Greenhouse Gas Reduction Calculation Methods for Climate Action Plan Measures

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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 2 to the SANDAG ReCAP: Regional Framework for Climate Action Planning. The document is separated into the following sections:

- Section 2 provides an overview of California's (State) policy approach to reduce greenhouse gas (GHG) emissions and the role of local Climate Action Plans (CAPs) in meeting the statewide GHG reduction target.
- Section 3 discusses the role of estimating GHG emissions reductions in the climate action planning cycle shown in Figure 1 below. Estimating GHG reduction potential of CAP measures is an essential part of the CAP development process, CAP monitoring and updates, and determining cost-effectiveness of CAP measures.
- Section 4 discusses the considerations and the process to select GHG reduction measures for CAPs.
- Section 5 provides an overview for estimating GHG reductions for CAP measures and methodology to estimate GHG reductions for typical CAP measures.
- Section 6 shows ways to present and visualize the GHG reduction results in a CAP.
- Section 7 discusses emerging issues related to estimating GHG reductions.

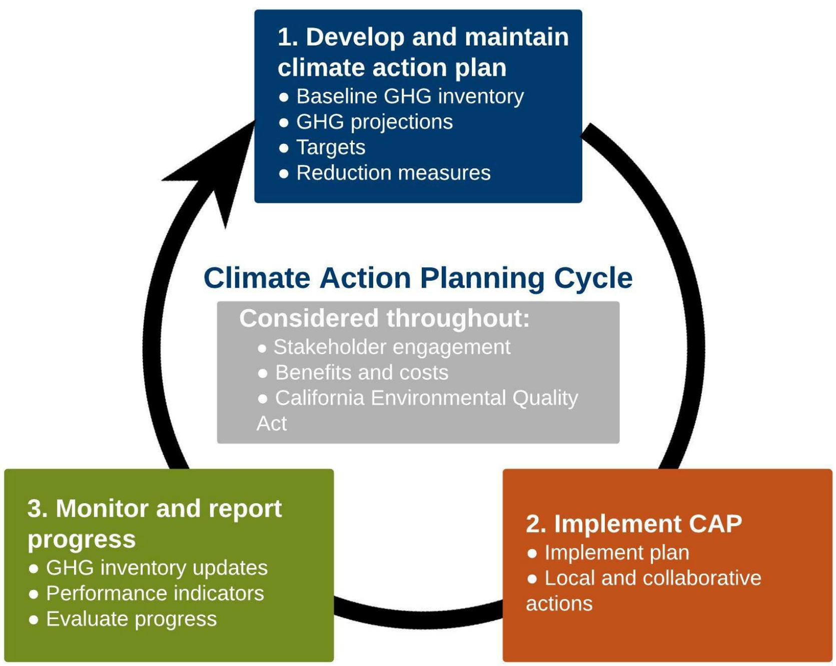


Figure 1 Conceptual Diagram of the Climate Action Planning Process

2 California's Approach to GHG Reduction and Relationship to CAP Measures

The main legislative and executive actions related to GHG emissions reduction targets in California are the following:

- AB 32 (2006): Reduce statewide GHG emissions to 1990 levels by 2020;
- SB 32 (2016): Reduce statewide GHG emissions to 40 percent below 1990 levels by 2030; and

- Executive Order S-3-05: Reduce statewide GHG emissions to 80 percent below 1990 levels by 2050.

Understanding the sources of emissions is critical to developing strategies to reduce emissions. Figure 2 summarizes the sources of statewide GHG emissions in California by sector of the economy. The transportation sector contributes the most followed by industrial emissions (which includes industrial natural gas consumption), and then electricity generation. The residential and commercial sector emissions come mostly from natural gas consumption. Emissions from on-road vehicles, electricity, and natural gas end-use consumption represent the majority of emissions in California.

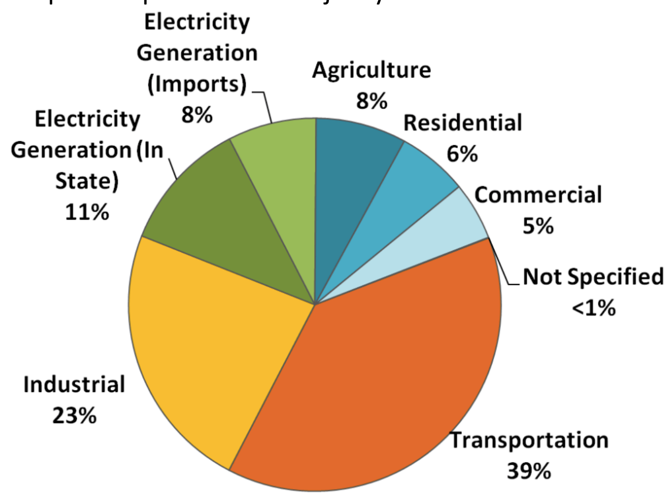


Figure 2 2015 California Statewide GHG Emissions by Sector of the Economy (CARB, 2017a)

Local community-wide inventories similarly help to inform local GHG reduction strategies. Local community-wide inventories typically estimate emissions from five main categories: transportation, electricity, natural gas, solid waste, and water/wastewater. Figure 3 compares three inventories of different geographic scales in the San Diego region (a large city, a small city, and the entire San Diego region).[1] While differences exist, the general distribution of emissions is similar to that of the State's, with transportation, electricity, and natural gas accounting for the majority of emissions.

[1] In this document, a small city in the context of the San Diego region refers to a city with population less than 50,000 and a large city refers to a city with population larger than 200,000.

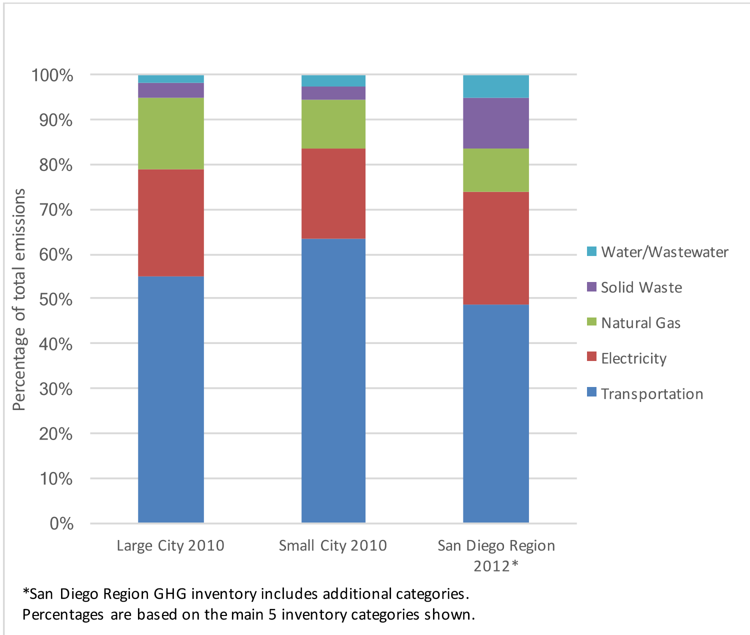


Figure 3 Typical Distribution of Emissions Categories Across Geographic Scale

2.1 CARB Scoping Plan

California's *2017 Climate Change Scoping Plan* (2017 Scoping Plan) includes a suite of measures to reduce statewide GHG emissions to the adopted target by 2030 (Figure 4). The Plan focus significantly on transportation fuels, electricity, and natural gas, including measures to improve energy efficiency, reduce vehicle miles traveled (VMT), and reduce the GHG intensity of the fuels through increased renewable energy and a shift to ZEVs. In addition, California Air Resources Board (CARB) includes reductions expected from the Cap-and-Trade Program. These State reduction strategies will help reduce emissions locally and should be reflected as statewide reduction measures in local CAPs. However, not all strategies included in the 2017 Scoping Plan would yield reductions in local CAP (e.g. Cap-and-Trade program).

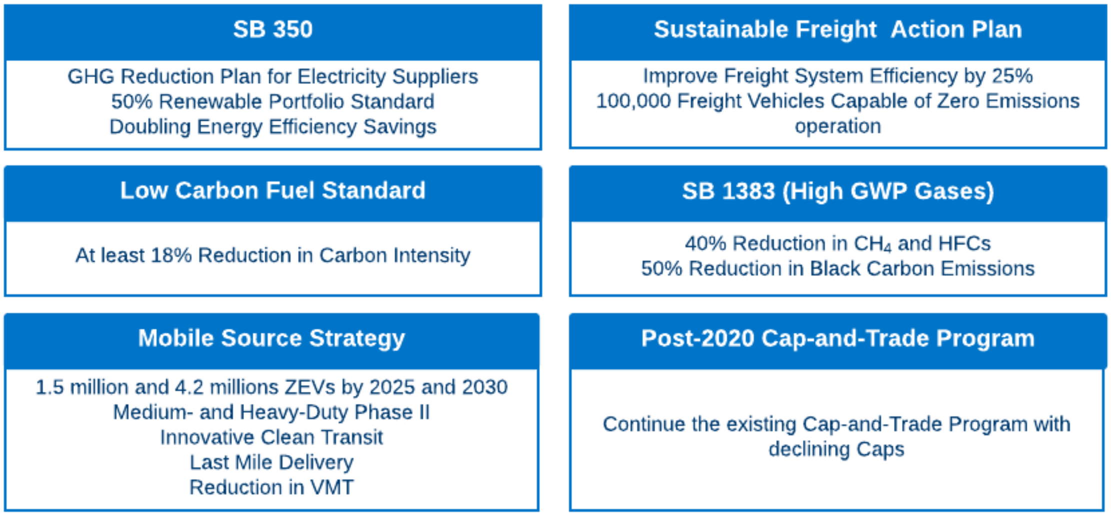


Figure 4 GHG Reduction Strategies in CARB 2017 Scoping Plan (CARB, 2017b)

2.2 Role of Local CAP Measures in Contributing to Statewide Targets

In the 2017 Scoping Plan, CARB recognizes the important role local governments can play in contributing to achievement of statewide targets:

> Local governments can implement GHG emissions reduction strategies to address local conditions and issues and can effectively engage citizens at the local level. Local governments also have broad jurisdiction, and sometimes unique authorities, through their community-scale planning and permitting processes, discretionary actions, local codes and ordinances, outreach and education efforts, and municipal operations…These local actions complement statewide measures and are critical to supporting the State's efforts to reduce emissions. Local efforts can deliver substantial additional GHG and criteria emissions reductions beyond what State policy can alone, and these efforts will sometimes be more cost-effective and provide more co-benefits than relying exclusively on top-down statewide regulations to achieve the State's climate stabilization goals. (CARB 2017b, p.97)

While local measures support state policies to reduce GHG emissions, they are tailored to meet local needs and circumstances.

2.3 Overall Approach to Reduce GHG Emissions

In general, the method for reducing GHG emissions is to reduce fossil fuel combustion because most GHG emissions (primarily CO_2) are associated with fossil fuels. GHG emissions can be decreased by reducing activity levels of the major emitting activities, such as shifting VMT to alternative modes of transportation, or making electricity and natural gas use more efficient. Ideally, once activity levels are reduced, the focus is on decarbonizing the system, or reducing the carbon intensity of the system. For example, reducing the carbon content of electricity can reduce emissions in other sectors as a result of electrifying transportation and converting natural gas to electricity. Figure 5 illustrates this approach.

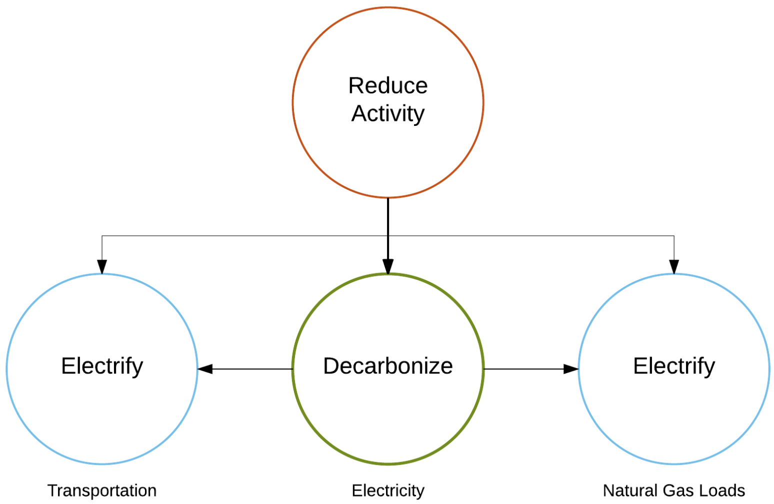


Figure 5 Conceptual Diagram of Overall GHG Reduction Strategy

This overall concept of GHG reduction approaches forms the basis for categorizing and organizing CAP GHG reduction measures. Most measures either reduce activity levels or the emission factor (GHG intensity) of those activities. The following sections illustrate these approaches as applied to each category of emissions in a CAP and form the organizing structure of this Appendix.

2.3.1 Strategies to Reduce Transportation Emissions

The basic strategies to reduce activity and/or reduce GHG intensity are as follows in the transportation sector:

- Reduce Fuel Use – Reduce fuel use through efficiency or conservation. This can be accomplished through vehicle emissions standards that result in higher fuel efficiency as well as from local traffic calming measures that reduce the amount of fuel needed.
- Reduce VMT – Reduce the emissions-causing activity, in this case VMT. This can be accomplished by shifting a portion of the miles driven by passenger vehicles to alternative modes of transportation, including transit, biking, and walking, or from land-use changes.
- Increase Use of Cleaner Fuels – For the miles that cannot be shifted to alternative modes, decrease the carbon content of those fuels by using lower emission alternatives, including electricity.

2.3.2 Strategies to Reduce Building Energy Emissions

A similar approach can be applied to building energy :

- Reduce Energy Use – Reduce electricity and natural gas use through efficiency or conservation. This is typically done through building and appliance efficiency standards and local measures and actions to encourage building owners and occupants to conserve energy.
- Increase Use of Renewable Energy – The carbon content of electricity can be reduced through policies promoting alternative sources of generation and converting to renewable sources of natural gas. California is reducing the carbon content of electricity through its Renewables Portfolio Standard and increased local renewable distributed energy, such as behind-the-meter photovoltaic (PV) systems.

This overall approach is in line with the "loading order" adopted in the California Energy Commission (CEC) and California Public Utilities Commission (CPUC)'s Energy Action Plan. The "loading order" prioritizes investments in energy efficiency and demand responses, then in renewable energy and distributed generation, and, last, in fossil fuel sources and infrastructure improvements (CEC, 2005).

2.3.3 CAP Transportation Measures that Support Statewide GHG Reduction

Using the basic strategies to reduce emissions from the transportation category as described in Section 2.3.1, Figure 6 illustrates how local CAP measures support federal and State regulations to reduce emissions. To help reduce VMT, the State adopted SB 375, which directs metropolitan planning organizations (MPOs) to develop Sustainable Communities Strategies to reduce emissions from passenger vehicles related to land use. The state adopted SB 743 to update the CEQA guidelines to address VMT. Local jurisdictions can develop additional CAP measures, such as modifying parking requirements that would support the objectives of SB 375, or those that encourage alternative modes of transportation to support CEQA streamlining for city projects.

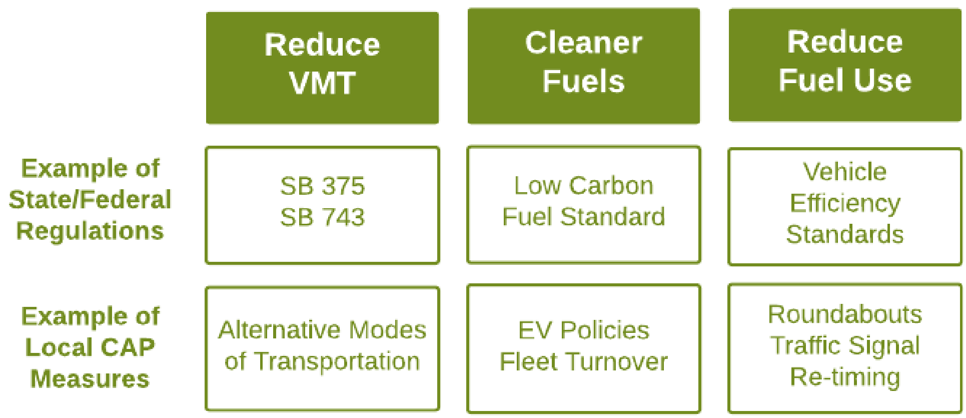


Figure 6 Examples of Local Transportation Measures that Support Federal and State Regulations

2.3.4 CAP Building Energy Measures that Support Statewide GHG Reduction

Similar to the transportation measures, building energy measures within a CAP can support statewide regulations . Figure 7 provides examples of how local CAP measures help achieve the State goals, such as reach codes that require new buildings to be more efficient than under State law and programs through local financing methods such as property-assessed clean energy (PACE) financing.

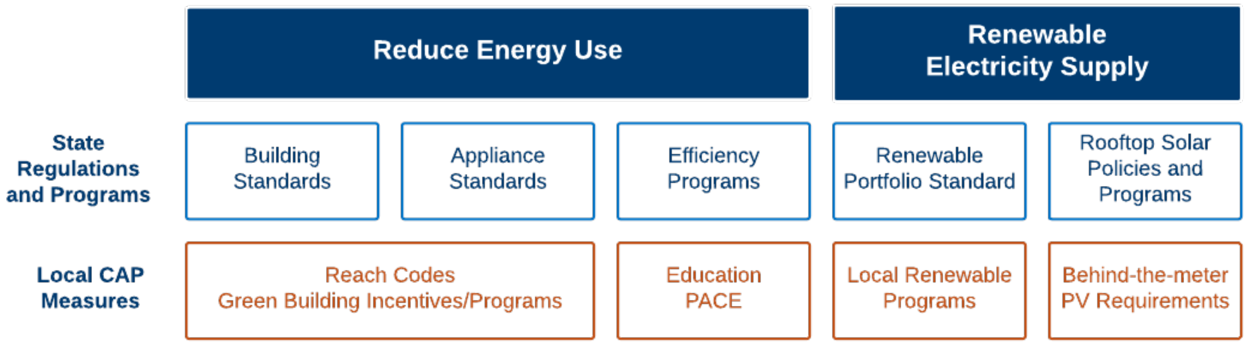


Figure 7 Examples of Local Building Energy Measures that Support Federal and State Regulations

3 Purpose and Role of GHG Reduction Analysis in the Climate Action Planning Cycle

Estimating the GHG reduction potential of CAP measures is an integral part of the climate action planning cycle, including:

- developing and maintaining CAPs;
- monitoring and reporting progress;
- other aspects of climate action planning, such as benefit-cost analysis.

Figure 8 illustrates the overall climate action planning cycle. Section 3.1 to Section 3.3 indicate where estimating GHG reductions plays a role.

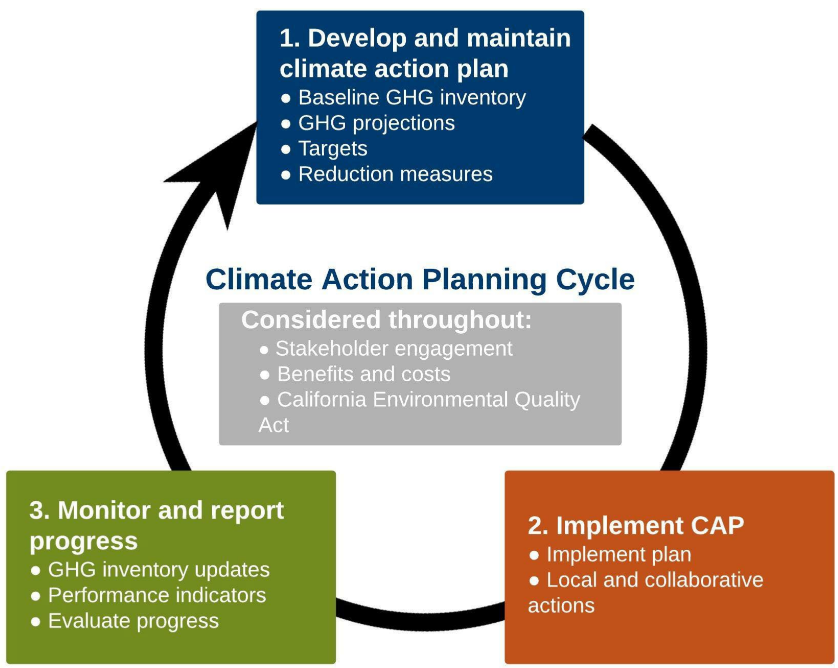


Figure 8 Conceptual Diagram of the Climate Action Planning Process

3.1 Develop and Maintain CAPs

GHG reduction estimates for measures form the main part of a CAP. Once a baseline emissions level is determined, an emissions projection is developed, and reduction targets have been established, the

GHG reduction measures demonstrate how emissions will be reduced to meet the target levels. Figure 9 conceptually illustrates the role of GHG reduction in helping a jurisdiction achieve adopted targets.

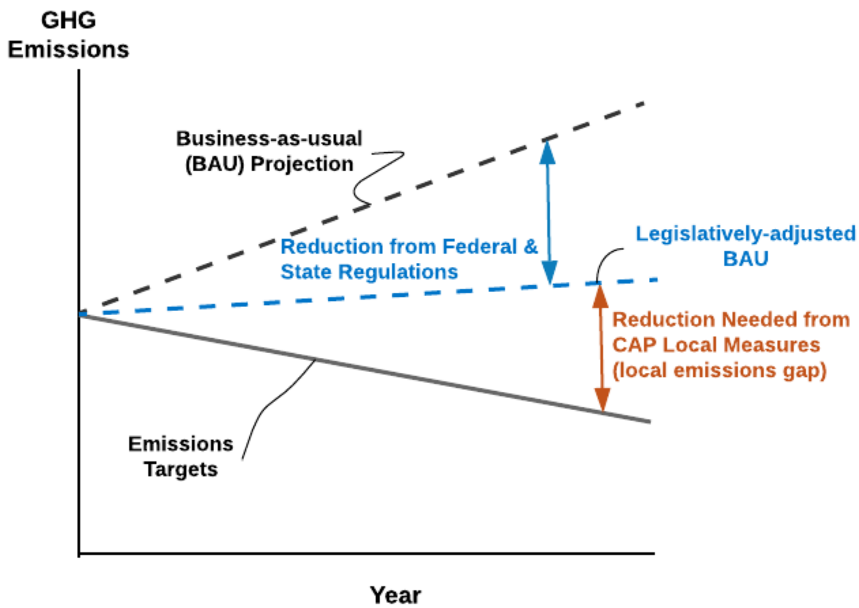


Figure 9 Role of GHG Reduction in Climate Action Plan Development Process

There are two broad categories of GHG reduction measures: those resulting from federal and State regulations, and those from local CAP measures.

Federal and State regulations that reduce GHG emissions affect baseline and projected emissions in local jurisdictions. CAPs typically account for the impact of these regulations to determine how much additional GHG reduction is needed from local CAP measures—often called the local emissions gap (Figure 9)—in order to reach the target. The projected emissions level after reduction from federal and State regulations beyond the baseline year is sometimes called the "legislatively-adjusted business-as-usual (BAU)."

Examples of federal and State regulations accounted for in CAPs include the federal Corporate Average Fuel Economy (CAFE) standards, which regulate vehicle fuel economy and tailpipe emissions from on-road vehicles; California's Renewables Portfolio standard (RPS), which sets requirements for the amount of renewable energy in electricity supplied; and the CARB Advanced Clean Cars program, which seeks to reduce tailpipe emissions from light- and medium-duty vehicles in the same way as the federal standards but also to increase the number of zero emission vehicles (ZEVs), such as battery electric vehicles and fuel cell vehicles. GHG reduction from existing federal or State regulations may change if the federal or State government takes action to re-evaluate and revise existing regulations.

GHG reductions from federal and State regulations can be significant, but after a BAU projection takes into account the effect of federal and State regulations (i.e., is adjusted for the GHG reduction impacts of existing federal and State legislative measures), then only local measures are available to meet emissions targets.

Once federal and State regulations are taken into consideration, a local jurisdiction must identify actions within its authority to reduce emissions to meet targets. Local CAP measures represent a jurisdiction's commitment to reduce emissions.

Local jurisdictions may periodically update the CAP. This would include activities that are similar to those undertaken to develop the original CAP and could include: updating the GHG inventory and emissions projection to reflect updated data, re-evaluating GHG reduction targets to reflect any updated guidance from CARB and/or other relevant legislation and estimating the GHG reduction potential from additional measures to help reach overall reduction targets.

3.2 Monitor and Report Progress

Part of the SANDAG ReCAP is the development of a CAP monitoring and reporting structure to be considered by local jurisdictions in the San Diego region. The structure considers monitoring in levels of increasing detail. It starts with an overall GHG inventory to determine progress toward adopted GHG targets. It then assesses emissions by category to determine whether any further insights can be drawn about where and why emissions have changed, evaluates specific GHG reduction measures, including any performance targets and progress indicators, and determines whether the supporting, often non-quantifiable, activities included in the CAP were completed. This comprehensive structure allows for a high-level evaluation of overall targets and sufficient detail to evaluate measures and actions to help determine what activities are working well and what changes might be needed to improve others.

Figure 10 summarizes the monitoring framework and the role of GHG reduction estimates in the monitoring process.

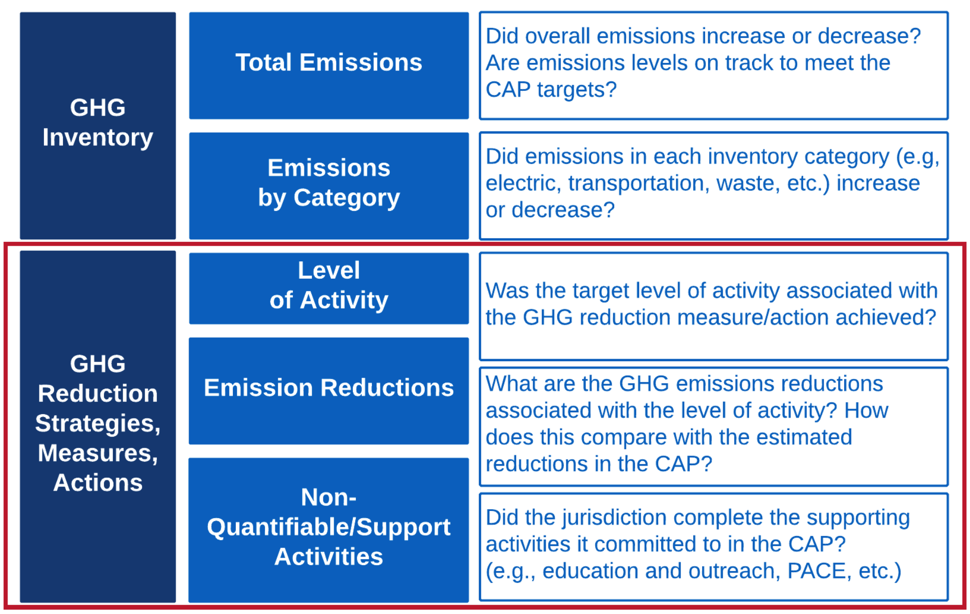


Figure 10 Climate Action Plan Monitoring Framework

If emissions are not decreasing sufficiently to reach adopted targets or if particular measures are not leading to expected reductions, it might be necessary to remove or modify ineffective measures and to identify additional CAP measures.

Another aspect of assessing the GHG reduction potential of CAP measures is to track federal and State regulations to understand their contribution to overall GHG emissions levels. If, for example, federal and State regulations change and do not lead to expected projected emissions reductions, the local gap will become larger and additional local emissions reductions measures will be needed to meet the targets.

3.3 Other Aspects of Climate Action Planning

GHG reduction analysis plays a role in the cost-effectiveness of CAP measures. The net cost or benefit per metric ton (MT) of GHG emissions reduced (typically expressed as \$/MT CO_2e reduced) provides one way to compare the effectiveness of CAP measures.

Unlike in the assessment of GHG reduction of a measure in a particular target year, the calculation of a \$/MT CO_2e requires use of the cumulative total GHG reduction over the life of a given measure (technology or activity). For example, to determine the \$/MT CO_2e from solar panels installed in 2016, the total GHG emission reductions from the solar panels over their useful life (25 years) must be used along with the net costs and benefits of the system over the same period. Technical Appendix 3 describes the methods in detail.

4 Selecting CAP GHG Reduction Measures

Local CAP measures represent a jurisdiction's commitment to reduce GHG emissions, the following sections describe the considerations and processes to select CAP measures.

4.1 Considerations for Selecting CAP GHG Reduction Measures

This Appendix focuses on the GHG reduction potential of common CAP measures; however, there are several factors to consider when selecting CAP measures, including the factors listed below. Determining whether to include or exclude a particular measure may require tradeoffs between these factors.

- Authority – Whether the local jurisdiction has authority in a particular area to take actions to reduce emissions. For example, local governments generally have broad land use and permitting authority but cannot regulate the renewable energy content of utilities or emissions standards for cars and trucks.
- Data Availability – Whether sufficient data are available to quantify GHG reductions. Some measures require specific information about the number of projects or permits for a specific type of project, which may not be readily available. Also, if data are not available to estimate GHG reductions for inclusion in the CAP, they also may not be available during the monitoring process.
- Feasibility – Whether it is feasible for local jurisdictions to implement the measure in their community. GHG reduction measures should be feasible for the jurisdiction based on community development, demographics, and other characteristics.
- New Development – Whether and how a measure will impact requirements for new development projects is an important factor. This topic is discussed in relation to CEQA in the Technical Appendix 5.
- Financial Impacts – The benefits and costs over time of implementing a CAP measure. Determining the financial impact includes three main parts: (1) the cost to the local jurisdiction to implement CAP measures, (2) the cost-effectiveness of the measure to reduce GHG emissions, and (3) the financial impacts to participants who comply with or engage in activities defined in the CAP measure. These topics are discussed in detail in Technical Appendix 3 and 4.

- <u>Co-benefits</u> – While the primary focus is to reduce GHG emissions, many CAP measures have additional benefits, such as improved air quality, local economic benefits, improved public health and quality of life, and protection of natural resources. Measures that meet these other priorities may be included in CAPs. Understanding the benefits beyond the GHG reductions can help to put CAP measures into a broader context.

There are relationships among these factors. For example, a CAP measure may have a very low cost to implement but result in minor GHG reductions. Another measure may have a higher implementation cost but reduce GHG emissions significantly and also have important associated co-benefits. Local jurisdiction staff and decision-makers balance these and other factors when determining the most appropriate suite of GHG reduction measures to meet targets.

4.2 Master List of Reduction Measures

There are twelve adopted CAPs in the San Diego region as of April 2018, with a range of CAP strategies, measures, actions, and supporting activities. This Regional Framework includes a master list of reduction measures as a technical resource for local jurisdictions. The list can be used to assist in identifying potential measures during the CAP development or update process. Figure 11 summarizes the master list of measures by emissions category for CAPs in the San Diego region.

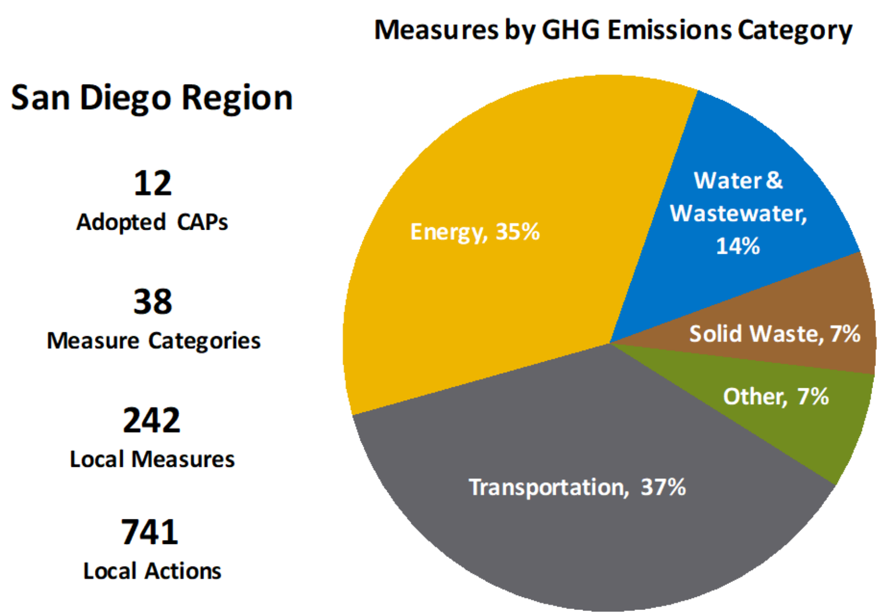


Figure 11 Categorizing GHG Reduction Measures in Adopted CAPs (San Diego Region, as of April 2018)[2]

Table 1 documents the 38 measure categories included in the region's CAPs and lists the number of measures and local actions identified for each.

Table 1 Number of Measures and Actions by Emissions Category, Strategy, and Measure Category

[2] There are 242 local measures and 741 local actions in the 12 CAPs adopted as of April 2018. This number does not mean there are 242 unique types of measures or 741 unique types of actions.

Emissions Category	GHG Reduction Strategy	Measure Category	Measures	Actions
Transportation	Zero Emission/Alternative Fuels	Agriculture Vehicles/Equipment	2	2
		Government Fleet	8	20
		Construction and Landscape Vehicles/Equipment	6	7
		Zero Emission/Alternative Fuel Infrastructure	11	53
		Preferred Parking	3	12
		Vehicle Retirement Program	1	6
	Fuel Use Reduction	Transportation Systems Management (TSM)	7	12
	VMT Reduction	Transportation Demand Management (TDM) Outreach and Education	10	30
		Active Transportation	12	36
		Shared Mobility Services	2	8
		Smart Growth Development	10	38
		Complete Streets	4	12
		Mass Transit	6	25
		Commuter Incentives and Rewards	7	23
Energy	Zero Net Energy	Zero Net Energy	1	4
	Cogeneration	Cogeneration	1	3
	Energy Use Reduction	Energy Efficiency Retrofits	36	131
		Reduce Heat Island Impacts	1	0
		Smart Meters/Appliances	3	11
		New Construction Reach Codes	6	8
	Renewable Energy	Increase Citywide renewable supply	8	20
		Increase Renewable Supply (behind the meter, e.g., Solar PV)	21	55
		Solar Water Heater	7	19
Water & Wastewater	Methane Capture	Methane Capture	2	2
	Recycled/Reclaimed & Gray Water	Recycled/Reclaimed & Gray Water	9	21
	Water Conservation	Indoor and Outdoor	13	45
		Outdoor	5	20
		Rate Structures	2	3
	Water Utility Improvements	Water Utility Improvements	3	6
Solid waste	Methane Capture	Methane Capture	1	2
	Solid Waste Reduction & Recycling	Solid Waste Reduction & Recycling	17	53
Other	Trees & Open Space	Easements	2	11
		Shade Trees	2	11

		Urban Forest	12	29
	Direct Investment Program	Direct Investment Program	1	3
		Total	**242**	**741**

Figure 12 and Figure 13 provide examples of the types of measures classified together for the respective measure categories.

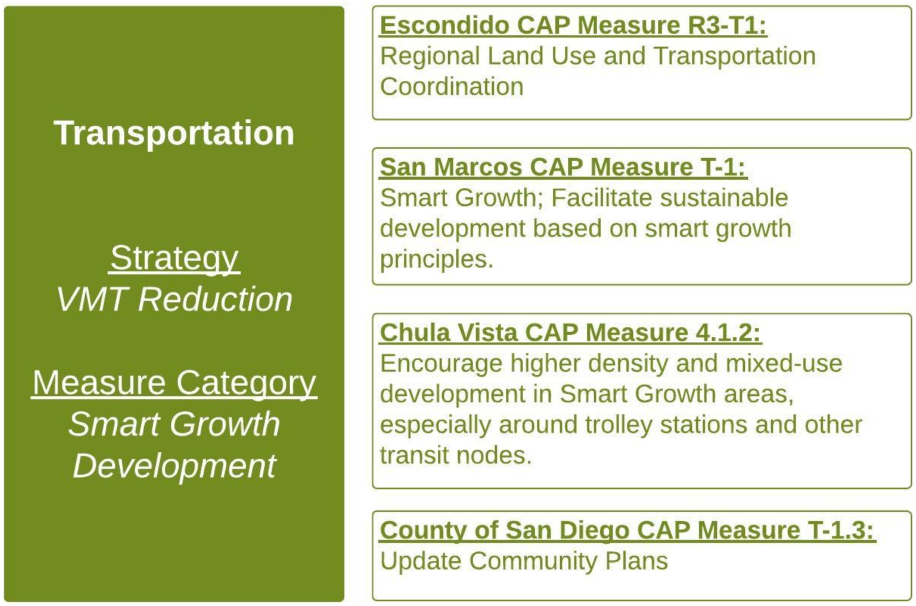


Figure 12 Select Measures Included in *Smart Growth Development* Measure Category

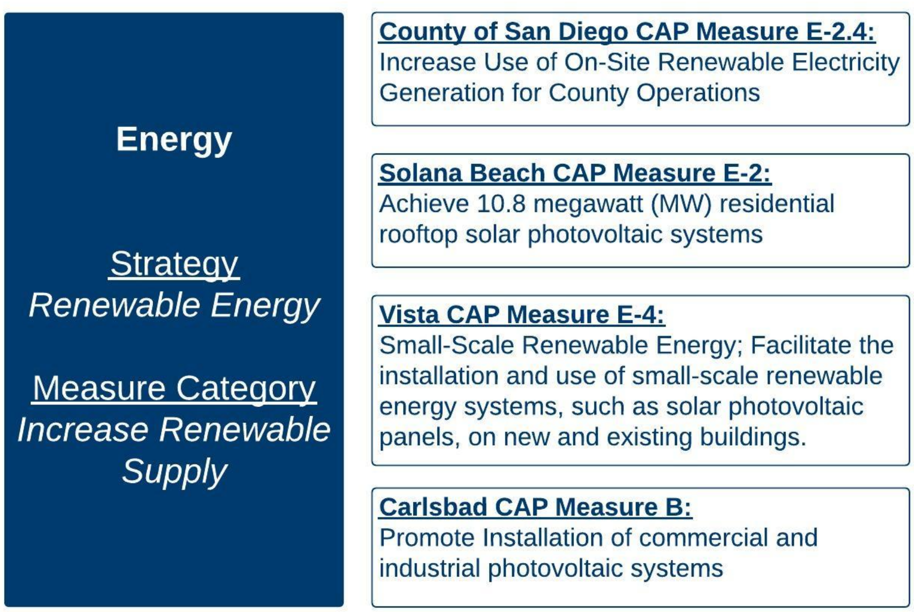


Figure 13 Select Measures Included in *Increase Renewable Supply* Measure Category

Measures and actions can be categorized several different ways in addition to emissions category, strategy and measure category. Other ways to categorize measures include:

- By policy type: mandatory, voluntary, or supporting
- By action type: education, incentive, ordinance, municipal code, etc.
- By customer type: residential, commercial/industrial, city/county, agricultural, etc.
- By building type: new construction, existing construction, jurisdiction facilities, etc.

The master list does not include the GHG reduction potential of the measures, because the reduction potential of the same measure may differ in each jurisdiction due to different input data. However, the methods to calculate emissions reductions from common CAP measures are discussed in this Appendix Section 5.5 through Section 5.9.

This list will be updated and expanded periodically as more jurisdictions adopt new CAPs or update existing CAPs.

4.3 GHG Reduction Measures Matrix

To facilitate the development of CAP GHG reduction measures, a matrix is typically used to organize information and identify data that may be needed. It also can be an efficient way to communicate a lot of information in a relatively small space in the CAP document. Because staff members from multiple departments participate in the CAP development process, the matrix can also serve as a tool to share information and progress on the GHG reduction measures. A completed matrix serves as the organizational structure and main content of the CAP document. Typical fields of information in a GHG reduction measure matrix include:

- Emissions Category – Organized by the broad emissions categories in the inventory, including transportation, energy, water, solid waste, etc.
- CAP Strategy – CAPs generally have several broad strategies to reduce emissions. These can include increasing building efficiency, renewable energy, clean transportation, zero waste, etc. Multiple strategies can be associated with one emissions category.
- CAP Measure – Measures are more specific expressions of broad strategies. For example, measures under the building efficiency strategy can seek to increase building efficiency in new or existing homes. Multiple measures can be associated with one strategy.
- Local Action – These are the specific actions that a local jurisdiction would take to implement the measure. These can include adopting ordinances, developing and implementing programs, or educational outreach. In the case of a "qualified" CAP, local actions must demonstrate substantial evidence for estimating GHG emissions reductions.
- Performance Indicators or Metrics – Each action can have associated performance metrics for tracking progress, which can be evaluated during the monitoring and progress reporting phase. Technical Appendix 6 includes a more detailed discussion of this phase.
- Supporting Activities – These are activities that can be implemented by the local jurisdiction that support implementation of an action or measure but may not directly lead to quantifiable GHG reduction. For example, educating residents about incentives or rebate programs and making available a PACE financing program to help residents implement efficiency projects may facilitate GHG reducing activities but do not directly reduce emissions. In the case of PACE

financing, the energy efficiency retrofit or PV system installed is what would be considered a quantifiable GHG reducing activity.

Figure 14 shows examples of information that could be included in a GHG reduction measure matrix.

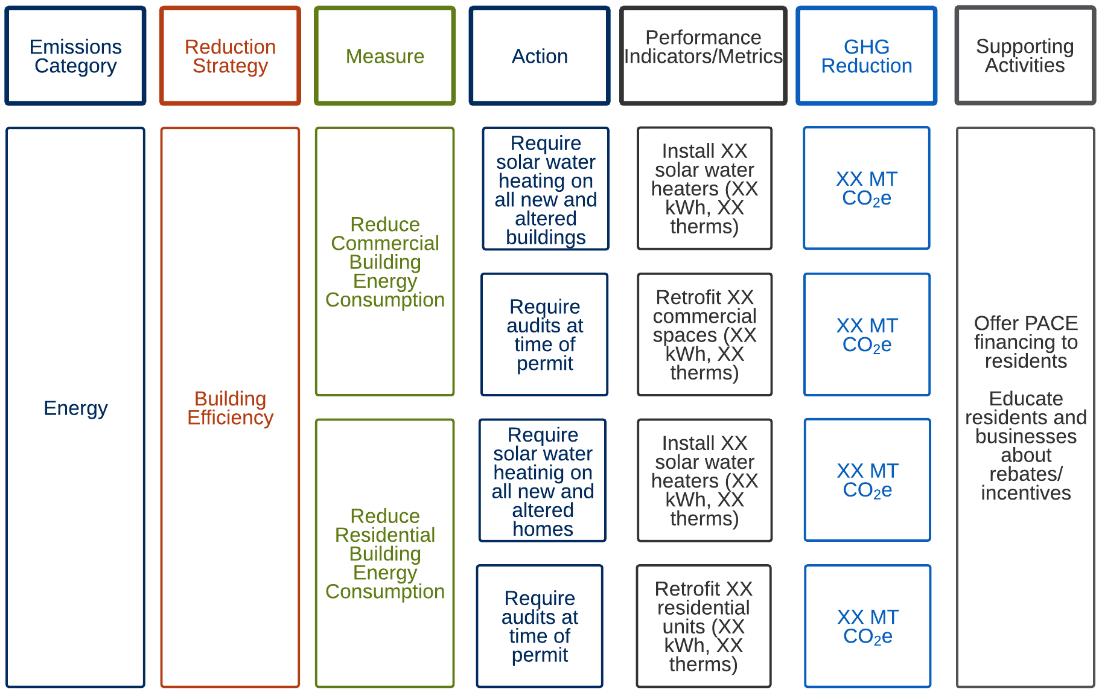


Figure 14 CAP GHG Reduction Measure Matrix Example

In addition, it can be helpful also to have other fields to collect related useful information.

- Data Needs – Identifying the data necessary to estimate the GHG reduction from a specific action.
- Implementation-Related Information – CAPs often include a section on implementation. Collecting this information during the GHG reduction measure development process provides important information to be considered by staff and decision-makers. Additional fields could include the department responsible for implementing a measure, the timeframe for implementation, and cost information, including internal implementation costs and measure-by measure benefit cost analysis results.

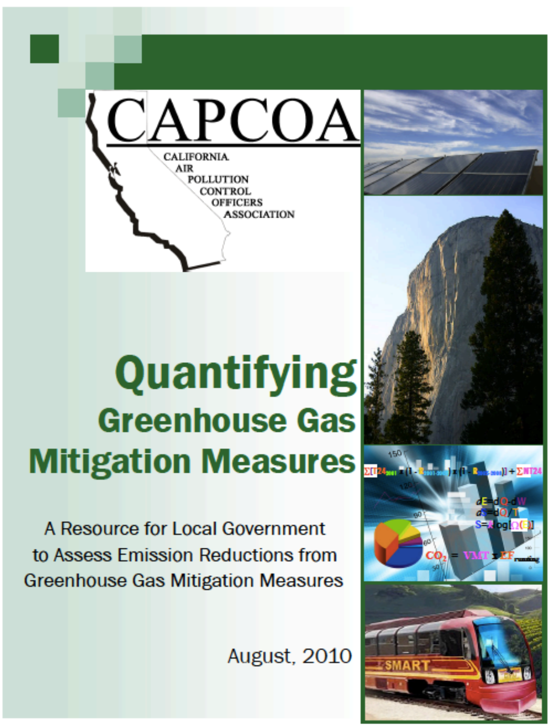
5 Methods to Estimate GHG Reduction from CAP Measures

Currently, there is no standardized or official protocol or method used by jurisdictions in California to calculate GHG reductions from CAP measures, unlike estimating community-scale GHG inventories, where almost all jurisdictions in California use the *U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions* (ICLEI U.S Community Protocol). The following section includes an overview of methods and considerations to estimate GHG reductions in the Regional Framework, as well as limitations of existing GHG reduction methods and tools.

5.1 Overview of Existing GHG Reduction Methods and Tools

5.1.1 CAPCOA - GHG Quantification Report

In 2010, the California Air Pollution Control Officers Association (CAPCOA) developed *Quantifying Greenhouse Gas Mitigation Measures: A Resource for Local Government to Assess Emission Reduction from Greenhouse Gas Mitigation* (CAPCOA GHG Quantification Report) to provide a standardized method to estimate GHG and criteria pollutant emissions reductions from measures at the project level. Figure 15 shows a screenshot of the CAPCOA GHG Quantification Report and its list of transportation measures.



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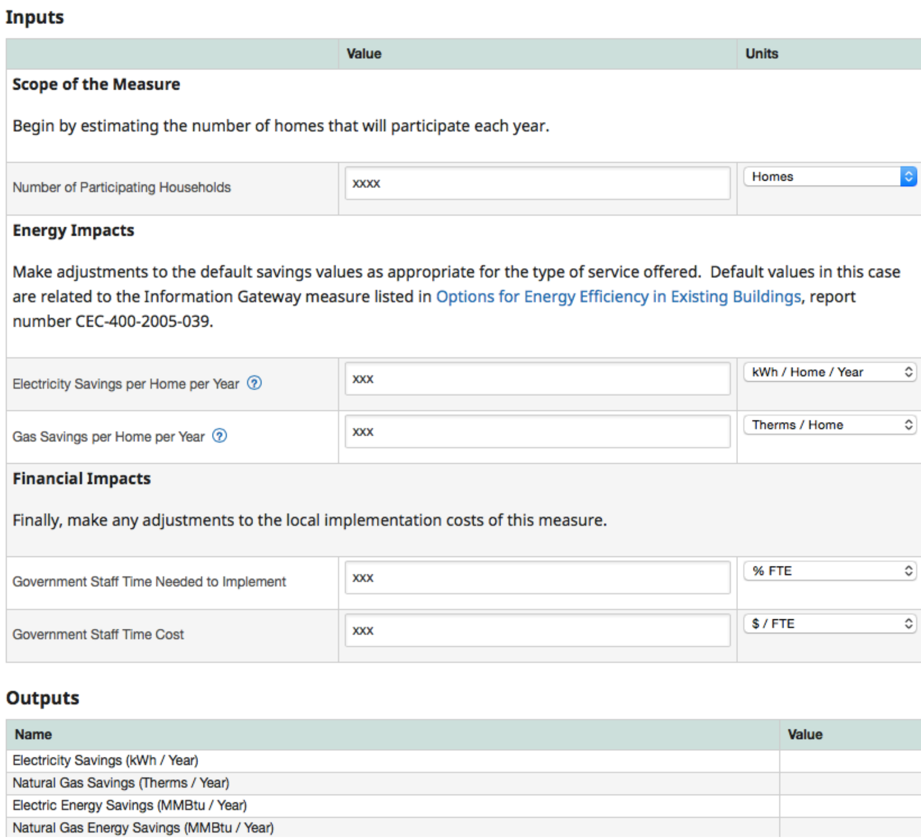
	3.4.4	Implement Subsidized or Discounted Transit Program	230	TRT-
	3.4.5	Provide End of Trip Facilities	234	TRT-
	3.4.6	Encourage Telecommuting and Alternative Work Schedules	236	TRT-
	3.4.7	Implement Commute Trip Reduction Marketing	240	TRT-
	3.4.8	Implement Preferential Parking Permit Program	244	TRT-
	3.4.9	Implement Car-Sharing Program	245	TRT-
	3.4.10	Implement a School Pool Program	250	TRT-1
	3.4.11	Provide Employer-Sponsored Vanpool/Shuttle	253	TRT-1
	3.4.12	Implement Bike-Sharing Programs	256	TRT-1
	3.4.13	Implement School Bus Program	258	TRT-1
	3.4.14	Price Workplace Parking	261	TRT-1
	3.4.15	Implement Employee Parking "Cash-Out"	266	TRT-1

Figure 15 CAPCOA GHG Quantification Report and Transportation Measure Examples

5.1.2 ICLEI – SEEC ClearPath Tool California

The Statewide Energy Efficiency Collaborative (SEEC) ClearPath tool, developed and managed by ICLEI, the State of California, the Climate Registry, and others, is a web-based tool that local governments can use to calculate emissions reductions and develop CAP scenarios. Figure 16 is a screenshot of the inputs needed to be entered into the ClearPath Tool to calculate the GHG reduction of a residential energy retrofit measure.



Inputs

	Value	Units
Scope of the Measure Begin by estimating the number of homes that will participate each year.		
Number of Participating Households	xxxx	Homes
Energy Impacts Make adjustments to the default savings values as appropriate for the type of service offered. Default values in this case are related to the Information Gateway measure listed in Options for Energy Efficiency in Existing Buildings, report number CEC-400-2005-039.		
Electricity Savings per Home per Year	xxx	kWh / Home / Year
Gas Savings per Home per Year	xxx	Therms / Home
Financial Impacts Finally, make any adjustments to the local implementation costs of this measure.		
Government Staff Time Needed to Implement	xxx	% FTE
Government Staff Time Cost	xxx	$ / FTE

Outputs

Name	Value
Electricity Savings (kWh / Year)	
Natural Gas Savings (Therms / Year)	
Electric Energy Savings (MMBtu / Year)	
Natural Gas Energy Savings (MMBtu / Year)	

Figure 16 Example of ClearPath Tool – Inputs and Outputs of a GHG Reduction Measure

5.1.3 Limitations of Existing GHG Reduction Methods and Tools

The CAPCOA GHG Quantification Report focuses on the "quantification of projects and mitigation under CEQA . . . [m]ost of the measures quantified in the [CAPCOA GHG Quantification] Report are project-level in nature" (CAPCOA 2010, p.9). However, some of the methods discussed in the CAPCOA report and the literature substantiating it can be adapted and used to estimate GHG reductions from community-wide CAP measures. For example, the CAPCOA GHG Quantification Report discusses a measure titled "price workplace parking" that is expected to reduce employee commute VMT by charging for employee parking. It provides information on the range of effectiveness and can be used both at the project-level, as well as CAP-level. However, the CAPCOA GHG Quantification Report recognizes that "a full analysis of plan-level impacts will require consideration of additional factors, depending on the nature of the measure" (CAPCOA 2010, p.9).

The SEEC ClearPath tool includes CAP scenario analysis that is applicable to any jurisdiction using the tool. To be consistent with GHG inventories and reduction measures in the San Diego region, off-model estimates and calculations would have to be entered into the ClearPath tool as the forecast "growth factor." For each emission category, the user is required to enter a "growth factor" of the activity or emission factor, which is the compound annual growth rate that will occur over each five-year period within the CAP horizon (SEEC, 2013). This growth rate would be affected by the impacts of CAP reduction measures.

5.2 Considerations for Estimating GHG Reduction from CAP Measures

To develop the methods to estimate GHG reduction from CAP measures, the following are the key considerations.

- Emission Factor – The GHG emission factor—the emissions per unit of activity—and how it changes over time affects GHG reduction calculations. For example, the vehicle fleet becomes more efficient in future years with lower GHG emissions per mile driven, reducing VMT will result in fewer GHG emissions reductions over time.
- Baseline Activity Level – The performance metrics for CAP measures are often based on a level of activity above and beyond baseline activity level. Therefore, to estimate the associated GHG reduction amount also depends on knowing the baseline activity level. For example, if a CAP measure seeks to reach a total of 1,000 MW of behind-the-meter PV in 2020, it is necessary to determine the amount of PV that was already installed in the baseline year and to calculate the amount of additional PV installed through 2020. GHG reduction estimates would be based on the incremental installations and not on the total PV in 2020.
- Activity Level – A change in the level of a GHG emitting activity affects the associated GHG reduction calculation. Reducing VMT will reduce GHG emissions even if the emissions factor remains the same.
- Performance Rate – A change in the performance rate of a system affects the GHG reduction calculation. For example, PV panels degrade over time and the amount of energy generated declines over time.
- Interaction among Measures – Interconnections among CAP measures affect the GHG reduction estimate. For example, an increase in the share of electric vehicles in the vehicle fleet will reduce the average vehicle emissions per mile driven, but also increases electricity use from charging, which may increase emissions in the electricity category.

5.3 Overview of Methods to Estimate GHG Emissions Reduction

As discussed in Section 4.3 GHG Reduction Measures Matrix, CAP strategies are generally broad and may include several measures. For example, CAP measures to require PV to be installed on new homes and expand PV installations at municipal facilities could both be organized under the same CAP strategy “Increase Renewable Electricity Supply.” Strategies are generally divided into two types: 1) those that reduce the activity level of an emissions-generating activity, sometimes called “quantity” measures; and 2) those that reduce the GHG intensity or emission factor of an emissions-generating activity, sometimes called the “rate” measures. This also matches California’s policy approach for reducing GHG emissions, as discussed in Section 3. Figure 17 provides a breakdown of sample strategies in each emissions category.

Emissions Category	CAP Strategy to Reduce Emission Factor (GHG Intensity)	CAP Strategy to Reduce Activity Level
Electricity	Increase Renewable Electricity Supply	Increase Building Efficiency
Natural Gas	Increase Renewable Natural Gas	Increase Building Efficiency
On-road Transportation	Increase Vehicle Fuel Efficiency and Zero Emission Vehicles	Reduce Vehicle Miles Traveled
Water and Wastewater	Develop Local Water Supply & Improve Water System Efficiency	Increase Water Efficiency
Solid Waste	Reduce Organics in the Waste Stream	Divert Waste from Landfills

Figure 17 Breakdown of CAP Strategies and the Associated Emissions Category

The general equation to estimate GHG emissions reductions for the five basic emissions-generating activities are similar, as shown in Equation 1.

Equation 1 General Equation to Estimate GHG Emissions Reduction

$$\Delta E_{category,n} = \Delta A_{category,n} * \Delta EF_{category,n}$$

Where

$\Delta E_{category}$	= emissions reduction from an emissions category in a given year, in metric tons (MT) of CO_2e
$\Delta A_{category}$	= change in activity level of a category in a given year, unit depends on the activity category
$\Delta EF_{category}$	= change in emission factor of a category in a given year, MT CO_2e per unit of activity

With

category	= [electricity, natural gas, transportation, water, wastewater, waste]
n	= a CAP horizon year, from baseline year to CAP horizon end year

In Equation 1, both activity level (A) and emission factor (EF) are variables. Each CAP measure may result in a change of activity level only, a change of emission factor only, or both. Each CAP strategy may include several measures that change both activity level and emission factor. The following is an example of each case:

- Increasing building efficiency changes the activity level (decreases kWh) in the electricity category;
- Implementing a vehicle replacement program using electric or natural gas vehicles changes the emission factor (decreases grams CO_2e/mile) in the transportation category; or
- Diverting organic waste from landfills changes both the activity level (lowers waste tonnage) and the emission factor (lowers MT CO_2e/ton) in the waste category.

The emission reduction calculation and data needs for each broader CAP strategy are discussed in Section 5.5 to Section 5.8, with sample calculations of typical measures included in the strategy.

There are other CAP strategies and measures that reduce overall emissions and increase climate resiliency, but do not fit in a specific emissions category. Examples of these strategies and measures include:

- Increasing carbon sequestration through conserved open space and natural lands;
- Increasing carbon sequestration through increased urban tree canopy cover; and
- Reducing heat island effect through rooftop gardens.

The emissions sequestration calculation for these measures does not follow the general equation and is discussed separately in Section 5.9.

5.4 Effect of Order of GHG Reduction Calculation of Inter-related CAP Measures – a Limitation

Equation 1 above shows the general equation to estimate GHG reductions from CAP measures; this involves multiplying the changes in an activity by the changes in the GHG intensity of that activity. However, measures that reduce the GHG intensity (e.g., electricity emission factor) and those that reduce the level of activity (e.g., electricity use) will happen at the same time. It is not possible to calculate both the effects of reduced intensity and reduced use simultaneously; therefore, it is necessary to calculate one before the other.

Figure 18 provides an example to illustrate the interrelationship of activity- and emission factor-related policies.

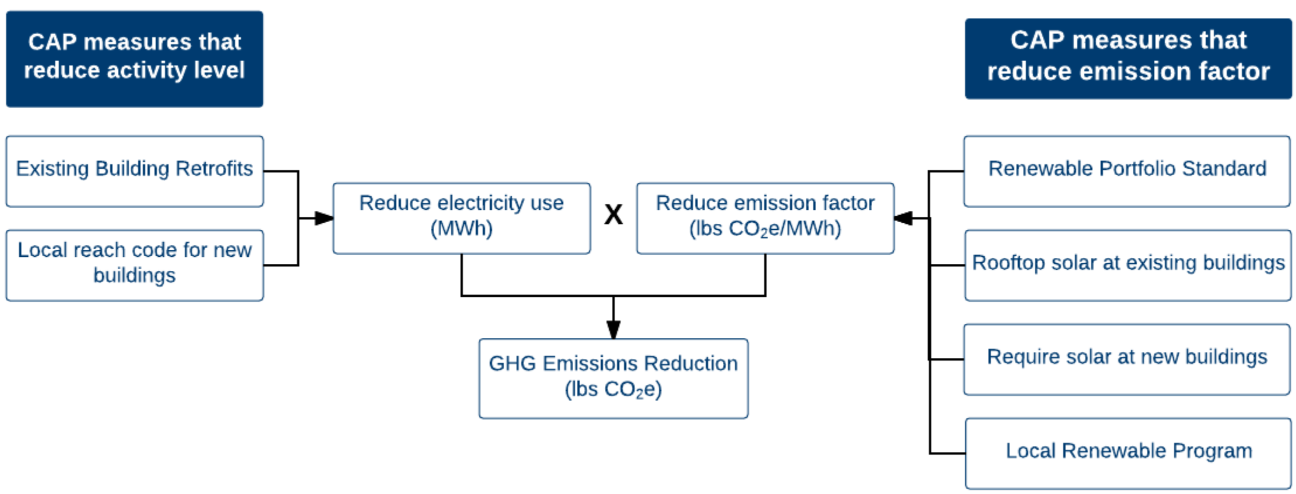


Figure 18 Example of Inter-related CAP Measures within One Emission Category[3]

The sequencing of calculations determines the magnitude of the emissions reduction of each measure. In this Appendix, the “emission factor first” or “rate first” approach is used. For example, the emissions reduction from the RPS, which increases renewable electricity and lowers the electricity emission factor,

[3] Alternatively, generation from behind-the-meter PV systems can be considered as reducing electricity supply from the grid. In this Appendix, the electricity emission factor represents the emission factor of all supply including behind-the-meter and grid supply, therefore generation from behind-the-meter PV is considered as an additional renewable supply that reduces electricity emission factor.

is calculated first. Then, the emissions reduction of a local energy efficiency measure would be calculated using a lower emission factor, since the RPS has already been accounted for.

The result would overestimate the emissions reduction from the RPS and underestimate those from the local energy efficiency measures. If the calculation order is reversed, then the opposite outcome arises: the reductions from local energy efficiency measures would be overestimated and the reduction from the RPS would be underestimated. The total combined reduction for the two measures will be the same regardless of the order, but the amount *allocated* to each will be skewed by the order in which it was calculated.

The “emission factor first” or “rate first” method is used in this Appendix. This is a reasonable approach, since the magnitude of change in the “emission factor” CAP measures (e.g., increase renewable supply through local renewable program) is typically greater than that from “quantity” CAP measures (e.g., increase building efficiency in existing and new buildings). Nonetheless, developing a method to divide the emission reduction equally between the two calculation approaches remains a methodological challenge to be addressed in the future, and is discussed in a paper published by EPIC (Anders, *et al*., 2015).

This issue can also affect the cost-effectiveness portion of the benefit-cost analysis results, since the GHG reduction over the lifetime of a project would differ depending on the order of these calculations. This is discussed in more detail in *Technical Appendix 3 – Benefit-Cost Analysis for CAP Measures*.

5.5 Emissions Reductions from Energy-Related Measures

Emissions reductions from energy-related measures generally can be separated into two categories:

- Increase in renewable electricity supply (Section 5.5.1)
- Increase in building efficiency (Section 5.5.2)

The following sections describe the methods and data needs for calculating GHG emissions reductions from State regulations and CAP measures within these two categories.

5.5.1 Increase Renewable Electricity Supply

Measures that increase the renewable content in the electricity supply generally provide a large portion of the overall GHG reductions in a CAP. This section discusses the method to estimate GHG reductions from these measures, which includes the following calculations:

1. Weighted average emission factor of all electricity supplied to a jurisdiction based on sources of electricity from all supplies
2. Overall renewable content of the electricity supply based on the renewable content of each supply (grid-supply and self-supply)
3. Overall emissions reduction from increasing renewable content
4. Emissions reduction from State regulations and CAP measures that increase renewable content

Figure 19 provides an overview of the process to adjust the weighted emission factor and estimate GHG reductions due to measures that increase the renewable content in the electricity supply.

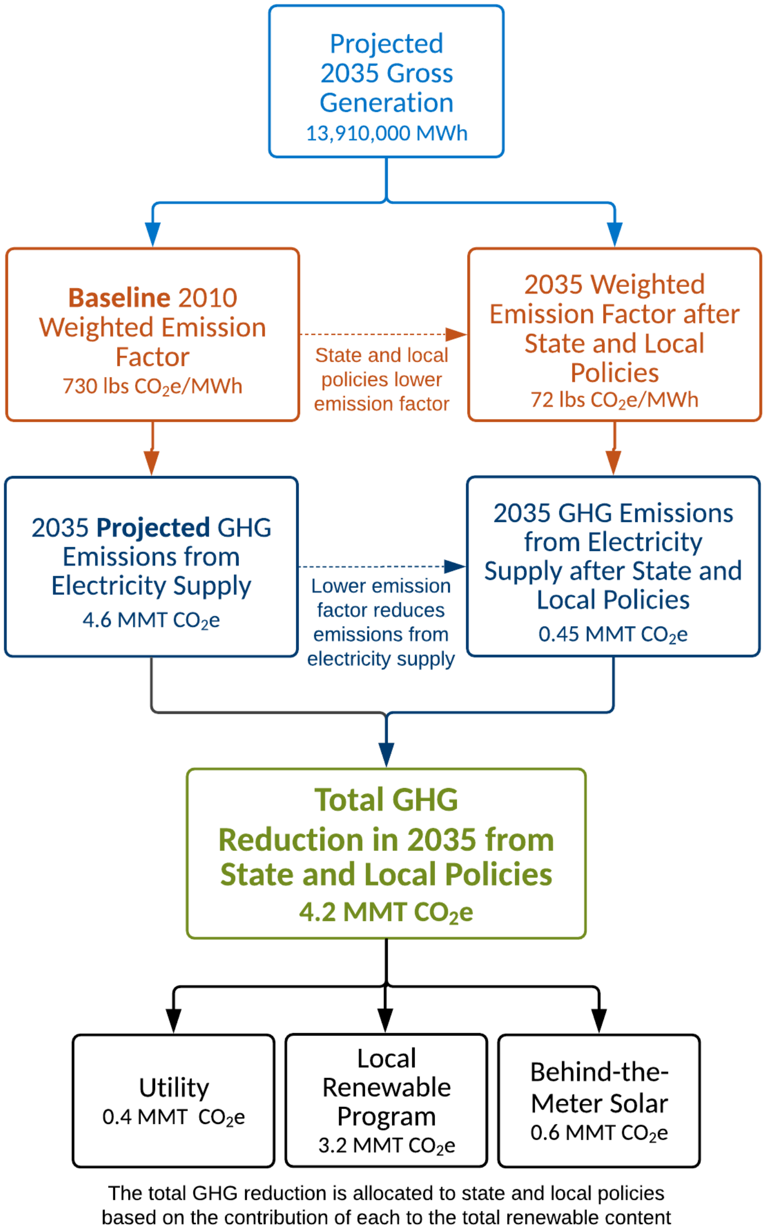


Figure 19 Process for Estimating GHG Reductions from Renewable Electricity Policies

5.5.1.1 Weighted Average Emission Factor of Electricity Supply

Estimating an emission factor for electricity is central to estimating GHG reductions for measures related to electricity. As discussed in the Technical Appendix 1: *GHG Inventories, Projections and CAP Target Selection* and in Figure 20 below, to estimate the emission factor, all electricity sources are considered; grid-supply (San Diego Gas & Electric [SDG&E] and other Electric Service Providers) and self-supply (e.g., behind-the-meter PV systems) are part of the electricity supplied to the jurisdiction. This inclusive view of electricity, called "gross generation," represents the total electricity generation needed to supply electricity end uses, including losses. To accurately estimate total emissions from the electricity and the effects of GHG reduction measures in this category, gross generation is considered.

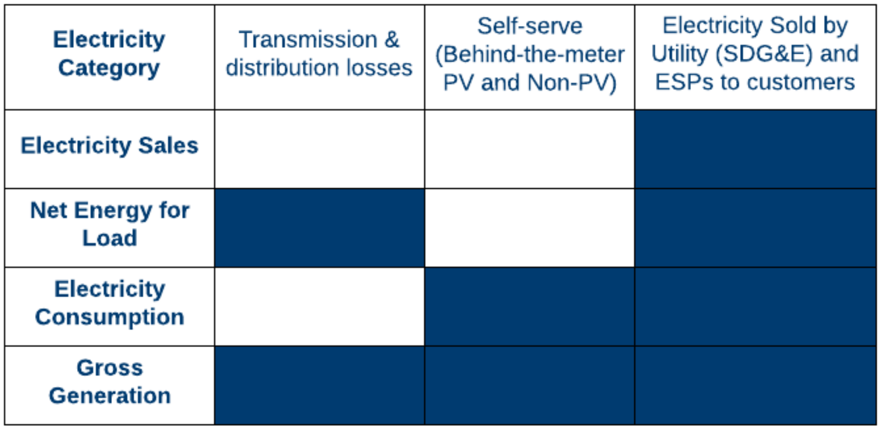


Figure 20 Example of Electricity Use Categories Defined by the California Energy Commission (CEC, EPIC 2017)

There are many different sources that supply electricity to customers, each with its own emissions profile. For example, about 15 percent of electricity sales in the SDG&E service territory is provided by suppliers other than SDG&E under direct access (DA). This portion of supply has a different emissions profile than SDG&E's supply. To account for this variation in supply sources, all sources should be included to create an average emission factor for the local jurisdiction. This approach provides an average emission factor that can be used to estimate the effects of activities to reduce electricity within the jurisdiction. For example, if a customer with behind-the-meter solar reduces electricity use, this approach would appropriately account for the emissions impact.

The weighted average emission factor calculated in this section accounts for the emissions of all supply sources included in the gross generation. The percentage of gross generation provided by each supply and the percentage of renewable content in each supply are key components to calculate the weighted average emission factor (Equation 2).

Equation 2 Weighted Average Electricity Emission Factor Calculation

$$EF_{electricity,n} = \sum_{supply} \left(P_{supply,n} * \frac{(1 - RE_{supply,n})}{(1 - RE_{SDG\&E,baseline})} * EF_{SDG\&E,baseline}\right)$$

Where

$EF_{electricity,n}$ = emission factor of the electricity (gross generation) in a jurisdiction in a given year, in lbs CO_2e per MWh

$P_{supply,n}$ = percent of gross generation supplied by an electricity supply in a given year, %

$RE_{SDG\&E,baseline}$ = renewable content of SDG&E supply in CAP baseline year, in lbs CO_2e per MWh, 2010-2016 SDG&E supply renewable content are given in Table 5 of Technical Appendix 1

$EF_{SDG\&E,baseline}$ = electricity emission factor of SDG&E supply in CAP baseline year, in lbs CO_2e per MWh, 2010-2016 SDG&E emission factors are given in Table 5 of Technical Appendix 1

With,

supply = all electricity supplies, including but not limited to: SDG&E, behind-the-meter PV, local renewable program

n = a CAP horizon year, from baseline year to CAP horizon end year

The following is an example of the weighted average emission factor calculation for a sample local jurisdiction that has a 2010 CAP baseline year with three electricity supplies (SDG&E, Community Choice Aggregation [CCA]), and behind-the-meter PV) in 2035. The renewable content and percent of electricity provided by each supply for 2035 are given in Table 2. The assumptions in Table 2 are based on State regulations and potential performance indicators of CAP measures. The percentage of gross generation supplied by CCA would be based on the anticipated participation rate of the program, a potential performance indicator of the program.

Table 2 Background Data for a Weighted Average Electricity Emission Factor Calculation Example

Year	Supply 1: Community Choice Aggregation		Supply 2: SDG&E		Supply 3: Behind-the-meter PV	
	% of Gross Generation Supplied $P_{CCA,2035}$	Renewable Content $RE_{CCA,2035}$	% of Gross Generation Supplied $P_{SDG\&E,2035}$	Renewable Content $RE_{SDG\&E,2035}$	% of Gross Generation Supplied $P_{solar,2035}$	Renewable Content in Supply $RE_{solar,2035}$
2035	70%	100%	17%	50%	13%	100%
Baseline year 2010: $EF_{SDG\&E,2010} = 736\ lbs \frac{CO_2e}{MWh}$, $RE_{SDG\&E,2010} = 10\%$						

Using data from Table 2 and Equation 2, the weighted average emission factor for this 2035 scenario is 72 lbs CO_2e/MWh (Equation 3).

Equation 3 Example of a Weighted Average Electricity Emission Factor Calculation

$$EF_{electricity,2034} = P_{SDG\&E,2035} * \frac{(1 - RE_{SDG\&E,2035})}{(1 - RE_{SDG\&E,2010})} * EF_{SDG\&E,2010} + P_{CCA,2035} * \frac{(1 - RE_{CCA,2035})}{(1 - RE_{SDG\&E,2010})} * EF_{SDG\&E,2010} + P_{solar,2035} * \frac{(1 - RE_{solar,2035})}{(1 - RE_{SDG\&E,2010})} * EF_{SDG\&E,2010} = 72\ lbs \frac{CO_2e}{MWh}$$

5.5.1.2 Overall Renewable Content of Electricity Supply

Some existing CAPs in the San Diego region include a goal to achieve 100 percent renewable electricity supply. This goal could apply to all or a portion of gross generation; that is, it could apply only to the portion of electricity supplied from the grid or gross generation. The approach summarized here assumes that it applies to gross generation. Based on this and concepts discussed above, the overall content of renewables in the supply is calculated using Equation 4 below.

Equation 4 Overall Renewable Content of Electricity Supply Calculation

$$RE_{electricity,n} = \sum_{supply} (P_{supply,n} * RE_{supply,n})$$

Where

$RE_{electricity,n}$ = overall renewable content of the electricity supply (gross generation) in a given year, %

$P_{supply,n}$ = percent of gross generation supplied by an electricity supply in a given year, %

$RE_{supply,n}$ = renewable content of an electricity supply in a given year, %

With,

supply = all electricity suppliers, including, but not limited to: SDG&E, behind-the-meter PV, local renewable program

n = a CAP horizon year, from baseline year to CAP horizon end year

Using the 2035 scenario discussed in Section 5.5.1.1 and data in Table 2, the overall renewable content of the electricity supply (gross generation) in this scenario is 91 percent (Equation 5). This value would change if it represented the renewable content of only grid supply or utility supply.

Equation 5 Example of Overall Renewable Content of Electricity Supply Calculation

$$RE_{electricity,2035} = P_{SDG\&E,2035} * RE_{SDG\&E,2035} + P_{CCA,2035} * RE_{CCA,2035} + P_{solar,2035} * RE_{solar,2035} = 91\%$$

With more aggressive strategies and CAP measures to increase renewable supply, the overall renewable content will approach 100% and the weighted average emission factor will decrease further. The weighted average emission factor is applied to all the measures that reduce electricity use (activity level), discussed in Section 5.5.2. As a result of the interaction between measures and the increasing renewable content (lower emissions), measures to reduce electricity use will yield fewer GHG reductions over time.

5.5.1.3 Emissions Reduction from Increasing Renewable Electricity Supply

To calculate the emissions reductions from all State regulations and CAP measures that increase renewable electricity supply, the total reduction associated with a particular level of clean electricity is calculated first and then allocated to each measure. The total reduction is based on the gross generation in a given year and the difference between the weighted average electricity emission factor for a baseline and target year (Equation 6).

Total Emissions Reduction from Increasing Renewable Supply

Equation 6 Emissions Reduction from Increasing Renewable Supply Calculation

$$\Delta E_{electricity,RE,n} = Elec_n * \Delta EF_{electricity,n} * 0.000453$$

Where

$\Delta E_{electricity,RE,n}$ = total emissions reduction from increasing renewable electricity supply in a given year, in MT CO_2e

$Elec_n$ = electricity gross generation, including all suppliers in a given year, MWh

$\Delta EF_{electricity,n}$ = difference in emission factor of the electricity (gross generation) in a jurisdiction in a given year compared with baseline year, in pounds CO_2e per MWh

0.000453 = conversion factor, MT CO_2e in a pound

With,

n = a CAP horizon year, from baseline year to CAP horizon end year

Using this method, the following example illustrates this approach to estimating the emissions reduction in 2035 (with a 2010 CAP baseline) from all measures that increase renewable supply in a jurisdiction (Table 3).

Table 3 Example of Emissions Reduction Calculation from Increasing Renewable Supply

Year	Gross Generation (GWh) $Elec_{2035}$	Baseline Emission Factor (lbs CO_2e/MWh)	Weighted Emission Factor (lbs CO_2e/MWh)	Difference between Baseline and Weighted Emission Factor (lbs CO_2e/MWh) $\Delta\, EF_{electricity,2035}$	Total Emissions Reduction (MMT CO_2e) $\Delta\, E_{electricity,RE,2035}$
2010	9,580	730	730	-	-
2035	13,910	730	72	658	4.16
MMT CO_2e = million metric ton CO_2e					

Allocating Total Emissions Reduction to Each Supply

Once the total emissions reduction from increasing renewable supply is estimated, it is allocated to each supply based on the percent contribution of each supply to overall renewable content (Equation 7).

Equation 7 Emissions Reduction from Each Supply Increasing Renewable Supply Calculation

$$\Delta\, E_{electricity,supply,n} = \Delta\, E_{electricity,RE,n} * \left(\frac{P_{supply,n} * RE_{supply,n}}{RE_{electricity,n}}\right)$$

Where

$\Delta\, E_{electricity,supply,n}$ = emissions reduction of an electricity supply from increasing renewable content in a given year, in MT CO_2e

$\Delta\, E_{electricity,RE,n}$ = total emissions reduction from increasing renewable electricity supply in a given year, in MT CO_2e, refer to Equation 6

$P_{supply,n}$ = percent of gross generation supplied by an electricity supply in a given year, %

$RE_{supply,n}$ = renewable content of an electricity supply in a given year, %

$RE_{electricity,n}$ = overall renewable content of the electricity supply (gross generation) in a given year (%), refer to Equation 4

With,

supply = all electricity supplies, including but not limited to: SDG&E, Behind-the-meter PV, Community Choice Aggregation

n = a CAP horizon year, from baseline year to CAP horizon end year

For the scenario given in Table 3, the total emissions reduction from increasing the renewable electricity supply is 4.16 MMT CO_2e in 2035 ($\Delta\, E_{electricity,RE,2035}$). Using this method, the emissions reduction from SDG&E increasing its renewable supply to 50% renewable electricity in 2035, is calculated in Equation 8. In this example, SDG&E supplies 17% of the gross generation.

Equation 8 Example of Emissions Reduction from SDG&E Providing Renewable Electricity

$$\Delta\, E_{electricity,SDG\&E,2035} = \Delta\, E_{electricity,RE,2035} * \left(\frac{P_{SDG\&E,2035} * RE_{SDG\&E,,2035}}{RE_{electricity,2035}}\right)$$

$$= 4.16 * \left(\frac{17\% * 50\%}{91\%}\right) = 0.4\, MMT\, CO_2e$$

The same method can be used to allocate the emissions reduction to the other two renewable electricity supplies (behind-the-meter PV and CCA). The results of the allocation are shown in Table 4.

Table 4 Example Calculation of Emissions Reduction from Each Supply Increasing Renewables

Supply	2035		
	% of Gross Generation Supplied by Renewables (Renewable Content)	Renewables from Each Category/Total	Emissions Reduction (MMT CO_2e)
SDG&E	9%	10%	0.40($\Delta\ E_{electricity,SDG\&E,2035}$)
CCA	70%	77%	3.19($\Delta\ E_{electricity,CCA,2035}$)
Behind-the-meter PV	13%	14%	0.57($\Delta\ E_{electricity,PV,2035}$)
Total	91%	100%	4.16 ($\Delta\ E_{electricity,RE,2035}$)

A CAP could include multiple measures that increase the renewable content of a supply. For example, the renewable content of a local renewable program could be affected by both the State's RPS in addition to local goals. In this case, the amount associated with the RPS would be shown as a reduction due to State policies and regulations, while the additional renewable content above State targets from local renewable energy programs would be shown as a local reduction. Also, increasing behind-the-meter PV capacity could be affected by State policies and regulations, as well as local CAP measures targeting existing buildings and/or new construction. The following two sections discuss State regulations and local CAP measures that increase renewable content.

5.5.1.4 California Regulations to Increase Renewables in Electricity

The California RPS and California Solar Programs and Policies are the two main state policies to increase renewable content in electricity supply.

California Renewables Portfolio Standard

Signed into law in 2011, the RPS requires all of California's electric service providers to increase procurement from eligible renewable electricity sources in supply to 33% of total procurement by 2020. In 2015, Governor Brown signed into law SB 350, which increases renewable electricity targets to 50% by 2030. All electric service providers must meet these RPS requirements, including utilities (SDG&E), electric service providers for DA customers, and other local renewable programs, including CCAs.

For electricity transmitted and distributed by SDG&E, including electricity provided to DA customers, it is assumed that SDG&E will meet the 2020 and 2030 RPS requirements. SDG&E exceeded the 2020 targets with a verified renewable content level of 35% and 43% in 2015 and 2016, respectively. Because local jurisdictions do not have authority to affect statewide renewable electricity standards, which are the purview of State regulatory agencies, CAPs generally account for the level of renewable electricity required by State law. However, since inventories monitor progress of GHG emissions, an inventory will account for the total renewable electricity supply in a given year regardless of whether it is above statewide targets. For example, a local jurisdiction will include GHG reductions for 2020 that assume that SDG&E will meet the 33% renewable electricity content requirement, but when a 2020 inventory is conducted, it will reflect the *actual* amount of renewable electricity supplied in that year. All emissions reductions from SDG&E (and suppliers for SDG&E's DA customers) that come from increasing renewable content (calculated using Equation 7) are attributed to the RPS and reduce the amount of overall GHG reductions required to reach emissions targets.

For local renewable programs that meet and exceed RPS requirements, such as CCA, a portion of the emissions reduction from the local renewable program will be attributed to the State RPS compliance, and the remaining reduction will be attributed to the local renewable program. For example, for a local renewable program that calls for 80% renewables by 2030, the emissions reduction associated with the RPS (50% renewable supply) will be allocated to the RPS and the reductions associated with the additional 30% portion will be allocated to the local program. The allocation to State versus local measures is shown in Equation 9 using a local renewable energy program that goes beyond the RPS requirement as an example.

Equation 9 Emission Reduction Calculation for Local Renewable Program in Compliance With RPS

$$\Delta\, E_{electricity,RPS,n} = \Delta\, E_{electricity,Local\ RE\ ,n} * (\frac{RE_{RPS,n}}{RE_{local\ RE,n}})$$

Where

$\Delta\, E_{electricity,RPS,n}$	= emissions reduction of a local renewable program in a given year, in compliance with RPS, in MT CO_2e
$\Delta\, E_{electricity,Local\ RE,n}$	= emissions reduction of local renewable program in a given year, in MT CO_2e
$RE_{RPS,n}$	= RPS requirement in a given year, fixed for 2020 and 2030 and interpolated for other years
$RE_{Local\ RE,n}$	= targeted renewable content of a local renewable program in a given year (%)

With,

n	= a CAP horizon year, from baseline year to CAP horizon end year

California Solar Programs and Policies

California has several policies and programs to encourage behind-the-meter PV systems, including the California Solar Initiative, New Solar Homes Partnership, net energy metering, and electricity rate structures designed for solar customers.

The latest CEC California Energy Demand 2018-2030 Revised Forecast (adopted in February 2018), has projections for behind-the-meter PV generation in the SDG&E planning area through 2030. The California Distributed Generation (DG) Statistics database includes capacities of behind-the-meter PV systems interconnected in a jurisdiction in a given year for each of the three Investor Owned Utilities (IOUs) planning area, including SDG&E. The DG Statistics provides detailed information about the behind-the-meter PV systems installed in a jurisdiction from the start year of incentive programs through the current year. This provides a historical record used to determine the capacity in a given year, such as a baseline year, and also can help determine trends in PV installation.

The compound annual growth rate of the SDG&E planning area solar generation projection is used to estimate the behind-the-meter PV growth rate for jurisdictions in the San Diego region and the electricity generation and associated emissions reduction from the California solar programs and policies. However, jurisdictions have different socio-economic characterizations that may impact solar system installation, so the regional factor may need to be calibrated to the local level. The estimated electricity generation in a jurisdiction from California solar programs and policies are given in Equation 10.

Equation 10 Estimate Electricity Generation from California Solar Policies and Programs

$$Elec_{PV,local,n} = Elec_{solar,regional,n} * (\frac{C_{PV,local} * 20\% * 8{,}760}{Elec_{PV,regional}})_{ave}$$

Where

$Elec_{PV,local,,n}$	= annual electricity generation from behind-the-meter PV systems in a jurisdiction in a given year, in MWh
$Elec_{PV,regional,,n}$	= annual electricity generation from behind-the-meter PV systems in the SDG&E planning area in a given year, in MWh
$C_{PV,local}$	= actual capacity of the behind-the-meter PV systems in a jurisdiction in a given year, in MW (dc)
20%	= average solar system capacity factor, ratio of average energy generated compared with nameplate capacity, in MWh/MW
8,760	= hours per year
With,	
n	= a CAP horizon year, from baseline year to CAP horizon end year

The data needs for the calculation are given in Table 5.

Table 5 Data/Information Needs Table for Emissions Reduction Calculation – California Solar Policies and Programs

Data/Information Needs	Data Timeframe	Data Source
Actual (interconnected) capacity of the behind-the-meter PV systems in a jurisdiction ($C_{PV,local}$)	CAP baseline year to most recent year	California DG Statistics
Annual electricity generation from behind-the-meter PV systems in the SDG&E planning area ($Elec_{PV,regional,n}$)	CAP baseline year to all horizon years	CEC energy demand forecast (currently available up to 2030)

The calculated annual electricity generation from behind-the-meter PV systems in a jurisdiction is used to calculate the percent of gross generation supplied by solar in a given year ($P_{solar,n}$). Then, this value is used to calculate the emission reduction from increasing renewable supply through PV systems (see Equation 11, adapted from Equation 7).

Equation 11 Emissions Reduction from Increasing Renewable Supply through Behind-the-meter PV Systems

$$\Delta\, E_{electricity,PV,n} = \Delta\, E_{electricity,RE,n} * (\frac{P_{PV,n} * RE_{PV}}{RE_{electricity,n}})$$

Where

$\Delta\, E_{electricity,PV,n}$	= emissions reduction from increasing renewable content through behind-the-meter PV systems in a given year, in MT CO_2e
$\Delta\, E_{electricity,RE,n}$	= total emissions reduction from increasing renewable electricity supply in a given year, in MT CO_2e, refer to Equation 6
$P_{PV,n}$	= percent of gross generation supplied by behind-the-meter PV systems in a given year (%), calculation based on Equation 10
RE_{PV}	= 100%, renewable content of PV supply (%)
$RE_{electricity,n}$	= overall renewable content of the electricity supply (gross generation) in a given year (%), refer to Equation 4

With,

n = a CAP horizon year, from baseline year to CAP horizon end year

Using the same example discussed in Section 5.5.1.3, the total emissions reduction from increasing renewable supply is 4.16 MMT CO_2e in 2035 ($\Delta E_{electricity,RE,2035}$). Using this method, the emissions reduction from behind-the-meter PV, which supplies 13% of the gross generation with 100% renewable in 2030, is calculated in Equation 12.

Equation 12 Example of Emissions Reduction from Behind-the-meter PV Providing Renewable Electricity

$$\Delta E_{electricity,PV,2035} = \Delta E_{electricity,RE,2035} * \left(\frac{P_{PV,2035} * RE_{PV,2035}}{RE_{electricity,2035}}\right) = 4.16 * \left(\frac{13\% * 100\%}{91\%}\right) = 0.57\ MMT\ CO_2e$$

This example focuses on State measures that affect behind-the-meter PV. However, CAPs generally include measures to increase behind-the-meter PV supply, such as requiring PV systems on newly constructed homes and installing PV on municipal facilities. Examples of local measures that increase renewable supply are given in Section 5.5.1.5.

Local measures to increase behind-the-meter PV are likely associated with the State's solar program. For example, locally-required PV installations on new construction may receive financial incentives from the New Solar Homes Partnership to reduce the upfront cost. To avoid double-counting the reductions from behind-the-meter PV, local CAP measures that increase behind-the-meter PV supply are subtracted from the expected statewide total of increasing behind-the-meter PV.

Emissions reductions from all PV measures, calculated using Equation 11, are allocated to local CAP measures based on the estimated solar capacity from each local action; the remaining capacity and emissions reduction are attributed to State solar policies and programs, as shown in Equation 13.

Equation 13 Emissions Reduction from Increasing Renewable Supply through California Solar Polices and Programs

$$\Delta E_{electricity,PV-state,n} = \Delta E_{electricity,PV,n} * \left(\frac{C_{PV,local,n} - C_{PV,CAP\ measures,n}}{C_{PV,local,n}}\right)$$

Where

$\Delta E_{electricity,PV-state,n}$ = emissions reduction from increasing renewable content through State solar policies and programs in a given year, in MT CO_2e

$\Delta E_{electricity,PV,n}$ = emissions reduction from increasing renewable content through behind-the-meter PV systems in a given year, in MT CO_2e

$C_{PV,local,n}$ = estimated capacity of the behind-the-meter PV systems in a jurisdiction in a given year, in MWs (dc)

$C_{PV,CAP\ measures,n}$ = estimated capacity of the behind-the-meter PV systems in a jurisdiction in a given year, as a result of CAP measures, in MWs (dc)

With,

n = a CAP horizon year, from baseline year to CAP horizon end year

In the example given in Equation 12, the emissions reduction from all PV providing renewable electricity (0.57 MMT CO_2e, $\Delta E_{electricity,PV,2035}$) is the result of both State solar programs and local CAP measures. The local CAP measures would result in 100 MW PV installation in the jurisdiction, while the estimated 2035 jurisdiction-wide PV capacity would be 900 MW. Equation 14 below shows the allocation of emissions reductions to State solar programs based on the capacity.

Equation 14 Example of Emissions Reduction from Increasing Renewable Supply through California Solar Polices and Programs

$$\Delta E_{electricity,PV-state,2035} = \Delta E_{electricity,PV,2035} * \left(\frac{C_{PV,local,2035} - C_{PV,CAP\ measures,,2035}}{C_{PV,local,2035}}\right)$$

$$= 0.57 * \left(\frac{900\ MW - 100\ MW}{900\ MW}\right) = 0.50\ MMT\ CO_2e$$

5.5.1.5 Local CAP Measures to Increase Renewable Electricity

The 2017 Scoping Plan recommends “local governments can also incentivize locally generated renewable energy...” as one of the local actions to reduce GHG emissions (CARB 2017b, p. 97). All of the currently adopted CAPs in the San Diego region have measures to increase renewable electricity through local CAP measures, including, but not limited to:

- Adopt ordinances to require new homes and commercial buildings to install PV systems;
- Provide local incentives or financing programs to encourage PV systems installation at existing homes and commercial buildings; and
- Achieve 100% renewable electricity through a CCA or similar program.

Figure 21 shows three examples of measures in currently adopted CAPs that aim to increase renewable electricity.

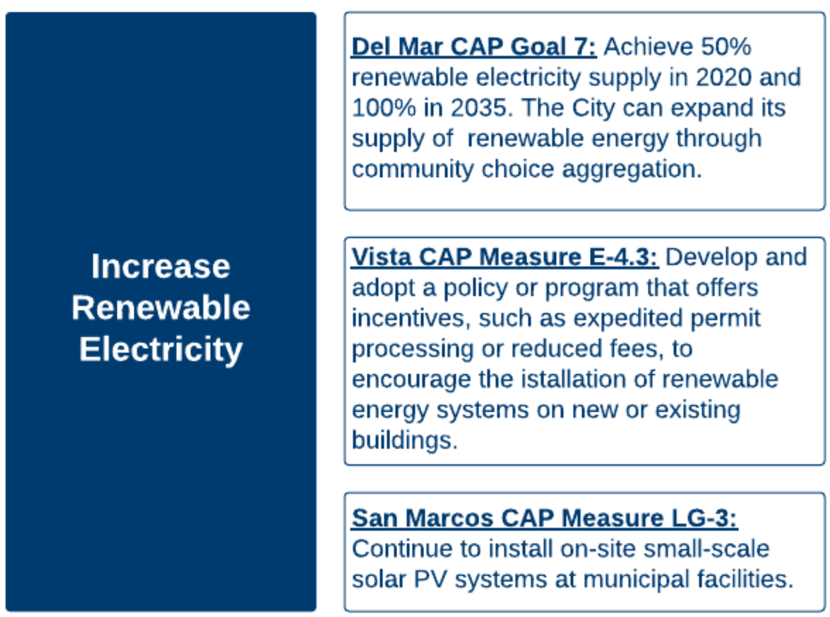


Figure 21 Examples of CAP Measures to Increase Renewable Electricity (Del Mar 2016, Vista 2013, and San Marcos 2013)

The following are the emissions reduction calculations for two typical CAP measures that increase renewable electricity.

Local Renewable Program

Local jurisdictions often include a local renewable program in their CAPs to reach a renewable electricity goal that is higher than required by State law. The local renewable program could be an additional electricity supply option, such as CCA or other local renewable programs. Such a program would have to supply electricity that meets RPS requirements but could provide higher levels of renewable electricity supply. In the San Diego region, several CAPs include goals to achieve 100% renewable electricity supplies.

As discussed in Section 5.5.1.4, a portion of the emissions reductions from the local renewable program would be attributed to RPS compliance and included in statewide emissions reductions, while the remaining reductions would be attributed to the local CAP measure. The allocation method and attribution to RPS-compliant supply ($\Delta\, E_{electricity,RPS,n}$) are discussed in Section 5.5.1.4 and Equation 9. The method to estimate GHG emissions reductions from local renewable measures is provided in Equation 15 .

Equation 15 Emission Reduction Calculation for Local Renewable Program

$$\Delta\, E_{electricity,CAP\ measure,n} = \Delta\, E_{electricity,Local\ RE,n} - \Delta\, E_{electricity,RPS\ ,n}$$

Where

$\Delta\, E_{electricity,CAP\ measure,n}$	= emissions reduction in electricity category through local renewable program in a given year, attributed to a local CAP measure, in MT CO_2e
$\Delta\, E_{electricity,Local\ RE,n}$	= emissions reduction of local renewable program in a given year, in MT CO_2e
$\Delta\, E_{electricity,RPS,n}$	= emissions reduction of local renewable program in a given year, in compliance with RPS, in MT CO_2e

With,

n	= a CAP horizon year, from baseline year to CAP horizon end year

PV Installation Ordinance

Local jurisdictions may include a CAP measure to adopt an ordinance that requires new homes and/or new commercial buildings to install PV systems. The estimated electricity generation from PV systems because of the ordinance is calculated using Equation 16.

Equation 16 Estimate Electricity Generation from PV Installation Ordinance

$$Elec_{PV,CAP\ measure,n} = \sum_{unit} (N_{unit,n} * C_{unit,PV}) * 20\% * 8{,}760 * 10^{-3}$$

Where

$Elec_{PV,CAP\ measure,n}$	= annual electricity generation from behind-the-meter PV systems in a jurisdiction in a given year, as a result of a CAP measure, in MWh
$N_{unit,n}$	= number of housing units or sq. ft. of commercial spaces affected by a CAP measure, after CAP baseline year up to year n
$C_{unit,PV}$	= capacity requirement of the PV system in the ordinance, for each type of unit, kW (dc) for housing units or kW (dc)/sq. ft. for commercial spaces
20%	= average solar system capacity factor, ratio of average energy generated compared with nameplate capacity, in kWh/kW
8,760	= hours per year
10^{-3}	= conversion factor, MWh in a kWh

With,

n = a CAP horizon year, from baseline year to CAP horizon end year

unit = including, but not limited to: new single-family unit, new multi-family unit, new commercial spaces, etc.

The data needs for calculating electricity generation from a PV ordinance are given in Table 6.

Table 6 Data/Information Needs Table for Emissions Reduction Calculation – PV Installation Ordinance

Data/Information Needs	Data Timeframe	Data Source
Number of new housing units each year by type (single-family, multi-family, etc.) $N_{unit,n}$	CAP horizon years	Jurisdiction (for recent years) or SANDAG (for forecast)
Square footage of new commercial space $N_{unit,n}$	CAP horizon years	Jurisdiction
PV system capacity requirement in the ordinance $C_{unit,PV}$	n/a	Jurisdiction, literature, and case studies

Jurisdictions can require different PV system capacity in new construction depending on the weather, location, and historical data of PV installations. The capacity requirement for residential units could be based on housing unit type and/or housing unit square footage. For example, the City of Santa Monica's adopted solar ordinance is based on square footage. It requires a minimum of 1.5 watts per-square foot (1.5 W/ sq. ft.) for single-family units and a minimum of two watts per square foot of building footprint (2 W/ sq. ft.) for low-rise multi-family units (City of Santa Monica, 2017). On the other hand, the City of Lancaster's mandatory solar requirements for new homes are based on capacity per-unit, with a minimum capacity requirement for each housing type (City of Lancaster, 2016). The New Solar Homes Partnership has a database of installed systems that can provide information to inform the development of a PV system requirement for new homes.

Local homeowners may install PV systems under the requirement of a local PV ordinance but receive benefits from State solar policies and programs. To avoid overestimating emissions reductions from PV, the maximum amount of behind-the-meter PV capacity and GHG reductions are capped at the projection associated with State solar programs and policies, as discussed in Section 5.5.1.4. The emissions reduction allocation to local CAP measures based on the estimated solar capacity that would result from each measure, is calculated using Equation 17.

Equation 17 Emissions Reduction from Increasing Renewable Supply through PV Installation Ordinance

$$\Delta\, E_{electricity,CAP\ measure,n} = \Delta\, E_{electricity,PV,n} * \frac{C_{PV,CAP\ measure,n}}{C_{PV,local,n}}$$

Where,

$\Delta\, E_{electricity,CAP\ measure,n}$ = emissions reduction in electricity category through a CAP measure (PV installation ordinance) in a given year, in MT CO_2e

$\Delta\, E_{electricity,PV,n}$ = emissions reduction of increasing renewable content through behind-the-meter PV systems in a given year, in MT CO_2e (Equation 11)

$C_{PV,local,n}$ = estimated capacity of the behind-the-meter PV systems in a jurisdiction in a given year, in MW (dc)

$C_{PV,CAP\ measure,n}$ = estimated capacity of the behind-the-meter PV systems in a jurisdiction in a given year, as a result of a CAP measure, in MW (dc)

With,

n = a CAP horizon year, from baseline year to CAP horizon end year

Using the example already provided in Equation 12, the emissions reduction from all PV providing renewable electricity (0.57 MMT CO_2e, $\Delta E_{electricity,PV,2035}$) is the result of both State solar programs and local CAP measures. The local CAP requirements would result in 100 MW PV installation in the jurisdiction, while the estimated 2035 jurisdiction-wide PV capacity would be 900 MW. Figure 18 below shows the allocation of emissions reduction to the local CAP measure based on the capacity.

Equation 18 Example of Emissions Reduction from Increasing Renewable Supply through PV Installation Ordinance

$$\Delta E_{electricity,PV\ ordinance,2035} = \Delta E_{electricity,PV,2035} * \left(\frac{C_{PV,PV\ ordinnce,2035}}{C_{PV,local,2035}}\right) = 0.57 * \left(\frac{100\ MW}{900\ MW}\right) = 0.07\ MMT\ CO_2e$$

5.5.2 Increase Building Efficiency

Increasing residential and commercial building efficiency reduces building energy use and, therefore, as long as supply is fossil-fuel based, also reduces GHG emissions. In general, the emissions reductions from building efficiency are calculated by multiplying energy reduction and the emission factor of the associated type of energy. The energy reduction amount depends on the measures, while the emission factors used are either the weighted average electricity emission factor ($EF_{electricity,n}$) or the fixed natural gas emission factor ($EF_{NG,n}$).

The approach for calculating GHG emissions reductions from State regulations and local CAP measures that increase building efficiency are described in the following sections.

5.5.2.1 California Regulations to Increase Building Efficiency

California has a range of statewide policies and programs to reduce energy use, such as building codes and standards, appliance standards, utility efficiency programs and other incentives, and rate structures. These programs help to reduce energy use in local jurisdictions and are accounted for as State measures in a CAP.

California Energy Efficiency Programs – Energy Efficiency Targets for IOUs

Since 2004, CPUC has adopted energy efficiency program portfolio performance targets for IOUs. CPUC adopts annual and 10-year cumulative goals for electricity and natural gas savings and allows the IOUs to develop their own programs and portfolios to achieve these goals. The most recent study, *Energy Efficiency Potential and Goals Study for 2018 and Beyond,* evaluates the energy efficiency potential from 2018 to 2030 during the post-2017 energy efficiency rolling portfolio planning cycle (CPUC, 2017). The study separates the overall energy efficiency goals into two categories: (1) rebate programs including behavior programs, and (2) net codes and standards that can be claimed by IOUs above and beyond what can be expected from statewide appliance and building standards.

SDG&E administers energy efficiency programs in the San Diego region. The total potential energy savings in the San Diego region (SDG&E service territory) can be allocated to each jurisdiction based on the proportion of a local jurisdiction's gross generation compared to the total for the SDG&E service territory. Jurisdictions may include building efficiency measures in the CAP, such as energy conservation ordinances and implementing efficiency retrofits at municipal facilities, which are likely to be associated with a State energy efficiency program. For example, local homeowners might perform energy audits for a major renovation under the requirement of the local residential energy conservation ordinance and use incentives from SDG&E's energy efficiency programs for the retrofit. To avoid double-counting, the energy and emissions reduction from any potential local building efficiency CAP measures that may overlap with State energy efficiency programs are subtracted in calculating the impact of the State programs.

The emissions reductions from reducing energy use (electricity and natural gas) under the State energy efficiency programs are estimated using Equation 19 for electricity savings and Equation 20 for natural gas savings.

Equation 19 Electricity Emissions Reduction from California Energy Efficiency Programs

$$\Delta E_{electricity,BE-State,n} = \Delta Elec_{BE-regional,n} * P_{electricity,Local-regional} * EF_{electricity,n} * 0.000453 - \Delta E_{electricity,BE-local,n}$$

Where

$\Delta E_{electricity,BE-state,n}$	= total emissions reduction from State energy efficiency program for a jurisdiction in a given year, in MT CO_2e
$\Delta Elec_{BE-regional,n}$	= annual electricity savings from State energy efficiency program in the SDG&E service area in a given year compared with CAP baseline year, in MWh
$P_{electricity,local-regional}$	= ratio of the gross generation (or net energy for load) of a jurisdiction to that of SDG&E service area, in CAP baseline year or average of most recent years
$EF_{electricity,n}$	= emission factor for the electricity (gross generation) in a jurisdiction in a given year, in lbs. CO_2e per MWh
$\Delta E_{electricity,BE-local,n}$	= total emissions reduction from CAP local building efficiency measures in a given year, in MT CO_2e
0.000453	= conversion factor, MT CO_2e in alb.

With,

n	= a CAP horizon year, from baseline year to CAP horizon end year

Equation 20 Natural Gas Emissions Reduction from California Energy Efficiency Programs

$$\Delta E_{NG,BE-State,n} = \Delta NG_{BE-regional,n} * P_{NG,Local-regional} * EF_{NG,n} - \Delta E_{NG,BE-local,n}$$

Where

$\Delta E_{NG,BE-state,n}$	= total emissions reduction from State energy efficiency programs for a jurisdiction in a given year, in MT CO_2e
$\Delta NG_{BE-regional,n}$	= annual natural gas savings from State energy efficiency programs in the SDG&E service area in a given year comparing with CAP baseline year, in therms
$P_{NG,Local-regional}$	= ratio of the natural gas use of a jurisdiction to that of SDG&E service area, in CAP baseline year or average of most recent years
$EF_{NG,n}$	= emission factor of natural gas in a jurisdiction in a given year, in MT per therm
$\Delta E_{NG,BE-local,n}$	= total emissions reduction from CAP local building efficiency measures in a given year, in MT CO_2e

With,

n	= a CAP horizon year, from baseline year to CAP horizon end year

To make sure the proportionate energy savings from the SDG&E service area to local jurisdictions are within a reasonable range of the actual energy savings from these programs, they can be compared with the actual energy efficiency savings in the jurisdiction from the SDG&E programs for the years when data are available. By request, SDG&E may provide the number of participants, estimated demand (kW), energy savings (kWh and therms), and the incentives in a jurisdiction expected through its energy efficiency programs. This allows for a valuable comparison to assess the energy savings allocated to local jurisdictions but is not used to determine future distribution of total energy efficiency savings among jurisdictions.

The data needs for calculating emissions reduction of State energy efficiency programs are given in Table 7.

Table 7 Data/Information Needs Table for Emissions Reduction Calculation – California Energy Efficiency program

Data/Information Needs	Data Timeframe	Data Source
Jurisdiction's net energy for load or gross generation, and natural gas use $P_{electricity,local-regional}$, $P_{NG,Local-regional}$	CAP baseline year to most recent year	From jurisdiction's emissions inventory
SDG&E service area's net energy for load or gross generation, and natural gas use $P_{electricity,local-regional}$, $P_{NG,Local-regional}$	CAP baseline year to most recent year	SDG&E, CEC energy demand forecast (historical value)
SDG&E service area annual electricity and natural gas saving estimates under the State energy efficiency programs $\Delta\ Elec_{BE-regional,n}$, $\Delta\ NG_{BE-regional,n}$	CAP horizon years	CPUC/Navigant Energy Efficiency Potential and Goals Study
Actual energy savings from SDG&E energy efficiency programs in the jurisdiction	CAP baseline year to recent years	SDG&E (by request)

The most recent CEC California Energy Demand 2018-2030 Revised Forecast contains historical values up to 2016 for net energy load and gross generation for the SDG&E planning area (CEC, 2018). For the *CPUC Energy Efficiency Potential and Goals* study, the most recent "2018 and beyond" study includes the estimates from 2018 to 2030. The energy savings reported in the studies are often cumulative savings and need to be converted to annual savings in a CAP horizon year to compare to the CAP baseline year.

SB 350: Doubling Energy Efficiency Savings by 2030

SB 350 (De León, 2015) directs the CEC, by November 1, 2017, to establish an energy efficiency target that achieves a statewide cumulative doubling of energy efficiency savings in electricity and natural gas final end use by 2030. CEC developed a final Commission report that proposed separate targets for electricity and natural gas savings. Once the targets for the SDG&E planning area are formally adopted by the CEC, the emissions reductions at local jurisdictions from SB 350 will be incorporated into local CAPs and future versions of this Appendix.

5.5.2.2 Local CAP Measures to Increase Building Efficiency

All of the currently adopted CAPs in the San Diego region have measures to increase building efficiency, in part because local governments have the authority to adopt building ordinances and to update local building codes to exceed minimum standards in the State building code. Energy efficiency CAP measures could apply to new construction, existing buildings, and residential and/or commercial/industrial buildings. Measures include, but are not limited to:

- Update local building codes for higher energy standards than the State-mandated building standards for new construction;
- Update local building codes to require renewable energy sources (e.g., solar) be used to heat water; and
- Adopt energy conservation ordinances that require building energy disclosure and benchmarking.

Figure 22 shows three examples of measures in currently adopted CAPs that aim to increase building efficiency.

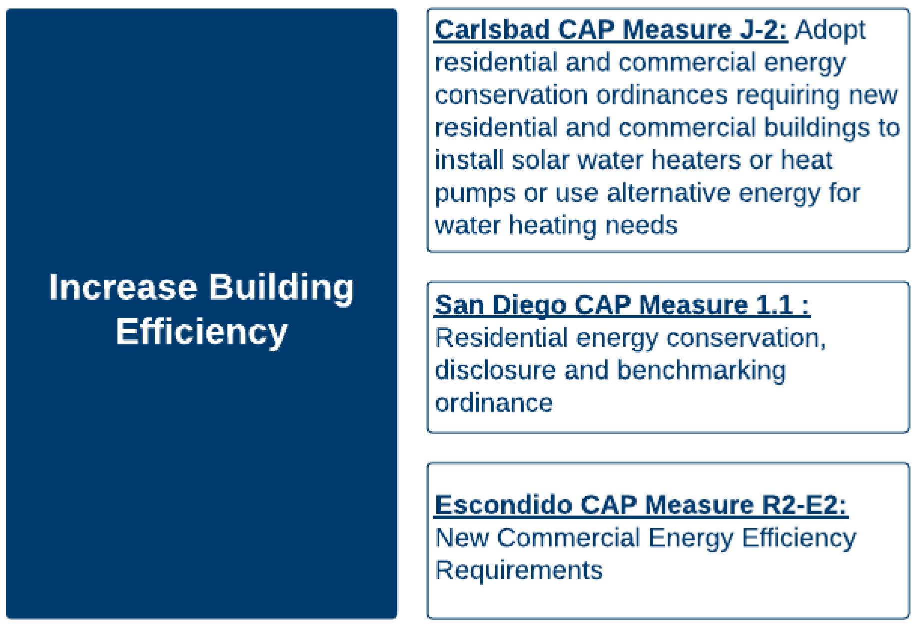


Figure 22 Example of CAP Measures to Increase Building Efficiency (Carlsbad 2015, Escondido 2013, and San Diego 2015)

The following are the emission reduction calculations for two typical CAP measures that increase building efficiency.

Require Energy Disclosure and Benchmarking of Existing Residential Homes

CAP measures may require energy disclosure and benchmarking of existing homes upon application for a permit to remodel or upon resale. Best practices from existing energy disclosure ordinances and programs show that after completing energy audits or benchmarking, a percentage of homeowners will perform energy retrofits and implement energy efficiency activities. For example, a study on the City of Austin's Energy Conservation Audit and Disclosure program indicates about 12% of residential units that complete energy audits will undergo the suggested energy retrofits (City of Austin, 2012).

By requiring energy disclosure and benchmarking of existing homes, the emissions reduction from reducing energy (electricity and natural gas) use can be calculated using Equation 21 for electricity and Equation 22 for natural gas.

Equation 21 Electricity Emissions Reduction from Residential Energy Audits

$$\Delta\, E_{electricity,CAP\ measure,n} = \sum_{unit} (N_{unit,n} * P_{audits-retrofits} * \Delta\, Elec_{unit,n}) * \ EF_{electricity,n} * 0.000453$$

Where

$\Delta\, E_{electricity,CAP\ measrue,n}$	= total emissions reduction in electricity category from residential energy audits in a given year, in MT CO_2e
$N_{unit,n}$	= number of housing units affected by this measure (completed energy audits), after CAP baseline year up to year n
$P_{audits-retrofits}$	= % of the units completed audits that perform energy retrofits (depends on the jurisdiction; 12% in City of Austin case study)
$\Delta\, Elec_{unit,n}$	= average annual electricity saving from energy retrofits, kWh (depends on types of energy retrofits; generally 15% of average electricity use at homes) [jurisdiction-specific] or energy upgrade program data [regional-specific])
$EF_{electricity,n}$	= emission factor of the electricity (gross generation) in a jurisdiction in a given year, in lbs. CO_2e per MWh
0.000453	= conversion factor, MT CO_2e in a lb.

With,

n	= a CAP horizon year, from baseline year to CAP horizon end year
unit	= including, but not limited to: retrofitted single-family unit, retrofitted multi-family unit

Equation 22 Natural Gas Emissions Reduction from Residential Energy Audits

$$\Delta\, E_{NG,CAP\ measure,n} = \sum_{unit} (N_{unit,n} * P_{audits-retrofits} * \Delta\, NG_{unit,n}) * \ EF_{NG,n}$$

Where

$\Delta\, E_{NG,CAP\ measure,n}$	= total emissions reduction in natural gas category from residential energy audits in a given year, in MT CO_2e
$N_{unit,n}$	= number of housing units affected by this measure (completed energy audits) after CAP baseline year up to year n
$P_{audits-retrofits}$	= % of the units completed audits that perform energy retrofits (depends on the jurisdiction; 12% in City of Austin case study)
$\Delta\, NG_{unit,n}$	= average annual natural gas saving from energy retrofits, therms (depends on types of energy retrofits; generally, 15% of average electricity use at homes) [jurisdiction-specific] or energy upgrade program data [regional-specific])
$EF_{NG,n}$	= emission factor of the natural gas in a jurisdiction in a given year, in MT per therm

With,

n	= a CAP horizon year, from baseline year to CAP horizon end year
unit	= including, but not limited to: retrofitted single-family unit, retrofitted multi-family unit

The data needs for calculating emissions reduction of a typical residential energy disclosure and conservation ordinance are given in Table 8.

Table 8 Data/Information Needs Table for Emissions Reduction Calculation – Residential Energy Disclosure and Conservation Ordinance

Data/Information Needs	Data Timeframe	Data Source
Number of housing units or percentage of total housing units effected by the energy disclosure and conservation ordinance (number of building permits, housing units sold) $N_{unit,n}$	CAP baseline year to most recent year	Jurisdiction and other agency
Number of existing housing units by type	CAP baseline year	Jurisdiction or SANDAG
Energy savings from a typical residential energy retrofit $\Delta\, NG_{unit,n}$, $\Delta\, Elec_{unit,n}$	CAP baseline year to most recent year	Jurisdiction, Center for Sustainable Energy (CSE), CPUC or CEC reports
Percentage of units that complete audits that perform energy retrofits $P_{audits-retrofits}$	n/a	Literature and case studies

The data input and emissions reduction calculated are given in Table 9 for a sample jurisdiction that requires all existing residential units seeking building permits for a remodel to perform energy audits; on average, 200 of these permits are issued every year.

Table 9 Require Energy Disclosure and Benchmarking of Existing Residential Example

Year	Homes Completing Energy Audits after Baseline Year	Homes Implementing Energy Retrofit after Baseline Year	Electricity Reduction per Home (kWh/year)	Natural Gas Reduction per Home (therms/year)	Electricity Emission Factor (lbs CO_2e/MWh)	Natural Gas Emission Factor (MT CO_2e/therm)	Emissions Reduction (MT CO_2e)
2030	3,000	360	1,200	60	400	0.0054	195

Requiring Solar Water Heaters in New or Existing Homes

Replacing electric and natural gas water heaters with solar water heaters (or other systems with renewable energy as the primary energy source) reduces conventional energy use. The method to calculate emissions reduction from replacing electric and natural gas water heaters with solar water heaters is given in Equation 23 for electricity and Equation 24 for natural gas.

Equation 23 Emissions Reduction from Replacing Electric Water Heater with Solar Water Heater

$$\Delta\, E_{electricity,CAP\ measure,n} = \sum_{unit} (N_{unit,n} * P_{EWH} * \Delta\, Elec_{unit,n}) * \ EF_{electricity,n} * 0.000453$$

Where

$\Delta\, E_{electricity,CAP\ measure,n}$ = total emissions reduction in electricity category from replacing electric water heaters with solar water heaters in a given year, in MT CO_2e

$N_{unit,n}$ = number of housing units affected by this measure after CAP baseline year up to year n

P_{EWH} = percentage of existing water heaters that are electric water heaters (%), 40% in general (California DG Statistics, 2017)

$\Delta\, Elec_{unit,n}$ = average annual electricity saving by replacing an electric water heater with a solar water heater, kWh. 2,849 kWh/heater in single-family homes based on 2010-2015 rebates data in San Diego region (California DG Statistics, 2017)

$EF_{electricity,n}$ = emission factor of the electricity (gross generation) in a jurisdiction in a given year, in lbs. CO_2e per MWh

0.000453 = conversion factor, MT CO_2e in a pound

With,
n = a CAP horizon year, from baseline year to CAP horizon end year
unit = including, but not limited to: new single-family unit, new multi-family unit, retrofitted single-family unit, retrofitted multi-family unit

Equation 24 Emissions Reduction from Replacing Natural Gas Water Heater with Solar Water Heater

$$\Delta E_{NG,CAP\ measure,n} = \sum_{unit} (N_{unit,n} * P_{NGWH} * \Delta NG_{unit,n}) * EF_{NG,n}$$

Where
$\Delta E_{NG,CAP\ measure,n}$ = total emissions reduction in natural gas category from replacing natural gas water heaters with solar water heaters in a given year, in MT CO_2e
$N_{unit,n}$ = number of housing units affected by this measure after CAP baseline year up to year n
P_{NGWH} = percentage of existing water heaters that are natural gas water heaters (%), 60% in general (California DG Statistics, 2017)
$\Delta NG_{nit,n}$ = average annual natural gas saving by replacing a natural gas water heater with solar water heater, therm. 109 therms/heater in single-family homes based on 2010-2015 rebates data in San Diego region (California DG Statistics, 2017)
$EF_{NG,n}$ = emission factor of the natural gas in a jurisdiction in a given year, in MT per therm

With,
n = a CAP horizon year, from baseline year to CAP horizon end year
unit = including, but not limited to: new single-family unit, new multi-family unit, retrofitted single-family unit, retrofitted multi-family unit

The data needs for calculating emissions reductions for a measure requiring new homes to install solar water heaters are given in Table 10.

Table 10 Data/Information Needs Table for Emissions Reduction Calculation – Require New Homes to Install Solar Water Heaters

Data/Information Needs	Data Timeframe	Data Source
Number of housing units affected by the measure (new housing units, number of building permits issued) $N_{unit,n}$	CAP baseline year to most recent year	Jurisdiction
Projected number of housing units affected by the measure every year by type (single-family, multi-family, etc.) $N_{unit,n}$	CAP horizon years	Jurisdiction, SANDAG
Average annual energy savings upon replacing electric/natural gas water heater with solar water heater $\Delta NG_{unit,n}$, $\Delta Elec_{unit,n}$	n/a	California DG Statistics

For commercial buildings, the energy used for water heating depends on the building type. For example, water heating energy use for office buildings, hotels, and restaurants varies significantly. Instead of using energy savings per water heater and the number of water heaters replaced, average energy intensity for water heating (kbtu/sq. ft.) for each type of commercial building, the square footage, and whether the building was newly built or retrofitted can be substituted in Equation 23 and Equation 24.

The *California Commercial End-Use Survey* provides commercial building survey data for water heating energy intensity for buildings in the SDG&E service territory; the National Renewable Energy Lab's (NRELs) solar fraction water heating model estimates the contribution of solar energy toward the total energy delivered to water tanks (Itron 2006, NREL).

5.6 Emissions Reduction from On-road Transportation Related Measures

Emissions reductions from on-road transportation related measures generally fall into three categories:

- Improve vehicle fuel efficiency
- Reduce VMT
- Reduce fuel use through improved traffic flow

The following sections describe the methods and data needs for calculating GHG emissions reductions from state regulations and local CAP measures within these categories.

5.6.1 Improve Vehicle Fuel Efficiency

This section discusses the general method to estimate GHG reductions from measures that reduce tailpipe emissions from vehicles through efficiency standards and increase ZEVs, which includes the following calculations:

- Average vehicle emission factor in San Diego region
- Emissions reductions from federal and State regulations
- CAP measures that increase ZEVs

5.6.1.1 Average Vehicle Emission Factor in San Diego Region

As discussed in Technical Appendix 1, the CARB Mobile Source Emissions Inventory EMFAC2014 model is used to determine the average GHG emission factor for vehicles in the San Diego region. The average GHG emission factor for the San Diego region is used for all jurisdictions in the region. The EMFAC2014 model results include the effect of all key federal and State regulations related to tailpipe emissions standards that were adopted before the 2015 model release date. The regulations accounted for in the model are:

- Federal Corporate Average Fuel Economy (CAFE) standards and California Advanced Clean Car (ACC) Program for passenger cars and light-duty vehicles. The State's ACC program includes tailpipe emissions standards equivalent to the CAFE standards for vehicle model years 2017-2025, and a ZEV program that requires manufacturers to produce increasing numbers of ZEVs and plug-in hybrid electric vehicles for model years 2017-2025 (CARB, 2015).
- U.S. Environmental Protection Agency (EPA)'s Phase I GHG Regulation and CARB Tractor-Trailer GHG Regulation for heavy-duty vehicles (heavy-duty trucks, tractors, and buses). This regulation includes GHG emission standards for model year 2014-2018 heavy-duty vehicles, and CARB's Tractor-Trailer GHG Regulation includes the aerodynamic and tire improvements requirements to reduce GHG emissions from heavy-duty trucks (CARB, 2015).

The Low Carbon Fuel Standard (LCFS), which requires a reduction of at least 10% in the carbon intensity of California's transportation fuels by 2020, is not included in the EMFAC2014 model; most of the emissions reduction benefits come from changes in the production phase of the fuel cycle rather than the combustion phase in vehicles. Therefore, the LCFS does not have a significant impact on tailpipe GHG emissions reduction (CARB, 2015). In the previous version of the Mobile Source Emissions Inventory model, EMFAC2011, the emissions impacts of the LCFS were provided in the model output.

The average vehicle emission factor for each CAP horizon year is calculated using the method for emissions from the on-road transportation category described in Technical Appendix I, and is based on both the distribution of VMT in each vehicle class and its emission rate (Equation 25).

Equation 25 Average Vehicle Emission Factor Calculation

$$EF_{transp,n} = \sum_{class,fuel} (VMT\ Distr_{class,fuel,n} * \ CO_2\ RUNEX_{class,fuel,n}) * 1.01$$

Where

$EF_{transp,n}$	= average vehicle CO_2 emission factor of all vehicle classes and fuel types in the San Diego region, in a given year (grams CO_2e per mile)
$VMT\ Distr_{class,fuel}$	= Percentage of total VMT for a given vehicle class with a given fuel, in a given year (%)
$CO_2\ RUNEX_{class,fuel}$	= CO_2 running exhaust emissions for a given vehicle class with a given fuel, in a given year (grams CO_2 per mile)
1.01	= Conversion factor from CO_2 to CO_2e
$Class$	= EMFAC2011 vehicle class categories, EMFAC2014 Technical Documentation Table 6.1
$Fuel$	= Gas, Diesel, Electric
n	= CAP horizon year, from baseline year to CAP horizon end year

Using Equation 25 and EMFAC results, the average vehicle emission factors from 2015-2050 in the San Diego region are shown in Figure 20 below. These emission factors include the effect of all federal and State regulations related to tailpipe GHG reductions adopted before 2015.

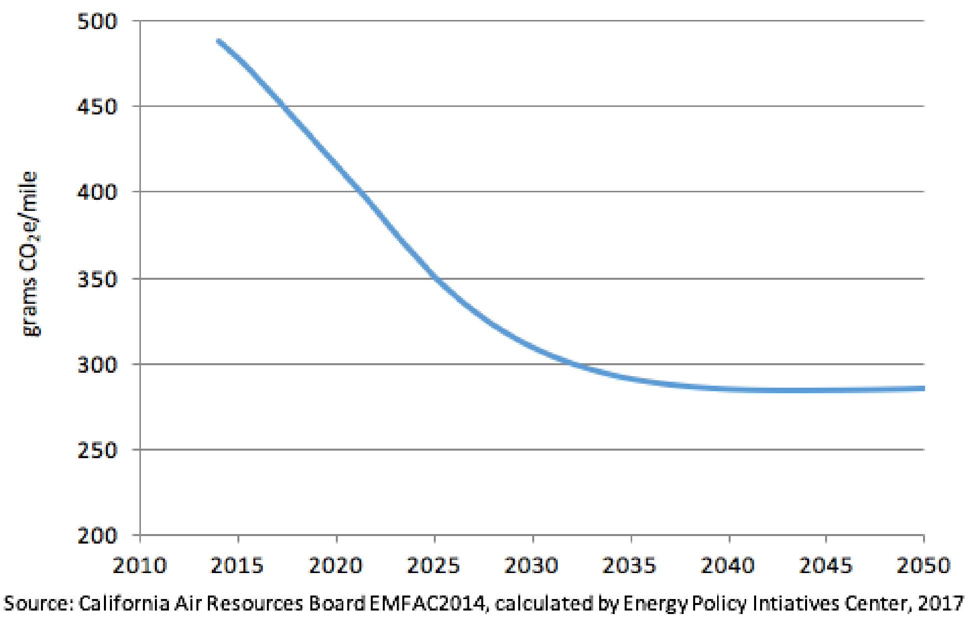


Figure 23 Average Vehicle Emission Factor in San Diego Region (2015-2050)

As new and more efficient vehicles replace older vehicles and the number of ZEVs increases, the average vehicle emission factor decreases over time. Regulations related to tailpipe GHG emissions reductions accounted for in EMFAC2014 apply to new vehicles up to model year 2025, after which the decrease in the average vehicle emission factor levels off, as shown in Figure 23.

Because the average vehicle emission factor decreases over time, CAP measures that reduce VMT yield a smaller amount of GHG emissions reductions in later CAP horizon years.

CARB released the latest model version, EMFAC2017, in March 2018 and is awaiting EPA approval for use in transportation conformity analysis. EMFAC2017 includes an updated ZEV sales forecast based on a 2017 midterm review of the ACC program and a GHG module that provides GHG emission estimates directly, including CO_2, CH_4 and N_2O, assuming complete combustion of the fuel (all carbon content of the fuel is converted to CO_2) and CH_4 and N_2O emission rates based on CARB vehicle testing data. No off-model CO_2 to CO_2e emission factor conversion will be needed once EMFAC2017 is approved. EMFAC2017 also incorporates new federal and State regulations related to tailpipe emissions standards that were adopted as of December 2017. The additional regulations and policies reflected in EMFAC2017 include 1) EPA Phase 2 GHG standards for heavy-duty vehicles, and 2) CARB's Truck and Bus Regulation compliance requirement before registration for medium-duty and heavy-duty vehicles through SB1. Even through there is no update on the ZEV regulation, EMFAC2017 refined the assumptions and inputs for ZEV forecast.

5.6.1.2 Federal and State Regulations to Improve Vehicle Fuel Efficiency

As discussed in Section 5.6.1.1 above, the EMFAC2014 model accounts for all key federal and State regulations related to tailpipe GHG emissions. The emissions reductions due to federal and State regulations are the difference between the BAU average vehicle emission factor and the average vehicle emission factors from EMFAC (calculated using Equation 25). The reduction is calculated using Equation 26 below. In previous EMFAC versions, it was possible to calculate the effects of individual federal and

State regulations. However, because EMFAC2014 provides only the projections of the effects of all regulations combined, the emissions reductions due to federal and State regulations are calculated using Equation 26.

Equation 26 Emissions Reduction Calculation: Reducing Tailpipe Emissions and ZEVs

$$\Delta E_{transp,FE,n} = VMT_n * \Delta EF_{transp,n} * 10^{-6}$$

Where,

$\Delta E_{transp,FE,n}$ = total emissions reduction in transportation category from increasing vehicle fuel efficiency and ZEVs in a given year, in MT CO_2e

VMT_n = VMT in a given year, miles per year

$\Delta EF_{transp,n}$ = difference in average vehicle emission factor in a given year calculated using Equation 25 and BAU average GHG emission factor, in grams CO_2e per mile

10^{-6} = conversion factor, MT per gram CO_2e

With,

n = a CAP horizon year, from baseline year to CAP horizon end year

Using Equation 26, an example of the emissions reduction calculation is given in below Table 11.

Table 11 Example of Emissions Reduction from Increasing Tailpipe Emission Standards and Zero Emission Vehicles

Year	Total VMT (miles/year) VMT_{2030}	Average Vehicle Emission Factor (g CO_2e/mile)		Difference in Average Vehicle Emission Factor (g CO_2e/mile) $\Delta EF_{transp,2030}$	Emissions Reduction (MT CO_2e) $\Delta E_{transp,FE,2030}$
		With no Policy Impact after Baseline Year (Business-as-usual)	With impact of Adopted Policies		
2030	545,645,333	406	297	109	59,932

Separating the Effects of the State's ZEVs Program

It is possible to estimate the GHG emissions reduction associated with ZEVs. An estimated ZEV penetration rate for new passenger cars, based on the goals set for California ZEV program, is included in EMFAC2014. EMFAC2014 assumes 2% of all new passenger car sales in 2016 are ZEVs. This increases to 15% in 2025 and remains constant for all years after 2025 (CARB, 2015). The ZEV penetration rate from 2016-2050 and estimated miles driven by ZEVs as a percentage of total miles are given in Figure 24.

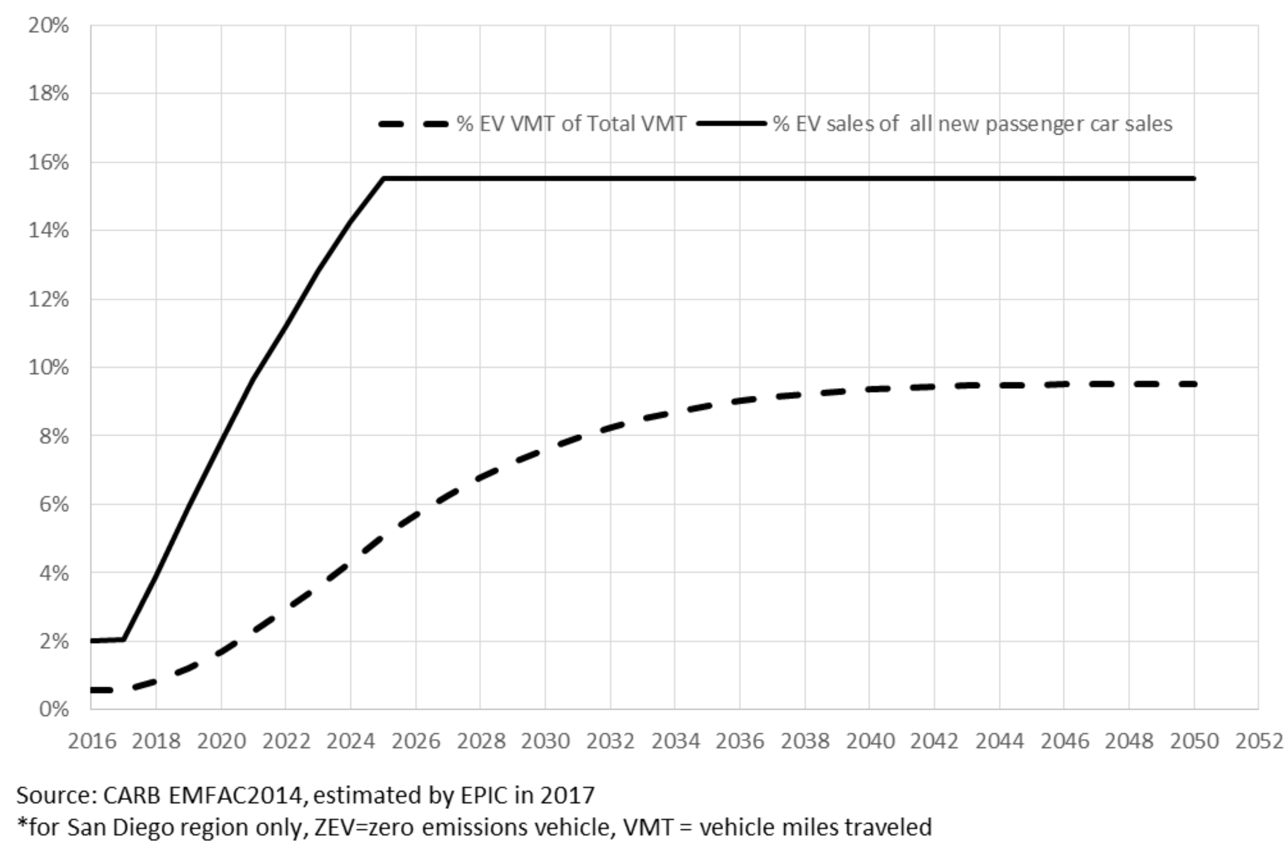


Figure 24 San Diego Region ZEVs Penetration Rate in CARB EMFAC2014 Model (2016-2050)

To calculate the effect of the ZEV program in future years, the average vehicle emission factor through all horizon years is calculated by keeping the ZEV penetration rate fixed from a chosen baseline year. For example, for a CAP baseline year of 2016, the ZEV penetration rate in 2025 would still be 2% (same as the baseline year) rather than 15% (that provided by EMFAC2014). The difference between this average vehicle emission factor and the EMFAC2014 average vehicle emission factor is due to the impact of the State's ZEV program only. Using the example shown in Table 11, the emissions reductions from California's ZEV program are calculated with Equation 27 and shown in Table 12.

Equation 27 Emissions Reduction Calculation: California ZEVs Program

$$\boxed{\Delta\, E_{transp,Cal\ ZEV,n} = VMT_n * \Delta\, EF_{transp,n} * 10^{-6}}$$

Where

$\Delta\, E_{transp,Cal\ ZEV,n}$	= total emissions reduction in transportation category from State ZEV program in a given year, in MT CO_2e
VMT_n	= VMT in a given year related to a jurisdiction, miles per year
$\Delta\, EF_{transp,n}$	= difference in average vehicle emission factor with the impact of State ZEV programs and BAU average vehicle emission factor, in grams CO_2e per mile
10^{-6}	= conversion factor, MT per gram CO_2e

With

n	= a CAP horizon year, from baseline year to CAP horizon end year

Table 12 Example of Emissions Reduction from California ZEVs Program

Year	Total VMT (miles/year) VMT_{2030}	Average Vehicle Emission Factor ($g\ CO_2e/mile$)		Difference in Average Vehicle Emission Factor ($g\ CO_2e/mile$) $\Delta\ EF_{transp,2030}$	Emissions Reduction ($MT\ CO_2e$) $\Delta\ E_{transp,Cal\ ZEV,2030}$
		With no Policy Impact after Baseline Year (Business-as-usual)	With impact of State ZEV programs		
2030	545,645,333	406	385	21	11,810

The number of new ZEVs, as a result of State ZEV programs, can be calculated using Equation 28 below.

Equation 28 Projected Number of ZEVs Travel to, from or within a Jurisdiction

$$ZEV_n = VMT_n * P_{ZEV\ VMT-total\ VMT,n} * \frac{Default\ ZEV_n}{Default\ ZEV\ VMT}$$

Where

ZEV_n = projected number of ZEVs that travel to, from, or within a jurisdiction in a given year

VMT_n = VMT in a given year related to a jurisdiction, miles per year

$P_{ZEV\ VMT-total\ VMT,n}$ = ratio of ZEV VMT to total VMT in a given year, EMFAC2014 default value for San Diego region, % (Figure 21)

$Default\ ZEV\ VMT_n$ = ZEV VMT in a given year, EMFAC2014 default value for San Diego region, miles per year

$Default\ ZEV_n$ = projected number of ZEVs in a given year, EMFAC2014 default value for San Diego region

With,

n = a CAP horizon year, from baseline year to CAP horizon end year

The number of ZEVs calculated using Equation 28 does not represent the actual number of ZEVs owned by residents in the jurisdiction; rather, it is calculated from the miles traveled using ZEVs in a jurisdiction. The average daily miles driven by ZEVs (ZEV VMT divided by number of ZEVs in a given year) from 2012 to 2030 in the San Diego region is obtained from EMFAC2014. This value is 35 miles per vehicle.

In this Appendix, a conservative approach is taken that limits the maximum emissions reduction related to increased ZEVs. Instead of using the level estimated based on the State's ZEV programs, (i.e., 15% of new vehicle sales in 2025 are EVs), this appendix assumes that there will be no more ZEV miles driven locally than what is already in the EMFAC model.[4] Therefore, emissions reductions from local ZEV measures are subtracted from the total value derived from EMFAC2014 to avoid double-counting. This is similar to the approach discussed in the renewable electricity section to limit emissions reductions from behind-the-meter PV systems at the level expected from the State's solar programs (Section 5.5.1.4).

The emissions reductions allocated to the CAP measures that increase ZEVs are discussed in Section 5.6.1.3.

[4] This approach may change if local jurisdiction has aggressive local measures to increases ZEVs beyond the State goal or the new ZEV sales assumptions embedded in future EMFAC model changes.

5.6.1.3 Local CAP Measures to Support State Goals for ZEVs (Alternative Fuel Vehicles)

The 2017 Scoping Plan recommends that local government incentivize infrastructure for alternative fuels and electric vehicles as one of the actions to reduce GHG emissions (CARB 2017b, p. 97). CAPs in the San Diego region include measures to increase ZEVs, especially electric vehicles (EVs). For example, local governments can modify municipal codes to alter parking standards to require preferred parking for ZEVs and update building codes to require electric vehicle charging stations (EVCS). CAP measures that seek to increase ZEVs include, but are not limited to:

- Adopt building codes to require EVCS installation in new construction projects,
- Transition to a more efficient municipal fleet and integrate ZEVs into the fleet, and
- Update parking standards to prioritize ZEV preferred parking spaces.

Figure 25 shows three examples of measures in currently adopted CAPs that aim to increase ZEVs.[5]

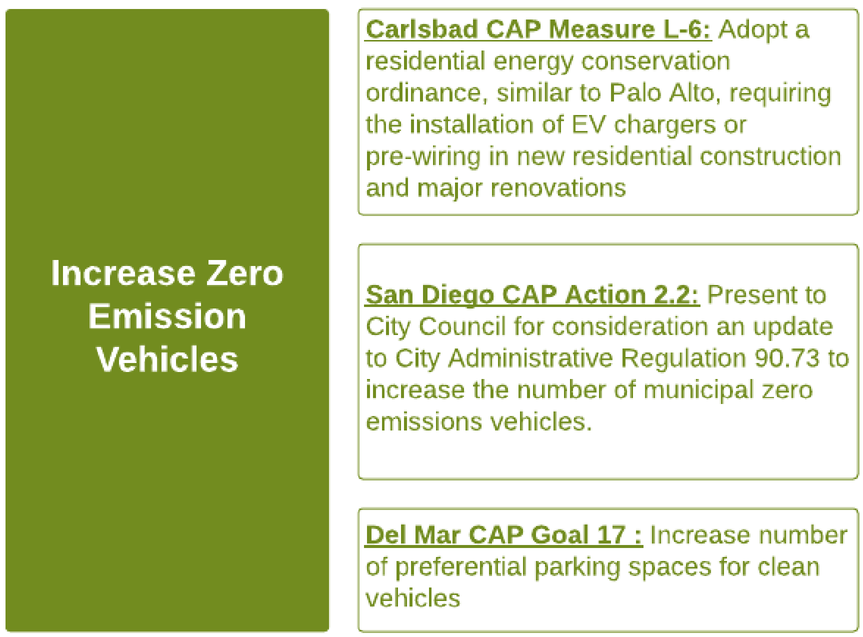


Figure 25 Example of CAP Measures to Increase ZEVs (Carlsbad 2015, Del Mar 2016, and San Diego 2015)

The following are emissions reduction calculation examples for two typical CAP measures that focus on increasing ZEVs:

<u>Require EVCS's in New Construction</u>

Local jurisdictions may require new construction projects to make a certain percentage of the parking spaces ready to support future EVCS equipment or require EVCS installation at a certain percentage of the parking spaces. For the measure to be counted as a local CAP measure, the requirements must be more stringent than those in the California Green Building Standards Code (CalGreen Code). The mandatory and voluntary measures related to EVs in the most recent version (2016 CalGreen Code) are given in Table 13.

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[5] The CAPs and measures referenced here were not calculated based on EMFAC2014. They were calculated based on previous versions of EMFAC models, so the approach discussed in this Appendix may differ from the approaches used in the CAPs.

Table 13 2016 California Green Building Standards Code Requirement for Electric Vehicle Charging Stations

Category	CalGreen 2016 Mandatory Measures	CalGreen 2016 Tier 1 and Tier 2 Voluntary Measures
Residential Single-family	EV capable (Section 4.106.4.1)	EV ready (Section A.4.106.8.1)
Residential Multi-family	3% of total number of parking spaces (no less than one) be EV capable (Section 4.106.4.2)	5% of total number of parking spaces (no less than one) be EV capable (Section A.4.106.8.2)
Nonresidential	6% of total number of parking spaces (no less than one) be EV capable (Section 5.106.4.3.1)	8% (Tier 1) and 10% (Tier 2) of total number of parking spaces (no less than one) be EV spaces capable (Section A5.106.5.3.1 and A5.106.5.3.2)
EV – electric vehicle, EV capable – install raceway to accommodate 40-amp minimum electrical circuit for future electric vehicle supply equipment, EV ready - Install 40-amp minimum electrical circuit Source: California Building Standards Commission, 2016		

Equation 29 is used to calculate the estimated number of EVCS that could result from a CAP measure to require EVCS in new construction projects.

Equation 29 Estimate Number of Charging Stations from Requiring Electric Vehicle Charging Stations Installation at New Constructions

$$EVCS_{CAP\ measure,n} = \sum_{unit} (N_{unit,n} * P_{unit,parking} * P_{unit,parking-EVCS})$$

Where

$EVCS_{CAP\ measure,n}$ = number of EVCS in a jurisdiction in a given year, as a result of a CAP measure

$N_{unit,n}$ = number of housing units or square footage of commercial spaces affected by a CAP measure, after CAP baseline year up to year n

$P_{unit,parking}$ = parking requirement for each building type, number of spaces per housing unit or number of spaces per commercial square feet.

$P_{unit,parking-EVCS}$ = % of parking spaces required to have EVCS installation for each building type, from the CAP measure

With,

n = a CAP horizon year, from baseline year to CAP horizon end year

unit = building type, including, but not limited to: new single-family unit, new multi-family unit, new commercial sq. ft.

The data needs for calculating the number of charging stations are given in Table 14.

Table 14 Data/Information Needs Table for Emissions Reduction Calculation– Require EVCS Installation at New Constructions

Data/Information Needs	Data Timeframe	Data Source
Number of new housing units each year by type (single-family, multi-family, etc.) $N_{unit,n}$	CAP horizon years	Jurisdiction (for recent years) or SANDAG (for forecast)
Square footage of new commercial space each year $N_{unit,n}$	CAP horizon years	Jurisdiction
Parking requirements for each type of housing unit and commercial space $P_{unit,parking}$	Current	Jurisdiction's municipal code parking standard

Using Equation 29, the data inputs and the number of EVCS calculated for a CAP measure that requires new residential multi-family units to install EVCS at five percent of parking spaces are given below in Table 15.

Table 15 Requiring EVCS Installation at Multi-Family Units Example

Year	Number of New Multi-Family Units after Baseline Year $N_{MF,2030}$	Multi-Family Parking Requirement $P_{MF,parking}$	% of Parking Space Required with EVCS $P_{MF,parking-EVCS}$	New EVCS after Baseline Year $EVCS_{MF,2030}$
2030	300	2.5 parking space per unit	5%	38

The method to estimate emission reductions from this measure assumes that all parking spaces with EVCS would only be used for EV parking, and that all miles associated with the vehicles parked at the spaces are from new ZEVs. As discussed in Section 5.6.1.2 on the State's ZEV program, a conservative approach is taken to limit the maximum emissions reduction related to ZEVs at the level of emissions reduction expected from the State's ZEV program. The reduction is allocated to each local measure using the ratio of new EVs as a result of the local measure and new ZEVs as a result of the State's ZEV program, as show in the Equation 30.

Equation 30 Emissions Reduction from Local Policies to Increase ZEVs

$$\Delta\, E_{transp,CAP\ measure,n} = \Delta\, E_{transp,Cal\ ZEV,n} * \frac{ZEV_{CAP\ masure,n}}{ZEV_n}$$

Where

$\Delta\, E_{transp,CAP\ measure,n}$ = emissions reduction from a CAP measure that increase ZEV in a given year, in MT CO_2e

$\Delta\, E_{transp,Cal\ ZEV,n}$ = total emissions reduction from California ZEV program in a given year, in MT CO_2e

$ZEV_{CAP\ measure,n}$ = projected number of ZEVs in a jurisdiction as a result of a CAP measure, in a given year

ZEV_n = projected number of ZEVs that travel to, from, or within a jurisdiction in a given year (from Equation 28)

With,

n = a CAP horizon year, from baseline year to CAP horizon end year

Transition to a More Efficient Municipal Fleet

Local jurisdictions can integrate ZEVs or more fuel-efficient vehicles into their municipal fleet to reduce both vehicle fossil fuel use and its associated emissions. The emissions reduction from reducing fossil fuel use can be calculated using Equation 31.

Equation 31 Emissions Reduction from Transition to a More Efficient Municipal Fleet

$$\Delta E_{transp,CAP\ measure,n} = \sum_{fuel} (\Delta V_{fuel,n} * EF_{fuel}) * 10^{-3}$$

Where

$\Delta E_{transp,CAP\ measure,n}$	= emissions reduction in transportation category from a CAP measure that increases fuel economy in a given year, in MT CO_2e
$\Delta V_{fuel,n}$	= fuel reduction of the municipal fleet, in a given year, in gallons
EF_{fuel}	= emission factor of a vehicle fuel, kg CO_2e per gallon
10^{-3}	= conversion factor, MT CO_2e per kg

With,

fuel	= fuel type, including, but not limited to: gasoline, diesel, B5 biodiesel, B20 biodiesel
n	= a CAP horizon year, from baseline year to CAP horizon end year

The CARB statewide GHG inventory documentation index, which is updated annually, provides emission factors (in kg per gallon) for gasoline, ethanol, diesel, biodiesel, and renewable diesel. However, the emission factors from the index cannot be used directly because they refer to the emissions per unit of pure fuel, while the fuel sold is blended. For example, the B5 biodiesel sold on the market contains 5% pure biodiesel and 95% diesel, while the “gasoline” sold on the market is a blend of bio-ethanol and gasoline (gasoline-ethanol blend). On average from 2010-2014, 10% of California’s gasoline-ethanol blend is bio-ethanol (CARB, 2016).

The fuel types in Equation 31 refer to the fuel types sold on the market. They are the blended fuel not pure fuel. Therefore, the emission factor of a pure fuel is converted to reflect the blend sold on the market, as shown in Equation 32.

Equation 32 Emission Factor of a Vehicle Fuel

$$EF_{fuel} = \sum_{pure\ fuel,GHG} (EF_{pure\ fuel,GHG} * F_{pure\ fuel-fuel} * GWP_{GHG})$$

Where

EF_{fuel}	= emission factor of a given fuel, kg CO_2e per gallon
$EF_{pure\ fuel,GHG}$	= emission factor of a given pure fuel, kg of GHG per gallon
$F_{pure\ fuel-fuel}$	= fraction of a pure fuel in a fuel mix, based on California statewide inventory technical documentation
GWP_{GHG}	= Global Warming Potential of a given GHG, unitless

With,

GHG	= CO_2, CH_4 and N_2O
fuel	= fuel type, including, but not limited to: gasoline, diesel, B5 biodiesel, B20 biodiesel
pure fuel	= pure fuel type in statewide inventory, such as gasoline, diesel, ethanol, biodiesel, renewable diesel

The data needs for calculating the emissions reduction are given in Table 16.

Table 16 Data/Information Needs Table for Emissions Reduction Calculation – Transition to a More Efficient Municipal Fleet

Data/Information Needs	Data Timeframe	Data Source
Municipal fleet fuel purchased by fuel type $V_{fuel,n}$	CAP baseline year to most current years	Jurisdiction
Municipal fleet fuel use reduction potential or target $\Delta V_{fuel,n}$	CAP horizon years	Jurisdiction (e.g., fleet vehicle replacement plan)
Emission factor of a fuel EF_{fuel}	n/a	CARB statewide GHG inventory documentation index
Fraction of fuel mix $F_{pure\ fuel-fuel}$	n/a	CARB statewide GHG inventory documentation index

The emission factor for a vehicle fuel can be calculated for recent years, and the average can be used for projections in the CAP. For a CAP measure that reduces 5,000 gallons of fleet gasoline use in 2020, the data input and emissions reduction calculated are given in Table 17.

Table 17 Transition to a More Efficient Municipal Fleet Example

Year	Municipal Fleet Gasoline Reduction (gallons) $\Delta V_{fuel,2020}$	Average Gasoline Mix $F_{pure\ fuel-fuel}$	Emission Factor of the Gasoline Mix (kg CO_2e/gallon) EF_{fuel}	Emissions Reduction (MT CO_2e) $\Delta E_{transp,CAP\ measure,2020}$
2020	5,000	10% pure ethanol, 90% gasoline	8.2	41

5.6.2 Reduce Vehicle Miles Traveled

The 2017 Scoping Plan indicates that "*local governments can develop land use plans with more efficient development patterns that bring people and destinations closer together in more mixed-use, compact communities that facilitate walking, biking, and use of transit*" (CARB 2017b, p. 97). It also includes a section titled *Potential State-Level Strategies to Advance Sustainable, Equitable Communities and Reduce Vehicle Miles of Travel* that discusses additional potential strategies the State could pursue to help achieve future VMT reduction (CARB, 2017b). Increasing alternative modes of transportation, such as public transit, biking, and walking, and increasing land use density, can reduce VMT. Improving pedestrian facilities and bicycle lanes and increasing the frequency of transit may support the land use plans that encourage mixed-use development. In this Appendix, the VMT reduction focuses on commuter VMT, the miles driven by the labor force in the jurisdiction to and from work, even though these measures may also reduce non-commuter VMT.

The State-level strategies to achieve additional VMT reductions are in addition to VMT reductions from regional transportation planning, such as SB 375 and the resulting Sustainable Communities Strategies, and through CEQA guidelines for project-level transportation impacts analysis.

5.6.2.1 Local CAP Measures to Reduce VMT

CAPs in the San Diego region have measures to reduce VMT. The measures include, but are not limited to:

- Provide incentive programs to employees to reduce commuter VMT
- Build additional bicycle lanes and improve sidewalks
- Coordinate with SANDAG, other jurisdictions, and public transit agencies to improve mass transit routes and schedules

Since January 1, 2011, a city or county must, upon substantial updates to the circulation element of the General Plan, comply with the requirements of the Complete Streets Act (AB1358, 2008), which requires improvements to roadways to accommodate all users rather than just vehicles. Complete streets would include pedestrian and bicycle pathway improvements, which are also typical measures in a CAP.

Figure 26 shows three examples of such measures in currently adopted CAPs.

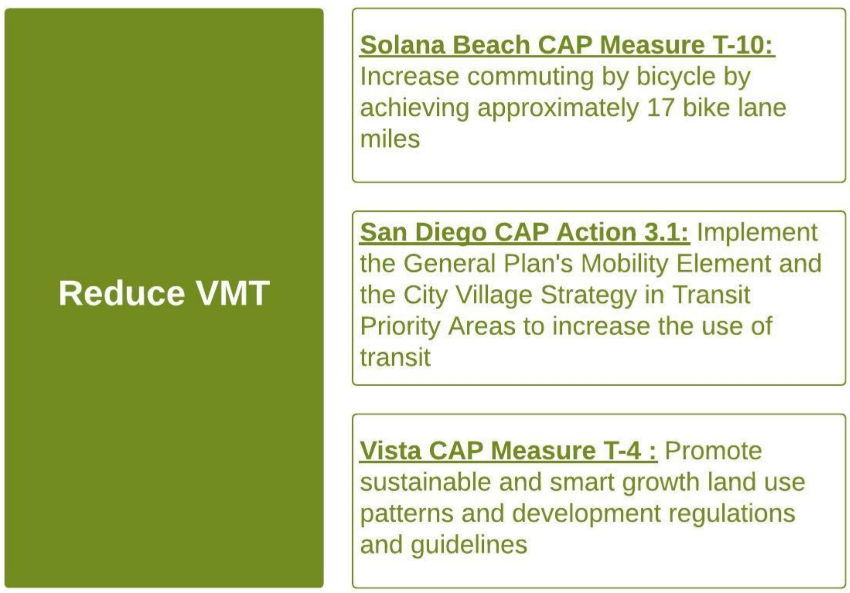


Figure 26 Example of CAP Measures to Reduce Vehicle Miles Traveled (Solana Beach 2017, San Diego 2015, and Vista 2013)

The following is the emissions reduction calculation example for a typical CAP measure to reduce VMT.

<u>**Increase Commuting by Bicycle by Increasing Bicycle Lane Miles**</u>

A continuous network of protected bicycle lanes and improved bicycle facilities at transit centers can increase commuting by bicycle and reduce peak-hour vehicle trips and the associated VMT. One way to increase the share of workers commuting by bicycle is to increase the bicycle lane miles per square mile. For example, to increase one bicycle lane mile per square mile, the City of San Diego (approximately 370 square miles) needs to add 370 miles of new bicycle lanes, while the City of Solana Beach (3.5 square miles) needs to add 3.5 miles of new bicycle lanes.

The emissions reduction from increasing bicycle lane miles can be calculated using Equation 33.

Equation 33 Emissions Reduction from Increasing Bicycle Lane Miles

$$\Delta E_{transp,CAP\ measure,n} = EF_{transp,n} * \Delta VMT_{bike} * P_{workforce,n} * (N_{lane-area,n} * 1\%) * 10^{-6}$$

Where

$\Delta E_{transp,CAP\ measure,n}$	= emissions reduction in the transportation category from a CAP measure that increases alternative modes in a given year, in MT CO_2e
$EF_{transp,n}$	= average vehicle emission factor in the San Diego region in a given year, grams CO_2e per mile
ΔVMT_{bike}	= VMT avoided by commuting by bicycle, miles per year, calculated based on commuter trips avoided per workday and number of workday per year
$N_{lane-area,n}$	= additional bicycle lanes (Class II or better) installed since baseline year up to year n, in bicycle lane miles per square mile, calculated based on the difference between planned and current bicycle lane miles, and the land area
$P_{workforce,n}$	= work force or labor force in the jurisdiction in a given year
1%	= percentage increase in the share of workers commuting by bicycle as a result of one additional bicycle lane mile per square mile (Dill and Carr, 2003)
10^{-6}	= conversion factor, MT CO_2e per gram

With,

n	= a CAP horizon year, from baseline year to CAP horizon end year

The data needs for calculating the emissions reduction are given in Table 18.

Table 18 Data/Information Needs Table for Emissions Reduction Calculation – Increasing Bicycle Lane Miles

Data/Information Needs	Data Timeframe	Data Source
Average round-trip distance for bicycle commuters	CAP baseline year to most current year	Jurisdiction, SANDAG, literature or case study
Workforce or labor force $P_{workforce,n}$	CAP horizon years	Jurisdiction or California Employment Development Department
Current bicycle lane miles by bicycle class $N_{lane-area,n}$	CAP baseline year to most current year	Jurisdiction
Planned or funded bicycle lane miles by bicycle class $N_{lane-area,n}$	CAP horizon years	Jurisdiction (Bicycle Master Plan)
Land area $N_{lane-area,n}$	CAP horizon years	Jurisdiction

The data input and emissions reduction calculated for a sample jurisdiction adding three miles of bicycle lanes per square mile by 2030 are given below in Table 19.

Table 19 Increasing Bicycle Lane Miles Example

Year	Additional Bicycle Lane Added Since Baseline Year (Bicycle Lane Miles per Square Mile) $N_{lane-area,2030}$	Labor Force $P_{workforce,2030}$	Average Round-trip Distance for Bicycle Commuters (miles/day)	Average Vehicle Emission Factor (g CO_2e/mile) $EF_{transp,2030}$	Emissions reduction (MT CO_2e) $\Delta E_{transp,CAP\ measure,2030}$
2030	3	8,000	8	297	36

5.6.3 Reduce Fuel Use Through Improved Traffic Flow

Improving traffic flow can reduce traffic delays and congestion, thereby reducing vehicle fuel consumption. Two typical examples of measures that local governments can implement to improve traffic flow include retiming traffic signals and installing roundabouts at intersections.

5.6.3.1 Local CAP Measures to Reduce Fuel Use Through Improved Traffic Flow

Improving traffic flow is different from the strategies discussed in previous two sections, such as measures that improve vehicle fuel efficiency (Section 5.6.1) or that reduce VMT (Section 5.6.2). This strategy does not reduce VMT but improves the efficiency of traffic flow, improves fuel efficiency, and, therefore, reduces fuel use. For example, with coordinated traffic signals, vehicles still travel the same distance on roads and intersections but without delay or congestion, and the average fuel economy (miles per gallon) improves.

Figure 27 shows three examples of measures in currently adopted CAPs that aim to improve traffic flow.

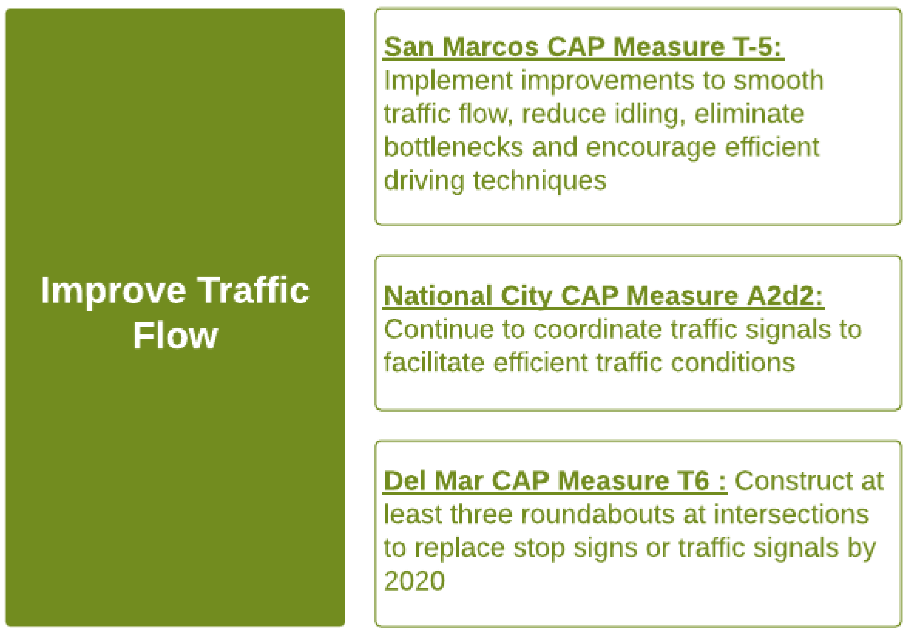


Figure 27 Example of CAP Measures to Improve Traffic Flow (San Marcos 2013, National City 2011, and Del Mar 2016)

Retiming Traffic Signals and Installing Roundabouts

The emissions reduction from retiming traffic signals and installing roundabouts can be calculated using Equation 34.

Equation 34 Emissions Reduction from Retiming Traffic Signals or Installing Roundabouts

$$\Delta E_{transp,CAP\ measure,n} = N_n * \Delta V_{fuel} * EF_{transp,n} * MPG_n * 10^{-6}$$

Where

$\Delta E_{transp,CAP\ measure,n}$ = emissions reduction in the transportation category from a CAP measure that improves traffic flow (e.g., retime traffic signals or install roundabouts) in a given year, in MT CO_2e

N_n	= additional traffic signals retimed or roundabouts installed since baseline year up to year n
$\Delta V_{fuel,n}$	= equivalent fuel savings per intersection with signals retimed or roundabouts installed in a given year, gallons per intersection per year
$EF_{transp,n}$	= average vehicle emission factor in the San Diego region in a given year, grams CO_2e per mile
MPG_n	= fuel economy of an average vehicle in the San Diego region, in a given year, miles per gallon
10^{-6}	= conversion factor, MT CO_2e in a gram

With,

n = a CAP horizon year, from baseline year to CAP horizon end year

In Equation 34, the equivalent fuel savings are fewer in later years because vehicles become cleaner and more efficient, so the gallons of fuel savings per intersection will decrease over time.

Even though this example measure is a fuel-saving measure (like the sample measure that obtains fuel savings through municipal fleet transition), the reduction calculation methods are different between these two types of measures. For the measures focused on vehicle fuel savings, the specific fuel type of the vehicles can be identified and emission factor for the specific fuel type can be used for calculation. For the measures focused on traffic flow improvements, the fuel type is unknown; therefore, the emission reduction is based on the fuel used for an average vehicle in the San Diego region. The EMFAC2014 model provides estimates of total VMT and total vehicle fuel consumption for the San Diego region. The fuel economy of an average vehicle in the San Diego region can be calculated using these two estimates.

Fuel savings per intersection per day are 54 gallons for small roundabouts (Varhelyi, 2002). However, fuel savings per intersection depend on the specific condition of potential sites, such as the traffic volume and road condition, so local or regional data should be used if available.

The data needs for calculating the emissions reduction are given in Table 20.

Table 20 Data/Information Needs for Measures to Retime Traffic Signals or Install Roundabouts

Data/Information Needs	Data Timeframe	Data Source
Estimated total VMT in San Diego region MPG_n	CAP horizon years	EMFAC2014 default estimate
Estimated total vehicle fuel consumption in San Diego region MPG_n	CAP horizon years	EMFAC2014 default estimate
Planned or funded roundabouts and traffic signal retiming projects N_n	CAP horizon years	Jurisdiction (capital improvement projects or circulation element projects)
Equivalent fuel savings per intersection with improved traffic flow $\Delta V_{fuel,n}$	n/a	Jurisdiction, SANDAG, literature or case study

The data input and emissions reduction estimates for a jurisdiction adding two roundabouts by 2030 are given below in Table 21.

Table 21 Install Additional Roundabouts Example

Year	Additional Roundabouts Installed since Baseline Year N_{2030}	Fuel Savings per Intersection (gallons/year) $\Delta\, V_{fuel,2030}$	Average Vehicle Fuel Economy (miles/gallon) MPG_{2030}	Average Vehicle Emission Factor (g CO_2e/mile) $EF_{transp,2030}$	Emissions Reduction (MT CO_2e) $\Delta\, E_{transp,CAP\ measure,2030}$
2030	2	19,710	29	297	340

5.7 Emissions Reduction from Water-Related Measures

In general, emissions from the water category account for less than 3% of a typical community-wide inventory, but water conservation and developing reliable local supply options are highly valued, particularly in response to California's recent statewide drought conditions. Many jurisdictions in the San Diego region do not manage their own water systems; therefore, collaboration between jurisdictions and water agencies is needed to support water-related measures. Emissions reductions from water-related measures generally fall into two categories:

- Develop local water supplies and improve water system efficiency
- Increase water conservation

The following sections describe the methods and data needs for calculating GHG emissions reductions from local CAP measures within these categories.

5.7.1 Develop Local Water Supply and Improve Water System Efficiency

As discussed in Technical Appendix 1, on average, over 85% of the water used in San Diego may be imported by the San Diego County Water Authority (SDCWA), the wholesale water provider for 24 retail water agencies. The water is delivered from the State Water Project and the Colorado River. Developing local water supplies (e.g., local surface water) may reduce the amount of water needed from more energy-intensive, upstream sources. Reducing the energy associated with water used in the region also reduces GHG emissions. Also, improving water system efficiency, such as maintaining water pipeline pressure and using energy recovery equipment at water treatment plants, can reduce the energy needed to treat and deliver the water locally.

The section describes local CAP measures to develop the local water supply and improve water system efficiency.

5.7.1.1 Local CAP Measures to Develop Water Supply & Improve Water System Efficiency

Figure 28 shows three examples of measures in currently adopted CAPs that aim to develop the local water supply and improve water system efficiency.

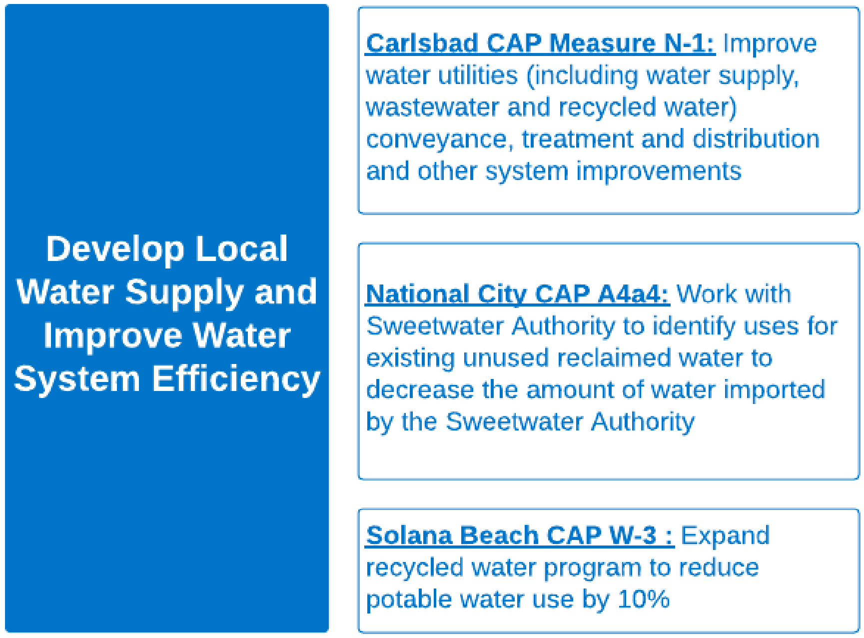


Figure 28 Example of CAP Measures to Develop Local Water Supply and Improve Water System Efficiency (Carlsbad 2015, National City 2011, and Solana Beach 2017)

The following is the emissions reduction calculation for a typical CAP measure that expands a recycled water program.

Recycled Water Program Expansion

This measure assesses the energy and associated emissions reductions from replacing potable water with recycled water. For example, a community park could water its grass and other landscaping with recycled water rather than potable water. By expanding use of a recycled water program, this measure does not reduce overall water use; rather, it reduces potable water use and the volume of purchases. The energy needed to treat and deliver recycled water for landscaping and irrigation purposes is often lower than the energy needed to supply, treat, and deliver potable water. These energy savings are the basis for the GHG reductions.

The emissions reductions from a recycled water expansion program can be calculated using Equation 35.

Equation 35 Emissions Reduction from a Recycled Water Expansion Program

$$\Delta\, E_{water,CAP\ measure,n} = W_{R,n} * \sum_{segment} (\Delta\, EI_{P-R,segment} * EF_{segment} * 10^{-3}) * 0.000453$$

Where

$\Delta\, E_{water,CAP\ measure,n}$	= emissions reduction in the water category from a CAP measure in a given year, in MT CO_2e
$W_{R,n}$	= volume of additional recycled water provided to the jurisdiction from the expanded program in a given year, in gallons or acre feet
$\Delta\, EI_{P-R,segment}$	= the difference between energy intensity of recycled water and potable water at a segment of the water cycle (kWh/acre-foot or kWh/gallon)
$EF_{segment}$	= electricity emission factor at a segment of the water cycle (lbs CO_2e/MWh)
10^{-3}	= conversion factor, kWh in a MWh

0.000453 = conversion factor, MT CO_2e in a pound

segment = upstream supply, local conveyance, local treatment, local distribution, local recycled water treatment, local recycled water distribution[6]

n = a CAP horizon year, from baseline year to CAP horizon end year

The data needs for calculating the emissions reduction are given in Table 22.

Table 22 Data/Information Needs for Emissions Reduction Calculation – Recycled Water Expansion Program

Data/Information Needs	Data Timeframe	Data Source
Planned or funded additional recycled water supply $W_{R,n}$	CAP horizon years	Jurisdiction, water agency and recycled water provider
Tertiary (advanced) water treatment energy intensity $\Delta\, EI_{P-R,segment}$	n/a	Water reclamation facility, literature or case study
Recycled water distribution energy intensity $\Delta\, EI_{P-R,segment}$	n/a	Water reclamation facility, literature or case study

The treatment process for recycled water, called tertiary or advanced water treatment, is one step further than the wastewater treatment process. The energy use per unit of recycled water for water treatment depends on water quality, treatment technology, and treatment procedure. Data from the specific water reclamation facilities that provide the recycled water should be used when available.

The data input and emissions reduction estimates for an example of a jurisdiction expanding its recycled water use by 300 acre-foot by 2030, are given below in Table 23.

Table 23 Recycled Water Expansion Program Example

Year	Additional Recycled Water (acre-foot)	Treatment + Distribution Energy Intensity for Recycled Water (kWh/acre-foot)	Upstream Energy Intensity for Imported Water (kWh/acre-foot)	Treatment + Distribution Energy Intensity for Imported Water (kWh/acre-foot)	Electricity Emission Factor (lbs CO_2e/MWh)	Emissions Reduction (MT CO_2e)
2030	300	38	1,816	43	400	98

5.7.2 Increase Water Conservation

This section describes the methods to calculate GHG emissions reductions from local CAP measures that reduce water use and the associated energy.

5.7.2.1 Local CAP Measures to Increase Water Conservation

Like the local CAP measures to reduce energy use in buildings discussed in Section 5.5.2.2, local governments can develop ordinances and update local building codes to increase water efficiency for both indoor and outdoor water use, and for both new construction projects and existing buildings.

[6] A description of water cycle segments is in Technical Appendix I, Section 3.6.3 Water Energy Intensity.

Existing CAPs in the San Diego region have measures to increase water conservation. These measures include, but are not limited to:

- Requirements for plumbing fixtures and fittings that are more efficient than State building codes mandate
- Outdoor landscaping ordinances
- Water use disclosure and benchmarking ordinances

Figure 29 shows three examples of measures in currently adopted CAPs that aim to increase water conservation.

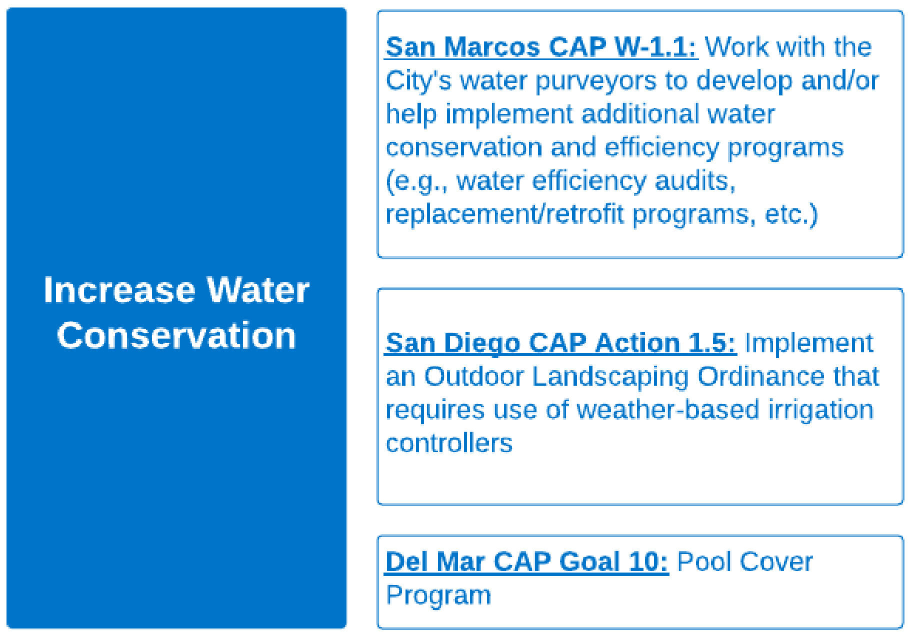


Figure 29 Example of CAP Measures to Increase Water Conservation (San Marcos 2013, San Diego 2015, and Del Mar 2016)

The following is the emissions reduction calculation for a water conservation and disclosure ordinance.

Require Water Disclosure and Benchmarking in Existing Homes

Water conservation ordinances for existing homes can reduce indoor water use through the replacement of old plumbing fixtures and fittings (showers, toilets, showerheads, and faucets) with more efficient (low-flow) versions. For example, the City of Berkeley's Commercial and Residential Conservation Ordinances report average indoor water savings of 2% per year for all participating households (City of Berkeley, 2011).

Emissions reductions that result from water disclosure and benchmarking ordinances for existing homes, such as water audits upon applying for a building permit for a remodel or upon resale, can be calculated using Equation 36. The indoor water reduction only considers the change in potable water use.

Equation 36 Emissions Reduction from Water Disclosure Ordinances

$$\Delta E_{water,CAP\ measure,n} = \sum_{unit}(N_{unit,n} * P_{audits-retrofits} * \Delta W_{unit,n}) * \sum_{source,segment}(P_{source,n} * EI_{source,segment} * EF_{source,segment} * 10^{-3}) * 0.000453$$

Where

$\Delta E_{water,CAP\ measure,n}$	= emissions reduction in the water category from a CAP measure in a given year, in MT CO_2e
$N_{unit,n}$	= number of housing units affected by this measure (completed audits) after CAP baseline year up to year n
$P_{audits-retrofits}$	= % of the units that have completed audits that also install water efficiency plumbing fixtures and fittings
$\Delta W_{unit,n}$	= average annual water savings from more efficient plumbing fixtures and fittings, gallons
$P_{source,n}$	= percent of potable water from each source, n, in a given year (acre-foot or gallon)
$EI_{source,segment}$	= energy intensity of a potable water source at a segment of the water cycle (kWh/acre foot or kWh/gallon)
$EF_{source,segment}$	= electricity emission factor of a potable water source at a segment of the water cycle (lbs CO_2e/MWh)
10^{-3}	= conversion factor, kWh per MWh
0.000453	= conversion factor, MT CO_2e per pound

With,

segment	= upstream supply, local conveyance, local treatment, local distribution[7]
source	= SDCWA treated, SDCWA untreated, local surface water, local groundwater
unit	= including but not limited to: retrofitted single-family unit, retrofitted multi-family unit
n	= year, from baseline year to CAP horizon end year

The data needs for calculating emissions reductions for a typical residential water disclosure and conservation ordinance are given in Table 24. The data needs are similar to the data needs in Table 8, which was for a residential energy disclosure and conservation ordinance.

[7] A description of water cycle segments is in Technical Appendix I, Section 3.6.3 Water Energy Intensity.

Table 24 Data/Information Needs Table for Emissions Reduction Calculation – Residential Water Disclosure and Conservation Ordinance

Data/Information Needs	Data Timeframe	Data Source
Number of housing units or percentage of total major renovation building permits by type (single-family, multi-family, etc.) $N_{unit,n}$	CAP baseline year to recent years	Jurisdiction
Number of existing housing units by type $N_{unit,n}$	CAP baseline year	Jurisdiction or SANDAG
Water savings from a typical home replacing water fixtures and fittings $\Delta\, W_{unit,n}$	CAP baseline year to recent years	Jurisdiction, Literature and case studies
Percentage of the units that completed audits that replace the water fixtures and fittings $P_{audits-retrofits}$	n/a	Literature and case studies
OR		
Types of "non-compliant" plumbing fixtures and fittings	n/a	Jurisdiction
Types of "required" efficient plumbing fixtures and fittings	n/a	Jurisdiction

No specific calculation example is given for this ordinance because the water reduction per home depends on what is required in this ordinance. The water reduction from this ordinance can be calculated in different ways:

- Average water savings at a single-family home from replacing fixtures and fittings
- The water savings from use of specific fixtures and fittings specified in the ordinance

The historical fixtures and fitting flow rates required by the CalGreen Code from 1980 to 2016 are given in Table 25. This can be used to determine "non-compliant" and "required" fixtures and fittings.

Table 25 Water Fixtures and Fittings Flow Rates required by California Green Building Standards Code (ConSol 2015 and California Building Standards Commission 2016)

	1980	1992	2005	2009	2011	2013	2016
Showerheads (gpm)	2.5	2.5	2.2	2.5	2	2	2
Toilets (gpf)	3.5	1.6	1.6	1.6	1.28	1.28	1.28
Faucets (gpm)	2.5	2.5	2.2	2.2	1.8	1.8/1.5	1.8/1.2
gpm: gallons per minute; gpf: gallons per flush Rates for faucets are for kitchen faucets and residential lavatory faucets. All flow rates are the CalGreen Code mandatory requirements, not voluntary measures.							

The *California Codes and Standards Research Report California's Residential Indoor Water Use 2nd Edition* provides comparisons of the flow rate requirements for water fixtures and fittings across CalGreen Code versions and the impact for a standard single-family home (ConSol, 2015). For example, a 1992 single-family home that replaces all water fixtures and fittings (showerheads, toilets, and faucets) with versions that comply with the 2016 standards will reduce annual indoor water use by 34%.

5.8 Emissions Reduction from Solid Waste-Related Measures

Emissions from the solid waste category typically account for approximately 5% of a community-wide inventory. Emissions reductions from solid waste-related measures generally come from two categories:

- Diversion of all waste from landfills
- Reduction of organic materials in the waste stream

The following sections describe the methods and data needs for calculating GHG emissions reductions from local CAP measures within these categories.

5.8.1 Divert Waste from Landfills

Diverting solid waste from landfills through waste source reduction efforts, recycling, and composting reduces the amount of waste disposed at landfills. Currently, the State has a policy goal to reduce waste generation (AB 341), and some local jurisdictions in the San Diego region also have zero waste plans and solid waste recycling programs to increase their waste diversion rate.

5.8.1.1 California Regulations to Divert Waste from Landfills

AB 341, passed in 2011, established a policy goal for California to reduce, recycle, or compost no less than 75% of waste generated in the State by 2020 (CalRecycle). It also requires jurisdictions to implement commercial solid waste recycling programs, and to achieve the 50% solid waste diversion rate requirements (SB 1016). Since AB 341 is a statewide policy goal to increase waste diversion, the 75% diversion requirement does not apply to each jurisdiction. Therefore, the impact of AB 341 is not included here. Local jurisdictions with higher than 50% solid diversion rate goals are counted as local polices to increase diversion rate.

5.8.1.2 Local CAP Measures to Divert Waste from Landfills

CAPs in the San Diego region have measures to reduce the amount of solid waste disposed at landfills. The measures include, but are not limited to:

- Develop Zero Waste Plans[8]
- Expand and mandate waste recycling programs for businesses and residents of multi-family dwellings
- Develop construction and demolition waste diversion ordinances

Figure 30 shows three examples of these measures in currently adopted CAPs.

[8] The United States Conference of Mayors (2015) adopts a definition of Zero Waste and a set of Zero Waste Principles that recognizes a hierarchy of material management (extend producer responsibility, reduce, repair, recycle, compost, down cycle and beneficial reuse, waste-based energy as disposal and landfill waste as disposal). Different jurisdictions in the regional have different "zero waste" goal in their plans. For example, the City of Oceanside's Zero Waste Strategy Resource Management Plan, adopted in 2010, has the goal to achieve 75% waste diversion by 2020. The City of San Diego's Zero Waste Plan, adopted in 2015, and has targeted 75% diversion by 2020, 90% by 2035 and "zero" by 2050.

Figure 30 Example of CAP Measures to Reduce Landfill Waste Disposal (Vista 2012, San Marcos 2013, and San Diego 2015)

The following is the emissions reduction calculation for a typical CAP measure that increases the waste diversion rate.

Develop Zero Waste Plan to Increase Solid Waste Diversion

Different types of waste have different CH_4 emission factors. For example, one MT of food waste produces more CH_4 than one MT of newspapers. Therefore, diverting one MT of food waste will reduce emissions more than the same quantity of newspapers. The method described here uses the average emission factor for typical mixed solid waste.

The reduction from increasing diversion rates is estimated using a top-down approach that compares the level of emissions in the waste category that would result from the diversion rate target and the BAU level. The reductions from other categories discussed in earlier sections use a bottom-up approach that only depend on the impact of program activities and do not depend on the BAU level of emissions. Achieving a 75% citywide waste diversion goal would result in different amount of emissions reductions depending on the size of the jurisdiction, and, therefore, the waste stream.

The waste reduction from this goal can be calculated in different ways:

- Based a target total waste disposal or per capita waste disposal amount, or
- Based on a target waste diversion rate

If a target waste reduction rate is used, it needs to be converted to an equivalent per capita disposal. The conversion is based on the method set by SB 1016 to determine the “50% per capita disposal target,” the per capita disposal equivalent to a 50% diversion rate for each jurisdiction. The “50% per capita disposal target” is calculated using the average of 50% of generation in 2003 through 2006 (CalRecycle, 2012). Each jurisdiction has a different per capita disposal that is equivalent to a 50% diversion rate. For example, the 50% diversion rate is 8.9 pounds per person per day (PPD) in San Marcos and four PPD in Imperial Beach.

Using this conversion method, the waste reduction is calculated using Equation 37 below.

Equation 37 Solid Waste Reduction Calculation

$$\Delta SW_n = SW_{BAU,n} - (2 * PPD_{50\%}) * (1 - DR_{target,n}) * P_n * 2{,}000 * 365$$

Where,

ΔSW_n	= mixed solid waste diverted (reduced) from landfill in a given year, in short tons
$SW_{BAU,n}$	= BAU mixed solid waste disposal by a jurisdiction projected for a given year, in short tons
$PPD_{50\%}$	= PPD equivalent to 50% diversion rate
$DR_{target,n}$	= waste diversion rate targeted for a given year in the CAP measure, in %
P_n	= projected population in a given year
2	= conversion factor, converting waste disposal (with 50% diversion rate) to waste generation
2,000	= conversion factor, lbs. in a ton
365	= conversion factor, days in a year

With,

n	= a CAP horizon year, from baseline year to CAP horizon end year

Using the waste reduction amount, the emissions reduction from increasing the solid waste diversion rate can be calculated using Equation 38.

Equation 38 Emissions Reduction from Increased Solid Waste Diversion Rate

$$\Delta E_{waste,CAP\ measure,n} = \Delta SW_n * EF_{msw} * (1 - 0.75) * (1 - 0.1)$$

Where

$\Delta E_{waste,CAP\ mesure,n}$	= emissions reduction in the waste category from a CAP measure in a given year, in MT CO_2e
ΔSW_n	= mixed solid waste diverted (reduced) from landfill in a given year, in short ton
EF_{msw}	= mixed waste emission factor, in MT CO_2e/short ton[9]
0.75	= default landfill gas capture rate, U.S. Community Protocol
0.1	= default oxidation rate, U.S. Community Protocol

With,

n	= a CAP horizon year, from baseline year to CAP horizon end year

The data needs for calculating the emissions reduction are given in Table 26.

Table 26 Data/Information Needs Table for Emissions Reduction Calculation – Increase Solid Waste Diversion

Data/Information Needs	Data Timeframe	Data Source
Projected/target waste diversion rate $DR_{target,n}$	CAP horizon years	Jurisdiction
OR		
Current total or per capita waste disposal $SW_{BAU,n}$	CAP baseline year to most recent year	Jurisdiction or CalRecycle
Projected/target waste disposal $SW_{target,n}$	CAP horizon years	Jurisdiction

[9] Described in Technical Appendix I, Section 3.8.2 Solid Waste Emission Factor.

The data inputs and emissions reductions calculated for a jurisdiction targeting an 80% waste diversion rate from landfills by 2030 are given below in Table 27.

Table 27 Increase Solid Waste Diversion Program Example

Year	Diversion Rate in Baseline Year	Targeted Diversion Rate $DR_{target,2030}$	Projected BAU Waste Disposal (tons) $SW_{BAU,2030}$	Projected Population P_{2030}	Per Capita Disposal Equivalent to 50% Diversion Rate $PPD_{50\%}$	Emissions Reduction (MT CO_2e) $\Delta\, E_{waste,CAP\ mesure,2030}$
2030	60%	80%	50,000	60,000	8	5,049

As jurisdictions in the San Diego region include different reduction or diversion targets by customer class (single-family residential, multi-family residential, commercial, etc.), this section will expand to include the data needs, assumptions, and extended methods for new measures.

5.8.2 Reducing Organics in the Waste Stream

5.8.2.1 California Regulations to Reduce Organic Waste

AB 1826, signed by Governor Brown in 2014, requires businesses to recycle their organic waste starting April 1, 2016, depending on the amount of waste they generate per week. Organic waste includes food waste, green waste, and landscaping and pruning waste.

Jurisdictions are required to provide information to CalRecycle on the organic waste recycling program implementation status by August 2018 (CalRecycle, 2017). Because the effectiveness of reducing organic waste from AB 1826 is currently unknown, the calculation method to estimate emissions is not currently provided here but could be included in future iterations of this Appendix.

5.9 Emissions Reduction from Other CAP Measures

Other CAP measures that reduce or offset overall emissions and increase climate resiliency include:

- Increase carbon sequestration through conserved open space and natural lands
- Increase carbon sequestration through increased urban tree canopy cover
- Reduce heat island effects through rooftop gardens

5.9.1 Increase Carbon Sequestration and Climate Resilience

Increasing urban tree canopy cover and preserving natural land reduces the concentration of CO_2 in the atmosphere and improves air quality. Increasing shaded streets with trees can reduce the temperature in urban areas and may lead to reduced energy needs for cooling.

Figure 31 shows three examples of measures in currently adopted CAPs that aim to increase carbon sequestration.

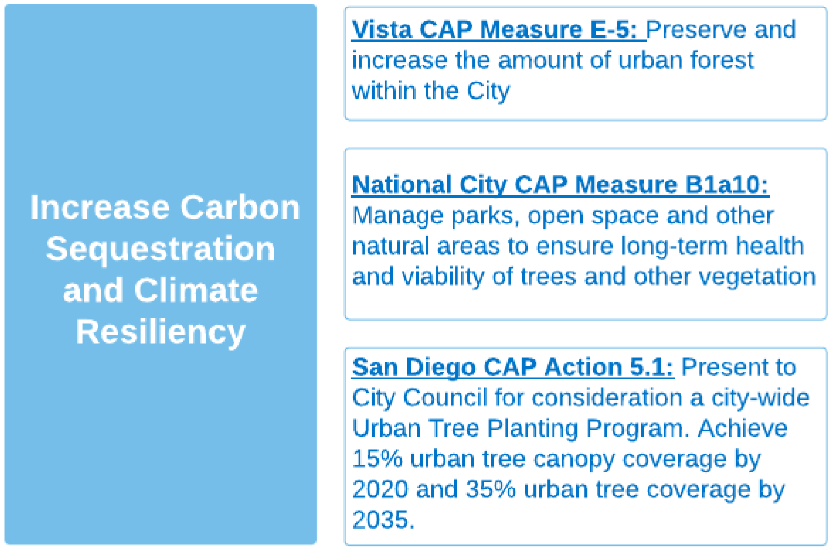


Figure 31 Example of CAP Measures to Increase Carbon Sequestration and Climate Resiliency (Vista 2012, National City 2011, and San Diego 2015)

The following is the emissions reduction calculation for a typical CAP measure that increases carbon sequestration by increasing urban tree planting.

Increase Urban Tree Planting.

The CO_2 sequestration rate of trees (CO_2 per tree per year) depends on the tree species, climate zone, planting location, age of the tree when planted, and other factors. The Center for Urban Forest Research (CUFR) Tree Carbon Calculator, developed by the U.S Forest Service, provides data on CO_2 sequestration rates for a variety of tree species. If tree information is unknown at the time of CAP development, the average (0.035 MT CO_2 per tree per year) or species-specific CO_2 sequestration rate of trees from the California Emissions Estimator Model (CalEEMod) (2016) is used. The emissions reduction from increased urban tree canopy planting can be calculated using Equation 39.

Equation 39 Emissions Reduction from Increased Urban Tree Planting

$$\Delta E_{CAP\ measure,n} = \sum_{tree\ species} (P_{tree\ species,n} * CS_{tree\ species})$$

Where,

$\Delta E_{CAP\ measure,n}$	= emissions reduction from a CAP measure in a given year, in MT CO_2e
$P_{tree\ species,n}$	= number of new trees planted from baseline year to a given year for each of tree species
$CS_{tree\ species}$	= carbon sequestration rate of each of tree species

With,

tree species	= type of new trees planted
n	= a CAP horizon year, from baseline year to CAP horizon end year

The data needs for calculating the emissions reduction are given in Table 28.

Table 28 Data/Information Needs Table for Emissions Reduction Calculation – Increase Urban Tree Planting

Data/Information Needs	Data Timeframe	Data Source
Planned number of new trees planted $P_{tree\ species,n}$	CAP horizon years	Jurisdiction
Carbon sequestration rate of an average or species-specific tree $CS_{tree\ species}$	n/a	CalEEMod, literature and case studies
OR		
Potential species, planting locations, ages of the new trees	n/a	Jurisdiction
Carbon sequestration of the new trees based on specific tree information	n/a	CUFR Tree Calculator

The data inputs and emissions reductions calculated for a sample jurisdiction planting 200 new trees every year are given below in Table 29.

Table 29 Increase Urban Tree Canopy Cover Example

Year	New Trees Planting (trees/year)	New Trees Planting after baseline year until 2030 $P_{tree\ species,2030}$	Average Tree Sequestration Rate (MT CO_2 per tree per year) $CS_{tree\ species}$	Emissions Reduction (MT CO_2e) $\Delta\ E_{CAP\ measure,n}$
2030	200	3,000	0.035	106

6 Visualization and Presenting Results

The emissions reductions from each measure, strategy, or emissions category can be presented in multiple ways to fit different purposes as shown in the following sections.

6.1 Separate Local GHG Reductions from Federal and State Regulations

The following chart (Figure 32) shows the local GHG emissions reductions separately from the reductions associated with federal and State regulations.

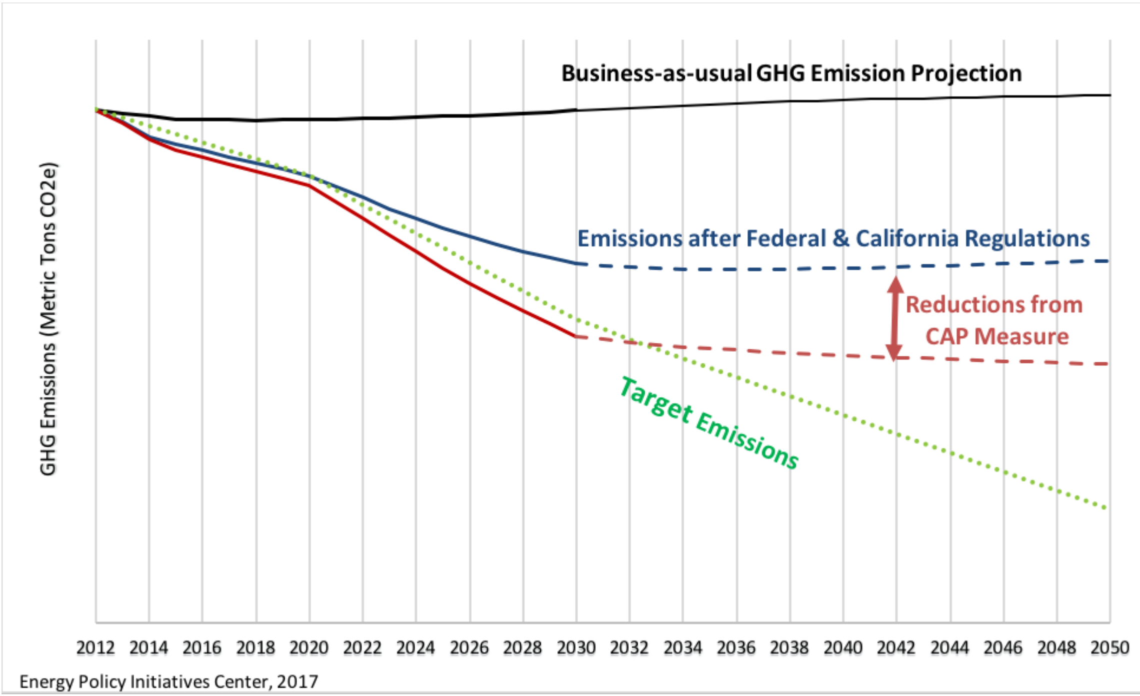


Figure 32 Visualization and Presenting Results: Separate the Effects of Federal, State and Local CAP Measures

The emission level after the reductions from federal and State regulations (dark blue line in Figure 29) is often called the "legislatively-adjusted BAU emissions." The difference between the "legislatively-adjusted BAU emissions" and target emissions (green line in Figure 29) is what the local jurisdictions need to reduce through the CAP's measures to meet the target, often called "the local gap." This chart provides a bigger picture of effects of local actions against the effects of federal and State regulations. It does not provide visualization of the reduction impact of each CAP measure.

6.2 Emissions Reduction Trend of Each CAP Strategy or Measure (Wedge Chart)

The following wedge chart (Figure 33) is another example that shows the emissions reduction trend of each CAP strategy or each CAP measure.

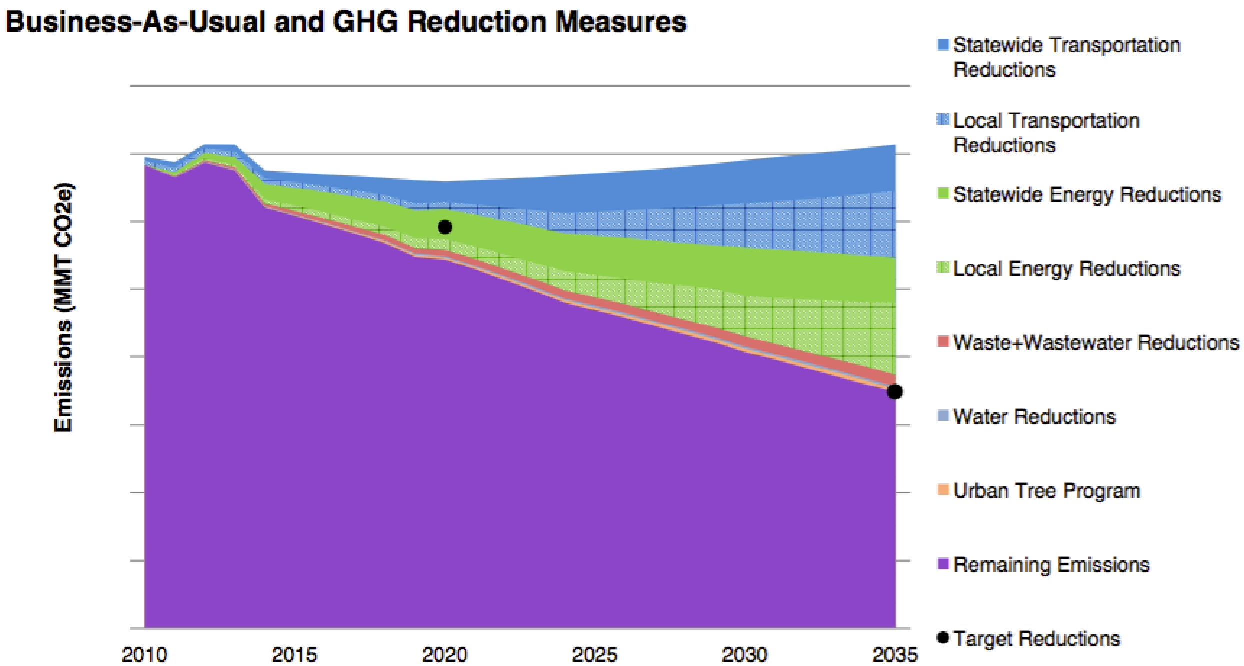


Figure 33 Visualization and Presenting Results: Emissions Reduction Trend from each CAP Strategy

Each colored wedge is the reduction amount from each potential CAP strategy. For example, the blue wedge at the top of the chart shows the reduction from statewide transportation regulations, and the cross-hatched blue wedge below shows the reductions from a local CAP's transportation strategy. The purple wedge shows the remaining emissions after all regulations and CAP measures are applied.

The wedge chart provides a comparison of the reduction impact from each strategy or measure across the CAP horizon years. It is important to note that the order of the wedges is not the implementation priority of each strategy. This chart does not mean that in year 2020 no local energy reduction or waste and wastewater reduction are needed. The CAP measures need to be implemented in earlier years and ramped up to meet future targets.

6.3 Emissions Reduction from CAP Strategies in Target Year (Bar Chart)

The following bar chart (Figure 34) is an example that shows the emission reduction from CAP strategies in target year 2030.

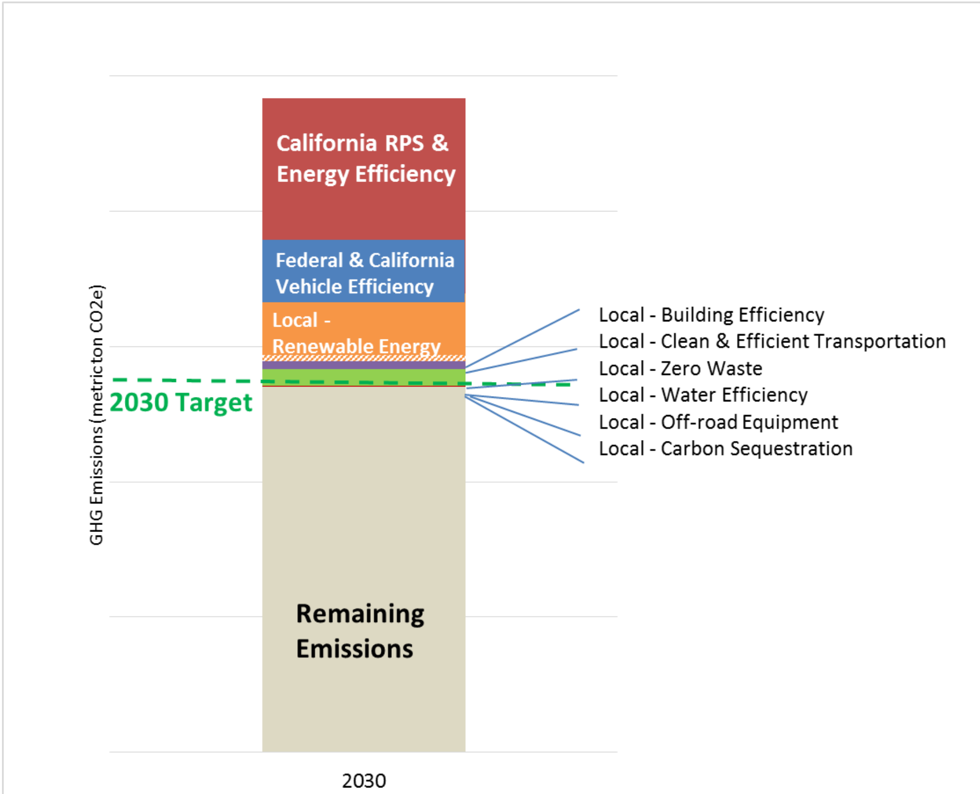


Figure 34 Visualization and Presenting Results: Emissions Reduction from CAP Strategies in Target Year

The bar chart is equivalent to showing a single year (2030) from the wedge chart discussed in previous section. In Figure 34, federal and State regulations make up the majority of emissions reductions; the local renewable energy strategy is the top local strategy. This chart shows that with all measures implemented, the CAP meets its 2030 target, which is the ultimate goal of the CAP. In contrast to the wedge chart, it does not show an emissions reduction trend.

Similar charts can be developed to see the impact of each strategy for different target years. For example, a local renewable energy program may take multiple years to launch and show little to no impact in target year 2020, but may have a larger impact in target year 2030 when it is fully implemented. Charts can also be developed to show the emissions reduction from each CAP measure in target years, if one or several measures have a significant reduction impact.

7 Emerging Issues

As noted above, while there are generally-accepted approaches to estimate GHG reductions for CAP measures, there are no accepted protocols. The approaches presented above represent approaches that capture many of the issues and considerations with current conditions. There are, however, emerging issues that affect the approaches described here. This section summarizes some of the key issues that should be considered as methods and approaches for GHG reductions estimates evolve.

7.1 Marginal Emission Factor of Electricity

Section 5.5.2 discusses the policies and programs that increase energy efficiency, where the emissions reduction is calculated using the weighted average electricity emission factor and the amount of energy reduced. While this emission factor considers all sources of electricity supply (metered and behind-the-meter), it is an annual average that does not represent the changes to the emissions rate that occur hourly and daily. The breakdown of electricity by resource type varies differently across hours in a day and across days in a year, which affects emission factor calculation. Figure 35 shows the emission factor (MT CO_2/h) across hours in February 18, 2018 of the electricity serving the California Independent System Operator (CAISO)'s load.

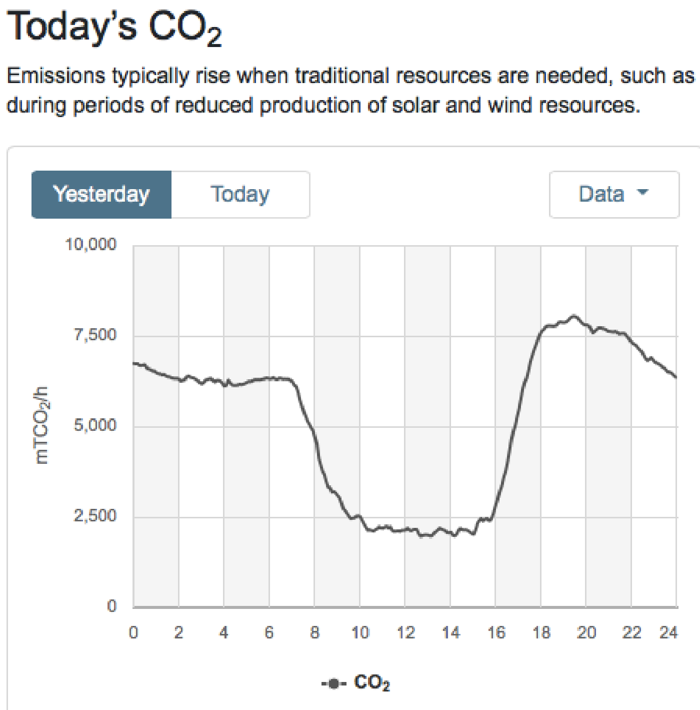


Figure 35 CAISO's CO_2 Emission per Hour on February 19, 2018 (CAISO, 2018)

Because the various resources supply the grid at different times of the day, actual hourly emissions reductions from energy conservation measures depend on the type of electricity not supplied as a result of the measure. The emissions avoided will depend on how the grid supplier dispatches electricity. For example, if a natural gas-fired peaker plant is used during the summer to meet electricity demand, avoiding electricity use at peak time reduces emissions from the peaker plant, which is approximately 1,000–1,200 lb. CO_2e/MWh. On the other hand, if electricity is conserved when excess renewables are available on the grid, there will be no emissions reduction during that time.

The marginal emissions factor would reflect such dispatch differences. Currently, there are different methods to estimate the marginal emission factor at different scales based on the literature and studies. The following are two examples:

- Methods to calculate the built margin and operating margin emissions for specific projects: *Guidelines for Quantifying GHG Reduction from Grid-Connected Electricity Projects*, developed by the World Resources Institute (WRI) and World Business Council for Sustainable Development (WBCSD) in 2007
- Methods to calculate the non-baseload power plants electricity emission factor for California, Balancing Authorities, and sub-regions: *Emissions & Generation Resource Integrated Database (eGRID)*, developed by U.S. EPA using power plant's capacity factor

Without detailed analysis of the load profile, electric service providers' power dispatch preferences, or information on hourly electricity emission factor, it is difficult to calculate a marginal emission factor. Instead, CAPs typically use an annual weighted average emission factor.

7.2 PV Generation and Renewable Energy Credits

Section 5.5.1 discusses the role of behind-the-meter PV system as a self-serve renewable supply and its contribution to jurisdiction-wide total renewable supply. It is assumed all electricity generated from PV systems are 100% renewable. However, for a PV system installed through a power purchase agreement (PPA), the renewable attributes of the electricity generated from the system depends on how the agreement is drawn. A PPA is a financial agreement where a solar company installs and maintains the solar system at a customer's premises and sells the electricity to the customer. Customers with a PPA pay little to no upfront and maintenance costs, and the cost for electricity is generally lower than utility's electricity rate. Customers can claim they are purchasing renewable electricity only if they retain the Renewable Energy Credits (RECs), which are the renewable attributes of the electricity. If the solar company retains the RECs, the customer cannot claim zero emissions from the electricity supplied.

Currently, it is not clear how many solar customers in the San Diego region operate under PPAs, and, of the customers who have PPA, the portion that own the RECs associated with the solar generation. Therefore, a certain percent of electricity generation from behind-the-meter PV systems may not be considered renewable since the RECs may be retained by the solar company and sold to third parties for compliance purposes.

7.3 Electrification of Natural Gas Load

The electrification of natural gas load, such as replacing residential natural gas appliances with electric appliances, reduces natural gas dependence and the GHG emissions associated with natural gas. Coupling the electrification of natural gas load with decarbonizing the electric grid with high renewables has a greater emissions reduction benefit. Section 5.5.2.2 discussed one type of electrification of the natural gas load by replacing natural gas water heaters with solar water heaters or electric water heaters powered by renewable electricity. With the State goal of residential zero net energy (ZNE), SB 350 mandating a doubling of energy efficiency by 2030, and potential future CAP measures to electrify the natural gas load, these emissions reduction impacts could be discussed in a future iteration of this Appendix.

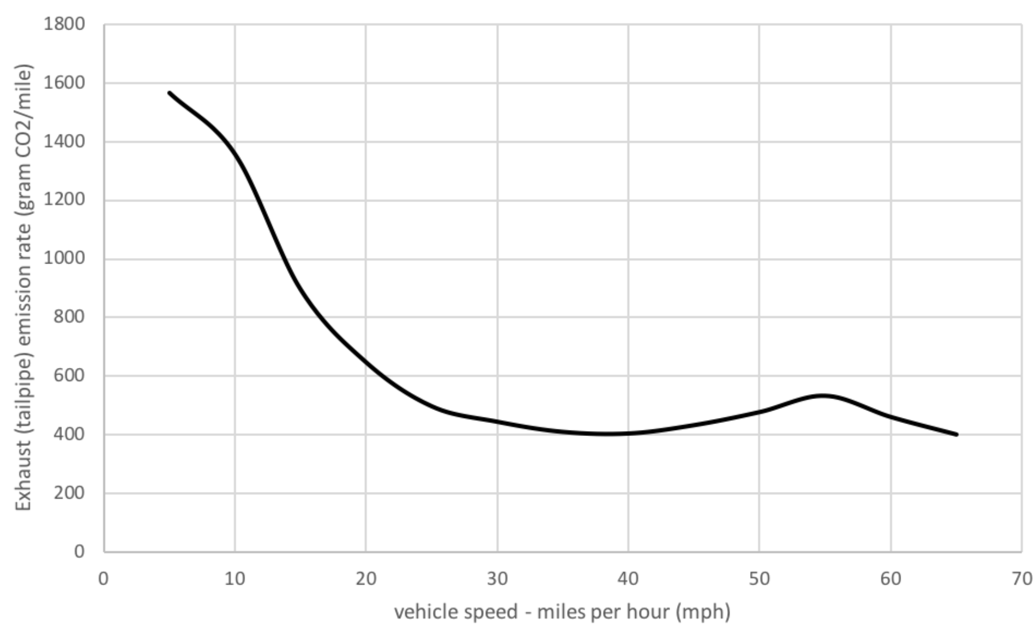
7.4 Impact of Transportation Network Companies on Shifting Travel Patterns

Transportation network companies (TNCs), such as Uber and Lyft, are the companies that provide prearranged transportation services for compensation using an online-enabled application or platform (such as smart phone apps) to connect drivers using their personal vehicles with passengers. TNCs have started to show an increasing presence on roads in recent years, especially in urban areas and city centers. The San Francisco County Transportation Authority's (SFCTA) study "*TNCs Today – A Profile of San Francisco Transportation Network Company Activity,*" conducted in 2017, shows that, on a typical weekday, TNC trips represent 15% of all vehicle trips within the City of San Francisco and an even larger percentage at peak time (SFCTA, 2017). The impact of TNCs on shifting travel patterns in the San Diego region is not clear. For example, if people shift from taking public transportation or other non-vehicle travel modes to riding with TNCs, a certain penetration of TNCs may decrease vehicle ownership while also creating new trips. While the activity level of TNCs at jurisdictions within the San Diego region may not be as high as that of San Francisco, further study on the impact of TNCs is needed when projecting future travel patterns and VMT, and while developing transportation polices.

SANDAG in its 2019-2050 Regional Plan will explore emerging technology (e.g., TNCs, autonomous vehicles) that could be implemented in the San Diego region. The SANDAG Emerging Technology White Paper presents the technological and societal trends that have the potential to change the region's transportation system and provides potential policy considerations (SANDAG, 2018).

7.5 Using Speed Bin Profile to Evaluate Traffic Calming Measures

Traffic calming measures, such as roundabouts or mini-circles, harmonize traffic flow for improved fuel efficiency of the system. Section 5.6.3 discusses two types of traffic calming measures: traffic flow improvement through roundabouts and traffic signal retiming. The emissions reduction is calculated based on fuel savings per intersection and the average vehicle fuel economy. While this emission calculation takes into account all types of vehicles that may pass through the intersection at an average speed, in reality, the vehicles pass through the intersections at a very low speed. The vehicle emission factor changes at different speed ranges. Figure 36 shows that the emission factors at low speeds (<20 mph) are higher than the emission factors at higher speeds.



Source: Data from CARB EMFAC2014, calculated by Energy Policy Initiatives Center, 2017
*for San Diego region in 2014 only

Figure 36 2014 Vehicle Speed and CO_2 Emission Rate for San Diego Region Only (CARB, EPIC 2017)

The current SANDAG Series 13 Travel Demand Model includes analysis on VMT by speed bin (the distribution of VMT at each speed range) for each jurisdiction's in-boundary trips. Once more information is available on the speed profile at the locations where the traffic calming measures are implemented, more accurate analysis on the emission reductions for the measure can be developed based on both the emission rate by speed bin and the speed profile.

7.6 Accounting Carbon Sequestration in Natural and Working Lands

One of the strategies in the 2017 Scoping Plan is to "develop and implement the Natural and Working Plan Implementation Plan to maintain these lands as a net carbon sink and avoid at least 15–20 metric tons of GHG emissions by 2030" (CARB 2017b, p.ES-13). Currently, the State agencies including California Natural Resources Agencies (CNRA), California Department of Food and Agriculture (CDFA), etc., is developing a Natural and Working Lands Climate Change Implementation Plan. The Plan, along with a will include an inventory and BAU emissions scenario through 2030, 2050 and 2010 for the natural and working land sector and quantify the emissions sequestration impact of land conservation and management activities (CARB 2017b).

While the expected net GHG emissions impact from land conservation and management activities will be modeled at the State level, the methodology, approaches and monitoring process may be value at local level and are essential to achieve the long-term GHG reduction goals.

8 Conclusion

This Appendix II to the SANDAG Regional Framework for Climate Action Planning discussed:

- California's policy approach for GHG emissions reductions and the role of local CAPs in meeting the statewide GHG reduction target;
- The role of GHG reduction estimation in the climate action planning cycle;
- The process and considerations when selecting CAP measures;
- Methods to estimate GHG reduction for typical CAP measures;
- Ways to visualize and present GHG reductions from CAP measures; and
- Emerging issues related to estimating GHG reductions.

This document is for community-wide climate action planning under the Regional Framework only and could be expanded to include calculations and data collection methods for more CAP measures in future iterations.

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