



REGIONAL CLIMATE ACTION PLANNING FRAMEWORK



TECHNICAL APPENDIX II

Methods to Calculate GHG Emissions Impacts of CAP Measures

VERSION 1.1: NOVEMBER 2020

PREPARED BY



PREPARED FOR

SANDAG

Prepared in partnership with the San Diego Association of Governments (SANDAG) and the Roadmap Program. This Program is primarily funded by California utility customers and administered by San Diego Gas & Electric Company under the auspices of the California Public Utilities Commission.

TABLE OF CONTENTS

1. Introduction	1
1.1 Guiding principles	2
1.2 Summary of Updates	2
2. California’s approach to reduce GHG emissions and relationship to CAP measures	3
2.1 CARB Scoping Plan	4
2.2 Role of local CAP measures in contributing to statewide targets	5
2.3 Overall approach to reduce GHG emissions	5
2.3.1 Strategies to reduce transportation emissions	6
2.3.2 Strategies to reduce building energy emissions	7
3. Purpose and role of GHG analysis in the climate action planning cycle	8
3.1 Develop and maintain CAPs	8
3.2 Monitor and report progress	10
3.3 Other aspects of climate action planning	10
4. Selecting CAP measures	10
4.1 Considerations for selecting CAP measures	10
4.2 Master list of CAP measures	11
4.3 CAP Measure Matrix	14
5. Methods to estimate GHG impact from CAP measures	15
5.1 Overview of existing methods and tools to estimate GHG impacts	16
5.1.1 CAPCOA – GHG quantification report	16
5.1.2 ICLEI – SEEC ClearPath tool California	16
5.1.3 Limitations of existing methods and tools to estimate GHG impacts	17
5.2 Considerations for estimating GHG impacts from CAP measures	18
5.3 Overview of methods to estimate GHG emissions impact	18
5.4 Effect of order of GHG impact calculation of inter-related CAP measures – a limitation	20
5.5 Emissions impact from energy-related measures	21
5.5.1 Increase renewable and zero-carbon electricity supply	21
5.5.2 Increase building efficiency	35
5.6 Emissions impact from on-road transportation related measures	42
5.6.1 Improve vehicle fuel efficiency	42
5.6.2 Reduce VMT	53
5.6.3 Reduce fuel use through improved traffic flow	56
5.7 Emissions impact from water-related measures	58
5.7.1 Develop local water supply and improve water system efficiency	58
5.7.2 Increase water conservation	61
5.8 Emissions impact from solid waste-related measures	64
5.8.1 Divert waste from landfills	64
5.8.2 Reducing organics in the waste stream	67
5.9 Emissions impact of carbon removal measures	67
6. Visualization and presenting results	70
6.1 Differentiate local CAP measures from federal and State regulations	70
6.2 Differentiate measures that avoid emissions from measures that remove emissions	70
6.3 Separate emissions impact by CAP strategy or measure (wedge chart)	71
6.4 Emissions impact from CAP strategies in target year (bar chart)	73

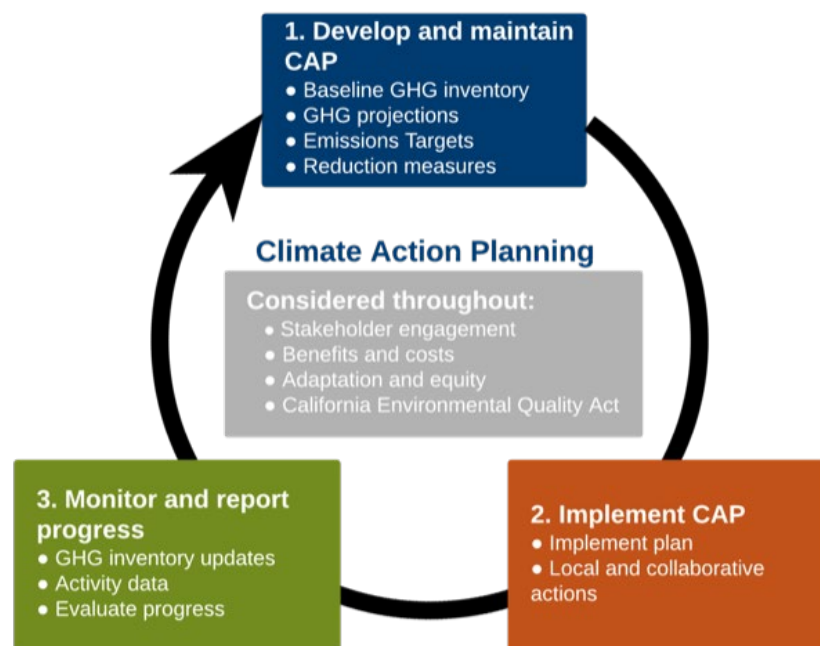
7. Emerging issues	74
7.1 Marginal emission factor of electricity	74
7.2 PV generation and renewable energy credits.....	75
7.3 Impact of transportation network companies on shifting travel patterns.....	75
7.4 Using speed bin profiles to evaluate traffic calming measures	76
7.5 Accounting for carbon stock changes in natural and working lands	77
8. Conclusion	77
9. References.....	78

1. Introduction

This document is the Appendix II to the SANDAG Regional Climate Action Planning Framework (ReCAP). 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 emissions targets.
- Section 3 discusses the role of estimating GHG emissions impacts in the climate action planning process shown in Figure 1. Estimating GHG emissions impacts 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 measures for CAPs.
- Section 5 provides an overview of and methodology for estimating GHG impact of CAP measures.
- Section 6 shows ways to present and visualize results in a CAP.
- Section 7 discusses emerging issues related to the method of estimating GHG impacts.
- Section 8 is the conclusion.

Figure 1 Climate action planning process



1.1 Guiding principles

This Appendix is developed under the following guiding principles:

- **Transparency:** calculation and data collection methods are transparent to readers;
- **Accepted methods:** methods are based on widely-recognized protocols;
- **Local relevance:** methods are relevant to the San Diego region and the local jurisdictions in the San Diego region;
- **Activity-based:** the GHG emissions impact is calculated based on emissions-causing activities within jurisdictions;
- **Regional consistency:** methods maintain consistency across jurisdictions within the San Diego region; and
- **Flexibility and adaptiveness:** methods are regularly updated to be consistent with current best practices.

1.2 Summary of Updates

In addition to general edits, the following are the key changes made to Version 1.0 of this appendix:

Section 2. California's approach to reduce GHG emissions and relationship to CAP measures

- A discussion of the impacts of Executive Order B-55-18 (2018) regarding carbon neutrality and the 2017 California statewide GHG inventory was added.

Section 4. Selecting CAP measures

- In Section 4.1, the incremental impact of CAP measures was added as a new consideration for selecting CAP measures to illustrate the importance of accounting for the impact of local CAP measures that are in addition to the impacts of federal and State regulations.
- The master list of CAP measures in Section 4.2 was updated to incorporate measures in new CAPs adopted from April 2018 to October 2020.
- In Section 4.3, new fields of information were recommended to be included in a CAP measure matrix.

Section 5. Methods to estimate GHG impacts from CAP measures

- Section 5.1 was revised to include updates to the existing GHG reduction methods and protocols.
- In each sub-section 5.5 – 5.7:
 - The latest data sources, methods, and regulatory updates since April 2018 were discussed and the impacts were incorporated.
 - New examples, as well as data needed to calculate GHG emissions impact from these examples, were added to reflect common CAP measures in recently adopted or updated CAPs.

Section 6. Visualization and presenting results

- A new sub-section (Section 6.2) was added to illustrate the differences between measures that avoid future emissions through regulations, policies, and programs and measures that remove and sequester carbon from the atmosphere.
- Section 6.3 was updated to emphasize the importance of cumulative GHG impacts.

Section 7. Emerging issues

The sub-sections were updated to incorporate the impact of new research, data, and legislation on the emerging issues mentioned in each sub-section.

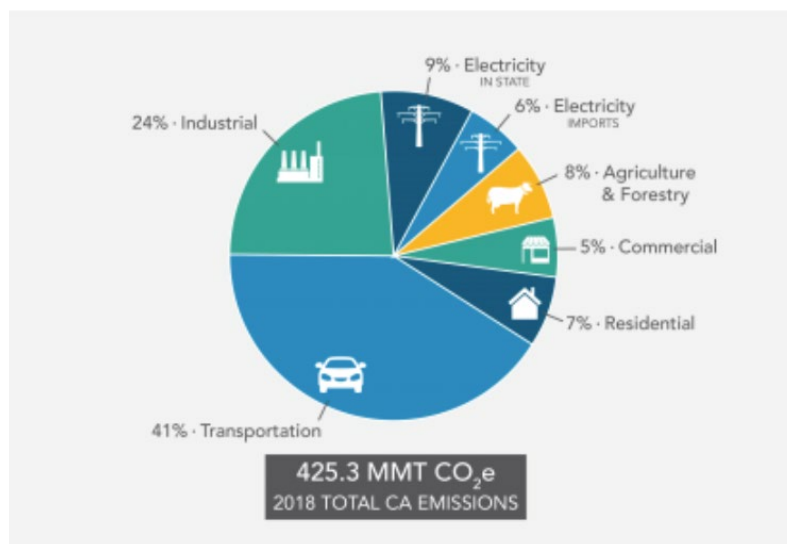
2. California's approach to reduce GHG emissions and relationship to CAP measures

The main legislative and executive actions related to GHG emissions 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;
- Executive Order S-3-05 (2015): Reduce statewide GHG emissions to 80 percent below 1990 levels by 2050; and
- Executive Order B-55-18 (2018): Achieve statewide carbon neutrality no later than 2045, and achieve and maintain net negative emissions thereafter.

Understanding the sources of emissions is critical to developing strategies to avoid future emissions. Figure 2 summarizes the sources of statewide 2018 GHG emissions by economic sector. The transportation sector is the largest emissions contributor, followed by industrial emissions, and then electricity generation. The industrial, residential, and commercial sector emissions come primarily from natural gas end-use. Emissions from transportation, and natural gas end-use (industrial, residential, commercial) and electricity generation (in-state and imports), represent the majority of emissions in California.

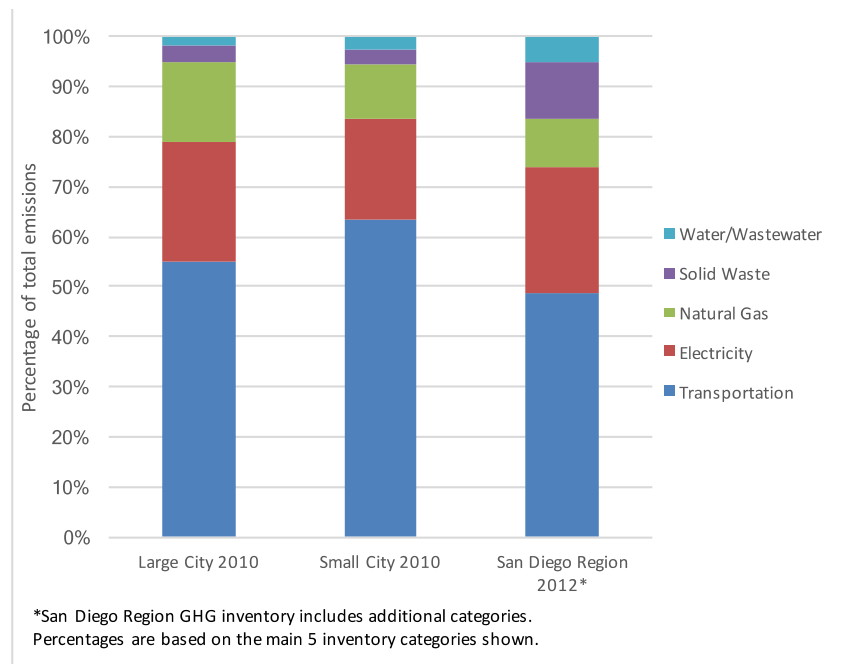
Figure 2 2018 California statewide GHG emissions by economic sector (CARB, 2020a)



Local community-wide inventories similarly help to inform local GHG strategies. Local community-wide inventories typically estimate emissions from five main categories: transportation, electricity, natural gas end-use, solid waste, water, and 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, 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 greater than 200,000.

Figure 3 Typical distribution of emissions categories across geographic scales



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 2017 Scoping Plan focuses significantly on transportation fuels, electricity generation, and natural gas end-use, with measures to conserve energy in buildings, reduce vehicle miles traveled (VMT), and reduce the GHG intensity of the fuels through increased renewable energy and a shift to zero emission vehicles (ZEVs). In addition, the California Air Resources Board (CARB) includes reductions expected from the Cap-and-Trade Program in the 2017 Scoping Plan. Certain State strategies will help reduce emissions locally and are reflected as statewide measures in local CAPs. However, not all strategies included in the 2017 Scoping Plan would have a measurable impact on local GHG emissions.

Figure 4 GHG strategies in CARB 2017 Scoping Plan (CARB, 2017)²

SB 350 GHG Reduction Plan for Electricity Suppliers 50% Renewable Portfolio Standard Doubling Energy Efficiency Savings	Sustainable Freight Action Plan Improve Freight System Efficiency by 25% 100,000 Freight Vehicles Capable of Zero Emissions operation
Low Carbon Fuel Standard At least 18% Reduction in Carbon Intensity	SB 1383 (High GWP Gases) 40% Reduction in CH ₄ and HFCs 50% Reduction in Black Carbon Emissions
Mobile Source Strategy 1.5 million and 4.2 million ZEVs by 2025 and 2030 Medium- and Heavy-Duty Phase II Innovative Clean Transit Last Mile Delivery Reduction in VMT	Post-2020 Cap-and-Trade Program Continue the Existing Cap-and-Trade Program with Declining Caps

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 strategies to address local conditions and issues and can effectively engage residents 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 air pollutant emissions impacts beyond what State policy can alone, and these efforts will sometimes be more cost-effective and provide more local co-benefits than relying exclusively on top-down statewide regulations to achieve the State's climate stabilization goals (CARB 2017, p.97).

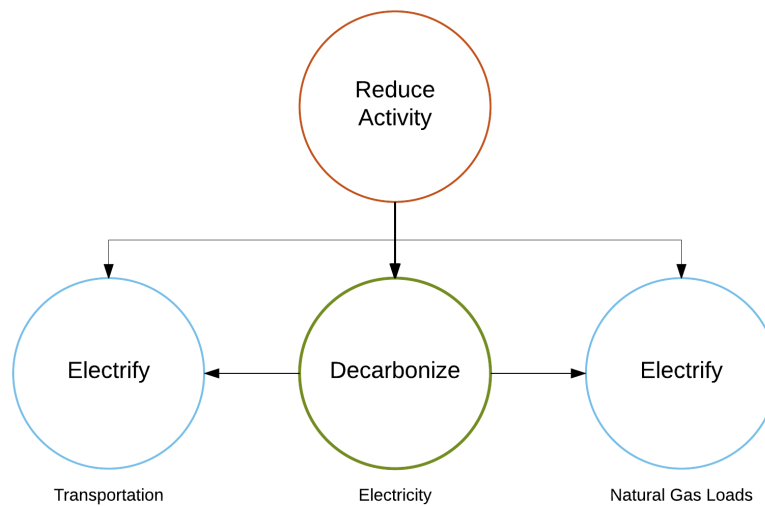
While local measures support the statewide targets, they are tailored to meet local needs and circumstances.

2.3 Overall approach to reduce GHG emissions

In general, the method to mitigate GHG emissions is to reduce fossil fuel combustion because most GHG emissions (primarily carbon dioxide (CO₂)) are associated with fossil fuels. GHG emissions can be avoided by reducing activity levels of the major emitting activities, shifting VMT to alternative modes of transportation, or using electricity and natural gas more efficiently. Once the activity levels are reduced, the focus is on decarbonizing the system, or reducing the carbon intensity of the system. Figure 5 illustrates this approach.

² Some of the strategies may have been updated since the Scoping Plan adoption. All targets within strategies are for 2030 unless stated otherwise.

Figure 5 Conceptual diagram of overall GHG strategy



This overall concept of GHG emissions reduction approaches forms the basis for categorizing and organizing CAP GHG 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 mitigate emissions in the transportation sector are as follows:

- **Reduce fuel use** – Reduce fuel use through vehicle 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 to shorten driving distances of certain trips.
- **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.

Figure 6 illustrates how local CAP measures support statewide GHG targets to achieve each strategy. For example, 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. Also, the State adopted SB 743 to update the CEQA guidelines to address VMT. To support CEQA analysis of the projects, local jurisdictions may develop additional CAP measures, such as modifying parking requirements in smart growth areas that would support the objectives of SB 375 or encouraging alternative modes of transportation to avoid vehicle trips.

Figure 6 Examples of local transportation measures that support statewide GHG targets and regulations

	Reduce VMT	Cleaner Fuels	Reduce Fuel Use
Example of State/Federal Regulations	SB 375 SB 743	Low Carbon Fuel Standard	Vehicle Efficiency Standards
Example of Local CAP Measures	Alternative Modes of Transportation	EV Policies Fleet Turnover	Roundabouts Traffic Signal Re-timing

2.3.2 Strategies to reduce building energy emissions

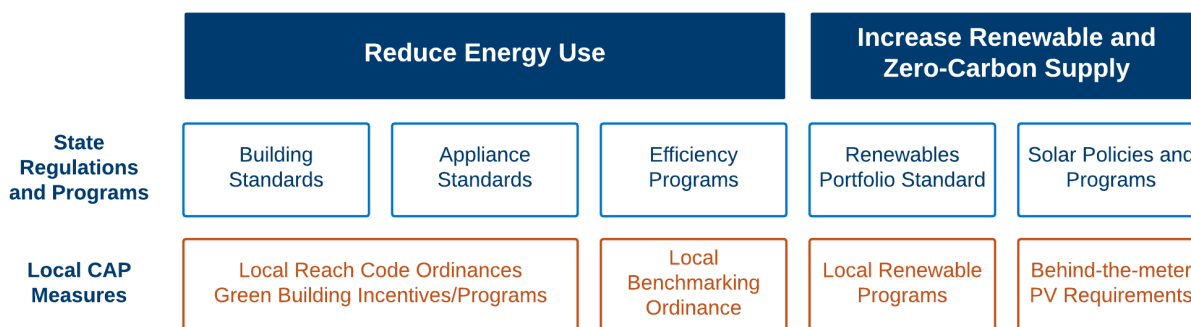
A similar set of strategies can be applied to reduce building energy emissions:

- **Reduce energy use** – Reduce electricity and natural gas use through energy efficiency or conservation. This is typically done through building and appliance efficiency standards and local actions to encourage building owners and occupants to conserve energy.
- **Increase use of renewable or zero-carbon energy** – The carbon content of electricity can be reduced through policies prioritizing 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 (RPS) and increased local renewable energy supply, 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).

Similar to the transportation measures, building energy measures within a strategy can support statewide targets. Figure 7 provides examples of how local CAP measures help achieve a CAP strategy and State goals, such as local ordinances that require new buildings to be more efficient than under the State’s building efficiency standards.

Figure 7 Examples of local building energy measures that support statewide GHG targets and regulations



3. Purpose and role of GHG analysis in the climate action planning cycle

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

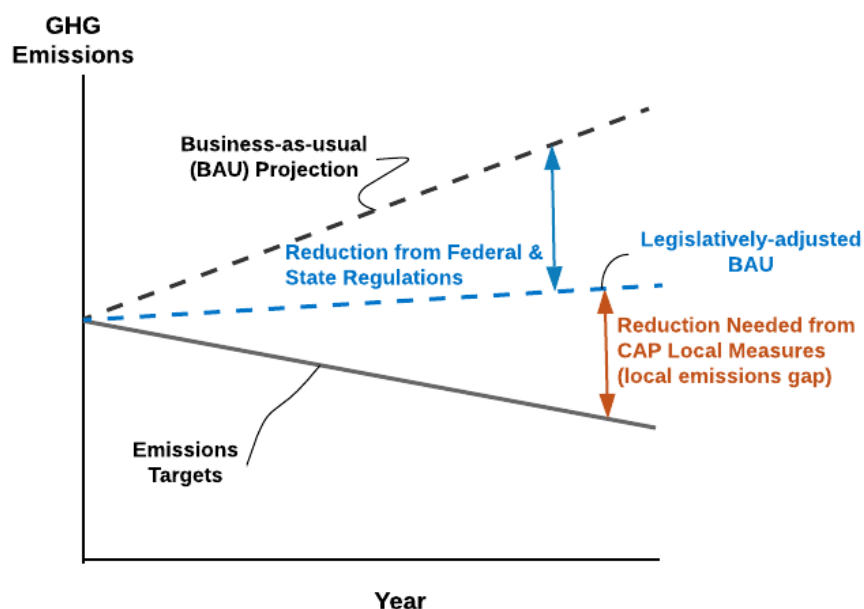
- Developing and maintaining CAPs;
- Monitoring and reporting progress; and
- Other aspects of climate action planning, such as benefit-cost analyses.

Section 3.1 through Section 3.3 indicate where estimating GHG impacts plays a role.

3.1 Develop and maintain CAPs

Estimating GHG impacts for measures form the main part of a CAP. Once a baseline emissions level is determined, an emissions projection is developed, and emissions targets have been established, the impact of GHG measures demonstrates how emissions will be reduced to meet the target levels. Figure 8 conceptually illustrates the role of GHG measure analysis in helping a jurisdiction achieve identified targets.

Figure 8 Role of GHG impact analysis in CAP development



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 into the future to determine how much additional action is needed from local CAP measures—often called the local emissions gap (Figure 8)—in order to reach the target emissions by a corresponding target year. The projected emissions level after the impact of federal and State regulations is sometimes called the “legislatively-adjusted business-as-usual (legislatively-adjusted BAU)” projection.

Examples of federal and State regulations accounted for in CAPs include the following: the federal Corporate Average Fuel Economy (CAFE) standards, which regulate vehicle fuel economy and tailpipe emissions from on-road vehicles; California’s RPS, which sets requirements for the proportion of renewables 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 aims to increase the number of ZEVs, such as battery electric and fuel cell electric vehicles. GHG impacts from existing federal or State regulations may change if the federal and/or State government takes action to re-evaluate and revise existing regulations.

GHG impacts 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 impacts of existing federal and State regulations), only local measures are available to meet emissions targets. Local jurisdictions must identify actions within their authority to reduce emissions to meet targets; these actions 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 projections to reflect updated data, re-evaluating GHG emissions targets to reflect any updated relevant legislation, guidance from CARB, or other relevant guidance and policies, and estimating additional measures to help reach overall targets.

3.2 Monitor and report progress

During the CAP monitoring process, if emissions are not trending towards the identified targets or if the implementation of particular measures is not leading to expected results, it might be necessary to remove or modify ineffective measures and to identify additional CAP measures.

Another aspect of assessing the GHG impact 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 impacts, the local gap will become larger and additional local measures will be needed to meet the targets.

3.3 Other aspects of climate action planning

Estimating GHG impact plays a role in assessing the cost-effectiveness of CAP measures. The net cost or benefit per metric ton (MT) of GHG emissions reduced (typically expressed as \$/MT CO₂e reduced) provides one way to compare the effectiveness of CAP measures.

Unlike in the assessment of GHG impact of a measure in a particular target year, the calculation of a \$/MT CO₂e requires use of the cumulative total GHG impact over the life of a given measure (technology or activity). For example, to determine the \$/MT CO₂e from solar panels installed in 2016, the total GHG emissions impacts 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 III describes these methods in detail.

4. Selecting CAP 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 measures

This Appendix focuses on the calculation of GHG impacts for CAP measures; however, there are several factors to consider when selecting CAP measures, including but are not limited to the factors listed below. Determining whether to include or exclude a particular CAP measure may require tradeoffs among these factors:

- **Authority** – Whether the local jurisdiction has authority in a particular area to take actions to mitigate emissions. For example, local governments have 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 impacts. Some measures may require specific information about the number of projects or permits for a specific type of project, which may not be readily available. If data are not available to estimate GHG impacts 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. CAP 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 Technical Appendix V.
- **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 III and Technical Appendix IV.

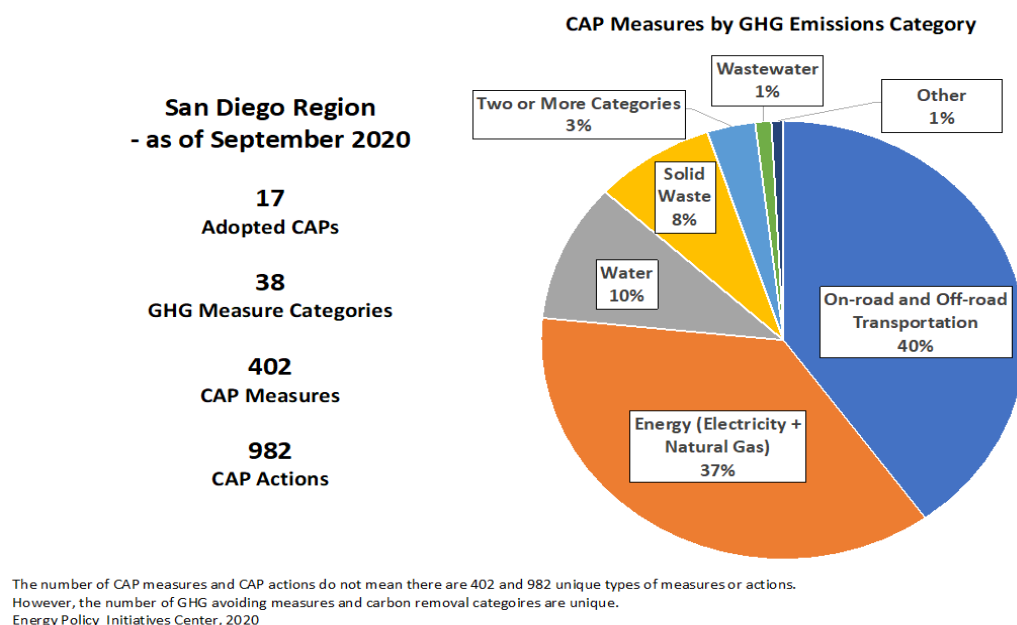
- **Co-benefits** – While the primary focus is to reduce GHG emissions, many CAP measures have additional benefits, such as improved air quality, local economic benefits, improved public health and quality of life, and protection of natural resources. Measures that meet these other priorities may be included in CAPs. Understanding the benefits beyond the GHG impacts can help to put CAP measures into a broader context.
- **Incremental Impact** – As discussed in Section 2.3 *Overall approach to mitigate GHG emissions*, many federal and State regulations are already in place to reduce GHG emissions. To avoid double-counting, it is important that the impacts from local CAP measures are in addition to any impacts from federal and State regulations. For example, because PV systems are now required for new single-family and low-rise multi-family residential units through the State’s 2019 Building Energy Efficiency Standards, they can no longer be attributed to a local CAP measure. However, PV requirements for new high-rise residential or non-residential buildings through a local ordinance may be used as a CAP measure because there is currently no statewide requirement.

There are relationships among these factors. For example, a CAP measure may have a very low cost to implement but result in minor GHG impacts. 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 impact measures to meet targets.

4.2 Master list of CAP measures

There are 17 adopted CAPs in the San Diego region as of September 2020, with a range of CAP strategies, measures, actions, and supporting activities. Several jurisdictions with adopted CAPs are currently updating their CAPs with new projections, targets, and measures.³ Figure 9 summarizes the master list of measures by emissions category for CAPs in the San Diego region.

Figure 9 Categorizing CAP measures in adopted CAPs
(San Diego region, as of September 2020)



³ The County of San Diego rescinded its 2018 CAP on September 30, 2020, after the completion of the master list of CAP measures. However, the CAP measures from the County of San Diego CAP are included in the master list as examples.

Table 1 documents the GHG strategy and measure types included in the region's CAPs and lists the number of measures and actions identified for each.

Table 1 **Number of measures and actions by strategy types in adopted CAPs**
(San Diego region, as of September 2020)

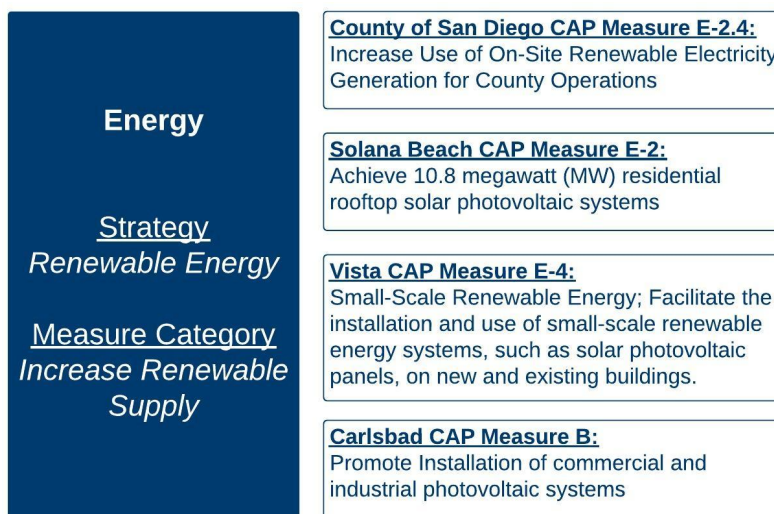
CAP Measure Types		Measures	Actions
Increase Alternative Fuel Vehicles (including Zero Emission Vehicles)	Vehicle Retirement Program	1	2
	Agriculture Vehicles and Equipment	2	2
	Alternative Fuel Infrastructure (e.g., EV charging)	18	86
	Alternative Fuel Vehicles	3	2
	Construction & Landscape Vehicles and Equipment	9	10
	Electric School Buses	2	2
	Government Fleet	12	30
	Preferred Parking for Alternative Fuel Vehicles	4	10
Reduce Vehicle Fuel Use	Traffic Flow Projects	15	20
Reduce Vehicle Miles Traveled	Bicycle & Pedestrian Mobility	21	52
	Intra-City Shuttle	1	5
	Land Use Planning (including Smart Growth)	14	35
	Mass Transit	10	32
	Multi-Modal Roadways & Complete Streets	2	12
	Parking Requirements	6	6
	Transportation Demand Management	29	63
Increase Energy Efficiency	Demand Response	3	
	Energy Retrofit	73	186
	New Construction	11	13
	Shade Trees	2	9
Increase Energy Efficiency & Renewable Energy	Zero Net Energy - New Construction	2	5
Increase Renewable Energy	Behind-the-meter PV & Other Renewables	32	91
	Citywide Renewable Supply (including CCA)	15	33
Increase Solid Waste Reduction & Recycling	Solid Waste Reduction & Recycling	29	81
Increase Methane Capture	Solid Waste	1	1
	Wastewater	4	2
Increase Water Conservation	Greywater & Rainwater Capture	4	15
	Rate Structures	3	10
	Water Efficiency	28	77
Increase Water Supply	Recycled Water & Potable Water Reuse	6	5
Increase Water Utility Efficiencies	Water Utility Improvements	7	2
Avoid New Building Energy & Vehicle Miles Traveled	Easements	3	12
Other	Cogeneration	1	3
	Direct Investment Program	1	3
	Reduce Heat Island Impacts	1	
Carbon Removal Strategy	Agriculture	3	11
	Shade Trees	1	2
	Urban forest	23	52
Total Number of Measures and Actions		402	982

Figure 10 and Figure 11 provide examples of the types of measures classified together for the respective measure categories.

Figure 10 Select measures included in “smart growth development” measure category



Figure 11 Select measures included in “increase renewable supply” measure category



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

- By action type: education, incentive, ordinance, municipal code, etc.
- By sector: residential, commercial/industrial, municipal, agricultural, etc.
- By building type: new construction, existing construction, municipal facilities, etc.

The master list does not include the GHG impact of measures because the impact of the same measure may differ in each jurisdiction due to different input data. However, the methods to calculate emissions impacts from common CAP measures are discussed in this Appendix in 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 CAP Measure Matrix

To facilitate the development of CAP 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 CAP measures. A completed matrix serves as the organizational structure and main content of the CAP document. Typical fields of information in a CAP measure matrix include:

- **Emissions category** – Organized by the broad emissions categories in the inventory, including transportation, energy, water, solid waste, etc.
- **Strategy** – CAPs generally have several broad strategies. These may include increasing building efficiency, renewable energy, clean transportation, zero waste, etc. Multiple strategies can be associated with one emissions category.
- **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 may 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 impacts.
- **Performance indicators or metrics** – Each action may have associated performance metrics for tracking progress, which can be evaluated during the monitoring and progress reporting phase. Technical Appendix VI includes a more detailed discussion of this phase.
- **Implementation actions** - Each local action may include multiple steps the jurisdiction needs to take in order to implement the local action. Technical Appendix IV 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 impacts. For example, educating residents about incentives or rebate programs and making available a property assessed clean energy (PACE) financing program to help residents implement efficiency projects may facilitate energy retrofit activities, but may not directly lead to energy reductions and GHG impact. In the case of PACE financing, the energy efficiency retrofit activity or PV system installed is what would be considered a quantifiable activity.

Figure 12 shows examples of information that could be included in a CAP measure matrix.

Figure 12 CAP measure matrix example

Emissions Category	Reduction Strategy	Measure	Action	Performance Indicators and Metrics	GHG Mitigated	Implementation Actions	Supporting Activities
Energy (electricity + natural gas)	Building Efficiency	Reduce Commercial Building Energy Consumption	Require non-gas water heating at new homes	Install XX alternative powered water heaters	XX MT CO ₂ e	1. Draft ordinance 2. Conduct cost effectiveness study	Offer PACE financing to residents Educate residents and businesses about rebates/incentives
			Require new projects to meet CalGreen Voluntary Tier 1	Energy Upgrade at XX commercial square footage	XX MT CO ₂ e	x y z	
		Reduce Residential Building Energy Consumption	Require non-gas water heating at new homes	Install XX alternative powered water heaters	XX MT CO ₂ e	x y z	
			Require energy retrofits for major renovation projects	Retrofit XX residential units	XX MT CO ₂ e	x y z	

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 impact from a specific action.
- **Co-benefits** – Identifying additional benefits associated with the measure or strategy, e.g., improved air quality, local economic benefits, improved public health, and quality of life.
- **Implementation-related information** – CAPs often include a section on implementation. Collecting this information during the CAP 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 impact from CAP measures

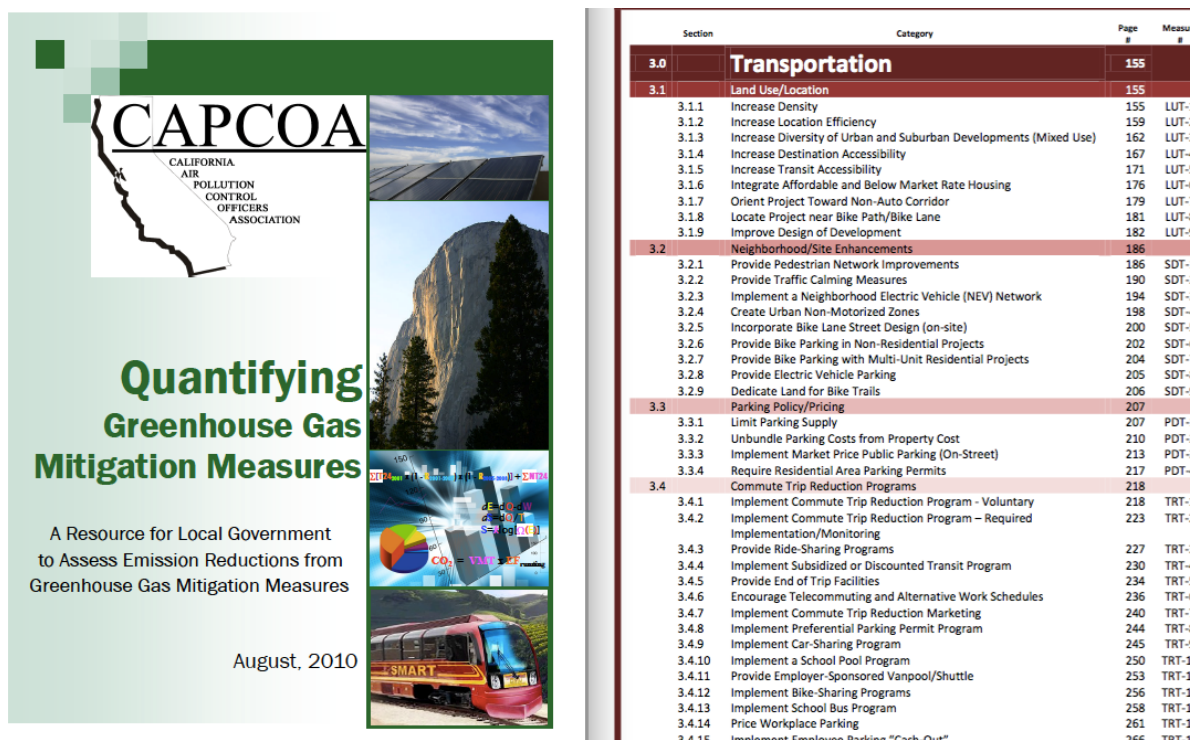
Currently, there is no standardized or official protocol or method used by jurisdictions in California to calculate GHG impacts from CAP measures, unlike estimating community-scale GHG inventories, where almost all jurisdictions in California use the *U.S. Community Protocol for Accounting and Reporting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

5.1 Overview of existing methods and tools to estimate GHG impacts

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 impacts from measures at the project level. CAPCOA initiated an update process of the *GHG Quantification Report* in late 2019; however, the timeline of the process is unknown. Figure 13 shows a screenshot of the *CAPCOA GHG Quantification Report* and its list of transportation measures.

Figure 13 CAPCOA GHG quantification report and transportation measure examples



The figure displays the cover of the CAPCOA GHG Quantification Report on the left and a table of transportation measures on the right.

CAPCOA GHG Quantification Report Cover:

- Logo:** CAPCOA CALIFORNIA AIR POLLUTION CONTROL OFFICERS ASSOCIATION
- Title:** Quantifying Greenhouse Gas Mitigation Measures
- Subtitle:** A Resource for Local Government to Assess Emission Reductions from Greenhouse Gas Mitigation Measures
- Date:** August, 2010
- Images:** A map of California, a solar panel array, a mountain landscape, a pie chart showing energy sources, and a SMART train.

Table of Transportation Measures:

Section	Category	Page #	Measure #
3.0	Transportation	155	
3.1	Land Use/Location	155	
3.1.1	Increase Density	155	LUT-1
3.1.2	Increase Location Efficiency	159	LUT-1
3.1.3	Increase Diversity of Urban and Suburban Developments (Mixed Use)	162	LUT-1
3.1.4	Increase Destination Accessibility	167	LUT-1
3.1.5	Increase Transit Accessibility	171	LUT-1
3.1.6	Integrate Affordable and Below Market Rate Housing	176	LUT-1
3.1.7	Orient Project Toward Non-Auto Corridor	179	LUT-1
3.1.8	Locate Project near Bike Path/Bike Lane	181	LUT-1
3.1.9	Improve Design of Development	182	LUT-1
3.2	Neighborhood/Site Enhancements	186	
3.2.1	Provide Pedestrian Network Improvements	186	SDT-1
3.2.2	Provide Traffic Calming Measures	190	SDT-1
3.2.3	Implement a Neighborhood Electric Vehicle (NEV) Network	194	SDT-1
3.2.4	Create Urban Non-Motorized Zones	198	SDT-1
3.2.5	Incorporate Bike Lane Street Design (on-site)	200	SDT-1
3.2.6	Provide Bike Parking in Non-Residential Projects	202	SDT-1
3.2.7	Provide Bike Parking with Multi-Unit Residential Projects	204	SDT-1
3.2.8	Provide Electric Vehicle Parking	205	SDT-1
3.2.9	Dedicate Land for Bike Trails	206	SDT-1
3.3	Parking Policy/Pricing	207	
3.3.1	Limit Parking Supply	207	PDT-1
3.3.2	Unbundle Parking Costs from Property Cost	210	PDT-1
3.3.3	Implement Market Price Public Parking (On-Street)	213	PDT-1
3.3.4	Require Residential Area Parking Permits	217	PDT-1
3.4	Commute Trip Reduction Programs	218	
3.4.1	Implement Commute Trip Reduction Program - Voluntary	218	TRT-1
3.4.2	Implement Commute Trip Reduction Program - Required	223	TRT-1
	Implementation/Monitoring		
3.4.3	Provide Ride-Sharing Programs	227	TRT-1
3.4.4	Implement Subsidized or Discounted Transit Program	230	TRT-1
3.4.5	Provide End of Trip Facilities	234	TRT-1
3.4.6	Encourage Telecommuting and Alternative Work Schedules	236	TRT-1
3.4.7	Implement Commute Trip Reduction Marketing	240	TRT-1
3.4.8	Implement Preferential Parking Permit Program	244	TRT-1
3.4.9	Implement Car-Sharing Program	245	TRT-1
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

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 impacts and develop CAP scenarios. Figure 14 is a screenshot of the inputs needed to be entered into the ClearPath Tool to calculate the GHG impact of a residential energy retrofit measure.

Figure 14 Example of ClearPath tool – inputs and outputs of a 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)	

5.1.3 Limitations of existing methods and tools to estimate GHG impacts

The *CAPCOA GHG Quantification Report* states that for 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 GHG Quantification Report* and the literature substantiating it can be adapted and used to estimate GHG impacts 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 and the 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 analyses that is applicable to any jurisdiction using the tool. To be consistent with GHG inventories and CAP measures in the San Diego region, off-model estimates and calculations would have to be developed and entered into the ClearPath tool as the forecast “growth factor” inputs. For each emissions 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 measures which are not used to adjust default growth factor entered by the user. While SEEC provides technical support for its members on the use of the free ClearPath tool, activity data must be gathered and input by local agency staff. The SEEC Program will sunset in December 2020; afterwards, technical assistance will be available through a membership fee system.

5.2 Considerations for estimating GHG impacts from CAP measures

To develop the methods to estimate GHG impacts 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 affect the calculations. For example, the vehicle fleet becomes more efficient in future years with lower GHG emissions per mile driven, and reducing VMT will result in reducing fewer GHG emissions over time.
- **Baseline activity level** – The GHG impact of a measure is compared to a baseline level of activity or a hypothetical BAU projection. For example, if a CAP measure seeks to reach a total of 50 MW of behind-the-meter PV in 2030, it is necessary to determine the amount of PV that was already installed in the baseline year or in a BAU projection and to calculate the amount of additional PV installed through 2030. GHG impacts in that year would be based on the incremental installations in that year compared with the baseline or the projection.
- **Interaction among measures** – Interconnections among CAP measures affect the GHG impacts. For example, an increase in the share of EVs in the vehicle fleet will lower the average vehicle emissions per mile driven, but would also increase electricity use from vehicle charging, which may increase emissions in the electricity category.

5.3 Overview of methods to estimate GHG emissions impact

As discussed in Section 4.3, CAP Measure Matrix, CAP strategies are 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 below a projected level, sometimes called “quantity” measures; and 2) those that reduce the GHG intensity or emission factor of an emissions-generating activity below a projected level, sometimes called “rate” measures. This also matches California’s policy approach for reducing GHG emissions, as discussed in Section 3. Figure 15 provides a breakdown of sample strategies in each emissions category.

Figure 15 Breakdown of CAP strategies by emissions category

Emissions Category	CAP Strategy to Reduce Emission Factor (GHG Intensity)	CAP Strategy to Reduce Activity Level
Electricity	Increase Renewable and Zero-Carbon 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 Use Efficiency
Solid Waste	Reduce Organics in the Waste Stream	Divert Waste from Landfills

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

Equation 1 General equation to estimate GHG emissions impact

$$\Delta = \Delta A_{category} * \Delta EF_{category}$$

Where

Δ = emissions impact from an emissions category in a given year, in metric tons (MT) of carbon dioxide equivalent (CO₂e)
 $\Delta A_{category}$ = 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 CO₂e per unit of activity

With

category = [electricity, natural gas, transportation, water, wastewater, solid 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 kilowatt hours [kWh]) in the electricity category;
- Implementing a vehicle replacement program using electric or compressed natural gas vehicles changes the emission factor (decreases grams CO₂e/mile) of the vehicle fleet in the transportation category; or
- Diverting organic waste from landfills changes both the activity level (lowers waste disposed tonnage) and the emission factor (lowers MT CO₂e/ton of waste disposed) in the solid waste category.

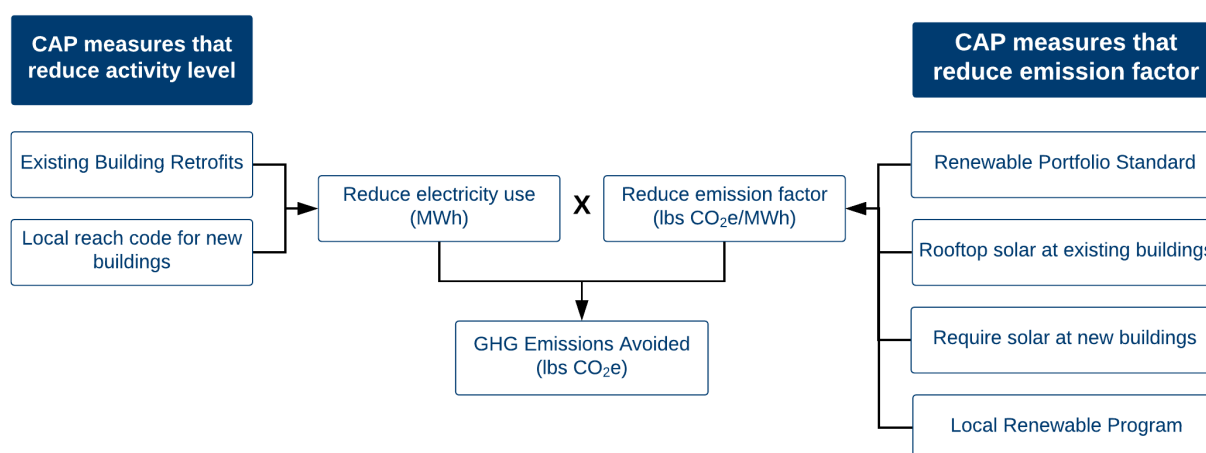
The emission impact calculation and data needs for each CAP strategy are discussed in Section 5.5 to Section 5.8, with sample calculations of typical measures included in each strategy.

5.4 Effect of order of GHG impact calculation of inter-related CAP measures – a limitation

Equation 1 above shows the general equation to estimate GHG impact 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) below projected levels 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 16 provides an example to illustrate the interrelationship of activity- and emission factor-related measures.

Figure 16 Example of inter-related CAP measures within one emission category⁴



The sequencing of calculations determines the magnitude of the emissions impact of each measure. In this Appendix, the “emission factor first” or “rate first” approach is used. For example, the emissions impact from the RPS, which increases renewable electricity and lowers the electricity emission factor, is calculated first. Then, the emissions impact of a local energy efficiency measure would be calculated using a lower emission factor, since the RPS has already been accounted for.

⁴ 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.

The result would overestimate the emissions impact from the RPS and underestimate those from the local energy efficiency measures. If the calculation order is reversed, then the opposite outcome arises: the impacts from local energy efficiency measures would be overestimated and the impact from the RPS would be underestimated. The total combined impact 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 because 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 impact equally between the two calculation approaches remains a methodological challenge to be addressed in 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, because the GHG impact over the lifetime of a project would differ depending on the order of these calculations. This is discussed in more detail in Technical Appendix III.

5.5 Emissions impact from energy-related measures

Generally, emissions impacts from energy-related measures can be separated into two categories:

- Increase in renewable and zero-carbon electricity supply (Section 5.5.1); and
- Increase in building efficiency (Section 5.5.2).

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

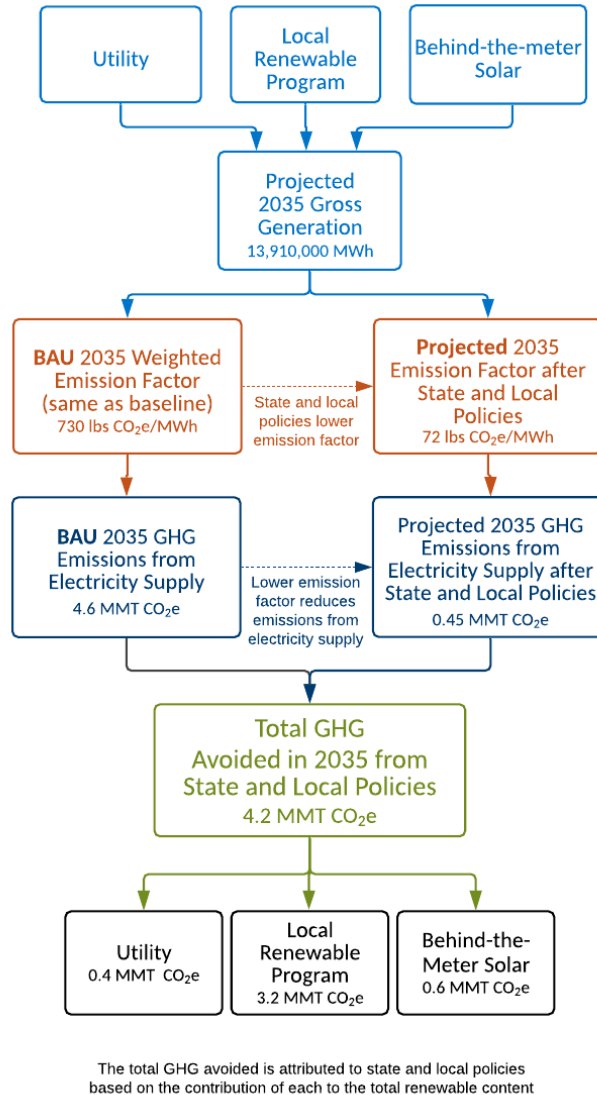
5.5.1 Increase renewable and zero-carbon electricity supply

Measures that increase the renewable and zero-carbon content in the electricity supply generally provide a large portion of the overall GHG impacts in a CAP. This section discusses the method to estimate GHG impacts 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 and zero-carbon content of each supply (grid-supply and self-supply);
3. Overall emissions impact from increasing renewable and zero-carbon content; and
4. Emissions impact from State regulations and CAP measures that increase renewable and zero-carbon content.

Figure 17 provides an overview of the process to adjust the weighted emission factor and estimate GHG impacts due to measures that increase the renewable content in the electricity supply.

Figure 17 Process for estimating GHG impacts from renewable electricity policies



Weighted average emission factor of electricity supply

Estimating an emission factor for electricity is central to estimating GHG impacts for measures related to electricity. As discussed in Technical Appendix I and shown in Figure 18 below, to estimate the emission factor, all electricity supplies to a jurisdiction are considered: grid-supply through the main utility (San Diego Gas & Electric [SDG&E], and other Electric Service Providers [ESPs]) and self-supply (e.g., behind-the-meter PV systems). This inclusive view of electricity, called “gross generation,” represents the total electricity generation needed, including losses, to supply electricity end uses in the jurisdiction.

Figure 18 Example of electricity use categories defined by the California Energy Commission (CEC, EPIC 2017)

Electricity Category	Transmission & distribution losses	Self-serve (Behind-the-meter PV and Non-PV)	Electricity Sold by Utility (SDG&E) and ESPs to customers
Electricity Sales			
Net Energy for Load			
Electricity Consumption			
Gross Generation			

Each of the supply sources has its own GHG emissions profile. A portion 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 may have a different GHG emissions profile from SDG&E's supply. To account for this variation in supply sources, all sources and their emission profiles are included to create an average emission factor for the local jurisdiction. The average emission factor can be used to estimate the effects of activities that reduce grid-supplied electricity within the jurisdiction. For example, if a customer with behind-the-meter solar uses less grid-supplied electricity, this approach would account for the emissions impact.

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

Equation 2 Weighted average electricity emission factor calculation

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

Where

$EF_{electricity,n}$ = emission factor of the electricity (gross generation) in a jurisdiction in a given year, in lbs CO₂e per megawatt hour (MWh)

$P_{supply,n}$ = 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 CO₂e per MWh. The 2010–2018 renewable content in SDG&E's supply is shown in Table 5 of Technical Appendix I

$EF_{SDG\&E,baseline}$ = electricity emission factor of SDG&E supply in CAP baseline year, in lbs CO₂e per MWh. The 2010–2018 SDG&E emission factors are shown in Table 5 of Technical Appendix I

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 2030. The renewable content and percent of electricity provided by each supply for 2030 are shown in Table 2. The assumptions in Table 2 are based on State regulations and the assumptions of CAP measures. The proportion of gross generation supplied by CCA would be based on the anticipated participation rate of the program and other assumptions of the program.

Table 2 Background data for a weighted average electricity emission factor calculation example

Year	Supply 1: CCA		Supply 2: SDG&E		Supply 3: Behind-the-meter PV	
	% of Gross Generation Supplied $P_{CCA,2030}$	Renewable Content $RE_{CCA,2030}$	% of Gross Generation Supplied $P_{SDG\&E,2030}$	Renewable Content $RE_{SDG\&E,2030}$	% of Gross Generation Supplied $P_{solar,2030}$	Renewable Content in Supply $RE_{solar,2030}$
2030	70%	100%	17%	60%	13%	100%
Baseline year 2010: $EF_{SDG\&E,2010} = 736 \text{ lbs} \frac{CO_2e}{MWh}$, $RE_{SDG\&E,2010} = 10\%$						

Using data from Table 2 and Equation 2, the weighted average emission factor for this 2030 scenario is 56 lbs CO₂e/MWh (Equation 3).

Equation 3 Example of a weighted average electricity emission factor calculation

$$EF_{electricity,2030} = P_{SDG\&E,2030} * \frac{(1 - RE_{SDG\&E,2030})}{(1 - RE_{SDG\&E,2010})} * EF_{SDG\&E,2010} + P_{CCA,2030} * \frac{(1 - RE_{CCA,2030})}{(1 - RE_{SDG\&E,2010})} * EF_{SDG\&E,2010} + P_{solar,2030} * \frac{(1 - RE_{solar,2030})}{(1 - RE_{SDG\&E,2010})} * EF_{SDG\&E,2010} = 56 \text{ lbs} \frac{CO_2e}{MWh}$$

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. 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 and zero-carbon content of electricity supply calculation

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

Where

$RE_{electricity,n}$ = overall renewable and zero-carbon content of the electricity supply (gross generation) in a given year, %
 $P_{supply,n}$ = gross generation supplied by an electricity supply in a given year, %
 $RE_{supply,n}$ = renewable and zero-carbon 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 2030 scenario and data in Table 2, both above, the overall renewable content of the electricity supply (gross generation) in this scenario is 91 percent (Equation 5). This value would change if the 100% renewable electricity supply applies to the gross generation.

Equation 5 Example of overall renewable content of electricity supply calculation

$$RE_{electricity,2030} = P_{SDG\&E,2030} * RE_{SDG\&E,2030} + P_{CCA,2030} * RE_{CCA,2030} + P_{solar,2030} * RE_{solar,2030} = 93\%$$

With more aggressive strategies and CAP measures to increase renewable and zero-carbon supply, the overall renewable and zero-carbon 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 and zero-carbon content (lower emissions), measures to reduce electricity use will yield fewer GHG impacts over time.

Emissions impact from increasing renewable and zero-carbon electricity supply

To calculate the emissions impacts from all State regulations and CAP measures that increase renewable and zero-carbon electricity supply, the total emissions impact associated with a particular level of clean electricity is calculated first and then attributed to each measure. The total impact 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 impact from increasing renewable and zero-carbon supply

Equation 6 Emissions impact from increasing renewable and zero-carbon supply calculation

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

Where

$\Delta E_{electricity,RE,n}$ = total emissions impact from increasing renewable and zero-carbon electricity supply in a given year, in MT CO₂e

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

$\Delta EF_{electricity,n}$ = difference in the projected emission factor of the electricity (gross generation) in a jurisdiction in a given year compared with BAU emission factor, in pounds CO₂e per MWh

0.000453 = conversion factor, MT CO₂e 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 impact in 2030 (with a 2010 CAP baseline) from all measures that increase renewable supply in a jurisdiction (Table 3).

Table 3 Example of estimating emissions impact from increasing renewable supply

Year	Gross generation (GWh) $Elec_{2030}$	BAU emission factor (lbs CO ₂ e/MWh)	Projected emission factor with State and local actions (lbs CO ₂ e/MWh)	Difference between BAU and projected emission factor (lbs CO ₂ e/MWh) $\Delta EF_{electricity,2030}$	Total emissions impact from increased renewable and zero-carbon supply (MMT CO ₂ e) $\Delta E_{electricity,RE,2030}$
2030	13,910	730	56	674	4.25
BAU emission factor is the 2010 baseline year electricity emission factor kept constant through CAP horizon year. MMT CO ₂ e = million metric tons CO ₂ e					

Allocating total emissions impact to each supply

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

Equation 7 Emissions impact from each supply increasing renewable and zero-carbon 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 impact of an electricity supply from increasing renewable and zero-carbon content in a given year, in MT CO ₂ e
$\Delta E_{electricity,RE,n}$	= total emissions impact from increasing renewable and zero-carbon electricity supply in a given year, in MT CO ₂ e; refer to Equation 6
$P_{supply,n}$	= gross generation supplied by an electricity supply in a given year, %
$RE_{supply,n}$	= renewable and zero-carbon content of an electricity supply in a given year, %
$RE_{electricity,n}$	= overall renewable and zero-carbon 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, CCA

n

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

For the scenario given in Table 3, the total emissions impact from increasing the renewable electricity supply is 4.25 MMT CO₂e in 2030 ($\Delta E_{electricity,RE,2030}$). Using this method, the emissions impact from SDG&E increasing its renewable supply to 60% renewable electricity in 2030 are calculated in Equation 8. In this example, SDG&E supplies 17% of the gross generation.

Equation 8 Example of emissions impact from SDG&E providing renewable electricity

$$\begin{aligned} \Delta E_{electricity,SDG\&E,2030} &= \Delta E_{electricity,RE,2030} * \left(\frac{P_{SDG\&E,2030} * RE_{SDG\&E,2030}}{RE_{electricity,2030}} \right) = 4.25 * \left(\frac{17\% * 60\%}{93\%} \right) \\ &= 0.47 \text{ MMT CO}_2\text{e} \end{aligned}$$

The same method can be used to attribute the emissions impact 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 of estimating emissions impact from each supply increasing renewables

Supply	2035		
	% of gross generation supplied by renewables from each supply	Portion of total renewables from each supply	Emissions impact (MMT CO ₂ e)
SDG&E	10%	11%	0.47($\Delta E_{electricity,SDG\&E,2030}$)
CCA	70%	75%	3.19($\Delta E_{electricity,CCA,2030}$)
Behind-the-meter PV	13%	14%	0.59($\Delta E_{electricity,PV,2030}$)
Total	93%	100%	4.25 ($\Delta E_{electricity,RE,2030}$)

A CAP could include multiple measures that increase the renewable and zero-carbon content of a supply. For example, the renewable and zero-carbon content of a local renewable program could be affected by both the State's RPS and local goals. In this case, the amount associated with the RPS would be shown as the impact due to State policies and regulations, while the additional renewable and zero-carbon content above State targets from local renewable energy goals would be shown as a local impact. 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.

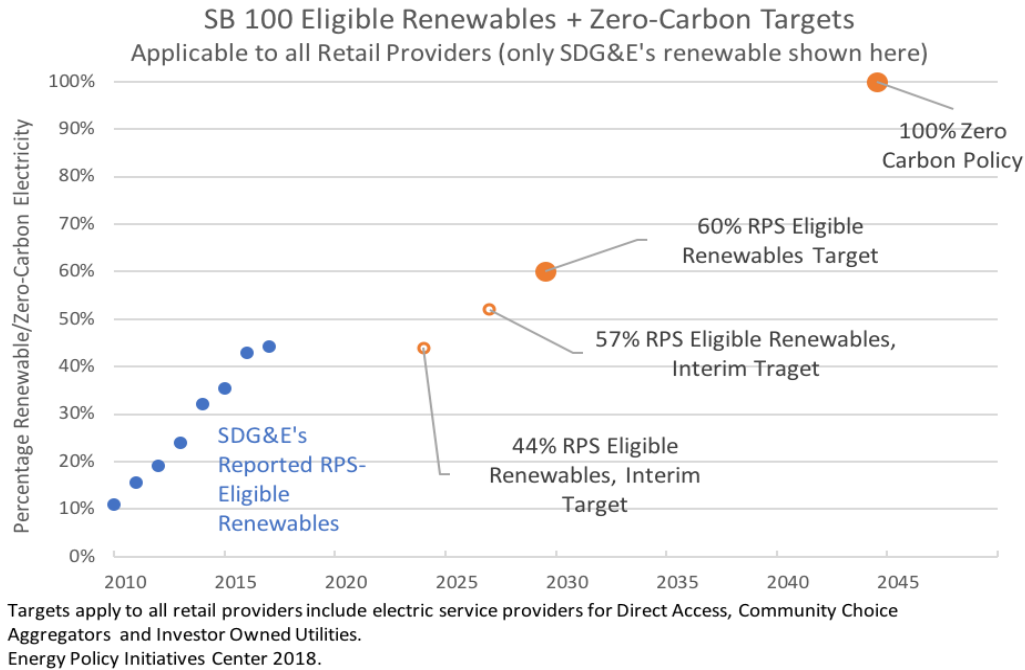
California regulations to increase renewables in electricity

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

California Renewables Portfolio Standard

Signed into law in 2011, the RPS requires all of California's electric retail providers to increase procurement from eligible renewable electricity sources to 33% of total procurement by 2020. In 2015, Governor Brown signed into law [SB 350 \(de León\) \(Chapter 547, Statutes of 2015\)](#), which increases renewable electricity targets to 50% by 2030. Under [SB 100 \(de León\) \(Chapter 312, Statutes of 2018\)](#), the 100 Percent Clean Energy Act of 2018, the RPS target has been increased to 60% by 2030. The legislation also provides goals for the years leading up to 2030 and establishes a State policy requiring eligible renewable resources and zero-carbon resources to supply 100% of all retail electricity sales by 2045. All electric retail providers must meet these RPS requirements, including utilities (SDG&E), ESPs for DA customers, and other local renewable programs, including CCAs. The renewable and zero-carbon targets are shown in Figure 19 below.

Figure 19 SB 100 Renewables and Zero-Carbon Electricity Target



SDG&E exceeded the 2020 targets with a renewable content level of 43% in 2018. Because local jurisdictions do not have authority to affect the RPS, CAPs generally account for the level of renewable electricity required by State law as part of the impacts allocated to the State. All emissions impacts from SDG&E and ESPs increasing renewable content (calculated using Equation 7), even if beyond the State mandates, are attributed to the RPS, and, therefore, to the State.

For local renewable programs that meet and exceed RPS requirements, such as a CCA, a portion of the emissions impact from the local renewable program is attributed to the State as part of RPS compliance, and the remaining is attributed to the local renewable program. For example, for a local renewable program that calls for 80% renewables by 2030, the emissions impact associated with the RPS (60% renewable supply) is attributed to the RPS and the impacts associated with the additional 20% is attributed to the local renewable program. The attribution of State versus local impact is shown in Equation 9 using a local renewable energy program that goes beyond the RPS requirement as an example.

Equation 9 Emission impact calculation for local renewable program in compliance with RPS

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

Where

$\Delta E_{electricity,RPS,n}$

= emissions impact of a local renewable program in a given year, in compliance with RPS, in MT CO₂e

$\Delta E_{electricity,Local RE,n}$

= emissions impact of local renewable program in a given year, in MT CO₂e

$RE_{RPS,n}$

= RPS requirement in a given year, fixed for RPS target years 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 2020–2030 Revised Forecast (adopted in February 2020), has projections for behind-the-meter PV generation in the SDG&E planning area through 2030 (CEC, 2020). The California Distributed Generation (DG) Statistics database provides 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 areas, including SDG&E. DG Statistics gives behind-the-meter PV systems installed in a jurisdiction from the start year of incentive programs through the current year allowing for a historical record of capacity in a given year, such as a baseline year, and 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 impact 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

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

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
$C_{PV,local}$	= historical 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 impact calculation – California solar policies and programs

Data/information needs	Data timeframe	Data source
Historical (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)

California solar mandate

The new California 2019 Building Energy Efficiency Standards (2019 Building Code), which went into effect on January 1, 2020, require all newly constructed single-family homes, low-rise multi-family homes, and detached accessory dwelling units (ADUs) to have PV systems installed, unless the building receives an exception (CEC, 2018).

The impact of the solar mandate on newly constructed single-family homes was incorporated into the 2020–2030 Revised Forecast, but not the prior version of the forecast. However, the impact of the solar mandate on newly constructed low-rise multi-family homes was not incorporated and needs to be calculated separately. Equation 11 below is adapted from the 2019 Building Codes Residential Compliance Manual Equation 7-1 and used to estimate the additional PV capacity from a sample new project in the San Diego region. The equation below estimates the minimum PV capacity required.

Equation 11 Estimated additional PV capacity from a newly constructed low-rise multi-family project due to 2019 Building Code

$$C_{PV,MFH} = \frac{CFA * A}{1,000} + N * B$$

Where

$C_{PV,MFH}$ = minimum capacity required from a newly constructed low-rise multi-family project, in a jurisdiction in a given year, due to 2019 Building Code, in kW

CFA = total conditioned floor area of the project, in square feet

A = adjustment factor by Climate Zone, Climate Zones 7–10 are applicable for San Diego region,
Climate Zone 7 = 0.572, Climate Zone 8 = 0.586,
Climate Zone 9 = 0.613, Climate Zone 10 = 0.627

N = number of dwelling units in the project

B = dwelling adjustment factor, Climate Zones 7–10 are applicable for San Diego region,
Climate Zone 7 = 1.15, Climate Zone 8 = 1.37,
Climate Zone 9 = 1.36, Climate Zone 10 = 1.41

To estimate the minimum PV system size required for an average multi-family unit, the prototype home from 2019 Building Codes Compliance Manual (6,960 square feet [ft²] of conditioned floor area and eight units), or from the jurisdiction's own estimates, can be used. With the minimum PV system size per unit and projected number of new units, the additional electricity generation from newly constructed low-rise multi-family homes can be calculated using Equation 12 below.

Equation 12 Estimated electricity generation from PV systems at newly constructed low-rise multi-family homes due to 2019 Building Code

$$Elec_{PV,MFH,n} = N_n * C_{PV,MFH} * 80\% * 20\% * 8,760 * 10^{-3}$$

Where

$Elec_{PV,MFH,n}$	= 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_n	= number of low-rise multi-family units, from 2020 to year n
$C_{PV,MFH}$	= minimum capacity required from a newly constructed low-rise multi-family project, in a jurisdiction in a given year, due to 2019 Building Code, in kW, calculated using Equation 11
80%	= percentage of homes that will install PV systems, assume 20% of the new homes would be exempt for other reasons, consistent with the assumptions in the 2020–2030 Revised Forecast mid-case scenario for newly-constructed single-family homes
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

The data needs for calculating electricity generation from a PV systems at newly constructed low-rise multi-family homes due to 2019 Building Code are given in Table 6.

Table 6 Data/information needs for emissions impact calculation – PV systems at newly constructed low-rise multi-family homes due to 2019 Building Code

Data/information needs	Data timeframe	Data source
Number of low-rise multi-family units N_n	From 2020 to a CAP horizon year	Jurisdiction or SANDAG
PV system capacity required in 2019 Building Code for low-rise multi-family homes $C_{PV,MFH}$	N/A	Calculated using Equation 11

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 ($P_{PV,n}$). Then, this value is used to calculate the emission impact from increasing renewable supply through PV systems (see Equation 13, adapted from Equation 7).

Equation 13 Emissions impact from increasing renewable supply through behind-the-meter PV systems

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

Where

$\Delta E_{electricity,PV,n}$ = emissions impact from increasing renewable supply through behind-the-meter PV systems in a given year, in MT CO₂e
 $\Delta E_{electricity,RE,n}$ = total emissions impact from increasing renewable electricity supply in a given year, in MT CO₂e; refer to Equation 6
 $P_{PV,n}$ = percent of gross generation supplied by behind-the-meter PV systems in a given year (%); refer to Equation 10 and Equation 12
 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 the previous sections, the total emissions impact from increasing renewable supply is 4.25 MMT CO₂e in 2030 ($\Delta E_{electricity,RE,2030}$). Using this method, the emissions impact from behind-the-meter PV, which supplies 14% of the gross generation with 100% renewable in 2030, is calculated in Equation 14.

Equation 14 Example of emissions impact from behind-the-meter PV providing renewable electricity

$$\begin{aligned} \Delta E_{electricity,PV,2030} &= \Delta E_{electricity,RE,2030} * \left(\frac{P_{PV,2030} * RE_{PV,2030}}{RE_{electricity,2030}} \right) = 4.25 * \left(\frac{14\% * 100\%}{93\%} \right) \\ &= 0.59 \text{ MMT CO}_2\text{e} \end{aligned}$$

This example focuses on State policies, programs, and mandates 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 non-residential projects and installing PV on municipal facilities. Local measures to increase behind-the-meter PV must be in addition to State policies, programs, and mandates in order to yield additional emissions impact. If a local action to install PV systems is associated with a State program, the emissions impact may not be additional; for example, if a municipal PV system is installed with utility incentives based on State requirements, or a school district's PV system is installed under a mandated State program. In this case, to avoid double-counting, the emissions impact due to the local action is subtracted from the expected statewide total of increasing behind-the-meter PV. Emissions impact from all PV measures, calculated using Equation 13, are attributed to local CAP measures based on the estimated solar capacity from each local action; the remaining capacity and emissions impact are attributed to State solar policies and programs.

In the example given in Equation 14, the emissions impact from all PV providing renewable electricity (0.59 MMT CO₂e, $\Delta E_{electricity,PV,2030}$) is the result of both State solar programs and additional local CAP measures. The local CAP measures would result in an additional 10 MW PV installation in the jurisdiction, while the estimated 2030 jurisdiction-wide PV capacity under State policies, programs, and mandates would be 90 MW. Equation 15 below shows the allocation of emissions impacts to State solar programs based on the capacity.

Equation 15 Example of emissions impact from increasing renewable supply through California solar policies, programs, and mandates

$$\Delta E_{\text{electricity},PV\text{-state},2030} = \Delta E_{\text{electricity},PV,2030} * \left(\frac{C_{PV,local,2030}}{C_{PV,2030}} \right) = 0.59 * \left(\frac{10 \text{ MW}}{100 \text{ MW}} \right) = 0.059 \text{ MMT } CO_2e$$

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 2017, 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 systems⁵;
- Provide local incentives or financing programs to encourage PV systems installation at existing homes and commercial buildings; and
- Supply higher than RPS required renewable electricity through a CCA program.

Figure 20 shows three examples of measures in currently adopted CAPs that aim to increase renewable electricity.

Figure 20 Examples of CAP measures to increase renewable electricity (Del Mar 2016, Encinitas 2018, and Lemon Grove 2020)



⁵ The local ordinance to require new homes to install PV are from CAP adopted prior to the 2019 Building Codes went into effect.

The following are the emissions impact 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 a CCA program. 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 90%-100% renewable electricity supplies.

A portion of the emissions impacts from the local renewable program would be attributed to RPS compliance and included in statewide emissions, while the remaining would be attributed to the local CAP measure. The method and attribution to RPS-compliant supply ($\Delta E_{electricity,RPS,n}$) were discussed in Equation 9. The method to estimate GHG emissions impacts from local renewable measures is provided in Equation 16.

Equation 16 Emission impact 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 impact in electricity category through local renewable program in a given year, attributed to a local CAP measure, in MT CO₂e
 $\Delta E_{electricity,Local\ RE,n}$ = emissions impact of local renewable program in a given year, in MT CO₂e
 $\Delta E_{electricity,RPS,n}$ = emissions impact of local renewable program in a given year, in compliance with RPS, in MT CO₂e

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 non-residential buildings to install PV systems. The estimated electricity generation from PV systems because of the ordinance is calculated using Equation 17.

Equation 17 Estimated electricity generation from PV installation ordinance

$$Elec_{PV,CAP\ measure,n} = GFA_n * C_{PV} * 20\% * 8,760 * 10^{-3}$$

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
 GFA_n = cumulative gross floor area ft² of commercial spaces affected by a CAP measure, after CAP baseline year up to year n
 C_{PV} = capacity requirement of the PV system in the ordinance, 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

The data needs for calculating electricity generation from a PV ordinance are given in Table 7.

Table 7 Data/information needs table for emissions impact calculation – commercial buildings PV installation ordinance

Data/information needs	Data timeframe	Data source
Cumulative gross floor area sq. ft. of commercial spaces affected by a CAP measure GFA_n	CAP horizon years	Jurisdiction
PV system capacity requirement in the ordinance C_V	N/A	Jurisdiction, literature, and case studies

Jurisdictions may require different PV system capacity in new construction depending on the weather, climate zone, and historical data of PV installations. The City of Carlsbad (2019a), located in Climate Zone 7, is the first jurisdiction in the San Diego region to adopt a non-residential PV ordinance. The minimum size requirement is 15 kW per 10,000 sq. ft. of gross area or a minimum five kW PV system for buildings under 10,000 sq. ft.

5.5.2 Increase building efficiency

Increasing residential and commercial building efficiency reduces building energy use and, as long as the supply is fossil-fuel based, also reduces GHG emissions. In general, the emissions impacts from building efficiency are calculated by multiplying energy impact and the emission factor of the associated type of energy. The energy impact 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 impacts from State regulations and local CAP measures that increase building efficiency are described in the following sections.

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. Not all State legislation related to energy efficiency or building decarbonization is discussed here; only the legislation that has a clear GHG implication in the San Diego region is discussed. One piece of legislation not included in this section is [AB 3232 \(Friedman\) \(Chapter 373, Statutes of 2018\)](#), which tasked the CEC to assess the potential to reduce GHGs in buildings by 40 percent below 1990 levels by 2030. Another piece of legislation not included is [SB 350 \(de León\) \(Chapter 574, Statutes of 2015\)](#), which directed the CEC to establish an energy efficiency target by November 1, 2017 that achieves a statewide cumulative doubling of energy efficiency savings in electricity and natural gas end use by 2030, relative to a 2015 base year.

California energy efficiency programs – energy efficiency targets for IOUs

Since 2004, the CPUC has adopted energy efficiency program portfolio performance targets for IOUs. The 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 2019 and Beyond*, evaluates the energy efficiency potential from 2020 to 2030 during the post-2019 energy efficiency rolling portfolio planning cycle (CPUC, 2019). 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.

The potential energy savings from each version of the study vary. Compared with the previous 2017 potential study, the 2019 potential study shows a decrease in potential energy efficiency savings from IOU rebate programs, largely due to electricity savings from many lighting measures transitioning to code or standard practice.

SDG&E administers energy efficiency programs in the San Diego region. The total potential energy savings in the San Diego region (or 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 benchmarking ordinances and implementing efficiency retrofits at municipal facilities, which are likely to be associated with a State energy efficiency program. For example, local building owners may submit energy use for benchmarking under the local energy benchmarking ordinance but use incentives from SDG&E's energy efficiency programs to fund energy retrofits. To avoid double-counting, the energy and emissions impact 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. If the local ordinance is beyond the State or utility program, such as through a local reach code, the energy savings and GHG impacts are credited to the local action only.

The emissions impacts from electricity and natural gas savings under the State energy efficiency programs are estimated using Equation 18 for electricity savings and Equation 19 for natural gas savings.

Equation 18 Electricity emissions impact from - California energy efficiency programs

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

Where

- $\Delta E_{elec, BE-state, n}$ = total emissions impact from State energy efficiency program for a jurisdiction in a given year, in MT CO₂e
- $\Delta E_{elec, BE-regional, n}$ = electricity impact from State energy efficiency program in the SDG&E service area in a given year compared with latest historical 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. CO₂e per MWh
- $\Delta E_{elec, BE-local, n}$ = total emissions impact from CAP local building efficiency measures in a given year, if applicable, in MT CO₂e
- 0.000453 = conversion factor, MT CO₂e in a lb.

With,

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

Equation 19 Natural gas emissions impact 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 impact from State energy efficiency programs for a jurisdiction in a given year, in MT CO₂e
- $\Delta NG_{BE-regional, n}$ = natural gas savings from State energy efficiency programs in the SDG&E service area in a given year comparing with latest historical 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 impact from CAP local building efficiency measures in a given year, in MT CO₂e

With,

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

To make sure the proportional 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 historical 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 impacts (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 impacts 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 impact by State energy efficiency programs are given in Table 8.

Table 8 Data/information needs for emissions impact calculation from the 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 GHG 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 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 2020–2030 Revised Forecast contains historical values up to 2018 for net energy load and gross generation for the SDG&E planning area (CEC, 2020). For the CPUC Energy Efficiency Potential and Goals study, the most recent “2019 and beyond” study includes the estimates from 2020 to 2030. If the 2020–2030 Revised Forecast is used in projection, it may be appropriate to use the previous 2018 and beyond Study (CPUC, 2017), which include energy savings from 2018 to 2030, so the energy in 2018 and 2019 are incorporated. The energy savings in the CPUC studies are reported in incremental savings (the annual energy and demand savings in the first year that the measure is implemented) and cumulative savings (the total from the energy efficiency program since 2020). When used to calculate the energy savings from CAP measures ($\Delta Elec_{BE-regional,n}, \Delta NG_{BE-regional,n}$), the data from CPUC studies need to be converted to energy savings in a CAP horizon year since the CAP's latest historical year .

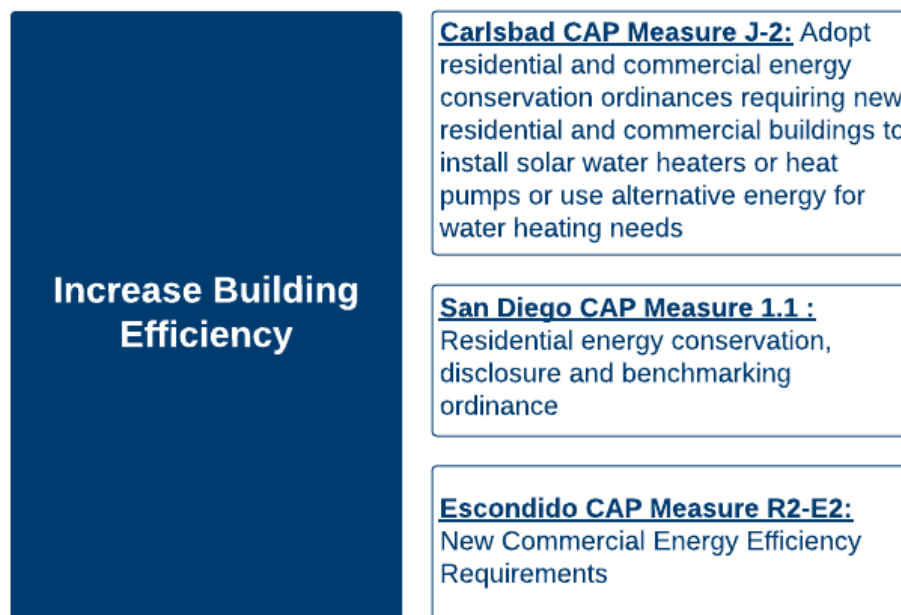
Local CAP measures to increase building efficiency

All the currently adopted CAPs in the San Diego region have measures to increase building efficiency. Local governments have the authority to adopt local ordinances 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 ordinances for higher energy standards than the State-mandated building standards for new construction;
- Update local ordinances 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 21 shows three examples of measures in currently adopted CAPs that aim to increase building efficiency.

Figure 21 Example of CAP measures to increase building efficiency
(Carlsbad 2015, Escondido 2013, and San Diego 2015)



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

Require energy retrofits of existing residential homes

CAP measures may require residential property owners conducting major renovations or additions with a permit value over a certain threshold to implement certain energy retrofit activities. An example is the City of Carlsbad's Residential Energy Conservation Ordinance, which sets a compliance threshold of \$60,000 (City of Carlsbad, 2019b). The required energy retrofit activities in the ordinance may depend on the age of the home (e.g., attic insulation, cool roof, lighting retrofit).

By requiring energy retrofit activities, the emissions impact from electricity and natural gas savings can be calculated using Equation 20 for electricity and Equation 21 for natural gas.

Equation 20 Emissions impacts from electricity savings – require residential energy retrofits

$$\Delta E_{\text{electricity}, \text{CAP measure}, n} = \sum_{\text{unit}} (N_{\text{unit}, n} * \Delta \text{Elec}_{\text{unit}, n}) * EF_{\text{electricity}, n} * 0.000453$$

Where

$\Delta E_{\text{electricity}, \text{CAP measure}, n}$	= total emissions impact in electricity category from residential energy retrofits electricity savings, in a given year, in MT CO ₂ e
$N_{\text{unit}, n}$	= number of housing units (projects) over the threshold that are required to implement energy retrofit activities, after ordinance effective year to year n
$\Delta \text{Elec}_{\text{unit}, n}$	= average annual electricity savings from energy retrofits, kWh
$EF_{\text{electricity}, n}$	= emission factor of the electricity (gross generation) in a jurisdiction in a given year, in lbs. CO ₂ e per MWh
0.000453	= conversion factor, MT CO ₂ e in a lb.

With,

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

Equation 21 Emissions impacts from natural gas savings - require residential energy retrofits

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

Where

$\Delta E_{\text{NG}, \text{CAP measure}, n}$	= total emissions impact in natural gas category from residential energy retrofits natural gas savings, in a given year, in MT CO ₂ e
$N_{\text{unit}, n}$	= number of housing units (projects) over the threshold that are required to implement energy retrofit activities, after ordinance effective year n
$\Delta \text{NG}_{\text{unit}, n}$	= average annual natural gas saving from energy retrofits, therms
$EF_{\text{NG}, n}$	= emission factor of the natural gas in a jurisdiction in a given year, in MT per therm

With,

n	= a CAP horizon year, from ordinance effective 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 impact of a typical residential energy retrofit ordinance are given in Table 9.

Table 9 Data/information needs table for emissions calculation – residential energy retrofit ordinance

Data/Information needs	Data timeframe	Data source
Number of housing units (projects) to be subject to the ordinance $N_{unit,n}$	CAP baseline year to most recent year	Jurisdiction
Energy savings from energy retrofit activities required in the ordinance $\Delta NG_{unit,n}$, $\Delta Elec_{unit,n}$	n/a	Jurisdiction's reach code cost-effectiveness study, statewide residential retrofit cost-effectiveness study (California Energy Codes & Standards, 2020)

The current statewide cost-effectiveness studies relate to energy efficiency measures exceeding the minimum requirements of the 2019 Building Codes. Local jurisdictions may utilize the statewide studies or develop their own cost-effectiveness study. The CEC and Building Standards Commission update Building Codes every three years; when new Building Codes (i.e., 2022 Building Codes) are released, the cost-effectiveness of local ordinances needs to be evaluated based on the new codes.

The data input and calculation are given in Table 10 for a sample jurisdiction that requires energy retrofits for major renovations, assuming the ordinance starts in 2021 and an average of 160 projects are subject to the ordinance per year.

Table 10 Require residential energy retrofits example

Year	Number of energy retrofits due to local ordinance through 2030	Electricity reduction per retrofit (kWh/home/year)	Natural gas reduction per retrofit (therms/year)	Electricity emission factor (lbs CO ₂ e/MWh)	Natural gas emission factor (MT CO ₂ e/therm)	Emissions impact due to energy retrofits (MT CO ₂ e)
2030	1,600	372	23	120	0.0054	240

Require or Incentivize alternatively-fueled water heaters

Replacing natural gas water heaters with an alternatively-fueled water heater (e.g., electric heat pump water heaters (HPWH), solar water heaters, or other systems with renewable energy as the primary energy source) reduces fossil fuel energy use. Many jurisdictions currently in the process of updating CAPs or implementing CAP measures to increase building efficiency are considering a fuel substitution approach. An example is the City of Carlsbad's Residential Water Heating Ordinance, which requires "developers of all new low-rise residential construction project...to install non-gas water heating equipment in their projects." The alternative options are installing a heat pump water heater paired with a PV system or a solar water heating system (City of Carlsbad, 2019c). The method to calculate additional electricity use and emissions added from replacing a gas storage water heater with an electric HPWH are given in Equation 22 for electricity and Equation 23 for natural gas. The net emissions impact by this example is the sum of the emissions impact from natural gas savings and the emissions added from electricity use.

Equation 22 Emissions added from replacing natural gas storage water heaters with an electric heat pump water heaters

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

Where

$\Delta E_{\text{electricity,CAP measure},n}$ = total emissions added in electricity category from replacing a natural gas storage water heater with an electric HPWH in a given year, in MT CO₂e
 $N_{\text{unit},n}$ = number of housing units affected by this measure after ordinance effective year up to year n
 $\Delta Elec_{\text{unit},n}$ = electricity use from an HPWH, kWh per year
 $EF_{\text{electricity},n}$ = emission factor of the electricity (gross generation) in a jurisdiction in a given year, in lbs. CO₂e per MWh
0.000453 = conversion factor, MT CO₂e in a pound

With,

n = a CAP horizon year, from ordinance effective 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 23 Emissions impact from replacing natural gas storage water heaters with an electric heat pump water heaters

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

Where

$\Delta E_{\text{NG,CAP measure},n}$ = total emissions impact in natural gas category from replacing a natural gas storage water heater with an electric HPWH in a given year, in MT CO₂e
 $N_{\text{unit},n}$ = number of housing units affected by this measure after ordinance effective year to year n
 $\Delta NG_{\text{unit},n}$ = natural gas use from a gas storage water heater, therms per year
 $EF_{\text{NG},n}$ = emission factor of the natural gas in a jurisdiction in a given year, in MT CO₂e per therm

With,

n = a CAP horizon year, from ordinance effective 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 impact from this example are given in Table 11.

Table 11 Data/information needs table for emissions impact calculation - replace natural gas storage water heaters with electric heat pump water heaters

Data/Information needs	Data timeframe	Data source
Number of housing units affected by the measure (e.g., new housing units, number of building permits issued for major renovations) $N_{unit,n}$	CAP baseline year to most recent year	Jurisdiction
Projected number of housing units affected by the measure every year by type (e.g., single-family, multi-family) $N_{unit,n}$	CAP horizon years	Jurisdiction, SANDAG
Energy uses of different types of water heaters (e.g., natural gas tank-based, electric HPWH, electric tank solar water heater with HPWH back-up) $\Delta NG_{nit,n}$ or $\Delta Elec_{unit,n}$	N/A	Statewide residential new construction cost-effectiveness study (California Energy Codes & Standards, 2020), climate zone-specific, or jurisdictional-specific cost-effectiveness studies
Average annual energy reduction upon replacing electric/natural gas water heater with solar water heater $\Delta NG_{unit,n}$, $\Delta Elec_{unit,n}$	N/A	California DG Statistics

5.6 Emissions impact from on-road transportation related measures

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

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

The following sections describe the methods and data needs for calculating GHG emissions impacts 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 impacts from measures that reduce tailpipe emissions from vehicles through efficiency standards and increase ZEVs and EV VMT (eVMT), which includes the following calculations:

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

Average vehicle emission factor in San Diego region

As discussed in Technical Appendix I, the CARB Mobile Source Emissions Inventory EMFAC2017 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 EMFAC2017 model results include the effect of all key federal and State laws, regulations, and legislative actions that were adopted as of December 2017. The regulations and standards aim to lower fleet average emission rates, improve air quality, and reduce GHG emissions (CARB, 2018). These additional or updated regulations accounted for in the model are:

- **California Advanced Clean Car (ACC) Program** for passenger cars and light-duty vehicles. The State's ACC program includes tailpipe emissions standards equivalent to 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 EVs for model years 2017–2025 (CARB, 2015). The impact of the ACC program has already been incorporated into the previous version EMFAC2014; however, EMFAC2017 includes updated assumptions in the ACC regulation based on its 2017 midterm review. The updates include: 1) ZEV sales forecast; 2) CO₂ emission rate and fuel efficiency forecast; and 3) criteria technology penetration and in-use emission factor (CARB, 2018).
- **Senate Bill 1 (The Road Repair and Accountability Act of 2017) and CARB Tractor-Trailer GHG Regulation** requires medium-duty or heavy-duty vehicles to verify compliance with CARB's Truck and Bus Regulation. EMFAC2017 assumes full compliance by 2023 (CARB, 2018). CARB's Tractor-Trailer GHG Regulation includes the aerodynamic and tire improvement requirements to reduce GHG emissions from heavy-duty trucks (CARB, 2015).
- **U.S. Environmental Protection Agency (EPA)'s Phase 2 GHG Regulation** for heavy-duty vehicles (heavy-duty trucks, tractors, and buses). This regulation built upon the Phase 1 standards with new requirements beginning with model year 2018 for trailers and model year 2021 for engines and vehicles, with phase-in through model year 2027 (CARB, 2018).

In September 2019, the EPA and the National Highway Traffic Administration published the "Safe Affordable Fuel-Efficiency (SAFE) Vehicle Rule Part One: One National Program" (SAFE Rule Part One). The SAFE Rule Part One revoked California's authority to set its own GHG emissions standards and set ZEV mandates in California included in EMFAC, as described above. CARB has estimated the emissions impacts from the SAFE Rule Part One and provided off-model adjustment factors for criteria pollutants, but not for GHGs, that can be used to adjust emissions output from EMFAC models. In April 2020, the federal agencies issued the Final SAFE Rule that relaxed federal GHG emissions and CAFE standards for model year 2021–2026 vehicles. In June 2020, CARB released off-model adjustment factors that could be used to adjust tailpipe CO₂ emissions outputs from EMFAC models to account for the impacts of SAFE Rule. The adjustment factors are for gasoline light-duty vehicles only and provided in the form of multipliers applied to emissions outputs from EMFAC model (CARB, 2020b).⁶

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, and 18% by 2030, is not included in EMFAC2017 and has not been included in the model since EMFAC2014. This is because most of the emissions impact 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 (CARB, 2015).

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 24).

⁶ The light-duty vehicle categories are LDA, LDT1, LDT2, and MDV in EMFAC model. The adjustment factors do not include upstream emissions associated with fuel demand, because EMFAC only estimates tailpipe and evaporative emissions.

Equation 24 Average vehicle emission factor calculation

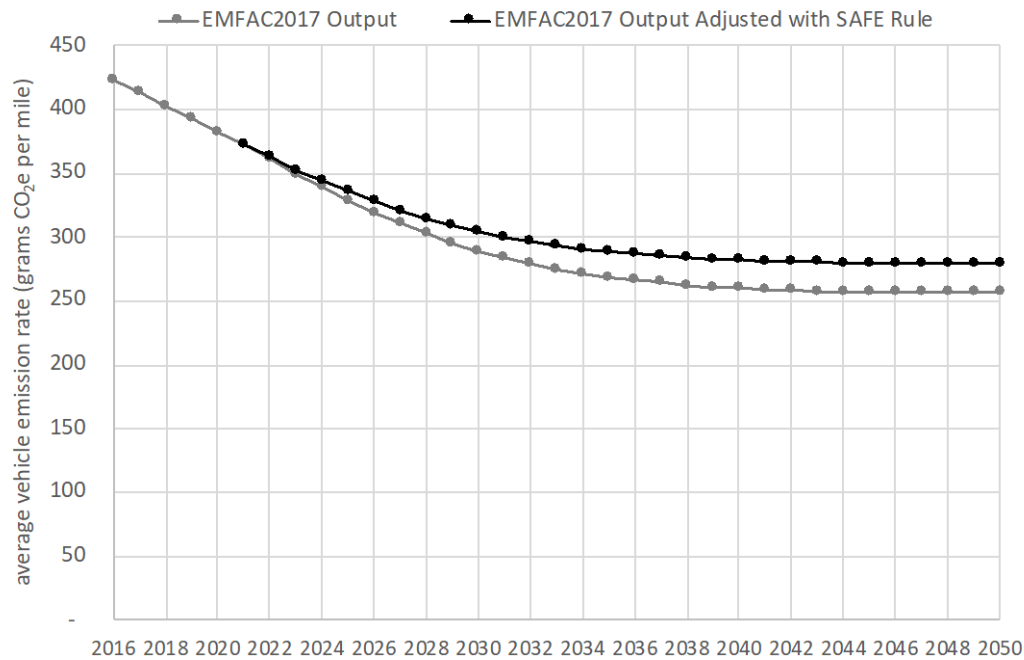
$$EF_{transp,n} = \sum_{class, fuel, GHG} (VMT\ Distr_{category, fuel} * RUNEX_{category, fuel, GHG} * GWP_{GHG})$$

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 ₂ e per mile)
$VMT\ Distr_{class, fuel}$	= percentage of total VMT for a given vehicle class with a given fuel, in a given year (%)
$RUNEX_{category\ fuel, GHG}$	= running exhaust emissions of a given vehicle, fuel and GHG (grams per mile)
GWP_{GHG}	= Global Warming Potential of a given GHG (unitless)
$Class$	= EMFAC2011 vehicle class categories, EMFAC2017 Technical Documentation Table 6.1-1
$Fuel$	= [Gas, Diesel, Electric, and Natural Gas]
GHG	= [CO ₂ , CH ₄ and N ₂ O]
n	= CAP horizon year, from baseline year to CAP horizon end year

Using Equation 24 and EMFAC results, the average vehicle emission factors from 2016–2050 in the San Diego region, before SAFE rule adjustment, are shown in Figure 21 below (dark gray line). These emission factors include the effect of all federal and State regulations related to tailpipe GHG reductions adopted before December 2017. The average vehicle emission factors adjusted with SAFE rule are shown in Figure 21 below as a black line. The difference with and without SAFE rule impact in 2050 is 9% for the whole fleet and would be significant more for light-duty vehicles.

Figure 21 Average vehicle emission factor in San Diego region (2016–2050)



Average vehicle emission rates in the San Diego region only. SAFE rule adjustment starts in 2021.

Source:

California Air Resources Board (CARB) EMFAC2017 Model

EMFAC Off-Model Adjustment Factors for Carbon Dioxide (CO₂) Emissions to Account for the SAFE Vehicles Rule Part One and the Final SAFE Rule (June 26, 2020)

Energy Policy Initiatives Center 2020

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 impacts accounted for in EMFAC2017 apply to new vehicles up to model year 2027, after which the decrease in the average vehicle emission factor levels off, as shown in Figure 21.

Because the average vehicle emission factor decreases over time, CAP measures that reduce VMT yield a smaller amount of GHG emissions impacts in later CAP horizon years. The average vehicle emission factors shown above are the vehicle running exhaust emission factors, not idling or starting emission factors, since the strategies in CAPs focus on reducing miles driven.

The latest regulatory measures adopted by the State after 2017, such as the Innovative Clean Transit (2018) Program and Advanced Clean Truck Program (2020), are not included in EMFAC2017, therefore, not included in the emission factor calculation. In September 2020, Governor Newsom issued EO N-79-20 with a State goal to: (1) require all in-state sales of new passenger cars and trucks be zero-emission by 2030; (2) require all medium- and heavy-duty vehicles, “where feasible,” be zero-emission by 2045; and (3) to transition to 100% zero-emission off-road vehicle and equipment, “where feasible,” by 2035. The EO also requires CARB to develop and propose regulations to meet the State goals. The impact of the EO will be incorporated in this Appendix once regulations are developed and incorporated in the EMFAC model.

Federal and State regulations to improve vehicle fuel efficiency

As above, EMFAC2017 accounts for all key federal and State regulations related to tailpipe GHG emissions. The emissions impacts due to federal and State regulations are the difference between the BAU average vehicle emission factors and the average vehicle emission factors from EMFAC (calculated using Equation 24). The difference is calculated using Equation 25 below. In versions prior to EMFAC2014, it was possible to calculate the effects of individual federal and State regulations. However, because EMFAC2017 provides only the projections of the effects of all regulations combined, the emissions impacts due to federal and State regulations are calculated using Equation 25.

Equation 25 Emissions impact calculation: reducing tailpipe emissions

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

Where,

$\Delta E_{transp,FE,n}$ = total emissions impact 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 24 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 25, an example of the emissions impact calculation is given in below Table 12.

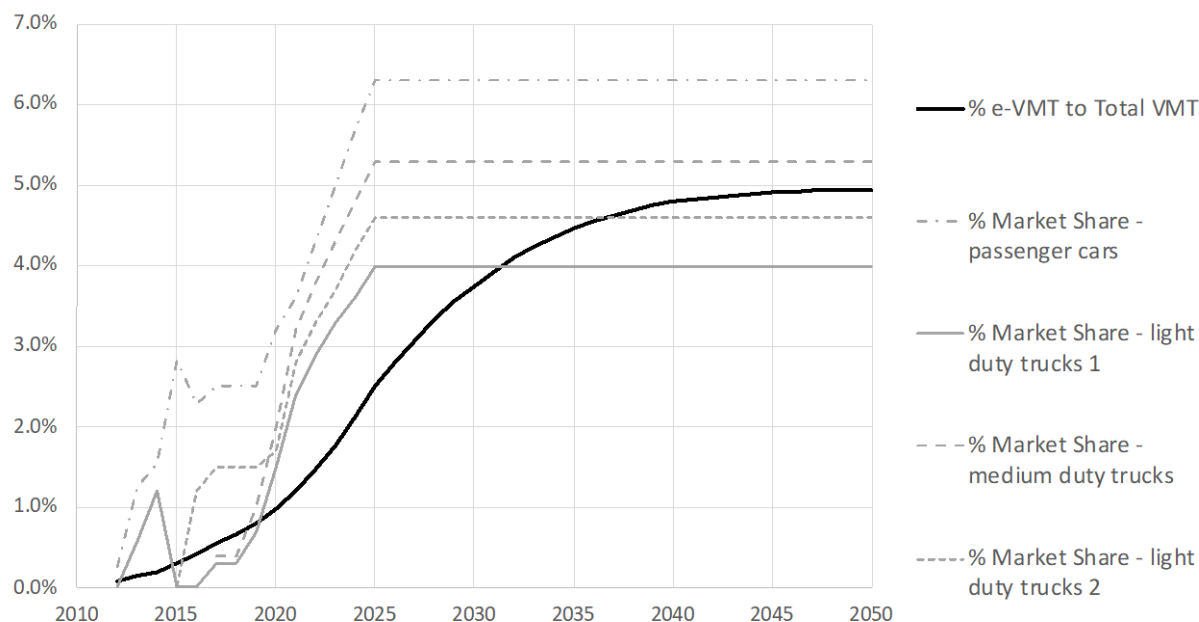
Table 12 Example of emissions impact from increasing tailpipe emission standards and ZEVs

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 impact (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 ZEV mandate

It is possible to estimate the GHG emissions impact associated with the ZEV mandate. Estimated ZEV penetration rates for new passenger cars, light-duty trucks, and medium duty trucks based on the goals set for California ZEV mandate, are included in EMFAC2017 (CARB, 2018). The ZEV penetration rates from 2016–2050 and estimated e-VMT as a percentage of total VMT are given in Figure 22.

Figure 22 San Diego region ZEVs penetration rates in CARB EMFAC2017 Model (2016–2050)



2012–2016 data are historical year data for San Diego region based on DMV vehicle registration.

2017+ data are projected estimates used in EMFAC2017 based on mid-range scenario of the Advanced Clean Car Midterm Review.

Source: California Air Resources Board (CARB) EMFAC2017 Model, Energy Policy Initiatives Center, 2020

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 be kept at 2% for passenger cars and 1% for light-duty trucks (same as the baseline year) rather than the projected estimates of 6% for passenger cars and 14% for light-duty and medium duty trucks. The difference between this average vehicle emission factor and the EMFAC2017 average vehicle emission factor is due to the impact of the State's ZEV mandate only. Using the example shown in Table 12, the emissions impacts from California's ZEV mandate are calculated with Equation 26 and shown in Table 13.

Equation 26 Emissions impact calculation: California ZEV mandate

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

Where

$\Delta E_{transp,Cal ZEV,n}$

= total emissions impact in transportation category from State ZEV mandate 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 mandate 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 13 Example of emissions impact from California ZEV mandate

Year	Total VMT (miles/year) VMT_{2030}	Average vehicle emission factor (g CO ₂ e/mile)		Difference in average vehicle emission factor (g CO ₂ e/mile) $\Delta EF_{transp,2030}$	Emissions impact (MT CO ₂ e) $\Delta E_{transp,Cal\ ZEV,2030}$
		With no policy impact after baseline year (business-as-usual)	With impact of State ZEV mandate		
2030	545,645,333	406	385	21	11,810

In this Appendix, a conservative approach is taken that limits the maximum emissions impact from increased eVMT to what is already embedded in the EMFAC model, unless additional local (regional or jurisdictional) funding is provided to incentivize ZEVs or increase eVMT. Other local ZEV measures are subtracted from the total value derived from EMFAC2017 to avoid double-counting.

Local CAP measures that support the State's ZEV mandate or provide additional emissions impact beyond State ZEV mandates are discussed in the section below.

Local CAP measures to increase alternative fuel vehicles or eVMT

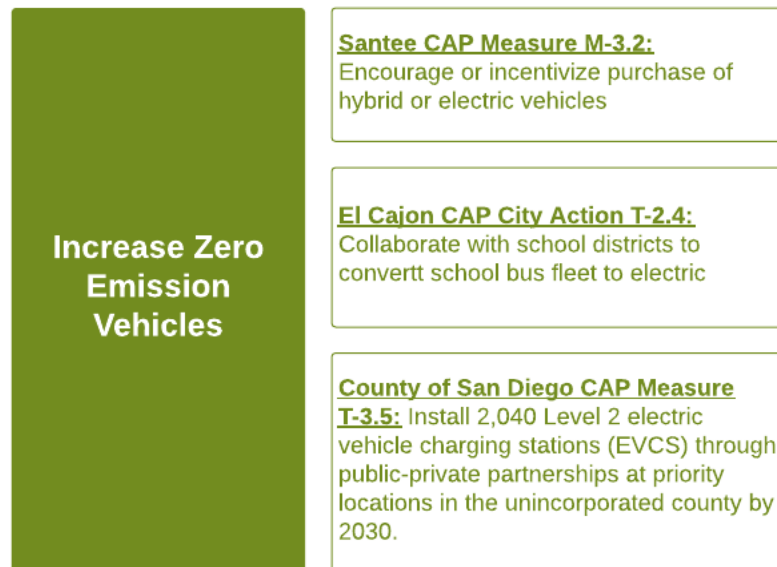
The 2017 Scoping Plan recommends that local government incentivize infrastructure for alternative fuels and electric vehicles as one of the actions to reduce GHG emissions (CARB 2017, p. 97). CAPs in the San Diego region include measures to increase ZEVs, especially EVs. For example, local governments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

- Building codes that 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 23 shows three examples of measures in currently adopted CAPs that aim to increase ZEVs.⁷

⁷ The CAPs and measures referenced here were not calculated based on EMFAC2017. 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.

Figure 23 Example of CAP measures to increase ZEVs
(El Cajon 2019, Santee 2020, County of San Diego 2018)



The following are emissions calculation examples for two typical CAP measures that focus on increasing ZEVs: 1) require EVCSs in new construction, which is assumed to support the State ZEV mandate; and 2) transition to a more fuel efficient municipal fleet, which is assumed to have additional impact beyond State ZEV mandate.

Require EVCSs in new construction

Local jurisdictions may require new construction projects to make a certain percentage of 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 in a local CAP, the requirements must be more stringent than mandatory requirements in California Green Building Standards Code Title 24, Part 11 (CALGreen Code). The mandatory and voluntary measures related to EVs in the most recent version (2019 CALGreen Code) are given in Table 14.

Table 14 2019 California Green Building Standards Code requirement for EVCSs

Category	CALGreen 2019 mandatory measures	CALGreen 2019 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	10% of total number of parking spaces (no less than one) be EV capable (Section 4.106.4.2)	15% (Tier 1) and 20% (Tier 2) 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 5.106.5.3)	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 EV supply equipment, EV ready - Install 40-amp minimum electrical circuit <i>Source: California Building Standards Commission, 2019</i>		

Equation 27 is used to calculate the estimated number of EVCSs that could result from a CAP measure that requires EVCSs in new construction projects.

Equation 27 Estimate number of charging stations from requiring EVCS 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 EVCSs 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 foot.
$P_{unit,parking-EVCS}$	= % 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 EVCSs are given in Table 15.

Table 15 Data/information needs for emissions impact calculation – require EVCS installation at new construction

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 27, the data inputs and the number of EVCSs calculated for a CAP measure that requires new residential multi-family units to install EVCSs at 10 percent of parking spaces are given below in Table 16.

Table 16 Requiring EVCS installation at new multi-family development example

Year	Number of new multi-family units after baseline year $N_{MF,2030}$	Multi-family parking requirement $P_{MF,parking}$	% of parking spaces required to have EVCS $P_{MF,parking-EVCS}$	New EVCS after baseline year $EVCS_{MF,2030}$
2030	300	2.5 parking spaces per unit	10%	75

The method to estimate emissions impacts from this measure assumes that all parking spaces with an EVCS would only be used for EV parking and charging, and that all miles associated with the vehicles parked at the spaces are eVMT. As discussed in the State ZEV mandates section, a conservative approach is taken to limit the maximum emissions impact related to ZEVs and the level of emissions impact expected from the State's ZEV mandate, unless local or regional funding are provided to incentivize ZEVs. The impact is attributed to each local measure using the ratio of eVMT as a result of the local measure and eVMT as a result of the State's ZEV mandate assumed in the EMFAC model, as shown in the Equation 28.

Equation 28 Emissions impact from local policies to support the State ZEV mandate

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

Where

$\Delta E_{transp,CAP\ measure,n}$ = emissions impact from a CAP measure that increases ZEV to support the State ZEV mandate in a given year, in MT CO₂e

$\Delta E_{transp,Cal\ ZEV,n}$ = total emissions impact from California ZEV mandate in a given year, for the jurisdiction, in MT CO₂e

$eVMT_{CAP\ measure,n}$ = projected eVMT as a result of a CAP measure, in a given year

$eVMT_{ZEV,n}$ = projected eVMT as a result of California ZEV mandate, in a given year

With,

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

Not all eVMT from ZEVs is driven within a jurisdiction's boundary. For example, a multi-family home resident may charge a vehicle at home, but drive to and from a different jurisdiction for work. The eVMT as a result of the EVCS may need to be adjusted using the ratio of total VMT and Origin-Destination VMT associated with the jurisdiction. The difference between total and Origin-Destination VMT is discussed in ReCAP Technical Appendix I.

Transition to a more fuel-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 impact from reducing fossil fuel use can be calculated using Equation 29.

Equation 29 Emissions impact from a transition to a more fuel-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 impact in transportation category from a CAP measure that increases fuel economy in a given year, in MT CO ₂ e
$\Delta V_{fuel,n}$	= fuel reduction of the municipal fleet, in a given year, in gallons
EF_{fuel}	= emission factor of a vehicle fuel, kg CO ₂ e per gallon
10^{-3}	= conversion factor, MT CO ₂ e 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 in the market contains 5% biodiesel and 95% diesel, while the “gasoline” sold in the market is a blend of bio-ethanol and gasoline (gasoline-ethanol blend). From 2010–2014, an average of 10% of California’s gasoline-ethanol blend was bio-ethanol (CARB, 2016).

The fuel types in Equation 29 refer to the fuel types sold in 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 in the market, as shown in Equation 30.

Equation 30 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 ₂ e 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
fuel

= CO₂, CH₄ and N₂O

= 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 impact are given in Table 17.

Table 17 Data/information needs for emissions impact calculation – transition to a more fuel-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 compared with the most recent year, the data input and emissions impact calculated are given in Table 18.

Table 18 Transition to a more fuel-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 ₂ e/gallon) EF_{fuel}	Emissions impact (MT CO ₂ e) $\Delta E_{transp,CAP\ measure,2020}$
2020	5,000	10% pure ethanol, 90% gasoline	8.2	41

5.6.2 Reduce VMT

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 2017, 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 impact (CARB, 2017). 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 land use planning that encourages mixed-use development. In this Appendix, the VMT impact focuses on commuter VMT, the miles driven by the labor force in a jurisdiction to and from work, even though these measures may also reduce non-commuter VMT.

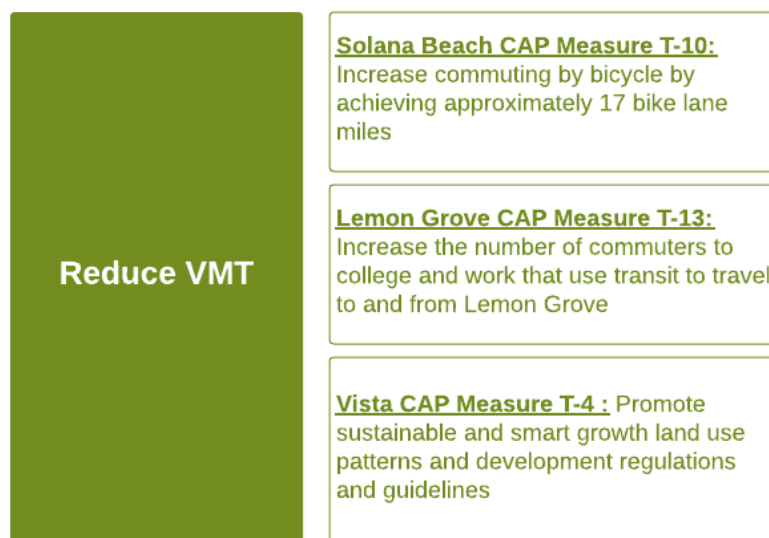
Local CAP measures to reduce VMT

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; and
- Coordinate with SANDAG, other jurisdictions, and public transit agencies to improve mass transit routes and schedules.

Figure 24 shows three examples of such measures in currently adopted CAPs.

Figure 24 **Examples of CAP measures to reduce VMT**
(Lemon Grove 2020, Solana Beach 2017, and Vista 2013)



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

Increase bicycle commuting by increasing bicycle lane miles

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. Based on empirical elasticity data, to increase one bicycle lane mile per square mile, the City of San Diego (approximately 370 square miles) would need to add 370 miles of new bicycle lanes, while the City of Solana Beach (3.5 square miles) would need to add 3.5 miles of new bicycle lanes.

The emissions impact from increasing bicycle lane miles can be calculated using Equation 31.

Equation 31 Emissions impact 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 impact in the transportation category from a CAP measure that increases alternative modes in a given year, in MT CO ₂ e
$EF_{transp,n}$	= average vehicle emission factor in the San Diego region in a given year, grams CO ₂ e per mile
ΔVMT_{bike}	= VMT avoided by commuting by bicycle, miles per year, calculated based on commuter trips avoided per workday and number of workdays 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 ₂ e per gram

With,

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

The data needs for calculating the emissions impact are given in Table 19.

Table 19 Data/information needs table for emissions impact 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, regional or jurisdiction-specific employment centers data, 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 impact calculated for a sample jurisdiction adding three miles of bicycle lanes per square mile by 2030 are given below in Table 20.

Table 20 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 ₂ e/mile) $EF_{transp,2030}$	Emissions impact (MT CO ₂ e) $\Delta E_{transp,CAP\ measure,2030}$
2030	3	8,000	8	297	36

5.6.3 Reduce fuel use through improved traffic flow

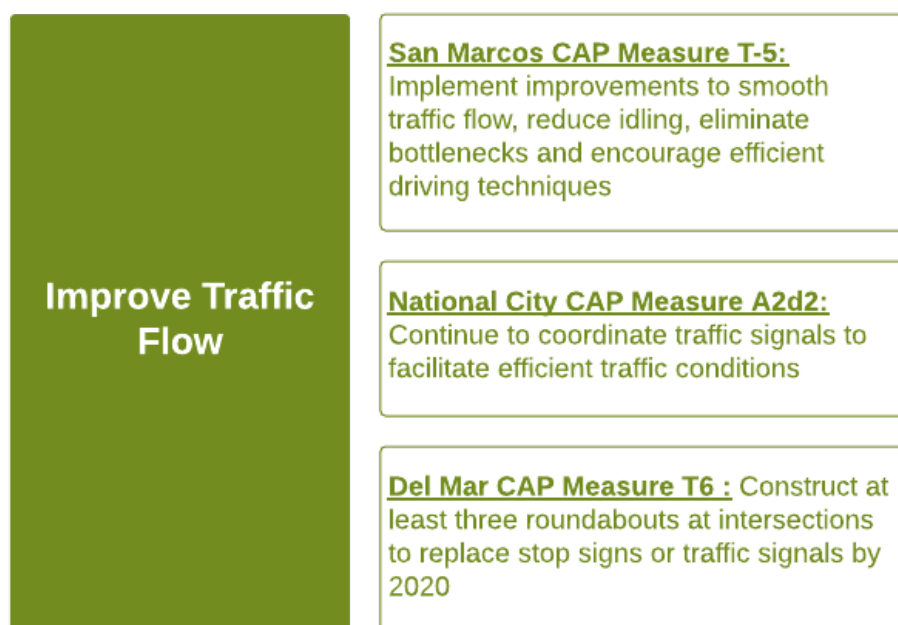
Improving traffic flow can reduce traffic delays and congestion, thereby reducing vehicle fuel consumption. Two typical examples of measures that local governments can implement to improve traffic flow include retiming traffic signals and installing roundabouts at intersections.

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 with less delay or congestion, and the average fuel economy (miles per gallon) improves.

Figure 25 shows three examples of measures in currently adopted CAPs that aim to improve traffic flow.

Figure 25 Examples 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 impact from retiming, or synchronizing, traffic signals and installing roundabouts can be calculated using Equation 32.

Equation 32 Emissions impact 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 impact 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 ₂ e
N_n	= additional traffic signals retimed or roundabouts installed since baseline year up to year n
$\Delta V_{fuel,n}$	= equivalent fuel reduction 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 ₂ e 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 ₂ e in a gram

With,

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

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

Even though this example is of a fuel-saving measure (similar to the sample measure that achieves fuel reduction through municipal fleet transition), the emissions impact calculation methods are different between these two types of measures. For the measures focused on vehicle fuel reductions, the specific fuel type of the vehicles can be identified so the 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 emissions impact is based on the fuel used for an average vehicle in the San Diego region. The EMFAC2017 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 reduction per intersection per day for small roundabouts is 54 gallons (Varhelyi, 2002). However, fuel reduction per intersection depends 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 impact are given in Table 21.

Table 21 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	EMFAC2017 default estimate
Estimated total vehicle fuel consumption in San Diego region MPG_n	CAP horizon years	EMFAC2017 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 reduction per intersection with improved traffic flow $\Delta V_{fuel,n}$	n/a	Jurisdiction, SANDAG, literature or case study

The data input and emissions impact estimates for a jurisdiction adding two roundabouts by 2030 are given below in Table 22.

Table 22 Install additional roundabouts example

Year	Additional roundabouts installed since baseline year N_{2030}	Fuel reduction per intersection (gallons/year) $\Delta V_{fuel,2030}$	Average vehicle fuel economy (miles/gallon) MPG_{2030}	Average vehicle emission factor (g CO ₂ e/mile) $EF_{transp,2030}$	Emissions impact (MT CO ₂ e) $\Delta E_{transp,CAP\ measure,2030}$
2030	2	19,710	29	297	340

5.7 Emissions impact 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 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 impacts from water-related measures generally fall into two categories:

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

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

5.7.1 Develop local water supply and improve water system efficiency

As discussed in Technical Appendix I, 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, the Colorado River, and the Carlsbad Desalination Plant.⁸ Developing local water supplies (e.g., local surface water or local recycled water for non-potable use) 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.

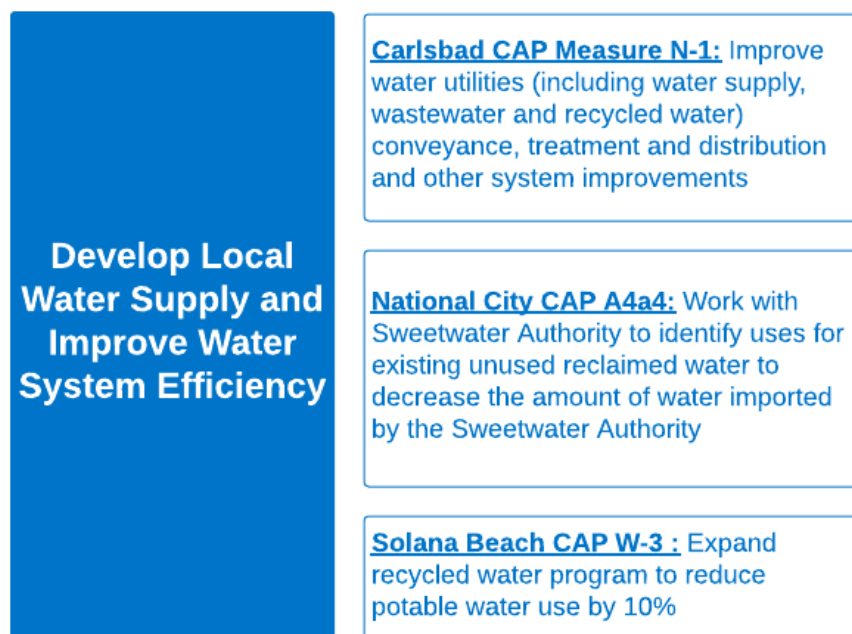
⁸ Carlsbad Desalination Plant started operation in December 2015.

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

Local CAP measures to develop water supply & improve water system efficiency

Figure 26 shows three examples of measures in currently adopted CAPs that aim to develop the local water supply and improve water system efficiency.

Figure 26 Examples 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 impact calculation for a typical CAP measure that expands a recycled water program.

Recycled water program expansion

This measure assesses the energy and associated emissions impacts 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 the use of a recycled water program, this measure does not reduce overall water use; rather, it reduces potable water use. 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 impacts.

The emissions impacts from a recycled water expansion program can be calculated using Equation 33.

Equation 33 Emissions impact 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 impact in the water category from a CAP measure in a given year, in MT CO ₂ e
$W_{R,n}$	= 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 in kWh/acre-foot or kWh/gallon
$EF_{segment}$	= electricity emission factor at a segment of the water cycle, in lbs CO ₂ e/MWh
10^{-3}	= conversion factor, kWh in a MWh
0.000453	= conversion factor, MT CO ₂ e in a pound
segment	= upstream supply, local conveyance, local treatment, local distribution, local recycled water treatment, local recycled water distribution ⁹
n	= a CAP horizon year, from baseline year to CAP horizon end year

The data needs for calculating the emissions impact are given in Table 23.

Table 23 Data/information needs for emissions impact 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.

⁹ A description of water cycle segments is in Technical Appendix I, Section 3.6.3 Water Energy Intensity.

The data inputs and emissions impact estimates for an example jurisdiction expanding its recycled water use by 300 acre-feet by 2030 are given below in Table 24.

Table 24 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 ₂ e/MWh)	Emissions impact (MT CO ₂ e)
2030	300	38	1,816	43	400	98

5.7.2 Increase water conservation

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

Local CAP measures to increase water conservation

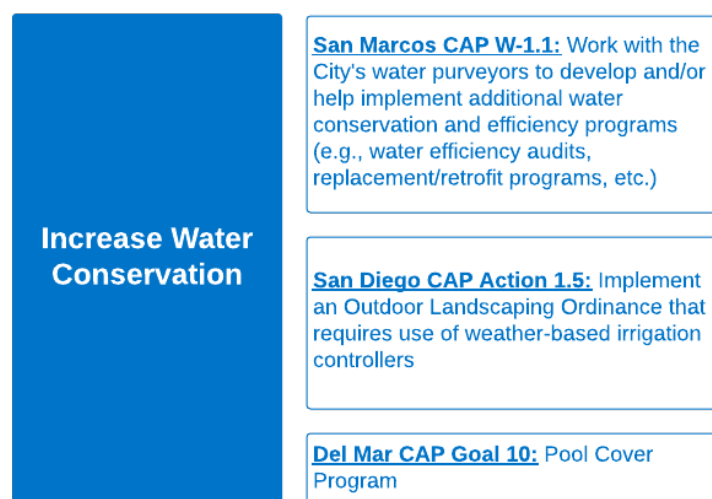
Like the local CAP measures to reduce energy use in buildings discussed earlier, local governments can develop local ordinances to increase water efficiency for both indoor and outdoor water use, and for both new construction projects and existing buildings.

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; and
- Water use disclosure and benchmarking ordinances.

Figure 27 shows three examples of measures in currently adopted CAPs that aim to increase water conservation.

Figure 27 Examples of CAP measures to increase water conservation (San Marcos 2013, San Diego 2015, and Del Mar 2016)



The following is the impact emissions 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 reductions of 2% per year for all participating households (City of Berkeley, 2011).

Emissions impacts 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 34. The indoor water reductions only considers the change in potable water use.

Equation 34 Emissions impact 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 impact in the water category from a CAP measure in a given year, in MT CO ₂ e
$N_{unit,n}$	= 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 reductions 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 ₂ e/MWh)
10^{-3}	= conversion factor, kWh per MWh
0.000453	= conversion factor, MT CO ₂ e per pound

With,

segment	= upstream supply, local conveyance, local treatment, local distribution ¹⁰
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

¹⁰ A description of water cycle segments is in Technical Appendix I, Section 3.6.3 Water Energy Intensity.

The data needs for calculating emissions impacts for a typical residential water disclosure and conservation ordinance are given in Table 25.

Table 25 Data/information needs for emissions impact 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 reduction 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 reduction at a single-family home from replacing fixtures and fittings; and
- The water reduction from specific fixtures and fittings specified in the ordinance.

The historical fixtures and fitting flow rates required by the CALGreen Code from 1980 to 2019 are given in Table 26. This can be used to determine “non-compliant” and “required” fixtures and fittings.

Table 26 Water fixtures and fittings flow rates required by California Green Building Standards Code (ConSol 2015, California Building Standards Commission 2016 and 2019)

Fixtures and Fittings	1980	1992	2005	2009	2011	2013	2016	2019
Showerheads (gpm)	2.5	2.5	2.2	2.5	2	2	2	1.8
Toilets (gpf)	3.5	1.6	1.6	1.6	1.28	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	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 impact from solid waste-related measures

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

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

The following sections describe the methods and data needs for calculating GHG emissions impact 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 \(Chesbro\) \(Chapter 476, Statutes of 2011\)](#)), 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.

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 \(Wiggins\) \(Chapter 343, Statutes of 2008\)](#)). 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 policies to increase diversion rate.

Local CAP measures to divert waste from landfills

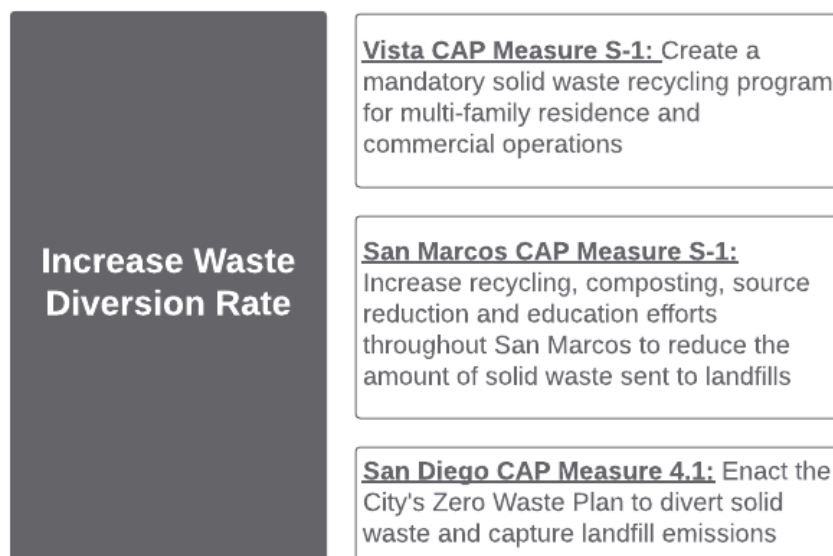
CAPs in the San Diego region have measures to reduce the amount of solid waste disposed at landfills. The measures include, but are not limited to:

- Develop Zero Waste Plans¹¹;
- Expand and mandate waste recycling programs for businesses and residents of multi-family dwellings; and
- Develop construction and demolition waste diversion ordinances.

Figure 28 shows three examples of these measures in currently adopted CAPs.

¹¹ 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 region 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 28 Examples of CAP measures to reduce landfill waste disposal (Vista 2012, San Marcos 2013, and San Diego 2015)



The following is the emissions impact 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 methane (CH₄) emission factors. For example, one MT of food waste produces more CH₄ than one MT of newspapers. Therefore, diverting food waste will avoid emissions more than the same quantity of newspapers. The method described here uses the average emission factor for typical mixed solid waste.

The emissions impact 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 emissions impact 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 impact depending on the size of the waste stream from the jurisdiction.

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 the City of San Marcos and four PPD in the City of Imperial Beach.

Using this conversion method, the waste reduction is calculated using Equation 35 below.

Equation 35 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 (avoided) 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 impact from increasing the solid waste diversion rate can be calculated using Equation 36.

Equation 36 Emissions impact from increased solid waste diversion rate

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

Where

$\Delta E_{waste,CAP\ measure,n}$	= emissions impact in the waste category from a CAP measure in a given year, in MT CO ₂ e
ΔSW_n	= mixed solid waste diverted (avoided) from landfill in a given year, in short ton
EF_{msw}	= mixed waste emission factor, in MT CO ₂ e/short ton ¹²
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 impact are given in Table 27.

Table 27 Data/information needs for emissions impact 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

¹² Described in Technical Appendix I, Section 3.8.2 Solid Waste Emission Factor.

The data inputs and emissions impact calculated for a jurisdiction targeting an 80% waste diversion rate from landfills by 2030 are given below in Table 28.

Table 28 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 impact (MT CO ₂ e) $\Delta E_{waste,CAP\ measure}$
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 (e.g., single-family residential, multi-family residential, commercial), 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

California regulations to reduce organic waste

[AB 1826 \(Chesbro\) \(Chapter 727, Statutes of 2014\)](#), 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). In addition, [SB 1383 \(Lara\) \(Chapter 395, Statutes of 2016\)](#), requires a 50% reduction in organic waste disposal from 2014 levels by 2020 and a 75% reduction by 2025. SB 1383 also requires that 20% of edible food be recovered for re-use, by 2025. CalRecycle is tasked with analyzing progress that State and local governments have made in the waste sector by July 1, 2020 (CalRecycle, 2019). Because the effectiveness of reducing organic waste from these regulations is currently unknown, the calculation method to estimate emissions is not provided here but could be included in future iterations of this Appendix.

5.9 Emissions impact of carbon removal measures

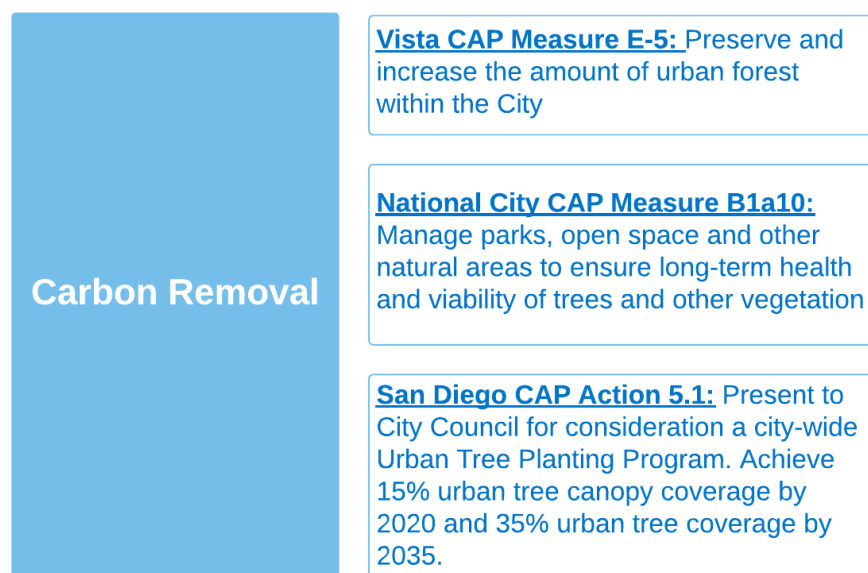
Other CAP measures may aim to remove carbon from the atmosphere and store carbon using natural or mechanical processes, rather than reduce GHG emissions through policies and programs. These CAP measures include:

- Increase carbon removal through conserved open space and natural lands; and
- Increase carbon removal through increased urban tree canopy cover.

Measures that increase carbon removal may also reduce GHG emissions and have other co-benefits. For example, increasing urban tree canopy cover and streets shaded with trees can increase climate resilience, reduce the temperature in urban areas, and may lead to reduced energy needs for air conditioning.

Figure 29 shows three examples of carbon removal measures in currently adopted CAPs.

Figure 29 Examples of carbon removal CAP measures
(Vista 2012, National City 2011, and San Diego 2015)



The following is an example of the impact of a carbon removal measure in terms of CO₂ sequestered.

Increase urban tree planting

The CO₂ sequestration rate of trees (CO₂ 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 CO₂ sequestration rates for a variety of tree species. If tree information is unknown at the time of CAP development, the average (0.035 MT CO₂ per tree per year) or species-specific CO₂ sequestration rate of trees from the California Emissions Estimator Model (CalEEMod) (2016) is used. The CO₂ sequestered from increased urban tree canopy planting can be calculated using Equation 37.

Equation 37 CO₂ sequestered from increased urban tree planting

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

Where,

$\Delta E_{CAP\ measure,n}$

$P_{tree\ species,n}$

$CS_{tree\ species}$

= CO₂ sequestered from a CAP measure in a given year, in MT CO₂

= number of new trees planted from baseline year to a given year for each of tree species

= carbon sequestration rate of each of tree species, MT CO₂ per year

With,

tree species

n

= type of new trees planted

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

The data needs for calculating the CO₂ sequestered are given in Table 29.

Table 29 Data/information needs for CO₂ sequestered 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 CO₂ sequestered calculation for a sample jurisdiction planting 200 new trees every year are given below in Table 30.

Table 30 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) $CS_{tree\ species}$	CO ₂ sequestered (MT CO ₂) $\Delta E_{CAP\ measure,n}$
2030	200	3,000	0.035	106

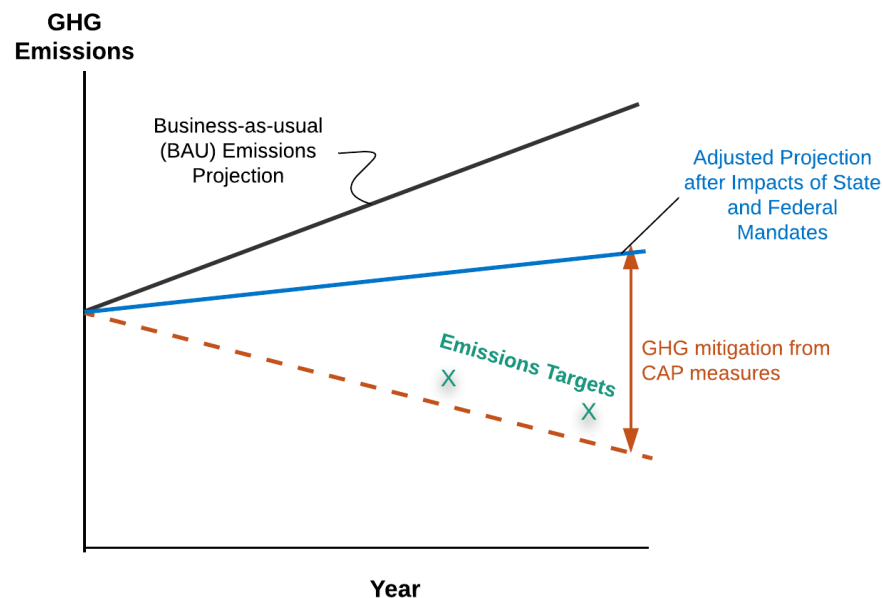
6. Visualization and presenting results

The emissions mitigated as a result of each measure or strategy can be presented in multiple ways to fit different purposes as shown in the following sections.

6.1 Differentiate local CAP measures from federal and State regulations

The following chart (Figure 30) shows impact of local CAP measures separately from the impact of federal and State regulations.

Figure 30 Visualization and presenting results: separate the effects of federal, State and local CAP measures

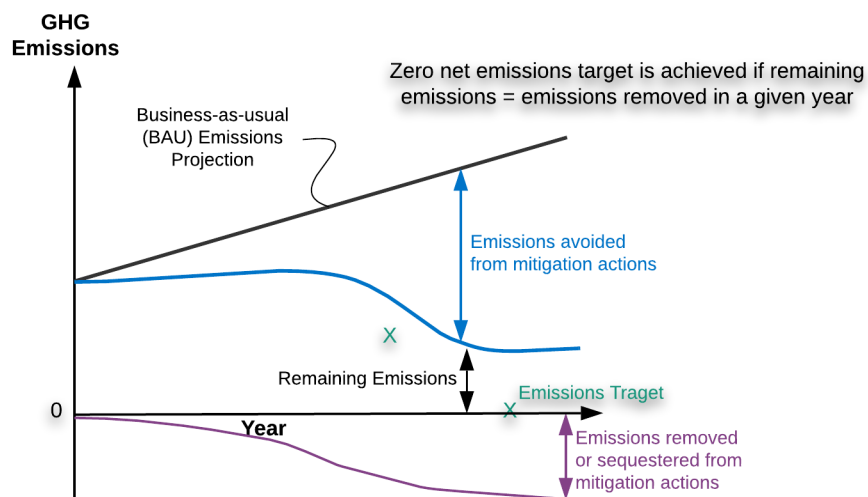


The emission level after the impacts of federal and State regulations (blue line in Figure 30) is often called the “legislatively-adjusted BAU emissions.” The difference between the “legislatively-adjusted BAU emissions” and target emissions (green X’s in Figure 30) is what the local jurisdictions need to reduce through the CAP’s measures, 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 impact of each CAP strategy or measure.

6.2 Differentiate measures that avoid emissions from measures that remove emissions

CAP measures may be separated into those that avoid future emissions through regulations, policies, and programs and those that remove and sequester carbon from the atmosphere using natural or mechanical process. To achieve carbon neutrality, or net zero emissions, the level of emissions that remain after actions to avoid future emissions must equal to those removed and sequestered. The following chart (Figure 31) shows the impact of emissions avoided and removed separately.

Figure 31 Visualization and presenting results: separate emissions avoided and removed

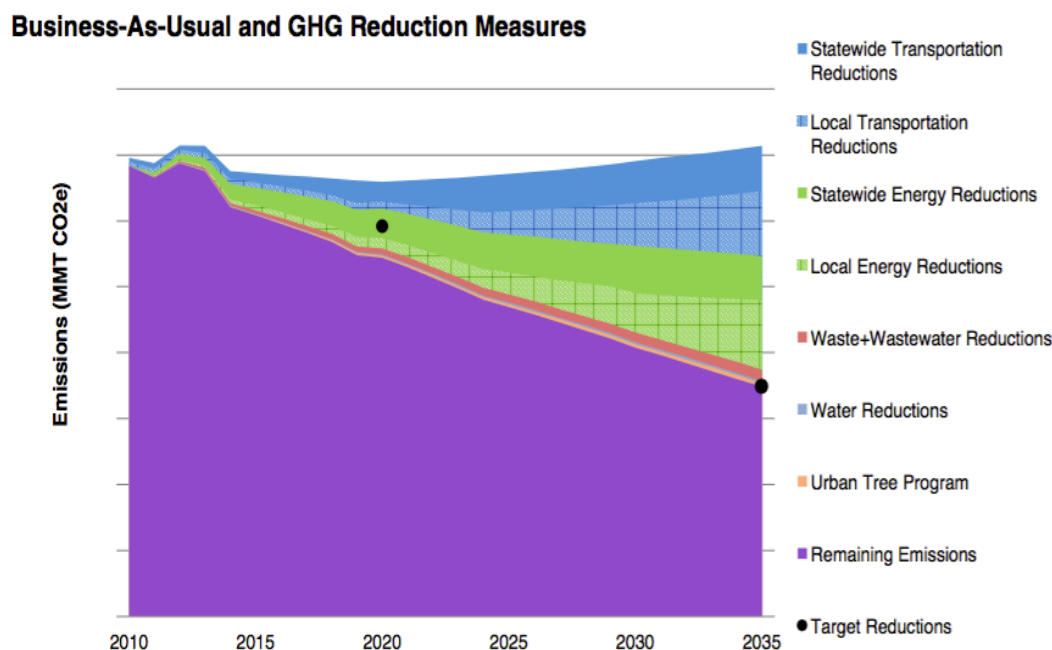


The emission level after accounting for emissions avoided from measures, including federal, State, and local CAP measures, is shown as the blue line in Figure 31. The impact of carbon removal and sequestration is shown as the purple line in Figure 31 and is independent of the BAU emissions projection. To achieve carbon neutrality or net zero emissions, there can still be remaining emissions after accounting for the emissions avoided; however, the remaining emissions have to be at least equal to the emissions removed and sequestered. This chart provides a conceptual framework of effects of different types of CAP measures. It does not provide visualization of the impact of each CAP strategy or measure, or separating the impacts of local, State or federal actions.

6.3 Separate emissions impact by CAP strategy or measure (wedge chart)

The following wedge chart (Figure 32) is an example that shows the emissions impact trend of each CAP strategy or each CAP measure.

Figure 32 Visualization and presenting results: emissions impact trend by CAP strategy



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

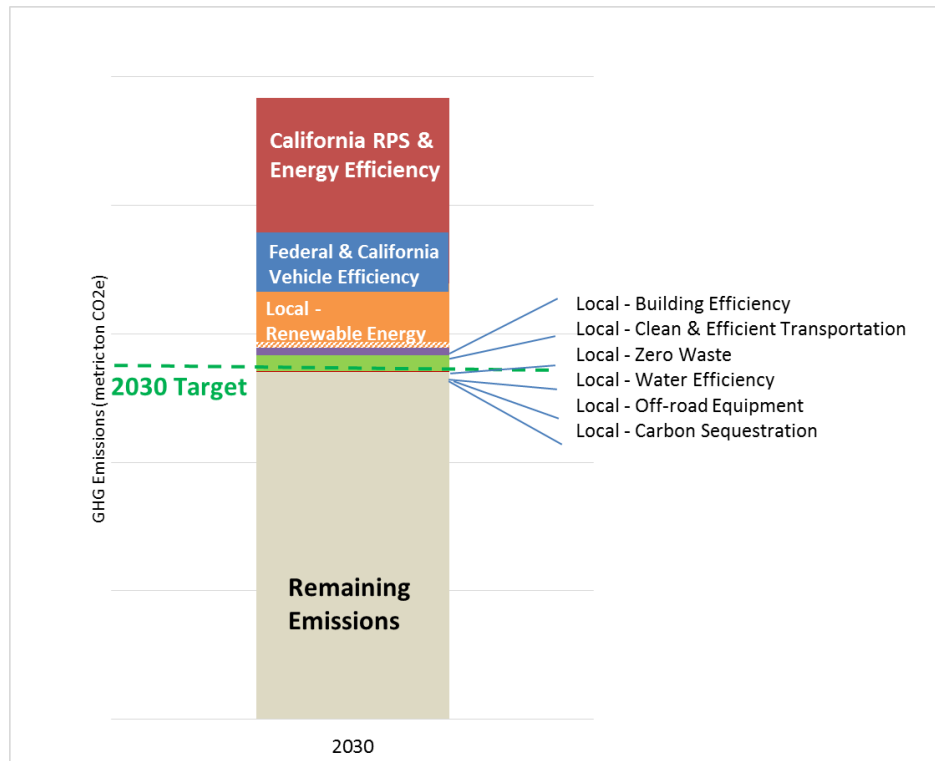
The wedge chart provides a comparison of the cumulative impact from each strategy or measure across the CAP horizon years. It is important to look at the cumulative impact because strategies and measures perform differently over time. A measure may not deliver significant GHG impact in early years but may result in greater impact in later years. Estimating and presenting the cumulative impact provides a more comprehensive way to evaluate the effectiveness of the measure over time. As indicated in the Scoping Plan "...Once GHGs are emitted into the atmosphere, they can have long lifetimes that contribute to global warming for decades. Policies that reduce both cumulative GHG emissions and achieve the single-year 2030 target provide the most effective path to reduce climate change impacts." (CARB 2017, p.26).

In addition, the order of the wedges does not reflect the implementation priority of each strategy. In other words, this chart does not mean that no local energy reduction or waste and wastewater reduction are needed in the year 2020. The CAP measures need to be implemented in earlier years and ramped up to meet future targets.

6.4 Emissions impact from CAP strategies in target year (bar chart)

The following bar chart (Figure 33) is an example that shows the emission impact from CAP strategies in target year 2030.

Figure 33 Visualization and presenting results: emissions impact 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 33, federal and State regulations make up the majority of emissions impacts; 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 impact 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 impact from each CAP measure in target years, if one or several measures have a significant impact.

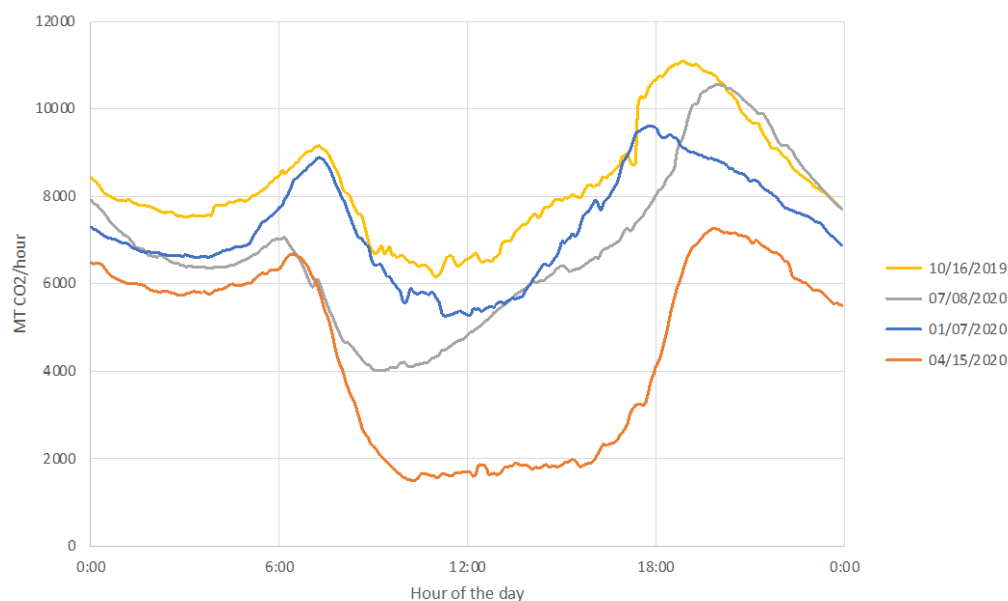
7. Emerging issues

As noted above, while there are generally accepted approaches to estimate the GHG impact of 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 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 impact is calculated using the weighted average electricity emission factor and the amount of electricity 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 the emission factor calculation. Figure 34 shows the emission factor (MT CO₂/h) across hours on four different days in each season of the electricity serving the California Independent System Operator (CAISO)'s load.

Figure 34 CAISO's CO₂ emissions per hour on four different days (CAISO, 2020)



Because the various resources supply the grid at different times of the day, actual hourly emissions impacts from energy conservation measures depend on the type of electricity not supplied as a result of the measure. The emissions impact 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. CO₂e/MWh. On the other hand, if electricity is conserved when excess renewables are available on the grid, there will be no emissions impact 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 marginal emission factors for a local jurisdiction or for the San Diego region. 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 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. A 2017 San Francisco County Transportation Authority (SFCTA) study shows that on a typical weekday, TNC trips represent 15% of all vehicle trips within the City of San Francisco, with an even larger percentage at peak time (SFCTA, 2017).

At the State level, SB 1014 established the Clean Miles Standard and Incentive Program to reduce the emissions from TNC vehicles. Through the program, a baseline of emissions from TNC vehicles on a per-passenger-mile basis has been established (CARB, 2019). By January 1, 2021, CARB and the CPUC will establish and implement annual targets starting in 2023 for the reduction below the baseline. The TNCs are required to develop GHG reduction plans to detail pathways to meet these targets.

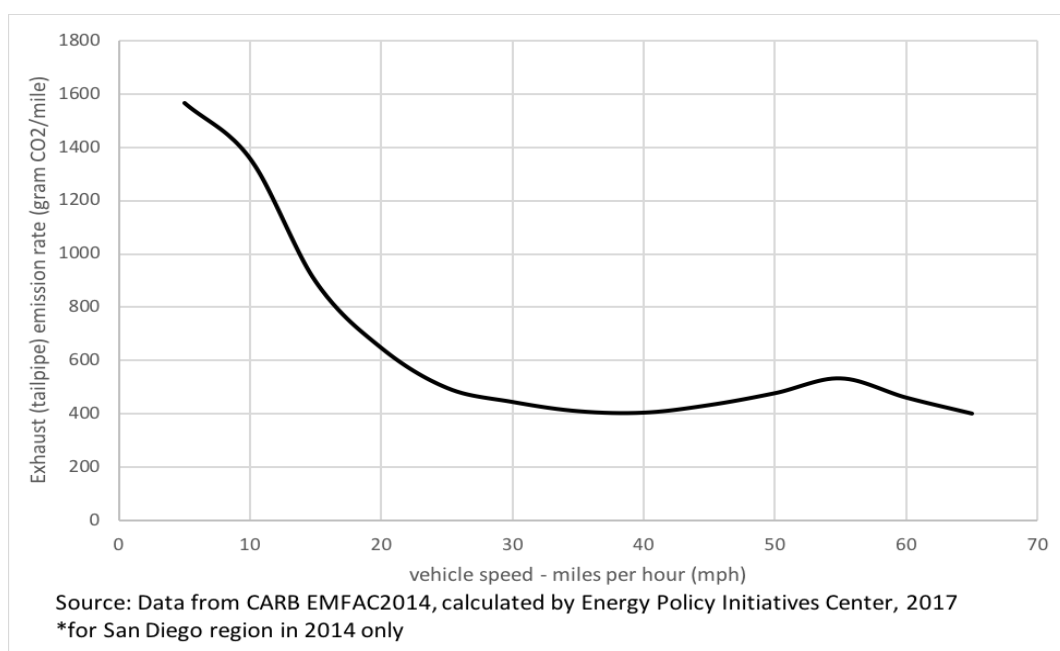
The impact of TNCs on shifting travel patterns in the San Diego region is not clear. For example, if people shift from public transportation or other travel modes to riding with TNCs, a certain penetration of TNCs may decrease vehicle ownership while also creating new trips. While the activity level 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 policies.

In *San Diego Forward: The 2021 Regional Plan*, SANDAG 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).

7.4 Using speed bin profiles 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 impact is calculated based on fuel reductions 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 35 shows that the emission factors at low speeds (<20 mph) are higher than the emission factors at higher speeds.

Figure 35 2014 vehicle speed and CO₂ emission rate for San Diego region only (CARB, EPIC 2017)



The current SANDAG 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 impacts for the measure can be developed based on both the emission rate by speed bin and the speed profile.

7.5 Accounting for carbon stock changes 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 2017, p.ES-13).

CARB has developed a natural and working lands inventory that estimates the carbon stored in the land base and the carbon stock change and resulting GHG flux associated with stock change among different land types. The types of natural and working lands included in the inventory are forest and other natural lands, urban land, cropland, soil carbon, and wetlands. Approximately 85% of the total carbon stocks in 2014 statewide is in forest and shrubland (CARB, 2018b).

Currently, State agencies, including CARB, the California Natural Resources Agencies (CNRA), and the California Department of Food and Agriculture (CDFA), are developing a Natural and Working Lands Climate Change Implementation Plan (State Agencies, 2019). The Plan will use the natural and working lands inventory and develop BAU emissions scenarios for the natural and working land sector and quantify the sequestration impact of land conservation and management activities (CARB 2017b).

While the expected impact from land conservation and management activities will be modeled at the State level, the methodology, approaches and monitoring process may be of value at the regional level and are essential to achieve the long-term carbon neutrality or net zero emissions goal.

8. Conclusion

This Appendix II to the SANDAG ReCAP discussed:

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

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

9. References

- Anders, S. Kim, J. Silva-Send, N. Gordon, C. Gu, Y. *Splitting the Electric Emissions Baby: Allocating Greenhouse Gas Reductions between Efficiency and Renewable Energy Policies*. In The Electricity Journal, Volume 28, Issue 8, 2015, Pages 29-42, ISSN 1040-6190 <https://doi.org/10.1016/j.tej.2015.09.004>. Accessed November 17, 2017
- CAISO. 2020. *Today's Outlook*. California Independent System Operator. <https://perma.cc/DR76-JSQC> Accessed July 9, 2020
- CALEEMOD. 2016. Version 2016.3.2. California Emissions Estimator Model. <https://perma.cc/45AC-2XE8> accessed May 8, 2019
- California Building Standards Commission. 2019. *California Green Building Standards Code (Cal. Code Regs., Title 24, Part 11)* <https://perma.cc/EH4W-Q9TT> Accessed June 23, 2020
- California Energy Codes & Standards, 2020. <https://perma.cc/ST2C-Y56E> Accessed June 12, 2020
- California Legislative Information. 2015. *SB350 Clean Energy and Pollution Reduction Act of 2015*. <https://perma.cc/4WCN-EMTT> Accessed July 22, 2020
- CalRecycle. 2012. *Per Capita Disposal and Goal Measurement (2007 and Later)*. <https://perma.cc/U6YD-85FC> Accessed May 8, 2019
2017. *Mandatory Commercial Organics Recycling (MORe)*. <https://perma.cc/QHB7-E4SP> Accessed July 22, 2020
2019. *Short-Lived Climate Pollutants (SLCP): Organic Waste Methane Emissions Reductions*. <https://perma.cc/R6ES-H3HL> Accessed July 22, 2020
- CARB. 2015. *EMFAC2014 Volume III - Technical Documentation*. California Air Resources Board. <https://perma.cc/5BYS-DBKU> Accessed April 25, 2019
2016. *California's 2000-2014 Greenhouse Gas Emission Inventory Technical Support Document*. <https://perma.cc/LB96-7439> Accessed April 30, 2020
2017. *California's 2017 Climate Change Scoping Plan. The strategy for achieving California's 2030 greenhouse gas target*. <https://perma.cc/FP86-L6YW> Accessed May 6, 2020
- 2018a. *EMFAC2017 Volume III – Technical Documentation*. <https://perma.cc/R3EX-L3JL> Accessed April 30, 2020
- 2018b. *An Inventory of Ecosystem carbon in California's Natural & Working Lands, 2018 Edition*. <https://perma.cc/Y8MQ-X8UD> Access July 9, 2020
2019. *SB 1014 Clean Miles Standard. 2018 Base-year Emissions Inventory Report*. <https://perma.cc/DT25-MERH> Access July 9, 2020
- 2020a. *California Greenhouse Gas Emissions Inventory – 2020 Edition*. <https://perma.cc/53MR-CQNW> Access October 29, 2020.
- 2020b. *EMFAC Off-Model Adjustment Factors for Carbon Dioxide (CO₂) Emissions to Account for the SAFE Vehicles Rule Part One and the Final SAFE Rule*. <https://perma.cc/A5FQ-GVXW> Accessed September 3, 2020.
- CEC. 2005. *Energy Action Plan II. Implementation Roadmap for Energy Policies*. California Energy Commission. <https://perma.cc/EZG8-B3QU> Accessed May 21, 2020
2019. *2019 California Energy Efficiency Action Plan*. Publication Number: CEC- 400-2019-010-SF <https://perma.cc/3TWB-CV78> Accessed June 11, 2020
2020. *California Energy Demand 2020–2030 Revised Forecast*. <https://perma.cc/P7UE-UYCC> Accessed March 23, 2020

- City of Carlsbad. 2015. *Climate Action Plan*. <https://perma.cc/RHN2-43XL> Accessed May 14, 2020
- 2019a. *Nonresidential Photovoltaic & Water Heating Ordinance*. <https://perma.cc/6G4J-9LN4> Accessed September 16, 2019
- 2019b. *Residential Energy Conservation Ordinance*. <https://perma.cc/Z7H8-FGDU> Accessed September 16, 2019
- 2019c. *Residential Water Heating Ordinance*. <https://perma.cc/C7HK-GHY6> Accessed June 15, 2020
- City of Del Mar. 2016. *Climate Action Plan*. <https://perma.cc/SEP7-39UJ> Accessed May 14, 2020
- City of Escondido. 2013. *Climate Action Plan*. <https://perma.cc/6VQK-R6LN> Accessed May 14, 2020
- City of National City. 2011. *Climate Action Plan*. <https://perma.cc/7MX7-UCWX> Accessed May 14, 2020
- City of San Diego. 2015. *Climate Action Plan*. <https://perma.cc/S3NS-JFHC> October 24, 2019
- City of San Marcos. 2013. *Climate Action Plan*. <https://perma.cc/WV32-M7E7> Accessed May 14, 2020
- City of Solana Beach. 2017. *Climate Action Plan*. <https://perma.cc/5RH7-3UC9> Accessed July 9, 2020
- City of Vista. 2012. *Climate Action Plan*. <https://perma.cc/BXP6-TSN6> Accessed May 14, 2020
- County of San Diego. 2018. *Climate Action Plan*. <https://perma.cc/F3W8-3WXY> Accessed July 22, 2020
- CPUC. 2017. *Energy Efficiency Potential and Goals Study for 2018 and beyond*. California Public Utilities Commission. Submitted by Navigant Consulting. Reference No. 174655 <https://perma.cc/8KKF-7G7>. Accessed April 30, 2019
2019. *Decision 19-08-034: Decisions for Adopting Energy Efficiency Goals for 2020 – 2030*. <https://perma.cc/RM8E-L7ZM> Accessed June 11, 2020
- Dill and Carr. 2003. *Bicycle Commuting and Facilities in Major U.S. Cities: If you Built Them, Commuters Will Use Them – Another Look*. Transportation Research Record: Journal of the Transportation Research Board 2003 1828, 116-123 <https://doi.org/10.3141/1828-14>. Accessed October 18, 2017
- SANDAG. 2015. *San Diego Forward: The Regional Plan. Appendix D: 2012 Greenhouse Gas Emission Inventory for the San Diego Region and Projections*. San Diego Association of Governments. <https://perma.cc/M3E5-FFWX> Accessed July 22, 2020
2018. *Emerging Technologies White Paper*. <https://perma.cc/RBM5-3JL8> Accessed July 22, 2020
- SEEC. 2013. *SEEC ClearPath California User Guide*. Forecast Module. Accessed January 19, 2019
- SFCTA. 2017. *TNCs Today – A Profile of San Francisco Transportation Network Company Activity*. San Francisco County Transportation Authority. <https://perma.cc/9RU6-Y6SP> Accessed July 9, 2020
- State Agencies. 2019. *January 2019 Draft California 2030 Natural and Working Lands Climate Change Implementation Plan* <https://perma.cc/755U-A63V> Accessed July 9, 2020
- WRI and WBCSD. 2007. *Guidelines for Quantifying GHG Reduction from Grid-Connected Electricity Projects*. World Resources Institute. World Business Council for Sustainable Development. <https://perma.cc/6PRC-M4SG> Accessed July 9, 2020