

September 2, 2025

Honorable Michelle L. Phillips, Secretary  
New York State Public Service Commission  
Three Empire State Plaza  
Albany, NY 12223-1350

Re: CASE 18-E-0138 – Proceeding on Motion of the Commission Regarding Electric Vehicle Supply Equipment and Infrastructure.

Dear Secretary Phillips:

On July 14, 2022, the Public Service Commission (Commission) issued the Order Approving Managed Charging Programs with Modifications (Managed Charging Order). The Managed Charging Order signaled an interest in the development of standards related to electric vehicle (EV) electric consumption measuring technology. To develop these standards, the Managed Charging Order established a three-phased process. In phase one, the Order directed the Electric Vehicle Technical Standards Working Group (TSWG) to establish eligibility criteria in order to determine what equipment will be considered for testing purposes. In phase two, the TSWG was tasked with measuring and evaluating the reliability and accuracy of the devices on the eligible equipment list. Finally, in phase three, the Managed Charging Order directed the TSWG to submit a comprehensive filing detailing the findings of the previous two phases and making recommendations to establish minimum standards and specifications for alternative metering technologies.

Please find the attached Technical Standards Working Group Report Addressing Electric Vehicle Supply Equipment and Telematics Accuracy, which provides a detailed summary of phases one and two and recommendations for incorporating EV electric consumption measuring technologies into the electric utilities' managed charging programs.

Sincerely,

s/Stephanie McDermott  
Assistant Counsel  
Office of General Counsel

NEW YORK STATE  
DEPARTMENT OF PUBLIC SERVICE

CASE 18-E-0138 – Proceeding on Motion of the Commission Regarding Electric Vehicle Supply  
Equipment and Infrastructure.

TECHNICAL STANDARDS WORKING GROUP REPORT  
ADDRESSING ELECTRIC VEHICLE SUPPLY EQUIPMENT  
AND TELEMATICS ACCURACY

Dated: September 2, 2025

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## Introduction

Managed charging is the process of managing when and how electric vehicles (EVs) charge, with the goals of reducing consumer and ratepayer costs, while improving grid reliability and still serving the consumer's charging needs. Managed charging programs for EVs can help to optimize grid load, reduce peak demand, and lower costs for EV drivers. In the Make-Ready Order, the Public Service Commission (Commission) directed the Joint Utilities to propose managed charging programs in their respective service territories.<sup>1</sup> The Joint Utilities currently run the managed charging programs as approved by the Commission in the Managed Charging Order and Managed Charging Modification Orders.<sup>2</sup>

One complication identified in the process of developing the managed charging programs is that the Commission's regulations require that only types of meters which have been approved by the Commission shall be used for the purposes of customer billing.<sup>3</sup> At this time, electric vehicle supply equipment (EVSE) and vehicle telematics are not meters that have been approved for use for customer billing.

In order to determine whether some modification to Commission regulations and policy should be considered, the Commission directed the utilities to propose a method for testing the accuracy of managed charging-enabling technologies. The Commission directed Department of Public Service staff (Staff) to convene the Electric Vehicle Technical Standards Working Group

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<sup>1</sup> Case 18-E-0138, Order Establishing Electric Vehicle Infrastructure Make-Ready Program and Other Programs (issued July 16, 2020) (Make-Ready Order).

The Joint Utilities consist of: Central Hudson Gas & Electric Corporation (Central Hudson), Consolidated Edison Company of New York, Inc. (Con Edison), New York State Electric & Gas Corporation (NYSEG), Niagara Mohawk Power Corporation d/b/a National Grid (National Grid), Orange and Rockland Utilities, Inc. (O&R), and Rochester Gas and Electric Corporation (RG&E).

<sup>2</sup> Case 18-E-0138, Order Approving Managed Charging Programs with Modifications (issued July 14, 2022) (Managed Charging Order), Order Approving Modification to Utility Managed Charging Program (issued February 16, 2023) (February 2023 Order), Order Approving Modification to Utility Managed Charging Program (issued June 23, 2023) (June 2023 Order), Order Approving Modifications to Managed Charging Programs and Making Tariffs Permanent (issued June 21, 2024) (June 2024 Order) (collectively, Managed Charging Modification Orders).

<sup>3</sup> 16 NYCRR §93.2 Acceptable Meters.

(TSWG) to consider the method(s) proposed by the utilities to establish metering and testing standards or criteria. Additionally, the Commission directed the TSWG to conduct a three-phased approach to further address the issues related to EVSE accuracy. These three stages were to culminate in a comprehensive filing to the Commission, which would recommend minimum standards and specifications for alternative metering technologies. Staff submits this report and recommendations, pursuant to that directive.

## Background

In the Make-Ready Order, the Commission directed Staff to organize a stakeholder process of interested parties and other state agencies to discuss managed charging and vehicle-to-grid integration and directed the utilities to file proposals for managed charging programs for mass market customers.<sup>4</sup> The managed charging program proposals would provide customers with an alternative to the existing voluntary time-of-use (TOU) rates that encourage off-peak charging. On December 4, 2020, each of the utilities filed proposals to describe or implement EV managed charging programs for mass-market customers to comply with the Commission's Make-Ready Program Order directives.

In furtherance of the Make-Ready Order's directive, Staff convened the Electric Vehicle Managed Charging Working Group (MCWG) on March 17, 2021, to consider and provide feedback on the utilities December 2020 managed charging proposals. Based on the MCWG meeting and comments received on the proposals due April 1, 2021, National Grid, NYSEG, and RG&E proposed revisions to their December 2020 Filings on June 4, 2021; Central Hudson, Con Edison, and O&R proposed no changes.<sup>5</sup>

Subsequently, the Commission issued the Managed Charging Order. In the Managed Charging Order, the Commission accentuated simple, transparent, and flexible residential managed charging programs that can provide essential benefits to the power grid in the form of flexible load, to EV drivers in the form of economic charging rates, and to other electric utility

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<sup>4</sup> Make-Ready Order, p. 124.

<sup>5</sup> Case 18-E-0138, Central Hudson Comments (filed June 4, 2021); Con Edison and O&R Reply Comments (filed June 4, 2021); NYSEG and RG&E Managed Charging Revised Proposal (filed June 4, 2021); National Grid Managed Charging Proposal (filed June 4, 2021).

customers in the form of efficient delivery rates.<sup>6</sup> As part of the approval process for the managed charging programs, the Managed Charging Order required the utilities to allow participation from both onboard vehicle telematics and networked L2 chargers.<sup>7</sup>

The Joint Utilities' light-duty managed charging programs consist of active and passive programs, both of which are intended to influence an EV driver's behavior to increase beneficial charging and provide an alternative to TOU rates. Active managed charging programs give the utility permission to actively control a participant's EV load to reduce stress on the grid. Passive programs provide incentives to participants to encourage them to charge their EV during off-peak hours. Under the current program structures, described in detail below, participation incentives fall under one of three designs, and a utility's program can provide more than one type of participation incentive: a volumetric kWh-based incentive, a flat incentive based on meeting a certain kWh threshold, or a flat incentive based on whether charging occurred during a specified period. The Joint Utilities' Managed Charging Programs Implementation Plans can be found on DMM in Case 18-E-0138.<sup>8</sup>

### **The Utilities' Managed Charging Programs**

#### *Central Hudson*

Central Hudson's managed charging program began November 14, 2023, and offers both passive and active managed charging programs, offering enrollment incentives of \$25 for both passive and active participation. Central Hudson's passive program provides volumetric incentives to award participants for off-peak charging. Central Hudson's active program provides participants with an incentive at the end of the NWA curtailment season (June 1-September 30), if the participant has opted out of no more than two events. Participants enrolled in the active managed charging program must be located in one of Central Hudson's Non-Wire Alternative (NWA) circuits.

#### *Con Edison and O&R*

Con Edison and O&R partner with the same vendor to offer passive managed charging programs with the same base structure, Smart Charge New York (SCNY). Participants are

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<sup>6</sup> Managed Charging Order, p. 22.

<sup>7</sup> Managed Charging Order, Ordering Clause 3.

<sup>8</sup> Case 18-E-0138, Joint Utilities' Managed Charging Program Implementation Plans (filed January 30, 2025).

eligible to receive a \$25 enrollment incentive. Participation incentives in the programs consist of an avoided on-peak charging incentive and an off-peak charging incentive. The avoided on-peak charging incentive provides a monthly incentive to participants for avoiding charging during a designated 4-hour peak window during the summer peak period of June 1 to September 30. Participants can also earn a bonus incentive when the participant records no charge sessions during the 4-hour on-peak period for the entire summer period. The off-peak charging incentive is volumetric and provides an incentive per kWh charged during off-peak hours.

#### *National Grid*

National Grid's current program structure launched in April 2023 and offers both passive and active managed charging opportunities. The program offers a \$25 enrollment incentive and a flat monthly incentive if a minimum percentage of the participant's charging occurs during off-peak hours and the participant charges a minimum amount of kWh at home during the month. Currently, these are at least 80 percent off-peak charging and 50 kWh of home charging.

#### *NYSEG and RG&E*

Launched on July 14, 2023, NYSEG and RG&E offer passive and active managed charging tiers under the OptimizEV program. Participants are eligible to receive enrollment incentives for start-up actions in each Tier. Participants in the baseline tier, which focuses on passive managed charging, are eligible for a one-time enrollment incentive of \$25, while participants in the advanced tier, which focuses on active managed charging, are eligible for a one-time enrollment incentive of \$150. In each month a baseline tier participant achieves 80 percent or greater charging during off-peak hours, they earn a volumetric incentive equivalent to the cost-based value for each kWh of off-peak charging (the average annualized cost differential between standard and off-peak residential rates). Advanced tier participants earn the volumetric cost-based value of their off-peak charging when they maintain an active daily charging schedule and agree to allow active managed charging of their vehicles. Advanced tier participants must also not override their managed charging such that an on-peak charging event greater than 15 minutes occurs more than three times per month.

#### *Formation of the TSWG*

While the managed charging programs utilize both onboard vehicle telematics and networked L2 chargers, questions emerged about the feasibility of using the technology as metering devices for billing purposes. To explore the concept further, the Commission directed

the utilities to file a proposal (Testing Proposal) and Staff to convene the TSWG to evaluate a method for testing the accuracy of managed charging-enabling technologies, with the following procedural requirements:

- (a) establish eligibility criteria to determine what equipment will be considered for testing purposes;
- (b) measure and evaluate the reliability and accuracy of the devices on the eligible equipment list;
- (c) consider the standards evaluated and/or adopted by other jurisdictions in this analysis; and
- (d) submit a comprehensive filing to the Commission for approval.<sup>9</sup>

The TSWG was facilitated by Staff and included members of the Joint Utilities and met eleven times from February 15, 2023 to July 30, 2024.<sup>10</sup> The TSWG was additionally attended by various stakeholders who actively contributed insights. Meeting presentations consisted of EVSE developers and operators (e.g., ChargePoint and Livingston), automakers that develop EVs (e.g., Ford and GM), managed charging software providers (e.g., Rolling Energy Resources, ev.energy, and WeaveGrid), and national labs and testing entities (e.g., Argonne, Tesco, EPA, and ICF). To inform the Testing Proposal, the working group examined various topics related to managed charging and submetering, including the status of standards used today. The working group delineated the objectives of the Testing Proposal, including the current state of the market, the roles and responsibility of the working group, and the testing protocols that should be evaluated in the absence of industry standards. As the working group meetings progressed, the participants determined that only devices that were used across multiple managed charging programs should be tested. Participants discussed testing implementation, including refining the testing protocol and steps to obtain a testing laboratory, and the eligible devices to test.

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<sup>9</sup> Managed Charging Order, Ordering Clause 6.

<sup>10</sup> Meeting presentations and recordings can be found in the Commission's Document and Matter Management System (DMM) in Case 18-E-0138 and Matter 22-02356.

*TSWG Testing Proposal*

On January 10, 2023, the Joint Utilities submitted the Testing Proposal.<sup>11</sup> The Testing Proposal expands on the three-phased approach required by the Commission, proposing that: in Phase One, the TSWG conduct formal outreach to industry (e.g., device manufacturers and related service providers) to gather existing testing- and accuracy-related information and documentation; in Phase Two, the TSWG tests devices using a data collection method that allows for the direct comparison of charging session energy consumption as measured by traditional metering devices, EVSE, EVs, and managed charging technology providers; and in Phase Three, the TSWG summarizes the results from the Phase One and Phase Two investigations as part of their comprehensive filing for Commission approval, incorporating the documented experiences of utilities, both in New York and out-of-state, on data accuracy or data quality issues that may be relevant to future decisions related to the approval of submetering alternatives. Additionally, the Testing Proposal suggests that the TSWG consider core issues beyond the scope of the metering accuracy testing proposal, such as what device standards should be in place for managed charging programs and how to define the accepted or preferred ways to meter or submeter EV charging loads in a beneficial way.<sup>12</sup>

*TSWG Phase One*

For Phase One, the Managed Charging Order directed that the TSWG shall establish eligibility criteria in order to determine what equipment will be considered for testing purposes.<sup>13</sup> During Phase One, the TSWG conducted outreach to industry (e.g., device manufacturers and related service providers) to gather any testing- and accuracy-related information. The Testing Proposal proposed to test the accuracy of EVs, EVSE and third-party managed charging providers, including multiple EV makes and models, with a focus on the most popular EVs in the market. Over the course of the working group meetings, the TSWG developed objectives and strategies to systematically gather accuracy data by advancing a benchmark study on the current state of the market regarding EV metering and quantifying

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<sup>11</sup> Case 18-E-0138, Joint Utilities' Proposal for a Method to Test the Accuracy of Managed Charging-Enabling Technologies (filed January 10, 2023) (Testing Proposal).

<sup>12</sup> Testing Proposal, pp. 2-3.

<sup>13</sup> Managed Charging Order, p. 27.

metering accuracy for different devices across different points of measurement (e.g., from an EVSE, the EV itself, or periodic state of charge readings).

During the December 9, 2022 TSWG meeting, the Joint Utilities presented on the state of the market for EV and EVSE metering and related efforts by other states (e.g., California, Maryland, Minnesota, Connecticut, Massachusetts, and North Carolina) that were also in the early stages of investigating the accuracy of these devices for submetering purposes.<sup>14</sup> Efforts in these states are summarized below, including additional activities that have occurred since the Joint Utilities' presentation.

*California  
Submeter Protocol Directives<sup>15</sup>*

This ruling addressed the development of a submetering protocol for plug-in electric vehicles (PEV), specifically, to generate subtractive utility bills for PEVs. The ruling requests comments and directs the California utilities to revise their Strawman proposal for a PEV submetering protocol based off the California Statewide PEV Submetering Pilot – Phase 2 Report (CA Phase 2 Report) that was submitted to the California Public Utilities Commission on April 26, 2019.

The CA Phase 2 Report examines the current state of submetering technology and its readiness for widespread deployment. The CA Phase 2 Report's main conclusion is that using submetering via a third-party to generate subtractive utility bills is not yet viable for full scale deployment. The CA Phase 2 Report identifies fundamental barriers to implementation including: (1) data accuracy; (2) data synchronization (confirming that meter data and submeter data are synchronized at comparable time intervals); (3) reliable data transfer, billing accuracy, and timeliness; and (4) process automation.

The CA Phase 2 Report highlights the need for standardized testing procedures and recommends that a performance verification protocol be developed and published. The CA Phase 2 Report recommends that the protocol should include specific testing protocols and

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<sup>14</sup> Case 18-E-0138, JU EV Metering TSWG Presentation (filed December 9, 2022).

<sup>15</sup> California Public Utilities Commission, [Decision 18-12-006, Administrative Law Judge's Ruling Directing Pacific Gas and Electric Company, Southern California Edison Company, and San Diego Gas & Electric Company to Respond to Outstanding Questions on the Development of a Submetering Protocol](#) (filed January 23, 2015) (Submetering Protocol Directives).

performance criteria to verify accuracy of the submeters before they can be used in subtractive billing. Additionally, the CA Phase 2 Report recommends continued regulatory support, particularly to support the adoption of PEVs and other DERs.

*Total Charge Management Report, December 2021*<sup>16</sup>

The California Energy Commission submitted the Total Charge Management Report in December 2021 (TCMR) that studied customer experience, driver engagement, and incentives needed to optimize charging events, by monitoring participation levels in real-world Vehicle-Grid Integration (VGI) programs and identifying participating households' motivations and concerns. Overall, the TCMR concluded that managed charging programs for EV show substantial potential for cost savings, renewable energy integration, and greenhouse gas emission reductions, while identifying critical infrastructure needs and customer engagement strategies for future VGI. However, the TCMR did not identify the accuracy, precision or reliability of the telematics data and instead focused on evaluating how telematics charging data can be utilized for grid performance measurement and program optimization.

*Submetering and Telematics Workshop*<sup>17</sup>

The California Public Utilities Commission held a submetering and telematics workshop on April 17, 2025. The workshop focused on the progress, challenges, and future direction of the PEV submetering protocol in California. A primary theme was the need to adapt the current protocol to be more flexible, cost-effective, and inclusive of emerging technologies like smart circuit breakers and telematics. The workshop contained discussions on telematics, meter data management agents, and how to foster collaborative solutions. Overall, the workshop highlighted the need for collaboration among stakeholders to address challenges, improve data accuracy, and develop standards that support the integration of submetering and telematics in California's energy landscape, proposing: (1) using the existing accuracy standard for PEV submetering protocol (1 percent in the lab, 2 percent in the field); (2) that telematics should be

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<sup>16</sup> California Energy Commission, CEC-500-2021-055, [Energy Research and Development Division FINAL PROJECT REPORT Total Charge Management of Electric Vehicles](#) (issued December 2021).

<sup>17</sup> California Public Utilities Commission, [Submetering and Telematics Workshop](#) (April 17, 2025).

permitted across all non-rate opportunities; and (3) that longer-term scalable telematics submetering protocol should be adopted.

*Maryland Public Service Commission*

Maryland's Public Service Commission issued Order No. 90587 in 2023,<sup>18</sup> granting the Electric Vehicle (EV) Workgroup's request to postpone the implementation of statewide EV metering regulations. The Workgroup cited complications due to: (1) the PSC's lack of authority over non-utility EV chargers (potentially under the Maryland Department of Agriculture's jurisdiction); (2) limited availability of testing equipment; (3) lack of consensus on testing standards; (4) the need to refine the customer billing process; and (5) practical and legal obstacles. The order requires the Workgroup to file status reports every six months, extends existing EV metering waivers, and directs EV Pilot Utilities to establish procedures for handling customer complaints about EV meter accuracy.

*Minnesota*

*Minnesota and Xcel Energy*

The Minnesota Utilities Commission approved the Xcel Energy EV Optimization Pilot on March 15, 2022.<sup>19</sup> The goal of the Xcel Energy (the Company) EV Optimization Pilot, launched on December 16, 2022, is to manage potential grid impacts of EVs by incentivizing participants to charge their EVs during off-peak hours. Participants participate in the program using compatible charging equipment, either provided by the Company or the customer, and compatible vehicles. The Company analyzes participants' charging data that is provided by charging equipment manufacturers and other third-party vendors on a quarterly basis. The term for the pilot was initially planned to be three years, expected to end in May 2025. However, the Company recently received Commission approval to continue operating the pilot until a permanent active managed charging program is approved by the Commission.

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<sup>18</sup> Maryland Public Service Commission, Order No. 90587, [EV Workgroup Metering Regulations Deferral](#) (issued April 12, 2023).

<sup>19</sup> Minnesota Utilities Commission, Docket Nos. E-002/M-21-101 and-002/M-17-401, [In the Matter of Xcel Energy's Petition for Load Flexibility Pilot Programs and Financial Incentive, Order Approving Modified Load-Flexibility Pilots And Demonstration Projects, Authorization Deferred Accounting, And Taking Other Action](#) (issued March 15, 2022).

*Connecticut  
Connecticut Electric Vehicle Charging Program*

The Connecticut Public Utilities Regulatory Authority approved a statewide EV Charging Program on July 14, 2021.<sup>20</sup> The EV Program Authorization Decision directed the electric distribution companies (EDC) to initiate a working group to inform the development of a two-tier managed charging program to launch by January 1, 2022. The baseline managed charging program established an off-peak charging period year-round with the inclusion of demand response events in the summer, while an advanced tier of the managed charging program requires participants to establish an off-peak charging schedule and gives the EDC permission to curtail charging based on grid needs.<sup>21</sup> The EV Program Authorization Decision recognized that some EV drivers have non-networked L2 chargers and directed the EDCs to develop a rebate program for drivers that purchase a device to connect to an EV's onboard diagnostic system, or to otherwise use an EV's onboard telematics. The EV Program Authorization Decision acknowledged that it is possible that onboard telematics may see future technological advancement and directed the EDCs to outline the vehicle capabilities necessary for a customer to participate in the managed charging programs. Subsequently, the Connecticut Public Utilities Regulatory Authority has directed the EDCs to begin a managed charging pilot program for multi-unit dwellings beginning January 1, 2025, in the EV Program Year 4 Decision. The EV Program Year 4 Decision states that the first phase of the pilot will use onboard vehicle telematics to enable participation with subsequent phases allowing additional options for participation through an EVSE such as a unique payment card.<sup>22</sup>

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<sup>20</sup> Connecticut Public Utilities Regulatory Authority, [Investigation into Distribution System Planning of the Electric Distribution Companies – Zero Emission Vehicles \(EV Program Authorization Decision\)](#) (issued July 14, 2021).

<sup>21</sup> Connecticut Public Utilities Regulatory Authority, [Annual Review of the Electric Vehicle Charging Program – Year 3](#) (EV Program Year 3 Decision) (issued November 29, 2023), pp. 6-7.

<sup>22</sup> Connecticut Public Utilities Regulatory Authority, [Annual Review of the Electric Vehicle Charging Program – Year 4](#) (issued December 4, 2024), pp. 10-14.

*Massachusetts*

The Massachusetts Department of Public Utilities (DPU) authorized EV charging infrastructure programs for up to five years in the DPU Order.<sup>23</sup> The DPU Order highlights that the utilities intend to assess alternative metering capabilities in residential EV programs and acknowledged that embedded EVSE meters and EV telematics may provide benefits such as eliminating the need for a second utility-owned meter, enablement of managed charging opportunities, and support for vehicle-to-grid capabilities. However, the DPU cautioned that there are significant hurdles to overcome before the technologies can be used for billing purposes, including technical, cybersecurity, and consumer protection concerns, as well as the lack of national standards for metering, testing, and evaluating the technologies.<sup>24</sup> The DPU instructed the utilities to work with EVSE providers and other stakeholder to explore the metering capabilities of networked EVSE and vehicle telematics in an effort to reach a consensus on data quality standards and were instructed to provide updates in annual reporting. In subsequent updates provided by the utilities, there continues to be recognition of potential benefits offered by EV onboard telematics or EVSE in lieu of a separate meter, but research and findings are ongoing.<sup>25</sup>

*North Carolina*

The North Carolina Public Utilities Commission authorized Duke Energy Carolinas, LLC and Duke Energy Progress, LLC (Duke) to conduct a managed charging pilot program from November 1, 2023 to October 31, 2024, with up to 200 residential customers.<sup>26</sup> Duke proposed partnering with certain automakers such as BMW, Ford, General Motors and Honda to test the Open Vehicle Grid Integration Platform which it says is developed by the OEMs and the Electric Power Research Institute to enable two-way communication between utilities and

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<sup>23</sup> Massachusetts Department of Public Utilities, [D.P.U. 21-90/D.P.U. 21-91/D.P.U. 92](#) (issued December 30, 2022) (Massachusetts DPU Order).

<sup>24</sup> DPU Order, pp. 269-270.

<sup>25</sup> Massachusetts Department of Public Utilities, [Investor-Owned Utility Electric Vehicle Charging Infrastructure Programs: 2023 Annual Reports Summary](#) (issued August 7, 2024).

<sup>26</sup> North Carolina Utilities Commission, DOCKET NOS. E-7, SUB 1266, E-2, SUB 1291, [Order Approving Electric Vehicle Managed Charging Pilot Programs](#) (issued June 24, 2022).

the EVs.<sup>27</sup> In addition, Duke proposed that a subset of the participants use utility grade meters to compare the accuracy of the onboard EV telematics. Six program participants ultimately had a revenue-grade meter installed. Duke's Final Program Report finds that the readings from telematics were 12.6% lower than the readings from revenue grade meters, with individual vehicle differences ranging from 5.4% to 17.8%.<sup>28</sup> In a final assessment of the program, Duke stated that vehicle telematics can be an effective and low hardware cost solution to enable participation in some forms of managed charging when focusing on shifting the load away from peak periods with incentives, but cautioned that the accuracy of telematics is a concern for certain use cases, such as billing. For use cases based on precise usage metrics and financial transactions, Duke posits that revenue-grade solutions continue to be a preferred approach absent advancements in telematics technology, but that telematics may be sufficient for non-billing purposes.<sup>29</sup> In addition, Duke noted that it was able to observe that telematics data at times undercounted or omitted charging sessions entirely when comparing the telematics data of the participants with a revenue grade meter.

*Benchmarking with Other States*

While the TSWG testing effort and each of the above discussed reports convey slightly different measurements and approaches to managing EV charging, there is a shared emphasis on developing standardized approaches and protocols for EV charging systems. This includes creating recommended practices for assessing energy measurement accuracy and establishing reliable methods for obtaining and comparing EV charging data. The similarities indicate a coordinated nationwide effort to address common challenges in EV charging infrastructure, data accuracy, and grid integration, with stakeholders working toward similar goals of improved system reliability and grid optimization.

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<sup>27</sup> Order Approving Electric Vehicle Managed Charging Pilot Programs, p. 2.

<sup>28</sup> Duke Energy Carolinas, LLC's and Duke Energy Progress, LLC's Final Report on the Companies' Electric Vehicle Managed Charging Pilot Programs (Duke Final Managed Charging Report) (filed April 30, 2025), p. 21.  
<https://starw1.ncuc.gov/NCUC/ViewFile.aspx?Id=03c7028b-1dea-41c5-8437-08ae1b2b972d>

<sup>29</sup> Duke Final Managed Charging Report, p. 45.

*Additional Phase One Activities*

In addition to Phase One research on how other states are viewing submetering and accuracy concerns, the TSWG ascertained what, if any, accuracy standards exist for EV charging technologies. Some EVSEs, mostly in commercial charging, meet the National Institute of Standards and Technology (NIST) Handbook 44 §3.10, a comprehensive document outlining standards for commercial weighing and measuring equipment, discussed in more detail in the “Measurement Accuracy Considerations” section below. While metering standards exist, including metering requirements specific to New York, none are used in the EV market today. Additionally, the TSWG identified a number of other considerations pertinent to its work: (1) the dynamic and nascent state of the EVSE and EV market, (2) incomplete national standards for EVSE and telematics testing, certification, and compliance, (3) metering accuracy in the laboratory being one element of the broader issue of data quality, and (4) metering approaches generally needing to be cost-effective, durable, and widely applicable.

*TSWG Phase Two*

For Phase Two, the Managed Charging Order directed the TSWG to measure and evaluate the reliability and accuracy of the devices on the eligible equipment list, taking into consideration the methods proposed in the Utilities’ filings. The Commission directed Staff to review the TSWG recommendations for compliance with customer privacy and consumer protections and is directed to bring such recommendations to the Commission for review in the event that the protections provided are inadequate. Based on the testing, the TSWG was required to outline the spectrum of reliability and accuracy of the chargers. To address customer privacy, all data collected during testing was anonymized to alpha-numeric designators for each manufacturer’s device under test.<sup>30</sup>

The TSWG developed data collection methods that allowed for the direct comparison of charging session energy consumption as measured by traditional metering devices, EVSE, EVs, and managed charging technology providers. The TSWG recommended that data collection be completed in a sequence of tasks:

- Task 1 - EV and EVSE Metering Accuracy Testing Setup and Protocol Development;
- Task 2 – acquisition of vehicle and data sharing agreements or partnerships;

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<sup>30</sup> Case 18-E-0138, Methodology for Testing the Accuracy of Data Collected from Managed Charging Enabling Technologies, Final Report, (filed September 12, 2024) (Report), p. iv.

- Task 3 - EV and EVSE Metering Accuracy Testing; and
- Task 4 - advisory support and report delivery.

As part of the Phase Two course of action, the Joint Utilities sent a Request for Information (RFI) on May 15, 2023 to obtain information about the testing capabilities in the market from technology providers including automakers, charging hardware/software providers, managed charging service providers, testing laboratories, and standards organization. The RFI was designed to further the TSWG's knowledge on the structure of the testing setup, testing protocol, implementation schedule and implementation costs.

Ultimately, the RFI:<sup>31</sup>

- Provided a list of multiple testing implementors, OEMs, and managed charging providers that were willing to support the effort;
- Identified multiple [4] locations to potentially do testing;
- Identified changes and improvements to the testing protocol and feedback on the device lists; and
- Provided informed though varied estimates of staff hours and implementation costs necessary to conduct testing.

Soon after the results of the RFI were received, the Joint Utilities employed Electric Power Research Institute (EPRI) as the implementation contractor to support the technical design and implementation of the Phase Two accuracy testing effort. EPRI's responsibilities included:

- Project management to coordinate testing implementation with stakeholders, including the Joint Utilities, Staff, industry experts, and participating technology providers such as managed charging service providers or EVSE/EV OEMs;
- Assisting in drafting and refining a testing protocol in support of the NY requirements (e.g., may be based upon NIST Handbook 44, ANSI C-12.20, etc.);
- Providing a testing/laboratory environment to implement the testing protocol;
- Coordinating the sourcing of eligible devices for testing;
- Conducting device testing, data collection, and analysis; and

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<sup>31</sup> Case 18-E-0138, Technical Standards Working Group Meeting Staff Presentation (filed July 27, 2023).

- Reporting on the Phase Two findings.

Starting in the last quarter of 2023, EPRI began the testing protocol by soliciting industry partnerships to support testing (e.g., loaner devices; telematics access; feedback on testing protocol, etc.). After the devices were procured, EPRI began the testing process which culminated in a report, the findings of which are described below.

## Summary of EPRI Testing Report

On September 12, 2024, the Joint Utilities, in conjunction with EPRI, filed the "Methodology for Testing the Accuracy of Data Collected from Managed Charging Enabling Technologies" summarizing the results of the testing process.<sup>32</sup> EPRI obtained charging data from three EVs, three telematic providers, four EVSEs, and two EVSE data hosts which was compared to energy measurements made using lab-grade instrumentation. All data collected was anonymized to alpha-numeric designators for each manufacturer's device under test.

### Methodology

The devices under test were compared against lab-grade instrumentation with NIST-traceable calibration. The calibrated standard measurement meter was placed upstream of the devices under test at two points: (1) the point of common coupling, representing the typical location of a utility revenue meter, and (2) the EV charger port. The assessment reports a "percent difference" instead of "percent error" due to power consumption and wiring losses between the standard metering locations and the EV's measurement sensor. EPRI's test protocol consists of a recommended practice for assessing the energy measurement accuracy of telematic systems for electric vehicle charging, as they are presented today. The protocol addresses the conditions, instruments, and methods for obtaining reliable measurements for EV charging data for comparing to telematics. EPRI notes that as manufacturers and telematic providers make changes to optimize data collection and accuracy, this test protocol will need revisions. EPRI recommends the developed protocol be presented to EV standards organizations as a first-order draft so a wider set of industries including EV manufacturers, telematic providers, and utilities can further contribute towards standardizing measurements.<sup>33</sup>

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<sup>32</sup> Case 18-E-0138, Methodology for Testing the Accuracy of Data Collected from Managed Charging Enabling Technologies, (filed September 12, 2024) (EPRI Report).

<sup>33</sup> EPRI Report, p. 11.

### Key Findings

As discussed in the Report, the testing determined that all of the energy measurement methods that EPRI evaluated underreported energy use compared to lab instruments.

- Level 2 EVSE had a best-case measurement difference of around -1 percent, but remote data processing systems do not consistently measure short-duration sessions (5 minutes or less), registering a measurement difference of -2 percent to -17 percent.
- DCFC chargers had a best-case measurement difference of -7 percent.
- EV telematics had a best-case measurement difference of -7 percent to -15 percent, which increased to -16 percent to -60 percent with auxiliary loads.<sup>34</sup> Under some auxiliary loading conditions, EVs failed to report energy use, either missing the session or reporting zero energy use.

In all cases, testing scenarios that involved charging less than five minutes and auxiliary loads dramatically altered measurement accuracy. Auxiliary loads, such as climate control, power steering, lighting, and infotainment systems, draw energy from the battery and can significantly impact the overall energy consumption and range of an EV. EVSE telematics generally corresponds with the EVSE metric results; however, these devices can be difficult to access. Measurement obtained from the EV and telematics showed poor accuracy, which varied widely based on the measurement point (e.g., meter, EVSE, EV, battery) and the calculation types (e.g., kWh, voltage and current, power factor, temperature monitoring, etc.). EPRI notes that EV metrology systems are not purpose-designed to support revenue grade energy metering, leading to the variation in measurement point and calculation type.

### Key Takeaways

The EPRI report recommends developing standards for session-based energy reporting from EVSE and for telematics-based energy measurement, with the goal of establishing a standard method for vehicles to report totalized energy at the vehicle inlet in a format usable by electric utilities and third parties. EPRI recommends that this standard method should include requirements for data formatting and reporting, ensuring all vehicle loads are accounted for, and

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<sup>34</sup> Auxiliary loads include climate control, infotainment systems, power steering, and power braking.

setting numeric resolution and accuracy requirements. The EPRI report also suggests additional testing of energy measurement capabilities, including charging at temperature extremes, charging of aged batteries, auxiliary load impacts, measurements during power export, and testing of more vehicle brands and models.

## Additional Considerations

### Measurement Accuracy Considerations (electronics, digital representation/transmission)

As determined by EPRI, accuracy can vary widely in EV managed charging technologies, and both EVSE and EV telematics can be affected by various conditions. Technology is readily available to make accurate measurements, but current lack of requirements in L2 residential chargers often results in 1) less-accurate components being used to manage costs, and 2) variation in the actual measurement point (from battery to charging plug).

In addition to physical measurement, telemetry, the process of transmitting that measurement reliably to a central location (in addition to more advanced operations), can introduce more variation. Unstandardized data types, also encountered in EPRI's study, often require what are referred to as "extract, transfer, load" (ETL) processes to produce data in a usable format to be aggregated. As the unique list of products being integrated grows, ETL processes grow, and each step introduces another chance of error. These errors can be human error (manual ETL), systemic errors (code), or rounding errors (depends on original physical measurement).

Accurate telemetry also requires reliable communications, but the degree of reliability can be flexible. Modern control system standards and the protocols that have been developed to manage geographically dispersed components are often designed to continue operating satisfactorily even with intermittent communications. Methods employed can involve store-and-forward capabilities, accumulator data registers, or redundant communications pathways. Communications reliability can also be maintained with proper cybersecurity, which protects systems from both malicious and negligent operation.

Repeatable data measurement should also be addressed, and in the metering industry is addressed, by meter design and testing standards. For reference, Title 1 (Department of Agriculture and Markets) of New York Codes Rules and Regulations (NYCRR) Part 220.2

(Specifications and Tolerances)<sup>35</sup> adopts the National Institute of Standards and Technology Handbook 44 (NIST HB 44), which documents recommendations that “are intended to encourage the design, installation, testing, and use of [commercial] weighing and measuring devices that provide for accurate, repeatable measurements; facilitate clear and transparent transactions for buyer and seller; and do not facilitate fraud.”<sup>36</sup> Applicable to EVs, NIST HB 44 includes Section 3.40 Electric Vehicle Fueling Systems, and Section 3.41 Non-Utility Electricity-Measuring Systems. The HB itself relies heavily on ANSI C12.1 and C12.20 to define technical meter capabilities and testing criteria for accurate measurements in various accuracy classes (usually 0.1 percent, 0.2 percent, 0.5 percent, and 1.0 percent or more) and includes testing for accuracy repeatability and reliability through different environmental conditions, external tampering effects, and device aging. Title 16 (Department of Public Service) NYCRR includes calibration requirements and traceability to NIST standards, which point to testing lab requirements and again, ANSI C12.

In general, NIST HB 44 and ANSI C12.1/12.20 do not recommend a certain percent tolerance for various applications, but instead prescribe technologies and testing criteria for a given tolerance level. Some benchmarks are typically 0.5 percent and 0.2 percent accuracy classes for revenue-grade metering (often depending on applicable load), 1-2 percent for non-revenue grade metering, and a 5 percent tolerance for “renewable energy certificate” (REC) programs,<sup>37</sup> like the NYSERDA New York Generation Attribute Tracking System (NYGATS).

While physical metering accuracy has been the focus of these testing efforts, care should be taken to keep the end goals in mind for managed charging, which includes telemetry, repeatability, data management, and reliability. Existing standards discussed in the following section may not directly apply to physical measurement accuracy, but they do support measurement accuracy in the broader managed charging field. Requiring just a satisfactory percent tolerance may not achieve all the desired goals of a managed charging program, but a combination of the following standards is likely to produce a more successful product.

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<sup>35</sup> 1 NYCRR §220.2 Specifications and Tolerances

<sup>36</sup> NIST Handbook 44-2025, [Specifications, Tolerances, and Other Technical Requirements for Weighing and Measuring Devices](#) (issued December 2024).

<sup>37</sup> New York Generation tracking System (NYGATS) Operating Rules, [Version 2.4](#) (issued June 2, 2023), p. 23.

### Emerging Standards for EV Charging Technologies

There currently exists a number of technical standards related to EV charging systems generally, and a collection of the most popular are represented in the table below. Applicable systems are addressed in relation to the given categories: market penetration, operational assets and improves integration efficiency, and the “ratings” are either Harvey Balls representing applicability (25 percent, 50 percent, 100 percent), or question marks where some industry input is required to clarify. The legend below uses Greek symbols to group together standards that are typically employed together or are interoperable in some capacity.

Notably, there are only a few standards that cover physical accuracy, as those standards have been heavily adopted by industries employing metering. One of the goals of this table is to help visualize how accuracy at the aggregation level requires many steps beyond physical measurement accuracy, from communications (cellular, Wi-Fi, hardwire, radio, satellite), to software, to data management, to interoperability protocols through a string of individual physical and possibly virtual devices. Interoperability in particular addresses standardizing data types to reduce the need for ETL processes discussed earlier needed to “fix” data from various sources, further reducing the chance of errors introduced in telemetry.

As EVMC programs grow, so does risk as utilities rely on the capabilities to reliably operate the grid. Cybersecurity becomes very important and can also impact data accuracy in telemetry. Often broken down into the “C-I-A Triad,” cybersecurity addresses data confidentiality, integrity, and availability. Data accuracy in telemetry is directly related to integrity and availability, ensuring that the data measured is the data that gets to the aggregation point (utility or utility technology partner), and the data is available in satisfactory intervals of time. Confidentiality may not be important in terms of accuracy, but it has been noted as a barrier of entry by customers who may not want unauthorized access to their charging behavior, and utilities may not want it to be publicly known how reliant they are on EVMC operations.

#### *Metering:*

Metering requirements specific to NYS as well as national standards include:

- Title 16 New York Codes, Rules, and Regulations (NYCRR) Part 92 (Operating Manual) and Part 93 (Approval of New Types of Electricity Meters);
- ANSI C12: Code for Electricity Metering; and

- NIST HB 44: Specifications, Tolerances, and Other Technical Requirements for Weighing and Measuring Devices.

*Software and Integration:*

A diversity of devices in EVSE need to communicate to a central location in standard languages and formats. Some commonly used standards are:

- Open Charge Alliance (OCA), Open Charge Point Protocol (OCPP), Open Smart Charging Protocol (OSCP), Open Automated Demand Response (OpenADR);
- IEEE 2030.5 Standard for Smart Energy Profile Application Protocol;
- IEEE 1547-2018: Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces;
- IEC 61850: Profile for Distributed Energy Resources Supporting IEEE 1547;
- Underwriting Laboratories (UL) 1741-SB, provides testing criteria for the certification of IEEE 1547;
- International Standard for Organization (ISO) 15118: Road vehicles - Vehicle to grid communication interface; and
- Supervisory Control and Data Acquisition (SCADA)/Unified Computing System (UCS) protocols: Modbus (and SunSpec interface), IEEE 1815 DNP3.

Standard	Applicable System	Applicable Category											
		Market Penetration			Operational Asset			Improves Integration Efficiency					
		L2 EVSE, EV	DER, DERMS	UCS, SCADA	Safety, Operation, Efficiency	Accuracy	Telemetry	DER	L2 EVSE	Bi-Directional Charging	EV	UCS, SCADA, DERMS	Cybersecurity
NEC		●	●	●	●			●	●	●			
Communications (Various)		○	●	●	●	●		●	●	●	●	●	●
ANSI C12.1		○	?	●		●							
NIST HB 44		○	?	●		●							
OpenADR ψ		○	●	?			●						
Open Chargepoint Protocol ψ		●	●	?			●	●	●	○			
Open Smart Charge Protocol ψ		○	●	?			●		○	○	●		
IEEE 2030.5 χ		●	●	?	●		○	●	●	●		●	●
IEEE 1547-2018 χ†§		○	?	?	●		●	●	●	●		●	○
IEC 61850 †‡		?	?	?			●	●	●	●			
UL 1741-SB †		○	?	?	●		●	●	●	●		●	
ISO 15118-2 and -20		●	?	?			●		●	●	○	●	
IEEE 1815 (DNP3) χ‡		○	?	●	●		●				●	●	
MODBUS χ§		○	?	●	●		●				●	○	

- ψ OpenADR is compatible with OCPP, OSCP is a complement to OCPP
- χ IEEE 1547 requires interface with one of: IEEE 2030.5, IEEE1825 (DNP3), or SunSpec MODBUS
- † IEC 618150 is a standard profile for IEEE 1547, UL 1741-SB provides a testing criteria for IEEE1547
- ‡ DNP3 includes standard device profiles to map IEC 61850
- § "SunSpec" MODBUS offers compliance with IEEE 1547

## Staff Proposal

Based on the results of the EPRI study, Staff does not recommend that EVSE or EV telematics be used for submetering at this time given their lack of consistent high-level accuracy. Though the utilities' current program designs do not utilize these devices as submeters, accuracy still plays an important role in the distribution of incentives. Accurate measurements are paramount to appropriately compensating participants for their behavior and subsequently the overall participant experience. Moreover, it is in the interest of all ratepayers that incentives are accurately calculated, ensuring that ratepayers do not overpay for the benefits achieved through the program. Staff notes that this latter concern is somewhat reduced by the fact that, according to the EPRI study, these devices tend to undercount the kWh utilized, thus the chances of overpayment are minimized.

In promoting accuracy in the utilities' managed charging programs, Staff does not currently recommend the adoption of any particular standard. Though accuracy standards for EVSE do exist, few manufacturers have coalesced around any particular standard. Staff is supportive of standards generally and is eager for the residential EVSE industry to coalesce around an accuracy standard, but believes that requiring one at this time would unduly limit program participation, potentially limiting participation for years as industry adapted. Similarly, Staff believes that requiring the use of specific certified chargers would harm program participation.

Furthermore, no standard for accuracy of EV telematics currently exists. Ultimately, Staff believes a standard needs to be developed for EV telematics to better support the programs of today and enable programs of the future. Staff is eager for this to happen expeditiously, based on the views and expertise of stakeholders nationwide, so that manufacturers have guidelines to design towards to meet the various needs of utility programs across the country. Even with expeditious development, it will likely take many years for vehicles designed to such standard to permeate the market. In the near-term absence of a standard, Staff supports the continued participation of EV telematics in the utilities' managed charging programs. Though they may be less accurate, according to the EPRI study, than even EVSE, EV telematics are a

popular and cost-effective way to participate in the program. Disallowing participation via this method would significantly impact program uptake during a crucial time for the formation of EV charging habits.

Utilities, even in the absence of a required standard, can work with their data providers to improve accuracy and transparency. EPRI's analysis indicated that telematics results may be influenced by opaque adjustment and error-correction processes. Scrutinizing these processes ensures they are reasonable from the outset and do not introduce unintended effects. For example, an energy estimate derived from battery state-of-charge data may become less accurate as the battery degrades. Utilities can mitigate these risks by verifying the "chain of custody" for data from their providers and confirming that it is as accurate and stable as practicable.

In addition to these actions, accuracy concerns can be mitigated programmatically in the interim in a way that balances considerations around accuracy, participation, simplicity, and fairness. Maintaining strong participation in managed charging programs in this stage will help build charging habits that are beneficial to the grid as EV adoption grows. Program simplicity is important both to effectively incent participant behavior and for quick administration of the incentives. Fairness is paramount across the work of the Commission. Below, Staff outlines five possible courses of action, all of which have unique benefits and drawbacks.

*Option 1: Flat incentive model*

Under the flat incentive model, utility incentives would largely mirror the current program design in National Grid's territory, in which participants receive a set incentive for charging off-peak at least a certain percentage of the time (for example, \$15 per month for charging more than 80 percent off-peak). Incentives that only require charge start/stop information, such as peak window incentives, would also be permitted as they do not rely on detailed kWh information.

A flat incentive design may mitigate accuracy concerns compared to a purely volumetric design, since the dollar amount paid to the participant is not tied to the precise kWh utilized, but rather the overall proportion of charging behavior. Instituting flat incentives would represent a relatively simple and straightforward option which would be easy for participants to understand. This option promotes fairness, treating participants consistently across device types.

However, there is limited experience with flat managed charging incentive designs in New York. National Grid is the only utility who has utilized this design, implementing and marketing it to customers beginning in September 2024. With only one year of experience to date, expanding this design to all utilities represents a risk if it is less enticing to customers to sign up or to modify their behavior compared to other models. To this point, rideshare drivers, who have less control than other drivers over when to charge their vehicles, may be less incented under this model compared to a volumetric design that rewards them for any off-peak charging they are able to achieve. Moreover, rideshare drivers are “super users” of electricity; a flat incentive payment may be too low to incent desired behavior.

*Option 2: Hybrid model*

The hybrid model is similar to the flat incentive model; under this option, customers participating through EV telematics would be eligible for a flat incentive as described under Option 1, while those participating through EVSE would be allowed to receive volumetric incentives. This option recognizes that, while not as accurate as meters, EVSE generally appear to be more accurate than EV telematics, and may be sufficiently accurate to support program designs tied more closely to the precise kWh utilized by the participant. This would enable greater incentive efficiency for EVSE participants, as they would be rewarded for any additional charging beyond a percent threshold.

As all participants using EV telematics would be compensated through a flat incentive structure, this option retains the drawbacks of Option 1 for much of the population, while introducing administration complexity. This option also introduces additional concerns regarding perceived participant fairness and customer understanding, as one participant may be incented differently than their neighbor, or may have to acclimate to a new incentive design if their method of participation changes. Moreover, some participants may currently enroll through both their EVSE and telematics, which would not be feasible under this model.

*Option 3: Incentive Buffer Model*

Under the incentive buffer model, participants using EV telematics would receive a slightly reduced incentive compared to EVSE, to account for their reduced accuracy. This model allows volumetric designs which may incentivize participants more effectively than a flat design, particularly rideshare drivers. Though the utility would have to manage two different incentive amounts, this model may be simpler to implement than Option 2, which would

introduce two entirely different incentive designs and calculations. The incentive buffer model would aim to protect the ratepayer, reducing the chance that ratepayers could overpay for the benefits achieved through the program by creating a buffer against inaccurate measurements.

As noted earlier, the EPRI study found that when inaccurate, EV telematics undercount the kWh utilized. This could mean that participants are in effect doubly penalized for their inaccurate devices—once by undercounting good behavior, and once by the reduced incentive value. Regardless of a double penalty, care would need to be taken to keep incentives for EV telematics high enough that these participants are still motivated to charge off-peak. This option additionally presents participant fairness concerns by inherently providing higher incentives to those with EVSE.

*Option 4: Intermediate Device Model*

Under the intermediate device model, the utilities would retain their current incentive designs, but participants would be required to use an intermediate device such as a submeter, smart breaker, or gateway. This option ensures and places the highest emphasis on accuracy, recognizing that both EV telematics and EVSE were shown to be inconsistent and less accurate than traditional meters.

The intermediate device model provides a significantly cheaper method of attaining accuracy than the installation of second meters, however, it is the most intensive and expensive of the options identified here, and as a result would likely have substantial impacts on participation. Moreover, by tying the incentive to a specific intermediate device, program designs like Con Edison's, in which participants are rewarded for all charging across the utility territory, would not be feasible.

*Option 5: Status Quo*

This option would involve maintaining the status quo across the utilities' managed charging programs, until such time as the industry has sufficiently coalesced around accuracy standards that could be required for participation. This option would avoid the participation, cost, fairness, and complexity concerns identified across the other options. However, as described earlier, as managed charging programs grow and additional devices are added, the risk of error increases, as does the risk to the grid as utilities begin to depend on these programs in grid operations. With continued growth, the programs could cross a threshold prior to widespread standard adoption at which these risks become active problems.

## Conclusion

The TSWG was tasked with evaluating the accuracy of EVs and EVSE for use as alternative metering technologies. As part of the TSWG's investigation, EPRI conducted the study, which is described herein. While the TSWG recognizes that the use of this technology is still in a nascent stage, it is nevertheless disappointing to see the poor accuracy performance of the technologies. At this time, the TSWG does not believe EVs or EVSE should be used as alternative metering technologies. However, the TSWG is confident that the technology could still be used to support the managed charging programs; potential options for doing so are outlined above.