NET ENERGY METERING EVALUATION

Final Research Plan

Submitted to:
California Public Utilities Commission
Energy Division

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FINAL RESEARCH PLAN

Itron, Inc. (Itron), Energy and Environmental Economics (E3), and Illume Advising have been contracted by the California Public Utilities Commission (CPUC) Energy Division to perform an evaluation that examines the cost-effectiveness of distributed energy resource (DER) technologies taking service on net-energy metering (NEM) tariffs. This document summarizes Energy Division's research questions and the Itron team's proposed technical approach to answering these questions.

I. BACKGROUND

California's NEM policies, beginning in 1995 with the original NEM tariff or "NEM 1.0," have encouraged the adoption of behind-the-meter (BTM) renewable DERs like solar photovoltaic (PV) systems, fuel cells, and distributed wind. Pursuant to Assembly Bill (AB) 327 (Perea, 2013), the CPUC adopted the current NEM structure, often referred to as "NEM 2.0" or "the NEM successor tariff," through the NEM 2.0 Decision (D.16-01-044) in January 2016.[1] NEM 2.0 went into effect in San Diego Gas and Electric Company (SDG&E)'s service territory on June 29, 2016, in Pacific Gas and Electric Company (PG&E)'s service territory on December 15, 2016, and in Southern California Edison Company (SCE)'s service territory on July 1, 2017. Under NEM 1.0 and NEM 2.0, the three large California investor-owned utilities (IOUs), or PG&E, SCE, and SDG&E (collectively, the "utilities"), have interconnected over 900,000 BTM PV systems representing approximately 8,000 MW_{AC} of capacity.[2]

The NEM 2.0 Decision largely preserved the previously existing NEM structure with the rationale that ongoing efforts rolling out residential time-of-use (TOU) rates and determining the locational value of DERs could help inform the next iteration of the tariff, and, therefore, major changes would be premature at that time. The Decision also required the Energy Division to consider adjustments to the NEM 2.0 tariff in the future. The Itron team's NEM 2.0 evaluation will assist the CPUC in assessing PG&E's, SCE's, and SDG&E's NEM 2.0 tariffs by examining the effects of NEM 2.0.

II. STUDY OBJECTIVES AND KEY RESEARCH QUESTIONS

The Itron team will conduct an evaluation to review PG&E's, SCE's, and SDG&E's NEM 2.0 tariffs. The evaluation will include a cost-effectiveness analysis consistent with the Standard Practice Manual (SPM) and the CPUC Decision guiding cost-effectiveness evaluation of DERs (D.19-05-019).[3] The evaluation will also include an analysis to compare the cost to serve NEM 2.0 customers and their total bill payments. The objectives of the evaluation are to examine the impacts of NEM 2.0 and to compare how different

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1 http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M158/K181/158181678.pdf

2 https://www.californiadgstats.ca.gov/charts/

3 http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M293/K833/293833387.PDF

metrics have changed following the transition from NEM 1.0 to NEM 2.0.[4] The evaluation will answer the following questions:

- What are the characteristics of systems installed under NEM 2.0?
- What are the characteristics of customers taking service under NEM 2.0?
- What have been the costs and benefits of the NEM 2.0 tariff to participating customers, rate payers, Program Administrators, and society as a whole?
- What is the utility's cost of service for different types of NEM 2.0 customers?
- Do different types of NEM 2.0 customers pay more or less than the cost of providing them electricity service before and after they install NEM systems?
- How have answers to the above questions changed from NEM 1.0 to NEM 2.0?

To complete this analysis, Itron will examine the following:

- Count and capacity of systems installed
- Solar PV and storage system design specifications (e.g., storage system duration, PV system tilt and azimuth)
- Capacity factor of systems
- Number of systems paired with energy storage and capacity of paired storage
- Number of systems capable of safely islanding from the utility grid during an outage in order to provide backup power to the customer
- Typical generation profiles for systems paired and not paired with energy storage
- Rates chosen by customers
- Utility costs (e.g., billing, administrative, and interconnection upgrade costs)
- Adoption rates
- Bill savings
- Expected payback period and internal rate of return after installing DERs
- Demographics of customers, including income level and race/ethnicity

[4] The primary objective of this study is to evaluate the cost-effectiveness of DERs taking service under NEM 2.0. Comparisons between NEM 1.0 and NEM 2.0 will be limited to literature review of prior NEM cost-effectiveness studies. The Itron team will not perform any cost-effectiveness test for the NEM 1.0 tariff.

- Geographic distribution of systems, including an analysis of the number of installations in Disadvantaged Communities as identified by the California Communities Environmental Health Screening Tool (CalEnviroScreen)[5]
- Number of DER manufacturers, project developers, and installers in California

III. SUMMARY OF APPROACH

a. Definitions

The following definitions are used throughout this research plan and are provided below for clarity:

- Production: The amount of energy (kWh_{AC}) generated from on-site generators (e.g., solar PV, fuel cells) during any given time period (e.g., hourly, daily, monthly).
- Energy Storage Charge/Discharge: The amount of energy (kWh_{AC}) leaving (discharge) or entering (charge) a battery storage system inverter.
- Utility Energy Delivered: The total energy (kWh) delivered by the utility to the customer during a given time period. Utility energy delivered is equivalent to Customer Energy Imported.
- Utility Energy Received: The total energy (kWh) received by the utility from the customer during a given time period. Utility energy received is equivalent to Customer Energy Exported.
- Consumption: The total energy (kWh) consumed by a home during a given time period. Energy consumption is equivalent to energy usage and gross load.
  - $Consumption = Utility\ Delivered + Production - Utility\ Received$
  - $Consumption = Customer\ Import + Production - Customer\ Export$

b. Overview

The NEM 2.0 evaluation will be divided into three main areas:

1. **Analysis of NEM 2.0 systems.** The Itron team will collect utility interconnection data to define the population of NEM 2.0 systems interconnected through the end of 2019. This will allow us to answer questions like: Are systems installed under NEM 2.0 materially different from NEM 1.0 systems in size, orientation, or otherwise?
2. **Cost-effectiveness analysis of NEM 2.0.** The Itron team will build a model that quantifies the cost-effectiveness of NEM 2.0 for participants, rate payers, Program Administrators, and society

[5] https://calepa.ca.gov/envjustice/ghginvest/

based on the SPM tests and consistent with CPUC D.19-05-019. Two additional sub-tasks will feed into this analysis:

a. **Analysis of generation and storage charge/discharge data.** The Itron team will leverage existing data sources and simulation tools to develop typical DER generation profiles with and without energy storage for use in the analysis.

b. **Analysis of utility billing and interval load data.** The Itron team will develop a set of residential and nonresidential load profiles that are representative of the statewide NEM 2.0 population to be used in the analysis.

3. **Cost of service analysis of NEM 2.0.** The Itron team will perform an analysis to compare the actual bill payments that NEM 2.0 customers make to an estimate of the utility costs needed to serve the customers.

c. Analysis of NEM Interconnection Data

The first step will be to characterize the population of NEM 2.0 systems interconnected by PG&E, SCE, and SDG&E. We will issue a data request to PG&E, SCE, and SDG&E and develop a comprehensive statewide dataset for all systems interconnected on or before December 31, 2019. This dataset will form the basis of the NEM 2.0 evaluation.

System Characteristics

Part of this study will require developing an understanding of NEM system characteristics such as system size, tilt, azimuth, and mounting configuration. Some fields, like system size, are likely well populated in the interconnection datasets, whereas others like tilt or azimuth may not be. We will attempt to fill these gaps using additional data sources like program application databases (e.g., California Solar Initiative (CSI), Solar on Multifamily Affordable Housing) in order to generate as robust a dataset as possible. This will allow us to quantify size and configuration differences between NEM 1.0 and NEM 2.0 systems.[6]

Demographic Distribution

The demographic trends for NEM PV adoption will be based on the American Community Survey (ACS)[7] datasets available through the Census Bureau. We will cross map the location of each system in the

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[6] The comparison of NEM 1.0 to NEM 2.0 systems will leverage information from the analysis of the California Solar Initiative (CSI). Many, though not all, PV systems installed under NEM 1.0 were incentivized through the CSI. Very few, if any, NEM 2.0 PV systems were incentivized through the CSI. The Itron team will not be requesting NEM 1.0 interconnection data from the IOUs.

[7] https://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml.

interconnection dataset to the census tract that shares demographic indicators over a relatively homogenized population.[8] The data contain several key indicators relevant to solar adoption such as:

- Median household income
- Median home value
- Home ownership (as percent of owner-occupied units)
- Education (as percent of population over 25 years) with high school or higher and bachelors and professional degrees
- Median age
- Race (percent of non-white population including single race and two or more races)

We will also map the location of each system to the top 25 percent scoring census tracts identified by the CalEnviroScreen tool.[9] CalEnviroScreen identifies disadvantaged communities (DACs) that are disproportionately burdened by, and vulnerable to, multiple sources of pollution.

d. Cost-Effectiveness Analysis of NEM 2.0

i. Analysis of Generation and Storage Charge/Discharge Data

A key input in the cost-effectiveness analysis will be DER generation and storage charge/discharge shapes that are representative of real-world operations. For this analysis, we will leverage all available metered data sources (e.g., CSI Impact Evaluation, Self-Generation Incentive Program Impact Evaluation) to develop representative generation profiles of NEM 2.0 systems, as well as charge/discharge profiles for systems paired with storage. This will help us develop a realistic depiction of how DER generation and storage charge/discharge is taking place relative to customer load and TOU retail rates.

ii. Load Shape Selection

Hundreds of thousands of DER systems have been interconnected since PG&E, SCE, and SDG&E transitioned to NEM 2.0. Rather than model the cost-effectiveness of DERs for each customer, we will select a set of prototypical load shapes that represent the overall NEM 2.0 population. The NEM interconnection list will be combined with utility billing and load research data to identify characteristics shared between customers and develop representative load shapes. Various combinations of these

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8 Note that when merging the NEM population datasets to ACS census tracts, we can only describe the neighborhoods in which NEM customers are present. Census tracts can include hundreds of thousands of households, and not all customers in those census tracts will be NEM customers.

9 https://oehha.ca.gov/calenviroscreen/report/calenviroscreen-30.

characteristics will be used to form groupings, or bins, of customers. The key characteristics that might define the bins include:

- Utility service territory and baseline territory
- Utility rate schedule and grandfathering status
- Enrollment in the California Alternate Rates for Energy (CARE) and Family Electric Rate Assistance (FERA) programs
- Customer rate class or sector
- Location, such as California Building Climate Zone
- Annual energy consumption and load factor
- Fraction of energy consumption covered by PV system

We will combine the available data for customers within each bin to create average sub-hourly (i.e., 15-minute) generation and usage profiles. These profiles will have weights associated with them such that cost-effectiveness and cost of service metrics can be aggregated and estimated at the population level.

To create the representative profiles that will serve as inputs to the analysis, we will first analyze NEM customer data received from the IOUs to develop distributed generation (DG) system performance profiles.

Solar PV Modeling

Using the system installation characteristics, the PV_LIB modeling toolbox, and NSRDB[10] weather data, we will simulate performance for all solar PV systems (or groupings of systems with similar characteristics) for which metered data are not available for all years being evaluated.[11] Simulations will account for system location, size, tilt, azimuth, and mounting method (e.g., fixed, single/dual axis tracking). These simulations will be based on typical meteorological year (TMY) weather and will incorporate all the learnings from the Final CSI Impact Evaluation Report (e.g., observed degradation rates, capacity factors).

Storage and PV + Storage Modeling

Storage systems will be modeled based on the characteristics of the system (e.g., size, duration), customer load shape, and retail rate. For residential customers without demand charges, the storage

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10 https://nsrdb.nrel.gov/

11 Itron will use PV_LIB toolbox to model solar PV generation. The PV_LIB Toolbox provides a set of well-documented functions for simulating the performance of photovoltaic energy systems. The toolbox was developed at Sandia National Laboratories. https://pvpmc.sandia.gov/applications/pv_lib-toolbox/

system will be modeled to perform TOU arbitrage (e.g., charge during low cost off-peak hours and discharge during high cost on-peak hours). For systems paired with PV, we will model systems with a PV-charging constraint, which is consistent with behavior observed in the 2018 Self-Generation Incentive Program (SGIP) Energy Storage Impact Evaluation Report. This is also a requirement in order to fully capture the Federal Investment Tax Credit (ITC), which we will model as well.

For nonresidential customers on rates with demand charges, we will model storage as primarily performing demand charge reduction. Rather than model ideal dispatch, which can over-estimate bill savings, we will take the observed bill reductions from the 2018 SGIP Energy Storage Impact Evaluation Report.

Modeling of Other DERs

For other DERs, like fuel cells and distributed wind, we will rely on historical SGIP data and the 2016–2017 SGIP Impact Evaluation Report to develop representative generation profiles. For example, a fuel cell would have a flat generation profile at a fixed capacity factor. Wind generation profiles can be developed using National Solar Radiation Database (NSRDB) data and turbine sizing information.

Consumption Calculation

We do not expect the utilities to have visibility into customer consumption. Instead, we will receive information from the utilities on energy delivered and energy received. Consumption must be calculated by adding PV production and storage charge/discharge to the energy delivered by the utility and subtracting the energy received from the utility. Once the system generation (production) and storage charge/discharge profiles are created, we will develop energy consumption profiles for each representative bin by adding the DER profiles back to the utility data. The consumption profile will form the basis of the baseline conditions. The load shape with the impact of DER built in serves as the "treatment" case, or the case with NEM 2.0. The difference in bill payments (accounting for any changes in tariff) and avoided costs associated with each shape will form the basis of the cost-effectiveness analysis.

iii. Cost-Effectiveness Analysis

Following analysis of NEM interconnection data, DER generation data, storage charge/discharge data, and utility load data, we will have developed a set of representative cases that will form the basis of Itron's cost-effectiveness analysis. Each case will have a load shape, tariff, and DER associated with it and will represent a fraction of the population. Itron will customize a version of Itron's cost-effectiveness model used for SGIP battery storage cost-effectiveness to conduct the analysis and conduct an analysis consistent with the SPM tests.[12] Itron's DER cost-effectiveness model was first developed in 2011 to evaluate the cost-effectiveness of all SGIP eligible technologies. It was updated in 2015 to reflect changes in technology costs and eligible technologies. In 2019 Itron updated the model again with an exclusive focus on energy storage costs and benefits.

Itron's DER cost-effectiveness tool is a highly flexible economic model that quantifies the various cash flows associated with the acquisition and operation of DERs including solar PV, solar thermal, combined heat and power (CHP), fuel cells, and energy storage. The model calculates the bill impacts of technologies throughout their lifetime and the associated acquisition costs including financing, insurance, and tax costs (or credits). Looking from different perspectives, the model will quantify the changes in the utility's marginal operating costs and will consider incentive payments and program administration/interconnection costs. The model will quantify the present value of all cost and benefit streams for the entire life of the technology, accounting for changes in retail rates, technology capital and operating costs, and changes in utility marginal costs. If necessary, we can also report on first year-only results to eliminate the uncertainty associated with forecasting marginal costs and retail rates. This will be particularly important if the Itron team ultimately moves forward with the 2019 Avoided Cost Calculator inputs – reporting first-year results separately will allow us to eliminate the uncertainty associated with certain assumptions such as the forecasted avoided costs in the calculator.

For this analysis we propose making the following updates to the DER cost-effectiveness model:

- **Load shapes.** Residential and nonresidential customer load shapes will be selected to be representative of the NEM 2.0 population as described above.
- **Retail rates.** We will select the most appropriate retail rates that represent the NEM 2.0 population based on the information received from the IOUs. We will account for all rate modifiers like the California Alternate Rates for Energy (CARE) Program, among others. We will also factor in the correct baseline territory and account for all-electric versus gas customers. Special consideration will be given to baseline rates and grandfathering provisions. We cannot assume that in the absence of the NEM generator, customers would have switched to TOU rates before they are required to. Instead, we must establish the appropriate baseline rate (potentially a tiered volumetric rate for residential customers) and account for when customers would be required to transition to TOU rates. Since grandfathering provisions are highly variable, we will consider sensitivity analyses to examine the influence of rate grandfathering on overall cost-effectiveness.

[12] Itron's cost-effectiveness model was most recently updated for the 2019 SGIP Energy Storage Market Assessment and Cost-Effectiveness Report. This report is pending release and the model is not yet publicly available. A complete description of the model and its functionality are included in the 2015 SGIP Cost-Effectiveness study: https://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=7889

- **Technology characteristics.** We will define the characteristics of NEM 2.0 systems installed at each customer location based on interconnection data provided by the IOUs. Relevant metrics will include PV system size/tilt/azimuth, storage technology (e.g., lithium ion, flow battery), system size (kWh/kW), round trip efficiency (RTE), degradation rate, and capital cost assumptions. We expect that some of these characteristics will not be available from the IOU interconnection data. In these cases, we will use best available information from secondary sources like program impact evaluations or literature reviews.
- **Utility avoided costs.** We will update the cost-effectiveness model with the most recently approved and publicly available version of the CPUC Avoided Cost Calculator to develop representative marginal costs for PG&E, SCE, and SDG&E.[13] We may consider sensitivities that explore changes to the avoided costs, such as high distribution avoided cost scenarios. We will also explore additional benefits and costs associated specifically with NEM 2.0 DERs that are not accounted for in the Avoided Cost Calculator. Any benefits or costs that accrue to all DERs (e.g., energy efficiency, heat pump water heaters, smart thermostats) such as avoided methane leakage and avoided fuel volatility, are out of scope for this analysis because they could be captured in the Avoided Cost Calculator. Parties can provide input on changes to the Avoided Cost Calculator in the CPUC's Integrated Distributed Energy Resources proceeding. However, other benefits like resiliency and the ability to ride through outages are specific to PV + Storage systems. We will explore sensitivities that account for these benefits that are specific to NEM 2.0 systems. We will be careful not to double-count any benefits that are planned to be included in the 2020 version of the Avoided Cost Calculator, if those inputs are ultimately used in this analysis. The same is true of costs like distribution upgrade costs or one-time metering costs.
- **Incentive program assumptions.** We will define the incentive levels offered by programs like SGIP and the implied program administration costs to match the incentive rates offered at the time of interconnection. We may consider sensitivity analyses with and without the SGIP incentive, or with and without the increased reliability adder. These sensitivities may also be tied to technology sensitivities that include resiliency benefits that accrue to storage participants.[14]
- **Global assumptions.** We will update marginal tax rates/credits, discount rates, and other financing assumptions.

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[13] We recognize that a considerable overhaul of the CPUC Avoided Cost Calculator is expected during the first half of 2020. To the extent possible, we will attempt to include the avoided costs from the 2020 avoided cost calculator as inputs for this analysis. However, we will not delay the release of this report pending the release of the 2020 avoided cost calculator.

[14] We would model resiliency benefits with an assumed value of lost load (VLL) that appears as a benefit in the Participant Cost Test. In this scenario, we may also consider increased measured costs potentially due to a panel upgrade.

The DER cost-effectiveness model's primary purpose will be to evaluate the cost-effectiveness of customer-sited resources under NEM 2.0 using the SPM tests including, the Total Resource Cost (TRC) Test, the Participant Cost Test (PCT), the Program Administrator (PA) Cost Test, and the Rate Payer Impact (RIM) Test. Each test evaluates the tariff's cost-effectiveness from alternative perspectives, assessing the impact of the tariff on society, participants, Program Administrators, and rate payers. We will evaluate cost-effectiveness using 2019 as a base year and for the duration of the life of the systems. We will report results for the first year as well as the net present value of all costs and benefits during the life of the measure. Per CPUC D.19-05-019, we will report the cost-effectiveness using all SPM tests.

Other Financial Metrics

We will ensure that the NEM 2.0 evaluation's cost-effectiveness analysis provides stakeholders with information on first year as well as total and levelized savings and costs. The cost-effectiveness tool will develop estimates of the cost-effectiveness of systems installed under NEM 2.0 under a wide range of customer demographics, geographic strata associated with various avoided cost assumptions, solar system designs, system sizes, customer sizes, and utility rates. The stratification will be developed to highlight the range of cost effectiveness under the NEM 2.0 tariff. A weighting scheme will be developed so each cost-effectiveness run is assigned a weight that is proportional to the number of NEM 2.0 systems represented by the sample point.

The customized model will use information on system costs and the value of energy savings to develop estimates of payback periods and internal rates of return for NEM 2.0 systems. These data will provide additional information on the financial impacts of NEM 2.0 and help to describe the customers for whom the NEM 2.0 tariff is more cost-effective from the participant's perspective.

Energy, Bill, and Avoided Cost Savings

The customer's bill savings and avoided costs will be calculated based on the difference between the energy consumption shape without the DER and the net load shape with the impact of the DER. Itron will use the cost-effectiveness model's bill and avoided cost savings module to calculate energy and bill savings applying strata-specific attributes of the NEM 2.0 tariff and utility rates. We will carefully account for the customer's baseline rate when quantifying bill savings, both in the first time and over time. Working with the IOUs, we will determine appropriate rate transition dates to assign when customers change from grandfathered rates to new TOU rates. We expect there will be considerable intra-customer variability on the grandfathering provisions. We will create sensitivities to explore the effect of rate transition date on overall cost-effectiveness. We must also make assumptions about rates and potential rate increases over time. While this is a backwards-looking study, DERs are expected to have a useful life of 10–20 years and we must account for all the costs and benefits accrued during the life of the measure. Therefore, we must make assumptions about rates over time. We will consider various sensitivities to capture a range of rate outcomes and their impact on overall cost-effectiveness.

The Itron team will collect information from the utilities on rates, interconnection fees, other grid upgrade costs borne by the customer (e.g., interconnection costs and interconnection upgrade costs for projects larger than 1 MW), and non-bypassable charges applicable to NEM 2.0 customers. We will delineate the bill impact of TOU rates, demand charges, interconnection fees and costs, and non-bypassable charges. These various components of the cost-benefit calculation will be called out separately to shed light on their effect on the various SPM tests.

Program Costs

The Itron team will reach out to the utilities to acquire program costs associated with implementing the NEM 2.0 tariff. Itron will request information on the incremental costs of setting up a NEM 2.0 billing account, any one-time incremental metering costs, and any interconnection costs borne by the utility. Itron will coordinate with the utilities and the CPUC to better understand their integration costs and request data on the necessary integration costs associated with NEM 2.0.

PV and Storage Measure Costs

Itron will develop estimates of DER costs using information on the capacity and year of installation for customer-sited systems. Itron will undertake a limited literature search to refine our measure cost estimates. If NEM 2.0 has led to an increase in PV system sizing, an increase in the total cost of the system may be observed relative to previous NEM analyses. We will leverage publicly available sources like Lawrence Berkeley National Lab's "Tracking the Sun" report and SGIP application data, which includes limited cost information.[15] We will also request NEM 2.0 contract information from the IOUs or the CPUC to further ground our assessment of DER installed costs. The development of measure costs must also account for any warranty costs or one-time maintenance costs.

As this is a backwards-looking study, we will attempt to ground our assumptions on facts and attempt to describe the world as it existed when NEM 2.0 systems were interconnected. Having said that, we recognize that there is considerable variability among customers – not all storage system installations are the same. Furthermore, this analysis requires that we project costs and benefits 10–20 years into the future. This creates uncertainties that we will address using sensitivity analyses. We will consider sensitivities such as:

- The useful life of the DER. Solar PV systems are expected to last approximately 20 years without any major replacements. Energy storage systems are usually warrantied for 10 years. If the life of the measure is longer or shorter, it can affect the overall cost-effectiveness. These systems have no marginal fuel costs, so longer useful lives tend to increase the cost-effectiveness.

15 https://emp.lbl.gov/tracking-the-sun

However, unexpected system failures or degradation can also result in a shorter useful life. We will explore a high/mid/low case for measure life.

- Equipment costs, system maintenance, and warranty costs. Publicly available sources like Lawrence Berkeley National Laboratory's Tracking the Sun report and SGIP application data are useful sources for average equipment costs. However, the reality is that installation costs can vary considerably from one customer to the next. A home that requires a panel upgrade to accommodate an energy storage system will face higher upfront costs than a system that does not require a panel upgrade. We will capture this variability in installed costs with sensitivity analyses. We will explore a high/mid/low case for installed costs. This will also account for maintenance/warranty plan costs.

For the modeling of the solar and solar + storage, we will assume that customers are taking advantage of the Federal ITC. The ITC will be modeled as a benefit to the customer. In the case of storage, we will also create a constraint that the system must charge from on-site PV to capture the full value of the ITC.

e. Cost of Service Analysis

The full cost of service analysis compares an estimate of the utility cost of servicing NEM 2.0 customer with their bills. The utility cost of servicing a NEM 2.0 customer is based on their use of the grid and an allocation of the fixed costs of service. Itron will use information from the utility's General Rate Case (GRC) Phase 2, regulatory costs, and NEM customer incremental costs to help develop estimates of the cost of service for NEM 2.0 customers.

The total cost of service has inputs or components that are similar to the cost-effectiveness analysis, but it also differs from the cost-effectiveness analysis. The total cost of service estimates the cost of servicing the remaining or net load while the cost-effectiveness analysis is based on an estimate of the cost savings from the reduction in usage after becoming a NEM 2.0 customer. For the cost-effectiveness analysis, the cost savings from reduced usage will be evaluated using either a DER system's lifetime of avoided costs or a lifetime of bill savings, depending upon the specific test (TRC, PA, PCT, or RIM). The cost-effectiveness analysis requires a lifetime forecast of the avoided costs and bill savings to compare to the cost of the measure or the cost of a program. In comparison, the cost of service analysis compares the customer bill from the analysis year to costs of servicing the customer.

The cost of service analysis will reproduce, to the degree possible, the revenue allocation from the most recent GRC Phase 2 for PG&E, SCE, and SDG&E for NEM 2.0 customers. The GRC costs are the largest component of the full costs of service but not all costs are assigned through this process. Additional costs include regulatory costs and fees including, but not limited to, nuclear decommissioning charges, public purpose program charges, and Department of Water Resources (DWR) bond charges. These additional regulatory fees and charges will be added to the GRC costs along with estimates of additional costs that are unique to NEM customers. Additional costs unique to NEM customers will be requested for the utilities but will include interconnection costs, additional billing costs, and NEM application and processing costs.

GRC costs include marginal costs associated with generation energy and capacity costs, marginal transmission and distribution capacity costs, and marginal customer and new business access costs. The Itron team will work with the utilities to develop a fuller understanding of costs, formulas, and data associated with each utility's GRC Phase 2 costs to ensure appropriate cost development. The utility marginal costs will be multiplied by the NEM account's costing determinants, including hourly energy usage, peak demand coincident with generation, transmission and distribution peaks, and their maximum demand. The equal percentage marginal costs (EPMC) scalar factors will be obtained from the utilities and applied to their respective marginal costs to ensure that estimated costs are consistent with revenue responsibility levels. We will work with each utility to reproduce their GRC Phase 2 methods as closely as possible.

Itron will work with the CPUC to develop appropriate scenarios associated with the cost of service analysis. These scenarios may be based on the use of net load vs. consumption as was undertaken for the previous NEM cost of service analysis. For costs that are based on quantity, such as generation costs, costs should be based on net load. For costs that are based on potential usage, it may be better to use consumption. Itron will review scenarios using net load as a low-cost case for transmission and distribution costs and consumption as a high-cost case for these costs.

The cost of service will be compared to the customer bills. The billing costs will use similar components developed for the cost-effectiveness analysis. The customer bill cost will be based on the net load.

V. PROJECT TIMELINE

The NEM 2.0 evaluation study will be completed and delivered to the CPUC Energy Division no later than June 30, 2020. Below we provide various interim milestones leading up to the conclusion of the study:

- November 27, 2019: Draft Research Plan released
- December 6, 2019: Public workshop on Draft Research Plan
- December 20, 2019: Informal comments due on Draft Research Plan
- January 2020: CPUC Energy Division and Itron respond to comments on Draft Research Plan
- January to February 2020: Director of CPUC Energy Division approves Final Research Plan through letter to NEM service list
- TBD before June 30, 2020: Draft NEM 2.0 Evaluation Report
- TBD before June 30, 2020: Workshop on draft report
- On or after June 30, 2020: Final report and webinar on final report

FINAL RESEARCH PLAN – COMMENTS DISCUSSION

The NEM 2.0 Lookback Study Draft Research Plan was released by Energy Division on November 27, 2019. A public workshop on the Draft Research Plan was held at the CPUC on December 6, 2019. Energy Division requested informal comments on the Draft Research Plan by December 20, 2019. Informal comments were received from Solar Rights Alliance (SRA), Coalition of California Utility Employees (CUE), California Public Advocates Office (CalAdvocates), Solar Energy Industries Association (SEIA), California Solar and Storage Association (CALSSA), Vote Solar, Sunrun, the Joint Investor-Owned Utilities (IOUs) (i.e., PG&E, SCE, and SDG&E), and Solar Consumer Advisor.

Below we provide a summary of the comments received and a brief discussion of Energy Division's and the Itron team's response to the comments. These comments serve as a companion to the Final Research Plan, which has incorporated all changes deemed necessary to the Draft Research Plan. Comments are grouped by overarching topic.

I. TERMINOLOGY

SCA, SEIA, CALSSA, and Vote Solar requested that Itron clarify terminology used in the Draft Research Plan. SCA asked Itron to clarify that production was production from PV, consumption was total site consumption of electricity, draw is defined as the site's import of electricity from the grid, and return is defined as the site's export of electricity to the grid. Itron has included a terminology section in the Final Research Plan. In the terminology section, production is now defined as the production of electricity from PV, and consumption is defined as the consumption of electricity by the site. Itron has provided two equations to calculate consumption. One equation describes electricity from the utility's point of view using utility-delivered and utility-received electricity, while the second equation describes electricity from the customer's point of view using customer-imported and customer-exported electricity. These equations are identical. While Itron has not adopted SCA's use of Draw and Return, the terms used in the Research Plan have been clarified.

$$Consumption = utility\ Delivered\ kWh + PV\ produced\ kWh - utility\ Received\ kWh$$

$$Consumtion = customer\ Imported\ kWh + PV\ produced\ kWh - customer\ Exported\ kWh$$

$$Net\ Load = utility\ Delivered\ kWh - utility\ Received\ kWh$$

$$Net\ Load = customer\ Imported\ kWh - customer\ Exported\ kWh$$

II. THE AVOIDED COST CALCULATOR

The NEM cost-effectiveness analysis relies on avoided costs to calculate the benefits for the TRC, PA, and RIM tests. The CPUC and E3 are in the process of updating the Avoided Cost Calculator (ACC) for 2020. The update is scheduled to be completed by Q2 2020. SRA, Sunrun, CUE, SEIA, CALSSA, and Vote Solar all commented to express their desire for the cost-effectiveness analysis to incorporate the 2020 update of the ACC. In the comments from SEIA, CALSSA, and Vote Solar they "urge Itron and the staff not to base the cost-effectiveness element of this study on the flawed 2019 ACC. To the extent that the 2019 ACC is used, it should be limited to indicative analyses of first-year costs and benefits."[16]

The Joint IOUs also commented on the 2019 ACC, noting that the "2019 ACC's modeling assumptions do not necessarily reflect the IOUs' marginal costs." Even with the agreed-upon need to update the ACC, the IOUs state that they "encourage Itron to develop its analysis such that it can readily accept the results of the 2020 ACC when available, this study should proceed as scheduled. If time allows the 2020 ACC to be incorporated into this study, those results should be used. If not, the 2019 ACC should be used without selective alteration."[17]

It is critical that the NEM 2.0 Lookback Study be completed on time so that the CPUC can begin development of the successor tariff. Given the timing of this study and the ACC update, Itron will move forward using the 2019 ACC. Itron will develop the model so that the 2020 ACC results can be easily incorporated into the model, assuming the ACC outputs are in a similar format to the 2019 ACC outputs. If the 2020 ACC results are ready within the appropriate timeline for this study, Itron will incorporate them into the model.

SEIA, Vote Solar, and CALSSA suggest that if it is necessary that the 2019 ACC be used, it should be limited to using an hourly profile that is based on the 2018 CAISO prices that would not assess the full lifecycle cost-effectiveness. Itron has interpreted this to imply a desire to develop an estimate of cost-effectiveness in 2019 from first-year avoided cost compared to other DER costs. Given the substantial measure costs in the TRC and the potentially large integration cost in the PA and RIM tests, it may be necessary to annualize these costs to develop reasonable estimates of first-year TRC, PA, and RIM test estimates that compare first-year costs and benefits. This request may be similar to the IOUs' request for a first-year RIM test. If Itron understands the request correctly, Itron agrees that there is value in presenting the first year of these calculations.

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16 Informal Comments of the Solar Energy Industries Association, The California Solar & Storage Association, and Vote Solar on Draft NEM 2.0 Study Plan, Page 6.

17 Joint IOUs Informal Comments on December 6, 2019 Workshop on the NEM Successor Tariff Evaluation Research Plan, Page 1-2.

III. NEM 1.0 VERSUS NEM 2.0 SYSTEM CHARACTERISTICS

The NEM 2.0 evaluation requires that Itron determine if systems installed under NEM 1.0 and NEM 2.0 are similar or systematically different. Itron has proposed to use information included in the IOU interconnection datasets, including the system size, tilt, azimuth, and mounting configurations. SCA comments that our approach "will not produce meaningful results". SCA correctly states that "all kinds of variables affect size and configuration differences". Itron does not have access to many of the variables that affect size and configuration; thus, we will use the information that is available.

Itron has extensive experience working with the IOU interconnection data and will compare the system characteristics in the interconnection data across NEM 1.0 and NEM 2.0 systems. Itron will also compare these data to available customer usage data (net load and customer consumption data if available). This approach will allow the study to determine if the systems differ following the implementation of NEM 2.0 or if the relationship between system characteristics and available customer usage data differ following the implementation of NEM 2.0.

The comparison of system characteristics under NEM 1.0 and NEM 2.0 is not intended to determine the change in the optimal size of systems associated with the change is rates. The comparison of system characteristics under NEM 1.0 and NEM 2.0 is intended to determine if/how PV systems have changed over this time period. The NEM tariff is only one of many things that have changed over this time period. Determining the optimal PV size under alternative tariffs and determining what has contributed to observed changes in PV characteristics is outside the scope of this evaluation.

IV. NEM 1.0 VERSUS NEM 2.0 COST-EFFECTIVENESS

The Joint IOUs state that "evaluating the successor tariff program in a vacuum without regard for the impact of the original tariff will fail to assess the cumulative impacts of the NEM program as a whole, as well as make it difficult, if not impossible, to truly understand if the successor tariff satisfies AB 327's express statutory requirements."[18] The scope of the NEM 2.0 cost-effectiveness and cost of service evaluation does not include a rigorous evaluation of the cost-effectiveness of the NEM 1.0 tariff. The results from the previous evaluation of the NEM 1.0 cost of service and RIM test results will be compared with those found during the NEM 2.0 evaluation. The comparison will look at how changes in different inputs have contributed to differences in the results from these two analyses.

[18] Ibid, page 1

V. SEGMENTATION OF CUSTOMER CHARACTERISTICS OR CUSTOMER BINNING

To characterize the cost-effectiveness and cost-of-service of customer-sited DERs and the NEM 2.0 tariff for alternative customer groups, it is necessary to develop data on customer consumption and net load shapes. These data will be used to develop estimates of bill and avoided cost savings from the installation of DERs and to develop estimates of post-installation bills and cost-of-service. SCA, CalAdvocates, SEIA, CALSSA, Vote Solar, and the Joint IOUs commented that Itron needs to provide more information on the customer characteristics for the binning of customers. The Joint IOUs suggested that the segmentation be extensive, but they also understand the need to balance segmentation against analytical complexity. The Itron team agrees with the need for balance, adding that the desire for and cost of extensive segmentation also needs to be balanced against the value of the benefits from segmentation. Segmentation that incorporates all available rate options may lead to marginally more accurate results but provide little benefit if few or no customers on NEM 2.0 previously took (baseline) or currently take service on a particular rate.

Itron agrees with the Joint IOUs that segmentation should include information on utility, technology type, the most common rate schedule taken by customers within each customer type, be dependent on grandfathering status, customer baseline territory or climate zone, customer consumption bins (usage), load factor bins for non-residential customers, and the size of the DER relative to the customer consumption. The exact rate, consumption characteristics, DER size, and load factor attributes will be determined after combination and review of the interconnection and customer usage information. The binning and calculation of cost-effectiveness will include estimation by customer type including, but not necessarily limited to, residential, small commercial, medium/large industrial and commercial and agricultural customers.

CalAdvocates suggested that the cost-effectiveness analysis include segmentation by customer class, disadvantaged community status, and customer characteristics that include home ownership and median household income. Itron will include customer rate information including CARE and FERA in the cost-effectiveness customer segmentation. Customer home ownership and median household income are not currently included in the list of likely customer segmentation variables. Itron understands the interest in DER cost-effectiveness by customer economics but believes that segmentation by CARE and FERA will incorporate much of the information associated with cost-effectiveness and customer economics.

VI. RATEPAYER IMPACT TEST (RIM)

The Draft Research Plan mistakenly described the RIM test as detailing the costs and benefits of the non-participant when it would more accurately be described as the costs and benefits of all ratepayers. This incorrect description has been updated in the Final Research Plan.

The Joint IOUs also stated that "it is important to evaluate the successor tariff program from the TRC, RIM, and PCT perspectives, but the final research scope should clarify that the RIM test, not TRC, is the more meaningful test in the context of this evaluation. The TRC evaluates technologies, not tariffs, and is intuitively of less use in the context of NEM."[19] While Itron agrees that the RIM test is an effective test when evaluating a tariff, the cost-effectiveness of the tariff is not the only objective of this evaluation. The RFP requests a "lookback evaluation of the NEM successor tariff to analyze the costs and benefits of customer-sited resources taking service on the NEM successor tariff." Discussions between Itron and the CPUC have led to the Research Plan scope that includes a cost-effectiveness evaluation of the customer-sited resource or technology on the NEM successor tariff, which is accomplished using the TRC, PCT, and RIM perspectives. The TRC and PCT test values will help to describe the cost and benefits of customer-sited resources from society's and the participant's point of view. These objectives are consistent with the RFP's request for estimates of payback period, internal rate of return (IRR), and an overall assessment of DER economics. The TRC, PCT, and the additional metrics requested in the RFP help to describe the strength of the DER marketplace under the NEM 2.0 tariff. The evaluation will also produce the cost-effectiveness of the tariff, which is effectively accomplished using the RIM test. Careful consideration of all the SPM cost-effectiveness tests will present relevant information from multiple points of view and Itron is not taking a position on which test's outcome is most meaningful for this research.

The Joint IOUs also requested that Itron present the cost shift associated with the NEM successor tariff program in 2020. If Itron correctly understands this request, the IOUs are asking Itron to report on the first-year RIM benefits and costs. Itron sees value comparing the first-year avoided cost benefits and the bill saving costs, but the RIM costs also incorporate other program costs including potential interconnection costs, marginal billing and accounting costs, and potential marginal grid update costs. These additional RIM costs are likely presented as first-year upfront costs that would need to be annualized or abstracted from for this comparison. Given the annualization of these first-year program costs, Itron agrees that there is value in presenting the first year of the NPV calculations. CalAdvocates has requested that the analysis report the total magnitude (in dollars) of the lost revenues associated with NEM customers. This is an output of the cost-effectiveness model and this information will be presented.

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19 Ibid, page 2.

VII. PROGRAM EVALUATION, DEMOGRAPHICS, AND SYSTEM CHARACTERIZATION

The Joint IOUs requested that Itron be careful in our use of the American Community Survey (ACS) to characterize NEM 2.0 customers. Itron agrees that care is needed in the use of these data and the characterization of the results. Itron will carefully review these data as part of the program description and how systems are distributed by customer demographics, income, and ethnicity/race. Itron will also review these findings with the observed geography distribution of systems, including the number of installations in disadvantaged communities. Itron has experience combining the ACS with California DER customer data through the CSI evaluation. Comparing the earlier distribution of CSI installations with those installed under NEM 2.0 will be facilitated by the income and demographic information derived from the recent CSI evaluation.

In the Joint IOUs' comments on additional attributes that could impact the cost-effectiveness results they included the Federal Income Tax Credit (ITC), incentives, and financing methods. During the data request process, the IOUs have verified that few, if any NEM 2.0 customers received CSI incentives. Other programs such as SGIP, Single-Family Affordable Solar Homes (SASH), Multifamily Affordable Solar Housing (MASH), or the New Solar Homes Partnership (NSHP) may have impacted the cost effectiveness of BTM PV or PV and storage systems. Itron will include these potential incentive streams in a sensitivity analysis. Itron also has experience with including the ITC in cost-effectiveness analyses and will use a sensitivity scenario to determine how the lack of the ITC could impact the cost-effectiveness for tax-exempt public agencies and some low-income individuals. Additionally, Itron has experience using the cost-effectiveness model to simulate the cost-effectiveness under alternative financing arrangements. Itron will work with the CPUC to determine the most effective financing scenarios to examine.

CalAdvocates requested that information on financing options and the number of customers who have entered financing arrangements that extend 15–20 years be included in the demographic and system characterization. Itron will review the information that is available in the interconnection dataset. It is currently not clear if these data are available. To the extent that they are reliably available, Itron will report on these questions. It is unlikely that the number of customers who have entered into longer financing arrangements will be a meaningful statistic given the likelihood of a large share of missing data, but Itron will report on the share of customers with these arrangements if the data are sufficiently robust.

VIII. DER COSTS

The TRC and the PCT include the technology measure costs and maintenance costs in the denominator. SCA and the Joint IOUs provided comments concerning the source of measure, installation, and maintenance costs. The Joint IOUs also pointed out that the interconnection database now collects information on measure costs on behalf of the CPUC. Itron agrees that it is very important that these various costs be well grounded, and we will request the available DER costs from the CPUC to better ground our estimates. Itron will also look to reports by the National Renewable Energy Laboratory, Lawrence Berkeley National Lab, Energy Sage, Greentech Media/Wood Mackenzie, Lazard, and Bloomberg New Energy Finance. The technology, installation, and maintenance costs will be carefully analyzed and clearly presented in the models and reports. Itron will be transparent, clearly reporting the input values and sources. The measure, installation, and maintenance costs are also likely attributes for sensitivity analyses.

CUE also expressed the desire that the cost-effectiveness calculations include the cost of fraud. Itron will investigate how to include an estimate of how fraud impacts the cost of customer-sited generation in the model. Fraud could be included in a sensitivity analysis, potentially as an increase to the measure cost.

IX. GREENHOUSE GAS ABATEMENT COST PERSPECTIVE

The Joint IOUs requested that Itron report the results of the SPM cost-effectiveness tests from a greenhouse gas (GHG) abatement cost perspective. Itron has experience presenting costs and benefits from a GHG abatement cost perspective. The characterization of cost and benefits from a GHG perspective, however, is not directly in the scope of this project. The CPUC's Integrated Resource Planning (IRP) proceeding is a better venue to analyze GHG abatement costs.

X. SOLAR PV SIMULATION APPROACH

In the Draft Research Plan, Itron asked if the PVLib toolbox should be used to develop solar profiles. The Joint IOUs expressed support for using a public tool but also had concerns that PVWatts (one of the solar production models available in PVLib) tends to overestimate actual PV production when compared with IOU-specific customers. Itron has experience using PVLib in Python to implement PVWatts. We plan to modify the inputs to the model so that they reflect what has been learned from Itron's evaluation of the CSI program. Itron will work with the IOUs to ensure that the solar production files produced by the updated version are representative of actual customer segments within each utility.

XI. COST OF SERVICE ANALYSIS

For the cost of service analysis, Itron will follow the Energy Division's guidance on General Rate Case sources of information. The current plan is to use each IOU's most recently approved General Rate Case Phase 2. SEIA, CALSSA, and Vote Solar expressed a concern with using the results of the GRC Phase 2 as different parties had proposed different marginal costs and hourly allocations. While Itron appreciates SEIA, CALSSA, and Vote Solar's concerns, the cost of service analysis is an approximation by its very nature. It is important that the analysis use readily available values. While the development of the input values may not always be transparent, the use of approved values increases the transparency of the study.

The cost of service analysis will also use the Equal Percentage of Marginal Cost Scalar for each utility and cost component. This approach is consistent with decades of California ratemaking practice. The rates used to calculate customer bills in the cost of service analysis will reflect the NEM 2.0 rates that customers are receiving service on at the end of 2019.

The Joint IOUs requested that the cost of service analysis use the TOU time dimension for calculating bills. For the cost of service analysis, Itron will develop estimates of NEM 2.0 customer bills for 2019. If the customer or group of customers is on a TOU rate, the customer bill will be developed using the TOU time dimensions and rates. If the customer or group of customers is on a grandfathered rate that is a tiered rate or a rate with grandfathered TOU periods, their rate attributes will be used to develop estimates of their bills for 2019. The cost of service analysis for 2019 will be based on the comparison of estimates of customers' 2019 bills and the most recently approved GRC Phase 2.

XII. ADDITIONAL COSTS AND BENEFITS BEYOND THE AVOIDED COST CALCULATOR

SEIA, CALSSA, and Vote Solar requested that Itron consider additional benefits that customer-sited net metered systems provide. They listed avoided fuel volatility, avoided methane leakage, reliability and resilience benefits and grid services. Itron consulted with Energy Division and ultimately decided that any benefits or costs that accrue to all DERs (e.g., energy efficiency, heat pump water heaters, smart thermostats), such as avoided methane leakage and avoided fuel volatility, are out of scope for this analysis because they could be captured in the Avoided Cost Calculator. Parties can provide input on changes to the Avoided Cost Calculator in the CPUC's Integrated Distributed Energy Resources proceeding. Other benefits that are specific to NEM 2.0 DERs, such as the ability of energy storage to provide resiliency benefits, can be considered in scope. We have updated the Research Plan to include a discussion of these benefits as sensitivities. The Itron team will work closely with Energy Division to ensure consistency across other rulemakings and the appropriateness of extraneous costs and benefits.

XIII. INTEGRATION COSTS

Itron has reached out to the IOUs to develop estimates of their interconnection costs and additional integration marginal costs associated with BTM DERs that should be incorporated into a cost-effectiveness analysis. Itron will work with the CPUC to determine the appropriate costs and how to allocate these costs to different NEM 2.0 customers.

SEIA, CALSSA, and Vote Solar requested that Itron review the integration costs associated with the CAISO and the WECC utilities. Itron will review these costs and compare them to what is provided by the IOUs. Itron will discuss with the CPUC the need for sensitivity scenarios associated with these costs if the costs provided by the IOUs differ substantially.

CalAdvocates has suggested that Itron consider adding an additional cost associated with the increased marginal cost needed to service the late afternoon ramp created by BTM generation. They suggested that the ramping costs could be “based on flexible RA prices included in the Energy Division’s publicly available Resource Adequacy report. The development of an additional RA costs for the TRC, PA, and RIM test could be incorporated into a sensitivity analysis.