Pacific Gas and Electric Company

EPIC Final Report

Program	***Electric Program Investment Charge (EPIC)***
Project	***EPIC 3.27–Multi-Purpose Meter***
Reference Name	***EPIC 3.27, Next Generation Meter-EVSE Integration***
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Acronyms

A.	Application
AMI	Advanced Metering Infrastructure
ANSI	American National Standards Institute
AP	Access Point
API	Application Programming Interface
CC&B	Customer Care and Billing
CEC	California Energy Commission
CPU	Central Processing Unit
CPUC	California Public Utilities Commission
CSVS	Cloud Solutions Vendor Service
D.	Decision
DER	Distributed Energy Resource
EPIC	Electric Program Investment Charge
EV	Electric Vehicle
EVSE	Electric Vehicle Supply Equipment
FAS	Field Automation System
GB	Gigabyte
GHG	Greenhouse gas
GIS	Geographic Information System
GPS	Global Positioning System
Hz	Hertz
ID	Identification
IEEE	Institute of Electrical and Electronics Engineers
IOU	Investor-Owned Utility

IP	Internet Protocol
IT	Information Technology
KPI	Key Performance Indicator
kVARh	kilovar-hour
kWh	kilowatt-hour
LTE	Long-Term Evolution
MB	megabyte
MDM	Meter Data Management
MDMS	Meter Data Management System
MHz	Megahertz
NGM	Next Generation Meter
NIC	Network interface card
PG&E	Pacific Gas and Electric Company
PV	Photovoltaic
RF	Radio frequency
SCE	Southern California Edison Company
SD	Secure Digital
SDG&E	San Diego Gas & Electric Company
SmartMeter™ Network Headend	The system that manages and communicates bi-directional operational data with the millions of deployed SmartMeters.
TOU	Time-of-Use
U.S.	United States
V	Volts

1 Executive Summary

This report summarizes the project objectives, technical results, and lessons learned for the EPIC 3.27 Multi-Purpose Meter project as listed in the EPIC Annual Report. The EPIC 3.27 Project is also referred to as the "Next Generation Meter (NGM) EVSE Integration" project.

In support of the State of California's clean energy goals, PG&E can support the transition from fossil fueled vehicles to Electric Vehicles (EV) by incentivizing customers to migrate by providing additional pathways for accessing EV charging-specific electrical rates for their EV charging.

If a separate meter is used to access EV charging-specific rates, the cost of this meter, associated equipment, and installation labor are in total considered to be costly and reduce the value to the customer of accessing these EV charging-specific electric rates. To improve the appeal of EV adoption, a solution that reduces the overall cost of installing Electric Vehicle Supply Equipment (EVSE) with access to the EV charging-specific electric rate is needed.

The primary objective of this project was to demonstrate an EVSE with an integrated utility-grade electric meter. Such an EVSE with an integrated utility-grade meter eliminates several of the labor and equipment costs, as well as complications of potentially inaccurate billing data and unreliable or unavailable network communication associated with installing an EVSE without a utility-grade electric meter.

In addition, the solution needed to be integrated into the existing PG&E SmartMeter communications network, enabling the reliable and timely delivery of billing data into PG&E back-office systems, and enabling a future billing integration.

For such a scenario, the EVSE with an integrated utility-grade electric meter, in addition to its other benefits as described herein, would provide an additional potential demand response control.

Previously in EPIC 2.29, "Mobile Meter Applications", PG&E created and demonstrated the NGM solution. The modular capabilities, accuracy, and size of this NGM solution made it an excellent choice to leverage for this EPIC 3.27 project.

The drivers of this NGM/EVSE integration project were:

- To develop a submeter prototype for EVSE integration in support of the State's transportation electrification goals.
- To provide a safer and more cost-effective means of installing and servicing EVSE metrology.
- To increase metering accuracy to utility grade (0.2%) to provide utility billing-quality information.
- To integrate the meter into PG&E networks and host systems to ensure accurate and robust transmission and reception of billing and operational data.
- To facilitate ongoing EVSE billing integration efforts.
- To add additional value with grid data, outage detection, and multiple redundant communications paths.
- To enable the ability to potentially respond to future demand peaks including from increasing EV charging loads.

The EPIC 3.27 project needed to take the EPIC 2.29 NGM and enhance it by means of:

- Redesigning the NGM Core for full modular capability and ease of replacement.
- Providing both internal ("Integrated") and external ("Retrofit") EVSE integrations.
- Integrating the Network Interface Card (NIC) to provide access to EVSE data via the existing SmartMeter network.
- Utilizing standard American National Standards Institute (ANSI) C12 communication protocols to integrate billing data into the existing PG&E SmartMeter network headend system.
- Supporting and promoting emerging submetering standards.

Key Objectives

To fulfill these goals, this project established the following objectives:

- Design, develop and fabricate prototype EVSEs with integrated NGM units, providing utility grade accuracy for new installations.
- Design, develop and fabricate a combination of NGM Core, High Voltage Board, and Disconnect Switch ("Retrofit Box") to allow adoption and installation of solution for existing deployed EVSE.
- Make the solution modular for simplified, cost effective, and safe servicing.
- Build the solution to ANSI standards.
- Incorporate the data captured into the network head end host system via the ANSI C12.19 and C12.22 protocols, positioning the NGM for integration into PG&E back-end systems and eventual billing.
- Expand the existing NGM communications options (4G/LTE, Wi-Fi, Bluetooth, and GPS) to also utilize the existing PG&E SmartMeter network that currently communicates with over 5.5 million SmartMeters.
- Install and demonstrate the prototypes at PG&E facilities.

Key Takeaways

From the beginning of this project, a key purpose was to demonstrate to the industry and regulator how utility-grade metrology and reliable communications capability could be packaged for integration within an EVSE to provide the consumer benefits in support of California's electrification goals. The demonstration for this purpose was accomplished.

Key Accomplishments

The following summarizes key accomplishments of the project over the project duration:

- Developed and produced 25 NGM/EVSE integration prototypes. 13 units were designed as integrations internal to the selected vendor's EVSE. An additional 12 were Retrofit units designed (specifically developed for the aftermarket) for external integration with any existing Level 2 installed EVSE.
- Demonstrated communication including metrology data with the SmartMeter network headend test system.
- Demonstrated integration of the EVSE meter into residential and commercial EVSEs in partnership with an existing EVSE manufacturer.
- Redesign and establishment of modular "plug and play" capability for metrology and communications.

Challenges and Resolutions

This project faced multiple challenges.

- The development of successful solutions by a global team (United States, Canada, Israel) during the COVID-19 pandemic complicated all stages of the Project. Bans on travel and limits on physical interaction, as well as impacts on personnel and supply chain all presented obstacles to the Project.
- Development of the NGM's ANSI C12.19 table structure simultaneously with the development of the SmartMeter network headend integration software ("NGM plugin") presented challenges in coordination. Interpretation of the ANSI C12.19 standard itself was required to be synchronized with all parties.

Conclusion

The NGM/EVSE solution fulfilled project goals, passed defined tests, and met prototype requirements. These included the integration of the EVSE usage data into the NGM, the SmartMeter network communications NIC to the NGM Core, remote disconnection capability at the submeter service point, the integration of the NGM Core directly into the vendor EVSE, and the creation of the external Retrofit meter product for aftermarket EVSE integration. Both billing and diagnostic data reads from the integrated NGM can now be directly transmitted to the SmartMeter network headend system for further billing integration development.

In August 2022, the Commission released its Decision 22-08-024 "Decision Adopting Plug-In Electric Vehicle Submetering Protocol and Electric Vehicle Supply Equipment Communication Protocols" as part of its Order Instituting Rulemaking (OIR) R18-12-006. This Decision specifies an alternative direction for EV submetering for utility customers. Therefore, PG&E will re-assess its options for the application of the NGM to EVSE submetering. As EV adoption expands and submetering options are selected for EV charging needs, the market for submetering and its nuances will become more apparent. Studying the evolution and maturation of this market will allow PG&E to better understand the rate of customer adoption of submetering for EV charging, the types of customer and business segments that the submetering will primarily serve, adoption gaps, and what segments of the market may need additional technology options.

In the interim, PG&E believes there are considerable use cases to explore where the NGM can add value to customers. These may include alternatives to traditional utility meters, resiliency, or other behind-the-meter assets in alignment with the climate and energy goals of the State of California.

2 Introduction

This report documents the project achievements, highlights key learnings from the project that have industry-wide value, and identifies future opportunities for PG&E to leverage the results of this project.

Pursuant to PG&E's approved 2018-2020 EPIC triennial plan, PG&E initiated, planned, and implemented the following project: 3.27 Multi-Purpose Meter. Through the annual reporting process, PG&E has kept CPUC staff and stakeholder informed on the progress of the project. The following is PG&E's final report on this project.

3 Project Summary

In EPIC 2.29 PG&E created the NGM. This EPIC 3.27 project leveraged the NGM development for utility-grade submetering and communication integrated into an EVSE to provide customers with simplified and more cost-effective access to EV rates. This project had the following deliverables:

- Redesign the NGM Core as a modular solution and design meter housing.
- Establish ANSI C12 table construction and methodology in the NGM itself.
- Develop a NIC to current networking standards and integrate it with the NGM using ANSI C12.18 standards.
- Integrate PG&E SmartMeter Network communications.
- Modify the SmartMeter headend system to accept the NGM's ANSI C12.19 data.
- Integrate the NGM Core metrology and communications into a new EVSE offering from a third-party vendor.
- Design and fabricate a solution external to the EVSE for use in situations where there is an existing EVSE already present.

3.1 Issue Addressed

The project was chartered to develop a solution capable of supporting a simplified pathway for residential customers with EVSEs to access EV charging-specific rates. The intention was to avoid bulky and expensive conventional round meter installations. It was also entrusted with improving safety and ease of maintenance with a redesigned modular solution. In addition, the project worked to drive and align toward other subtractive billing efforts and submetering's emerging standards and goals.

3.2 Project Objectives

To accomplish the objectives for this project, the following key items were developed:

- Redesign to NGM core, including introduction of the NIC, resizing, and layout adjustments to support a "plug and play" approach to installation and replacement by means of a modular solution.
- Designed and developed software in the SmartMeter network headend "NGM plugin" to support the pull and presentation of NGM billing data in a shared interpretation of the standard C12.19 format.
- Created the ANSI C12 coding and data storage structure for the NGM's information containment.
- Developed the external housing for the combination of NGM Core, High Voltage board, and disconnect switch. This assembly is commonly referred to as a "Retrofit Box".
- Integrated existing EVSE products with NGM Core metrology and communications.

- Created and tested prototypes of all solution components, having designed them to meet ANSI and UL standards.
- Tested both the residential and commercial EVSE products with NGM integrations and actual vehicle charging sessions.
- Transferred billing and diagnostic data from the NGM into successful appearances in the SmartMeter network headend system reporting and user interfaces.
- Actively contributed to the formation and application of California submetering initiatives and standards.

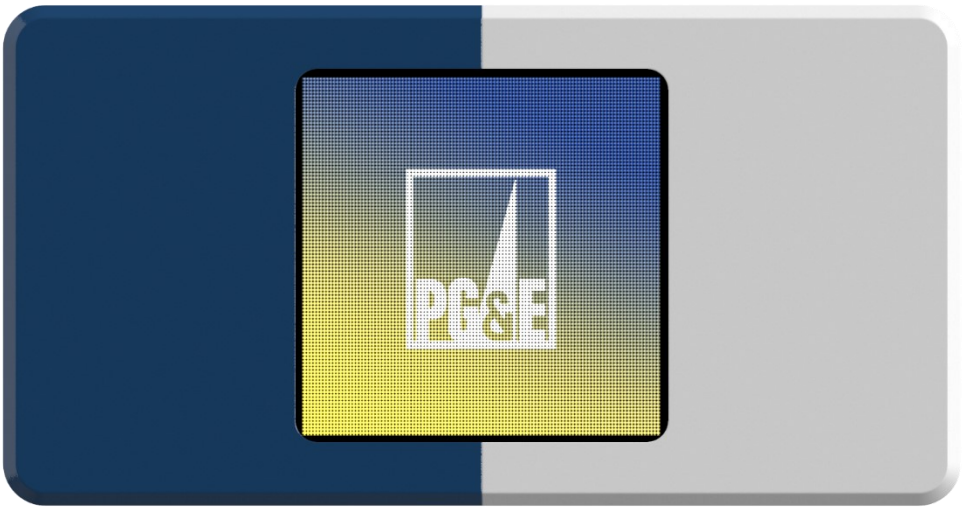


Figure 1. Next Generation Meter Core Visualization

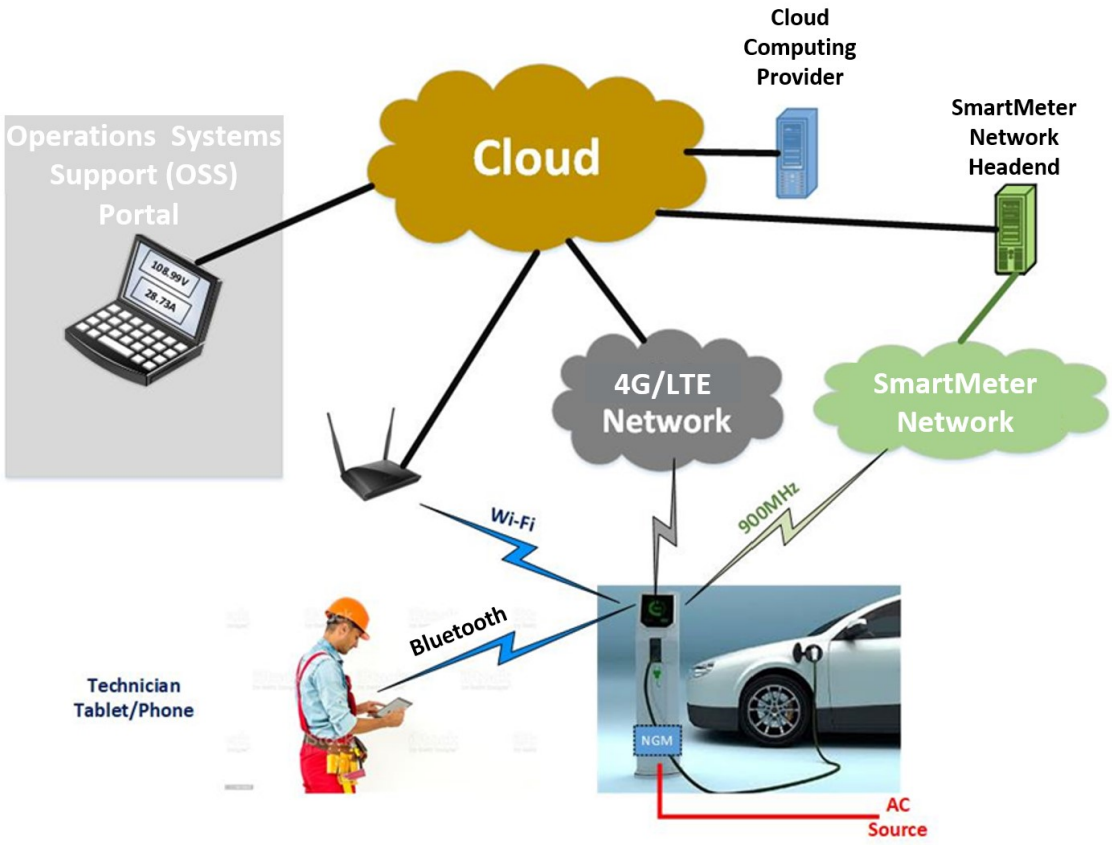


Figure 2. EPIC 3.27 Full Test Environment

3.3 Scope of Work and Project Tasks

The Major Tasks required for the EPIC 3.27 Project were as follows:

- NGM Core Redesign/NIC Integration: Marry the metrology and communications components into a single NGM Core. Take the entire NGM as designed in EPIC 2.29 and redesign the NGM Core for modular ease of installation. Integrate the NIC communication with the NGM via the ANSI C12.18 protocol. Design and deploy a test network isolated from PG&E production (*Figure 2*). Transmit ANSI C12.19 data from the NGM via the NIC into the SmartMeter network headend system.
- NGM C12.19/SmartMeter network headend Integration: Establish shared interpretation of the ANSI C12.19 standard between PG&E and the SmartMeter network headend system. Modify an existing meter type recognized by SmartMeter network headend to serve as a prototype for the integration. Create a SmartMeter network headend plugin interface to interpret the ANSI C12.19 data from the NGM and put it into SmartMeter network headend's reporting and data retention systems. Validate accurate billing and diagnostic meter data is accessible via the SmartMeter network headend user interface and reporting functions.
- NGM/EVSE Internal Integration: Physically incorporate the NGM Core (without its external packaging) into 3rd party EVSE products. Utilize the NGM's metrological component for the EVSE itself instead of the one native to the EVSE due to its increased accuracy. Present both

Residential and Commercial EVSE solutions. Validate continued NGM communications in multiple modes.

- NGM/EVSE External Integration ("Retrofit"): Design and fabricate a solution for NGM installation outside the EVSE (for existing installed EVSEs as a Retrofit). Physically incorporate the NGM Core into the Retrofit Box. Connect and monitor a general market leading EVSE via the NGM in the Retrofit Box. Validate continued NGM communications in multiple modes.

3.3.1 Tasks and Milestones

- Establish test environments in Israel, Canada and Fremont, California, VPN connectivity between them, and Network configuration for the NGM test network. (*Figure 3*)
- Establish requirements, redesign, and fabricate prototypes for the NGM Core for size reduction and NIC integration.
- Establish C12 table construction and methodology in the NGM.
- Connect the ANSI C12.18 protocol connections internal to the core between the NIC and the NGM.
- Modify the SmartMeter network headend system to accept the NGM's ANSI C12.19 data as transferred by the NIC. Achieve this by the modification of an existing meter type in the NIC for ease of prototype development within scope of project.
- Integrate the NGM Core metrology and communications into a new EVSE offering from a third-party vendor.
- Design and fabricate a solution external to the EVSE for use in existing installed EVSE situations.
- Test solutions in the Lab and a PG&E "meter farm" location in Fremont, California.
- Observe confirmed and validated data appearing in both the SmartMeter network headend system user interface and the EVSE vendor headend application.

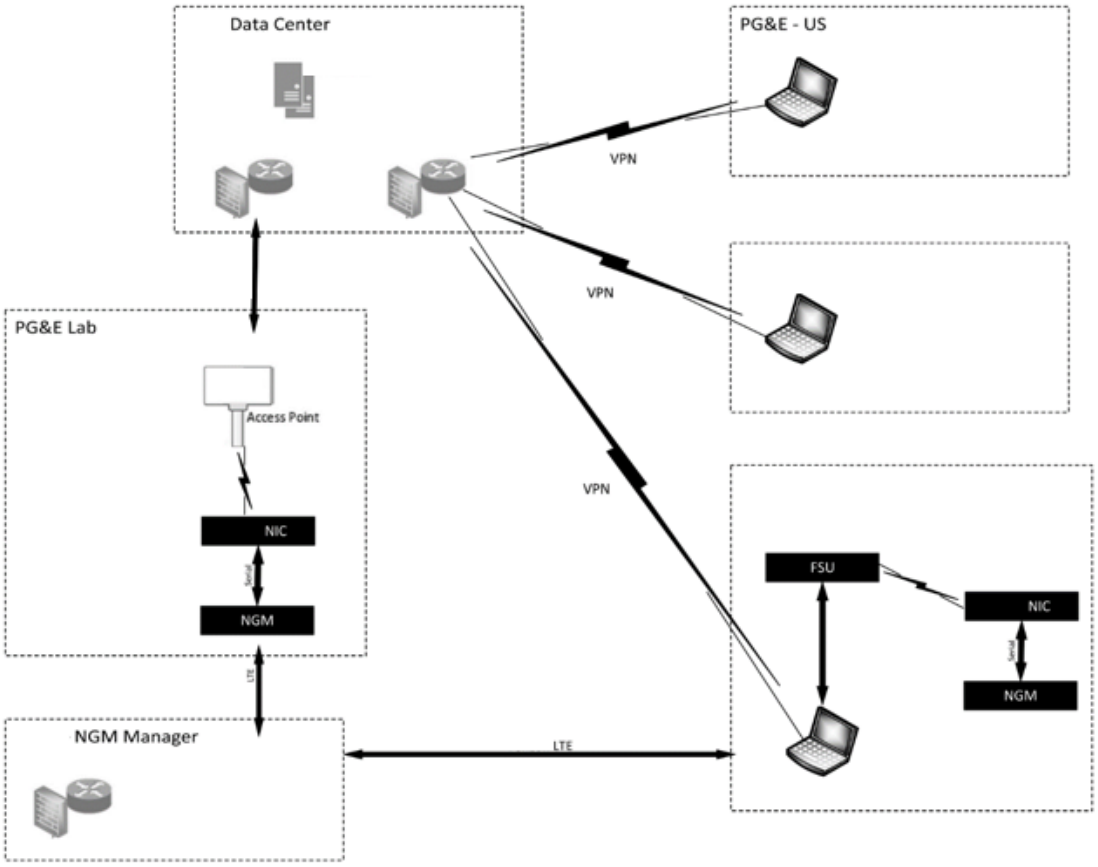


Figure 3. EPIC 3.27 NGM Test Network

4 Project Activities, Results, and Findings

4.1 Technical results and findings–NGM Core Redesign/NIC Integration

4.1.1 Technical Development and Methods

NGM Core activity for EPIC 3.27 was a combined effort of design, development, execution, and testing among three parties: PG&E, a product design firm, and a vendor for engineering and fabrication functions. Enhanced packaging was developed to make the NGM Core an easily replaceable module, as well as separating low voltage (metering and communications) from the high voltage components. This enables flexible applications while maintaining core design.

Testing included verification that the NGM functionality, performance, and accuracy as it existed in EPIC 2.29 (when the NGM was initially developed) was maintained. This insured that the redesign of the NGM Core and the addition of SmartMeter network communications functionality had no deleterious effects on the meter's performance and access to its billing and diagnostic information.

A display was also added to the NGM Core to present billing and operational data in the Retrofit installation mode. The LCD display shows energy consumption & export (kWh), power (kW), voltage (V), and current (A).

ANSI C12.18 Device capabilities were added to the NGM with the NGM communicating with the NIC. The NIC is based on the communications vendor's System on Chip (SoC) platform as configured for energy meters and other host devices in Smart Energy Networks (SEN). This interface card communicates with the NGM-C12 using a 3-wire UART (serial port) implementing the ANSI C12.18 protocol. General-Purpose Input/Output (GPIO) ports are used to sense and control the NIC *(Figure 5).*

The revised NGM-C12 system interface conforms to the ANSI C12 specification, acting as a C12.18 Device. The supplied ANSI C12.18 API/Stack is proven to communicate with a multitude of ANSI C12.18 meters and embedded communication modules.

The NGM Core communicates using 4G/LTE, Wi-Fi, and the 900 MHz SmartMeter network. 4G/LTE and Wi-Fi communicate with the reporting and diagnostic applications located in a commercial cloud computing system. The NIC communicates with Access Points (APs) via the SmartMeter network and then on to PG&E or vendor servers. It then populates data in the SmartMeter network headend system. The NGM also communicates by Bluetooth with the handheld maintenance terminal used by PG&E technicians.

The NGM can communicate by Wi-Fi for maintenance and development, and through registered Wi-Fi networks to the Internet and a commercial cloud computing system. 4G/LTE also allows communications with a commercial cloud computing system.

The NGM supports both a single backbone connection (sharing over the NGM/EVSE interface protocol, as part of the EVSE-NGM protocol) or Cellular modems in parallel. The communication content over the 900 MHz network is limited to the billing data that was implemented as part of the EPIC 3.27 NGM-NIC5 Integration project.

The NGM Core's mechanical enclosure is based on a durable and high-quality material and takes the shape of as small a form factor as possible.

The NGM mechanical design was done in collaboration with an external design company (under PG&E's oversight and responsibility).

Setting external dimensions, industrial design, connector selection, safety and electrical constraints was done in cooperation with a communications engineering company.

Figure 4. NGM Core Visualization

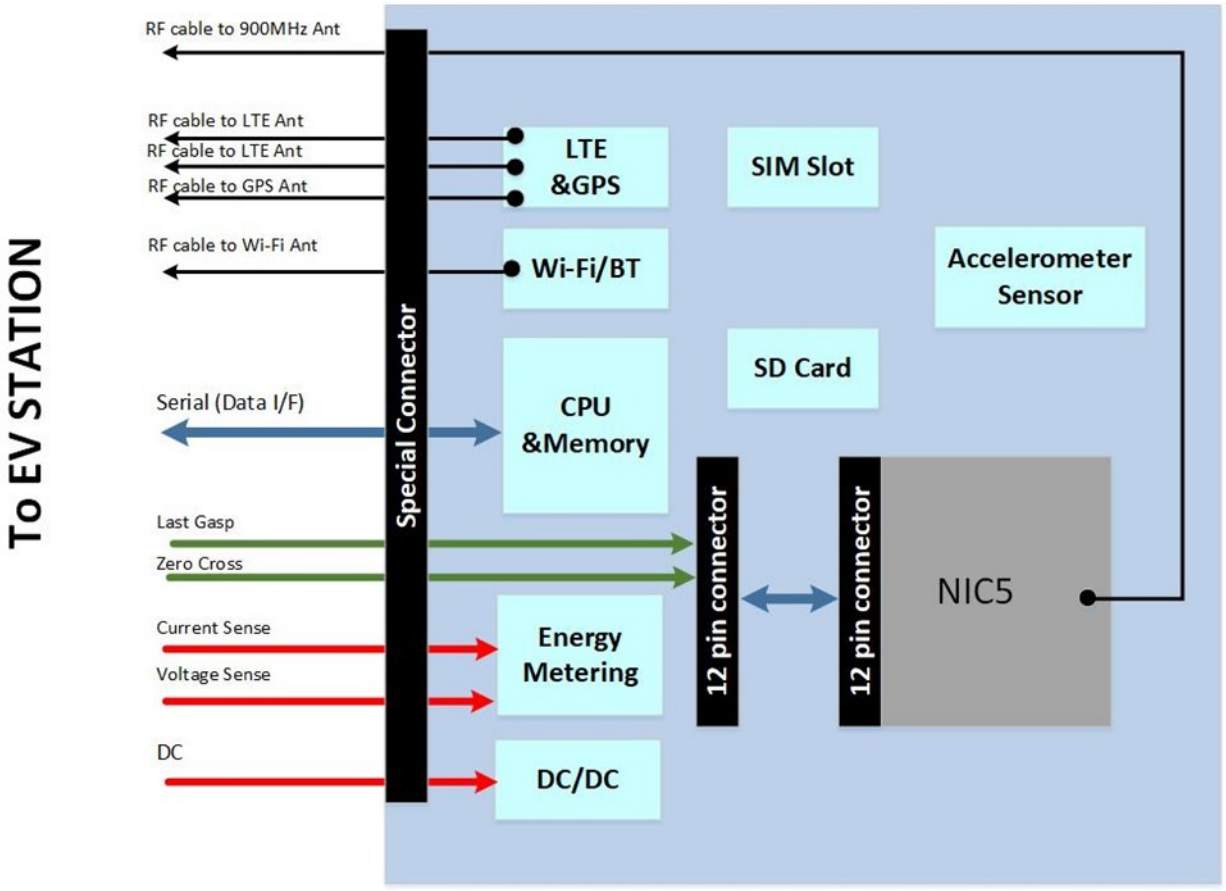


Figure 5. NGM Core High Level Block Diagram

The new NGM Core contains the following blocks *(Figure 5*):

- CPU + memories
- Wi-Fi/Bluetooth modem
- GPS Receiver
- 4G/LTE modem
- SIM Card slot
- SD Card slot
- Single Phase Energy Meter
- Accelerometer
- NIC daughter board
- On board DC/DC converter
- EVSE connector

Design components meet temperature range: -40 to +85C (industrial grade), except the CPU core (-35 to +85C)

The New NGM is designed to meet the following Safety standards:

- UL61010-1
- UL60950-1
- UL 94
- UL 508
- UL 2735

The NGM is designed to meet the following EMC standards: FCC Part 15 subpart B, class B.

The NGM is designed to meet the following radio standards: FCC Part 15.

For technician debugging the NGM includes a Wi-Fi/Bluetooth modem.

The Project life cycle included the following tasks:

- Create the System Requirements document, which guides the project design.
- Create the System HW and SW Specifications documents.
- Components selection
- Board Schematic design
- Mechanical design
- Heat dissipations simulation
- SW architecture design
- SW development
- Board layout
- PCB production
- PCB Assembly
- Board verification
- Mechanical production
- Mechanical verifications
- SW verifications
- System validation (PCBA + Mechanical +SW +Antennas)

The result is a validated NGM Core.

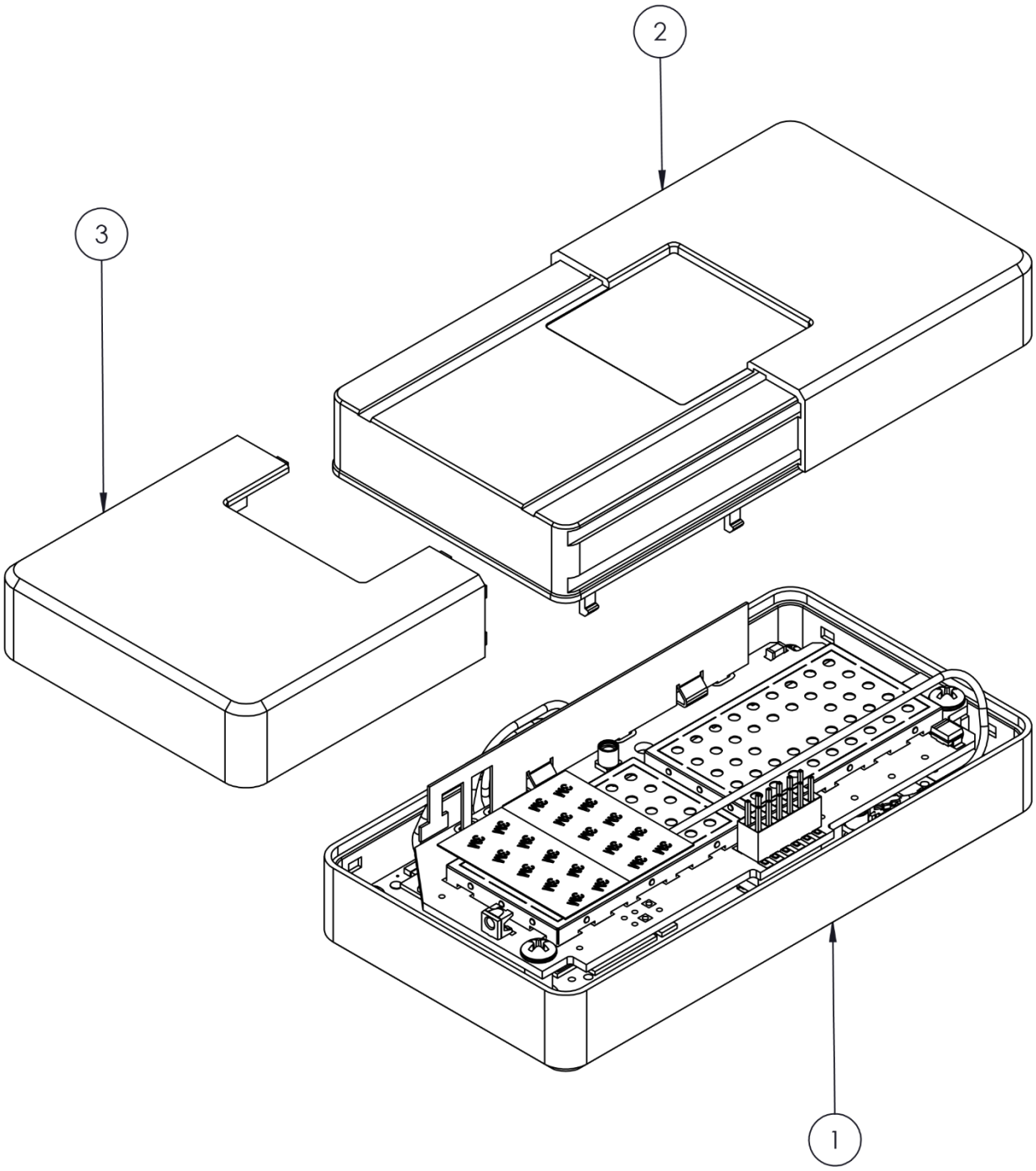


Figure 6. NGM Core Schematic

4.1.2 Challenges

Managing and coordinating the efforts of a global cross-functional team is a challenge under normal conditions. These conditions were exacerbated under the COVID-19 pandemic impacting the cooperative work of a worldwide team (United States, Canada, Israel). Delays in material supply and staff availability were substantial and forced redesign in certain test conditions when original

components were not immediately available. Different standards in different countries (SIM configuration, RF standards) required additional design and corrective activities. Global shipment difficulties in transporting fabricated units also directly impacted the project.

Designing the NGM involved the following challenges:

- To design the system to be small enough to fit the required pre-defined size.
- To design a system that is low power.
- To overcome potential heat dissipation issues internally and externally to meet the appropriate temperature range.
- To design RF interfaces that enable external antenna use (such as 4G/LTE and GPS) while keeping the NGM Core a plug and play unit.
- To design the internal cabling while maintaining fidelity.
- To design the removable NGM Core so that the user experience remains consistent and intuitive regardless of the specific application utilizing it.
- To design external interface to EVSE although there is no standard in the market.
- To design a display that has good visibility while keeping low power consumption.

Figure 7. NGM Core - Internal View

4.1.3 Results and Observations

A dramatically redesigned NGM core met all requirements. Reduced component size, enhanced communications capabilities including with the SmartMeter network, and plug-and-play replacement capability all operated as outlined in the System Requirements document. The NGM Core with cover can be used in an after-market external integration solution (“Retrofit”), while without the NGM Core cover a successful redesign allows for internal integration with newly manufactured EVSEs. The NGM Core is

small and compact, and its modular design allows the reuse of the NGM Core in multiple and future use cases. This required ample design exploration and considerations (Current and future applications, budget/costs, materials).

Figure 8. NGM Core - Final Visualization

Figure 9. EPIC 3.27 NGM Core

4.2 Technical results and findings–NGM C12.19/SmartMeter Network Headend Integration

4.2.1 Technical Development and Methods

NGM network integration activity for EPIC 3.27 was a combined effort of Design, Development, Execution and Testing between 3 parties–PG&E, the network and host system provider, and a development firm for NGM coding and testing. Testing included creation and verification of the ability for the NGM to successfully integrate the NIC hardware, populate and maintain billing and operational information in C12.19 tables, and to effectively communicate that data over the PG&E SmartMeter 900 MHz wireless network to the receiving host system (SmartMeter network headend) in order to prepare the NGM for the integration of EV usage information into PG&E billing systems in a subsequent project.

The Project life cycle included the following tasks:

- Creating the System Requirements document, which guides the project design.
- Creating the System SW Specifications documents.
- SW architecture design.
- Discussions, workshops, and documentation exchange with the SmartMeter network headend team and subcontractor to understand the required interfaces and the content format.
- SW and FW development.

- SW and FW verifications.
- SW and FW validation.

Challenges

There were significant challenges in this aspect of the project. The agreement with the communications vendor for a successful prototype limited the scope of possible integrations. There was no modification of the NIC communications module firmware scoped within the project. Therefore, for the purposes of prototype, instead of a meter type specific to the NGM, another preexisting meter type was adapted as a special effort separate from standard SmartMeter network headend integration activities.

Since this limited the development to solely prototype status, a further formal SmartMeter network headend standardization project would be required on the path to production. For the prototype, a customized interface coding plugin was supplied by a 3rd party subcontractor to the communications vendor. This required additional management and planning and complicated the development effort by requiring additional global coordination with India and Canada in addition to Israel.

NIC availability was also a major issue. Due to pandemic-related material shortages, the delivery of NICs was delayed by six months, forcing PG&E to secure additional NICs of slightly different design by alternative means to best maintain the development schedule.

4.2.2 Results and Observations

The outcome was a successful integration of the NGM with the PG&E SmartMeter network and SmartMeter network headend host system, allowing all available metering and billing information to flow from the NGM though the NIC and into the SmartMeter network headend data repository via ANSI C12 protocols. The integration is performing as expected.

This positions the NGM to be monitored and read remotely via the PG&E standard meter network as well as bringing billing information into a common PG&E data integration system for observation, utilization, and management.

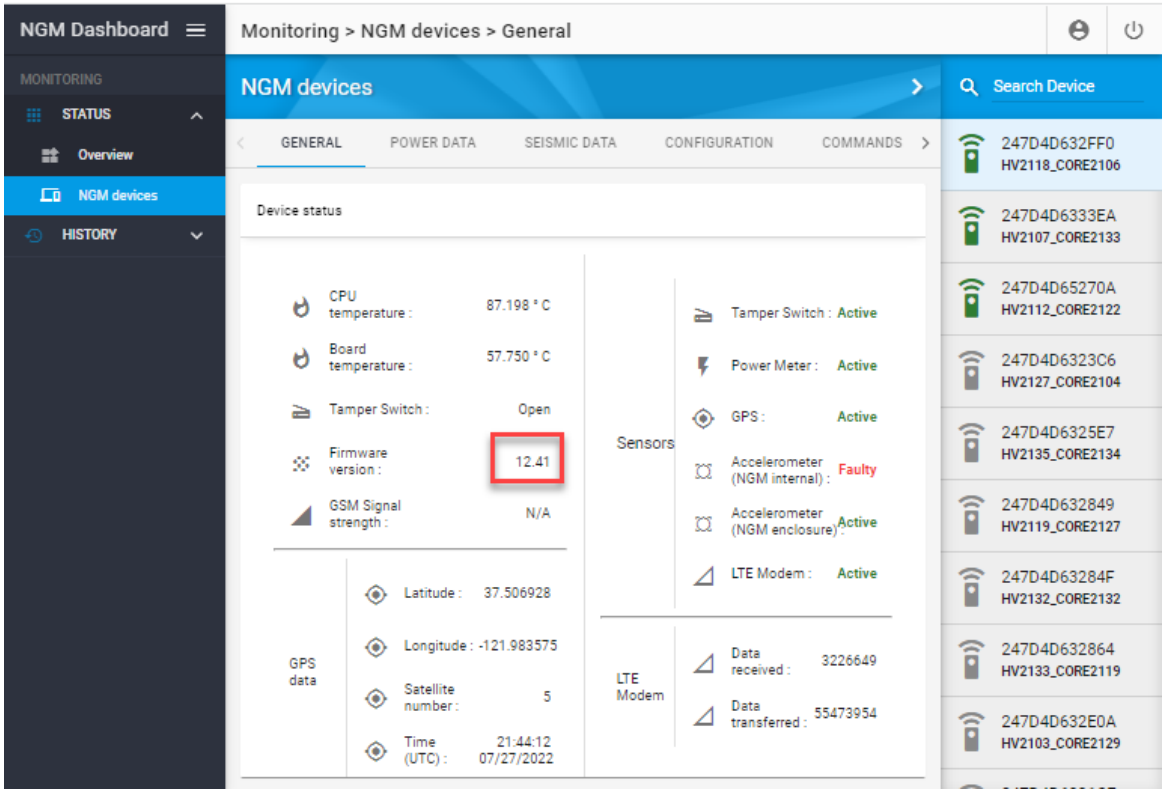


Figure 10. EVSE Vendor Host System NGM Interface

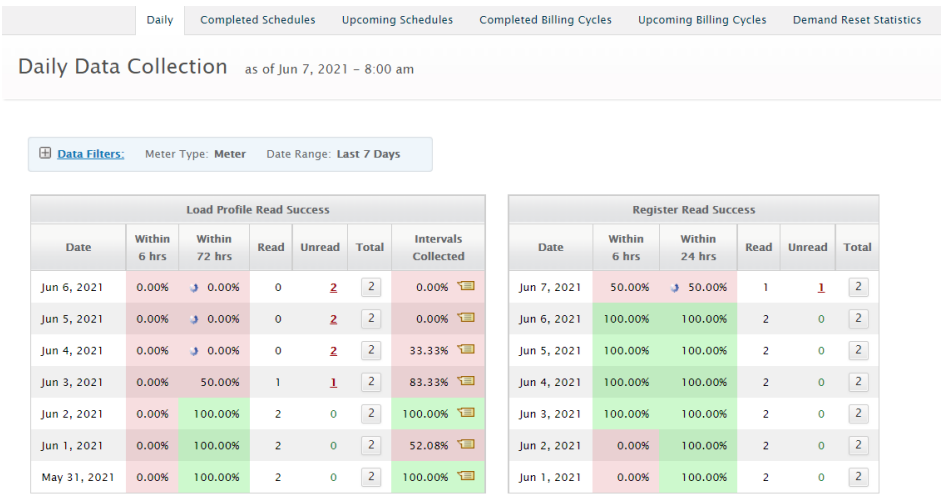


Figure 11. SmartMeter Network Headend System Report

4.3 Technical results and findings–NGM/EVSE Internal Integration

4.3.1 Technical Development and Methods

NGM Core/EVSE integration activity for EPIC 3.27 was a combined effort of Design, Development, Execution and Testing between PG&E and the EVSE vendor and subcontractor who supplied the EVSEs and supported the integration effort with their EVSE data host system application. Testing included creation, fabrication, and verification of the ability for the EVSE to have successfully internally integrated the NGM hardware, and the communication of charging transaction session information into the EVSE host system as well as providing the EVSE usage and communicating the associated billing data upstream into the SmartMeter network headend.

Figure 12. Commercial and Residential EVSEs

Figure 13. NGM Core used in EVSE Integration

The EVSE–NGM Connector supports the following interfaces:

1. High voltage pins which require large physical separation between the pins (safety requirements)
    - Single phase current sensing
    - DC input to power the meter chip
2. Low voltage pins
    - EV interface
    - DC inputs
    - Last gasp signal
    - Zero crossing signal
3. Antennas cable connectors, including
    - 4G/LTEx2 (MIMO)
    - GPS
    - Wi-Fi/Bluetooth
    - SmartMeter network (900MHz)

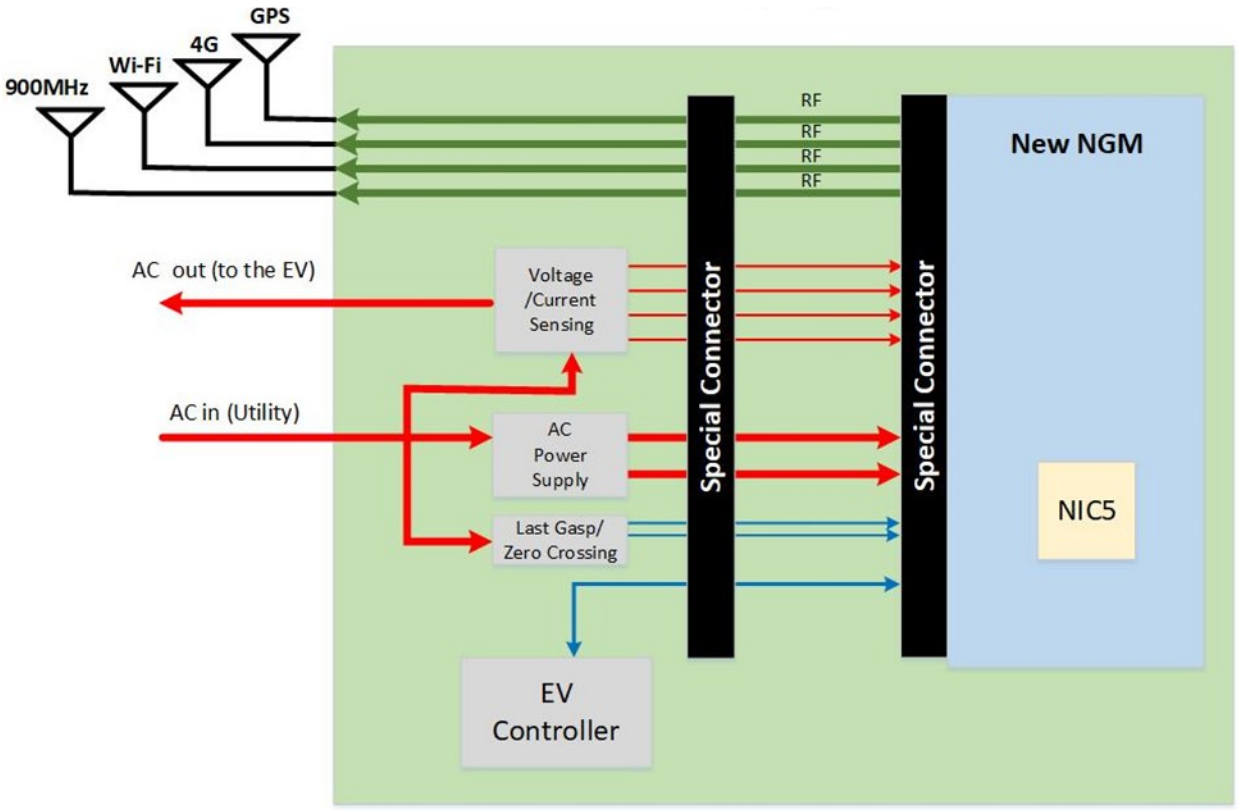


Figure 14. NGM/EVSE Block Diagram

The project life cycle included the following tasks:

- Creating the System Requirements document, which is input to the project design.
- Selection of the EVSE partner
- System HW and SW Specifications documents
- Components selection
- Board Schematic design
- Mechanical design
- SW architecture design
- SW development
- Board layout
- PCB production
- PCB Assembly
- Board verification
- Mechanical production
- Mechanical verifications
- SW verifications
- System validation (PCBA + Mechanical +SW +Antennas)

The result is the integration of the NGM Core into the vendor's EVSE.

4.3.2 Challenges

There was a technical challenge in the physical integration of the NGM hardware as the uncovered core did not readily fit within the confines of the EVSE vendor's Commercial and Residential EVSEs. The solution was to create an extender ring which provided additional spacing adequate for the space requirements of an uncased NGM Core and the additional NGM components.

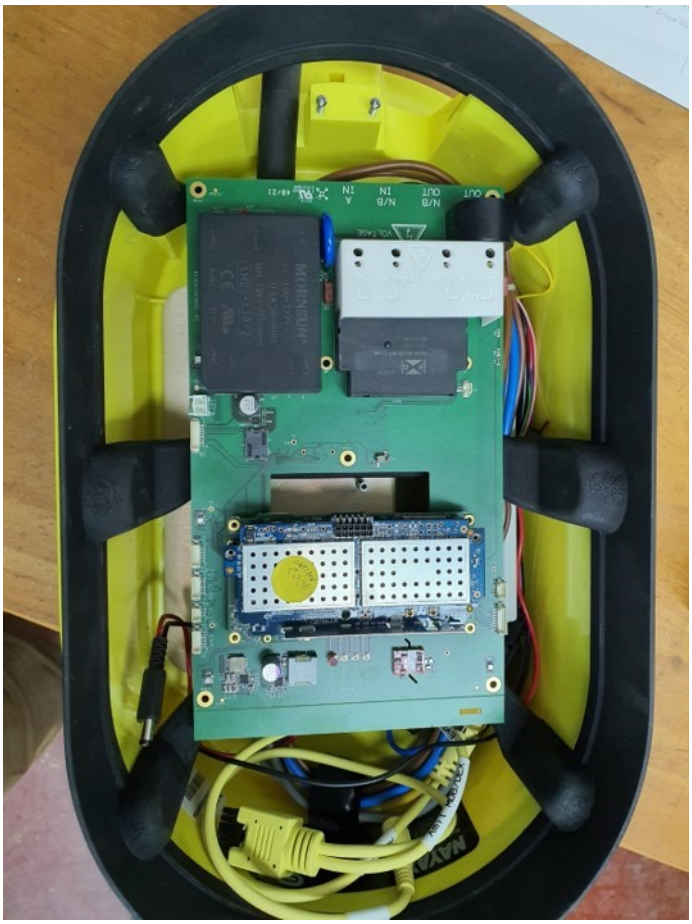


Figure 15. EVSE with NGM Core Installed

Other challenges to the Project included:

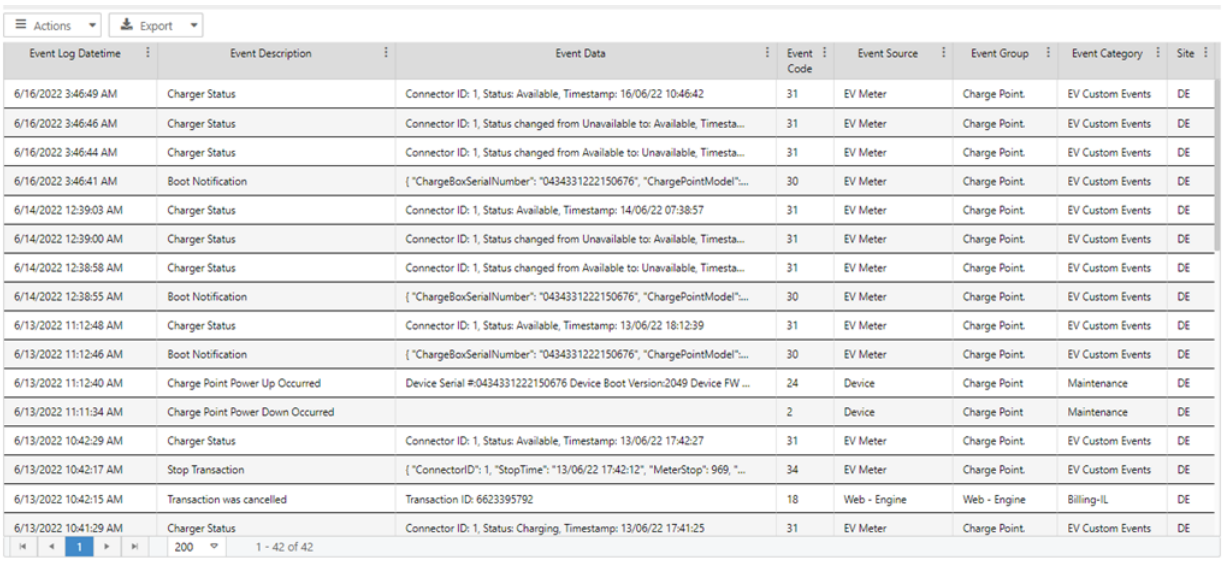
- Reaching agreement on the interface between NGM and the EVSE controller, both the physical layer and the protocol.
- An additional high-level challenge was to identify an EVSE vendor that agreed to work with PG&E on the NGM integration at this project stage without any advance commercial purchasing commitments.

4.3.3 Results and Observations

The outcome of the project is that there was a successfully integration with a vendor's EVSE to implement the integrated NGM/EVSE solution for both the residential and the public EVSE units. Both versions match the project as detailed in the System Requirements document.

This concept can be duplicated with other EVSE vendors, who would match the NGM Core to their own EVSE solutions.

Figure 16. Commercial EVSE Install - Fremont Meter Farm



Actions | Export

Event Log Datetime	Event Description	Event Data	Event Code	Event Source	Event Group	Event Category	Site
6/16/2022 3:46:49 AM	Charger Status	Connector ID: 1, Status: Available, Timestamp: 16/06/22 10:46:42	31	EV Meter	Charge Point.	EV Custom Events	DE
6/16/2022 3:46:46 AM	Charger Status	Connector ID: 1, Status changed from Unavailable to: Available, Timesta...	31	EV Meter	Charge Point.	EV Custom Events	DE
6/16/2022 3:46:44 AM	Charger Status	Connector ID: 1, Status changed from Available to: Unavailable, Timesta...	31	EV Meter	Charge Point.	EV Custom Events	DE
6/16/2022 3:46:41 AM	Boot Notification	{ "ChargeBoxSerialNumber": "0434331222150676", "ChargePointModel":...	30	EV Meter	Charge Point.	EV Custom Events	DE
6/14/2022 12:39:03 AM	Charger Status	Connector ID: 1, Status: Available, Timestamp: 14/06/22 07:38:57	31	EV Meter	Charge Point.	EV Custom Events	DE
6/14/2022 12:39:00 AM	Charger Status	Connector ID: 1, Status changed from Unavailable to: Available, Timesta...	31	EV Meter	Charge Point.	EV Custom Events	DE
6/14/2022 12:38:58 AM	Charger Status	Connector ID: 1, Status changed from Available to: Unavailable, Timesta...	31	EV Meter	Charge Point.	EV Custom Events	DE
6/14/2022 12:38:55 AM	Boot Notification	{ "ChargeBoxSerialNumber": "0434331222150676", "ChargePointModel":...	30	EV Meter	Charge Point.	EV Custom Events	DE
6/13/2022 11:12:48 AM	Charger Status	Connector ID: 1, Status: Available, Timestamp: 13/06/22 18:12:39	31	EV Meter	Charge Point.	EV Custom Events	DE
6/13/2022 11:12:46 AM	Boot Notification	{ "ChargeBoxSerialNumber": "0434331222150676", "ChargePointModel":...	30	EV Meter	Charge Point.	EV Custom Events	DE
6/13/2022 11:12:40 AM	Charge Point Power Up Occurred	Device Serial #:0434331222150676 Device Boot Version:2049 Device FW ...	24	Device	Charge Point	Maintenance	DE
6/13/2022 11:11:34 AM	Charge Point Power Down Occurred		2	Device	Charge Point	Maintenance	DE
6/13/2022 10:42:29 AM	Charger Status	Connector ID: 1, Status: Available, Timestamp: 13/06/22 17:42:27	31	EV Meter	Charge Point.	EV Custom Events	DE
6/13/2022 10:42:17 AM	Stop Transaction	{ "ConnectorID": 1, "StopTime": "13/06/22 17:42:12", "MeterStop": 969, "...	34	EV Meter	Charge Point.	EV Custom Events	DE
6/13/2022 10:42:15 AM	Transaction was cancelled	Transaction ID: 6623395792	18	Web - Engine	Web - Engine	Billing-IL	DE
6/13/2022 10:41:29 AM	Charger Status	Connector ID: 1, Status: Charging, Timestamp: 13/06/22 17:41:25	31	EV Meter	Charge Point.	EV Custom Events	DE

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Figure 17. Vendor EVSE Application Host System

4.4 Technical results and findings–NGM/EVSE External Integration ("Retrofit")

4.4.1 Technical Development and Methods

NGM External Integration to an EVSE (Retrofit Box) activity for EPIC 3.27 was a combined effort of design, development, execution, and testing between three parties: PG&E, a design firm, and a vendor for electrical engineering and fabrication. Testing included verification of the form, fit, and function of the Retrofit Box as well as verification that all operation processes performed as expected in allowing the NGM to monitor, meter, and communicate EVSE usage activity. In addition, the product needed to have an appropriate look and operational feel as its primary implementation is expected to be installation within residential garages with existing EVSEs.

The New NGM is able to meter an existing EVSE, as an external box (self-contained meter box: Voltage/current sensing, power supply and disconnect switch are inside the box) that is attached using wires to the EVSE. The disconnect function can serve the utility and larger community by providing an additional load management control.

The External box is a Retrofit solution for existing EVSEs and includes the following components:

- New NGM installed on the new I/F mating connectors
- Remote disconnect switch
- Current and voltage sensors (which will be located as close as possible to the interface connector)
- 1 Phase AC: 120V (1H), 120/208V (2H), 120/240V (2H) to DC
- Last Gasp and Zero crossing circuits
- Super capacitors–capacity TBD
- New NGM Antennas
- AC IN and out terminals (to be specified by PG&E)

PG&E approved the external box mechanical 3D design.

The Retrofit Box AC input is single phase.

The Retrofit Box shall be installed before the AC input to the EVSE.

The Retrofit Box shall have to support cable between the Retrofit AC output and the EVSE AC input connection. This cable loss shall be considered during calibration procedures.

For the Retrofit Box, the NGM can measure up to 60A of EV charging current plus the EVSE's own power consumption.

The current and voltage sensors as well as the disconnect switch support the 60A of the EV charging plus the EVSE's power consumption.

The NGM firmware accounts for the EVSE's power consumption when calculating net EV charging energy provided.

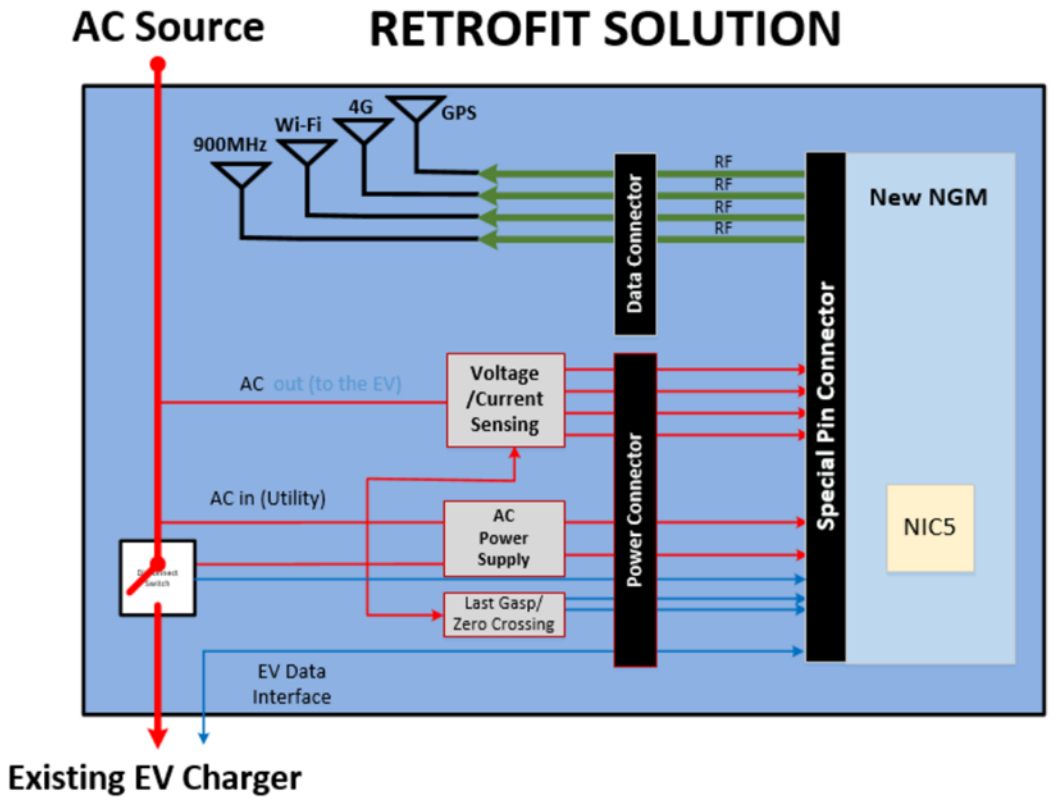

Figure 18. Retrofit Box - Block Diagram

The Project life cycle included the following tasks:

- System Requirements document details, which are the inputs to the project design.
- System HW and SW Specifications documents.
- Components selection.
- Board Schematic design.
- Mechanical design.
- Heat dissipations simulation.
- SW architecture design.

- SW development.
- Board layout.
- PCB production.
- PCB Assembly.
- Board verification.
- Mechanical production.
- Mechanical verifications.
- SW verifications.
- System validation (PCBA + Mechanical +SW +Antennas).

The result is the Retrofit Box prototype as defined in the System Requirements document.

4.4.2 Challenges

Challenges included the need to design an appealing package for residential use, the design of an isolated high voltage board, external EVSE connectivity, and the presence of a disconnect switch to cut power remotely as may be needed for future applications. For the purposes of the prototype, visibility into the internal placement of the NGM Core and its display was also required.

Designing the Retrofit involved the following challenges:

To design the system to be small enough to fit the required pre-defined size.
To design a system that is low power.
To overcome potential heat dissipation issues and to meet the temperature range.
To explore key considerations of eventual NEMA 3R testing requirements.

4.4.3 Results and Observations

The outcome of the Retrofit box sub-project matches the project System Requirements document. The solution is aesthetically pleasing as well as functional, plus it provides data visibility via the display as designed.

The Retrofit box has been 3D printed in its prototype form and will need the materials and fabrication process modifications to achieve NEMA 3 Standard compliance for production.

The Retrofit box can be used with existing Level 2 EVSEs. The Retrofit Box resides before the EVSE and thus does not require any interior modification of the EVSE itself.

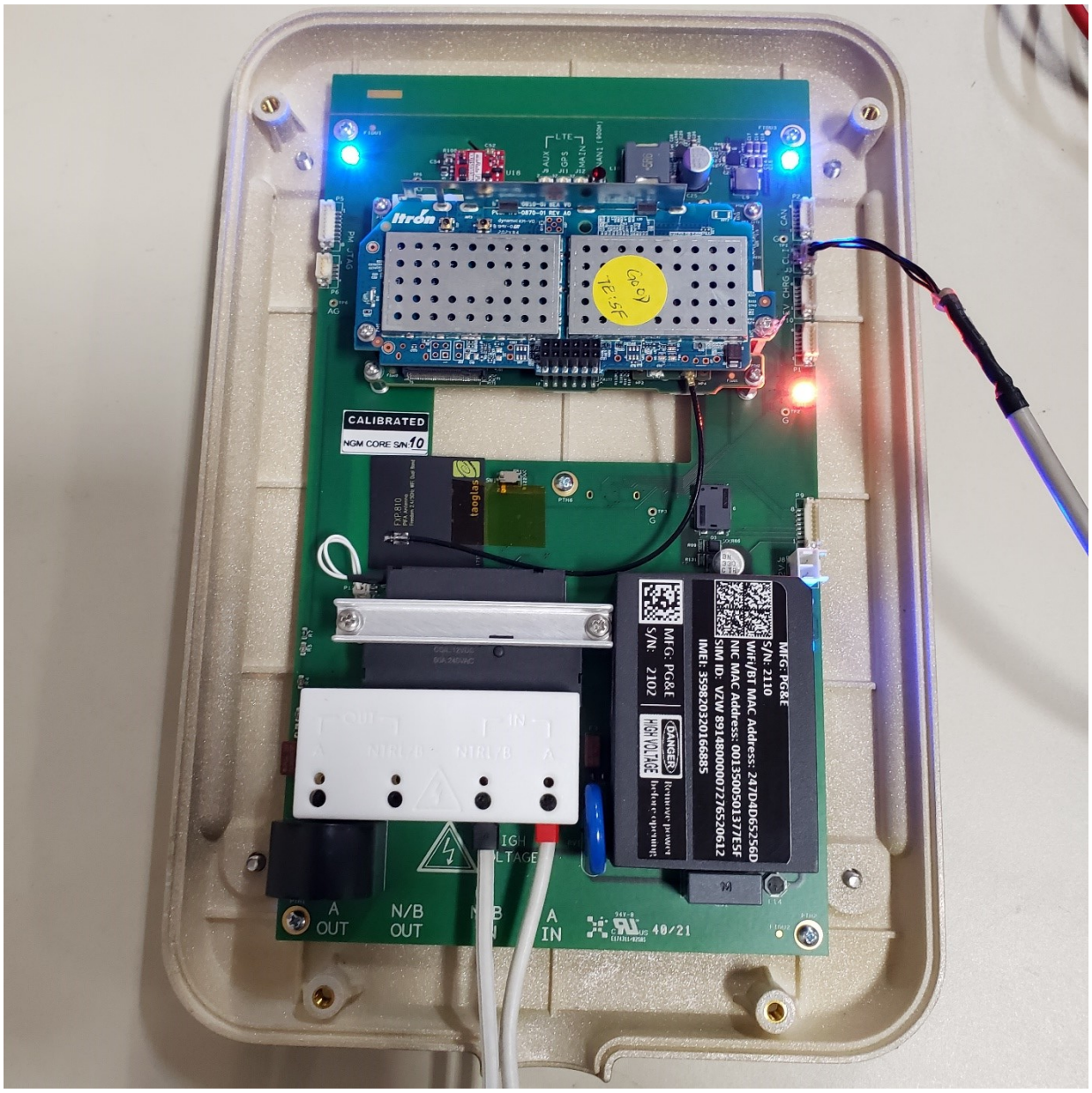

Figure 19. Retrofit Box Internals

Figure 20. EPIC 3.27 Retrofit Box

5 Value proposition

The purpose of EPIC funding is to support investments in technology demonstration and deployment projects that benefit the electricity customers of PG&E, San Diego Gas and Electric (SDG&E), and Southern California Edison (SCE). This project has demonstrated that a utility-grade meter and utility-

grade communications can be successfully integrated into existing EVSE to enable simplified, safe, and cost-effective access to EV charging-specific electric rates.

5.1 Primary Principles

The primary principles of the EPIC program, as clarified by D.12-05-037, are to invest in technologies and approaches that provide electricity ratepayer benefits, defined as promoting greater reliability, lower costs, and increased safety. This EPIC project contributes to these primary principles in the following ways:

- Greater reliability: The NGM supplies higher utility-grade metrology data than standard EVSE metrology. In addition, it provides for the collection and the transmission of additional data (temperature, power quality, etc.) not currently available in the metering of EVSEs. The non-integrated Retrofit Box solution also contains a load disconnect switch which provides future options for load management control.
- Lower costs: Allows for plug-and-play communications and metrology module replacement, resulting in simplified maintenance and expedited technical service.
- Increased safety: The separation of high and low voltage components enables the NGM Core to be incorporated into EVSEs for easy and safe installation without exposure to high voltage hazards.

5.2 Secondary Principles

EPIC also has a set of complementary secondary principles. This EPIC project contributes to the following three secondary principles: societal benefits, greenhouse gas (GHG) emissions reduction, the loading order, low-emission vehicles/transmission, economic development, and efficient use of ratepayer funds.

Societal benefits: The NGM integration allows the customer incentive to increase EV adoption and as a result provides additional societal value by improving the environment, expediting service calls, and enabling development of a unified customer billing experience.

GHG emissions reduction: The increase of EV adoption in California will reduce greenhouse gas emissions by promoting the migration from traditional fossil fuel vehicles to EVs.

Low-emission vehicles/transmission: The increase of EV adoption in California will promote the migration from traditional fossil fuel vehicles to EVs.

Efficient use of ratepayer funds: The costs required to develop the NGM/EVSE integration are easily offset by a tiny fraction of the potential savings in lower EV charging-specific electric billing rates.

5.3 Key Accomplishments

The following summarizes key accomplishments of the project over its duration:

Accomplishments include:

- Developed and produced 25 prototypes of NGM EV Integration. 13 units were designed as integrations internal to the selected vendor's EVSE. An additional 12 were Retrofit units designed for external integration with any existing Level 2 installed EVSE.

- Integrated the NIC with the NGM Core to enable SmartMeter network communications. This complements the existing cellular, Wi-Fi, Bluetooth, and GPS communication options.
- Developed software and firmware to ANSI C12 data storage and communication standards.
- Integrated NGM metrology data into the EVSE Customer Application.
- Integrated meter information, including billing data, into the PG&E SmartMeter network headend test system.
- Demonstrated integration of the EVSE meter into residential and commercial EVSEs in partnership with an existing EVSE manufacturer.
- Redesigned and established modular “plug and play” capability for metrology and communications.
- Performed all the above with a cohesive and focused global team of management, technical, and support personnel.

Figure 21. Integrated and Retrofit NGM EVSE Installs - Fremont Meter Farm

Figure 22. Commercial Integrated NGM EVSE - San Ramon ATS

Figure 23. Retrofit Installation–ATS in San Ramon

Figure 24. Retrofit Box Install

5.4 Key Recommendations

As EV adoption expands and the submetering option is selected for EV charging needs, the market for submetering products and services, and nuances thereof, will become more apparent. The key recommendation is for PG&E to continue studying the evolution and maturation of this market to enable a better understanding of the rate of submetering adoption for EV charging, the types of customer and business segments that submetering will primarily serve, adoption gaps, and what segments of the market may need additional technology options. This will enable PG&E to re-assess and continue to evaluate the path-to-production options for the NGM related to EV charging use cases as prototyped and demonstrated through this EPIC 3.27 project. This continued assessment of the development of the submetering market will help inform future direction of product development and better understand segments of the market where it will help close adoption gaps and provide additional technology options for customers.

In the interim, PG&E believes there are considerable use cases to explore where the NGM can add value to customers. These may include alternatives to traditional utility meters for home metering, resiliency, or other behind-the-meter assets in alignment with the climate and energy goals of the State of California.

5.5 Technology transfer plan

5.5.1 IOU's technology transfer plans

A primary benefit of the EPIC program is the technology and knowledge sharing that occurs both internally within PG&E, and across the other IOUs, the CEC, and the industry. In order to facilitate this knowledge sharing, PG&E will share the results of this project on its public web site (www.pge.com/epic), the public EPIC Database (www.epicpartnership.org), and in public workshops as applicable.

5.5.2 Adaptability to other Utilities and Industry

The following findings of this project are relevant and adaptable to other utilities and the industry:

The NGM technology and integration strategy utilize the ANSI C12 standards on communication, and as such are portable to different utility environments. The multiple forms of communication employed (SmartMeter network, Wi-Fi, Bluetooth, and 4G/LTE) allow different channels for the integration of data from such diverse points as the SmartMeter network headend system (also utilized by SCE and SDG&E) and a commercial cloud computing system. The NGM solution itself is under patent submission and can be independently licensed to other utilities.

5.6 Data Access

Upon request, PG&E will provide access to data collected that is consistent with the CPUC's data access requirements for EPIC data and results.

6 Conclusion

The NGM/EVSE solution fulfilled project goals, passed defined tests, and met prototype requirements. These included the integration of the EVSE usage data into the NGM, the SmartMeter network communications NIC to the NGM Core, remote disconnection at the submeter service point, the integration of the NGM Core directly into the vendor EVSE, and the creation of the external Retrofit meter product for aftermarket EVSE integration. Both billing and diagnostic data reads from the integrated NGM can now be directly transmitted to the SmartMeter network headend system for further billing integration development.

The NGM/EVSE solution supports the State of California's drive toward mass adoption of EVs. It addresses both the need for simplified access to EV charging-specific rates as well as a safe, modular solution with increased communications capabilities over multiple networks. It works whether integrated into an EVSE or used externally to an EVSE thereby enabling any Level 2 EVSE to be submetered.

The NGM/EVSE solution is ready to be further trialed, formally certified, prepared for production, and released. The NGM/EVSE could be used as a component in the electrification effort for PG&E's EV fleet infrastructure upgrade.

In August 2022, the Commission released its Decision 22-08-024 "Decision Adopting Plug-In Electric Vehicle Submetering Protocol and Electric Vehicle Supply Equipment Communication Protocols" as part of its Order Instituting Rulemaking (OIR) R18-12-006. This Decision specifies an alternative direction for EV submetering for utility customers. Therefore, PG&E will re-assess its options for the application of

the NGM to EVSE submetering. As EV adoption expands and submetering options are selected for EV charging needs, the market for submetering and its nuances will become more apparent. Studying the evolution and maturation of this market will allow PG&E to better understand the rate of customer adoption of submetering for EV charging, the types of customer and business segments that the submetering will primarily serve, adoption gaps, and what segments of the market may need additional technology, product or service options.

In the interim, PG&E believes there are considerable use cases to explore where the NGM can add value to customers. These may include alternatives to traditional utility meters, resiliency, or other behind-the-meter assets in alignment with the climate and energy goals of the State of California.