Opinion Dynamics

BUILD AND TECH EVALUATION

COST EFFECTIVENESS MEMORANDUM

APRIL 16, 2026

Boston | Portland | San Diego | San Francisco

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I. INTRODUCTION

As California continues to expand building decarbonization offerings in pursuit of statewide climate goals, it is critical that programs with similar objectives and outputs rely on consistent impact estimation and monetization protocols.[1] Consistent assessments documenting each program's relative costs and benefits will enable policymakers to refine and optimize the suite of decarbonization offerings while minimizing ratepayer and taxpayer financial burden to the fullest extent possible. The energy industry should take this opportunity to reconsider the most appropriate metrics to track and compare building decarbonization program performance.

Currently, there is no specific California protocol for measuring the cost-effectiveness of decarbonization programs. While there is significant precedent for evaluating the cost-effectiveness of energy efficiency programs in California and directives for distributed energy resource (DER) programs in general, these practices may not all be directly applicable to building decarbonization programs or non-ratepayer-funded programs.

Opinion Dynamics, as the BUILD and TECH[2] developmental[3] independent evaluator, is charged with reviewing the existing cost-effectiveness evaluation frameworks for California's suite of ratepayer-funded programs to propose a cost-effectiveness measurement approach that aligns with the various program and policy goals set by SB 1477. This memorandum summarizes the existing California benefit-cost analysis (BCA) policy landscape and defines the BCA protocols, methodologies, and inputs applicable to the SB 1477 programs. We also comment on where the existing BCA frameworks, which are rooted primarily in California's extensive precedent of administering energy efficiency (EE) programs, may require innovations or adjustments to better value decarbonization programs, as well as highlight areas where BCA precedents offer potentially conflicting guidance on appropriate BCA practices for the SB 1477 programs.

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[1] Monetization in this context refers to the conversion of impacts, represented in native units such as kWh, therm, or greenhouse gas impacts, into dollars through the application of avoided cost factors or other valuation inputs.

[2] The Building Initiative for Low Emissions Development (BUILD) Program, along with the Technology and Equipment for Clean Heating (TECH) Initiative, were authorized under Senate Bill (SB) 1477 (Stern, 2018) and established by the CPUC in D.20-03-027. These two decarbonization pilot programs "are designed to develop valuable market experience for the purpose of decarbonizing California's residential buildings in order to achieve California's zero-emissions goals." (D.20-03-027 at 2).

[3] Developmental evaluation integrates third-party evaluation directly into a program's design, implementation, and reporting processes. Its purpose is to support evidence-based decision-making and deliver near real-time feedback that drives continuous improvement. This approach is particularly valuable for new, evolving programs and market transformation initiatives. Because program elements and priorities may shift over time, it is essential to have an evaluation process that remains flexible and adaptable throughout the program's lifecycle. For the evaluation of TECH, we used our Whole Independent Systems Evaluation Approach™ (WISE™), integrating evaluation within the program design, implementation, and reporting processes in this way supports evidence-based decision-making and continuous improvement.

1.1 RESEARCH QUESTIONS

This memo addresses the following cost-effectiveness research questions.

1. What current EE cost-effectiveness analysis practices and methodologies are most relevant for evaluating building decarbonization programs or measures in California? What are the relevant CPUC decisions, historical precedents, and natural corollaries (e.g., fuel substitution through energy efficiency portfolios), and how would energy efficiency precedent suggest these be applied to evaluate the cost-effectiveness of building decarbonization programs?
2. What program or policy goals should be reflected in a building decarbonization-specific cost-effectiveness framework? How, if at all, should abatement cost be considered in a building decarbonization cost-effectiveness framework?
3. What, if any, key value streams would be missing or mischaracterized if the energy efficiency cost-effectiveness framework were applied unmodified to building decarbonization? Where are there gaps in the data? What costs should be included in the calculation of abatement cost?

1.2 RESEARCH TASKS

To address these research questions, we conducted the following research tasks:

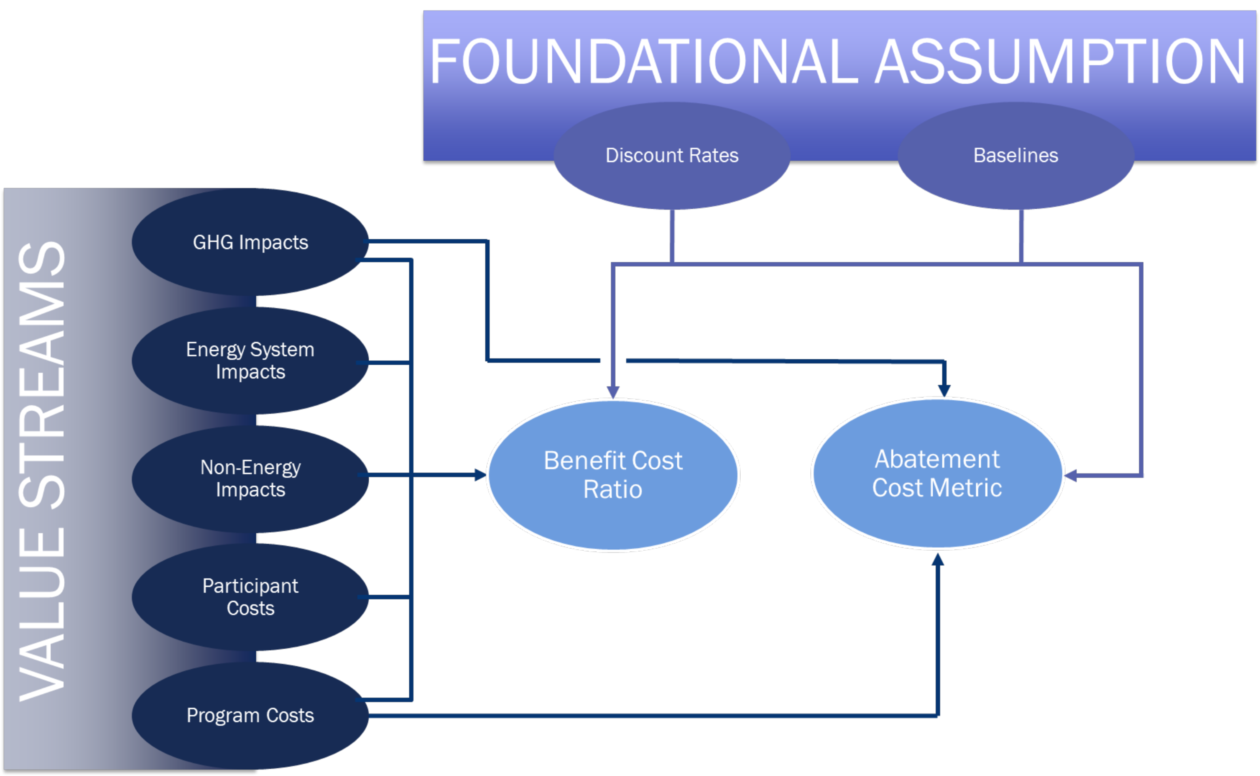
- Reviewed existing energy efficiency policy language, public reports, and regulatory decisions and documented their application to building decarbonization and the BUILD and TECH pilots, given that these pilots are focused on market transformation.
- Based on the above, identified a list of potential cost and benefit value streams, associated metrics, and foundational assumptions that collectively form a BCA framework. This BCA framework reflects what energy efficiency precedent suggests could be applied to BUILD and TECH.
- Identified gaps that would exist if this BCA framework were applied unmodified to building decarbonization programs and recommend changes or innovations in evaluation approaches or methods.

2. BCA FRAMEWORK

As building decarbonization programs like BUILD and TECH continue to expand in number, scope, and budget across California and the nation, we should take this opportunity to rethink the role of cost-effectiveness analysis in decarbonization program evaluation. Often, as seen with BUILD and TECH, new legislation and funding sources create opportunities to reevaluate the standard practices that have long been used in our industry. This is a chance to be intentional about which practices we should maintain and which ones need to evolve to meet the current needs of regulators, program administrators, and evaluators.

This section presents our two proposed BCA metrics, two foundational assumptions, four value streams, and shows how they relate (Figure 1). In the following sections, we explore each BCA metric, foundational assumption, and value stream in further detail. Although not a component of our proposed BCA Framework, the recommendations we make for each foundational assumption and value stream could significantly impact the calculation of the Total System Benefits (TSB) achieved by BUILD and TECH. Throughout the memo, we identify decision points that will would have the most significant impact on the calculation of TSB.[4]

Figure 1. BCA Metrics, Foundational Assumptions, and Value Streams



[4] Beginning in 2024, the TSB metric became the primary goal metric for CPUC energy efficiency portfolios administered by California IOUs and other program administrators. TSB, which is shown in dollars, is a single metric that combines various previously distinct value streams into a single combined monetized output that represents the value of an energy efficiency resource to the grid. See Total System Benefit Technical Guidance v1.1. Accessible at https://pda.energydataweb.com/api/view/2530/DRAFT%20TSB%20Tech%20Guidance%20081621.pdf

2.1 BCA METRICS

Benefit-Cost Ratios (BCRs) are unitless. They represent the relative magnitude of the present value of program benefits (in dollars) to program costs (also in dollars). The most common use for BCR metrics is to determine if the benefits of a program outweigh the costs; if so, the BCR will be greater than 1.0. Yet, a BCA can employ a wide range of methodologies, frameworks, and inputs, and these choices can dramatically alter the resulting BCR. Further, the primary goal of the SB 1477 programs is to reduce greenhouse gas (GHG) emissions, not simply to create positive net benefits. For example, if the programs failed to reduce GHG emissions but generated sufficient participant and utility non-energy impacts (NEIs) to offset costs, could they truly be considered successful decarbonization programs?

To address this question, we propose **two complementary metrics** that serve distinct purposes in evaluating BUILD and TECH – a BCR metric and an abatement cost metric.

2.1.1 BENEFIT COST RATIO

The CPUC has consolidated issues of cost-effectiveness testing under the Rulemaking (R.)14-10-003.[5] Currently, as ordered in D.19-05-019 the Total Resource Cost test "shall be considered the primary test for all Commission activities, including filings and submissions, requiring cost-effectiveness analysis of distributed energy resources, except where expressly prohibited by statute or Commission decision." and "all Commission activities, including filings and submissions, requiring cost-effectiveness analysis of distributed energy resources, except where expressly prohibited by statute or Commission decision, shall also review and consider the results of the Program Administrator Cost test and the Ratepayer Impact Measure test. Determinations shall include a discussion of the other tests."[6] Given that the BUILD and TECH programs are DER programs,[7] these requirements would apply to both programs, and any filings or submissions requiring cost effectiveness analysis should use the TRC as the primary BCR, include results from the Ratepayer Impact test and the Program Administrator Cost, and include discussions of the Societal Cost Test and the Participant Cost Test. However, given that BUILD and TECH are not ratepayer-funded programs and considering the primary goal of the programs is reductions in greenhouse gas emissions, we offer the following proposal for consideration.

The first metric we propose is a BCR metric, grounded in California's long history of applying benefit-cost analysis to energy efficiency programs. The CPUC recently adopted the **Societal Cost Test (SCT)** in Decision (D.) 24-07-015 ("SCT Decision") for informational purposes in all DER proceedings. The SCT is the only California Standard Practice Manual (CA SPM) BCR that explicitly and comprehensively values GHG reductions, and it provides a strong foundation for establishing a full cost-effectiveness protocol for building decarbonization programs.

The SCT calculates costs and benefits from the perspective of all of society. Different CA SPM tests reflect different perspectives. For example, the **Total Resource Cost (TRC) test** considers the perspective of all ratepayers, so all costs and benefits accruing to ratepayers are included. The Participant Cost Test (PCT), by contrast, considers only the perspective of the participating customer, including their direct costs and benefits but excluding program administrative costs. In the SCT Decision, the CPUC highlighted the difference in purpose of the TRC versus the SCT.

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[5] Order Instituting Rulemaking to Create a Consistent Regulatory Framework for the Guidance, Planning, and Evaluation of Integrated Distributed Energy Resources.

[6] D.19-05-019 Decision Adopting Cost-Effectiveness Analysis Framework Policies For All Distributed Energy Resources (2019).

[7] The BUILD and TECH programs are included in the list of customer-facing DER programs in Appendix A of the CPUC DER Action Plan accessible at: https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M467/K470/467470758.PDF

"As such, the TRC, as confirmed in D.19-05-019 (Integrated Distributed Energy Resources or IDER Decision), is the CPUC's primary test to be used in cost-effectiveness evaluations of DER programs. In contrast, societal benefits and costs have not been consistently used to assess cost-effectiveness of DERs. The primary reason for this approach is that the question of quantifying the cost of harm to society from current use of fossil-fuel energy sources, is different than the question of what particular clean energy program should be paid for by California ratepayers."

Given that BUILD and TECH are not ratepayer-funded programs, and that their primary goal is indeed to reduce the harm to society from current fossil-fuel energy sources, the SCT Decision logic supports the application of the SCT to the BUILD and TECH programs. Programs funded exclusively through ratepayer funds may merit a different cost-effectiveness test based on prior CPUC policies and decisions.

The application of the SCT also aligns with the program theory for a decarbonization program. The CPUC D.24-07-015 defines societal costs as "[t]he monetized indirect costs that result from the provision of energy service borne by all members of society, including future generations, rather than directly borne by ratepayers. These costs include adverse health impacts, air pollution, climate change, and other environmental damages resulting from the production of energy."[8] The primary goal of the SB 1477 programs is GHG reductions, which indicates the importance of valuing the impact of marginal GHG emissions on broader society. The National Standard Practice Manual (NSPM) for DERs[9] states that the SCT cost and benefit value stream includes all costs incurred to acquire the DER resource and all benefits resulting from the DER resource, including all utility system and non-utility system costs and benefits.[10]

Other CA SPM tests, such as the Ratepayer Impact test, Participant Cost test, Program Administrator Cost test, and Total Resource Cost test do not include, or do not fully include, the benefits to broader society caused by a reduction in GHG emissions and are therefore not aligned with the primary goals of BUILD and TECH. Together, this supports using the SCT as the primary test of the cost-effectiveness of the SB 1477 programs.

2.1.2 ABATEMENT COST

The second metric we propose is abatement cost—**the cost per metric ton of avoided carbon dioxide equivalent (MT CO_2e)**—required under SB 1477, which created the BUILD and TECH programs. While not technically a cost-effectiveness metric, abatement cost provides a streamlined, outcome-focused perspective directly tied to program contributions to California's climate goals. By narrowing the focus to emissions reductions, an abatement cost metric reduces the complexity of BCA calculations, since the full range of benefits do not need to be measured and no benefits, including emissions reductions, need to be monetized. It also facilitates ready comparison with other programs and policies, both within and beyond consumer-facing energy programs, that are designed to address climate change.

Further, for BUILD and TECH specifically, there is clear legislative support for measuring this abatement costs. SB 1477 requires only three key metrics to be evaluated for BUILD—(1) number of installed systems, (2) total GHG impacts, and (3) cost per metric ton of GHG reduction—and three for TECH—(1) market share for eligible technologies, (2) projected

[8] Decision Adopting The Societal Cost Test. Rulemaking 22-11-013. July 11, 2024

[9] While the NSPM is meant for a broader audience than just California and necessarily does not incorporate or weight California-specific precedent or considerations in developing their recommendations, the document is useful for our purposes because it provides a clear articulation of current best practices with regard to benefit cost analysis. Full citation: National Energy Screening Project. *National Standard Practice Manual for Benefit-Cost Analysis of Distributed Energy Resources.* August 2020.

[10] NSPM for DERs section E.4

utility bill savings, and (3) cost per metric ton of avoided GHG emissions. Beyond these requirements, the legislation leaves the development of additional metrics to the evaluator, California Public Utilities Commission (CPUC), and program implementers.

Taken together, the SCT and abatement cost provide **complementary insights**: the SCT captures the full range of societal benefits and costs, while abatement cost focuses narrowly on GHG reductions. Using both metrics will enable policymakers to optimize the deployment of ratepayer and taxpayer funds across decarbonization offerings while ensuring consistency with broader program theory, design, and goals.

KEY TAKEAWAY #1

The Societal Cost Test is the most appropriate cost-effectiveness metric for BUILD and TECH because it is the only California test that explicitly and comprehensively values greenhouse gas reductions, making it well-aligned with the programs' decarbonization goals and providing a strong foundation for a building decarbonization–specific cost-effectiveness protocol.

In parallel, using the abatement cost allows for a direct assessment of the cost of a decarbonization program relative to its primary goal of GHG reductions. It is an important metric that can help policymakers to prioritize the programs that will allow California to meet the state's energy and climate goals with minimal impact on ratepayers and taxpayers.

2.2 BCA FOUNDATIONAL ASSUMPTIONS

We established our proposed BCA framework by making two foundational assumptions critical to developing a sound approach: selecting the **discount rate** and identifying the **appropriate baseline** from which to quantify value streams. Each is introduced more fully below.

2.2.1 DISCOUNT RATES

Discounting refers to the practice of reducing future costs and benefits to reflect their value today. When costs and benefit streams occur over time unevenly, such as an upfront initial investment in a high-efficiency heat pump that reduces future natural gas usage and increases electric usage over the next 20 years, discounting all cost and benefit streams into a present value allows for a more meaningful comparison of costs and benefits.[11] The choice of a discount rate (i.e., the factor used to discount, or reduce, future costs and benefits to convert them into a present value) is a critical input to a BCA analysis and the calculation of TSB and can have a significant impact on the end results. The higher the discount rate, the more future costs and benefits are discounted, thus resulting in a *lower* present value. Following the use of the SCT to define the BCA boundaries, we recommend using a societal discount rate to calculate the net present value of all value streams included in the BCA. In D.24-07-015, the CPUC adopted a societal discount rate as an input to the SCT adopted for informational purposes. Further, the use of a societal discount rate aligns with

[11] The simplest explanation of why future costs and benefits are worth less in the present is related to what economists call the time value of money. The idea is if $1 can be invested today to create $1.50 next week, then paying (or receiving) $1 today is equivalent to $1.50 next week. More broadly, this relates to the opportunity cost (if I spend that $1 today, then I cannot invest it, thus forfeiting the $1.50 next week) as well as risk aversion. In this example, the discount rate is 50% per week.

NSPM guidance on the application of the SCT. Decision 24-07-015 adopts a three percent per year discount rate, which is within the bounds for a societal discount rate recommended by the NSPM.

KEY TAKEAWAY #2

Application of a societal discount rate is consistent with existing guidance on SCT calculations and is consistent with decarbonization program theory.

2.2.2 BASELINES

A **baseline** is a counterfactual forecast of relevant value streams that would have occurred absent program intervention, from which an intervention's impacts can be measured. This is often dictated by program theory, building codes, equipment standards, and/or standard practice in a market. For instance, an energy efficiency program that seeks to influence residential customers to purchase a high-efficiency AC unit when their existing unit is at or near the end of its useful life would likely use the least efficient commercially available AC unit (often the minimum efficiency unit allowed by equipment standards) of similar size as the baseline from which to measure energy impacts. It is important to note that the baseline in this example is not a static number, but rather the annual (or hourly) usage the least efficient commercially available unit would be expected to consume over the effective useful lifetime of the unit.

The selection of a baseline, or counterfactual, on which to evaluate program impacts is one of the most important methodological decisions that must be made when establishing a BCA framework or a calculation of TSB. The baseline represents a counterfactual forecast that would have occurred absent program intervention in each year of the measure's lifetime, also known as an effective useful life (EUL).[12] All value streams, from energy impacts, to GHG impacts, to non-energy impacts, to incremental costs, are all measured relative to this counterfactual baseline scenario.

For BUILD, this baseline is dictated by the CPUC decision enabling the BUILD and TECH programs. BUILD relies on a dual-fuel code-compliant version of the participants' new construction building as the baseline. The CPUC ordered, in Decision 20-03-027, "[t]he standard practice, or reference baseline, for residential new buildings shall be assumed to be a building built for dual fuel for both the BUILD program and the TECH Initiative until at least the 2022 California Energy Code becomes effective."[13] This baseline was reaffirmed in the most recent edition of the BUILD Program Guidelines (Second Edition).[14]

However, this question quickly becomes complicated for TECH retrofits, which account for all TECH activity to date. TECH relies on an existing conditions baseline, meaning the baseline counterfactual forecast is effectively defined by the energy-using equipment and energy usage patterns of each participating home pre-intervention (after controlling for some exogenous factors through applying a control group or control strategy). The use of meter-based impact methodologies to assess the impacts of TECH is discussed in Section 2.3.2 below.

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[12] The EUL of a measures is an estimate of the median number of years that a measure is still installed and operable.

[13] CPUC Decision 20-03-027 Decision Establishing Building Decarbonization Pilot Programs. Rulemaking 19-01-011. April 6, 2020. Accessible at: https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M331/K772/331772660.PDF

[14] Building Initiative for Low Emissions Development (BUILD) Program, Second Edition. February 2025. https://efiling.energy.ca.gov/GetDocument.aspx?tn=262399&DocumentContentId=98932

Based on TECH's program design and guidance from the CPUC, we believe the CPUC should explore using a dual baseline to estimate lifetime GHG impacts for the TECH program.[15] This approach would allow for accurate first-year savings developed through consumption analysis while adjusting impacts in the later years of the measure EUL to avoid inflating lifetime GHG impacts and TSB. This recommendation is based on three considerations, listed below:

1. The CPUC ordered that TECH be implemented as an upstream or midstream program.
2. TECH is primarily a fuel substitution program, encouraging the displacement or elimination of natural gas usage at participating sites.
3. TECH relies on meter-based consumption analysis to estimate ex ante impacts.

We explore each of these considerations in the subsections below.

Midstream Program Design

Although TECH is not an energy efficiency program, it is a midstream program, and the CPUC's guidance clearly outlines which baseline assumptions should apply to midstream energy efficiency programs. Upstream/midstream energy efficiency programs should use a code-minimum baseline in all measure application type (MAT) scenarios.[16] Even though CPUC guidance and rules relevant to energy efficiency programs are not directly applicable to TECH, given that energy efficiency programs are well-established and CPUC guidance is robust, reviewing these related concepts offers insights into best practices for determining baselines for the TECH program.

The rationale is rooted in program theory. Midstream programs primarily interact with contractors or installers and not customers directly. This limits the opportunity for the program to drive the customer's initial decision to install *some* type of new equipment (regardless of efficiency) because this initial decision is most often already made by the time a customer engages with a contractor or installer. Therefore, it is common for program administrators and evaluators to assume the program is not *causing* any more early replacements than would have otherwise occurred absent program intervention. However, a 2022 impact evaluation of the CPUC's fuel substitution program found "a majority of participants who installed their heat pumps as a replacement or in addition to their existing system reported that their previous heating system worked well, indicating a higher incidence of early replacement than the normal replacement intended for this type of program."[17]

Therefore, as a midstream program, the application of the CPUC guidance for energy efficiency programs to TECH would imply that TECH should employ a code baseline to estimate all value streams. However, evidence from the 2022 Fuel Substitution Impact Evaluation suggests that midstream fuel substitution program installations may include early replacement measures.

Fuel Substitution

[15] The CPUC Energy Efficiency Policy Manual describes a dual baseline as a baseline approach that "reflects the difference between the savings that should be credited for the initial years of installation based upon the pre- existing or replaced equipment versus the savings credit in later years that should be based upon an eventual pre-existing equipment replacement assumed to occur if the measure had not been installed as part of the program. At the later date, when the pre-existing equipment would have been replaced due to normal turnover for reasons such as imminent failure or remodeling, an alternate equipment efficiency baseline should be utilized." (CPUC EE Policy Manual at VI.7.d) A dual baseline requires two savings calculation periods: the remaining useful life (RUL) period that uses the pre-existing equipment as a baseline and the second baseline period (i.e., the difference between the installed measure's EUL and the RUL) which uses code baseline or industry standard practice as the baseline from which to measures savings. The CPUC EE policy manual can be accessed at :https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/energy-efficiency/eepolicymanualrevised-march-20-2020-b.pdf

[16] CPUC Resolution E-4818. Measure level baseline assignment and preponderance of evidence guidance to establish eligibility for an accelerated replacement baseline treatment. March 2, 2017. Accessible at: https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M179/K264/179264220.PDF

[17] DNV. "PY2020 HVAC Fuel Substitution" Group A Impact Evaluation. (2022).

The CPUC fuel substitution technical guidance also offers an analog.[18] Although the CPUC is clear that the fuel substitution technical guidance applies to only fuel substitution measures funded by energy efficiency incentives, given the similarity of such measures to the measures incentivized by TECH, this guidance can help shed light on the issue of defining an appropriate baseline. The guidance cites CPUC Resolution E-4818 and CPUC Resolution E-4939, Attachment A to justify application of a code or industry standard practice baselines for normal replacement measure application types, a dual baseline consisting of existing conditions followed by code/industry standard practice for early replacement, and the application of an existing condition baseline only for specific measures types (Behavioral, Retro-commissioning and Operational, Add-on Equipment and Building Weatherization).

The document also recommends using a consistent baseline technology for cost-effectiveness testing, which assumes that the end user who replaces a functioning gas furnace with a heat pump, for example, would have purchased a code-minimum gas furnace absent program intervention. Under a dual baseline scenario, the methodology assumes the customer would have purchased a code-compliant gas furnace at the end of the first baseline (i.e., at the end of the RUL period).

Therefore, this source also suggests applying a code or industry standard practice baseline for, at minimum, a portion of the EUL for TECH installations. It further indicates that a dual baseline may be appropriate, and the baseline should be consistent in technology and fuel type.

METER-BASED IMPACT METHODOLOGY

The TECH implementer and evaluator rely on meter-based consumption analysis methodologies to calculate ex ante and ex post energy impacts of participation. This approach to estimating impacts inherently relies on an existing conditions baseline to estimate first-year impacts. Further, to calculate lifetime impacts, the program implementer multiplies the first-year savings by the measure's EUL, effectively assuming an existing conditions baseline for each year of the deemed EUL for heat pumps and heat pump water heaters found in the CA eTRM.

This approach to calculating lifetime GHG impacts implies that the existing conditions would have remained the same throughout the entire deemed lifetime of the efficient measure; in other words, the existing heating or cooling systems in a participant's home would not have been replaced over the EUL period in the absence of program intervention. This very likely exaggerates the GHG benefits of TECH by implicitly assuming, for example, that the gas furnaces or water heaters TECH participants replaced at the time of program participation would have otherwise continued to operate in the counterfactual forecast for the full deemed EUL of the new heat pumps, which is currently 23 years in the case of HVAC heat pumps and 20 years for heat pump water heaters.[19]

As a point of comparison, Net Metered Energy Consumption (NMEC) programs follow a similar practice and apply an existing conditions baseline for the duration of the measure's EUL, which implies full acceleration (i.e., absent the program intervention, the participant would not have replaced their existing equipment for at least the full timespan of the measure EUL). The NMEC rulebook does not require evidence of full acceleration. Still, it does state, "[p]rojects shall conform to the program influence guidance for Accelerated Replacement in Resolution E-5115 in all respects except demonstration of existing equipment viability, or as modified by a future CPUC decision or resolution." This does place the burden of proving *some* level of acceleration on the program implementation team to support the assignment of an accelerated replacement MAT. The recent impact evaluation of site-level NMEC programs highlights the

[18] CPUC. Fuel Substitution Technical Guidance for Energy Efficiency. Version 2.0. October 13, 2022. https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/building-decarb/fuel-substitution-technical-guide-v2.docx

[19] CPUC Resolution E-5350. Approval of the Database for Energy-Efficient Resources updates for Program Year 2026-2027 and revised version for Program Years 2025 and 2024. Available at: https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M546/K557/546557227.PDF

importance of determining the appropriate MAT and EUL, placing specific importance on detailed project documentation to facilitate this key decision.[20]

> *"Unlike an NMEC project's savings, which are meter-based, the measures' EUL, which indicates how long the first-year savings will persist, must be based on measure life studies and other documentation as with non-meter-based custom projects. As a result, the EUL needs to be carefully reviewed by evaluators as the resulting lifetime savings are important for cost-effectiveness and total system benefit calculations. The lack of clear MAT and EUL documentation for many projects made this essential part of the evaluation more inefficient, time-consuming and, potentially, inaccurate." NMEC Impact and Net-to-Gross Evaluation, Program Years 2020–2022.*

The TECH program's application of a deemed EUL to meter-based first-year impacts ignores these concerns in a way that overstates both TSB and lifetime GHG impacts. Further, given the long deemed EULs of TECH installations, the distortion caused by applying first-year savings to every year of the EUL is increased relative to the shorter EULs more often seen in NMEC programs. However, it is impractical for TECH to apply a custom EUL for each installation to ensure alignment of EUL assumptions with the estimation of first year savings. An alternative approach would be to apply a dual baseline to TECH installations. The existing equipment baseline would still define the counterfactual baseline scenario for the RUL of the existing equipment, but then, after the RUL, the counterfactual baseline scenario would be updated to assume code-compliant equipment. A common assumption in EE evaluation is that the RUL of the pre-existing equipment is one-third of the installed measure EUL. Using deemed savings estimates of similar measures from energy efficiency programs under each MAT scenario, the CPUC could provide simple adjustment factors that would allow for an improvement to the current practice without being computationally burdensome.

KEY TAKEAWAY #3

A dual baseline approach accommodates the novelty of TECH's program design (i.e., midstream program design, fuel substitution measures, and meter-based impact measurement) while maintaining consistency with EE best practices in California.

2.3 BCA VALUE STREAMS

We also propose four value streams: greenhouse gas (GHG) impacts, energy system impacts, non-energy impacts, and program and participant costs. While each value stream can include both positive impacts (benefits) and negative impacts (costs), generally speaking, GHG impacts, energy system impacts, and non-energy impacts are counted as benefits of a decarbonization program (which can accrue to multiple groups, such as the program implementer, participants, general society, etc.), while program and participant costs will reflect the cost of implementing the program. We examined relevant existing protocols, CPUC decisions, guidance documents, and other industry reports relevant to the SB 1477 programs, and summarized key findings for each framework component and value stream. We also identified where the current approach may be insufficient to accurately assess the costs and benefits of the SB

[20] DNV. "Site-Level Normalized Metered Energy Consumption (NMEC) Impact and Net-to-Gross Evaluation, Program Years 2020–2022." CPUC Group D. (2024).

1477 programs given their unique design, theory of change, and objectives. Finally, we analyzed each value stream to determine both the appropriate impact estimation—using native units such as kWh, therms, or tons of CO_2e—and the corresponding valuation, converting these impacts into monetary values.

2.3.1 GHG IMPACTS

The CPUC offers clear guidance on both quantifying and monetizing GHG impacts. Consistent with their treatment in the SCT, this guidance states that electric emissions for BUILD and TECH should be estimated by applying long-run hourly marginal emissions rates by Title 24 climate zones (CZ) to energy impacts.[21] The most recent CPUC Avoided Cost Calculator (ACC) inputs also include adders to account for the increased refrigerant leaks associated with increased heat pump adoption. Natural gas emissions should be estimated by applying a constant factor composed of a combustion-based constant and a methane leakage adder. The GHG impacts of changes in delivered fuel consumption should be estimated using constant combustion-based emissions rates.[22]

Further, GHG impacts should be monetized by applying the social cost of carbon. Given the goals of SB 1477 programs and the nature of the harm induced by increased GHG emissions, the social cost of carbon is the most applicable method to monetize the GHG impacts associated with decarbonization programs. CPUC Decision 24-07-015 and the subsequent CPUC Decision 22-05-002 offer the most logical sources from which to draw inputs.

KEY TAKEAWAY #4

GHG impacts are clearly relevant and should be included in a BCA in alignment with EE protocols, e.g., long-run marginal hourly emissions rates from electric impacts that account for refrigerant and fugitive methane leakages. Impacts should be monetized through the application of the social cost of carbon.

2.3.2 ENERGY SYSTEM IMPACTS (ELECTRIC AND NATURAL GAS)

Although many methodologies may be appropriate for calculating the ex ante energy impacts for BUILD and TECH, the methods employed by program implementers are appropriate and broadly consistent with CPUC precedent, as described below. BUILD leverages code compliance energy models, which is consistent with best practices for evaluating the energy impacts of new construction energy programs.

[21] See the 2024 Distributed Energy Resources Avoided Cost Calculator Documentation For the California Public Utilities Commission for details on how long run marginal emissions factors are developed for application in the ACC.

[22] 2024 Distributed Energy Resources Avoided Cost Calculator Documentation For the California Public Utilities Commission. Accessible at: https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/demand-side-management/acc-models-latest-version/updated-2024-acc-documentation-v1b.pdf

TECH relies on meter-based consumption analysis to estimate ex ante impacts,[23] which is appropriate given the varied installation scenarios[24] and is consistent with CPUC policy[25] and national protocols.[26] However, certain methodological considerations warrant further consideration (e.g., the issue of the appropriate baseline from which to measure impacts and interplay with EUL selection, as discussed in Section 2.2.2).

The CPUC has determined that the marginal costs developed for the ACC should be applied to value incremental increases in energy consumed.[27] The same decision also incorporated natural gas infrastructure cost impacts into the ACC to be used for new construction projects. As described in the 2024 Distributed Energy Resources Avoided Cost Calculator Documentation For the California Public Utilities Commission ("ACC Documentation"), "[t]he ACC includes an electric avoided cost calculator and a natural gas avoided cost calculator (including an avoided natural gas infrastructure calculator). The ACC determines several types of avoided costs, including avoided generation capacity, energy, ancillary services, GHG emissions, high global warming potential gases, transmission and distribution capacity, and natural gas infrastructure."[28]

KEY TAKEAWAY #5

Reliance on building simulation modeling for BUILD and meter-based impacts for TECH to estimate energy impacts is appropriate and consistent with California precedent. Reliance on the ACC outputs to monetize energy impact is also appropriate.

ALIGNMENT WITH BEST PRACTICES AND PROGRAM THEORY

In the Phase 4 Amended Scoping Memo and Ruling of the Building Decarbonization Proceeding (R.19-01-011), the CPUC is considering adopting a zonal decarbonization pilot program, which would use location-based prioritization to identify and capitalize on decarbonization opportunities.[29] With a location-based program design, areas of the grid that can accommodate increased electric usage are targeted and therefore, systemwide average avoided costs will no longer be appropriate and would underestimate the benefits such a program. Therefore, program theory would support applying a more granular impact estimation process and a highly granular impact monetization process. If, for example, zones with ample existing electric grid infrastructure to support decarbonization are selected, the costs of electrification could be overstated by applying CZ-level transmission and distribution avoided costs to value program electric impacts.

[23] TECH implementers employ OpenEEmeter (previously known as CalTrack) methods. See https://docs.caltrack.org/en/latest/technical-appendix.html

[24] Opinion Dynamics previously found existing eTRM deemed parameters were often ill-suited for estimating savings appropriately for TECH installations. https://pda.energydataweb.com/api/downloads/3998/TECH_Engineering%20Desk%20Reviews_RevisedDraft_2024.06.28.docx

[25] Similar meter-based methodologies are used to develop ex ante TECH impacts and implement the CPUC's NMEC programs. NMEC explicitly assumes an existing conditions baseline and requires normal replacement measures that occur within the same period to be removed through model adjustments. Rulebook for Programs and Projects Based on Normalized Metered Energy Consumption. Version 2.1 Accessible at: https://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M520/K881/520881077.PDF

[26] IPMVP notes Option C is preferred when measure impacts are more uncertain, and this is certainly the case for electrification measures. See Efficiency Valuation Organization. *International Performance Measurement and Verification Protocol – Core Concepts.* March 2022. EVO 10000-1:2022.

[27] CPUC Decision 22-05-002 Adopting Changes to the Avoided Cost Calculator. August 12, 2024. Accessible at: https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M537/K784/537784099.PDF

[28] 2024 Distributed Energy Resources Avoided Cost Calculator Documentation for the California Public Utility commission. Version 1b. Accessible at https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/demand-side-management/acc-models-latest-version/updated-2024-acc-documentation-v1b.pdf

[29] CPUC Assigned Commissioner's Amended Scoping Memo And Ruling (Phase 4 Scoping Memo. July 1, 2024. Accessible at: https://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M534/K700/534700375.PDF

Similarly, if the natural gas infrastructure is nearing capacity, the benefits of electrification could be understated by the application of CZ or utility average natural gas transmission and distribution valuation factors.

KEY TAKEAWAY #6

More granular avoided costs are required to fully capture the cost and benefits of zonal decarbonization.

2.3.3 NON-ENERGY IMPACTS

Changes in energy consumption and production create health impacts that are unaccounted for in energy markets. Given the potential magnitude of such impacts, they represent one of the most important non-energy impacts associated with changes in energy consumption and production. A Statewide Air Quality Adder of $14/MWh was recently adopted by the CPUC for use in the SCT to account for the non-embedded health benefits derived from reducing natural gas used in electricity generation.[30] This value was sourced from the *Quantifying the Air Quality Impacts of Decarbonization and Distributed Energy Programs in California* report ("Air Quality report").[31] The monetized health impacts include mortality (from PM2.5 & Ozone), hospital admissions for asthma, all respiratory hospital admissions, school loss days, and emergency room visits due to asthma. For a BUILD and TECH, these impacts represents a non-energy cost instead of a non-energy benefit, because increased electrification will require increased electric production.

Beyond health impacts, other key non-energy impacts, such as thermal comfort and noise reduction, should be included in the SCT as benefits. As discussed further below, a BCA needs to be balanced, and the inclusion of the entire participant contribution of a new heat pump requires the inclusion of the whole, incremental benefits, including all *non-de minimis* non-energy impacts. This is consistent with the NSPM, which states that "impacts that are relevant (i.e., within the scope of a BCA test) and material (i.e., are expected to have a material impact on the results) should be accounted for in the BCA regardless of whether they are hard to quantity."[32]

ALIGNMENT WITH BEST PRACTICES AND PROGRAM THEORY

Monetized annual health savings from eliminating natural gas combustion in buildings are significantly higher than from eliminating natural gas in electricity generation in California. As modeled in the Air Quality Report, eliminating emissions from natural gas generation in California would lead to just less than $1 billion in health savings, while eliminating all emissions associated with direct natural gas use in buildings for both the residential and commercial sectors (for purposes of space heating, water heating, cooking, and clothes drying) would lead to $7.35 billion in health savings. As the report states, "[p]rograms that reduce direct use of fossil fuels, such as electrification programs and natural gas energy efficiency, are likely to have an air quality benefit that is orders of magnitude greater than that of programs such as electric energy efficiency and rooftop solar that impact air quality solely by reducing emissions from gas generators."

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[30] Embedded costs are those already included in the market price of energy. For example, at least a portion of the marginal damage caused by NOx and SOx are represented in the market price for electricity because they have been internalized to the electric markets through the U.S. Clean Air Act requirements. Similarly, in California, a portion of the marginal damage associated with GHG emissions has been internalized through the statewide Cap and Trade program. When accounting for the full economic marginal damage of such externalities, it is important to avoid doubling counting impacts, which can be accomplished by only adding incremental or non-embedded costs, not currently represented in market prices.
[31] Energy and Environmental Economics. *Quantifying the Air Quality Impacts of Decarbonization and Distributed Energy Programs in California.* 2021. Accessible at: https://www.ethree.com/wp-content/uploads/2022/01/CPUC-Air-Quality-Report-FINAL.pdf
[32] NSPM for BCA of DERs. Page 4-18 – 4-19.

Given that reducing or eliminating natural gas combustion within buildings is the primary means by which BUILD and TECH create GHG reductions, excluding this site impact value stream in the BCA and calculation of TSB of these programs leads to underestimating program benefits. Further, impacts vary considerably by census tract, ranging from $0.7 million to $57 million, suggesting that targeted electrification programs can potentially deliver significant health benefits.

KEY TAKEAWAY #7

Inclusion of the air quality impacts of changes in electricity generation is necessary but not sufficient for decarbonization programs. Given the magnitude of potential air quality impacts of changes in building-level natural gas combustion, a granular treatment of site impacts is necessary to fully capture the value of building decarbonization programs.

2.3.4 PROGRAM AND PARTICIPANT COSTS

According to the NSPM, reliance on the SCT framework for a decarbonization program implies that both program administration costs and participant costs should be included in the BCA. Program implementation costs are more straightforward and should be included directly in the BCA. The program administration and implementation costs should be included in the assessment of the program's cost-effectiveness under an SCT because these represent a real cost borne, ultimately, by California ratepayers or taxpayers.[33]

Participant costs are more complicated. A principal attribute of a well-designed BCA is balance or symmetry across value streams. Balance is achieved when all cost and benefit value streams included in a BCA are consistent with the same counterfactual scenario, and any time one cost or benefit from a category of impacts is included, then all costs and benefits of that impact category must be included. For example, suppose the full incremental cost of installing a heat pump is included in the analysis. In that case, the full incremental benefits should also be included, including both energy and non-energy benefits. Further, in the case of TECH, the incremental energy impacts are calculated relative to an existing conditions baseline. This implies that in the counterfactual scenario, the participant would have taken no action and continued to use their existing heating or water heating system, representing a participant cost of zero dollars. Therefore, symmetry would imply that the participant costs are calculated relative to the same counterfactual scenario, and the full cost of the heat pump is included in the BCA.[34] If a dual baseline approach is ultimately adopted, precedent and guidance exist from CA EE programs on accurately calculating customer cost.[35]

ELECTRICAL PANEL UPGRADES

A unique consideration for fuel substitution decarbonization programs such as TECH, is the treatment of panel upgrades. A recent study of electrical panels in residential buildings in California found that a minimal proportion of single-family buildings (3%) are the smallest size and therefore will require full panel upgrades, but significantly more (32%) will require "the addition of load management systems to support comprehensive electrification."[36] This

[33] This is supported by both the NSPM for DERs and the CA Standard Practice Manual.

[34] Incremental participant cost is the difference between actual costs and the counterfactual costs. So if the counterfactual participant costs are zero, the incremental participant costs are the full cost of the heat pump minus zero.

[35] In a dual baseline approach, customer cost is calculated as the net present value of assumed customer payments in the counterfactual scenarios. This includes the full initial customer outlay of the installed, program incentivized equipment, less the present value of the code-compliant equipment the customer is assumed to otherwise have purchased at the end of the RUL period.

[36] Eric Daniel Fournier, Robert Cudd, Samantha Smithies, Stephanie Pincetl. "Quantifying the electric service panel capacities of California's residential buildings." Energy Policy, Volume 192. (2024)

proportion is corroborated by Opinion Dynamics' review of TECH program tracking data, which indicated that approximately 3% of single-family TECH participants required a panel upgrade to accommodate their heat pump.[37] However, Opinion Dynamics previously found that the likelihood of panel upgrades and optimization varied greatly by climate region but could be much higher in marine climates and multifamily homes.[38] The costs of these upgrades, which can be significant, will be borne by some participants and not others depending on the characteristics of their home.

Existing cost-effectiveness frameworks account for other value streams that similarly occur in discrete steps, and, following BCA best practices and precedent in California suggests the costs of electrical panel upgrades should be generalized. For instance, the ACC documentation, when discussing the methane leakage adder, notes, "reducing natural gas usage will lead, in the long run, to reduced methane leakage that is likely to occur in a step-wise fashion, where large cumulative reductions in natural gas usage result in reductions in leakage that occur in relatively large "steps." By applying that large, long-run reduction to each BTU of natural gas reduction, we are "smoothing out" the step-wise function and spreading the same total reduction in GHGs more evenly over time. This is similar to how we currently treat avoided generation capacity in the ACC, where even a small change in peak energy usage is considered to have capacity value, even though only relatively large changes will actually avoid the construction of a new power plant."[39] Therefore, analogous treatment would imply that the incidence and cost of panel upgrades, including upsizing, optimization, and/or the implementation of other load management systems, should be studied, the long-run expected value estimated, and then applied on a per-kWh basis to TECH and other electrification programs.

KEY TAKEAWAY #8

Panel upgrade and optimization costs should be applied in a smoothed, weighted average basis to all installations regardless of whether the project actually required panel modifications.

[37] Based on analysis of TECH claims through July 2024.
[38] Fuel Substitution Behind the Meter Infrastructure Market Study: Equity Segment. Opinion Dynamics. May 2024. Accessible at: https://pda.energydataweb.com/api/view/3967/Fuel%20Substitution%20Behind%20the%20Meter%20Infrastructure%20Market%20Study%20Equity%20Segment%20FINAL_pda.pdf
[39] 2024 Distributed Energy Resources Avoided Cost Calculator Documentation for the California Public Utilities Commission

3. FINDINGS AND RECOMMENDATIONS

The key takeaways from this memo, which are highlighted throughout the preceding sections, are summarized together in Table 1 below. In Section 2.1, Section 2.2, and Section 2.3 we provide support for each key finding.

Table 1. Summary of Key Takeaways

Takeaway #	Component	Key Takeaway	Research Question
BCA Metrics			
1	BCA Metrics	The Societal Cost Test is the most appropriate cost-effectiveness metric for BUILD and TECH because it is the only California test that explicitly and comprehensively values GHG reductions, making it well-aligned with the programs' decarbonization goals and providing a strong foundation for a building decarbonization–specific cost-effectiveness protocol. In parallel, using the abatement cost allows for a direct assessment of the cost of a decarbonization program relative to its primary goal of GHG reductions. It is an important metric that can help policymakers to prioritize the programs that will allow California to meet the state's energy and climate goals with minimal impact on ratepayers and taxpayers.	1 and 2
BCA Foundational Assumptions			
2	Discount Rates	Application of a societal discount rate is consistent with existing guidance on SCT calculations and is consistent with decarbonization program theory.	1
3	Baselines	A dual baseline approach accommodates the novelty of TECH's program design (i.e., midstream program design, fuel substitution measures, and meter-based impact measurement) while maintaining consistency with EE cost effectiveness best practices in CA.	1 and 2
BCA Value Streams			
4	GHG Impacts	GHG impacts are clearly relevant and should be included in a BCA in alignment with EE protocols, e.g., long-run marginal hourly emissions rates from electric impacts that account for refrigerant and fugitive methane leakages. Impacts should be monetized through the application of the social cost of carbon.	1 and 2
5	Energy Impacts	Reliance on building simulation modeling for BUILD and meter-based impacts for TECH to estimate energy impacts is appropriate and consistent with CA precedent. Reliance on the ACC outputs to monetize energy impact is also appropriate.	1 and 2
6	Energy Impacts	More granular avoided costs are required to fully capture the cost and benefits of zonal decarbonization.	2 and 3
7	Non-Energy Impacts	Inclusion of the air quality impacts of changes in electricity generation is necessary but not sufficient for decarbonization programs. Given the magnitude of potential air quality impacts of changes in building-level natural gas combustion, a granular treatment of site impacts is necessary to fully capture the value of building decarbonization programs.	3
8	Program and Participant Costs	Panel upgrade and optimization costs should be applied in a smoothed, weighted average basis to all installations regardless of whether the project actually required panel modifications.	3

Based on the key findings, we offer the following recommendations in Table 2 below.

Table 2. Summary of Recommendations

Recommendation #	Recommendations
BCA Metrics	
1	▪ Out of the existing CA Standard Practice Manual BCA tests, the **SCT is the most appropriate and should be required for building decarbonization programs**. ▪ The SCT should rely on a societal discount rate and should be designed to be symmetrical (i.e., relevant and material non-energy impacts should all be included in the analysis, as should participant costs).
2	▪ At a minimum, abatement cost is a critical companion metric to any BCA of a building decarbonization program. ▪ Yet, given the goals of building decarbonization programs, **the CPUC should consider if abatement cost should be the primary cost analysis metric on which building decarbonization programs should be evaluated.** By focusing on abatement cost as the primary metric, the CPUC could reframe the discussion from costs versus benefits to investment versus impact.
BCA Foundational Assumptions	
3	▪ The CPUC should not assume all existing EE BCA practices, requirements, and precedents are appropriate for decarbonization programs. **The CPUC should provide guidance specific to conducting BCA for decarbonization programs.**
4	▪ Given the long measure lives of TECH equipment, the CPUC should **explore how to apply a dual baseline adjustment to TECH impacts**, including all electric, gas, and GHG impacts as well as participant costs. This will present a more accurate reflection of the total GHG impact of, and TSB generated through, the TECH Initiative. ▪ The dual baseline approach could be as simple as a deemed proration factor developed from the CA eTRM or other inputs and could differ by specific installation scenarios (e.g. when existing equipment is over a pre-determined age threshold). Participant costs, where relevant, would also need to be adjusted to remain consistent with a dual baseline counterfactual.
BCA Value Streams	
5	▪ Most inputs used in BCA of EE portfolios are well-suited for BCA of decarbonization programs. **Where BCA of EE portfolios and decarbonization programs can be consistent, they should be consistent.**
6	▪ The CPUC should **explore development of geographically granular avoided costs and NEIs to better reflect the full costs and benefits of decarbonization programs**, including leveraging granular estimates of the air quality impacts of reduced natural gas combustion in buildings.
7	▪ **Panel upgrade and optimization costs should be included** in the BCA of decarbonization programs **and should be applied on a smoothed, weighted average basis** to all installations regardless of whether the project actually required panel modifications.