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BEFORE THE PUBLIC UTILITIES COMMISSION OF THE STATE OF CALIFORNIA

Order Instituting Rulemaking to Create a Consistent Regulatory Framework for the Guidance, Planning and Evaluation of Integrated Distributed Energy Resources.	Rulemaking 14-10-003

ADMINISTRATIVE LAW JUDGE'S RULING SEEKING RESPONSES TO QUESTIONS AND COMMENT ON STAFF AMENDED PROPOSAL ON SOCIETAL COST TEST

Summary

Following an August 8, 2017 workshop, the Commission's Energy Division revised its proposal on adoption of a Societal Cost Test. Parties are directed to file comments on the amended proposal and respond to specific questions contained in this Ruling. Comments and responses shall be filed no later than 30 days from the issuance of this Ruling; replies shall be filed no later than 45 days from the issuance of this Ruling.

Background

The scope of this proceeding includes the issue of the continued development of technology-neutral cost-effectiveness methods and protocols, including, but not limited to, the refinement and enhancement of valuation or cost-effectiveness methods and informing or determining a preferred approach to bid evaluation within the competitive solicitation framework.

Over the course of this proceeding, the Commission's Energy Division (Staff) has been developing a proposal to adopt a Societal Cost Test (Staff Proposal) as part of phase three of its four-phase cost-effectiveness framework.[1] On February 9, 2017 and April 3, 2017, two related rulings were issued in this proceeding addressing this matter.

The February 9, 2017 Ruling initially introduced the Staff Proposal, which recommended inclusion of an air quality value, a social discount rate, and a greenhouse gas adder to estimate the value of the reduced carbon emissions that distributed energy resources provide. The Staff Proposal recommended adoption of the Societal Cost Test and modified Total Resource Cost (TRC) and Program Administrator Cost (PAC) tests.

In the April 3, 2017 Ruling, a staff proposal addendum (Addendum) indicated a more urgent need for development of the greenhouse gas adder in order to consider the impact of the adder in an upcoming Energy Efficiency Potential Study. Staff proposed an interim greenhouse gas adder based upon preliminary results from the RESOLVE model.[2]

Parties filed comments and replies to both rulings.

Decision 17-08-022 adopted a series of values based upon the California Air Resources Board Cap-and-Trade Allowance Price Containment Reserve Price as an interim greenhouse gas adder value for use in the avoided cost calculator when analyzing the cost-effectiveness of distributed energy resources. The Commission also determined that development of a permanent greenhouse gas adder will be considered in the future, in coordination with Rulemaking (R.) 16-02-007 and, if and when adopted, will replace the interim greenhouse gas adder.

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[1] *See* October 9, 2015 Administrative Law Judge Ruling introducing the four phase proposal. The four phases are: 1) improve the existing cost-effectiveness framework; 2) improve the relationship between cost-effectiveness and system conditions through a coordinated effort with Rulemaking (R.) 14-08-013 (the Distribution Resources Plan (DRP) proceeding); 3) improve models and methods to accurately reflect policies; and 4) expand the cost-effectiveness framework to create an all-source all-technology valuation framework.

[2] RESOLVE Model is a capacity expansion model, based on linear programming techniques, used to identify least-cost portfolios of future resources that satisfy the multiple state policy goals required by the Integrated Resource Planning statute, including reducing greenhouse gas emissions and maintaining reliability.

On August 8, 2017, a workshop was held to provide clarity to the parties on the multiple aspects of the Staff Proposal. Following the workshop, Staff continued to research and analyze related issues and, accordingly, revised the proposal in response to analysis and party comments. The revised proposal, herein referred to as Addendum #2 (*see* Attachment 1), is discussed briefly below.

Discussion

The Addendum #2 refines the original Staff Proposal, provides additional information, and makes more detailed recommendations for the proposed cost-effectiveness tests in general and the two adders specifically. As provided in more detail in Attachment 1, the Addendum #2 recommends the Commission:

- Adopt the modified TRC and PAC tests as replacements for the existing TRC and PAC tests;
- Adopt a modified Ratepayer Impact Measure (RIM) test that is modified in the same manner as the TRC and PAC tests;
- Adopt the Societal Cost Test as an additional test to be used initially for information purposes only but allow each resource proceeding to determine how (if at all) to use the test in decision-making;
- Require all distributed energy resources activities that use the TRC and PAC tests to use the modified TRC, modified PAC, and Societal Cost tests;
- Revise nomenclature such that the value for the greenhouse gas adder used in the modified TRC and PAC tests is referred to as the "avoided cost of carbon abatement" and the greenhouse gas adder value used in the Societal Cost Test is referred to as the "avoided social cost of carbon;"
- Consider and determine the "avoided cost of carbon abatement" in R.16-02-007 and then adjust the value to avoid inaccuracies;
- Adopt the high impact value (as developed by the Interagency Working Group on Social Cost of Greenhouse Gases) as the "social cost of carbon;"
- Adopt a 3 percent discount rate for the Societal Cost Test, as proposed in the February 9, 2017 Staff Proposal;

- Use the US Environmental Protection Agency's Co-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA Tool) to compute and adopt an Interim Air Quality Adder until a more robust model can be developed; and
- Authorize Staff to continue to study and analyze improvements to the distributed energy resources cost-effectiveness framework, including the development of a common resource valuation method, and issue reports on its findings and subsequent proposals.

Parties are directed to review the Addendum #2 in Attachment 1 of this Ruling and respond to the questions below. Responses to the questions and comments on Addendum #2 shall be filed no later than 30 days from the issuance of this Ruling; replies are due no later than 45 days from the issuance of this Ruling.

Questions on Addendum #2

1. Explain why the Commission should or should not adopt the modified TRC and PAC tests as replacements for the existing TRC and PAC tests.
2. Explain why the Commission should or should not also adopt a modified Ratepayer Impact Measure (RIM) test that is modified in the same manner as the TRC and PAC tests.
3. Explain why the Commission should or should not adopt the Societal Cost Test as an additional test to be used initially for information purposes only. If the Commission adopts the Societal Cost Test as an additional test, explain why the Commission should or should not then allow each resource proceeding to determine how (if at all) to use the test in decision-making.
4. Explain why the Commission should or should not require all distributed energy resources activities that currently use the TRC and PAC tests to instead use the modified TRC, modified PAC, and Societal Cost tests.
5. Explain why the Commission should or should not revise its nomenclature such that the value for the greenhouse gas adder used in the modified TRC and PAC tests is referred to as the "avoided cost of carbon abatement" and the greenhouse gas adder value used in the Societal Cost Test is referred to as the "avoided social cost of carbon."

6. Explain why the Commission should or should not determine the "avoided cost of carbon abatement" in R.16-02-007 Explain why the Commission should or should not adjust this value in order to avoid double counting.
7. Explain why the Commission should or should not adopt the high impact value, developed by the Interagency Working Group on Social Cost of Greenhouse Gases, as the "social cost of carbon."
8. Explain why the Commission should or should not adopt a 3 percent discount rate for the Societal Cost Test.
9. Explain why the Commission should or should not use the USEPA COBRA Tool to compute and adopt an Interim Air Quality Adder until a more robust model can be developed. If you believe that another model should be used, explain why and provide a detailed description of how that model should be used instead.
10. Explain why the Commission should or should not authorize Staff to continue to study and analyze improvements to the distributed energy resources cost-effectiveness framework, including the development of a common resource valuation method, and issue reports on its findings and subsequent proposals. Are there additional improvements that should be considered?

IT IS RULED that parties shall file comments on the Addendum #2 in Attachment 1 of this Ruling and responses to the questions contained herein no later than 30 days from the issuance of this Ruling; reply comments shall be filed no later 45 days from the issuance of this Ruling.

Dated March 14, 2018 at San Francisco, California.

/s/ KELLY A. HYMES

Kelly A. Hymes
Administrative Law Judge

Attachment 1

Distributed Energy Resource Cost-Effectiveness Evaluation:
Further Recommendations on the Societal Cost Test
An Energy Division Staff Proposal Addendum #2

Distributed Energy Resource Cost-Effectiveness Evaluation: Further Recommendations on the Societal Cost Test

An Energy Division Staff Proposal Addendum #2

This revised proposal is the second addendum to the February 2017 Staff Proposal: Distributed Energy Resources Cost Effectiveness Evaluation: Societal Cost Test, Greenhouse Gas Adder, and Greenhouse Gas Co-Benefits

California Public Utilities Commission
March 14, 2018

Acknowledgements

This Staff Proposal was primarily authored by Joy Morgenstern of the Energy Division, with considerable assistance from Energy Division intern Miranda Domico and Energy Division Deputy Director Simon Baker. Substantial contributions came from Integrated Resource Planning staff Nathan Barcic, Citlalli Sandoval, and Forest Kaser. Invaluable technical assistance was provided by staff of the California Air Resources Board (CARB), the U.S Environmental Protection Agency (USEPA), and Energy Division's consultants, Energy and Environmental Economics (E3).

Energy Division Staff Proposal Addendum #2

Background

On February 9, 2017, the Administrative Law Judge issued a ruling in Rulemaking (R.) 14-10-003 seeking stakeholder comments on several aspects of distributed energy resource (DER) cost-effectiveness, including an Energy Division Staff Proposal on "Distributed Energy Resources Cost Effectiveness Evaluation: Societal Cost Test, Greenhouse Gas Adder, and Greenhouse Gas Co-Benefits" (Staff Proposal) and a literature review and analysis of the various cost-effectiveness tests performed by the Regulatory Assistance Project, Effectiveness Tests for Evaluation of Distributed Energy Resources: A Literature Review." The Staff Proposal recommended the adoption of a Societal Cost Test (SCT), and modified Total Resource Cost (TRC) and Program Administrator Cost (PAC) tests.

The proposed SCT is defined in the Staff Proposal as the TRC test with three additional components:

1. **Societal Discount Rate:** Staff recommended use of a societal discount rate, which is lower than the current discount rate, so as to give more weight to the interests of future generations. The specific societal discount rate recommended was 3 percent real. This discount rate would replace the discount rate currently used

2. **Greenhouse Gas (GHG) Adder:** The GHG adder estimates the value of the reduced carbon emissions that DERs provide, in addition to the value of the GHG carbon allowance permits that utilities are required to buy as part of California's Assembly Bill (AB) 32 cap and trade program for 2020 GHG targets (which are already included in current DER cost-effectiveness tests).

3. **Air Quality Adder:** The Air Quality Adder measures the impact of air pollution from electric power plants on human health. It can be used to estimate the reduction in health-related costs that occurs when electricity use is reduced by DERs in California. The reduction of health-related costs occurs when fewer air pollutants, such as SO_2, NOx, and PM 2.5[1], are emitted by fossil fuel and biomass power plants.

The modified TRC test is defined in the Staff Proposal as the traditional TRC test with only one additional component, the GHG adder, and the modified PAC test is defined as the traditional PAC test with only one additional component, the GHG adder. On August 29, 2017, D.17-08-022 adopted an Interim GHG Adder, which was subsequently added to the Avoided Cost Calculator. Since an earlier Decision, D.16-06-007, ordered all resources that estimate

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[1] NOx refers to Nitrogen Oxides, SO_2 to Sulfur Dioxide, and PM 2.5 to particulate matter (very small particles) 2.5 microns in width or less. All three of these pollutants, either by themselves or in combination with other pollutants, have serious human health impacts.

avoided costs to use the most recent version of the Avoided Cost Calculator, D.17-08-022 implicitly adopts the modified TRC and PAC tests.

Since the release of the Staff Proposal in February 2017, Staff has carefully examined the comments received on the Staff Proposal, and continued to research and analyze related issues. As a result, Staff recommends a refinement to the original proposal. This Addendum provides additional information and makes more detailed recommendations for the proposed cost-effectiveness tests in general, and the two adders specifically. In each of these areas, Staff presents some discussion, and then recommendations.

General Recommendations

- **Adopt the modified TRC and PAC tests as replacements for the existing tests**. While this has implicitly been done because of the adoption of the Interim GHG Adder and its inclusion in the latest version of the Avoided Cost Calculator, Staff recommends that the

- **Adopt the SCT as an additional test to be used, initially, for informational purposes only, allowing each resource proceeding to determine how (if at all) to use the test in its decision-making.** An informational SCT can provide more information to the Commission and to stakeholders on the environmental impacts of programs, and should be required for all applications, advice letters, evaluations, or any other activity where cost-effectiveness analysis is required. Staff sees a long-term goal of having the same cost-effectiveness test used in decision-making across all similarly situated resource proceedings, but recognizes that this can only happen over time with experience using the different cost-effectiveness tests, including the proposed SCT and modified TRC/PAC, in various proceedings. The Integrated Resource Planning (IRP) proceeding[2] is a logical context in which information gained from using the SCT in the various resource proceedings could help clarify a cross-resource societal perspective. IRP engages in a technology-neutral analysis to determine optimal, least-cost resource portfolios, given constraints such as meeting the state's climate goals. The information gained from using the SCT to value DERs can provide IRP with values for societal costs and benefits that, when used as inputs to IRP could potentially affect the resource mix in the optimal portfolio. Staff further recommends that the Commission review the use of the informational SCT after a set period of time. Staff suggests three years as the review period.

- **Require all DERs to use these tests.** Those programs that do not use the traditional Standard Practice Manual tests, such as low income programs which have developed their own tests, and programs ordered by statute to include specific inputs to the cost-effectiveness analysis, should still use the most recent version of the Avoided Cost Calculator, which includes a GHG adder, for any test that uses avoided cost inputs. In

[2] R.16-02-007

addition, those programs should develop a societal test based on one of their specific cost-effectiveness tests, which should include the same elements – avoided cost inputs which include the SCT-specific adders from the Avoided Cost Calculator, and a social discount rate.

- **Adopt a 3 percent discount rate for the SCT**, as stated in the original Staff Proposal.

- **Staff will continue to issue white papers, proposals, and research reports for stakeholder comment that address issues associated with the improvements to the DER cost-effectiveness framework.** Staff expects to issue several reports during 2018, on SCT-related topics including:
    - Development of a permanent air quality adder method, including any future refinements as described below.
    - Proposed model for measuring the co-benefits of reducing hydrofluorocarbons, as stated in the original Staff Proposal.

  In addition, Staff from the Integrated Distributed Energy Resource (IDER) and IRP proceedings are working together on the development of a Common Resource Valuation Method, which is closely related to IDER cost-effectiveness, and anticipates issuing reports or proposals on broader cost-effectiveness topics, including:
    - Coordinating IDER cost-effectiveness with IRP and Least Cost Best Fit analysis;
    - Incorporating Local Net Benefits Analysis into the Avoided Cost Calculator; and
    - Guidelines for a more consistent DER cost-effectiveness framework.

- **Any modification of the Avoided Cost Calculator that affects the TRC and PAC tests should also be applied to the Ratepayer Impact Measure (RIM) test.** Since the RIM test uses avoided cost inputs, it should be modified in the same manner as the TRC and the PAC tests.

GHG Adder

The Staff Proposal suggested two possible sources for the value of the GHG adder. It could be based on the marginal cost of abatement (i.e., the cost of achieving California's GHG reduction goals), or on the social cost of carbon (i.e., the damage costs resulting from climate change). The Staff Proposal recommended basing the GHG adder on the marginal cost of abatement, and expressed a preference for a GHG adder that is determined as part of the Commission's IRP proceeding (either explicitly, or derived from the preferred IRP plan identified in that proceeding).

The Staff Proposal also noted that an interim GHG adder may be needed, and may have to be determined by another method, depending on the pace of the IRP proceeding. Several months after the Staff Proposal was released, Staff identified a timing issue in the Energy Efficiency proceeding where the IDER proceeding needed to develop an Interim GHG Adder that could be used in the Energy Efficiency Potential Study, which is used to determine Energy Efficiency program goals. Staff was concerned that if goals were set using the existing TRC or PAC tests, the goals would become outdated if the modified TRC and PAC tests were later adopted.

As a result, Staff proposed an interim GHG adder, based on preliminary IRP modeling results. D.17-08-022 adopted an Interim GHG adder, but rejected Staff's proposed values and instead adopted values based on the California Air Resources Board (CARB) Cap-and-Trade Allowance Price Containment Reserve price (Cap-and-Trade APCR Price). The Cap-and-Trade APCR Price is a cost-containment mechanism, which includes a set-aside pool of allowances that can only be purchased by covered entities at set prices. The Decision points out that "(t)here is insufficient evidence in the record to determine if the Cap-and-Trade APCR Price can be equated with a marginal carbon abatement price. However, because it represents the highest cost of compliance with California's cap and trade requirements, the Cap-and-Trade APCR Price is the best interim value currently available to approximate the societal costs of greenhouse gas emissions.[3]"

Thus, D.17-08-022 does not resolve the question of whether the GHG adder should be based on a marginal carbon abatement cost or the social cost of carbon, and it adopts only a temporary value for the adder, which will expire at the latest in March 2019.

The comments on the Staff Proposal led Staff to further consider the merits of both approaches. Staff noticed that while some parties argued for use of one or the other approach, several parties seemed to see the merits of both approaches. For example, the Institute for Policy Integrity states that "using the avoided cost approach will result in the Commission comparing the costs of proposed DER projects to the costs of other policies that the state is using to reduce greenhouse gas emissions. The costs of these other policies are perhaps a rough proxy for how much society is willing to pay to reduce greenhouse gas emissions, but they do not reflect the actual benefit to society of those reductions. In contrast, the Social Cost of Carbon is designed to reflect the best available estimate of the benefit to society of reducing a ton of carbon emissions."[4] NRDC agrees that the damage cost is the appropriate input for a societal cost test, but supports using the Marginal Abatement Cost as a starting point[5]. The Sierra Club argues that "(a)batement costs and damage costs are two different things, and each has a separate role in the cost-effectiveness framework."[6] The Sierra Club also states that "the Commission should include forecasted electric-sector GHG compliance costs in every cost-effectiveness test that is meant to capture utility costs,"[7] and that therefore modified TRC and PAC tests, which should include a GHG adder based on marginal abatement costs, should replace the existing TRC and PAC tests. In addition, they argue that the cost of compliance (i.e., the marginal abatement cost) is internal to

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[3] D.17-08-022, p. 11

[4] Institute for Policy Integrity reply comments, April 6, 2017, p. 5

[5] NRDC reply comments, April 6, 2017, p. 3

[6] Sierra Club comments, March 23, 2017, p. 18

[7] Sierra Club comments, March 23, 2017, p. 17

the utility and damage cost are external, and that "(t)he SCT should include both internal and external GHG costs."[8]

The Sierra Club's comments, in particular, led Staff to examine further the two proposed methods of determining the GHG adder, and the purpose of using the adder in the different cost-effectiveness tests. The PAC test is a relatively straightforward estimate of the utility's costs and benefits, designed to minimize the utility's revenue requirement. The TRC test is structurally similar to the PAC test – the only significant difference is that the TRC includes the participant's costs and excludes incentive costs. The TRC is designed to minimize the total expenditures of the utility and the program participants together. Both of these tests compare the out-of-pocket costs of a DER to the electric grid benefits (in the form of avoided costs) of a DER. As such, it seems logical to limit these tests to costs that are borne by ratepayers and the financial, energy-related benefits that accrue to ratepayers. A GHG adder based on the marginal cost of abatement would be the most logical to use for these tests, since it reflects the actual costs that ratepayers will likely incur to meet California's GHG goals, as required by state law.

The SCT, on the other hand, is not intended to be a purely financial test. It is intended to capture environmental costs and benefits that are paid for and received by society – those values that economists refer to as "externalities." While "society" and "ratepayers" are largely the same group of people, they do not pay the costs or accrue the benefits in the same ways or at the same rates. This raises many questions. First, how much should ratepayers (whose energy use *causes* the negative environmental impacts) be liable for the environmental costs to all members of society, who incur any public health costs associated with that energy use? Second, to what extent should the Commission, whose jurisdiction does not generally include public health issues, be concerned with these impacts? These questions are difficult to answer. However, as explained in the Staff Proposal, there is a clear statutory basis for inclusion of environmental impacts in the cost-effectiveness framework,[9] and in fact California energy policy has for many years implicitly valued the environmental benefits of energy efficiency, customer load reductions, and renewable energy. Those environmental benefits are received by society when ratepayers consume less carbon-emitting energy, and in turn, if ratepayers do not do so, society will have to bear a greater externality cost. That cost, for greenhouse gases, is the damage cost associated with climate change. Therefore, Staff is now recommending that the GHG adder used in the SCT be based on the social cost of carbon.

While we recognize that the criticisms and difficulties related to the social cost of carbon are still valid – it is inherently difficult to estimate any such controversial, complicated, and uncertain societal costs – we now believe that it is the more appropriate estimate for the SCT.

[8] Sierra Club comments, March 23, 2017, p. 19

[9] Public Utilities Code Sections 701.1(a)(1) and 701.1(c).

The next question, then, is how to estimate the social cost of carbon. Staff was persuaded by the arguments of the Institute for Policy Integrity to use the value recommended by the Interagency Working Group (IWG) for the social cost of carbon.[10] The IWG was formed in 2010 by President Obama, with the goal of determining values for the social costs related to greenhouse gas emissions that could be used in Federal government and state climate change mitigation efforts. Our concerns with this value remain – it is highly uncertain, due to the difficulty of measuring the impacts of climate change, particularly over the long term; and there is uncertainty about the future source of updated values, given that the IWG has been disbanded. However, both the broad scope of the IWG's membership, which consisted of representatives from 12 agencies and offices, including the Departments of Energy, Commerce, Agriculture and Transportation, the Environmental Protection Agency, and the Office of Management and Budget, as well as the eminence of the National Academies of Sciences, Engineering, and Medicine, which performed the research, has led Staff to believe that, despite the uncertainties discussed above, IWG values represent the best and most widely-accepted estimates of the social cost of carbon. Staff intends to work with the California Air Resources Board, and other state agencies as appropriate, to ensure that future estimates of the social cost of carbon are based on the most recent evidence and science.

Hence, Staff is modifying its previous recommendation that the GHG adder be based on the marginal cost of abatement, and instead recommending the use of two separate GHG adders – a marginal abatement cost to be used in the modified TRC and PAC tests, and a social cost of carbon to be used in the SCT. We recommend use of the IWG's social cost of carbon as the basis of the SCT GHG adder, and a marginal cost of carbon abatement as the basis of the GHG adder used for the TRC and PAC tests.

Staff further recommends the following specific modifications and details:

1. Change in nomenclature: The recommendation that the SCT use a different basis for its GHG adder than the other cost-effectiveness tests could easily lead to confusion. Hence, Staff recommends that the Commission not use the term "GHG adder." Staff suggests that the Commission refer to the value we are using for the TRC and PAC as the "avoided cost of carbon abatement," and use the term "avoided social cost of carbon" for the value we are using for the SCT. Staff recommends including these two new avoided costs in the Avoided Cost Calculator, with the understanding that the avoided social cost of carbon would be used only for the SCT, and the avoided cost of carbon abatement would be used for all other cost-effectiveness tests which use avoided cost inputs.

2. Relationship to IRP: Staff recommends that the avoided cost of carbon abatement be determined in the IRP proceeding. In the short term, this means replacing the Interim GHG Adder adopted in August 2017 with the "GHG Adder based on RESOLVE results for use in demand-side cost-effectiveness analyses," as shown in Table 6 (p. 118) of the recent IRP

[10] Institute for Policy Integrity comments, March 23, 2017, p. 10

decision, D.18-02-018. In the long term, this value should be proposed, updated, and litigated in the IRP proceeding, since that proceeding is conducting the optimization modeling which provides the best estimates of the costs of achieving the state's GHG goals. Any values determined in the IRP proceeding should be adjusted before incorporation into the Avoided Cost Calculator, mostly to avoid double-counting, as follows:

a. The avoided cost of carbon abatement used in the Avoided Cost Calculator should **not** include the cap and trade carbon allowance selling price, which has already been incorporated into the avoided cost of energy.

b. The avoided cost of carbon abatement used in the Avoided Cost Calculator should replace not only the existing GHG adder, but also the Avoided Renewable Portfolio Standard (RPS) cost. This is necessary because the IRP optimization model considers the impact on total system costs when it chooses energy resources. For example, the model would choose to add a certain amount of energy efficiency only after considering the impact on total system costs of making that choice, and the total system costs would include not only the costs of the energy efficiency, but also the reduced cost of the RPS requirement that always results from energy efficiency procurement.

c. The avoided cost of carbon abatement used in the Avoided Cost Calculator may require adjustment if different dollar years are used in the different models (i.e., if the IRP modeling uses 2016 dollars and the Avoided Cost Calculator uses 2018 dollars, the values will have to be aligned.)

3. Value for Social Cost of Carbon: The IWG's social cost of carbon report[11] reports four sets of values for the social costs of carbon. These values are based on three different studies, each of which produces a range of possible values. The first three sets of values are the average of the mid-range (i.e., most likely) values of these different studies, calculated using different discount rates, and the fourth is a "high impact" value. The high impact value represents higher-than-expected impacts from temperature change, and is taken from a higher end (95th percentile) of the range of possible values. Staff recommends that the value adopted for use in the SCT be the high impact value proposed by the IWG[12] and shown in Table 1 below. Staff is recommending the high impact value because of the seeming consensus in the scientific community, as discussed below, that the lower values represent a lower bound for the damage costs related to climate change. It does not seem consistent with California's ambitious GHG goals to value the cost of *not* achieving those goals based on a number which omits many of the impacts of climate change that California seeks to protect itself from. The

[11] Interagency Working Group on Social Cost of Greenhouse Gases, United States Government; *Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866*

[12] *ibid*, p. 4 Table ES-1

catastrophic wildfires of 2017 heighten concerns about adequately estimating the societal costs of climate change in our state.

Table 1: Social Cost of Carbon, 2010 – 2050 (in 2007 dollars per metric ton of CO2)[13]				
Year	**5% Average**	**3% Average**	**2.5% Average**	**High Impact (95th Percentile at 3%)**
2010	10	31	50	86
2015	11	36	56	105
2020	12	42	62	123
2025	14	46	68	138
2030	16	50	73	152
2035	18	55	78	168
2040	21	60	84	183
2045	23	64	89	197
2050	26	69	95	21

Staff believes that there is extensive evidence that the IWG average values underestimate the damage costs associated with climate change. Institute for Policy Integrity points out, "this [average] value is likely an underestimate because some forms of damage, like catastrophic risks, are omitted."[14] The Institute for Policy Integrity points to several studies, and Staff have examined additional studies, which agree that the IWG's average values represent a lower bound, partially because they do not include the full effects of most catastrophic events. In a separate study, the Institute for Policy Integrity provides a list of damages excluded from the IWG's estimates, which includes damages from wildfires and damages to infrastructure, both of which are significant concerns for California utilities.[15]
The CARB Climate Change Scoping Plan states that "[i]t is important to note that the [IWG's social cost of carbon], while intended to be a comprehensive estimate of the damages caused by carbon globally, does not represent the cumulative cost of climate change and air pollution to society. There are additional costs to society outside of the [IWG's social cost of carbon], including costs associated with changes in co-pollutants, the social cost of other GHGs including methane and nitrous oxide, and costs that cannot be included due to modeling and data limitations. The IPCC[16] has stated that "the [IWG's social cost of carbon]

[13] Technical Support Document, *op cit,* p. 4 Table ES-1

[14] Institute for Policy Integrity comments, March 23, 2017, p. 11

[15] Institute for Policy Integrity, *The Social Cost of Greenhouse Gases and State Policy*, p.5

[16] Intergovernmental Panel on Climate Change

estimates are likely underestimated due to the omission of significant impacts that cannot be accurately monetized, including important physical, ecological, and economic impacts."[17]

Revesz et al.[18] state four reasons why the future costs of climate change could be higher than the IWG average costs: (1) The impacts of historic temperature changes suggest that societies and economies may be more vulnerable than current models predict and that weather variability is more important than average weather in determining impacts, particularly for crop growth and food security; (2) The models omit damages to labor productivity, to productivity growth, and to the value of the capital stock, including buildings and infrastructure; (3) the models assume that the value that people attach to ecosystems will remain constant, and do not take in account that as a commodity becomes more scarce its value increases; and (4) the analysis assumes a constant discount rate, but for impacts that are both highly uncertain and occurring in the distant future, a discount rate that declines over time may be more appropriate.

The IWG states "there is extensive evidence in the scientific and economic literature on the potential for lower-probability, but higher impact outcomes from climate change, which would be particularly harmful to society and thus relevant to the public and policymakers. The fourth [high] value is thus included to represent the marginal damages associated with these lower-probability, higher-impact outcomes."[19]

The costs of climate change associated with electricity infrastructure, and its resultant impact on California's economy, are not included in the IWG models, which is of particular concern to California ratepayers. Those impacts include the effects of extreme heat, which reduces the efficiency of the grid. For example:

- Line sag decreases transmission efficiency;
- Thermal efficiency of power plants decreases;
- Thermal efficiency of solar panels decreases;
- A recent study[20] estimates decreases in wind production across the northern hemisphere of 8-40 percent, affecting wind turbine efficiency;
- Other system components, such as transformers, cannot cool down, and so are more prone to overheat, resulting in lower efficiency and increased maintenance and replacement cost; and
- Cooling demand increases significantly during both day and night.

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[17] California Air Resources Board's California's 2017 Climate Change Scoping Plan, p. 41

[18] Richard l. Revesz et al., *Global Warming: Improve Methods of Climate Change*, 508 Nature 173, 2014

[19] Technical Support Document, *op cit*, p. 3

[20] Kristopher B. Karnauskas et al, *Southward shift of the global wind energy resource under high carbon dioxide emissions*, Nature Geoscience 11, 2018

Finally, the impacts of flooding are only partially included in the IWG models. This could be significant for California utilities. For example, Pacific Gas and Electric Company reports[21] that 26 percent of their substations lie within FEMA's 100 year flood zone, and 39 percent within FEMA's 500 year flood zone[22]. Significant percentages of other PG&E transmission and distribution system infrastructure also lie within these zones.

Staff believes there is ample evidence that the IWG's average values do not fully consider the impact of many climate change impacts that California is already encountering. Therefore, we find that the high impact value is the more appropriate and defensible estimate.

Air Quality Adder

The Staff Proposal did not provide a specific recommendation for the air quality adder, but rather proposed using one of two USEPA models as part of a research project, combined with a stakeholder process, to determine the best methods and values for estimating this adder. Staff subsequently examined these two models, as well as four additional models, which were recommended as the best tools for examining pollution impacts. Staff determined that, as a first step, USEPA's Co-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA) model (see textbox below) could be used to determine a state-wide approximation of the human health impacts of reducing power plant emissions, with a goal of eventually modifying the approach to enable more geographically granular results.

Using the COBRA tool, Staff computed a value which we propose to use as an Interim Air Quality Adder, which estimates the reduction in health-related costs that occur when electricity use is reduced by DERs in California. Staff proposes using this adder until such time as a more robust model for determining the air quality impacts of electricity generation can be developed.

[21] Pacific Gas and Electric Company, *Climate Change Vulnerability Assessment*, 2016

[22] FEMA's 100 year and 500 year flood zones are defined as the areas which have a 1 in 100 and 1 in 500 chance, respectively, of flooding in a given year. These probabilities do not take into account the increased likelihood of flooding due to climate change.

What is the COBRA Model?
The COBRA model estimates the impacts of changes in emissions levels on human mortality and morbidity (e.g., heart attacks, hospital admissions, acute bronchitis, respiratory symptoms, asthma exacerbations, and lost work or school days) and the related economic value of the impacts (e.g., changes in health care costs, earnings). The economic value of most health effects occurs in the same year as the emissions changes. For non-fatal heart attacks and for premature mortality (which accounts for most of the economic impacts) the change in risk and the related value from emissions changes occurs over a 20-year period. For example, suppose the COBRA results for a particular decrease in emissions during 2018 are $100 in cost savings, of which $98 is attributable to decreased mortality, and the rest to health care costs. Thus, a decrease in emissions in 2018 will lead to a decrease in health care costs of $2 in 2018, and a decreased cost to the economy over the subsequent 20 years of $98 because the (slightly) cleaner air in 2018 led to fewer deaths.

The COBRA model provides baseline levels of pollutants in several categories and a number of economic sectors, and allows the user to calculate the impacts of decreasing emissions of those pollutants. Using COBRA's baseline levels for California, Staff determined that the total cost of NOx, SO_2 and PM 2.5[23] emissions from California's electric power plants was between approximately $500 million to $1.2 billion in 2017. While this is a relatively small impact compared to other states whose electric generation is not as clean as California's, Staff believes that this is still a sizable economic impact. [24]

Using the COBRA tool, Staff determined a value of $5.20/MWh, which we propose to use as an Interim Air Quality Adder. The section below details the process that was used to determine this value, and the rationale for doing so:

1. Using COBRA's baseline estimation of pollutants for 2017 and a 3 percent discount rate (consistent with the rate proposed for the Societal Cost Test), the model was run using 2014 emissions data on SO_2 and NOx from USEPA's Emissions & Generation Resource Integrated Database (eGRID).

2. Initial results used the state-specific emissions rates from eGRID's summary tables, which indicated that the total human health cost associated with a 1 GWh reduction in generation at power plants located in California ranges from $1,668 to $3,771. Approximately two-thirds of this cost is attributable to SO_2 emissions, and the rest from NOx emissions.

[23] NOx refers to Nitrogen Oxides, SO_2 to Sulfur Dioxide, and PM 2.5 to particulate matter (very small particles) 2.5 microns in width or less. All three of these pollutants, either by themselves or in combination with other pollutants, have serious human health impacts.

[24] For example, the human health costs of Pennsylvania's power plant emissions range from $900 million to $2 billion, or about twice California's, with about one-third our population.

3. Staff further analyzed the data and determined that while the eGRID summary data gave a reasonable first approximation, it would be possible to develop a more accurate data set. Hence, the following changes were made:

- An examination of the power plants emitting high levels of SO_2 found that approximately 30% of the 2014 SO_2 emissions came from coal-burning power plants which have been retired since 2014[25]. The data were updated to eliminate these retired coal plants.
- Other retired plants, as determined from the most recent California Energy Commission's Quarterly Fuel and Energy Report Power Plant Owner Reporting Database, were eliminated.
- Individual plant PM 2.5 emissions, from the CARB Emissions Inventory data, were added.
- Staff determined that the initial results could lead to double-counting, as the original emissions rates were based on total California electricity generation, including RPS (i.e., the emissions rates were determined by dividing total power plants emissions by total generation). Since the Avoided Cost Calculator, as discussed below, adjusts the adders by the annual percentage of non-RPS generation, using the initial results in the Avoided Cost Calculator would amount to double-counting generation from RPS facilities. Hence, all power plants with zero emissions were eliminated and their generation was not included in the emissions rates.
- Since the cost-effectiveness framework is largely concerned with the marginal cost impact of reducing electricity generation, the emissions and generation of each plant was adjusted by multiplying by a "non-baseload factor," which measures the extent to which each plant is *not* used for baseload (i.e., is a load-following or peaker plant). The resulting emissions data are shown in Table 2. Note that because of the magnitude of the emissions rates, the Terawatt-hour (TWh) level was used for the actual COBRA model run.

Table 2

	PM 2.5	NOx	SO_2
tons/GWh	0.013091	0.121348	0.009228
tons/TWh	13.09	121.35	9.23

4. Using the revised data set, Staff calculated that the avoided human health costs associated with a 1 GWh reduction in generation at power plants range from $2638 to $5965, as shown in Table 3. According to USEPA, the low and high estimates are derived using two sets of assumptions about the sensitivity of adult mortality and non-fatal heart attacks to changes in ambient PM 2.5.[26] Approximately half of the total cost is attributable to PM 2.5 emissions,

[25] Most of the rest of the SO_2 emissions came from biomass plants.

[26] User's Manual for the Co-Benefits Risk Assessment (COBRA) Screening Model Manual, p. 24

and 25% each to SO_2 and NOx. Parties can verify these results by using the emissions information in Table 2 as inputs to the COBRA model, and can examine the revised data set used to determine these emissions, which will be posted on the IDER cost-effectiveness page of the CPUC website.

Table 3: 2017 Avoided Human Health Costs of 1 GWh Reduction in Electricity Generation*	
Total Health Benefits (low estimate)	$2,638.07
Total Health Benefits (high estimate)	$5,964.78
Mortality (low estimate)	$2,594.11
Mortality (high estimate)	$5,887.68
Infant Mortality	$6.38
Nonfatal Heart Attacks (low estimate)	$4.00
Nonfatal Heart Attacks (high estimate)	$37.13
Hospital Admits, All Respiratory	$2.00
Hospital Admits, Cardiovascular (except heart attacks)	$3.25
Acute Bronchitis	$0.27
Upper Respiratory Symptoms	$0.34
Lower Respiratory Symptoms	$0.01
Emergency Room Visits, Asthma	$0.15
Minor Restricted Activity Days	$0.00
Work Loss Days	$0.07
Asthma Exacerbation	$19.24
**Includes only in-state non-zero emissions generation, adjusted for marginal generation. Results are in $2017 and represent the value per GWh of emissions reductions*	

5. Staff chose to use the high estimate, for several reasons. The analysis does not include criteria pollutants such as volatile organic compounds (VOCs) for which there was no data. It also ignores emissions from electricity imported from other states, which makes up about 20 percent of California's electricity. While inclusion of benefits that accrue to non-residents of California is questionable, the damages that impact non-residents are caused by California ratepayers, and so this might be something for decision-makers to consider. In addition, there may be spillover effects of emissions from out-of-state plants.

6. Using the high value and approximating the human health care costs avoided by a 1 GWh reduction in electricity generation results in about $6000, $6 per MWh, or $0.006 (0.6 cents) per kWh.

Staff designed this adder to be used as an input to the Avoided Cost Calculator, which determines the value of avoiding the marginal generation unit for each hour, which in most hours is a gas turbine. Reducing load reduces the RPS obligation of the utility, Since RPS facilities avoid the need to run natural gas plants, the Avoided Cost Calculator adjusts the air quality adder (and the GHG adder) by the percentage of non-RPS in each year (i.e., the air quality adder is multiplied by 1 minus the annual RPS fraction). In addition, the Avoided Cost Calculator estimates the hours in which the marginal generation unit is likely to be a zero-emissions RPS unit rather than a gas turbine and so the air quality adder (and the GHG adder) will be zero for those hours.

This adder measures only the effects of reducing electricity generation at power plants in California. It would not be appropriate to use this adder for DERs that resulted in other types of emissions reductions, such as electric vehicles.

Staff recommends a future research study to determine a more complex model which can consider the following refinements:

- More granular geographic data, such as emissions rates that are specific at the very least to the utilities' territories;
- Using USEPA's BenMap model, a more complex model similar to COBRA, which would use local air quality models, rather than the average air quality model embedded in COBRA. This would provide much more accurate estimates of local air quality impacts;
- Mapping of DERs (particularly DERs with known locations, such as residential solar) with local emissions levels, to the extent that resulting emissions can be determined;
- Estimation of avoided human health costs of emissions reductions resulting from fuel-switching due to building and transportation electrification, including concurrent emissions increases from increased electricity generation;
- More time-granular data, which would more accurately measure air quality impacts due to changes in electric loads, and different air quality impacts, at different times of the day or year;
- Estimates of the impact of various fuel sources (e.g., the impact of biomass generation, which seems to be contributing significant levels of pollutants;
- Estimates for changes in when and how often plants are likely to be dispatched, since emissions rates depend not only on how many hours a plant is running, but how often the plant starts up; and
- Improved data inputs, including determining new sources of data (e.g., possible use of the California Air Resources Board's data instead of, or in addition to, USEPA data) and new types of data (e.g., inclusion of additional pollutants).

(END OF ATTACHMENT 1)