Benefit-Cost Analyses for Climate Action Plan Measures

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Prepared for the San Diego Association of Governments (SANDAG)

Prepared by the Energy Policy Initiatives Center (EPIC)

About EPIC

The Energy Policy Initiatives Center (EPIC) is a non-profit research center of the USD School of Law that studies energy policy issues affecting California and the San Diego region. EPIC's mission is to increase awareness and understanding of energy- and climate-related policy issues by conducting research and analysis to inform decision makers and educate law students.

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1 INTRODUCTION

This document is Appendix 3 to ReCAP: Regional Climate Action Planning Framework. The document is separated into eight sections. Section 2 provides an overview of benefit-cost analyses, including perspectives analyzed, types of benefits and costs considered, and key terms and concepts. Section 3 defines the metrics used in a benefit-cost analysis[1] (BCA). Section 4 provides a discussion on how to interpret results and the methods used to conduct a BCA. Section 5 provides examples of measure inputs and assumptions. Section 6 outlines the various ways to visualize and communicate results. Section 7 discusses limitations in the methods as defined in this document. Section 8 is the conclusion.

While the methods can be applied to Climate Action Plans (CAPs) for jurisdictions outside the San Diego region, some data and information presented in this document are specific to the San Diego region and jurisdictions in the San Diego region.

1.1 Guiding Principles

This document is developed under the following guiding principles:

- **Transparency:** methods are transparent to readers and uncertainty is recognized to the extent possible;
- **Use of accepted methods:** methods are based, to the extent possible, on those generally-accepted and utilize standard economic approaches and metrics;
- **Data-driven:** methods incorporate applicable benefits and costs for multiple perspectives, which are supported by relevant and available data;
- **Local relevancy:** methods are relevant to the San Diego region and the jurisdictions in the San Diego region to the extent possible;
- **Regional consistency:** methods are applied consistently across measures within a CAP and across different CAPs to the extent feasible; and
- **Flexibility and adaptability:** methods are regularly updated to be consistent with best practices.

2 BENEFIT-COST ANALYSIS OVERVIEW

A BCA of a CAP's measures is designed to assist jurisdictional staff, decision-makers, community members, and other stakeholders understand the potential economic impacts of those measures. The BCA answers two questions: (1) **What is the benefit or cost for each measure to reduce one metric ton of carbon dioxide equivalent (MT CO_2e)?**; and (2) **What are the financial impacts to participants (e.g., home and business owners) associated with each measure?** It should be noted that BCA results should not be taken out of the broader context of a CAP, and are only one consideration of many when analyzing measures to include in or already included in a CAP (Figure 1).

[1] A benefit-cost analysis is also commonly referred to a cost-benefit analysis. Nomenclature used here is consistent with the U.S. EPA and that used in other SANDAG projects.

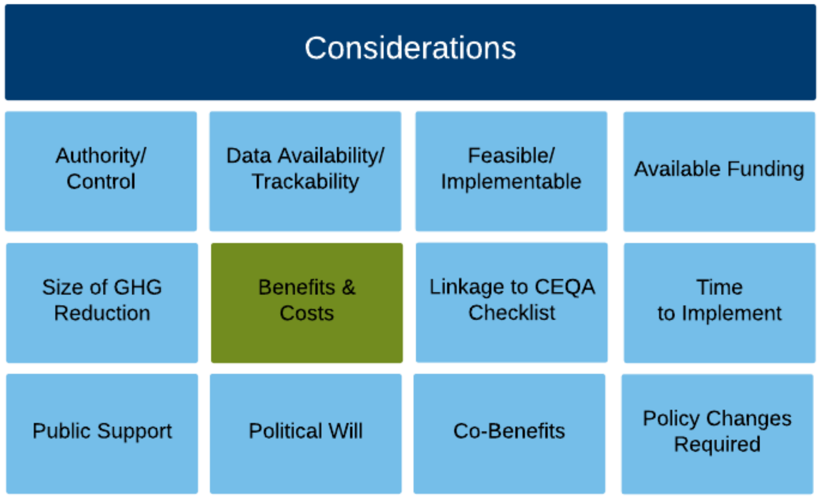

Figure 1. Considerations for Analyzing CAP Measures

2.1 When to Conduct CAP Benefit-Cost Analyses

The overall climate action planning cycle is depicted in Figure 2. The time at which a BCA is conducted during this cycle can vary by jurisdiction and results can be applied differently at each stage.

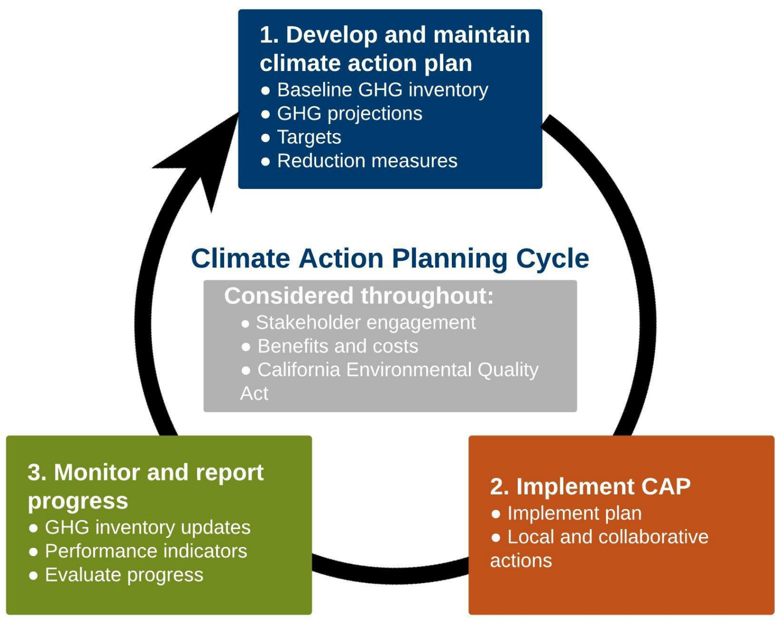

Figure 2. Conceptual Diagram of the Climate Action Planning Process

2.1.1 Develop and Maintain CAP

When the benefits and costs are analyzed during the CAP development stage, results can assist decision-makers and stakeholders in selecting measures that are viable in their jurisdiction. Additionally, when a CAP is updated, a new BCA can be conducted to analyze the impacts of the new CAP version. This is especially important when significant changes are made to CAP measures or when new measures are added.

2.1.2 Implement CAP

Analyses conducted after CAP adoption can assist in identifying which CAP measures to prioritize and results can be used in outreach materials to educate the public on potential positive impacts to the community beyond greenhouse gas (GHG) reductions.

2.1.3 Monitor and Report Progress

During the monitoring and reporting stages, new jurisdiction-specific data will become available that can be used to update inputs into the CAP BCA, adjusting the results to more accurately reflect impacts of a CAP measure.

2.2 Perspectives

One consideration, when evaluating the benefits and costs of CAP measures, is to determine whose benefits and costs are being evaluated. In the context of a CAP measure, there are multiple perspectives that determine the scope of analysis, including the **Administrator** of the program (e.g., the jurisdiction), **Participants** in the program (e.g., residents and businesses within the jurisdiction), and those who pay the cost to subsidize programs (**Non-Participants**; e.g., taxpayers or utility ratepayers). The **Measure** perspective, which combines these three main perspectives, allows for a more comprehensive view and includes costs to administer CAP programs, benefits and costs to homes and businesses, and the cost of providing any subsidies. Adding externalities, which are not accounted for in the direct costs and benefits, to the Measure perspective provides a broader **Societal** perspective.

The framework in Figure 3 summarizes these five perspectives, identifies who is potentially affected by a measure, and provides examples of their respective benefits and costs. The framework described here has been adapted from the California Standard Practice Manual, which is used by the California Public Utilities Commission (CPUC) to evaluate the cost-effectiveness of energy efficiency programs and has recently been adapted into a National Standard Practice Manual (CPUC 2001; NESP 2017).

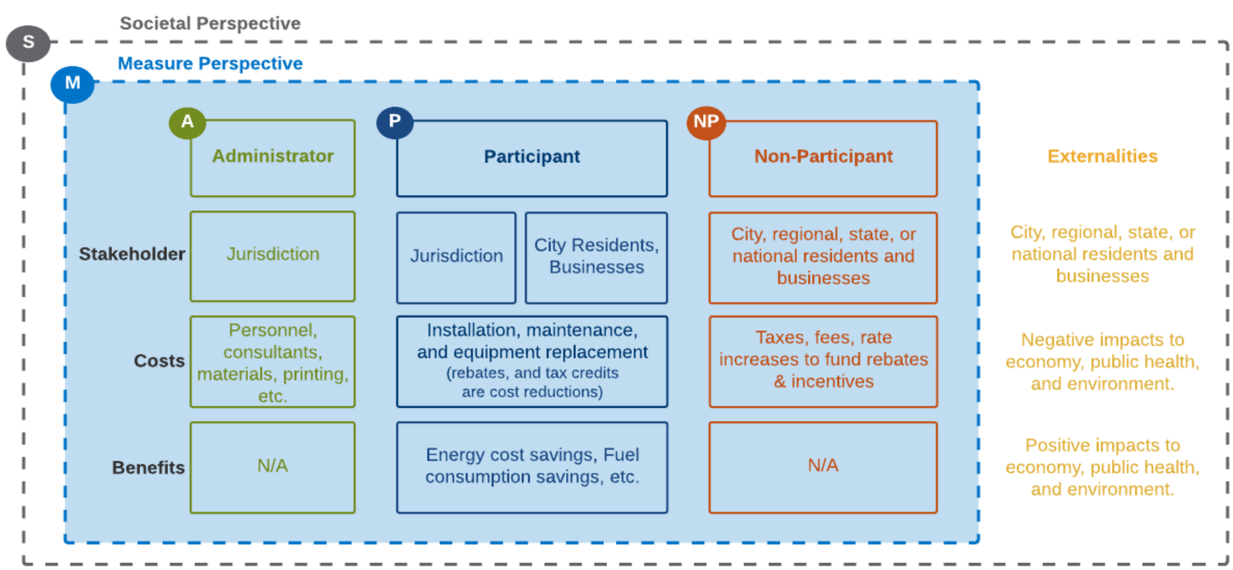

Figure 3. Conceptual Framework of BCA Perspectives

2.2.1 Administrator Perspective

The Administrator Perspective answers the question: **What are the financial benefits and costs to the jurisdiction as a result of implementing CAP measures?** While there are likely no direct monetary benefits to the jurisdiction associated with CAP administration-related activities, there are several types of costs that could be incurred, including personnel, consultants, and supplies/materials. Activities covered by this perspective primarily include research, development, implementation, monitoring, and enforcement of CAP programs and policies. However, capital costs associated with measures that directly affect municipal operations (e.g., energy efficiency retrofits for municipal facilities, replacing municipal fleet vehicles with hybrid or zero-emission vehicle [ZEV] alternatives) are not included here, but are under the Participant perspective.

It is recommended that a BCA be performed in partnership with a CAP implementation cost analysis (see Technical Appendix 4—CAP Implementation Cost Analysis); all costs for the Administrator perspective can be obtained from an implementation cost analysis or by following the methodology identified in Technical Appendix 4.

2.2.2 Participant Perspective

The Participant perspective answers the question: **What are the financial benefits and costs to residents, businesses, and the jurisdiction to participate in or take action to comply with a CAP measure?** There are benefits and costs associated with a home or business owner participating in or complying with an action defined in a CAP measure. For example, a residential energy efficiency retrofit measure could result in costs to the homeowner that include audit and reporting costs, in addition to the capital needed for the retrofit itself. The reduction in energy consumption due to the retrofit would then provide the homeowner with benefits in the form of energy bill reductions over the lifetime of that retrofit. Participants can also receive cost reductions in the form of rebates, incentives, and tax credits, which are considered a cost to Non-Participants.

For the jurisdiction, this perspective includes all capital costs directly associated with the jurisdiction's participation in or compliance with a CAP measure as well as the resulting benefits.

2.2.3 Non-Participant Perspective

The Non-Participant perspective answers the question: **What are the financial benefits and costs, if any, to subsidize activities of participants?** Residents and businesses within the jurisdiction could incur indirect costs or realize indirect benefits even if they are not engaging in an activity defined in a CAP measure. In general, Non-Participant costs are defined as the cost to subsidize activities of Participants through rebates, incentives, and tax credits. Non-Participants incur this cost through taxes, fees, and/or utility surcharges. Who is defined as a Non-Participant can vary and is not limited to those within the geographic boundary of the jurisdiction (Figure 4).

Level	Incentive Type	Revenue Source	Geographic Scope	Non-Participants
National	Federal tax credit	U.S. tax revenue	U.S.	U.S. taxpayers
State	State grant	California tax or other revenue	California	California taxpayers
Regional	Utility incentive	SDG&E surcharge	SDG&E territory	SDG&E customers
Jurisdiction	Jurisdictional rebate	Local tax	Jurisdiction	Jurisdiction residents & businesses

Figure 4. Examples of Non-Participants at Various Levels

2.2.4 Measure Perspective

The Measure perspective answers the question: **What are the total financial benefits and costs associated with a CAP measure?** The three perspectives defined above provide discrete and valuable insights, but individually do not represent a complete view of the monetary impacts of a CAP measure. For instance, looking solely at the Participant perspective may obscure the true cost of a measure, particularly if an action is highly subsidized and/or the jurisdiction incurred large costs for educational outreach to encourage that action. The Measure perspective combines the Administrator, Participant, and Non-Participant perspectives for a more programmatic view of the direct benefits and costs associated with a CAP measure.

2.2.5 Societal Perspective

The Societal perspective answers the question: **What is the overall financial benefit or cost to society for a given CAP measure?** This is the broadest perspective; it adds the benefits and costs associated with external impacts to the Measure perspective. The difference between the Measure and Societal perspectives is the total benefit or cost of externalities. Potential externalities include impacts to the economy, public health, and the environment. In general, externalities are more difficult to quantify and a qualitative assessment may need to be incorporated where sufficient quantitative data is not available.

In addition to measure-specific externalities, the U.S. Environmental Protection Agency's (EPA's) social cost of carbon (SCC) is applied to all measures to estimate a base level of avoided environmental damages and health costs associated with the reduction of carbon dioxide (CO_2).

2.3 Types of Benefits and Costs

The benefits and costs associated with a CAP measure fall into one of two categories: direct and external.

2.3.1 Direct Benefits and Costs

Direct benefits and costs are those directly related to implementing a CAP measure or engaging in an action defined by a CAP measure (Figure 5). Typical direct benefits include cost savings in the form of utility bill or fuel purchase reductions. Typical direct costs include the purchase, installation, and maintenance of equipment or other services (e.g., a solar photovoltaic [PV] system). Financial incentives or subsidies, such as rebates and tax credits, are considered cost reductions, or negative direct costs, for Participants.

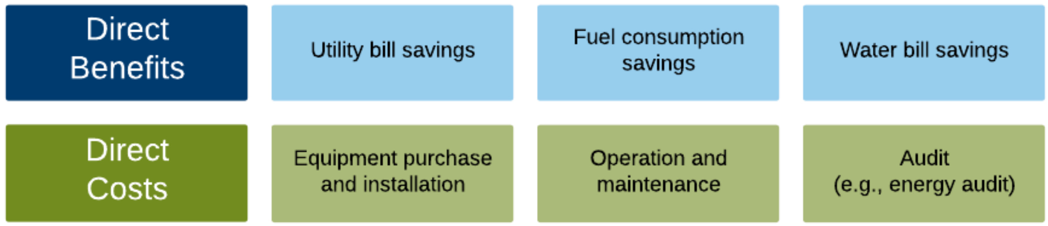

Figure 5. Examples of Potential Direct Benefits and Costs Related to CAP Measures

2.3.1.1 Considerations for Estimating Direct Benefits and Costs

All relevant direct benefits and costs must be identified in order to accurately capture the value of the CAP measure(s) being analyzed. Key considerations to assist in identifying direct benefits and costs include:

- **Useful life:** benefits and costs that are experienced over the entire lifetime of a project or action should be considered. For some measures, the useful life could be a short period of time (e.g., traffic signal retiming, water rate increases) or much longer (e.g., urban forestry, mass transit). See Section 2.4.2 for further discussion on useful life.
- **Incremental activity:** CAP BCAs look at the impact of the CAP relative to business-as-usual behavior. For some measures, this means that the incremental cost associated with an action should be considered (e.g., a measure that aims to replace a municipal fleet with alternative fuel vehicles). While municipalities switch out vehicles as they reach their useful life with or without the CAP, the CAP only specifies which type of vehicle to purchase. As such, the difference in cost between the alternative fuel vehicle and non-alternative fuel vehicle should be considered as the cost of the action defined in the measure.

2.3.2 External Benefits and Costs

Benefits and costs associated with positive or negative externalities are the result of indirect effects of an action (Figure 6) and tend to be more difficult to quantify. Positive externalities generally associated with a CAP include public health benefits from reduced air pollution, increased ecosystem service value, and reduced national dependency on imported fossil fuels. Examples of negative externalities include pollution created from the disposal of solar panels at the end of their useful life and public health costs associated with poor air quality from fossil fuel extraction, production, and combustion.

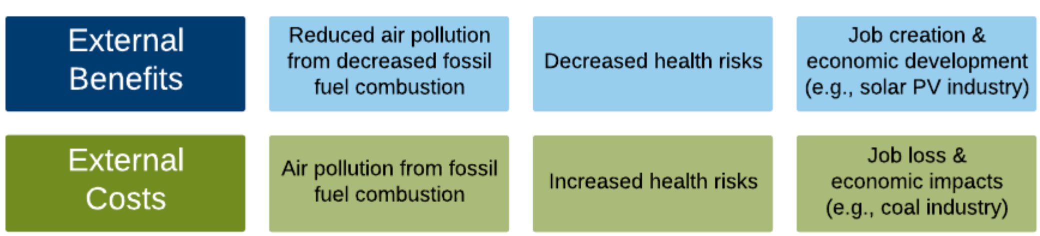

Figure 6. Examples of Potential External Benefits and Costs Related to CAP Measures

2.3.2.1 Considerations for Estimating External Benefits and Costs

Key considerations to assist in identifying externalities to include in the analysis are:

- **Geographic Scale:** effects of external costs and benefits accrue at different geographic scales. There can be local, regional, statewide, national, and global effects from actions. For example, reducing emissions from a power plant located in a densely-populated neighborhood will improve local air quality, which can affect the public health of local residents, while at the same time reducing GHG emissions, which affects global climate. Some measures may have widely distributed external costs and benefits, such as reducing emissions from cars and trucks.
- **Scope:** an important consideration when considering externalities is to determine what to include and exclude from the scope of analysis. For example, when evaluating the effects of different transportation fuels, there are several scopes of analysis: well-to-tank, which evaluates the effects of getting the fuel to the vehicle; tank-to-wheels, which evaluates the effects of combusting fuel to power a vehicle; and well-to-wheels, which evaluates the effects from the entire fuel production cycle through combustion.
- **Consistency:** whether to include external factors for one measure but not others. It is likely that estimates for external costs and benefits will not be available for all measures, so it could be misleading to include the effects for certain measures but not others.
- **Timeline of Effects:** external cost and benefits can impact society at different times. For example, reducing tailpipe emissions in a city may have an immediate effect on air quality and thus public health. On the other hand, reducing GHG emissions, while connected to local air quality, may affect global climate over years or decades.

2.4 Benefit-Cost Analyses Key Terms and Concepts

This section provides definitions and discussions around the following key terms and concepts involved in a CAP BCA: target year, useful life, installation year, and normalized dollars.

2.4.1 Target Year

The target year represents a point in time when the impacts of a CAP measure are being considered and is most often associated with a target or goal year identified in the CAP (e.g., 2020 and 2030). In addition to target years identified in a CAP, a BCA can analyze activity necessary to achieve a certain level of emissions in an interim-target year (e.g., 2025). The BCA considers benefits and costs over the useful life of all actions that contribute to GHG reductions in the target year; however, results are specific to GHG reductions in the target year (Figure 7).

Dollar values expressed in a target year are not necessarily actual benefits or costs to be realized in that particular year. The total benefits and costs accrued over the useful life are apportioned to the GHG reductions associated with that measure. The values in the target year reflect the value of the GHGs reduced in that year and are used in lieu of actual cash flows assigned to the target year because costs and benefits in earlier years are partially responsible for GHG reductions in that year. For instance, a solar PV system installed in 2015 will still be reducing GHGs in the 2020 target year; however, the bulk of the capital costs were experienced earlier on.

2.4.2 Useful Life

A useful life (project life) is the operating life of a project and represents how long a project will last before it must be replaced. BCAs examine the benefit and cost streams over the entire useful life to accurately capture all benefits and costs associated with a measure. Actions identified in CAP measures typically have a project life that extend past the target year(s) identified in the CAP (Figure 7). Restricting the analysis to only the target year could significantly undervalue or overvalue the impacts of a measure. For example, increasing miles of bicycle lanes can have high upfront capital costs with benefits (fuel reductions from commuters) spread over a long useful life (greater than 25 years). Stopping the analysis before the project has reached the end of its useful life would reduce the benefits associated with that action, placing a higher emphasis on the costs.

2.4.3 Installation Year

The installation[2] year (install year) is the initial year in which an action occurs. Measures can include multiple installation years. For example, the year in which a household installs a solar PV system is that household's install year; however, not all solar PV systems will be installed in a single year to achieve GHG reductions in the CAP, but over a number of years. For most measures, the installation year is not included as part of the useful life and no benefits or GHG reductions are achieved in that year. This accounts for construction periods (e.g., installing a solar PV system, constructing a bicycle lane) during which GHG reductions are not achieved, but capital is being outlaid.

A BCA considers the benefits, costs, and GHG reductions associated with all installation years leading up to the target year. Figure 7 depicts the relationship between the installation year, target year, and useful life. In this conceptual example, a measure has a goal of reducing 40 MT CO_2e in the target year, 2020. To achieve this goal, an incremental level of activity is taken between 2015 and 2018 (installation years), where each project reduces ten MT CO_2e annually over its useful life, seven years. In this simplified example, there would be no further GHG emission reductions after activity in the fourth installation year reached the end of its useful life, 2025, so long as no additional activity occurs.

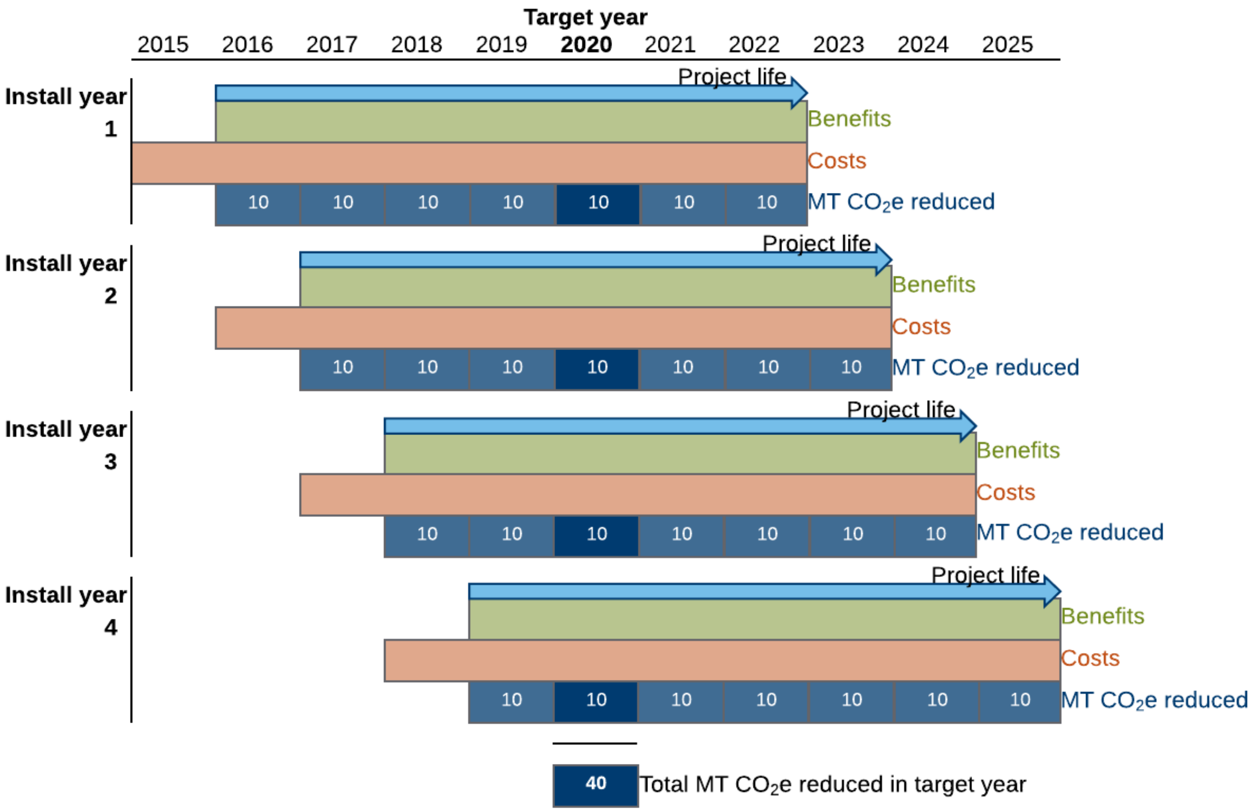

Figure 7. Illustration of Target Year, Installation Year, and Useful Life for a Measure

[2] Note: the term 'installation' is being used here to refer to any general type of activity that begins, not necessarily the direct install of equipment. This can also include an alternative fuel vehicle purchase, home retrofit, water rate increase, etc.

2.4.4 Normalized Dollars

Dollar values are normalized to a base year to accurately analyze historic and current benefit and cost data. This process reduces the interannual impact of external influencers, such as inflation and deflation, on the value of goods or services. While several indices exist to normalize dollar values, the Consumer Price Index (CPI) is one of the most common to be applied (FRB Dallas 2017). Normalization must be done using the same base year for all measures in the BCA for consistency and to allow for comparison across measures.

3 BENEFIT-COST ANALYSES METRICS

Several metrics can be used to analyze the results of a BCA (Figure 8). The applicability of each metric will vary depending on the needs of each jurisdiction and how they anticipate applying the BCA in the decision-making process. Additionally, metrics should be analyzed together and in coordination with calculated GHG reductions to understand the feasibility and practicality of a given measure; no individual metric should be used on its own for decision-making purposes. The following sections describe each metric in more detail.

Net Present Value (NPV)	Net cost or benefit over the life of the project. Considers stream of costs and benefits and discounts to present.	**benefits - costs**
$/MT CO_2e	NPV of project over the total greenhouse gases reduced during that project's lifetime.	**NPV / GHGs**
Benefit-Cost Ratio (BCR)	Ratio of cumulative discounted benefits and cumulative discounted costs.	**benefits / costs**
Discounted Payback Period	Number of years until the cumulative discounted benefits equal or exceed the cumulative discounted costs of a project.	**benefits = costs**
Return on Investment (ROI)	Difference between the non-discounted benefits and costs over the non-discounted costs during project's lifetime.	**benefits - cost / costs**
Internal Rate of Return (IRR)	Discount rate needed to achieve a NPV equal to zero over the project's life	**NPV = 0**

Figure 8. Potential Metrics for a CAP Benefit-Cost Analysis

Not all metrics can be calculated or are applicable for each BCA perspective. For instance, even though the internal rate of return (IRR) and return on investment (ROI) values can be calculated for the administrator perspective, they do not reasonably describe the cost-effectiveness of a jurisdiction's CAP implementation costs because the jurisdiction would have no corresponding benefits associated with implementation. As such, they should not be included in the analysis to avoid confusion.

Also, while a metric may be appropriate for a perspective, it might not always be available. For instance, a payback period cannot be calculated for measures whose benefits never outweigh the costs. Additionally, a benefit-cost ratio (BCR) can only be calculated for perspectives with both a benefit and cost stream.

3.1 Net Present Value (NPV)

Net present value, or NPV, is a common way to express the results of a BCA. In a BCA, it is important to account for the time value of money; receiving ten dollars today is worth more than receiving ten dollars in the future. Calculating the NPV addresses this concern by applying a discount rate to both the benefits and costs. This metric represents the difference between the present value benefits and present value costs of an action over its useful life.[3]

3.1.1 Discount Rate

A discount rate, *r*, is used to convert future values to present worth. According to the U.S. EPA, projects within a short to medium lifespan (less than 50 years) are assigned a discount rate of approximately 3%, derived from consumer-time preferences based on the interest rate of a risk-free asset such as a government bond (U.S. EPA 2010). Conversely, the federal Office of Management and Budget (OMB) assigns a standard discount rate of 7%, derived from the opportunity cost of private capital, measured by the before-tax rate of return to investment, for projects with similar lifespans (OMB 2000). To account for this range in recommendations, a 5% discount rate is applied as the default value with a 3% and 7% discount rate used for sensitivity analyses.[4] The discount rate selected is a key variable and has an impact on BCA results. Higher discount rates lower the value of future welfare (i.e., lessens the value of future dollars relative to the baseline year in the analysis), while lower discount rates place a higher value on future welfare. Additionally, higher discount rates tend to make projects less attractive when costs are paid upfront and benefits are spread out over many years.

Additionally, all values are discounted back to the same year, regardless of an individual measure or action start year; this ensures that the individual measure results are compatible and comparable with other measures analyzed in a CAP. The baseline year selected typically aligns with the CAP's baseline year. The example in Figure 9 illustrates how a CAP can have measures with actions that begin in different years, but all are discounted to the same baseline year in the analysis. In this example, Measure 1 begins in 2015 and Measure 2 begins in 2017, but both are discounted back to the 2015 baseline year.

[3] Present value in this context and going forward represents the value in the start year of the analysis, not the current year.
[4] Both the EPA and OMB suggest performing a sensitivity analysis with a suite of discount rates to identify how results respond to different time-value preferences.

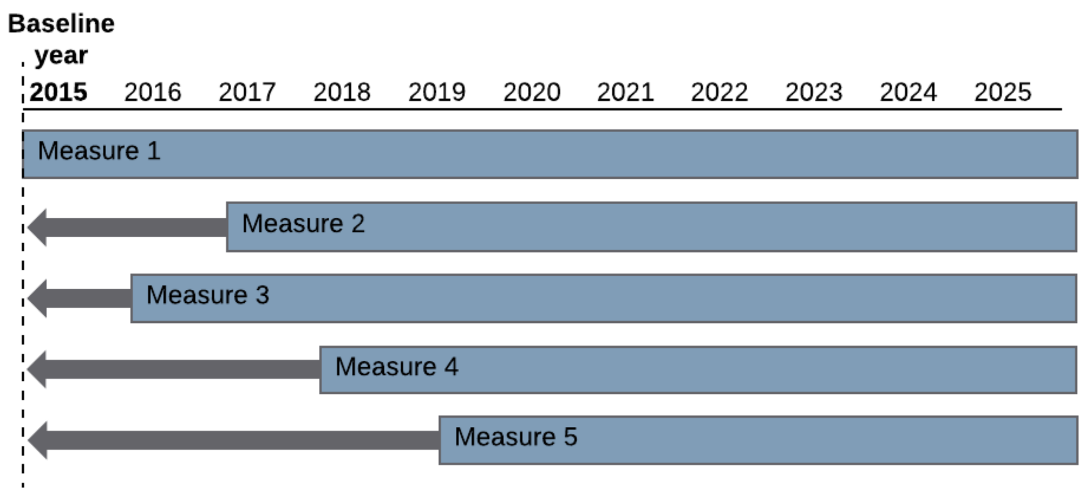

Figure 9. Discounting Measures with Different Start Years

3.1.2 Net Benefit vs. Net Cost

When summing all benefits and costs of an action over its useful life, the NPV can be either positive (net benefit) or negative (net cost). A net benefit indicates that benefits received outweigh the costs incurred, and a net cost indicates the reverse.

3.2 Dollar per Metric Ton of CO_2e

The dollar per metric ton of carbon dioxide equivalent ($/MT CO_2e) represents the total benefit or cost associated with reducing one MT CO_2e in any given year by taking an action defined in that particular CAP measure. This metric builds on the NPV of a measure and is another standard metric to include in a CAP BCA. It is a way of standardizing the results of all measures that allows for comparisons across measures, and provides a way to estimate the annual value of a measure in relation to its GHG reductions in that year. Like the NPV, a positive value indicates a net benefit per ton reduced, whereas a negative value indicates a net cost per ton reduced.

3.2.1 Weighted Average Dollar per Metric Ton of CO_2e

As described earlier, most measures will have multiple installation years associated with their defined action(s) and the benefits, costs, and GHGs reduced from an activity in one year could be different from the same type of activity in the following year (e.g., changes in installation price, rebates that have since expired, etc.). Since the GHGs reduced in the target year are not always equal for all actions in years previous, it is necessary to calculate a weighted average dollar per MT CO_2e. By calculating a weighted average, all costs and benefits associated with the actions taken to achieve the GHG reductions in the target year are incorporated into the analysis and then scaled according to their contribution of GHG reductions in the target year.

3.3 Benefit-Cost Ratio

The BCR is a metric commonly used to assess the relationship between the benefits and costs of a project or action. If a BCR is greater than one, then benefits of the measure outweigh costs; if it is less than one, costs outweigh benefits. While this metric does not provide a great deal of insight for a single measure, it does illustrate the relative cost-effectiveness when comparing multiple measures against each other; measures with higher BCR values tend to be more cost-effective. For the Participant perspective only, treatment of subsidies (rebates and incentives) can impact the result. Treating subsidies as cost-reductions reduces the denominator, whereas including them as benefits to the

Participant increases the numerator. The inclusion of a subsidy as a cost-reduction or benefit to the Participant must be consistent across measures to allow for comparable results. Methodologies outlined in this document identify all subsidies as cost-reductions to the Participant.

3.4 Payback Period

A payback period is the amount of time required for the cumulative benefits of a project to equal or surpass the cumulative costs of an action or measure (Figure 10). Payback periods can only be shown for measures (or perspectives) that have a positive NPV; a negative NPV indicates that the benefits will never equal or outweigh the costs over an action's lifetime.

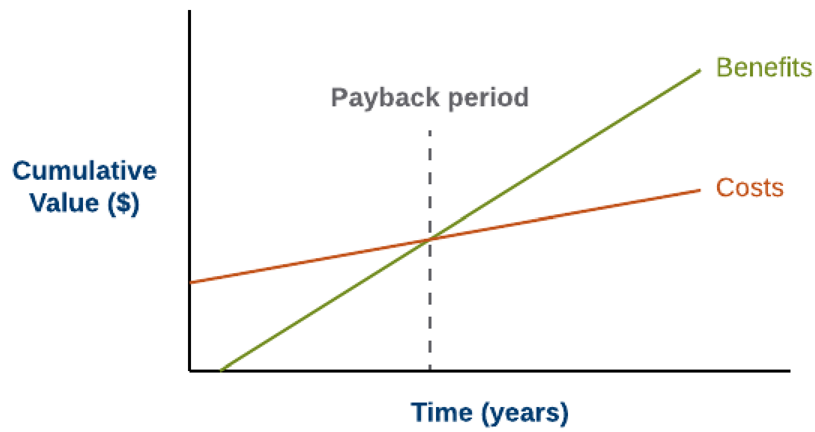

Figure 10. Conceptual Diagram of an Action's Payback Period

There are two types of payback periods that can be considered: simple and discounted. The simple payback period is the easiest to calculate, as it ignores the time value of money. The discounted payback period does take into consideration the time value of money and, by discounting future values, the time required for benefits to exceed costs is extended further into the future. As such, a discounted payback period is recommended for any CAP BCA.

3.5 Return on Investment

ROI is a metric that measures the rate of return, or profitability, for a project to evaluate its efficiency. ROIs are expressed as a percentage; the higher the percentage, the greater the return or profitability of a project. For measures where costs significantly outweigh benefits, a highly negative ROI value can be obtained (not to exceed -100%). Like the BCR, the ROI is useful when comparing multiple actions to understand which are potentially the most cost-effective. Similar to the payback period, ROIs can be calculated using simple or discounted benefits and costs. A simple ROI is more easily understood and is more comparable to actual interest rates, which do not account for future discounting. As such, a simple ROI is recommended for any CAP BCA.

3.6 Internal Rate of Return

The IRR represents the discount rate necessary to achieve an NPV equal to zero given the benefits and costs of a measure or action over its useful life. Similar to the ROI, the IRR is expressed as a percentage; a higher percentage generally means a project is more desirable, and negative IRRs indicate the benefits never outweigh the costs. The IRR is used to compare projects and determine which projects are better investment opportunities.

4 METHODS FOR ANALYZING BENEFITS AND COSTS

The BCA for each CAP measure follow the same general methods outlined in Figure 11.

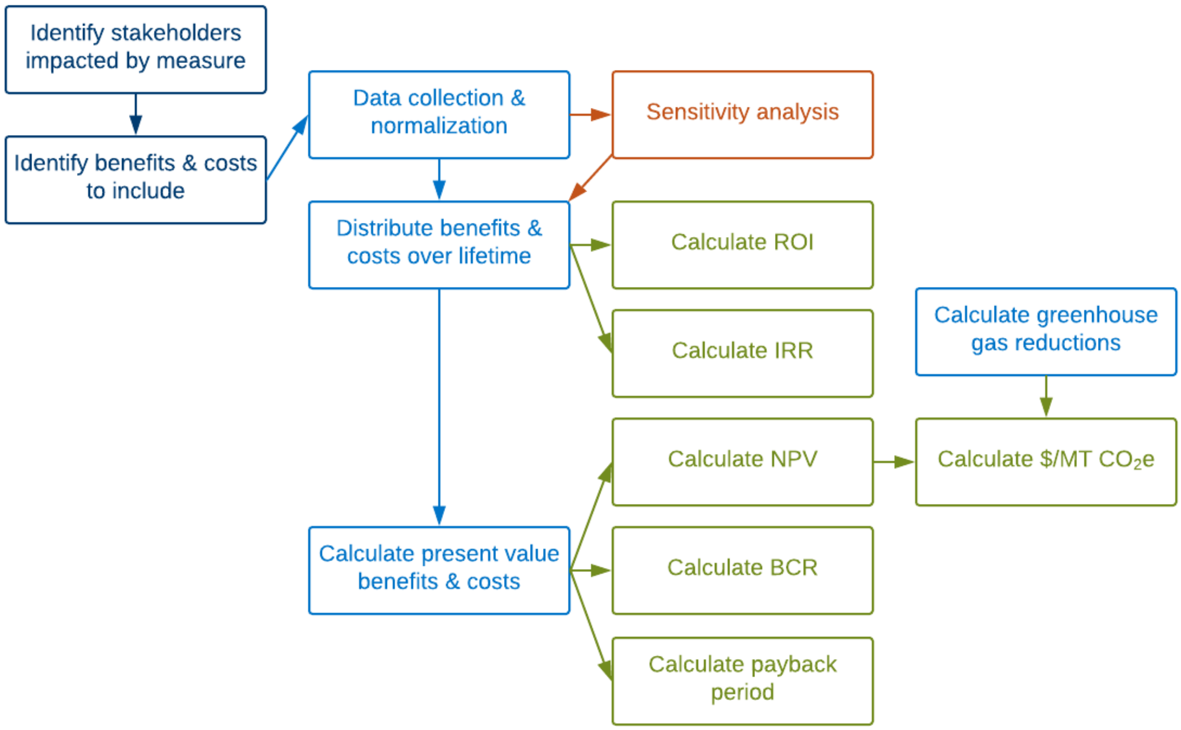

Figure 11. General Methods for Climate Action Plan Benefit-Cost Analyses

For all measures, GHG calculations must be consistent with those used in estimating GHG reductions for the CAP (see Technical Appendix 2 – GHG Reduction Calculation Methods for CAP Measures for further discussion). Additional data may be required to apply calculated GHG reductions at an individual activity level (e.g., average GHGs reduced per solar PV system installed, average mode share switch per mile of bicycle lane installed). Requirements will vary by measure, but defining assumptions and collecting data all follow the same methods detailed here.

4.1 Identification of Stakeholders Impacted and Benefits/Costs

The data collection process is guided by identifying stakeholders impacted in each perspective. The following sections help to identify those groups and the benefits/costs included in the analysis that are received/incurred by each.

4.1.1 Administrator Perspective

The Administrator perspective is comprised solely of jurisdiction departments and agencies that will undertake some type of activity related to implementing the CAP measure. Jurisdiction costs for CAP implementation can be collected from a CAP implementation cost report (see Technical Appendix 4 – CAP Implementation Cost Analysis).

4.1.2 Participant Perspective

An individual measure can have multiple Participant groups that are impacted depending on the level of specificity for each CAP measure. The solar PV system example in Figure 12 shows that, at a higher level, stakeholders include residential and commercial customers, and more specific sub-stakeholders are identified based on the type of construction. For the solar PV measure, the costs associated with installations on existing construction can vary greatly compared to the costs of installing solar PV systems during construction of a new home or commercial building. The individuals who comprise the two types of construction groups can also vary: existing construction typically refers to current home or business owners, whereas new construction can include developers. For some measures, the jurisdiction can also be considered a stakeholder under this perspective (e.g., installation of solar PV on municipal buildings).

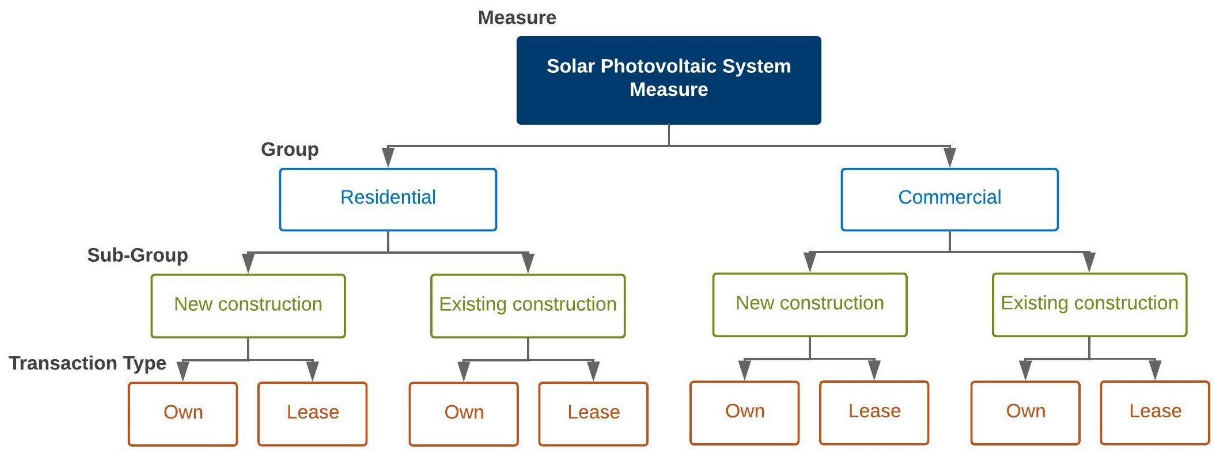

Figure 12. Potential Stakeholders Impacted by a Solar PV System Ordinance

Key questions asked for each identified Participant include:

- Are there any upfront costs for purchase/installation?
- Are there any ongoing maintenance costs and, if so, at what frequency are they incurred (e.g., annually, biannually)?
- Does the activity reduce consumption (electricity, natural gas, water, fuel, etc.)?
- What rebates and incentives are available?
- What rate schedules apply to Participant groups?
- What type of transaction is involved (e.g., purchase or lease)?
- Are there permitting requirements associated with the measure?

4.1.3 Non-Participant Perspective

Non-Participants are those who fund rebates and incentives (through taxes, fees, etc.) that Participants use to offset costs. Data needed to estimate the impact on Non-Participants is the same as that for any rebates or incentives identified for Participants (shown as cost reductions for Participants and costs for Non-Participants).

4.2 Data Collection and Normalization

Data collection follows the hierarchy outlined in Figure 13. Data specific to the jurisdiction are used whenever possible for benefit and cost values, as well as for key assumptions (e.g., useful life). In instances where data specific to the jurisdiction are unavailable or incomplete (e.g., due to limited historic activity), regional or statewide data can be applied. In the absence of sufficient regional or statewide data, estimates provided in current literature can be used. Local datasets provide information on historical installations specific to the jurisdiction (e.g., California Solar Initiative Solar Thermal data). Regional datasets are not specific to the jurisdiction, but to the local region (e.g., county-level data, water district program data). State datasets refer to data and/or case studies at the State level; case studies might not include the jurisdiction. Examples of best available literature include reports from federal agencies (e.g., USDA Forest Service) applicable to regions broader than the State level.

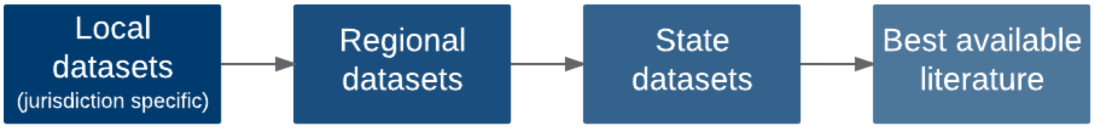

Figure 13. Data Collection Hierarchy for Climate Action Plan Benefit-Cost Analyses

All collected dollar values must be normalized to the same base year using the CPI. Normalization reduces interannual impacts of outside influences (inflation, deflation, etc.) on dollar values. Failing to normalize data can skew results of the analysis. Any year can be selected as the base year[5] (or year to normalize all values to) as long as the same base year is used consistently throughout the BCA. All dollar values used must be normalized before integrating them into calculations using the following equation:

Equation 1. Normalization of Data Values Using Consumer Price Index

$$X_0 = X_t * \frac{CPI_0}{CPI_t}$$

Where,

X_0	= normalized dollar value in base year
X_t	= nominal dollar value in year *t*
CPI_0	= Consumer Price Index in base year
CPI_t	= Consumer Price Index in year *t*

When the dollar year is not specified for data value(s) in a report or literature used, the year of publication is applied for normalization.

4.3 Distribution of Benefits and Costs over Lifetime

For each measure, the benefit and cost streams are laid out over the entire lifetime associated with that particular activity for the particular perspective(s) being analyzed. In the example in Figure 14, 2015 is considered the first installation year and the useful life is seven years (2015-2022). The year 2016 is considered the second install year and the benefits and costs go out through 2023 (a seven-year life). This example does not differentiate between perspectives, but the same process is applied to each by adding or removing the appropriate benefits and costs for that perspective and measure. Additionally, each install year will have corresponding GHGs that are reduced annually. Annual GHG reductions for a particular install year will not vary by perspective.

[5] Note: the base year used for normalization is separate from the baseline year used in a CAP and for discounting.

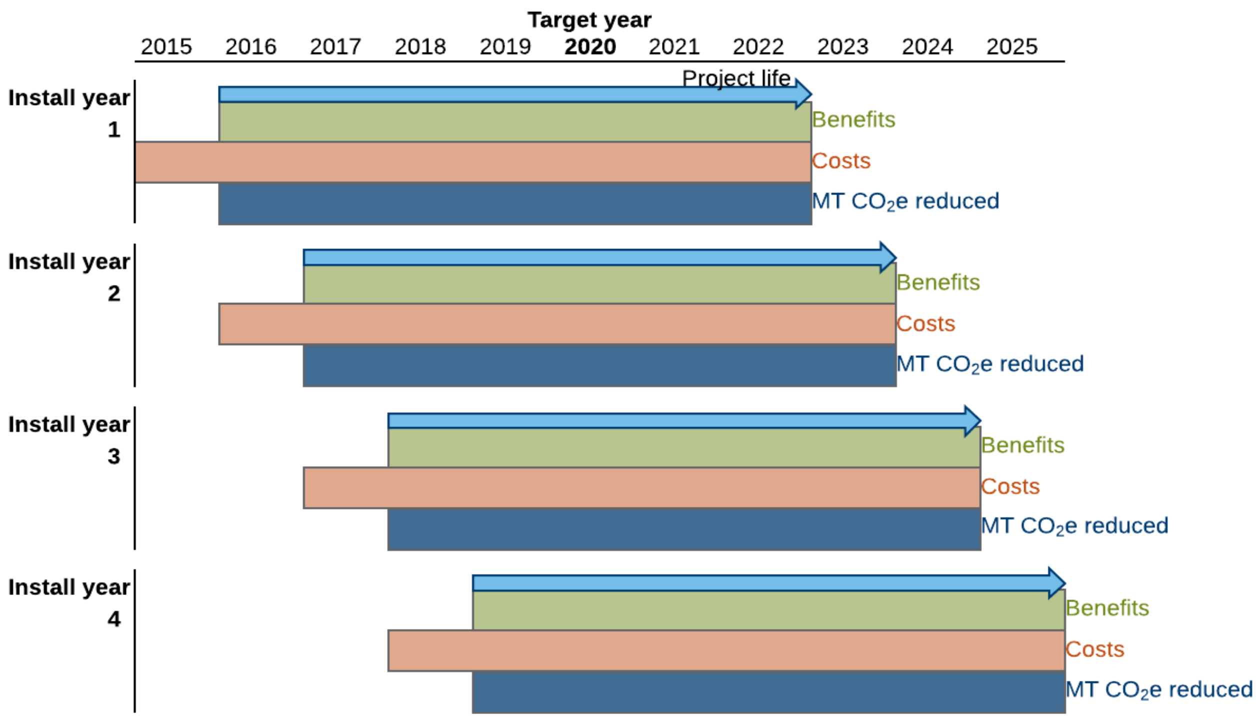

Figure 14. Example of Benefits and Costs Laid Out Over Useful Lives for Multiple Install Years

4.4 Calculate Present Value Benefits and Costs

Once all benefits and costs have been laid out over the action's useful life, the discount rate is applied to both the benefit and cost streams for each installation year to calculate their respective present values (Equation 2 and Equation 3, respectively).

Equation 2. Present Value Benefits Calculation

$$PV_{benefits} = \sum_{t=0}^{T} \frac{B_t}{(1+r)^t}$$

Equation 3. Present Value Costs Calculation

$$PV_{costs} = \sum_{t=0}^{T} \frac{C_t}{(1+r)^t}$$

Where,

$PV_{benefits}$	= present value of benefits stream
B_t	= benefits in year *t*
PV_{costs}	= present value of costs stream
C_t	= costs in year *t*
r	= discount rate
T	= useful life of measure/action

4.4.1 Present Value Benefits and Costs in Target Year

Present value benefits and costs represent the total of each over all useful lives. However, a CAP BCA is meant to show results with respect to a particular target year. To achieve this, the present value benefits and costs are apportioned to the GHGs reduced over each install year's useful life and then multiplied by the GHGs reduced in the target year for that install year (Equation 4 and Equation 5). Results are totaled for all install years to calculate the total benefit and cost in the target year for a given measure.

Equation 4. Present Value Benefits in Target Year Calculation

$$PV_{benefits}\ in\ target\ year = \frac{PV_{benefits}}{\sum_{t=0}^{T} GHGs_t} * GHGs_{t=target\ year}$$

Equation 5. Present Value Costs in Target Year Calculation

$$PV_{costs}\ in\ target\ year = \frac{PV_{costs}}{\sum_{t=0}^{T} GHGs_t} * GHGs_{t=target\ year}$$

Where,

$PV_{benefits}$	= present value of benefits stream
PV_{costs}	= present value of costs stream
$GHGs_t$	= greenhouse gases reduced in year *t*
T	= useful life of measure/action

4.5 Calculate Net Present Value

NPV is calculated as the difference between the present value benefits and the present value costs for each install year (Equation 6).

Equation 6. Net Present Value Calculation

$$NPV = PV_{benefits} - PV_{costs}$$

Where,

NPV	= net present value
$PV_{benefits}$	= present value of benefits stream
PV_{costs}	= present value of costs stream

4.5.1 Net Present Value in Target Year

Similar to the present value benefits and costs, NPV must be apportioned across all GHGs reduced over each install year's useful life to find the NPV in the target year. This can be done using Equation 4 and substituting *NPV* in for $PV_{benefits}$ or more simply by subtracting the target year's present value costs from the target year's present value benefits (Equation 7).

Equation 7. Net Present Value in Target Year Calculation

$$Anticipated\ NPV\ in\ target\ year = Anticipated\ PV_{benefits}\ in\ target\ year - Anticipated\ PV_{costs}\ in\ target\ year$$

4.6 Calculate Dollar per Metric Ton of CO_2e

The dollar per MT CO_2e is calculated by dividing the NPV for each install year by the total GHGs reduced over its useful life (Equation 8).

Equation 8. Dollar per Metric Ton of CO_2e Calculation

$$Dollar\ per\ MT\ CO_2e = \frac{NPV}{\sum_{t=0}^{T} GHGs_t}$$

Where,

NPV	= net present value
$GHGs_t$	= greenhouse gases reduced in year *t*
T	= useful life of measure/action

4.6.1 Weighted Average Dollar per Metric Ton of CO_2e

Since GHG reductions in the target year are not necessarily the same for each install year,[6] weighted average values must be calculated to accurately reflect the dollar per metric ton CO_2e of a particular measure in the target year. The weighted average can be found using Equation 9.

Equation 9. Weighted Average Dollar per Metric Ton of CO_2e Calculation

$$Weighted\ average\ \$/MT\ CO_2e = \frac{\sum_{j=1}^{k}(\$/MT_j * GHGs_{target\ year;j})}{\sum_{j=1}^{k} GHGs_{target\ year;j}}$$

Where,

$\$/MT_j$	= dollar per metric ton of install year *j*
$GHGs_{target\ year;j}$	= greenhouse gases reduced in target year by actions in install year *j*
j	= install year
k	= number of install years

4.7 Calculate Benefit-Cost Ratio

The BCR is calculated by dividing the present value benefits by the present value costs for a given install year (Equation 10).

Equation 10. Benefit-Cost Ratio Calculation

$$BCR = \frac{PV_{benefits}}{PV_{costs}}$$

Where,

BCR	= benefit-cost ratio
$PV_{benefits}$	= present value of benefits stream
PV_{costs}	= present value of costs stream

4.7.1 Weighted Average Benefit-Cost Ratio

Since GHG reductions in the target year are not necessarily the same for each install year,[6] weighted average values must be calculated to accurately reflect the BCR of a particular measure in the target year. The weighted average can be found using Equation 11.

Equation 11. Weighted Average Benefit-Cost Ratio Calculation

$$Weighted\ average\ BCR = \frac{\sum_{j=1}^{k}(BCR_j * GHGs_{target\ year;j})}{\sum_{j=1}^{k} GHGs_{target\ year;j}}$$

Where,

BCR_j	= benefit-cost ratio of install year *j*
$GHGs_{target\ year;j}$	= greenhouse gases reduced in target year by actions in install year *j*
j	= install year
k	= number of install years

[6] E.g., reductions from a solar PV system installed in 2015 will offset less GHGs in 2020 than a system of the same size installed in 2019 when a system degradation rate is applied.

4.8 Calculate Discounted Payback Period

Determining the payback period requires calculating the cumulative flow of discounted benefits and discounted costs for a given install year (Equation 12). The cumulative cash flow for any given year is the sum of the benefits and costs (both discounted in this case) for that year and all previous years. The number of years with a negative cumulative discounted cash flow, *n*, starts in Year One and goes up to the year before cumulative discounted benefits are greater than cumulative discounted costs.

Equation 12. Discounted Payback Period Calculation

$$DPP = n + \frac{CF_n}{CF_{n+1}}$$

Where,

DPP	= discounted payback period
n	= number of years with a negative cumulative discounted cash flow
CF_n	= discounted cash flow in year *n*
CF_{n+1}	= discounted cash flow in year *n + 1*

4.8.1 Weighted Average Discounted Payback Period

Since GHG reductions in the target year are not necessarily the same for each install year,[7] weighted average values must be calculated to accurately reflect the discounted payback period of a particular measure in the target year. The weighted average can be found using Equation 13.

Equation 13. Weighted Average Discounted Payback Period Calculation

$$Weighted\ average\ DPP = \frac{\sum_{j=1}^{k}(DPP_j * GHGs_{target\ year;j})}{\sum_{j=1}^{k} GHGs_{target\ year;j}}$$

Where,

DPP_j	= discounted payback period of install year *j*
$GHGs_{target\ year;j}$	= greenhouse gases reduced in target year by actions in install year *j*
j	= install year
k	= number of install years

4.9 Calculate Return on Investment

Unlike most other calculations, the ROI is found using non-discounted benefits and costs. The ROI is a ratio between the difference of all benefits and costs and the costs (Equation 14).

Equation 14. Return on Investment Calculation

$$ROI = \frac{\sum_{t=0}^{T}(B_t - C_t)}{\sum_{t=0}^{T} C_t}$$

Where,

ROI	= return on investment
B_t	= benefits in year *t*
C_t	= costs in year *t*
T	= useful life of measure/action

[7] E.g., reductions from a solar PV system installed in 2015 will offset less GHGs in 2020 than a system of the same size installed in 2019 when a system degradation rate is applied.

4.9.1 Weighted Average Return on Investment

Since GHG reductions in the target year are not necessarily the same for each install year,[8] weighted average values must be calculated to accurately reflect the ROI of a particular measure in the target year. The weighted average can be found using Equation 15.

Equation 15. Weighted Average Return on Investment Calculation

$$Weighted\ average\ ROI = \frac{\sum_{j=1}^{k}(ROI_j * GHGs_{target\ year;j})}{\sum_{j=1}^{k} GHGs_{target\ year;j}}$$

Where,

ROI_j	= discounted payback period of install year *j*
$GHGs_{target\ year;j}$	= greenhouse gases reduced in target year by actions in install year *j*
j	= install year
k	= number of install years

4.10 Calculate Internal Rate of Return

The IRR is found by setting the NPV equal to zero and solving for the discount rate, *r* (Equation 16).

Equation 16. Internal Rate of Return Calculation

$$NPV = 0 = \sum_{t=0}^{T} \frac{B_t - C_t}{(1+r)^t}$$

Where,

NPV	= net present value
B_t	= benefits in year *t*
C_t	= costs in year *t*
r	= discount rate to be solved for (IRR)
T	= useful life of measure/action

Excel or other analytical software is used to accurately calculate the IRR. Manually solving for the IRR requires inputting a series of estimated values for the IRR into Equation 16 until an approximate IRR is found that yields and NPV of approximately zero.

4.10.1 Weighted Average Internal Rate of Return

Since GHG reductions in the target year are not necessarily the same for each install year,[8] weighted average values must be calculated to accurately reflect the IRR of a particular measure in the target year. The weighted average can be found using Equation 17.

Equation 17. Weighted Average Internal Rate of Return Calculation

$$Weighted\ average\ IRR = \frac{\sum_{j=1}^{k}(IRR_j * GHGs_{target\ year;j})}{\sum_{j=1}^{k} GHGs_{target\ year;j}}$$

Where,

IRR_j	= discounted payback period of install year *j*
$GHGs_{target\ year;j}$	= greenhouse gases reduced in target year by actions in install year *j*
j	= install year

[8] E.g., reductions from a solar PV system installed in 2015 will offset less GHGs in 2020 than a system of the same size installed in 2019 when a system degradation rate is applied.

k = number of install years

4.11 Sensitivity Analyses

A sensitivity analysis is used to estimate the impact of a select input on analysis results, while holding all other inputs constant. For example, the discount rate can be varied to determine if valuing future dollars more or less has a significant impact on BCA results. Once an appropriate input has been identified to change for the sensitivity analysis, methods documented in Sections 4.2–4.10 are applied to calculate the new set of BCA results.

5 DATA NEEDS AND ASSUMPTIONS – MEASURE EXAMPLES

The following are examples of data needs and assumptions for typical CAP measures. These examples are illustrative only; actual inputs and assumptions in a BCA should be based on the details provided in the jurisdiction's CAP measure and available data for that jurisdiction. Example measures included here are:

- **Energy-related measures**
    - *Example 1:* Adopt a residential solar PV ordinance
    - *Example 2:* Adopt a residential energy conservation ordinance
- **Water-related measures**
    - *Example 3:* Adopt a residential water conservation ordinance
    - *Example 4:* Adjust water rate structures to encourage water conservation
    - *Example 5:* Adopt a landscaping ordinance requiring weather-based irrigation controllers
- **Transportation-related measures**
    - *Example 6:* Switch out municipal fleet vehicles with ZEVs
    - *Example 7:* Increase number of miles of bicycle lanes
    - *Example 8:* Retime traffic signals
    - *Example 9:* Install roundabouts
- **Urban forestry-related measures**
    - *Example 10:* Increase canopy cover of urban forest

As jurisdictions in San Diego County complete BCAs for their CAPs, this list will expand to include the data needs and assumptions for new measures.

5.1 Energy-Related Measures

The following sections detail measure specific inputs for energy-related measures.

5.1.1 Example 1: Adopt a residential solar PV ordinance

Increasing renewable energy production on residential buildings through solar PV system installation is a common measure in CAPs. To achieve this goal, new and/or existing residential units would need to install solar PV systems to offset a portion of their energy consumption. Table 1 documents costs, benefits, externalities, and general inputs and assumptions typical of this type of measure. For benefits and costs, the corresponding perspective is identified along with potential sources. Current literature is cited where appropriate and indicates inputs with no available locally-specific data.

Table 1. Data Inputs for a Residential Solar PV Measure

Measure - Adopt a residential solar photovoltaic ordinance		
Input	**Perspective[1]**	**Source(s)**
Costs		
Ordinance development and adoption	A	*provided by jurisdiction staff
Program education and outreach	A	*provided by jurisdiction staff
Program monitoring and reporting	A	*provided by jurisdiction staff
Average solar PV system permit cost	P	*provided by jurisdiction staff
Average solar PV system purchase and installation cost	P	Millstein et al. 2016
Annual operations and maintenance cost	P	NREL 2015
Inverter replacement cost (every 10 yrs)	P	NREL 2015, NREL 2017
Rebates and Incentives	P, NP	Millstein et al. 2016
Federal Investment Tax Credit (ITC)	P, NP	SEIA 2016
Tax Deductions (commercial only)	P, NP	SEIA 2017; USDT IRS 2017a; USDT IRS 2017b
Benefits		
Residential electricity bill reduction (based on electricity rates)	P	CEC 2016
Externalities included		
Social cost of carbon	S	US EPA 2016
Other inputs and assumptions		
Useful life of average PV system		Kneifel et al. 2016
Percentage of systems leased (PPA)		GTM Research 2015
Annual decline in PV production		NREL 2015
Effective commercial tax rate		USDT OTA 2016; US GAO 2016

[1]A: Administrator, P: Participant, NP: Non-participant, S: Societal

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5.1.2 Example 2: Adopt a residential energy conservation ordinance

Reducing energy consumption of existing residential housing stock through enforcement of an ordinance is another common CAP measure. To achieve this goal, single- and multi-family residential units would need to conduct an energy audit retrofit, which would result in a percentage of those units undergoing an energy efficiency retrofit (e.g., install energy efficient appliances, weatherize the building, and/or replace windows). Table 2 documents costs, benefits, externalities, and general inputs and assumptions typical of this type of measure. For benefits and costs, the corresponding perspective is identified along with potential sources. Current literature is cited where appropriate and indicates inputs with no available locally-specific data.

Table 2. Data Inputs for a Residential Energy Conservation Measure

Measure - Adopt a residential energy conservation ordinance		
Input	**Perspective[1]**	**Source(s)**
Costs		
Ordinance development and adoption	A	*provided by jurisdiction staff
Program education and outreach	A	*provided by jurisdiction staff
Program monitoring and reporting	A	*provided by jurisdiction staff
Average energy audit cost	P	SDG&E 2016
Average energy efficiency retrofit cost (single-family)	P	DNV KEMA 2014
ARRA incentives (single-family)	P, NP	DNV KEMA 2014
Other incentives (single-family)	P, NP	DNV KEMA 2014
ARRA loan (single-family)	P, NP	DNV KEMA 2014
Average energy efficiency retrofit cost (multi-family)	P	DNV KEMA 2014
Incentives (multi-family)	P, NP	DNV KEMA 2014
Benefits		
Residential electricity bill reduction (based on electricity rates)	P	CEC 2016
Residential natural gas bill reduction (based on natural gas rates)	P	SDG&E historical tariffs
Externalities included		
Social cost of carbon	S	US EPA 2016
Other inputs and assumptions		
Useful life of average energy efficiency retrofit		DNV KEMA 2014
Number of residential units		SANDAG Series 13 forecast
Percentage of owner-occupied units		SANDAG Series 13 forecast
Percentage of units sold annually		SDAR 2013
Percentage of units remodeled annually		*provided by jurisdiction staff
Percentage of energy audits that lead to energy efficiency retrofits		*provided by jurisdiction staff
ARRA loan term (single-family)		ACEEE 2014
ARRA loan interest rate (single-family)		ACEEE 2014

[1]A: Administrator, P: Participant, NP: Non-participant, S: Societal

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5.2 Water-Related Measures

The following sections detail measure-specific inputs for water-related measures.

5.2.1 Example 3: Adopt a residential water conservation ordinance

Reducing water consumption in the housing stock reduces energy consumption associated with the conveyance, distribution, and treatment of water, as well as reductions in energy consumption associated with water end-uses (e.g., heating). To achieve this goal, residential units would need to complete a water conservation retrofit (e.g., install water efficient appliances). Table 3 documents costs, benefits, externalities, and general inputs and assumptions typical of this type of measure. For benefits and costs, the corresponding perspective is identified along with potential sources. Current literature is cited where appropriate and indicates inputs with no available locally-specific data.

Table 3. Data Inputs for a Residential Water Conservation Measure

Measure - Adopt a residential water conservation ordinance		
Input	**Perspective[1]**	**Source(s)**
Costs		
Ordinance development and adoption	A	*provided by jurisdiction staff
Program education and outreach	A	*provided by jurisdiction staff
Program monitoring an reporting	A	*provided by jurisdiction staff
Average water conservation retrofit cost	P	Pacific Institute 2016
Average rebate	P, NP	SoCal WaterSmart 2017 rebate schedule
Benefits		
Residential water bill reduction (based on water rates)	P	*provided by jurisdiction staff
Externalities included		
Social cost of carbon	S	US EPA 2016
Other inputs and assumptions		
Useful life of average water conservation retrofit		Pacific Institute 2016
Residential fixtures included in analysis		Pacific Institute 2016; DeOreo et al. 2011
Water saved per water conservation retrofit		Pacific Institute 2016; DeOreo et al. 2011

[1]A: Administrator, P: Participant, NP: Non-participant, S: Societal — Energy Policy Initiatives Center, USD 2018

5.2.2 Example 4: Water rate changes to encourage water conservation

Some jurisdictions use increases in water rates paid by commercial and residential consumers to obtain reductions in consumption. By reducing water consumption, the participant affected (commercial or residential) would see reductions in both end use water and water-related end use energy consumption (e.g., heating). Table 4 documents costs, benefits, externalities, and general inputs and assumptions typical of this type of measure. For benefits and costs, the corresponding perspective is identified along with potential sources. Current literature is cited where appropriate and indicates inputs with no available locally-specific data.

Table 4. Data Inputs for a Water Rate Structure Measure

Measure - Water rate changes to encourage water conservation		
Input	**Perspective[1]**	**Source(s)**
Costs		
Water management plan development and adoption	A	*provided by jurisdiction staff
Program education and outreach	A	*provided by jurisdiction staff
Program monitoring and reporting	A	*provided by jurisdiction staff
Residential water bill increase (based on water rates)	P	*provided by jurisdiction staff or local w ater agency
Benefits		
NA		
Externalities included		
Social cost of carbon	S	US EPA 2016
Other inputs and assumptions		
Price elasticity of water		CA Climate Change Center 2009
Baseline gallons per capita per day (GPCD, 2010)		Jurisdiction Urban Water Management Plan
Population estimate		SANDAG Series 13 forecast

[1]A: Administrator, P: Participant, NP: Non-participant, S: Societal — Energy Policy Initiatives Center, USD 2018

5.2.3 Example 5: Adopt a landscaping ordinance requiring weather-based irrigation controllers

Reductions in water-related energy consumption can also be achieved through measures that reduce outdoor water consumption. One way to achieve this goal is to adopt a measure requiring weather-based irrigation controllers (WBICs) for residential units. Table 5 documents costs, benefits, externalities, and general inputs and assumptions typical of this type of measure. For benefits and costs, the corresponding perspective is identified along with potential sources. Current literature is cited where appropriate and indicates inputs with no available locally-specific data.

Table 5. Data Inputs for an Outdoor Water Conservation Measure

Measure - Adopt a landscaping ordinance requiring weather-based irrigation controllers		
Input	**Perspective[1]**	**Source(s)**
Costs		
Ordinance development and adoption	A	*provided by jurisdiction staff
Program education and outreach	A	*provided by jurisdiction staff
Program monitoring and reporting	A	*provided by jurisdiction staff
Incremental weather-based irrigation controller purchase cost (WBIC over non-WBIC)	P	Energy Solutions et al. 2011
WBIC installation (small lot)	P	Energy Solutions et al. 2011
Annual service fee (small lot)	P	Energy Solutions et al. 2011
WaterSmart rebate (small lot)	P, NP	SoCal WaterSmart 2017 rebate schedule
WBIC installation (large lot)	P	Energy Solutions et al. 2011
Annual service fee (large lot)	P	Energy Solutions et al. 2011
WaterSmart rebate (large lot)	P, NP	SoCal WaterSmart 2017 rebate schedule
Residential electricity bill increase (due to system operation, based on electricity rates)	P	CEC 2016
Benefits		
Residential water bill reduction (based on water rates)	P	*provided by jurisdiction staff or local w ater agency
Externalities included		
Social cost of carbon	S	US EPA 2016
Other inputs and assumptions		
Useful life of average WBIC system		Energy Solutions et al. 2011
Incremental energy demand per WBIC system		Energy Solutions et al. 2011
Percentage of lots considered large		Hanak and Davis 2006
Water saved per system		ConSol 2010

[1]A: Administrator, P: Participant, NP: Non-participant, S: Societal — Energy Policy Initiatives Center, USD 2018

5.3 Transportation-Related Measures

The following sections detail measure specific inputs for transportation-related measures.

Measures that involve a reduction in fuel consumption also reduce air pollution within the jurisdiction. Several key pollutants have been identified and included in previous transportation assessments by SANDAG (e.g., *San Diego Forward: The Regional Plan*) (Table 6). The avoided health effects associated with reduced criteria pollutants are included as externalities for these measures.

Table 6. Criteria Pollutant Externalities Included for Transportation Measures

Criteria Pollutants Included (externalities)			
Description	**Value**	**Input**	**Source**
Transportation Measures	**$/MT**	**g/mi**	
CO_2	*Varies*	*Varies by year*	CARB. EMFAC2011 Web Database; CARB. EMFAC2014 Web Database; CARB 2015. EMFAC2014 Volume III - Technical Documentation; SANDAG 2015. San Diego Forward: The Regional Plan
$PM_{2.5}$	*$422,281*		
PM_{10}	*$128,708*		
NOx	*$6,716*		
ROG	*$5,856*		
SO_2	*$34,868*		

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5.3.1 Example 6: Switch out municipal fleet vehicles with zero emission vehicles

Municipalities can achieve emission reductions through changes to their fleet vehicles. A primary way to achieve this is to replace gasoline and diesel fleet vehicles with alternative-fuel vehicles such as hybrids or electric vehicles. Table 7 documents costs, benefits, externalities, and general inputs and assumptions typical of this type of measure. For benefits and costs, the corresponding perspective is identified along with potential sources. Current literature is cited where appropriate and indicates inputs with no available locally-specific data.

Table 7. Data Inputs for a Municipal Fleet Transition Measure

Measure - Switch out municipal fleet vehicles with zero emission vehicles		
Input	**Perspective**[1]	**Source(s)**
Costs		
Vehicle purchase plan development and adoption	A	*provided by jurisdiction staff
Program monitoring and reporting	A	*provided by jurisdiction staff
Incremental cost of zero emission vehicle over non-ZEV alternative	P	Kelley Blue Book. *specific to ZEV models considered in analysis and corresponding non-ZEV alternatives
Municipal electricity bill increase (due to charging, based on electricity rates)	P	CEC 2016
Benefits		
Value of avoided gasoline purchases	P	US EIA 2017a; US EIA 2017b
Externalities included		
Social cost of carbon	S	US EPA 2016
Value of avoided criteria pollutants	S	SANDAG 2015
Other inputs and assumptions		
Number of vehicles in municipal fleet		*provided by jurisdiction staff
Municipal fleet fuel consumption		*provided by jurisdiction staff
Criteria pollutant emissions		CARB. EMFAC2011 Web Database
Average useful life of municipal vehicle		City of San Diego 2011
Average miles per gallon of current fleet vehicles		CARB. EMFAC2007
Average ZEV miles per battery charge		Kelley Blue Book. *specific to ZEV models considered in analysis
Average ZEV kWh per battery charge		Kelley Blue Book. *specific to ZEV models considered in analysis

[1]A: Administrator, P: Participant, NP: Non-participant, S: Societal

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5.3.2 Example 7: Increase number of miles of bicycle lanes

Emission reductions in the transportation sector can also be achieved by encouraging commuters within the jurisdiction to reduce the number of miles they commute by passenger vehicle. Increasing the number of bicycle lanes provides commuters with an alternative mode of travel to and from work. Table 8 documents costs, benefits, externalities, and general inputs and assumptions typical of this type of measure. For benefits and costs, the corresponding perspective is identified along with potential sources. Current literature is cited where appropriate and indicates inputs with no available locally-specific data.

Table 8. Data Inputs for a Bicycle Lane Measure

Measure - Increase number of miles of bike lanes		
Input	**Perspective[1]**	**Source(s)**
Costs		
Bicycle master plan development and adoption	A	*provided by jurisdiction staff
Program monitoring and reporting	A	*provided by jurisdiction staff
Construction cost per mile (Class I lanes)	P	*provided by jurisdiction staff
Maintenance cost per mile (Class I lanes)	P	*provided by jurisdiction staff
Construction cost per mile (Class II lanes)	P	*provided by jurisdiction staff
Maintenance cost per mile (Class II lanes)	P	*provided by jurisdiction staff
Construction cost per mile (Class III lanes)	P	*provided by jurisdiction staff
Maintenance cost per mile (Class III lanes)	P	*provided by jurisdiction staff
Benefits		
Value of avoided gasoline purchases	P	US EIA 2017a; US EIA 2017b
Externalities included		
Social cost of carbon	S	US EPA 2016
Value of avoided criteria pollutants	S	SANDAG 2015
Other inputs and assumptions		
Average useful life of a bike lane		CARB 1995
Average commute distance avoided		*provided by jurisdiction staff
Average workdays a year		*provided by jurisdiction staff
Percentage increase in bike mode share per mile bike lane		Dill and Carr 2003
Size of labor force		SANDAG Series 13 forecast
Criteria pollutant emissions		CARB. EMFAC2011 Web Database
Average miles per gallon of current fleet vehicles		CARB. EMFAC2007

[1]A: Administrator, P: Participant, NP: Non-participant, S: Societal

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5.3.3 Example 8: Retime traffic signals

In addition to measures that target reducing vehicle miles traveled (VMT), CAPs can include measures that reduce the fuel consumption of vehicles on the road. By retiming traffic signals, the flow of traffic improves, reducing the fuel consumed by vehicles. Table 9 documents costs, benefits, externalities, and general inputs and assumptions typical of this type of measure. For benefits and costs, the corresponding perspective is identified along with potential sources. Current literature is cited where appropriate and indicates inputs with no available locally-specific data.

Table 9. Data Inputs for a Traffic Signal Retiming Measure

Measure - Retime traffic signals		
Input	**Perspective[1]**	**Source(s)**
Costs		
Traffic light master plan development and adoption	A	*provided by jurisdiction staff
Program monitoring and reporting	A	*provided by jurisdiction staff
Cost to retime a signal light (staff time)		*provided by jurisdiction staff
Benefits		
Value of avoided gasoline purchases	P	US EIA 2017; US EIA 2017
Externalities included		
Social cost of carbon	S	US EPA 2016
Value of avoided criteria pollutants	S	SANDAG 2015
Other inputs and assumptions		
Average useful life of retimed traffic signals		Tarnoff and Ordonez 2004
Fuel saved per intersection per day (gasoline)		City of San Diego 2014
Criteria pollutant emissions		CARB. EMFAC2011 Web Database

[1]A: Administrator, P: Participant, NP: Non-participant, S: Societal — Energy Policy Initiatives Center, USD 2018

5.3.4 Example 9: Install roundabouts

Installing roundabouts is another way to achieve emissions reductions through improved traffic flow and subsequent reductions in vehicle fuel consumption. Table 10 documents costs, benefits, externalities, and general inputs and assumptions typical of this type of measure. For benefits and costs, the corresponding perspective is identified along with potential sources. Current literature is cited where appropriate and indicates inputs with no available locally-specific data.

Table 10. Data Inputs for a Roundabouts Measure

Measure - Install roundabouts		
Input	**Perspective[1]**	**Source(s)**
Costs		
Roundabout design and planning	A	*provided by jurisdiction staff
Program monitoring and reporting	A	*provided by jurisdiction staff
Average roundabout installation cost	P	*provided by City staff
Benefits		
Value of avoided gasoline purchases	P	US EIA 2017; US EIA 2017
Externalities included		
Social cost of carbon	S	US EPA 2016
Value of avoided criteria pollutants	S	SANDAG 2015
Other inputs and assumptions		
Average useful life of a roundabout		US DoT FHA 2010
Fuel saved per intersection per day (gasoline)		Varhelyi 2002
Criteria pollutant emissions		CARB. EMFAC2011 Web Database

[1]A: Administrator, P: Participant, NP: Non-participant, S: Societal — Energy Policy Initiatives Center, USD 2018

5.4 Urban Forestry-Related Measures

The following section details specific inputs for urban forestry-related measures.

Urban forestry measures can also reduce air pollution within the jurisdiction. Several criteria pollutants have been identified (Table 11) and the avoided health effects associated with reduced criteria pollutants are included as externalities for these measures.

Table 11. Criteria Pollutant Externalities Included for Urban Forestry Measures

Criteria Pollutants Included (externalities)			
Description	**Value**	**Input**	**Source**
Urban Forestry Measure		**lbs/tree**	
O_3	*$1.04*	*Varies by tree age*	McPherson et al. 2000. Tree Guidelines for Coastal Southern California Communities; McPherson et al. 2006 Coastal Plain Community Tree Guide
NO_2	*$1.04*		
SO2	*$1.28*		
PM_{10}	*$0.76*		
VOC	*$1.48*		
BVOC	*$1.48*		

Energy Policy Initiatives Center, USD 2018

5.4.1 Example 10: Increase canopy cover of urban forest

Urban forestry measures typical of CAPs set goals for increases in tree canopy within the jurisdiction, reducing CO_2 through carbon sequestration. Table 12 documents costs, benefits, externalities, and general inputs and assumptions typical of this type of measure. For benefits and costs, the corresponding perspective is identified along with potential sources. Current literature is cited where appropriate and indicates inputs with no available locally-specific data.

Table 12. Data Inputs for an Urban Forest Measure

Measure - Increase percent cover of urban forest		
Input	**Perspective[1]**	**Source(s)**
Costs		
Urban forestry plan development and adoption	A	*provided by jurisdiction staff
Program monitoring and reporting	A	*provided by jurisdiction staff
Average purchase and planting cost per tree	P	*provided by jurisdiction staff
Average removal cost per tree	P	McPherson et al. 2005
Average annual maintenance cost per tree	P	*provided by jurisdiction staff
Average annual infrastructure damage cost per tree	P	McPherson et al. 2000
Average annual liability and legal cost per tree	P	McPherson et al. 2000
Municipal water bill increase (increased water consumption)	P	*provided by jurisdiction staff
Grants received (# of trees with purchase and planting costs offset annually)	P, NP	*provided by jurisdiction staff
Benefits		
NA		
Externalities included		
Social cost of carbon	S	US EPA 2016
Value of avoided criteria pollutants	S	McPherson et al. 2006
Rain interception benefits per gallon	S	McPherson et al. 2000
Other inputs and assumptions		
Average useful life of a tree		
Baseline forest cover (2010)		Jurisdiction Urban Forestry Plan
Estimated number trees per acre for 100% cover		USDA Forest Service 2010
Tree mortality rate		McPherson et al. 2011
Total acres in City included in analysis		*provided by jurisdiction staff
Criteria pollutant reductions per tree		McPherson et al. 2000
Water demand per tree (first 3 years only)		Jurisdiction Urban Forestry Plan
Rainfall interception per tree		McPherson et al. 2000

[1]A: Administrator, P: Participant, NP: Non-participant, S: Societal

Energy Policy Initiatives Center, USD 2018

6 PRESENTING THE RESULTS

Results of a CAP BCA are divided into three sections:

- Cost-effectiveness of CAP measures;
- Impact on CAP measure participants; and
- Summary of results for individual measures.

The first two sections answer the primary questions of a CAP BCA and the third provides a detailed summary of results specific to individual measures for further analysis by decision-makers. This section details the variety of ways in which results for each section can be visualized.

6.1 Cost-Effectiveness of CAP Measures

Four primary visualization tools have been identified that describe the cost-effectiveness results of CAP measures:

- Tables
- Scatterplots
- Paired bar graphs
- Marginal abatement cost curves

6.1.1 Tables

Tables provide $/MT CO_2e results by perspective for each measure in the CAP to achieve GHG reductions in the target year (Table 13). In addition, they summarize the total $/MT CO_2e for the entire CAP (Table 13, bottom row).

Table 13. CAP Measures Summary Results Example Table

2020 Target Year - $/MT CO_2e

CAP Measure	Administrator	Participant	Non-Participant	Measure	Society	GHGs Reduced in 2020 (MT CO_2e)
Measure 1	($2)	($200)	($150)	($352)	($336)	3,000
Measure 2	($10)	$300	($110)	$180	$196	1,500
Measure 3	($0.3)	$100	($75)	$25	$41	7,500
Measure 4	($2)	($150)	-	($152)	($136)	2,000
Measure 5	($0.2)	($50)	-	($50.20)	($34)	150,000
Measure 6	($1)	$150	($50)	$99	$115	35,000
Measure 7	($4.0)	$125	($88)	$29	$59	2,000
Measure 8	($5)	($50)	-	($55)	($39)	15,000
Measure 9	($0.7)	$25	-	$24	$40	120,000
Measure 10	($2)	$75	-	$73	$89	65,500
Total	**($0.97)**	**$14**	**($8)**	**$5**	**$21**	**401,500**

*All dollar values are in 2010$

Energy Policy Initiatives Center, USD 2018

6.1.2 Scatterplots

Scatterplots present results for a single perspective and illustrate the relationship between a measure's $/MT CO_2e and corresponding GHG reductions (MT CO_2e) in the target year; it is important to consider both the cost-effectiveness and GHG reduction potential of each measure when comparing them. While this type of figure only illustrates a single BCA metric for each measure ($/MT CO_2e),[9] it readily shows the reader those measures that are the most cost-effective as well as those that are the least. Each point on a scatterplot represents an individual measure and is found by plotting the GHGs reduced by that measure along the x-axis versus the dollar per MT for that measure along the y-axis (Figure 15 and Figure 16). The higher a measure is on the plot, the more cost effective it is (e.g., Measure 2, Figure 16); the lower a point is, the less cost effective it is (e.g., Measure 1, Figure 16). Similarly, measures further to the right on the plot reduce more GHGs than measures to the left (e.g., Measure 5 versus Measure 4, Figure 16). A drawback of a scatterplot is its inability to clearly show multiple perspectives in one figure.

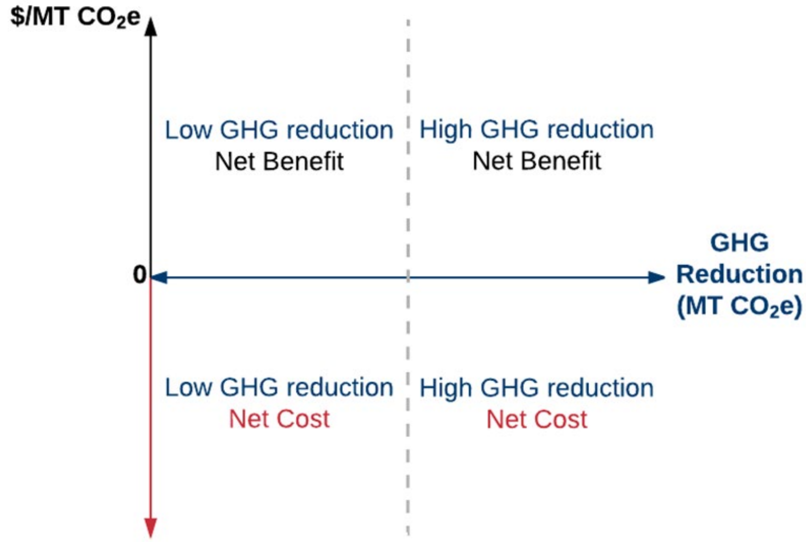

Figure 15. Interpreting Results of a Scatterplot

[9] Dollar per metric ton is a standardized metric that allows for comparison across measures on a per ton basis.

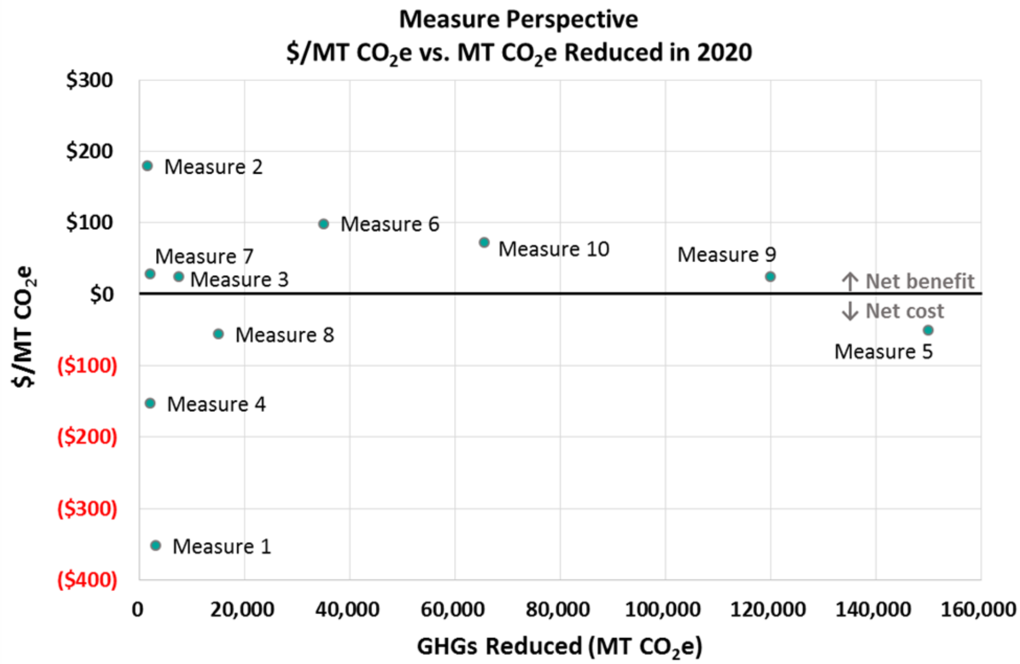

Figure 16. Illustrative Scatterplot Example

6.1.3 Paired Bar Graphs

Similar to a scatterplot, paired bar graphs make it easier to see how measures relate to each other with regard to GHG reductions and overall benefit or cost; GHGs reduced are shown in the bottom bar graph and dollar per MT CO_2e reduced is included in the top bar graph (Figure 17). Unlike a scatterplot, a bar graph can show more than one perspective at a time, making it possible to analyze multiple components at once.

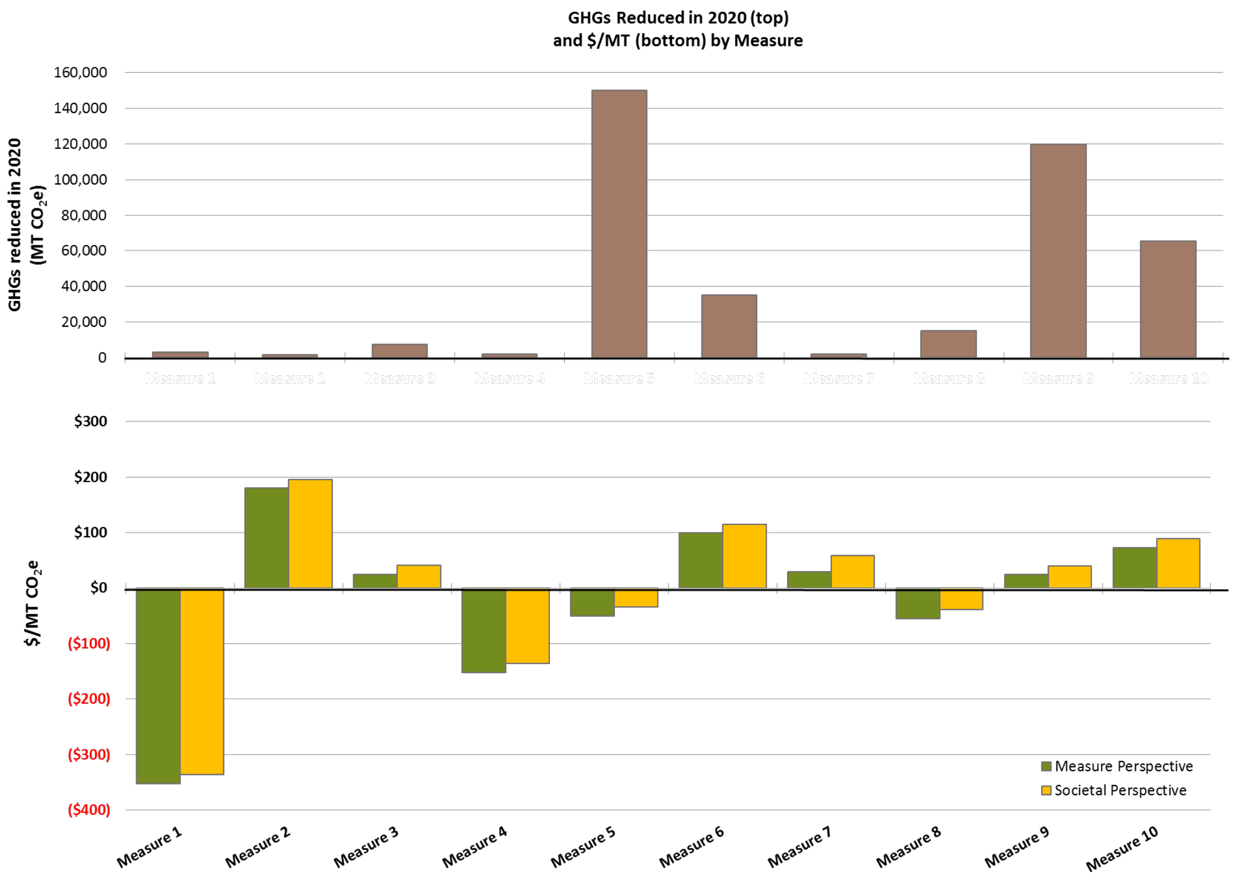

Figure 17. Illustrative Paired Bar Graph Example

6.1.4 Marginal Abatement Cost Curves

A marginal abatement cost curve (MACC) is another way to express how measures relate to each with respect to the dollar per MT and GHGs reduced (Figure 18; Creyts et al. 2007). A MACC is structured like a scatterplot—the y-axis is the $/MT CO_2e and the x-axis is the GHGs reduced. However, there are some noticeable differences. Here, measures or policy options are indicated by a bar rather than a point, and traditional MACCs generally express the $/MT in terms of cost; this means that a positive value represents a cost and a negative value represents a benefit. Additionally, the x-axis is expressed as cumulative GHGs reduced, where the width of a bar represents the potential GHGs reduced by that measure and measures (bars) are ordered from the most cost-effective to the least cost-effective (highest benefit to highest cost).

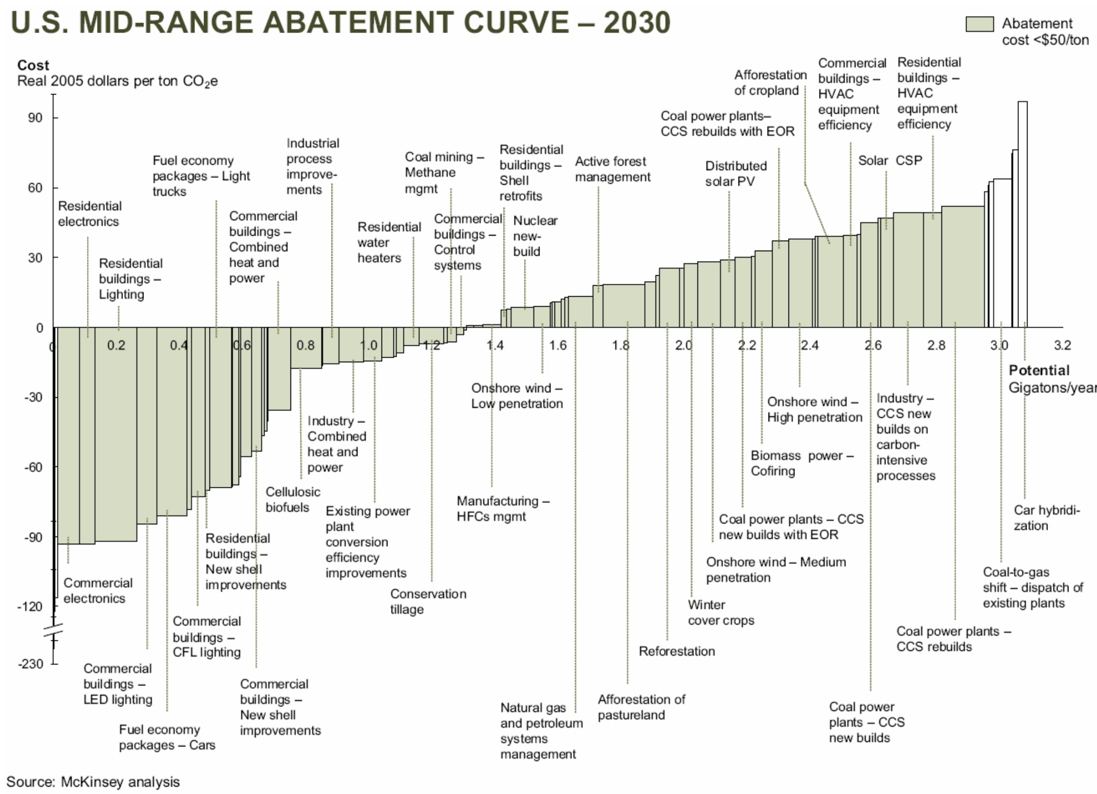

Figure 18. Marginal Abatement Cost Curve Example (McKinsey Curve)

A drawback to using a MACC is that measures with comparatively low GHG reductions to other measures in a CAP can be hard to identify; the width of the bar would be flattened on a scale necessary to accommodate measures with large GHG reductions (Figure 19).

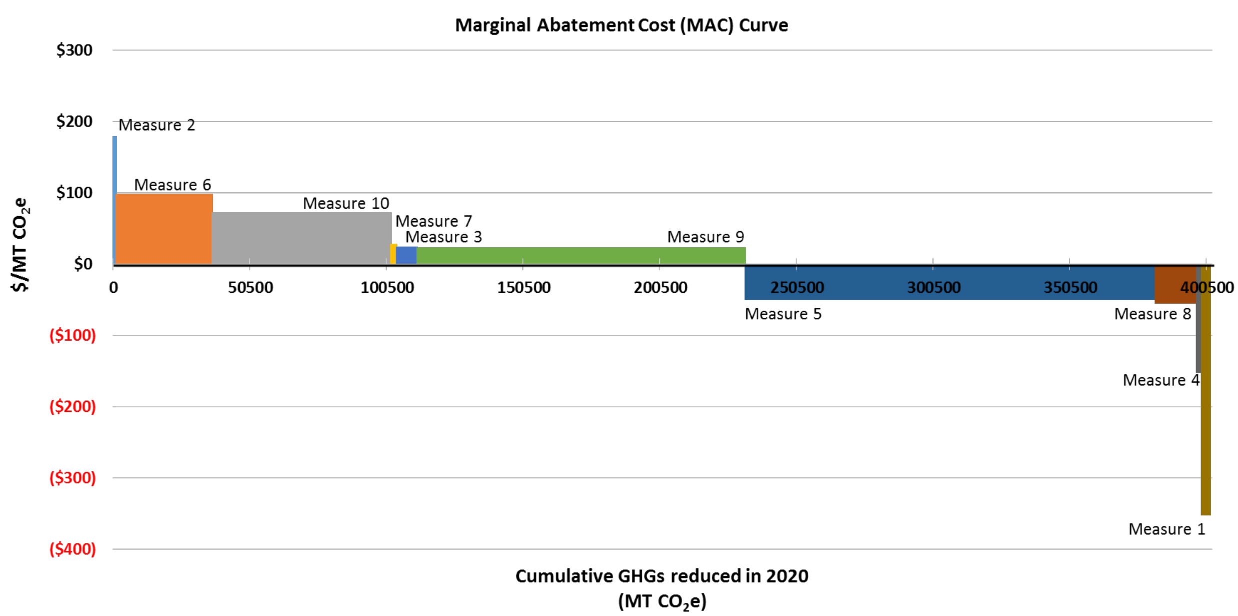

Figure 19. Illustrative Example of Marginal Abatement Cost Curve Drawback

6.2 Impact of CAP Measures on Participants

BCA results that show the impact of CAP measures on participants can be included in a summary table (Table 14). In addition to these BCA results, the Participant $/MT CO_2e and GHGs reduced for each measure can be included for added context. As a reminder, some measures might not have results available for all BCA metrics (see Section 3).

Table 14. Individual Measure Results – Example Table

2020 Target Year - Participant BCA Metrics

CAP Measure	BCR	Discounted Payback Period (yrs)	ROI	IRR	GHGs Reduced in 2020 (MT CO_2e)	$/MT CO_2e (Participant)
Measure 1	0.65	-	-	-	3,000	($200)
Measure 2	6.54	5	322%	28%	1,500	$300
Measure 3	2.34	13	102%	10%	7,500	$100
Measure 4	0.09	-	-	-	2,000	($150)
Measure 5	-	-	-	-	150,000	($50)
Measure 6	1.00	1	246%	18%	35,000	$150
Measure 7		6	356%	30%	2,000	$125
Measure 8	0.89	-	-	-	15,000	($50)
Measure 9	1.07	3	78%	7%	120,000	$25
Measure 10	1.36	16	115%	15%	65,500	$75

*All dollar values are in 2010$ Energy Policy Initiatives Center, USD 2018

6.3 Summary Results by Measure

Summary tables for individual measures provide a complete set of results for a particular measure in a CAP (Table 15). These tables allow for a more comprehensive look at the overall impact of CAP measures as it relates to cost-effectiveness and financial impacts on various stakeholder groups.

Table 15. Individual Measure Results Example Table

Illustrative Solar PV Measure – 2020 Target Year

	Administrator	Participant	Non-Participant	Measure	Society
Present Value Benefits	-	$1,250,000	-	$1,250,000	$1,300,000
Present Value Costs	($8,000)	($1,000,000)	($175,000)	$1,183,000	$1,183,000
Net Present Value	($8,000)	$250,000	($175,000)	$58,244	$117,000
GHGs (MT CO_2e)			**2,000**		
$/MT CO_2e	($4)	$125	($88)	$29	$59
BCR	-	1.25	-	1.06	1.10
Discounted Payback Period	-	7.62	-	10.80	8.90
ROI	-	130%	-	105%	114%
IRR	-	12%	-	6%	9%

*All dollar values are in 2010$ Energy Policy Initiatives Center, USD 2018

Summary tables for individual measures also show sensitivity analysis results. The example in Table 16 illustrates how cost-effectiveness of a measure changes in response to varying the discount rate. Similar tables can be developed to show results for other metrics and for other types of sensitivity analyses (see Section 4.11).

Table 16. Individual Measure Sensitivity Analysis Results Example Table

Illustrative Solar PV Measure – 2020 Target Year

Discount Rate	Administrator	Participant	Non-Participant	Measure	Society
3%	($6)	$160	($120)	$34	$45
5%	($4)	$125	($100)	$21	$30
7%	($3)	$100	($90)	$7	$15

*All dollar values are in 2010$ Energy Policy Initiatives Center, USD 2018

7 LIMITATIONS

There are inherent limitations with any BCA resulting in a degree of uncertainty that should be taken into account. The following limitations should be considered.

7.1 Data Availability and Case Studies

When considering the benefit and cost impacts of a particular CAP measure, the following limitations apply.

7.1.1 Data Availability

Estimates for current and future costs and benefits are limited to the data presently available. For some measures, such as a solar PV measure, extensive datasets exist with historic costs associated with installation and operation that can be applied at a local level. However, not all measures have readily available data to apply to BCA calculations. For instance, commercial zero net energy (ZNE) construction projects are relatively new in the marketplace and the costs can vary widely depending on the type of commercial project. Case studies reported in the literature are applied in analyses where necessary, as they are representative of the best available data; however, they may not be entirely reflective of current and/or future conditions.

Additionally, costs and benefits associated with CAP measures are subject to changes in future conditions, such as:

- Population growth and demands;
- Technological advancements and available technology;
- Energy/fuel availability;
- Residential and commercial development stock; and
- Trends in consumer demands and producer supply.

7.1.2 Monetizing Externalities

Methods described here emphasize the inclusion of as many externalities as possible within the geographic scope of the jurisdiction. However, not all externalities can be readily monetized, and their lack of inclusion in the quantitative assessment can skew results by reducing the potential benefits and/or costs experienced under the Societal perspective. For example, little is known about how increasing the number of bicycle lanes will affect the number of bicycle-auto accidents and how that translates to a medical cost or savings.

As better data becomes available, more externalities can be included in CAP BCAs. For those not included in the quantitative analysis, a qualitative assessment can be included in the report to acknowledge they exist.

7.1.3 Developing Ranges

Current BCA results are calculated using average cost and benefit values (most likely estimates); however, an array of possibilities can exist for Participants. For instance, the purchase price of a solar PV system will not be the same for each homeowner, but will generally fall within a range of costs. Ideally, high and low estimates would be developed to identify the range in impacts to Participants (Figure 20). However, many inputs currently lack sufficient data to determine suitable ranges. Developing high and low estimates using only select variables can create inconsistencies in results across measures and would misrepresent the true high and/or low estimate impact. As better and more complete data sets become available, the development of ranges can be further explored.

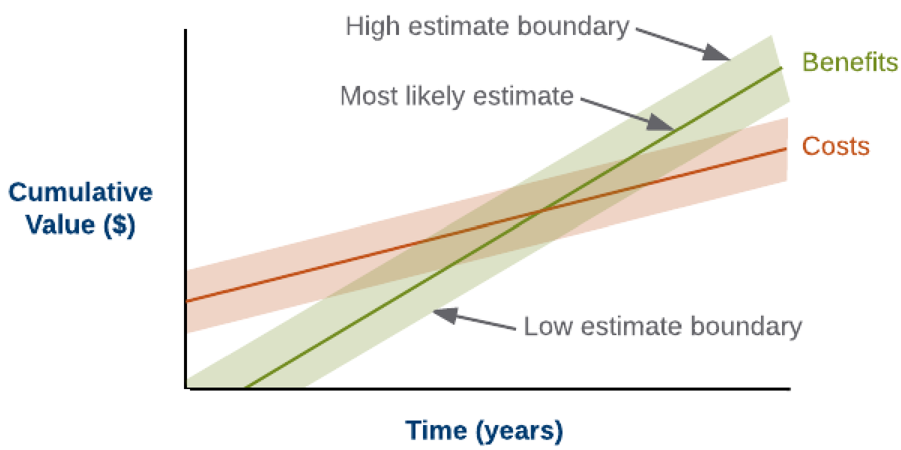

Figure 20. Conceptual Diagram of Benefit and Cost Ranges

7.2 Scope of Impacts

The approach detailed in this document considers only those benefits and costs anticipated to be experienced within the jurisdiction. There are other benefits and costs that can accrue outside of the jurisdiction as a result of implementing a CAP. For instance, the production and disposal of materials (e.g., solar PV panels and hybrid vehicle batteries) can have a suite of costs and benefits associated with them. This can include:

- Financial gain by manufacturers
- Increase in sector jobs
- Pollution externalities from hazardous waste disposal at end of useful life
- Reduction in pollution caused by traditional energy production (e.g., coal)

While the methods described in this document can be applied to benefits and costs, the time and resources needed to consider benefits and costs outside of the jurisdiction can be extensive and are often prohibitive.

7.3 Timeframe Analyzed

The timeframe used in a CAP BCA can impact the analyses results. The timeframe includes the use of past historic activity and the selection of a future target year.

7.3.1 Application of Historic Data

BCA calculations incorporate historic data where applicable to account for past activity that leads to GHG reductions included in the CAP to achieve emission reduction targets. For example, if a CAP has a baseline year of 2010, all related GHG reduction activity between 2010 and the CAP's target year(s) would be considered to calculate the $/MT CO_2e for their respective measures. It is important to note that historic activity would have occurred prior to CAP adoption and is thus not an impact on the jurisdiction or its residents and businesses as a direct result of the CAP. Past activity incorporated into an analysis can under or overestimate the impact of post-CAP adoption activity as prices, rebates, and other variables change over time.

7.3.2 Target Year Selection

Any analysis that involves future projections has some level of uncertainty, which typically increases the further out into the future the projection goes (Figure 21). To reduce uncertainty associated with projections made further out, the BCA is restricted to a near-term target year (e.g., 2020 instead of 2035). As an example, a solar PV system measure has a useful life of 25 years. Using a target year of 2020, future projections extend to 2045 to capture the benefits and costs of that measure. If 2035 is selected as the target year for the BCA analysis, projections would need to extend to 2060. For measures with even longer useful lives, this would require extending projections even further into the future, significantly increasing the uncertainty associated with the results.

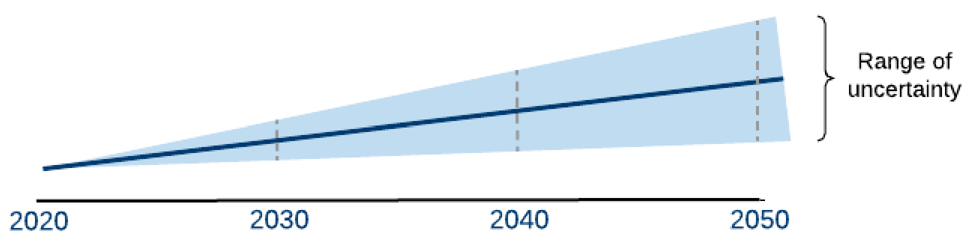

Figure 21 Illustrative Example of Increasing Uncertainty with Future Projections

7.4 Greenhouse Gas Reduction Methodologies

The cost-effectiveness of CAP measures ($/MT CO_2e) pairs benefit and cost data with GHG reductions. How reductions are calculated in the CAP for inter-related measures[10] will impact the GHG reductions attributed to each measure and, consequently, the cost-effectiveness ($/MT CO_2e) for each measure. If GHG reduction estimates are lowered for a measure, the benefit or cost per metric ton will be magnified; if increased, the benefit or cost per metric ton will be reduced (Table 17).

[10] E.g., one measure reduces electricity consumption (energy efficiency retrofit) and a second reduces the emissions factor (install solar PV). For further discussion on how estimated GHG reductions can vary see Section 5.4 in Technical Appendix 2 – Greenhouse Gas Reduction Calculation Methods for CAP Measures.

Table 17. Effects of GHG Calculations

Effects of GHG Calculations		
Net Benefit		
Net present value	$1,000	$1,000
GHGs reduced (MT CO_2 e)	50	75
$/MT CO_2 e	$20	$13
Net Benefit		
Net present value	($1,000)	($1,000)
GHGs reduced (MT CO_2 e)	50	75
$/MT CO_2 e	($20)	($13)

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While methods for GHG reduction calculations would be consistent for an individual CAP, they may not be consistent across CAPs. This discrepancy can give varying results when comparing CAPs with similar measures.

7.5 Comparing BCA Results for Multiple CAPs

BCA results for one CAP are not necessarily comparable to results of another. Dissimilarities arise when two or more CAP BCAs have different baseline years (for discounting purposes) and use different base years for normalization.

Different baseline years can create two disparities; it changes the amount of discounting that occurs by the target year and can result in the inclusion of more or less historic data. The amount of discounting that occurs can influence the present value of a dollar in a particular year; CAP activity analyzed in 2020 will be discounted back ten years with a baseline year of 2010, but only five years if the baseline year is 2015. Also, since trends in pricing can change over time, the application of more historic data in one CAP relative to another can inherently favor or disfavor one CAP measure over the same measure in the other CAP (see section 7.3.1 for more discussion on historic data limitations).

In addition, the year at which dollar values are normalized within a CAP BCA can distort the relationship between a result in one CAP and a relevant measure in another; two CAP BCAs could be calculated with the same data, but if normalized to different years, one would appear more or less favorable than the other. Table 18 illustrates how the value of $100 in 2015 dollars can changed when normalized to different years using the CPI.

Table 18. Effects of Normalization

Effects of Normalization	
Dollar value	$100
Reported year of value	2015
When normalized:	
Normalized to 2010	$92
Normalized to 2015	$100
Normalized to 2017	$103

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8 CONCLUSION

This Appendix 3 to ReCAP discussed:

- The purpose of benefit-cost analyses for CAP measures and how they can be integrated into the climate action planning cycle;
- Key terminology, concepts, and metrics used in a CAP BCA;
- Methods to analyze the benefits and costs of CAP measures;
- Data needs and assumptions for common CAP measures;
- Presenting results for a CAP BCA; and
- Limitations associated with a BCA for CAP measures.

This document is for community-wide climate action planning under ReCAP only and may be updated to include new data collection and calculation methods in the future.

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