Societal Cost Test Impact Evaluation

CPUC STAFF REPORT ON THE IMPACT OF A SOCIETAL COST TEST ON RESOURCE PROCUREMENT

January 2022

California Public Utilities Commission

Prepared by Energy Division staff and Energy Division's consultants at Energy and Environmental Economics, Inc. (E3):

Gabe Mantegna (E3)

Jen Cardona (E3)

Mengyao Yuan (E3)

Arne Olson (E3)

Aaron Burdick (E3)

Alireza Eshraghi (CPUC)

Joy Morgenstern (CPUC)

Acknowledgements: The authors would like to thank colleagues for all the discussions, reviews, and other contributions to the preparation of this document.

Contents

Table of Figures

Executive Summary

In 2019, CPUC Decision 19-05-019 ordered the testing of a Societal Cost Test (SCT) in the Integrated Resource Planning (IRP) proceeding (Rulemaking 20-05-003). The testing of an SCT was assigned to IRP so that the impact of societal costs on both supply and demand side resource procurement could be considered. An SCT is one of the five cost tests envisioned in the California Standard Practice Manual used for evaluating demand side resources[1], but it has never been consistently implemented into decision making in California.

This staff report presents the results of this testing. This work tests an SCT both in the RESOLVE capacity expansion model, which is used for resource planning in the IRP proceeding, and in the context of Distributed Energy Resource (DER) cost effectiveness[2]. Studying the incorporation of the SCT into RESOLVE first is critical to providing an accurate and fair measure of DER cost effectiveness under an SCT, because the SCT can change the supply-side portfolio which may change the shape of DER avoided costs[3].

This work finds that, under a "core" scenario which incorporates central estimates for all societal cost components (social cost of carbon, air quality impacts, methane leakage, and a social discount rate), an SCT would result in minimal changes to the supply-side portfolio (Figure 1) currently proposed in the IRP proceeding[4], and the cost-effectiveness of DERs (Figure 2). This is because the societal costs modeled are a similar magnitude to the costs that are already being incurred to meet California's carbon abatement targets, based on modeling a 2030 statewide Greenhouse Gas (GHG) target of 38 Million Metric Tons (MMT).

However, this core scenario would lead to significant increases in cost effectiveness for most electrification measures, particularly building electrification (Figure 3). The results reflect the fact that reducing emissions from natural gas generators has a much lower potential to provide air quality benefits compared to the potential to achieve air quality improvements through electrifying buildings and transportation (Figure 4).

Under a sensitivity scenario in which 95th percentile estimates for the social cost of carbon and methane are used, an SCT does show increased clean energy resource procurement as cost effective. This scenario, the "High Social Cost of Carbon (SCC)" scenario, shows as cost effective additional clean energy resource procurement that would reduce electric sector emissions from 38 MMT to 19

---

1 Commission, California Public Utilities. *California Standard Practice Manual. Economic Analysis of Demand-Side Programs and Projects.* October 2001.

2 "Distributed Energy Resources" or "DERs" refers to all behind-the-meter electric sector resources. It encompasses both traditional load-reducing measures such as energy efficiency and behind-the-meter solar, and also carbon-reducing measures that add load such as electrification.

3 Note that "avoided costs" refers to the benefits of load-reducing measures such as energy efficiency. These benefits are called avoided costs because they consist of costs on the supply side (such as investment in new power plants) that are avoided.

4 California Public Utilities Commission. *Decision Adopting 2021 Preferred System Plan.* Proposed Decision. December 2021.

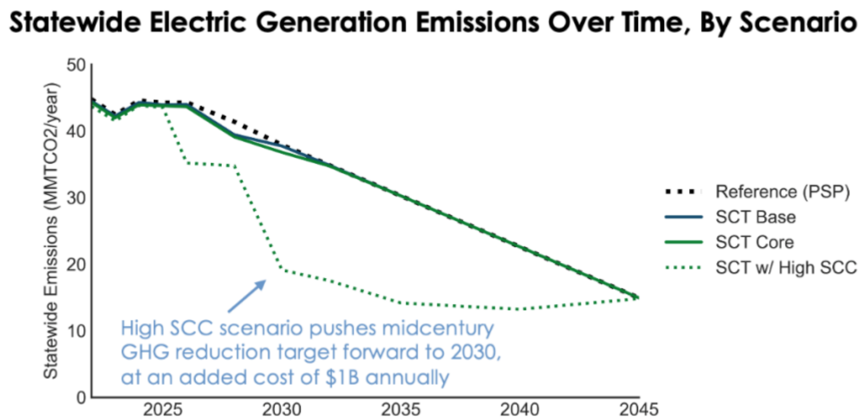
MMT by 2030, at an added annual cost of $1 billion. This scenario would also increase DER avoided costs by about 35 percent in most hours except the mid-day hours when solar generation is highest.

This work also highlights that basing decision making on an SCT, as opposed to a cost-effectiveness test such as the Total Resource Cost (TRC) test currently considered the primary cost-effectiveness test, could result in increases to electric rates, if any increased resource procurement shown as cost effective under an SCT were paid for through electric rates alone[5]. In this scenario, electricity rates would increase to finance the increased investments in clean electricity resources considered cost-effective under the SCT. However, the societal benefits of this increased investment would be enjoyed not only by investor-owned utility electric ratepayers but also by individuals who might not reside within the California investor-owned utility service areas, or within California at all. In addition, if the CPUC authorized additional clean energy resource investment based on the SCT using ratepayer funds, and these costs were included in investor-owned utility customers' electricity rates on a volumetric basis, the higher bills could cause hardship for lower income electricity customers. Considering the impact of an SCT on ratepayers is crucial to ensuring that disadvantaged communities, who have historically been disproportionately affected by non-monetized costs of energy use such as air pollution impacts, do not suffer substantial hardship in order to mitigate these impacts[6].

---

[5] Note that, since the budget for DER investment using ratepayer funds is limited, this increase would only happen if the DER investment budget was increased.

[6] See: Commission, California Public Utilities. *2019 Annual Affordability Report*. April 2021. Accessible at: https://www.cpuc.ca.gov/-/media/cpuc-website/industries-and-topics/reports/2019-annual-affordability-report.pdf



SCT Scenarios

- **Reference**: current IRP planning scenario, including GHG reduction targets determined by CARB
- **SCT Base**: decision-mandated scenario with social cost of carbon, interim air quality adder, and social discount rate
- **SCT Core**: same as Base but with updated (higher) air quality adder, and social cost of methane leakage
- **SCT w/ High SCC**: same as Core but with 95th percentile estimate of social cost of carbon and methane

Figure 1. Statewide electric generation emissions over time by societal cost scenario, with scenario descriptions included.

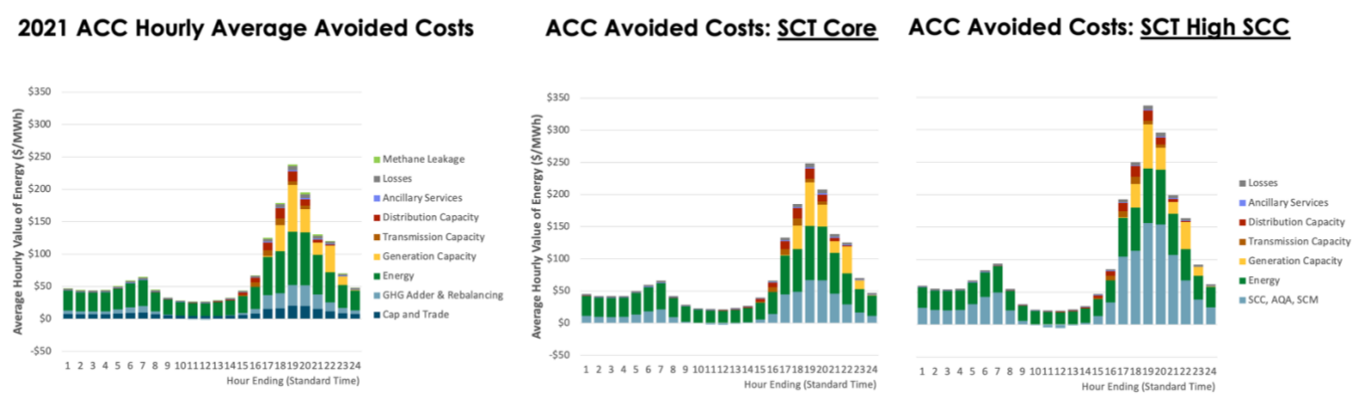


Figure 2. Avoided costs in the 2021 Avoided Cost Calculator under both the standard perspective (left) and the two SCT scenarios (right), SCT Core and SCT High SCC.

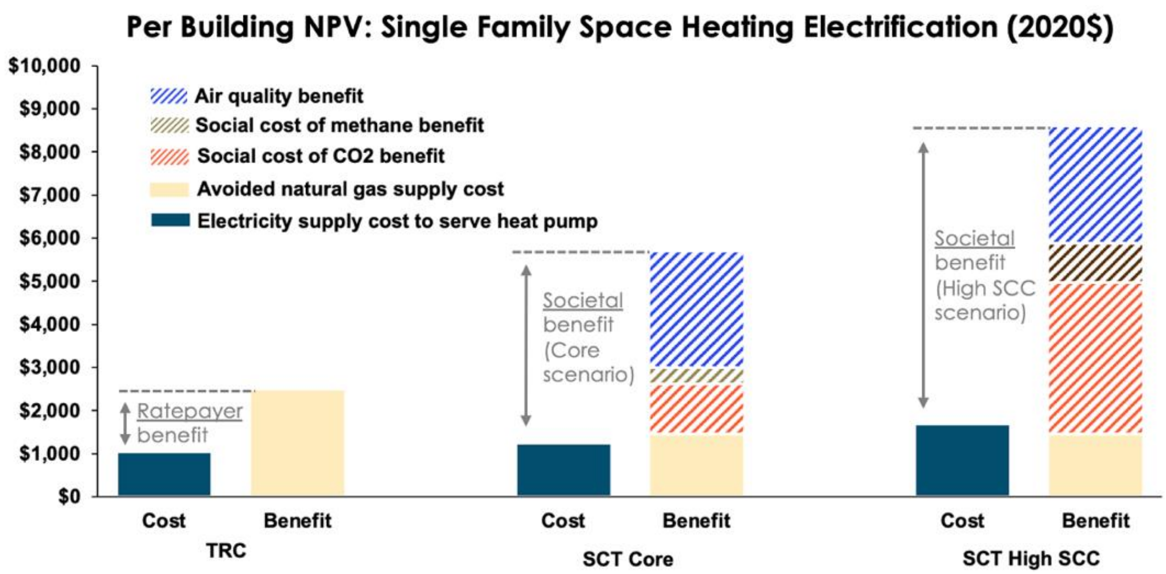


Figure 3. Cost effectiveness of a sample building electrification measure under a TRC vs the "Core" and "High SCC" SCT scenarios.

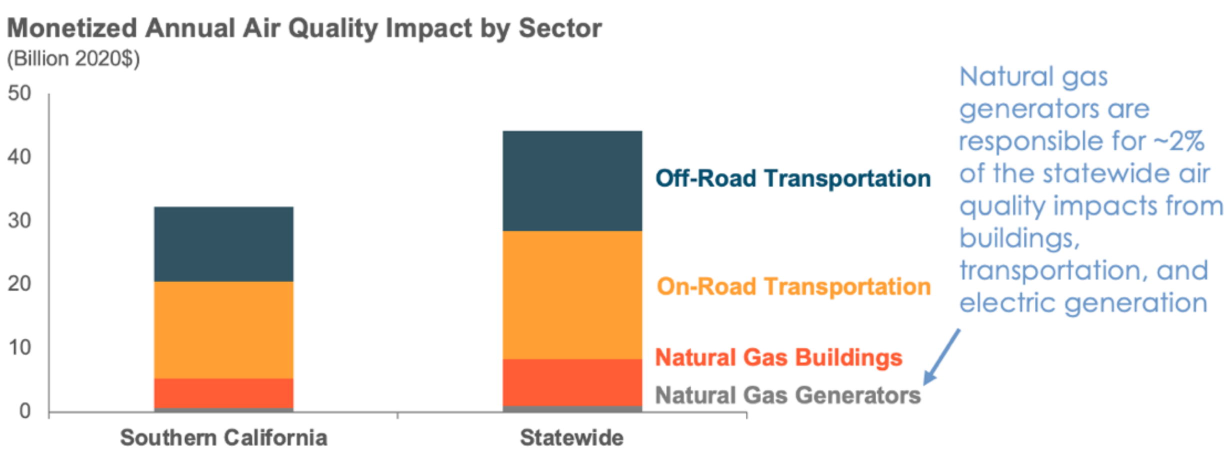


Figure 4. Monetized annual air quality impact from buildings, transportation, and natural gas generation in 2035, in both the South Coast Air Basin (left) and statewide (right).[7]

[7] Source: Mantegna, G., et al. *Quantifying the Air Quality Impacts of Decarbonization and Distributed Energy Programs in California.* 2021.

1. Introduction

In May 2019, a decision in the IDER proceeding (D.19-05-019) ordered a Societal Cost Test (SCT) to be tested in the Integrated Resource Planning (IRP) proceeding. This testing was assigned to IRP, rather than IDER, so that the impact of societal costs on both supply and demand side resource procurement could be examined. The decision mandated a three-element SCT, consisting of "a societal discount rate, an avoided social cost of carbon, and an air quality adder." The decision also authorized the testing of a fourth element -- methane leakage -- as part of the SCT. The current report describes the results of testing all four of these elements.

The decision ordered a testing and data gathering period through December 2020, followed by an evaluation period in 2021 to evaluate the information gathered from the testing period. During the evaluation period, CPUC's Energy Division ("Staff") was instructed to recommend to the Commission whether details of the SCT elements should be adopted as established in the 2019 decision, or revised pursuant to evaluation results. Further, Staff were directed to recommend the best approach for future use of the SCT, including how it should be used in decision-making. Based on the evaluation, recommendations, and comments, the CPUC will provide guidance on the SCT, final details of the SCT elements, and how the SCT should be used in decision-making, in the IDER proceeding, or in its successor proceeding.

This report describes the results of Staff's evaluation of an SCT (the 2021 evaluation period mentioned above). The impact of all four SCT components is tested, both separately and together in a "core" scenario. Staff are not yet recommending a future direction for adoption of an SCT, but are rather first seeking comment from stakeholders. Thus, this report is focused on the results of Staff's testing of an SCT.

Background on societal costs

Societal costs, in this context, are the "indirect" costs of electricity service that are borne by all of society, including future generations, rather than directly borne by ratepayers. These costs are not currently monetized, i.e., we do not pay these costs when we pay to use energy. Societal costs of using energy include human health impacts from degraded air quality, damages from climate change associated with greenhouse gas emissions, and many others. Although societal costs can be difficult to quantify and monetize, estimates of many societal costs are available in the literature, some of which are used in the current study. Societal costs can be contrasted with direct economic costs (e.g., costs of equipment and administration, changes in the utility's revenue stream, and the utility's avoided costs of providing services), which are traditionally the focus of cost effectiveness when regulators assess the cost effectiveness of DERs.

Societal costs have typically not been included in distributed energy resource cost effectiveness valuation or assessment of long-term resource planning and procurement in California, although guidelines for the former exist in the California Standard Practice Manual. First published in 1983, the Standard Practice Manual has been revised over time, with the most recent version published in 2001. The Standard Practice Manual identified four perspectives in cost-effectiveness evaluations: (a) participant perspective: the Participant test, (b) ratepayer perspective: the Ratepayer Impact Measure (RIM) test, (c) program administrator's perspective: the Program Administrator Cost (PAC) test, and (d) combination of the utility and participant perspective: the Total Resource Cost (TRC) test. The TRC, which is considered the primary cost-effectiveness test[8], measures program costs and benefits from the combined perspective of the program administrator (usually the utility) and the program participant. The current TRC test does not include any air quality impacts, but it does include a GHG adder that reflects the cost of meeting California's GHG targets. The Societal Cost Test (SCT) is a variation of the TRC that can include additional costs and benefits that may impact society at large, but do not directly impact the cost of providing energy services. The SCT has never been consistently implemented into decision making in California. Variations of the SCT have been used by the CPUC in proceedings, but only for evaluation purposes.

Energy-related societal costs are especially relevant to California, as the state has some of the most degraded air quality in the United States, particularly in the Los Angeles Basin and in the Central Valley. Air quality improvements are likely to bring significant human health benefits, particularly to disadvantaged communities which are often located near sources of air pollution. However, due to decades of improvements to pollution control technology at fossil fuel power plants, as well as investment in tens of GWs of renewable energy, natural gas power generation is only responsible for about 2% of the total air quality impacts associated with power generation, buildings, and transportation in California (Figure 5). This means that the potential for the electric sector, and any measures that reduce gas generation in the electric sector (such as electric energy efficiency), to impact air quality is minimal in comparison to the potential for measures such as electrification to impact air quality. Thus, it is crucial that any SCT that is implemented captures the air quality benefits of electrification.

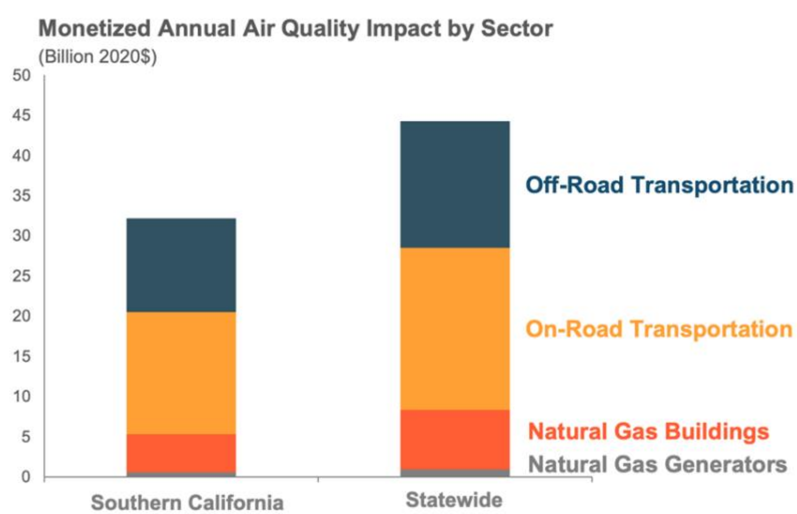


Figure 5. Monetized annual air quality impact by sector.[9]

---

[8] See D.19-05-017.

[9] Source: Mantegna, G., et al. *Quantifying the Air Quality Impacts of Decarbonization and Distributed Energy Programs in California*. 2021.

This study examines impacts of an SCT on both supply-side resource portfolios (through the RESOLVE model used in the CPUC IRP proceeding) and the avoided costs of distributed energy resources, including electrification cost-effectiveness (through the Avoided Cost Calculator developed in the CPUC IDER proceeding). Two steps are necessary because neither step on its own captures the entire picture of resource procurement. A visualization of these two steps, and the difference between them, is contained in Figure 6.

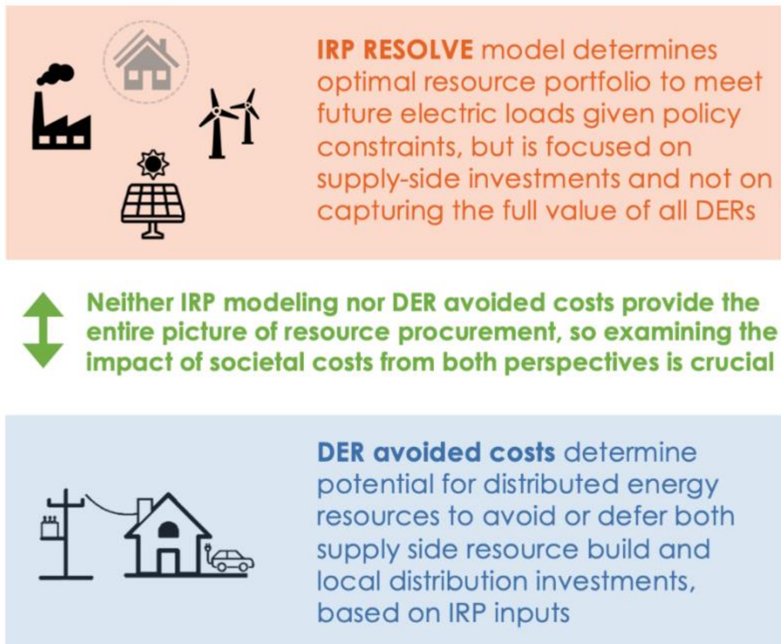


Figure 6. Visualization of IRP RESOLVE modeling and DER avoided cost calculations for resource procurement, and the importance of considering both steps in a Societal Cost Test.

2. Methodology

Summary of methodology

The present analysis examines the impacts of including SCT components in IRP RESOLVE modeling and distributed energy resource (DER) avoided cost calculations. The RESOLVE modeling determines optimal resource buildout and investments primarily on the supply side and does not fully capture all benefits of demand-side resources. The impacts of the SCT on the potential for demand-side resources to avoid or defer supply-side resource build and local distribution investments are further examined using the Avoided Cost Calculator (ACC), based on the resource portfolio selected in RESOLVE and other IRP inputs. Results from the DER avoided cost calculations are shown, including the impact on representative electrification measures. Examining the impact using this two-step process is crucial to ensuring that changes to the supply side portfolio under an SCT are reflected in the avoided costs used for DER cost-effectiveness evaluation.

The IDER decision mandates three SCT components—social cost of carbon (SCC), air quality adder (AQA), and social discount rate—to be tested. The decision also gives staff latitude to test the impact of methane leakage, which is also included in this analysis. These four SCT components are summarized below:

1. **Social cost of carbon (SCC):** represents the global climate damages associated with emitting CO_2. Note this is different from the GHG adder in the ACC, which reflects the cost of meeting our electricity sector GHG abatement targets.
2. **Air quality adder (AQA):** represents the impact of burning fossil fuels on human health due to degraded air quality.
3. **Social discount rate:** reflects a higher weighting of future benefits and costs (i.e. a lower discount rate compared to one based on the utility cost of capital).
4. **Methane leakage adder:** represents the impact of climate damages associated with emitting methane (CH_4).

These four SCT components are included in both the supply-side (RESOLVE) and demand-side (ACC) analysis. On the RESOLVE side, first the impact of each component is examined independently by including one component at a time. Then, the components are considered in conjunction in three SCT scenarios, described further below. All results are compared to a Reference scenario, which is the "38 MMT with 2020 IEPR with 2020 IEPR High EV" scenario picked as the Preferred System Plan scenario in the 2021 Preferred System Plan Proposed Decision.[10]

Finally, the four components are then considered in the DER cost effectiveness evaluation. The results from the core SCT scenario in RESOLVE are included as inputs to the ACC, in the same manner that results from RESOLVE are currently included in the ACC.

The next sections describe background and implementation details for each of the four SCT components, as well as methodological details of the DER cost effectiveness evaluation.

SCT components in RESOLVE: Social Cost of Carbon

The Social Cost of Carbon (SCC) is a monetization of the damages caused by one additional ton of CO_2 emitted, discounted to the present. In the RESOLVE modeling used in this study, the SCC is modeled as an extra price that generators must pay, similar to if a carbon tax were implemented. The values of SCC used in the present analysis come from the Obama Administration's Interagency Working Group (IWG) estimates,[11] which were recently adopted as interim values by the Biden Administration.[12] Two different SCC trajectories from the IWG are considered in the present work:

---

[10] Commission, California Public Utilities. *Decision Adopting 2021 Preferred System Plan.* Proposed Decision. December 2021.

[11] Interagency Working Grp. On Soc. Cost Of Carbon, Technical Support Document: Social Cost Of Carbon For Regulatory Impact Analysis Under Executive Order 12,866 at 5 (2010).

[12] Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide. Interim Estimates under Executive Order 13990. February 2021. https://www.whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument_SocialCostofCarbonMethaneNitrousOxide.pdf.

1. **Base SCC,** from a 3% discount rate, which is generally accepted as the "main" SCC value stream. This trajectory is adopted in our "core" SCT scenario.
2. **High SCC**, also from a 3% discount rate, but which reflects the 95th percentile of possible climate impacts from the IWG's modeling. This trajectory is used in a "High SCC" sensitivity scenario.[13]

Figure 7 shows SCC values for these two trajectories (Base SCC and High SCC).

IWG Social Cost of Carbon (2020$/metric ton)

	2020	2024	2030	2045
Base SCC (3% discount rate)	$53	$57	**$63**	$81
High SCC (3% discount rate, 95th percentile of damages)	$155	$170	**$192**	$249

Figure 7. Social cost of carbon values used in this study.

The SCC differs from the GHG adder in the ACC, which reflects the cost of reaching California's GHG goals. It also differs from the California Air Resources Board (CARB) cap-and-trade allowance cost, which is the cost of procuring GHG allowances under CARB's cap-and-trade program, and which is normally included in RESOLVE modeling but is replaced by the SCC in this work.

The effect of the SCC can be predicted by comparing it to shadow prices of the RESOLVE GHG emissions constraint, which reflect the marginal cost of meeting that constraint. If the SCC is greater than the shadow price of the GHG constraint in a given year, the SCC will cause RESOLVE to build a portfolio with lower emissions than the GHG constraint. This is illustrated in Figure 8. Figure 9 shows the Base SCC and High SCC for the years 2024, 2030, and 2045, compared to the GHG shadow price in the Reference case with a 38 MMT GHG reduction target.

[13] Note the IDER SCT Staff Proposal recommended the High SCC as the primary SCC value for an SCT, as the "mid" value is generally understood to be a lower bound for damage costs associated with climate change. See: Commission, California Public Utilities. *Decision Adopting Cost-Effectiveness Analysis Framework Policies For All Distributed Energy Resources.* May 2019.

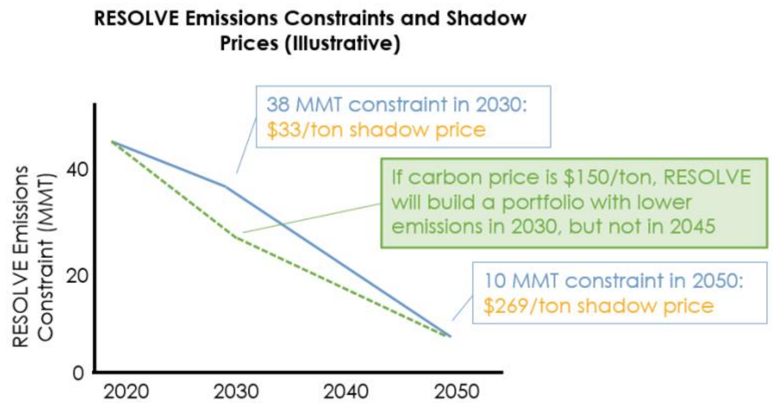


Figure 8. Illustration of the interaction of carbon price and GHG constraint in RESOLVE.

Social Cost of Carbon Compared To GHG Shadow Price in Reference (2020$/ton)

	2024	2030	2045
GHG Shadow Price in Reference Case (38 MMT)	$0	**$33**	$269
Base SCC	$57	**$63**	$81
High SCC	$170	**$192**	$249

Figure 9. Social Cost of Carbon compared to GHG shadow price in Reference case.

SCT Components in RESOLVE: Air Quality Adder (AQA)

The Air Quality Adder (AQA) represents the monetized impact of marginal gas generation on human health. The IDER decision that ordered this work specifies to test a $6/MWh "Interim Air Quality Adder", but grants staff the flexibility to use more robust values if they are available. The Interim AQA was determined using the EPA CO-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA) to estimate the air quality impacts of natural gas generation.[14] COBRA is specifically designed to be an easy-to-use screening tool and is not a tool designed for regulatory quality impact estimates. Hence, the interim value is useful only as a placeholder when more robust research is not available. Since subsequent research done for the IDER proceeding in 2020/2021 used state-of-the-art air quality modeling, in partnership with the University of California, Irvine, to develop an updated AQA, we included this updated research in the modeling, and believe the updated AQA is more accurate than the interim AQA.[15]

The impact of gas generators on air quality varies by region, as shown in Figure 10. However, the statewide average air quality adder is $14/MWh. There are two main reasons that the statewide average value is used instead of breaking the AQA out by region. The first is that it cannot be known with any certainty which gas generators will reduce their output in response to changes in the electricity resource portfolio. Many gas generators in the most affected areas such as the LA Basin,

---

[14] CO-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA). https://www.epa.gov/cobra.

[15] Mantegna, G. et al. *Quantifying the Air Quality Impacts of Decarbonization and Distributed Energy Programs in California.* 2021.

may need to run for electric reliability reasons, and due to the way power is scheduled across the Western Interconnection, the addition of solar power in California (for example) may result in reductions in gas generation in Washington or Arizona. This is also true for DER programs in California. Secondly, RESOLVE does not have any representation of local transmission constraints, further limiting our ability to identify changes in generation in the areas with high air quality impacts. Using a constant AQA value in RESOLVE ensures consistency across supply and demand sides. Hence, the two AQA values that are considered in this analysis are:

1. **Interim AQA,** which reflects the interim value of $6/MWh specified in the IDER decision.
2. **Updated AQA,** which reflects the higher AQA value of $14/MWh determined by the state-of-the-art air quality modeling done for the IDER proceeding in 2020/2021.

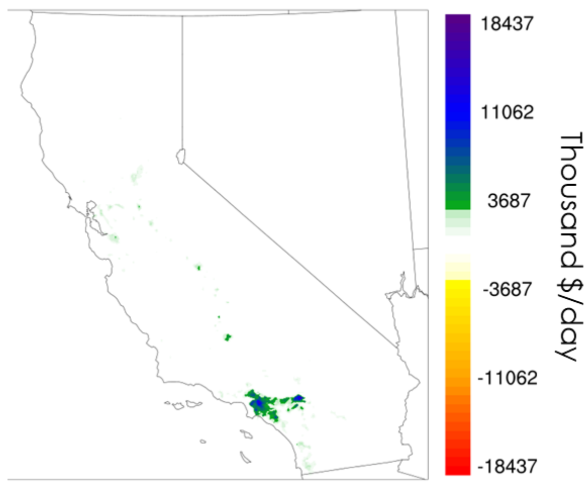


Figure 10. Monetized impact of California natural generators in human health.

SCT components in RESOLVE: Social Discount Rate

RESOLVE requires a discount rate to determine how to discount future costs to a single net present value (NPV). The RESOLVE model used to generate results for the 2021 Proposed PSP ruling uses a 5% real discount rate, which is intended to reflect the utility weighted average cost of capital (WACC). The IDER decision mandates the use of a "social discount rate" of 3%, as well as testing with the standard WACC values.

SCT components in RESOLVE: Methane leakage adder

The natural gas supply chain is known to leak a significant amount of methane, which is a potent greenhouse gas. The ACC includes an avoided cost from methane leakage, but it is restricted to in-state leakage only to ensure consistency with the California Greenhouse Gas (GHG) inventory. This in-state leakage is equivalent to about 0.6% of consumption. The total lifecycle leakage of the natural gas consumed in California is likely much closer to the estimated national average leakage rate of

2.3% of consumption[16], given that California imports ~95% of its natural gas. In this work, we apply this national average leakage rate of 2.3% and pair it with the IWG's social cost of methane to arrive at our methane leakage adder. The IWG's main value stream for social cost of methane is used to calculate the Base methane leakage adder, and the IWG's high value stream representing 95th percentile damages is used to calculate the High methane leakage adder, consistent with what was done for SCC. Figure 11 shows the trajectory of the IWG social cost of methane, and the resulting methane leakage adder values, in both the "base" (3% discount rate, median impacts) and "high" (3% discount rate, 95th percentile of impacts) scenarios.

Methane Leakage Adder

	2020	2025	2030	2045
Base Adder: IWG Social Cost of Methane, 3% discount rate, median impacts ($/t$CH_4$)	$1500	$1700	**$2000**	$2800
Equivalent $/tCO2 @ 2.3% leakage rate ($/t$CO_2$)	$13	$15	**$18**	$25
High Adder: IWG Social Cost of Methane, 3% discount rate, 95th percentile of impacts ($/t$CH_4$)	$3900	$4500	**$5200**	$7500
Equivalent $/tCO2 @ 2.3% leakage rate ($/t$CO_2$)	$33	$38	**$43**	$63

Figure 11. Social cost of methane values used in this study.

SCT Scenarios in RESOLVE

Three different SCT scenarios are analyzed that assume different magnitudes of societal costs for the four SCT components. The three SCT scenarios are described below:

- The **SCT Base** scenario assumes the lowest societal costs mandated by the IDER decision (Base SCC, Interim AQA, no methane adder, and a 3% social discount rate).
- The **SCT Core** scenario assumes the Base SCC, the updated AQA, the Base methane adder, and a 3% social discount rate. This is the primary SCT scenario.
- The **SCT with High SCC** scenario assumes higher social costs, including the High SCC, the updated AQA, the High methane adder, and a 3% social discount rate.

As described at the beginning of this section, all results are compared to a **Reference** scenario, which is the "38 MMT with 2020 IEPR with 2020 IEPR High EV (Managed Charging EV Profile)" modeled as the Preferred System Plan scenario in the 2021 Preferred System Plan Proposed Decision.

Figure 12 summarizes the three SCT scenarios examined in the present work and the SCT components that they include.

[16] Alvarez, R., et al. *Assessment of methane emissions from the U.S. oil and gas supply chain.* Science. 2018.

Scenario	Social Cost of Carbon	Air Quality Adder	Social Cost of Methane	Social Discount Rate?
SCT Base	Mid	Interim AQ Adder	None	Yes
SCT Core	Mid	**Updated AQ Adder**	**Mid**	Yes
SCT w/ High SCC	**High**	Updated AQ Adder	**High**	Yes

Figure 12. Summary of SCT scenarios and the components they include.

DER Avoided Costs Methodology

To test the impact of societal costs on cost effectiveness of demand side resource procurement, this work tests the impact of societal costs on avoided costs in the Avoided Cost Calculator (ACC), and subsequently on two sample electrification measures.

The ACC is an estimate of the marginal benefits to ratepayers of reducing load (these benefits are technically "avoided costs" on the supply side, hence the name). The goal of the ACC is to capture all costs that are avoided on the supply side and on the transmission and distribution grid when load is reduced or customer generation is increased, and because of this, the ACC uses several inputs from RESOLVE in the form of shadow prices (shadow prices reflect the implicit price of a constraint). In keeping with this framework of examining the marginal avoided cost of reducing load, in this work we examine what avoided costs would look like when societal costs are included, using a portfolio in RESOLVE that includes societal costs as a reference point. This methodology ensures that we are not double counting any avoided costs (which would happen if we were to simply add the societal costs on top of the current avoided costs). We develop a version of the ACC that includes societal costs, and in this version, there are two important changes: 1) the RESOLVE shadow price inputs for the ACC are changed to the shadow prices in the SCT Core or High SCC scenario of RESOLVE (both scenarios are modeled), and 2) new adders for the social cost of carbon, methane, and air pollution are added, as these are marginal costs of using energy that are seen by supply side resources in RESOLVE.

In addition to looking at the impact of societal costs on avoided costs in the ACC, we also examine the impact of societal costs on a sample vehicle electrification measure and a sample building electrification measure. Cost inputs for these two cost effectiveness tests are based on the CPUC's Residential Energy Cost Calculator.[17]

[17] For details about the Residential Energy Cost Calculator, see: Commission, California Public Utilities. *Utility Costs and Affordability of the Grid of the Future.* 2021. Accessible at: https://www.cpuc.ca.gov/-/media/cpuc-

3. RESOLVE Scenario Results

The following sections examine how each of the individual SCT components (i.e., social cost of carbon, air quality adder, methane leakage adder, and social discount rate) affect the Reference case RESOLVE results, including impact on the selected resource build and statewide GHG emissions from electric generation. In a subsequent section, the results of the three SCT scenarios (Base, Core, and High SCC) are shown.

Impact of SCC

Figure 13 shows the statewide emissions from electric generation through 2045 for the Reference, Base SCC, and High SCC cases. Although the Base SCC has a negligible impact on emissions compared to the Reference, the High SCC results in lower emissions in the years prior to 2045. This is expected based on a comparison of the SCC values and the Reference case marginal GHG reduction costs (shadow prices), as discussed earlier. This difference is most pronounced in the year 2030, where the High SCC scenario reduces emissions to 23 MMT. This reduction in emissions comes from an increase in renewable resources selected in earlier years. Figure 14 shows the new resource buildout relative to 2021 selected by RESOLVE for the Reference, Base SCC, and High SCC cases. There is significantly more solar and storage selected for the High SCC scenario in the year 2030 compared to the Reference and Base SCC scenarios, which have similar resource builds.

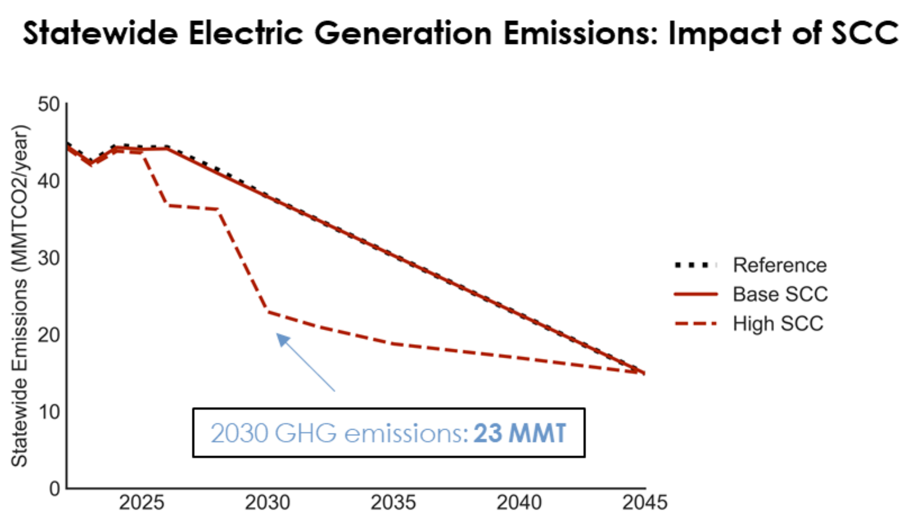


Figure 13. Statewide electric generation emissions over time for the Reference, Base SCC, and High SCC cases.

website/divisions/office-of-governmental-affairs-division/reports/2021/senate-bill-695-report-2021-and-en-banc-whitepaper_final_04302021.pdf

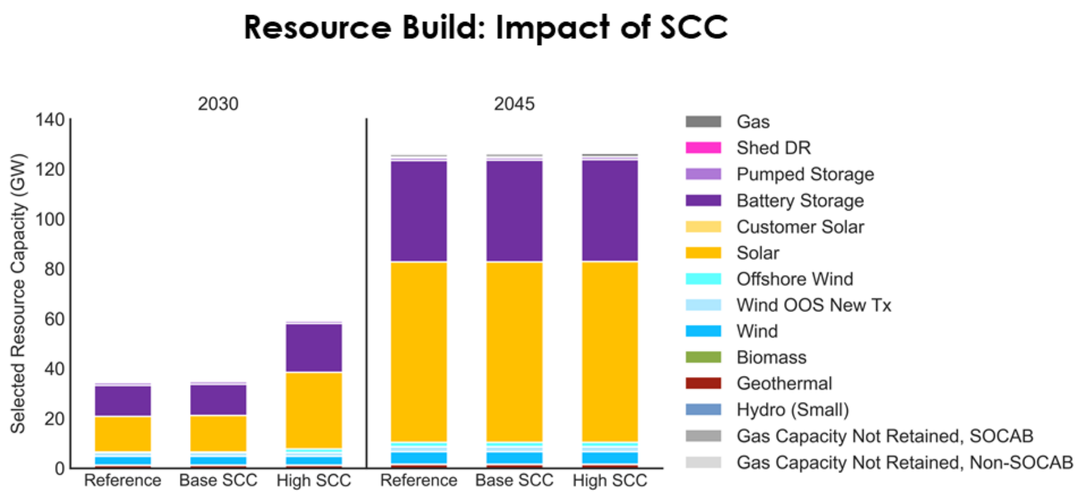


Figure 14. RESOLVE-selected new resource buildout relative to 2021 for the Reference, Base SCC, and High SCC cases.

Impact of Air Quality Adder

Figure 15 and Figure 16 show the impact of the air quality adder on statewide electric sector emissions and resource build, respectively. It is clear from these results that the air quality adder does not materially impact the emissions or the resource build on its own. This is because the 38 MMT GHG constraint already incorporates an implied value for GHG emissions that exceeds the total societal costs included under the Base and High AQAs.

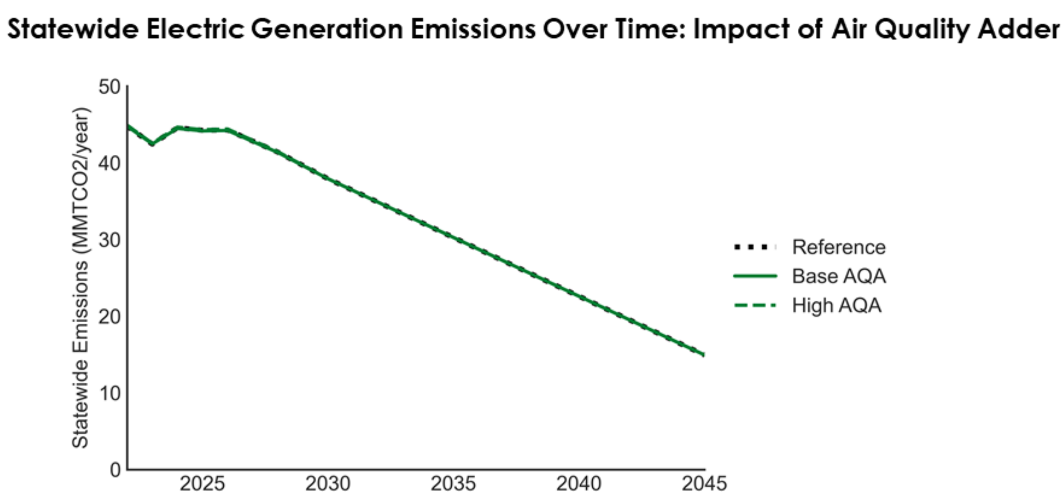


Figure 15. Statewide electric generation emissions over time for the Reference, Base AQA, and High AQA cases.

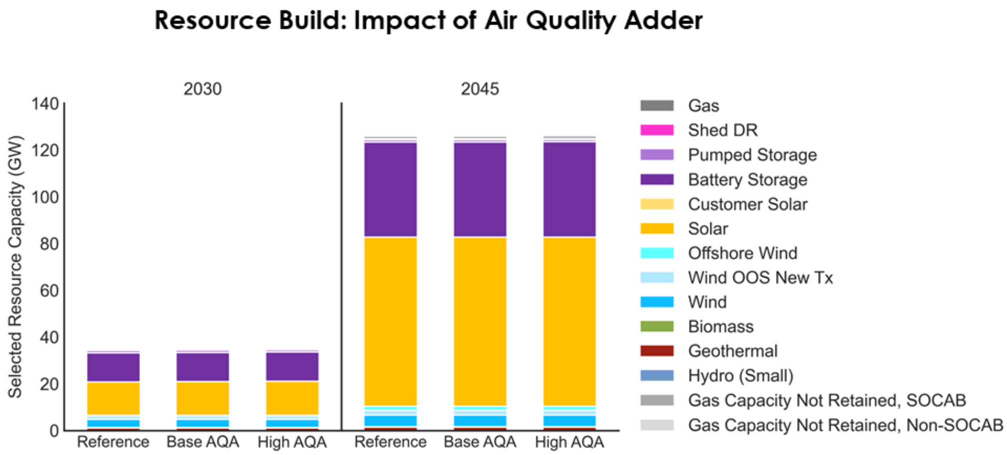


Figure 16. RESOLVE-selected new resource buildout relative to 2021 for the Reference, Base AQA, and High AQA cases.

Impact of Methane Leakage Adder

Figure 17 and Figure 18 show the statewide electric generation emissions and resource build considering methane leakage with a Base and High social cost of methane compared to the Reference case. Overall, the effects of including the methane adder are negligible compared to the results for the Reference case.

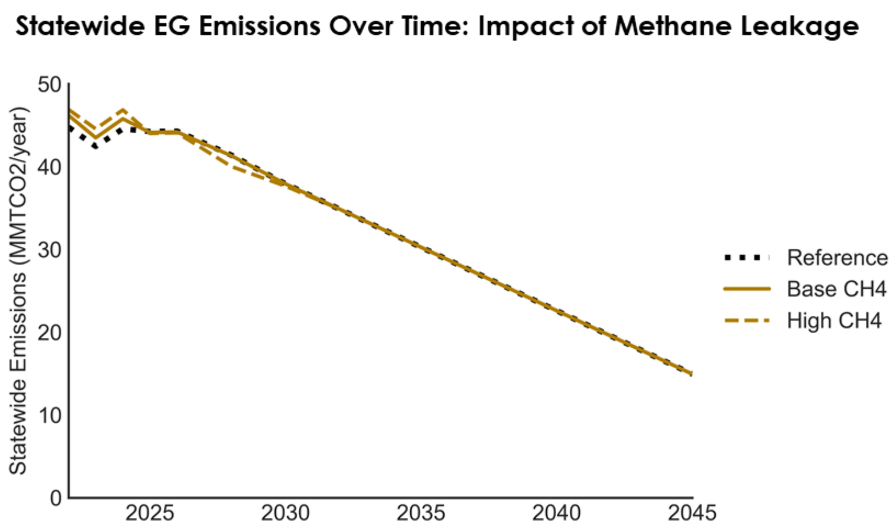


Figure 17. Statewide electric generation (EG) emissions over time for the Reference, Base Methane Adder, and High Methane Adder cases.

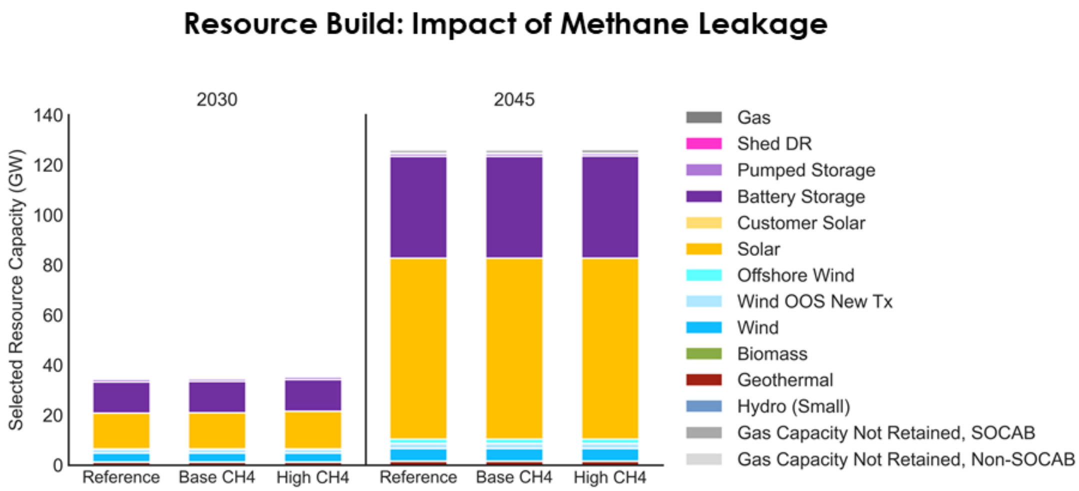


Figure 18. RESOLVE-selected new resource buildout relative to 2021 for the Reference, Base Methane Adder, and High Methane Adder cases.

One seemingly counterintuitive result is that the presence of a methane cost adder increases emissions relative to the Reference case in earlier years. This is because the social cost of methane increases the cost of natural gas generation (through increased fuel prices) but does not impact the cost of imported coal generation. As a result, imported coal generation replaces some natural gas generation to meet demand in earlier years, which is allowed for by the more lenient emissions target in those years[18].

Impact of Societal Discount Rate

A 3% real "social discount rate" is tested in RESOLVE compared to the 5% real discount rate used in the Reference case which is meant to reflect the utility cost of capital (WACC). As shown in Figure 19 and Figure 20, applying this lower 3% social discount rate does not significantly impact the optimization results, because the results (in terms of emissions) are driven by the GHG constraint. However, a social discount rate could have a more pronounced effect in the context of DER cost effectiveness, because upfront resource costs are not levelized as they are in RESOLVE.

[18] Note that, while no IOUs in California have coal contracts, there are some POUs in CAISO that have out-of-state coal contracts until 2026, which is why out-of-state coal generation is included in the RESOLVE model.

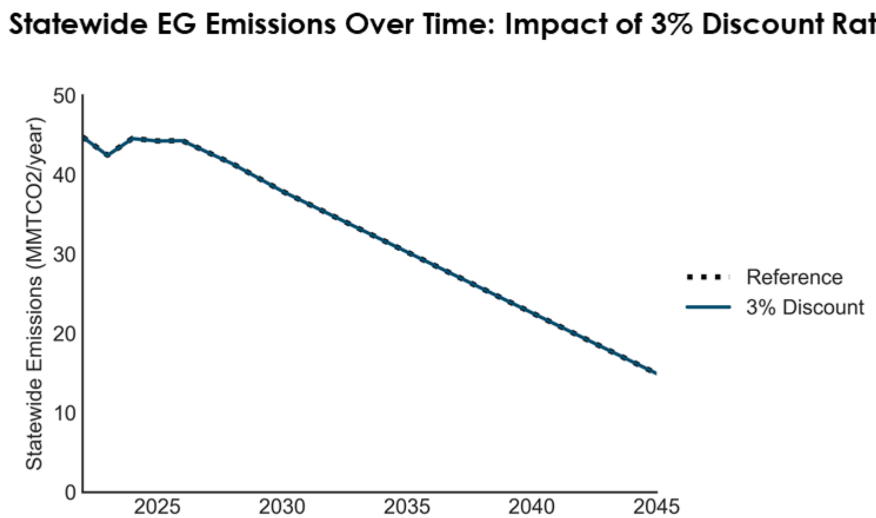


Figure 19. Statewide electric generation emissions over time for the Reference (5% discount rate) and 3% Social Discount Rate cases.

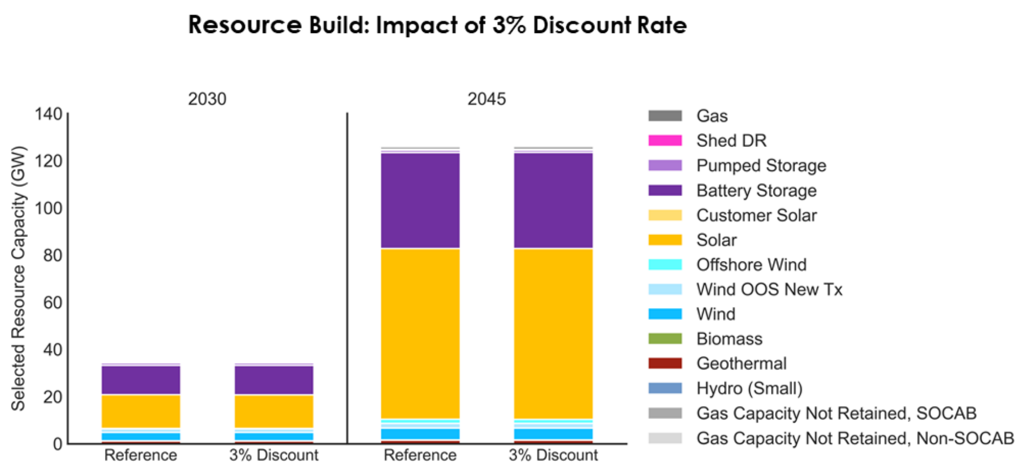


Figure 20. RESOLVE-selected new resource buildout relative to 2021 for the Reference (5% discount rate) and 3% Social Discount Rate cases.

SCT scenario RESOLVE results

The three SCT scenarios, outlined as a reminder in Figure 21 below, are examined, considering all SCT components together in RESOLVE. The magnitude of the various SCT components differs by scenario. The RESOLVE results for these three SCT scenarios are presented here.

Scenario	Social Cost of Carbon	Air Quality Adder	Social Cost of Methane	Social Discount Rate?
SCT Base	Mid	Interim AQ Adder	None	Yes
SCT Core	Mid	**Updated AQ Adder**	**Mid**	Yes
SCT w/ High SCC	**High**	Updated AQ Adder	**High**	Yes

Figure 21. SCT adders used in each scenario (included a second time for ease of reading).

Figure 22 shows the statewide electric generation emissions for each of the SCT scenarios compared to the Reference. Emissions are very similar between the Reference, SCT Base, and SCT Core scenarios. This is because reaching the existing GHG abatement targets costs about the same as the societal costs modeled (in other words, the existing GHG abatement targets are already doing a good job of internalizing societal costs). However, when the High social cost of carbon and methane costs are used, 2030 GHG emissions are reduced to 19 MMT. A breakout of the societal cost adders included in this scenario is shown in Figure 23.

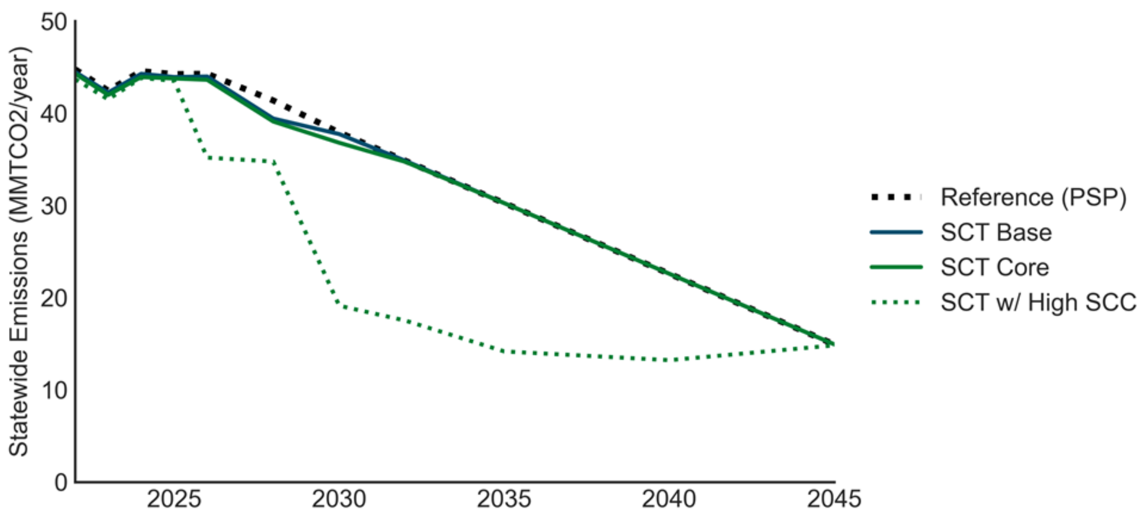


Figure 22. Statewide electric generation emissions over time for the Reference and SCT scenarios.

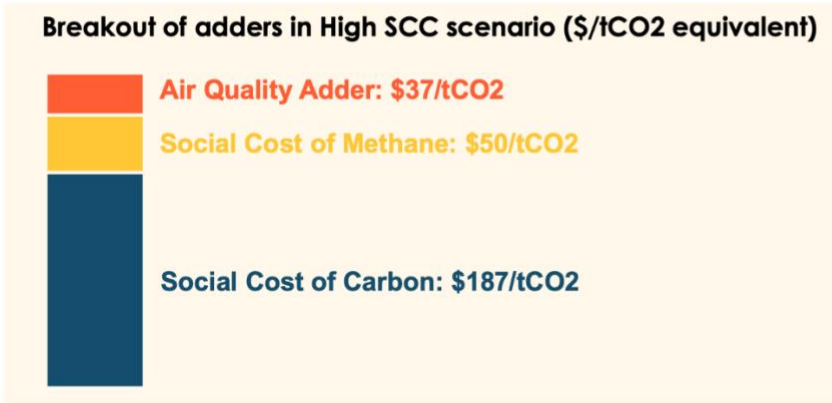


Figure 23. Breakout of societal cost adders in the High SCC scenario.

The 2030 statewide electric generation GHG emissions for each scenario are summarized in Figure 24. No scenarios result in lower emissions than the Reference case in 2045, as the Reference case includes a 12 MMT GHG target for 2045, in line with PATHWAYS midcentury decarbonization scenarios that show the level of electric sector GHG reductions that are likely to be necessary to meet California's economy-wide GHG reduction goals.[19]

Scenario	2030 Statewide GHG Emissions (MMT)
Reference (PSP)	38
SCT Base	38
SCT Core	37
SCT w/ High SCC	19

Figure 24. 2030 statewide GHG emissions from electric generation for the Reference and SCT scenarios.

The resources selected by RESOLVE in each scenario are shown in Figure 25. The High SCC scenario shows a significantly higher renewable resource build in 2030 (+23 GW of solar, +11 GW of battery storage, and +1.2 GW of offshore wind compared to the Reference case). There is no retirement of gas capacity in any scenario due to the system reliability needs amidst increased loads from electrification modeled by 2045.

[19] The 2045 electric sector GHG target is taken from the PATHWAYS High Biofuels scenario. Note this is not a fixed target that is binding, but rather a target that is intended to be representative of future targets that may be set for the electric sector. More details can be found in: Mahone, A. et al. *Deep Decarbonization in a High Renewables Future*. 2018.

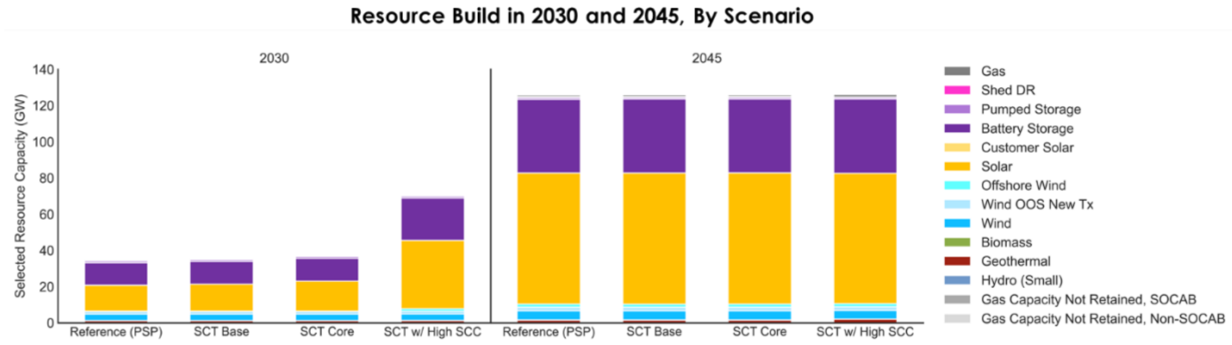


Figure 25. RESOLVE-selected new resource buildout relative to 2021 in 2030 and 2045 for the Reference and SCT scenarios.

Generation by resource for each scenario in 2030 and 2045 is shown in Figure 26. The SCT Core scenario shows very little change in generation compared to the Reference case. However, the High SCC scenario features significantly less energy from imports ("unspecified", mostly natural gas generation as well as some coal) and in-state gas generation due to the increased capacity of renewables selected in this scenario (Figure 25).

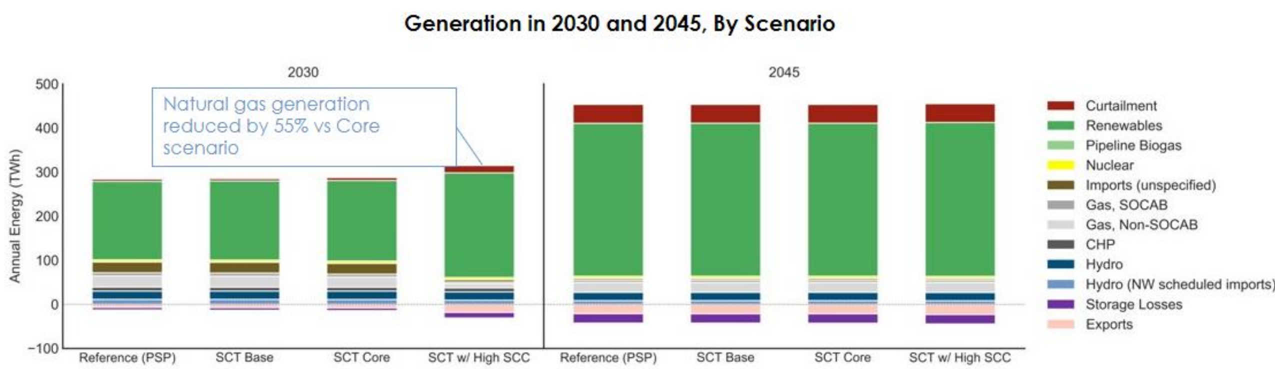


Figure 26. Electric generation by resource in 2030 and 2045 for the Reference and SCT scenarios.

The cost of the SCT scenarios is examined relative to the Reference case, with societal cost adders subtracted out. The increase in revenue requirement for the scenarios compared to the baseline (Reference case) is shown in Figure 27. The SCT Core scenario has a negligible cost increase compared to the Reference. The SCT with High SCC scenario increases costs by about $1B in 2030 relative to a revenue requirement of $40B for the Reference case. This cost increase is equivalent to a 0.5¢/kWh increase in average rates, or about $50/tCO_2$ abated. These costs would be in addition to the expected increase in electric rates over time, even in real terms (see Figure 28). Note that the net costs in some years in this figure are negative because of slight changes in resource dispatch due to the societal cost adders in the SCT scenarios, meaning that when the adders are subtracted out, the total cost is different from the Reference case.

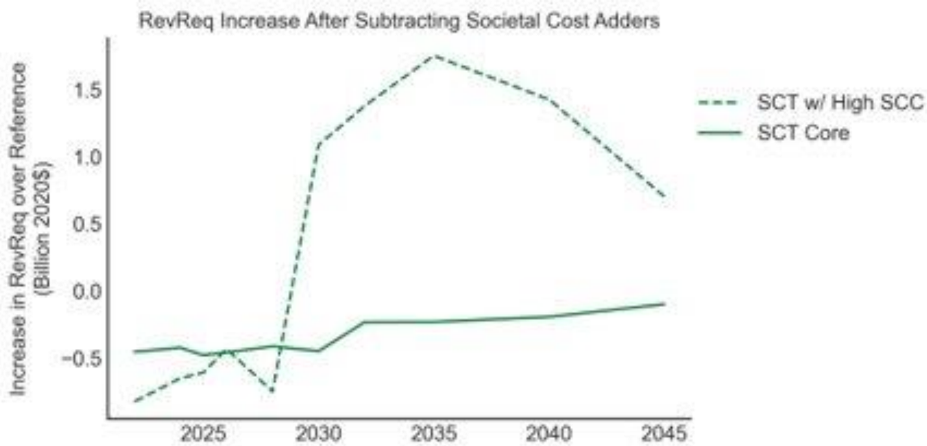


Figure 27. Increase in revenue requirement over time for the SCT Core and SCT with High SCC scenarios (relative to the Reference case).

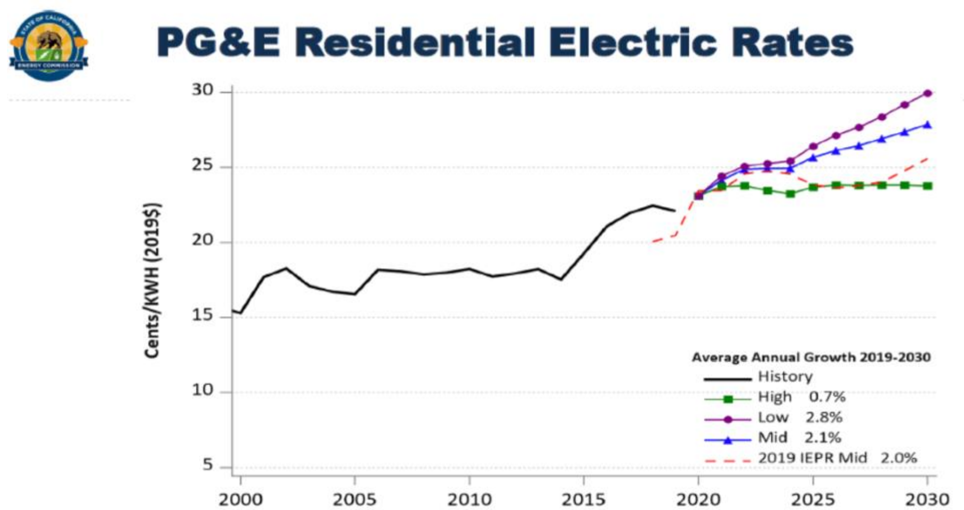


Figure 28. PG&E residential electric rates over time, with future projection range, in 2019 dollars. Note the three values for future trajectories reflect IEPR rate forecast scenarios.

In addition to running RESOLVE for the SCT scenarios with the baseline 38 MMT GHG constraint, the scenarios are also run with a 30 MMT GHG constraint to ensure that the analysis is robust to possible future changes to the GHG target. The impact of the SCT scenarios is similar despite the more stringent GHG target, with only the SCT with High SCC scenario driving additional resource selection. The statewide electric generation emissions for all scenarios are shown for the two different GHG targets side by side in Figure 29.

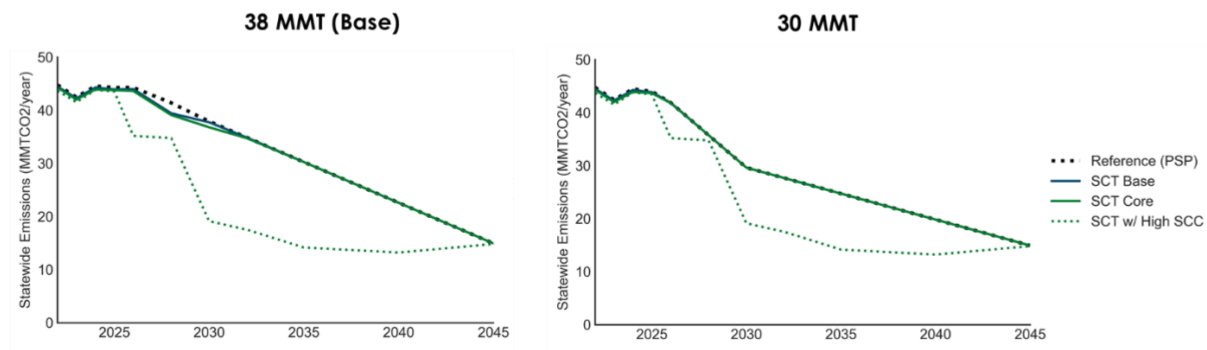


Figure 29. Statewide electric generation emissions for the Reference and SCT scenarios: 38 MMT GHG constraint (left); and 30 MMT GHG constraint (right).

Summary of SCT scenario RESOLVE results

The results of running RESOLVE for the SCT scenarios are summarized below:

- The SCT Core scenario does not change the main outcomes of the RESOLVE model compared to the 2030 Reference case, because the cost of reaching the existing GHG abatement targets is about the same as the costs of societal damages modeled.
- For the three SCT scenarios tested in RESOLVE, only the SCT with High SCC scenario causes additional resources to be built by 2030, while the SCT Base and SCT Core scenarios result in resource builds and emissions that are very similar to the Reference case.
- The system cost increases are negligible for the SCT Core scenario, after subtracting out the societal cost adders, while the SCT with High SCC scenario increases costs by about $1B/yr in 2030, which is equivalent to a 0.5¢/kWh increase in average rates. This scenario effectively accelerates the State's midcentury GHG reduction targets to 2030.
- No gas capacity is retired in any scenario due to system reliability needs.

4. DER cost effectiveness results

Avoided cost impact

This section examines the impact of the SCT on DER avoided costs using the SCT Core scenario societal cost components (i.e., Mid social cost of carbon, updated air quality adder, Mid social cost of methane, 3% social discount rate), and using the SCT High SCC scenario societal cost components (95th percentile social cost of carbon, updated air quality adder, 95th percentile social cost of methane, 3% social discount rate). Including the SCT Core components does not significantly change the hourly average avoided costs in the 2021 Avoided Cost Calculator (ACC) (Figure 30). This is because the societal cost adders slightly surpass the shadow price of the GHG constraint such that the GHG constraint is no longer binding. Thus, the GHG adder is effectively replaced with the cost adders that are of very similar magnitude, and the avoided costs are nearly unchanged. However, the SCT High SCC scenario does increase avoided costs by ~35% in most hours except the mid-day hours when solar generation is highest, due to the significantly higher social cost of carbon and methane adders as compared to the Core scenario.

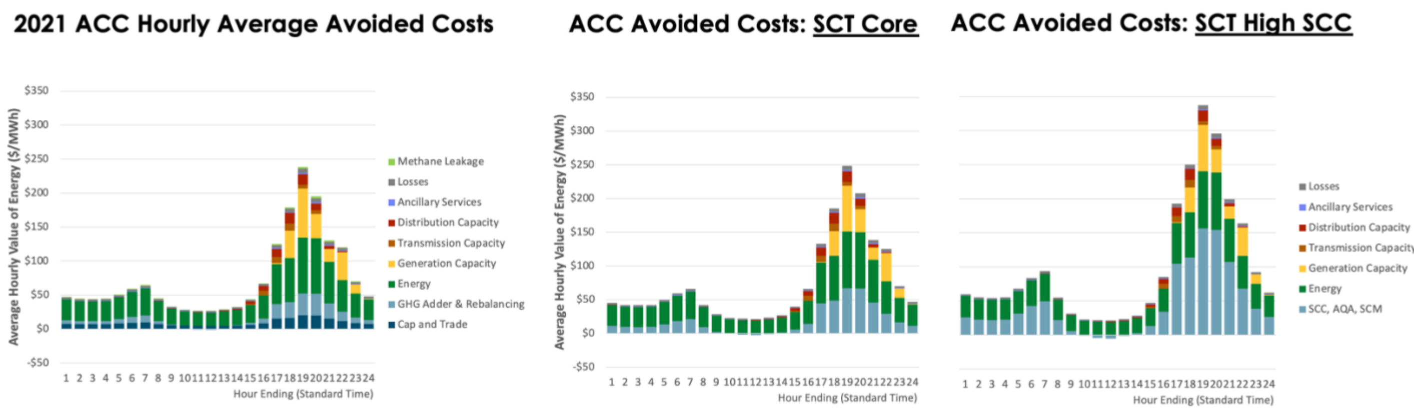


Figure 30. ACC hourly average avoided costs for reference 2021 ACC (left), and 2021 ACC under SCT Core and High SCC scenarios (right).

Although changes to the hourly avoided costs in the Core scenario are negligible, the SCT has a much more pronounced impact on electrification avoided costs, due to the significant air quality benefit of electrification. The following sections will examine the impact of the SCT on electrification cost effectiveness for representative measures in transportation and building electrification.

Transportation electrification measure impact

The cost effectiveness of a representative light duty vehicle electrification measure is evaluated under the SCT Core and High SCC scenarios compared to a TRC using avoided costs from the ACC as described above, measure cost inputs from the CPUC Residential Energy Cost Calculator, and updated air quality adder values described above from a recent E3 report[20]. The costs and benefits based on the SCT and TRC are shown side-by-side in Figure 31. The SCT Core scenario has a minimal impact on the electric sector supply cost (calculated using the ACC) but adds significant benefits from air quality and the SCC. The SCT High SCC scenario shows an even larger increase to benefits, due to the higher social cost of carbon used. Note that the costs in the SCT scenarios also increase due to the lower discount rate.

[20] Mantegna, G., et al. *Quantifying the Air Quality Impacts of Decarbonization and Distributed Energy Programs in California.* 2021.

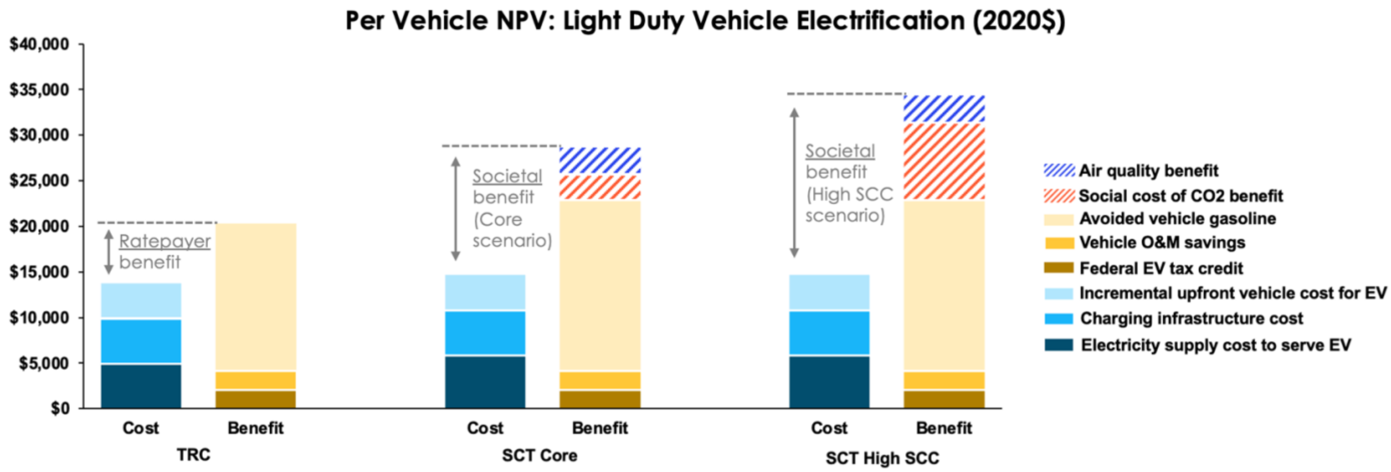


Figure 31. Costs and benefits of a representative light duty vehicle measure under TRC compared to SCT Core and High SCC scenarios.

It is important to note that the increased benefits in the SCT scenarios relative to the TRC represent societal benefits, rather than avoided costs that are seen directly by ratepayers. Thus, using an SCT to determine electrification program cost effectiveness could result in higher electric rates, if any increased incentives or program spending justified by an SCT are paid through via electric rates. However, these same ratepayers would also benefit from the electrification programs due to improved air quality.

Building electrification measure impact

We also examine a building electrification measure under the SCT Core and High SCC scenarios compared to the TRC using data from the same sources mentioned above for the transportation electrification measure impact. This representative measure assumes that a single-family household replaces an existing air conditioner with a heat pump at end-of-life so that there is no incremental capital cost for the measure (consistent with some households in the Residential Energy Cost Calculator). The costs and benefits of this measure under the SCT and TRC are shown in Figure 32. The impact of the SCT on the cost effectiveness of this particular building electrification example (which represents an electric-ready single-family residence) is more pronounced than it was for the previously shown transportation electrification measure, due to the relatively cheaper fuel cost in the baseline case for the building electrification example. It is important to note that certainly not all building electrification measures have zero incremental capital costs, as shown in this example—however, the approximate magnitude of increases to avoided costs (~2x) is likely to hold for most building electrification measures, due to the significant air quality benefit from building electrification of ~$1.20 per therm. Importantly, this value includes outdoor air quality impacts only, and not indoor air quality impacts, meaning that the true impact of building electrification on air quality is likely higher than this[21]. Note that, similar to the transportation electrification measure

[21] Indoor air quality impacts are not included in this value because a methodology does not yet exist to estimate monetized health impacts for indoor air quality improvements. However, this is an active area of research, so monetized

above, the costs in the SCT scenarios are higher due to the lower discount rate used (3% real vs 5% real). Also note that the avoided natural gas supply cost in the SCT scenarios is lower than the TRC because the natural gas avoided costs in the ACC include a cost of CO2 abatement and cost of air pollution damages, which are subtracted out for the SCT scenarios and added separately as indicated.

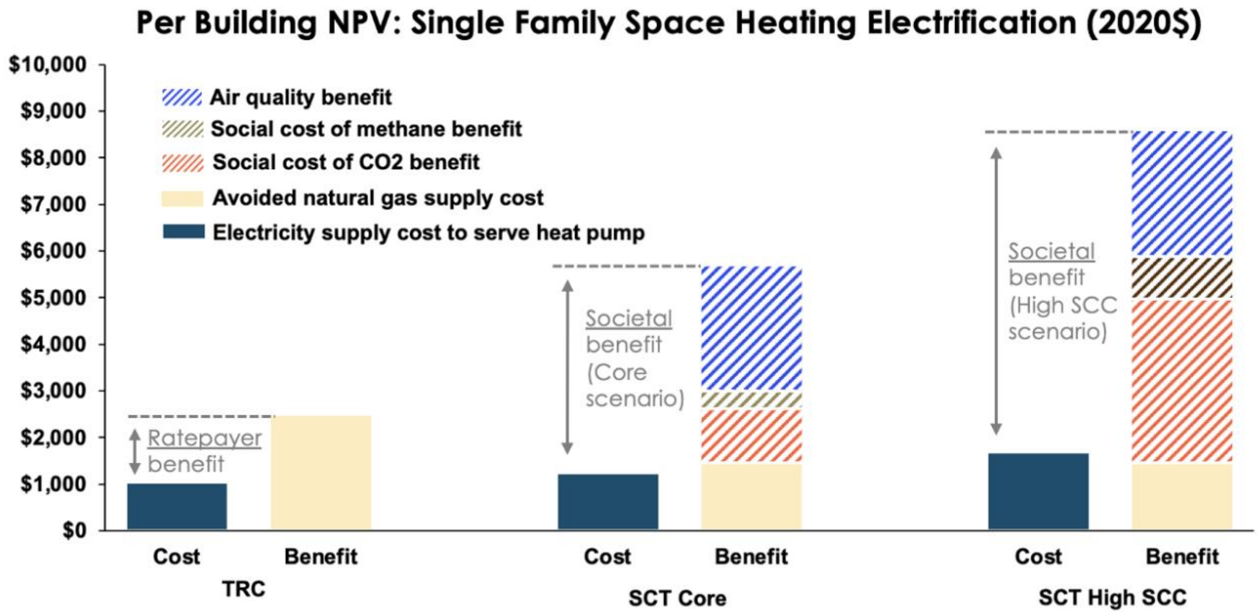


Figure 32. Costs and benefits of a representative building electrification (single family space heating) measure under the TRC compared to the SCT Core and High SCC scenarios. Note the air quality benefit shown here includes outdoor air quality benefits only, and not indoor air quality benefits.

Summary of DER cost effectiveness results

The results of the evaluation of the impact of an SCT on DER cost effectiveness are summarized below:

- An SCT, under the Core scenario, would cause negligible changes to DER avoided costs for electricity supply in 2030, because the societal cost adders effectively replace the GHG adder. This means that the cost effectiveness of most DERs, such as electric energy efficiency and rooftop solar, is unlikely to be significantly affected by an SCT. However, the SCT High SCC scenario results in an increase to avoided costs of about ~35% in most hours (except the mid-day hours where there is negligible avoided gas generation).
- An SCT, under the Core scenario, and even more so under the High SCC scenario, is likely to show modest increases to the cost effectiveness of transportation electrification compared

estimates of indoor air quality impacts could be included in the future. See more details in: Mantegna, G., et al. *Quantifying the Air Quality Impacts of Decarbonization and Distributed Energy Programs in California.* 2021.

with a TRC. The impact is likely to be significantly larger for medium- and heavy-duty vehicle electrification.

- An SCT (similarly, under the Core scenario, but even more so under the High SCC scenario) is likely to show significant increases to the cost effectiveness of building electrification measures, relative to a TRC. The avoided cost from air quality damages for gas combustion in buildings is $1.20/therm (including outdoor air quality impacts only and not indoor air quality impacts), which is approximately equal to current rates.
- It should be noted that, unlike with gas generation, localized air quality adders can be used to calculate the societal benefits of reduced transportation and heating fuels. This is because the location of the consumption impact is known – it is in fact a specified input to the analysis. Thus, electrification measures can be targeted to achieve the maximum societal benefit. This is unlike electric load-reducing measures, where the air quality benefits may fall outside of the most affected areas or even outside of California.
- When interpreting these results, it is important to keep in mind that any increased benefits shown by an SCT relative to a TRC are societal benefits, rather than ratepayer benefits, and therefore basing cost effectiveness on an SCT could cause an increase to rates.

5. Equity implications of this work

The CPUC is committed to furthering principles of environmental and social justice, as highlighted in the CPUC's Environmental and Social Justice Action Plan[22]. This work is an important contribution to these efforts, as societal costs such as air quality and climate change disproportionally impact disadvantaged communities. Therefore, incorporation of these costs could help ensure that impacts on disadvantaged communities are included in decision-making.

This work has two important implications related to equity: 1) the current resource procurement cost effectiveness methodologies used in the IRP and IDER proceedings already reflect societal costs to some extent, due to the inclusion of GHG reduction targets which have a cost of meeting them that is similar to the societal cost of using energy, and 2) the biggest potential for resource procurement to achieve benefits in disadvantaged communities is through electrification, which is likely to see significant increases to cost effectiveness under an SCT. However, it is important to recognize that paying for any increased resource procurement shown as cost effective under an SCT could result in increases to electric rates, which could adversely impact low-income communities that spend a higher percentage of their income on energy costs.

6. Key takeaways and conclusions

There are several key takeaways from this work:

- Under the "core" scenario in which central estimates for all societal cost adders are used, an SCT would not lead to any increases in renewable resource build in RESOLVE, nor would it

[22] Commission, California Public Utilities. *Environmental & Social Justice Action Plan.* 2021.

lead to any increases to the cost effectiveness of distributed energy resources such as electric energy efficiency. This result occurs because the societal cost adders in the SCT Core scenario are a similar magnitude to the cost we are already paying to meet our GHG abatement targets. However, this result is sensitive to resource costs, and to the social cost of carbon. Under lower resource costs and/or a higher central estimate for the social cost of carbon, this result could change.

- Under the "High SCC" sensitivity scenario in which 95th percentile estimates for the social cost of carbon and methane are used, there are significant impacts to renewable resource build in RESOLVE, with the model choosing to build enough renewables to reduce emissions to 19 MMT, lower than the GHG target of 38 MMT in the Reference case. This scenario would lead to a level of electric sector decarbonization by 2030 similar to the State's midcentury electric sector decarbonization target, which would increase renewable resource build costs about $1B/yr in 2030, or 0.5¢/kWh, after subtracting out the societal cost adders. It is worth noting, however, that achieving earlier reductions of GHG emissions would not only lead to increased costs, but also to societal benefits by way of reduced climate impacts.
- The cost effectiveness of distributed energy resource procurement would increase under the High SCC scenario as well, with avoided costs increasing by ~35% in most hours, except the mid-day hours when solar generation is highest.
- The one measure type that would see significant increases to cost effectiveness under the Core SCT scenario is electrification measures. For building electrification, the SCT Core scenario would increase the benefits shown by ~2x relative to a TRC, and the SCT High SCC scenario would increase the benefits by ~3x relative to a TRC.

7. Questions for stakeholders

The CPUC is seeking feedback from stakeholders on this work, particularly on the following questions:

- Should the CPUC adopt an SCT, for informational purposes, across all proceedings that consider investments?
- How should the SCT be used (if at all) in modeling for the IRP proceeding?
- How should the SCT be used (if at all) in DER proceedings?
- Do you agree with the specific values used in the SCT as described above? If not, explain any modifications that you recommend.
- If an SCT is adopted, should the "Core" or "High SCC" scenario be used?
    - Note that the Biden administration Interagency Working Group is likely to update the "central" SCC value stream in 2022. One option could be to stick with the central value, and update as it is updated by the IWG.
- Should "society" be California-specific, such that federal tax benefits are included in the SCT? Federal tax benefits, such as the EV tax credit, are included in the results shown in this work, but do not necessarily have to be included in a future SCT, if "society" is defined broadly enough such that tax payments are considered a transfer payment.
- Do you have other suggestions for use of an SCT?