-CADD, UAS collected data and other various sources.
    - The three test cases identified for the project included:
        - Avian Cover Identification – Test case to evaluate the identification of assets (avian cover) through advanced analytics on RGB images and demonstrate value for continual maintenance and visual inspection.
        - Vegetation Encroachment Identification – Test case to evaluate identification of vegetation encroachment within a buffer zone around power lines, thereby assisting in identification of trees for maintenance and trimming.
        - Cataloging and Remote Asset Management – Test case to demonstrate ingestion of data from various data sources and cataloging metadata information of existing assets that enables remote visualization and management of assets.
    - It is recommended that SDG&E pursue additional evaluation of UAS technology for stakeholder groups within the company that will benefit from the aggregation of various sources of data into a data management platform that also provides advanced analytical capabilities. The evaluation should also focus on developing requirements for integration of this data management platform into the SDG&E information technology environment.

VI. CONCLUSION

A. Key Results for 2017 for SDG&E EPIC Projects

As of December 31, 2017, SDG&E committed all EPIC-1 and EPIC-2 funds for its 11 Commission-approved EPIC-1 and EPIC-2 projects. SDG&E performed work on all 11 of these projects and completed 10 of them in 2017. The remaining project is in progress and scheduled to be completed in 2018.

Attached to this Report as Appendices 1 to 15, are 15 final reports for the EPIC projects that have been completed to date. Two of the projects were split into multiple work modules, and a final report was prepared for each module. There is a total of 15 module final reports for the 11 projects. These EPIC final reports are also available on the SDG&E EPIC website at www.SDGE.com/EPIC.

B. Next Steps for SDG&E's EPIC Program

For the partially completed project, work will continue in 2018 on completion of the project plan and on performance of tasks in the plan.

Specifically, for the unfinished project, the following are the next steps:

- EPIC-1, Project 2: Devise and demonstrate additional use cases relative to visualization and situational awareness capabilities in system operations. Prepare a final report on the added use cases.

For the EPIC-1 and EPIC-2 projects, $14,457k was awarded to contractors through December 31, 2017.

Work will commence on SDG&E's proposed EPIC-3 projects once a Commission decision is issued approving SDG&E's EPIC-3 Application.

ATTACHMENT B

SDG&E 2017 EPIC PROJECT STATUS (EXCEL FILE)

Investment Program Period	Program Administrator	Project Name	Project Type	Brief Description of the Project (objective; scope; deliverables; schedule)	Date of the Award	Was this project awarded in the immediately prior calendar year?	Assignment to Value Chain	Encumbered Funding Amount ($000)	Committed Funding Amount ($000)	Funds Expended to date: Contract/Grant Amount ($000)	Funds Expended to date: In house expenditures ($000)	Funds Expended to date: Total Spent to date ($000)	Administrative and overhead costs to be incurred for each project	Leveraged Funds	Partners	Match Funding	Match Funding Split	Funding Mechanism	Intellectual Property	Identification of the method used to grant awards	If competitively selected, provide the number of bidders passing the initial pass/fail screening for project	If competitively selected, provide the name of selected bidder.	If competitively selected, provide the rank of the selected bidder in the selection process.	If competitively selected, explain why the bidder was not the highest scoring bidder, explain why a lower scoring bidder was selected.	If interagency or sole source agreement, specify date of notification to the Joint Legislative Budget Committee (JLBC) was notified and date of JLBC authorization. (This column is applicable to the CEC only.)	Does the recipient for this award identify as a California-based entity, small business, or businesses owned by women, minorities, or disabled veterans?	How the project leads to technological advancement or breakthroughs to overcome barriers to achieving the state's statutory energy goals (This column is applicable to the CEC only.)	Applicable metrics	Update
1st triennial (2012-2014)	SDG&E	Smart Grid Architecture Demonstrations	Pre-commercial Demonstration	The specific objectives of the project were to: perform pilot demonstration of key candidate prototype building blocks of the SDG&E smart grid architecture to determine their suitability for adoption in the architecture; document the results and make recommendations of whether specific building blocks should be adopted; and, provide demonstration results to support the implementation phase for any building blocks adopted.	03/15/2017	Yes	Distribution	1,406	1,406	1,344	57	1,402	N/A	0	None	0	N/A	A combination of in-house work and pay-for-performance contracts was used. A Request for Proposal (RFP) was released in third quarter of 2016, with contractor selection completed in 2017.	None to date	RFP	2	Quanta Technology, LLC	1st	N/A	N/A	Yes - (Team member AVECS)	N/A	The following metrics were identified for this project and evaluated during the course of the pre-commercial demonstration. These metrics are not exhaustive given the pre-commercial demonstration approach for this project. • Identification of barriers or issues resolved that prevented widespread deployment of technology or strategy o Identification and lowering of unreasonable or unnecessary barriers to adoption of smart grid technologies, practices, and services (PU Code § 8360) - Use of configuration inheritance and descriptive data point naming supported by IEC 61850 makes the task of configuring devices in substation and feeders considerably easier when contrasted to the conventional approach. Digitization of devices using IEC 61850 can potentially lower the barriers of adoption of newer technologies within the electric infrastructure. o Develop standards for communication and interoperability of appliances and equipment connected to the electric grid, including the infrastructure serving the grid (PU Code § 8360) - The industry has many standards that exist among several standards development organizations that may be applicable to multiple layers of the power systems architecture. A key standard is the IEC 61850 protocol suite. The extent of harmonization efforts that have included IEC 61850 show that the suite has the potential of becoming a key building block in the future smart grid architecture that enable effective communication and interoperability of equipment connected to the electric grid. • Safety, Power Quality, and Reliability (Equipment, Electricity System) - The use of IEC 61850 in the field could enable interoperability, improve protection coordination and provide effective information sharing between field devices and backend systems. The following sub-factors could be enhanced with the use of IEC 61850: o Increase in the number if nodes in the power system at monitoring points o Reduction in outage numbers, frequency, and duration. o Reduction in system harmonics	All project activities were completed in 2017. IEC 61850 was identified as a principal component of the new architecture. A representative test system was constructed, and a total of eleven use cases were defined to demonstrate the use of IEC 61850 standards. The recommendation is that SDG&E plan for long-term migration to an architecture that incorporates IEC 61850 standards.
1st triennial (2012-2014)	SDG&E	Visualization and Situational Awareness Demonstrations	Pre-commercial Demonstration	The objective of this demonstration project was to explore how data collected from sensors and devices can be processed, combined, and presented to system operators in a way that enhances grid monitoring and situational awareness. This project looked at how data currently unexploited and separately processed can be integrated and visually presented for strategic use by system operators. When transformed and presented in a visually integrated manner, this data can be invaluable for utilities to optimize grid operations as well as provide insights in the performance of the overall utility system. The demonstration of specific visualization and situational awareness concepts will be used to help SDG&E make choices on which options should be adopted into a future visualization and situational awareness system.	In-house only	No	Distribution	2,075	2,301	653	408	1,061	N/A	0	None	0	N/A	SDG&E EPIC funding used for work performed by the internal SDG&E project team.	None to date	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	The project tracking metrics will be the milestones in the project plan. Technical project metrics will include the completion of the initial specification for a visualization and situational awareness system, the demonstration of a system display mock-up, and the specifications and recommendations regarding adoption by SDG&E. Also, major project results will be submitted in technical papers and presentations for consideration by major technical conferences and publications. The following metrics were identified for this project and further explained in the final report: • Safety, Power Quality, and Reliability (Equipment, Electricity System). • Identification of barriers or issues resolved that prevented widespread deployment of technology or strategy. • Adoption of EPIC technology, strategy, and research data/results by others.	Major project activities completed in 2017. Based on the feedback from early users of the project results - which has been uniformly positive - this project has successfully achieved all its key objectives. Through the performed work, SDG&E has demonstrated novel solutions to the selected use cases, and, in the process, has also gained reusable software artifacts and substantial experience in integrating GIS, historical, asset management, and other major SDG&E computer systems. Both aspects will provide usability well beyond the direct utility of the software components produced by the project. The project committed additional funds by the end of 2017 to perform additional work on selected use cases to give them greater value and further development.
1st triennial (2012-2014)	SDG&E	Distributed Control for Smart Grids	Pre-commercial Demonstration	The objective of this project was to test alternatives for communication and control across distribution system resources to ensure that devices operate in a complementary manner and ensure optimum distribution system performance, reliability, and stability. The project tested distributed control methods and approaches to control distribution circuit resources and integrate them as part of a unified control scheme with other higher-level control systems, such as the distribution management system (DMS). The project assessed the scalability and performance of alternative control schemes.	06/01/2016	No	Distribution	1,392	1,392	1,333	53	1,386	N/A	0	None	0	N/A	SDG&E EPIC funds were applied to a combination of in-house work and a pay-for-performance contract. A prime contractor was selected by competitive procurement in the second quarter of 2016.	None to date	RFP for prime contractor and sole source for consultant to help prepare the RFP.	5	Quanta Technology, LLC	1st	N/A	N/A	No	N/A	The project tracking metrics will be the milestones in the project plan. Technical metrics for this project will be based on comparing the performance of distribution system operations when various new control schemes are in place with the performance of the same operations when the control schemes are not in place. These performance metrics will include measures of power quality, electrical loss reductions, asset health maintenance, and adaptability to new device types in the distribution system. Also, major project results will be submitted as technical papers and presentations for consideration by major technical conferences and publications. The following metrics were identified for this project and further explained in the final report: • Economic Benefits. • Safety, Power Quality, and Reliability (Equipment, Electricity System). • Identification of barriers or issues resolved that prevented widespread deployment of technology or strategy. • Effectiveness of information dissemination. • Adoption of EPIC technology, strategy, and research data/results by others.	2017 saw the completion of the project. The results provided quantifiable evidence that the distributed control of system resources could achieve benefits when compared to a conventional approach. Major benefits identified included: • Increase the utilization and contribution of DERs • Reduce and even prevent unintentional reverse power flow • Produce a flatter voltage profile over the length of a circuit • Bring voltage profiles back inside the permissible range after a system event • Reduce system electrical losses • Improve the power factor of a circuit • Reduce the number of operations of controllable assets like capacitor banks, voltage regulators and load tap changers • Dynamically adjust protection settings to increase system reliability The tests demonstrated that the greatest benefits were obtained when the control system was able to coordinate the control of two adjacent substations and when the regionally-based master controller was controlling the system, because it provided more possibilities for system optimization.
1st triennial (2012-2014)	SDG&E	Demonstration of Grid Support Functions of Distributed Energy Resources	Pre-commercial Demonstration	The objective of EPIC-1, Project 4, Demonstration of Grid Support Functions of Distributed Energy Resources (DER) was to demonstrate grid support functions of DER, which can improve distribution system operations. In other words, the objective was to assess the viability of using DER to provide non-traditional functions, such as volt/VAr optimization, fast-response peaking or emergency power, peak shaving, and distribution system status information. This project consisted of three modules: value assessment of grid support functions of DER, communication standards for grid support functions of DER, and demonstration and comparison of the EPRI and SDG&E DER hosting capacity analysis tools.	Calendar Year 2015 and Calendar Year 2017	No for first contract and Yes for second and third contracts	Distribution	1,200	1,200	1,012	83	1,095	N/A	0	None	0	N/A	EPIC funding of an internal SDG&E project team working with a pay-for-performance prime contractor. For Module 1 (which was a substantial part of this project), a prime contractor was selected by competitive procurement. Modules 2 and 3 were smaller efforts for which the contractors were selected by sole source.	None to date	RFP for prime contractor for first project module. Sole source for prime contractors for second and third modules.	3	Schweitzer Engineering Laboratories for first module. Klu and EPRI for second and third modules respectively.	1st	N/A	N/A	No	N/A	Technical metrics for the pre-commercial demonstration were determined during the demonstration planning phase. One measure of success for Module 1 of this project was whether it provided a basis for deciding which DER functions warrant commercial pursuit in future distribution system development. Metrics for this module also included the identification of suitable interoperability requirements, interconnection systems, and communication protocols that support the functions. In Module 2, the metrics included a determination of which communication standards are preferred to support the adoption of viable grid support functions. In Module 3 of this project, the metrics addressed the pros and cons of the SDG&E hosting capacity tool in comparison with the EPRI CRIVE DER hosting capacity tool.	The three modules of this project were successfully accomplished with collaboration of the SDG&E internal team and the contractors' team. Final reports were completed individually for each module. They were carefully reviewed by the internal stakeholders, the SDG&E internal team, and the contractors' team and then revised into final form for public release.
1st triennial (2012-2014)	SDG&E	Smart Distribution Circuit Demonstrations	Pre-commercial Demonstration	The objective of this project was to perform pilot demonstrations of smart distribution circuit features and associated simulation work to identify best practices for integrating new and existing distribution equipment in these circuits. Simulations took advantage of hardware-in-loop testing with a real-time digital simulator currently available at SDG&E. Using simulations to optimize one particular circuit, desired features were tested in that circuit to assess their suitability for widespread commercial adoption.	12/04/2015	No for first contract and Yes for second contract	Distribution	1,441	1,441	1,356	77	1,433	N/A	0	None	0	N/A	For both Module 1 and Module 2, SDG&E EPIC funds were applied to support a team of internal technical staff and pay-for-performance contractors. The contractors were selected as per SDG&E procurement policy.	None to date	RFP for prime contractor and sole source for consultant to help prepare the RFP.	4	Schweitzer Engineering Laboratories for first module. Quanta Technology, LLC for second module.	1st for Schweitzer Engineering Laboratories for first module.	N/A	N/A	No	N/A	The project tracking metrics included the milestones in the project plan. Technical metrics were developed to guide the actual demonstration work. In general, the ultimate measure of success was having a benchmark future distribution circuit design concept that helps advance future distribution system development. The circuit design can assimilate a wide variety of existing and emerging device types and has a protection system that allows this assimilation to be done without compromising reliability or safety. The following metrics were identified for Module 1 and further explained in the final report: • Economic Benefits. • Safety, Power Quality, and Reliability (Equipment, Electricity System). • Identification of barriers or issues resolved that prevented widespread deployment of technology or strategy. • Effectiveness of information dissemination. • Adoption of EPIC technology, strategy, and research data/results by others. The following metrics were identified for Module 2 and further explained in the final report. • Potential energy and cost savings • Economic benefits • Safety, Power Quality, and Reliability (Equipment, Electricity System) • Effectiveness of information dissemination	The project was concluded in 2017. As mentioned, the project was broken into two modules: Module 1: Demonstration of Advanced Circuit Concepts: Developed with the assistance of Schweitzer Engineering Laboratories, Inc. This module was developed in 3 phases: o Phase 1 of the project covered the evaluation and documentation of products and technologies currently available for improved distribution circuit design, system operation, and protection. o Phase 2 of the project included selection and modeling of three diverse SDG&E distribution circuits viz., coastal-residential, urban, and desert-rural in a modeled environment for demonstration of advanced circuit concepts. The observations and results captured were analyzed and the findings from stand-alone device testing provided inputs on how to modify the existing circuits for improved reliability and performance. o Phase 3 of the project included findings and recommendations from the demonstration in Phase 2. The recommended system architecture for commercial implementation of voltage support coordination scheme is provided. Module 2: Pre-Commercial Demonstration of Methodologies and Tools for Energy Storage Integration into Smart Distribution Circuits – All project activities were completed in the year 2017. The test included identification, evaluation, selection and demonstration of methodologies and tools for prospective use in planning future energy storage projects. Test result from the test system were documented and evaluated. Chosen tools, software programs and methodologies were recommended to stakeholders.
								7,514	7,740	5,698	678	6,377																	

Investment Program Period	Program Administrator	Project Name	Project Type	Brief Description of the Project (objective; scope; deliverables; schedule)	Date of the Award	Was this project awarded in the immediately prior calendar year?	Assignment to Value Chain	Encumbered Funding Amount ($000)	Committed Funding Amount ($000)	Funds Expended to date: Contract/Grant Amount ($000)	Funds Expended to date: In house expenditures ($000)	Funds Expended to date: Total Spent to date ($000)	Administrative and overhead costs to be incurred for each project	Leveraged Funds	Partners	Match Funding	Match Funding Split	Funding Mechanism	Intellectual Property	Identification of the method used to grant awards	If competitively selected, provide the number of bidders passing the initial pass/fail screening for project	If competitively selected, provide the name of selected bidder.	If competitively selected, provide the rank of the selected bidder in the selection process.	If competitively selected, explain why the bidder was not the highest scoring bidder, or explain why a lower scoring bidder was selected.	If interagency or sole source agreement, specify date of notification to the Joint Legislative Budget Committee (JLBC) was notified and date of JLBC authorization. (This column is applicable to the CEC only.)	Does the recipient for this award identify as a California-based entity, small business, or businesses owned by women, minorities, or disabled veterans?	How the project leads to technological advancement or breakthroughs to overcome barriers to achieving the state's statutory energy goals (This column is applicable to the CEC only.)	Applicable metrics	Update
2nd triennial (2015 - 2017)	SDG&E	Modernization of Distribution System & Integration of Distributed Generation and Storage	Pre-commercial Demonstration	The objective of this project was to demonstrate distribution system infrastructure modernization solutions, including advances in distribution system design to enable use of new technologies, such as power electronic components, new protection systems, distributed generation and alternative storage technologies. The work was focused on pre-commercial demonstration of emerging substation communication standards.	Calendar Year 2017	Yes	Distribution	2,009	2,009	1,927	44	1,971	N/A	0	None	0	N/A	A combination of in-house work and pay-per-performance were used.	None to date	Sole Source for prime contractor and competitive bid for equipment vendors.	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	The following metrics were identified for this project. Given the proof of concept nature of this EPIC project, these metrics are forward looking to prospective adoption of IEC 61850 standards. The main protection concerns that were identified in this project were speed and reliability. The following metrics address these concerns. i. Potential energy and cost savings: Due to reduced engineering efforts in the design process using IEC 61850 equipment, cost savings flow through to ratepayers. The integrated engineering tools make it easier to design the substation and test the equipment before deployment, which is hard to achieve now and is more time consuming with current legacy systems.	The project was completed in 2017. Stakeholders from SDG&E's substations and protection sections worked with the internal project team and contractor to plan and review the task work in this project. Options for performing the demonstration were explored, including at an actual substation or in a laboratory. Due to cost and risk considerations, it was decided to perform the demonstration in a laboratory using a substation mock-up. Intelligence was gathered on the status of the IEC standards and the vendor equipment options for the demonstration. The project team finished a successful laboratory demonstration for several substation-protection use cases. A key recommendation coming from the project was for SDG&E to further explore commercial adoption of IEC 61850. Internal stakeholders are doing so. Other technology transfer activities have included presentations at various conferences. Included were a presentation at the IEC 61850 Europe 2017 Conference in September 2017 and acceptance for presentation at DistribuTECH 2018 (presented in January 2018). The project was also presented at EPIC Symposiums on December 1, 2016 in Sacramento and on October 18, 2017 in San Diego.
2nd triennial (2015 - 2017)	SDG&E	Data Analytics in Support of Advanced Planning and System Operations	Pre-commercial Demonstration	This project was designed to address the anticipated "data tsunami" associated with more widespread system monitoring and more widespread use of controllable devices in the power system. It helped to create better data management. It also demonstrated solutions for the data management issues and challenges expected to accompany the extensive amount of real-time and stored data being archived from field devices and identify the data mining procedures and the data-archiving methods, utilizing this data to improve power system operations. Solutions that are deemed to be best practices were documented for use in improving the data management systems that support power system operations.	02/07/2017	Yes	Distribution	1,111	1,111	753	203	957	N/A	0	None	0	N/A	Combination of in-house work and pay for-performance contracts. A RFP was released in third quarter of 2016, with contractor selection completed in 2017.	None to date	RFP	2	Sparta Consulting, dba KPIT	1st	N/A	N/A	No	N/A	The following metrics were identified for this project and evaluated during the course of the pre-commercial demonstration. These metrics are not exhaustive given the pre-commercial demonstration approach for this project. • Safety, Power Quality, and Reliability (Equipment, Electricity System) – The use of machine learning and advanced data analytics can help stakeholders predict the failure of equipment based on current and historical operational data and other data. The following sub-factors could be analyzed with advanced data analytics: o Number of outages, frequency and duration reductions o Forecast accuracy improvement o Public safety improvement o Utility worker safety improvement • Economic Benefits – Advanced data analytics can provide significant economic benefits by helping the identification of failing or aging equipment, before they fail, thereby reducing operational expenditures and planning capital expenditures effectively. The following sub-factors could be affected with advanced data analytics: o Maintain/reduce operations and maintenance costs o Maintain/reduce capital costs o Improvement in system operation efficiencies	All project activities were completed in 2017. The pre-commercial demonstration included ingestion of several data sources into a data lake, test build of preliminary predictive models for major electric distribution asset management use cases, and visualization development using business intelligence tools to provide insight into the health of various assets on the utility distribution system. Based on the project findings, it is recommended that SDG&E and other utility stakeholders commercially adopt and implement advanced data analytics techniques for effective asset management.
2nd triennial (2015 - 2017)	SDG&E	Monitoring, Communications, and Control Infrastructure for Power System Modernization	Pre-commercial Demonstration	The objective of this project was to demonstrate advanced monitoring, communication and control infrastructure needed to operate an increasingly complex power system infrastructure. In other words, to test system controls to "sort" data and use what is helpful and useful.	01/24/2017	Yes	Distribution	1,305	1,305	1,266	22	1,288	N/A	0	None	0	N/A	Combination of in-house work and pay for-performance contracts. A RFP was released in third quarter of 2016, with contractor selection completed in 2017.	None to date	RFP	3	GE Grid Solutions	1st	N/A	N/A	No	N/A	The following metrics were identified for this project and evaluated during the course of the pre-commercial demonstration. These metrics are not exhaustive given the pre-commercial demonstration approach for this project. • Identification of barriers or issues resolved that prevented widespread deployment of technology or strategy o Develop standards for communication and interoperability of appliances and equipment connected to the electric grid, including the infrastructure serving the grid (PU Code § 8360) -The EPIC project demonstrated the potential value of OpenFMB in addressing interoperability issues that exist in the electric system today, with multiple vendor technologies/systems unable to interface or interact with each other in a seamless manner. OpenFMB could provide a framework that enables the coexistence of traditional IEDs or devices that operate in a centralized manner with new IEDs or devices (especially DERs) that have the capability to operate in a decentralized manner. o Identification and lowering of unreasonable or unnecessary barriers to adoption of smart grid technologies, practices, and services (PU Code § 8360) - This EPIC project established a potential OpenFMB framework that could be implemented in the secondary layer that sits between the enterprise layer in a utility control center, and the primary layer that sits on multiple devices or equipment in the field. Next generation of IEDs or DERs may provide the necessary communication technology and application framework that enable peer to peer communication between devices and routes the information through the OpenFMB framework to disparate systems in the backend. • Safety, Power Quality, and Reliability (Equipment, Electricity System) - The use of OpenFMB framework to deploy decentralized applications could enable interoperability and improve information sharing between field devices and backend systems. The following sub-factors could be enhanced with the use of OpenFMB: o Reduction in outage numbers, frequency, and duration. o Reduction in system harmonics o Increase in the number if nodes in the power system at monitoring points o Public safety improvement and hazard exposure reduction	All project activities were completed in 2017. The project focus was on pre-commercial demonstration of an Open Field Messaging Bus (Open FMB) for interoperability, peer-to-peer communication, and multiple protocol conversion. A representative test system was constructed, and a total of thirteen use cases were defined to demonstrate the use of OpenFMB for monitoring and control. As a result of this demonstration, it is recommended that work be continued to further define the OpenFMB standard so that it can be successfully utilized in future utility distribution system projects and deployments
2nd triennial (2015 - 2017)	SDG&E	System Operations Development and Advancement	Pre-commercial Demonstration	The objective of this project was to support continued modernization of SDG&E's power system via demonstrations of improved capabilities in system operations. The project demonstrated a systematic process for the realignment of operating practices with advances in technology, software and standards used in the power system. The realignment is broad and addresses system integration issues and technology transfer.	02/15/2017	Yes	Distribution	1,088	1,088	1,033	31	1,064	N/A	0	None	0	N/A	A combination of in-house work and pay-for-performance contracts was used. A RFP was released in third quarter of 2016, with contractor selection completed in 2017.	None to date	RFP	3	Quanta Technology, LLC	1st	N/A	N/A	No	N/A	The following metrics were used to evaluate the project from different perspectives including Project Success Factors, Project Implementation Milestones, and Technical Achievements. • Potential energy and cost savings • Economic benefits • Safety, Power Quality, and Reliability (Equipment, Electricity System • Identification of barriers or issues resolved that prevented widespread deployment of technology or strategy • Effectiveness of information dissemination	All project activities were completed in the year 2017. A PHIL (Power Hardware In the Loop) test system was developed to examine improvements of the distribution system containing modern system component by optimization, using the RAMCO (Regional Aggregation Monitoring and Circuit Optimizers) and LRAM (Local Resource Aggregation and Monitoring). Results from the test system were evaluated and concluded that, the system operated as intended and optimized the distribution system. The recommendation is that stakeholders pursue this system further and commercialize it.
2nd triennial (2015 - 2017)	SDG&E	Integration of Customer Systems into Electric Utility Infrastructure	Pre-commercial Demonstration	The project addressed the evolving gateway between customers and utilities. Specifically, it demonstrated the safe and reliable interoperability of customer systems with the distribution and transmission system and California Independent System Operator (CAISO) operations to improve grid operations and thereby increase ratepayer satisfaction and benefits.	Calendar Year 2017	Yes	Distribution	985	985	915	63	978	N/A	0	None	0	N/A	SDG&E EPIC funding applied to the internal project team work and a pay-for-performance contract.	None to date	Sole Source	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Project tracking metrics included whether the SDG&E/contactor project team met milestones in the project plan. Technical metrics for the demonstration work were identified during performance of the demonstration. Metrics for this project are based on comparing the performance of power system operations when various interoperability solutions are in place with the performance of operations when they are not in place. The commercial adoption of this project will be impacted by the following metrics: o Potential energy and cost savings ß The project demonstrated new technologies and analysis methods for monitoring, visualization, and root-cause analysis of distribution systems by using various measurement techniques and data sources and integrating them in one platform to provide a unique monitoring and visualization user experience. This will create significant cost savings through reducing the required nameplate capacity of energy storage and distribution generation facilities due to the enhancement of the operations by providing additional means of awareness about the system behavior. ß Avoided procurement and generation costs – Accurate monitoring enables utilities to predict generation costs especially through predicting dynamic events caused by varying characteristics of DER energy productions, loading effect of electric vehicle charging stations, and power electronic apparatus. o Economic Benefits ß Operation costs of the system can be significantly reduced by increased awareness and monitoring capability of the system. o Safety, Power Quality, and Reliability • Electric system power flow congestion reduction – Any possible congestion might be diminished due to the improved monitoring, and visibility of the system. Any probable failure, or transient behavior can be properly predicted to avoid possible damage to the personnel, or equipment. • Forecast accuracy improvement – With improved visibility of the system, better forecasting capability is provided for the system, and any undesired behavior can be avoided by properly designing protection systems. • Utility worker safety improvement and hazard exposure reduction – Utility workers safety can be considerably improved by enhanced awareness of distribution assets in the real-time mode. Other obtained safety related improvements include facilitated root cause analysis, operator and engineers training, and assessment of operation and design procedures for new technologies and approaches. • Increase in the number of nodes in the power system with monitoring capability – This project provided more visibility, and situational awareness through increasing number of devices which monitor the system performance. o Identification of barriers or issues resolved that prevented widespread deployment of technology or strategy	All project activities were completed in 2017. The key system capabilities that were successfully demonstrated and validated were: • Monitoring distribution assets in the field (outside of substations) in real-time, based on measurements received from monitoring devices. • Tapping into historical data collected to playback and investigate events over extended periods as selected and required by an operator or an engineer. This approach resolved major issues in previous systems due to lack of proper time synchronization and difficulty of alignment of the data points from various devices. • Providing a set of tools for pre/post event analysis based on various data types and sources; this feature was shown to be very effective for root cause analysis, training of operators and engineers, and assessment of operation and design procedures for new technologies and approaches.
2nd triennial (2015 - 2017)	SDG&E	Collaborative Programs in RD&D Consortia	Pre-commercial Demonstration	The objective of this project was to accomplish highly leveraged demonstration work through collaborative projects in industry R&D consortia. This included information and intelligence leveraging by better informing the project content in EPIC activities with the knowledge of relevant activities occurring in a worldwide sense.	For first module: GIS Surveyors, Inc (08/03/2017, GE Grid Solutions (09/01/2017), Harris Corporation (10/6/2017), Network Mapping (10/12/2017), Price Waterhouse Coopers (09/01/2017) For second module: Navigant Consulting (09/11/2017)	Yes	Distribution	1,561	1,561	755	75	830	N/A	0	None	0	N/A	SDG&E EPIC funds applied to an internal team and collaborative consortium to define, set up, and execute 2 collaborative pre-commercial demonstration project modules.	None to date	Competitive procurement	6 for module on UAS and 3 for module on customer propensity	For first module: GIS Surveyors, Inc, GE Grid Solutions, Harris Corporation, Network Mapping, Price Waterhouse Coopers For second module: Navigant Consulting	For first module: Top 3 bidders were all selected For second module: Rank 1 was selected	N/A	N/A	Yes (GIS Surveyors, Inc.)	N/A	• The commercial adoption methodologies and tools for estimating propensity for customer adoption of photovoltaics will be impacted by the following metrics. o Potential energy and cost savings · Avoided customer energy use (kWh saved) – The use of tools to estimate customer adoption of PV would lead to understanding the contribution of electric load from PV systems, which in turn will provide the customers with reduced energy usage and economic savings. · Avoided procurement and generation costs – Accurate estimation of customer PV adoption rates would enable utilities to estimate the avoided cost to procure energy from sources that might be inefficient or contribute to environmental pollution. o Environmental benefits ·Greenhouse Gas (GHG) emissions reductions – Adoption of PV would lead to reduced emissions from fossil fuel based sources which would have to be used in absence of renewable resources like PV. • The project metrics used to evaluate and test UAS technology and machine learning tools include: o Habitat area disturbance reductions - UAS technologies allow for a remotely operate vehicle to access sensitive habits without impacting the land through vehicular are personnel incursions. The use cases demonstrated a process to capture and analyze electrical facilities, surrounding vegetation and terrain features from an aerial drone. The UAS technology can reduce habitat area disturbance by replacing some required physical inspections with UAS derived inspections. o Wildlife fatality reductions (electrocutions, collisions) - This project module studied the feasibility of combining UAS derived imagery with deep learning analytics to determine the location and condition of avian covers on electrical facilities. The avian covers provide a level of protection against electrocution for birds with large wing spans resting on electrical distribution and transmission poles. Currently the avian covers are assessed by physical inspection taken from ground observation on scheduled maintenance intervals. UAS data capture and associated deep learning analytics could provide increase inspections, improved evaluation of the presence and condition of avian covers resulting in reducing the risk to wildlife. o Utility work safety improvement and hazardous exposure reduction - This project module studied several uses case for utilizing UAS technology and machine learning analytics to remotely observe, measure and catalog electrical facilities and surrounding terrain. The technology and process remove utility workers from making physical inspection where in many cases required access through hazardous terrain and complete inspections in close proximity to energized facilities and equipment.	Project development on demonstrations through collaborative R&D consortia focused on two modules. All project activities were completed in 2017. For the project module on forecasting customer adoption of photovoltaic (PV), the project team used machine learning to identify several important attributes driving adoption for disadvantaged communities (DAC) and other locations (non DAC) at the zip code level. Owner occupancy emerged as a key attribute explaining the difference in PV market share. The percentage of owner occupied homes is 50% for DAC zip codes compared to 63% for non-DAC zip codes. It is recommended that SDG&E not commercially adopt these methods and tools at this juncture, without more foundational work being done first. For the module on unmanned aerial systems (UAS) data lifecycle management and deep learning demonstration, the project demonstrated integration with existing and future SDG&E infrastructure, software applications and legacy data sets with the ability to ingest, store, analyze and report on SDG&E assets derived from Geographic Information System (GIS), Power Line Systems – Computer Aided Draft and Design (PLS-CADD), unmanned aircraft system (UAS) collected data and other various sources. Three test cases were demonstrated including equipment identification, vegetation encroachment identification, and cataloging and remote asset management. It is recommended that SDG&E pursue additional evaluation of UAS technology for stakeholder groups within the company that will benefit from the aggregation of various sources of data into a data management platform that also provides advanced analytical capabilities.
								8,059	8,059	6,649	438	7,088																	

ATTACHMENT C

SDG&E EPIC FINAL REPORTS
APPENDICES 1 through 15

Due to large electronic file size, the EPIC Final Reports are available here:
https://www.sdge.com/epic
or
https://www.sdge.com/regulatory-filing/21076/application-sdge-u902e-approval-electric-program-investment-charge-triennial-plan-2018-2020