Appendix D

2012 Greenhouse Gas Emissions Inventory for the San Diego Region and Projections

Appendix Contents

2012 Greenhouse Gas Emissions Inventory and Projections for the San Diego Region

A Summary of Methods and Data Used

Prepared For

San Diego Association of Governments

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1 INTRODUCTION

The San Diego Association of Governments (SANDAG) contracted the Energy Policy Initiatives Center (EPIC) to estimate the 2012 regional greenhouse gas (GHG) emissions for San Diego County, project emissions to 2050, and estimate the effect of existing statewide policies to reduce emissions. GHG emissions estimates are to be included in San Diego Forward: The Regional Plan and associated Environmental Impact Report. This report summarizes the methodologies and data used to conduct this analysis.

To the extent possible, EPIC followed the U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions[1] (U.S. Community Protocol) for the following emissions categories:

- On-road transportation
- Electricity and natural gas
- Water consumption
- Solid waste
- Wastewater
- Civil Aviation

EPIC estimated emissions for the remaining categories based on California Air Resources Board methods and those developed by EPIC based on local data. These categories include:

- Other Fuels
- Cogeneration
- Industrial
- Off-Road
- Land Use and Wildfires
- Rail
- Agriculture
- Marine Vessels

1.1 Summary of Results

Table 1 summarizes the results of the San Diego Regional GHG Emissions inventory for 2012.

[1] ICLEI Local Governments for Sustainability USA, U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions. Available at http://www.icleiusa.org/tools/ghg-protocol/community-protocol.

Table 1: Summary of Greenhouse Gas Emissions in the San Diego Region, 2012

Emissions Category	2012	
	CO_2e Emissions (Million Metric Tons)	Percentage of Total Emissions
Passenger Cars & Light Duty Vehicles	13.14	37.2%
Electricity	7.97	22.6%
Natural Gas	2.84	8.0%
Heavy Duty Trucks & Vehicles	1.89	5.4%
Solid Waste	1.75	4.9%
Other Fuels	1.64	4.6%
Industrial	1.43	4.1%
Aviation	1.37	3.9%
Off-Road	0.92	2.6%
Wildfire	0.81	2.3%
Other - Thermal Cogeneration	0.64	1.8%
Water	0.52	1.5%
Wastewater	0.16	0.5%
Rail	0.11	0.3%
Agriculture	0.08	0.2%
Marine Vessels (ocean-going vessels and harbor craft)	0.05	0.1%
Development and Sequestration*	(0.65)	N/A
Total	**34.67**	**100%**

* It is assumed that development leads to loss of vegetation and immediate loss of CO2e while sequestration accounts for absorption of CO_2e from increased vegetation. The sum of these emissions is negative (in parentheses), that is, there is net absorption in 2012.

Table 2 provides the Regional GHG Emissions Forecast for 2020, 2025, 2035, and 2050. This forecast includes the regional effects of existing (in 2012) statewide emission reduction policies and strategies, including: Advanced Clean Cars vehicle efficiency standards, Zero Emissions Vehicles Mandate, Low Carbon Fuel Standard, Renewable Portfolio Standard, energy efficiency and distributed solar programs, waste diversion, water conservation, Cap and Trade Program, and high global warming potential (GWP) strategies. The estimated reductions are based on the current implementation timeline for regulations, many of which do not currently extend beyond 2020 or 2025. Therefore, the emissions reductions are conservative estimates and the extension of current regulations and/or new future regulations would lead to additional reductions beyond what is estimated here. See Section 17 for the methods for calculating the reductions associated with these measures.

Table 2: Regional Greenhouse Gas Emissions Forecast

Emissions Categories	2012 Inventory	2020	2025	2035	2050
Passenger Cars & Light Duty Vehicles	13.14	11.18	9.24	7.69	7.46
Electricity	7.97	6.41	6.32	6.05	5.76
Natural Gas	2.84	2.79	2.76	2.73	2.69
Heavy Duty Trucks & Vehicles	1.89	1.89	1.99	2.03	2.33
Solid Waste	1.75	0.84	0.88	0.93	0.98
Other Fuels	1.64	1.64	1.65	1.66	1.66
Industrial	1.43	1.45	1.46	1.49	1.60
Aviation	1.37	1.52	1.59	1.72	1.82
Off-Road	0.92	0.95	1.14	1.47	1.79
Wildfire	0.81	0.81	0.81	0.81	0.81
Other - Thermal Cogen	0.64	0.65	0.67	0.71	0.77
Water	0.52	0.57	0.59	0.63	0.67
Wastewater	0.16	0.12	0.13	0.15	0.15
Rail	0.11	0.15	0.17	0.23	0.30
Agriculture	0.08	0.06	0.05	0.03	0.02
Marine Vessels (excluding pleasure craft)	0.05	0.05	0.05	0.05	0.05
Development + Sequestration	-0.65	-0.62	-0.60	-0.56	-0.51
Low Carbon Fuel Standard		-1.39	-1.39	-1.39	-1.39
Cap and Trade		-0.5	-0.5	-0.5	-0.5
High GWP Measures		-0.43	-0.43	-0.43	-0.43
Total	**34.7**	**28.1**	**26.6**	**25.5**	**26.0**

Note: emissions are presented in million metric tons of CO2e.

1.2 Overview of the Report

The Regional GHG Emissions Forecast, Table 2, is based on reasonably foreseeable emissions based on regulations currently in place. The emissions were calculated by first creating a business-as-usual (BAU) projection, then subtracting the estimated emissions reductions due to current regulations. This report describes the methodology used to both calculate the BAU projection and emission reductions associated with current regulations.

Section 2 provides common assumptions used to estimate GHG emissions. Sections 3 to 16 provide the methods used to create the BAU projection for each category of emissions. The BAU projection is based on anticipated growth in the region in the absence of policies and regulations to reduce GHG emissions. Each category section also describes how methods may vary from those used in the previous regional inventories[2] and, where applicable, limitations of the approach. Section 17

[2] The regional inventories from 2008 and 2010 are available at http://www.sandiego.edu/law/centers/epic/reports-papers/reports.php.

summarizes methods used to estimate the greenhouse gas reductions from existing statewide policies that will affect emissions into the future.

2 COMMON ASSUMPTIONS AND SOURCES

The following section provides common assumptions used in more than one emissions category.

2.1 Carbon Dioxide Equivalent

Carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) are the primary GHGs emitted by fossil fuel combustion from the majority of emissions categories. The combination of these gases is represented as carbon-dioxide equivalent (CO_2e), which is the common expression of GHG emissions.

In general, the Global Warming Potentials (GWPs) used to convert CH_4 and N_2O to CO_2e are consistent with 100-yr GWPs reported by the Intergovernmental Panel on Climate Change (IPCC) in their Fourth Assessment Report (AR4) in 2007[3] (see Table 3). However, transportation GHG emissions based on the EMFAC 2014 model were converted from CO_2 to CO_2e by multiplying by a conversion factor of 1.055.[4]

Table 3: Global Warming Potentials used in the Regional Greenhouse Gas Inventory

Greenhouse Gas	Global Warming Potential (GWP)
Carbon Dioxide (CO_2)	1
Methane (CH_4)	25
Nitrous Oxide (N_2O)	298

2.2 Background Data

Table 4 presents a summary of common activity data used to estimate overall GHG emissions. Activity data are those that lead directly or indirectly to GHG emissions.

Table 4: Common Data Used in the Regional Greenhouse Gas Inventory

Data Category	2012	2020	2035	2050
Population[5]	3,143,429	3,435,713	3,853,698	4,068,759
Electricity Use (GWh)[6]	19,737	21,550	25,846	30,116
Natural Gas Use (Million Therms)[7]	522	532	581	631
Water Consumption (Gallons)[8]	172,102,737,000	188,105,286,750	210,989,965,500	222,764,555,250

[3] Climate Change 2007: Working Group I: The Physical Science Basis, Section 2.10.2 Direct Global Warming Potentials, Table 2.14
[4] A conversion factor is required because only CO_2 emissions, not CO_2 equivalents, are modeled by the EMFAC model for on-road transportation. The conversion factor is derived by dividing the average CO_2e emissions (12,100 lbs/year) from a passenger fleet vehicle of 63.5% cars and 36.6% light duty trucks by the average CO_2 emissions (11,470 lbs/year) for the same fleet. U.S. Environmental Protection Agency, Unit Conversion, Emissions Factors, and Other Reference Data, November 2004, page 6. Available at http://www.epa.gov/cpd/pdf/brochure.pdf.
[5] SANDAG Series 13. Provided by SANDAG, email February 6, 2015.
[6] California Energy Demand 2015-2025 Revised Forecast, Volume 1: Statewide Electricity Demand, End-User Natural Gas Demand, and Energy Efficiency. California Energy Commission, Electricity Supply Analysis Division. Publication Number: CEC-200-2014-009-SF-REV.
[7] California Energy Demand Forecast 2015-2025.

Vehicle Miles Traveled (miles/day)[9]	79,473,075	84,814,180	90,661,689	94,479,905

2.3 Emissions Factors

Table 5 shows the emissions factors used to calculate the emissions reductions due to the major federal and state GHG mitigation measures described in Section 17. These factors change depending on the target year and as the state and federal measures, such as the Renewable Portfolio Standard, are implemented.

Table 5: Emissions Factors Used in the Regional Greenhouse Gas Inventory

Emissions Factor	Value	Units
Natural Gas CO_2e Emissions Factor[10]	0.0054	Metric Tons CO_2e/Therm
2012 Electricity CO_2e Emissions Factor[11]	785	lbs CO_2e/MWh
2012 Fleet CO_2e Emission Factor[12]	543	Grams CO_2e/Mile
2012 Passenger Vehicles Only CO_2e Emissions Factor[13]	478	Grams CO_2e/Mile

2.4 Business-as-Usual Emissions Projection

Table 6 provides the Business-as-Usual (BAU) projection for 2020, 2025, 2035 and 2050. The BAU projection is based on anticipated growth in the region in the absence of policies and regulations to reduce GHG emissions. The one exception to this is the on-road transportation sector. On-road transportation emissions are based on EMFAC2014 output, where BAU emissions projections from the transportation sector include the effects of California's Advanced Clean Cars Program, which includes the Federal Corporate Average Fuel Economy Standards, the Pavley tailpipe emissions standards (2012 – 2016 model years) and the Low Emissions Vehicles LEV III GHG regulation (2017 – 2025 model years). The transportation projections also include changes due to SB375, electric vehicle miles and California's heavy-duty aerodynamics regulation. In contrast, other sectors do not reflect effects of

[8] Based on the estimated reported per capita consumption of 150 gallons in 2010. San Diego County Water Authority, from chart "Water Authority Service Area Water Use" at http://www.sdcwa.org/sites/default/files/images/water-management/WaterUse1990-2014.

[9] EMFAC 2014, the latest version of the Emissions Factor model developed by California Air Resources Board to assess vehicle tailpipe emissions. Available at http://www.arb.ca.gov/msei/modeling.htm.

[10] California Air Resources Board Documentation of California's 2000-2012 GHG Inventory. Available at http://www.arb.ca.gov/cc/inventory/doc/doc_index.php. See also California's 2000-2012 Greenhouse Gas Emissions Inventory Technical Support Document 2014 Edition. Available at http://www.arb.ca.gov/cc/inventory/doc/methods_00-12/ghg_inventory_00-12_technical_support_document.pdf.

[11] Developed by EPIC from data from a) Federal Energy Regulatory Commission (FERC) Form 1. Available at http://www.ferc.gov/docs-filing/forms/form-1/viewer-instruct.asp and b) U.S. Environmental Protection Agency (EPA) Emissions & Generation Resource Integrated Database 2010 (eGrid). Available at http://www.epa.gov/cleanenergy/energy-resources/egrid/.

[12] EPIC, developed from EMFAC 2014 data.

[13] EMFAC 2014.

major state regulations on GHGs in the BAU projection. See sections below for methods and projections.

Table 6: Regional Business-As-Usual (BAU) Projection

Emissions Categories	2012 Inventory	2020	2025	2035	2050
Passenger Cars & Light Duty Vehicles	13.14	11.44	9.45	7.94	7.76
Electricity	7.97	8.63	9.18	10.09	10.99
Natural Gas	2.84	2.89	2.98	3.16	3.44
Heavy Duty Trucks & Vehicles	1.89	1.89	1.99	2.03	2.33
Solid Waste	1.75	1.91	2.00	2.13	2.25
Other Fuels	1.64	1.64	1.65	1.66	1.66
Industrial	1.43	1.45	1.46	1.49	1.60
Aviation	1.37	1.52	1.59	1.72	1.82
Off-Road	0.92	0.95	1.14	1.47	1.79
Wildfire	0.81	0.81	0.81	0.81	0.81
Other - Thermal Cogen	0.64	0.65	0.67	0.71	0.77
Water	0.52	0.57	0.59	0.63	0.67
Wastewater	0.16	0.17	0.18	0.20	0.21
Rail	0.11	0.15	0.17	0.23	0.30
Agriculture	0.08	0.06	0.05	0.03	0.02
Marine Vessels (excluding pleasure craft)	0.05	0.05	0.05	0.05	0.05
Development + Sequestration	-0.65	-0.62	-0.60	-0.56	-0.51
Total	**34.7**	**34.1**	**33.4**	**33.8**	**36.0**

Note: emissions are presented in million metric tons of CO2e.

2.5 Methods to Calculate 1990 Emissions

SANDAG first prepared a GHG inventory in 2009 to better understand the emissions sources in the region and to serve as a resource for local and regional decision makers as they consider ways to reduce emissions at the local and regional levels. To that end, emissions were calculated based on historical GHG emissions from 1990 to 2006 using the best available data, and then estimated future emissions to 2020[14]. The inventory includes the entire population and all economic sectors of San Diego County, with the exception of some military activities. To the extent possible, the study followed the same calculation methodology used by the California Air Resources Board (CARB) to develop the statewide GHG inventory. In some instances, when doing so could yield a more accurate or precise result or when data were unavailable, the project modified the CARB method.

[14] San Diego County Greenhouse Gas Inventory: A Summary of Methods Used, March 2009 – can be found at http://www.sandag.org/uploads/projectid/projectid_374_13259.pdf.

Subsequent to that initial study, in 2013, a 2010 GHG emissions inventory was developed. The 1990 GHG emission level of 29 MMT CO_2e is included in the appendix to that study (Table 2)[15].

3 ON-ROAD TRANSPORTATION

The on-road transportation category is the single largest contributor of GHG emissions in San Diego County, accounting for about 43% of total emissions in 2012. Emissions from on-road transportation are the result of fuel combustion (gasoline, diesel, electricity use) from motorized vehicles on San Diego County freeways, highways, streets, and roads. The vehicle classes included in this category are: passenger cars; light-, medium-, and heavy-duty trucks; buses; motor homes; and motorcycles.

3.1 Method Used to Estimate 2012 Emissions

To estimate emissions from on-road transportation activity, EPIC used EMFAC2014[16], the California Air Resources Board model for estimating emissions from mobile sources. Input files to run the model as well as output files containing all emissions data, including CO_2 were provided by SANDAG. While output emissions *projections* from EMFAC2014 include the effects of the most recent Advanced Clean Cars program[17], which includes federal fuel economy standards for passenger cars and light-duty trucks applying to new vehicle model years through 2025, SB375, electric vehicles and certain truck regulations, the effect of these regulations on GHG emissions are *de minimis* in 2012.

The GHG emissions associated with the generation of electricity used to power electric vehicle miles reflected in EMFAC 2014 are included in the Electricity category of this regional inventory.

3.2 Business-as-usual Projection

Emissions for 2012, 2020, 2035, and 2050 were estimated using EMFAC2014, with input and output files provided by SANDAG. Intermediate years were interpolated linearly. Output emissions include the effects of the most recent Advanced Clean Cars program[18], which includes federal fuel economy standards for passenger cars and light-duty trucks applying to new vehicle model years through 2016 and California's ZEV III GHG regulation[19] for model years 2017-2025. The projections also include the changes due to SB 375, electric vehicle miles and a heavy duty truck regulation as described below.

3.2.1 EMFAC2014 Assumptions

- EMFAC 2014 was used to develop on-road transportation GHG emissions for the baseline year 2012 and for 2025, 2035 and 2050. The regulations and standards that are accounted for in EMFAC2014 include: [20]

[15] Energy Policy Initiative Center, March 2013 San Diego County Updated Greenhouse Gas Inventory - can be found at http://catcher.sandiego.edu/items/usdlaw/EPIC-GHG-2013.pdf.
[16] EMFAC 2014.
[17] California Air Resources Board. California's Advanced Clean Cars Program. Available at http://www.arb.ca.gov/msprog/consumer_info/advanced_clean_cars/consumer_acc.htm.
[18] CARB, California's Advanced Clean Cars Program.
[19] California Air Resources Board. Zero Emission Vehicle (ZEV) Program, 2014. Available at http://www.arb.ca.gov/msprog/zevprog/zevprog.htm.
[20] Personal Communication with California Air Resources Board, email dated April 24, 2015.

  - Advanced Clean Cars Program[21], which includes the Federal Pavley GHG regulation (2012 – 2016 model years) and California's LEV III GHG regulation (2017 – 2025 model years).
  - The Heavy-Duty GHG Phase 1 (2013) regulation, which includes the 2013 Tractor-Trailer Greenhouse Gas Regulation Amendments and Federal Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles (this is also known as the Phase 1 / Smartway regulation
  - Truck and Bus Regulation (2014) Amendments
- What was previously known as the "CARB Heavy-Duty Vehicle Aerodynamics Regulation" was amended in 2013 (see item 2 above) and the amended regulation is reflected in EMFAC2014.[22]
- As per previous communication with CARB[23], EMFAC 2014 also includes effects of electric vehicle miles at a level of 15.7% of new vehicle sales per year through 2050.
- EMFAC2014 does not account for GHG benefits from the "Regulation to Reduce Greenhouse Gas Emissions from Vehicles Operating with Under Inflated Tires."[24] This is accounted for in the transportation forecast (Table 2).

3.3 Differences from Previous Inventory

Previous regional inventories of 2010 and 2012 were based on EMFAC2011 as well as regional origin-destination VMT data provided by SANDAG[25]. However, O-D VMT data was not used for this update. This regional inventory reflects only the update of EMFAC 2014.

4 ELECTRICITY

Electricity consumption is a significant source of greenhouse gas (GHG) emissions in San Diego County, accounting for about 23% of total emissions. The following sections summarize the methods used to estimate emissions from this category.

4.1 Method Used to Estimate 2012 Emissions

EPIC estimated emissions from electricity using the Built Environment (BE.2) method from the U.S. Community Protocol.[26] The method recommends multiplying the community's annual electricity use by the average annual electricity GHG emission factor expressed in pounds of CO_2e per megawatt-hour (lbs CO_2e/MWh). EPIC used annual electricity consumption data for San Diego County (San Diego region) provided by San Diego Gas & Electric[27] to estimate 2012 emissions.[28] Because about 9% of the electricity consumption in the SDG&E Service Territory occurs outside of San Diego County, where

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[21] CARB, California's Advanced Clean Cars Program, see http://www.arb.ca.gov/msprog/consumer_info/advanced_clean_cars/consumer_acc.htm
[22] Personal Communication with CARB, email dated April 24, 2015.
[23] Personal Communication between CARB, SANDAG, and EPIC, telephone conversation April 23, 2015.
[24] Personal Communication with CARB, email dated April 24, 2015.
[25] See Methodology for Regional Greenhouse Gas Inventory 2012 based on EMFAC2011, provided to SANDAG October 2014.
[26] ICLEI U.S. Community Protocol.
[27] San Diego Gas & Electric data request. Personal communication with Dinah Willer, SDG&E Account Manager (Email December 30, 2013).
[28] California Energy Demand Forecast 2015-2025.

needed the data was scaled to the San Diego Region by multiplying total demand by 91%. To account for transmission and distribution losses, that number was then increased by 6%.

The emissions factor for electricity represents a weighted average for all electricity use to serve electricity usage in San Diego County. Many sources affect the emissions factor for electricity, including the quantity and fuel source of the following sources of electricity:

- power plants owned by the local utility,
- power plants not owned by the local utility but from which it purchases electricity to supply customers,
- distributed generation, including photovoltaics, and
- cogeneration.

The GHG emission factor was derived using data from annual Federal Energy Regulatory Commission (FERC) Form 1 generation reports[29], U.S. Environmental Protection Agency (EPA) Emissions & Generation Resource Integrated Database 2010 (eGrid)[30], and SDG&E. Emission factors associated with electricity generated by SDG&E were derived from FERC Form 1 reports and in consultation with SDG&E.[31] For purchased power, EPIC developed emission factors based on FERC Form 1 data on purchased power and U.S. EPA's eGrid specific electric plant emissions. To account for thermal energy associated with cogeneration, U.S. EPA's eGRID also provides for the allocation of cogeneration emissions between electric production and thermal energy. The emissions factors derived for purposes of estimating regional GHG emissions were validated by SDG&E personnel for accuracy.

The emissions factor for electricity for 2012 is 785 lbs CO_2e/MWh. Because the San Onofre Nuclear Generation Station (SONGS) went offline in 2012, the calculated emissions factor for 2012 is higher than in the previous years.

4.2 Business-as-usual Projection

To project business-as-usual (BAU) emissions for the electricity category, the emissions factor for 2012 was held constant to 2050. Because the CEC's annual electricity consumption data is only forecasted to 2025, values beyond 2025 were extrapolated using a linear forecast based on the Series 13 San Diego regional population forecast developed by SANDAG.

4.2.1 California Energy Commission Forecast Assumptions

Because the inventory is based on energy data from the CEC, it is important to note the major assumptions in their forecasting methods. The following provides a list of programs and policies that are included in the CEC's electricity consumption forecast to 2025.[32]

- Renewable Portfolio Standard –15% of retail electricity sales in 2012.
    - Assumes direct access providers have the same GHG intensity as retail sellers
- Utility Energy Efficiency Programs – electric savings from 2013-14 program cycle

[29] Federal Energy Regulatory Commission (FERC) Form 1. Available at http://www.ferc.gov/docs-filing/forms/form-1/viewer-instruct.asp.
[30] U.S. Environmental Protection Agency (EPA) Emissions & Generation Resource Integrated Database 2010 (eGrid). Available at http://www.epa.gov/cleanenergy/energy-resources/egrid/.
[31] Personal communication with David Barker, SDG&E, email January 22, 2014.
[32] California Energy Demand Forecast 2015-2025.

- Residential Category
  - 1975 HCD Building Standards
  - Title 24 Residential Building Standards: 1978, 1983, 1991, 2005, 2010, 2013
  - Federal Appliance Standards 1988, 1990, 1992
  - 1976-82 Title 20 Appliance Standards
  - AB 1109 Lighting (Through Title 20)
  - 2002 Refrigerator Standards
  - 2011 Television Standards
  - 2011 Battery Charger Standards
- Commercial Category
  - Title 24 Non-Residential Building Standards: 1978, 1984, 1998, 2001, 2005, 2010, 2013
  - 1978 Title 20 Equipment Standards 2004 Title 20 Equipment Standards
  - 1984 Title 20 Non-Res. Equipment Standards
  - 1985-88 Title 24 Non-Residential Building AB 1109 Lighting (Through Title 20)
  - Standards 2011 Television Standards
  - 1992 Title 24 Non-Residential Building
  - 2011 Battery Charger Standards

4.3 Differences from Previous Inventory

In previous inventories, it was assumed that electricity providers other than SDG&E had the same emissions factor. In this version, to the extent possible, all sources of electricity have a separate emissions factor. A weighted average is used to calculate a final emissions factor, with total electricity consumed as the weighting factor.

4.4 Limitations

The method used to estimate an emissions factor for electricity consumed in San Diego County has limitations. First, due to lack of data, we used default values for several electricity sources in determining emissions from purchased power. Second, the latest version of U.S. EPA's eGrid only provides data for 2010. It is likely that emissions factors for power plants do not change significantly year to year, but having actual emissions factors for power plants for each year of the analysis would be more accurate. Third, the total electricity used to develop the emissions factor is greater than the total sales reported for SDG&E in Sempra Energy's SEC Form 10-K and the CEC in the 2015-2025 electricity forecast. This discrepancy is likely explained by the inclusion of transmission losses in some reported values but not in others.

5 NATURAL GAS

The combustion of natural gas for end-use applications accounts for 8% of GHG emissions in the San Diego region. This category calculates emissions from natural gas consumption for purposes other than electricity production, including commercial, industrial, and residential end-use consumption. Emissions associated with natural gas consumption during cogeneration are not included in this category, because those emissions are accounted for separately in the electricity category and the Other - Thermal Cogeneration category.

5.1 Method Used to Estimate 2012 Emissions

Emissions from natural gas consumption in the San Diego region were estimated using method Built Environment (BE.1) from the U.S. Community Protocol. To estimate emissions from the combustion of natural gas, the Protocol recommends multiplying community fuel use by an emissions factor for natural gas. EPIC used an emissions rate of 0.0054 MT CO_2e/therm for San Diego County, based on emissions factors for CO_2, N_2O, and CH_4 from the California Air Resources Board.[33] EPIC used community fuel use data from the California Energy Commission (CEC) Demand Forecast 2015-2025[34] for the SDG&E Service Territory and data provided by San Diego Gas & Electric.[35]

5.2 Business-as-usual Projection

To project business-as-usual (BAU) emissions for the natural gas category, EPIC used fuel use data from California Energy Commission (CEC) Demand Forecast 2015-2025 and SDG&E. Since natural gas consumption forecasts are not available out to 2050, EPIC extrapolated beyond 2025 using a linear projection based on SANDAG's Series 13 regional population.[36] When projecting emissions to 2050, the emissions factor for 2012 (0.0054 MT CO_2e) was held constant. See section 4.2.1 for assumptions included in the CEC Demand Forecast.

6 OTHER FUELS

The Other Fuels category represents about 5% of GHG emissions from fuels not accounted for in other categories. These fuels include distillate (other than in power production), coal (other than in power production), kerosene, gasoline (other than in the transportation category), liquefied petroleum gas (LPG), residual fuel oil (other than in power production), and wood. Emissions from this category are divided into sectors according to the California Air Resources Board (CARB) statewide GHG inventory: agriculture, commercial, residential, transport, energy, and manufacturing. The relative distribution of emissions by sector is provided in Figure 1.

[33] CARB 2000-2012 GHG Inventory.
[34] California Energy Demand Forecast 2015-2025.
[35] San Diego Gas & Electric data request. Personal communication with Dinah Willer, SDG&E Account Manager (Email December 30, 2013).
[36] SANDAG Series 13, provided via personal communication with Andrew Martin, SANDAG, email on February 6, 2015.

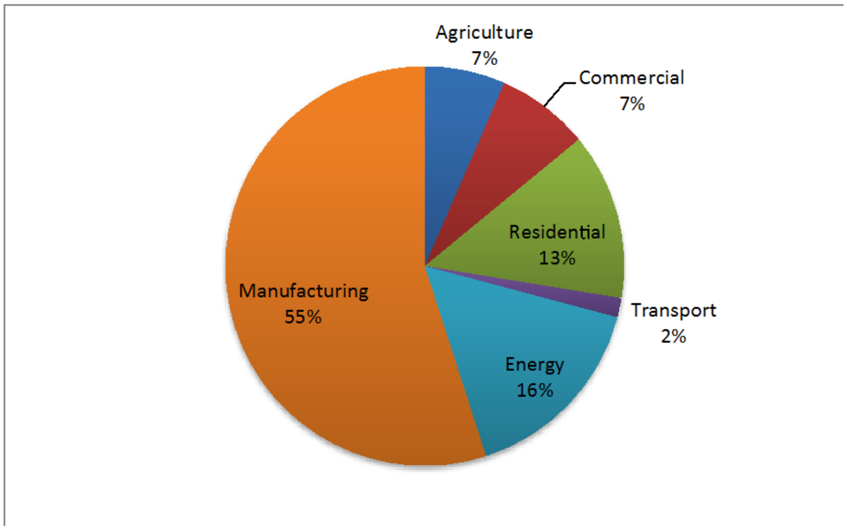

Figure 1 Relative Distribution of Greenhouse Gas Emissions from Other Fuels (2012)

6.1 Method Used to Estimate 2012 Emissions

EPIC used statewide GHG emissions from the California Air Resources Board's California state greenhouse gas inventory to calculate regional estimates.[37] Statewide emissions were scaled down to San Diego County using relevant economic, population, or transport data. At the time of developing this inventory, detailed GHG emissions from CARB's inventory were only available to 2011, so values from 2012 to 2050 were projected linearly.

6.1.1 CARB Categories Included

The following list is provided in terms of category numbers, subcategory numbers, codes, headings and fuel types used within each type of activity according to the CARB 2013 state inventory. CARB in turn uses the Intergovernmental Panel on Climate Change (IPCC) category, subcategory names and codes as specified in the IPCC 2006 Guidelines for GHG Inventories, to be consistent with the U.S. EPA when the U.S. EPA reports the national inventory to the Climate Change Convention. Below are only those categories, subcategories, activities and fuel types causing emissions in the San Diego region, as evidenced by the existence of economic activity data for these categories in the San Diego region.

Emissions from the following categories are taken from the California state inventory and scaled to San Diego County using gross income from agriculture production from 2008 and 2011.[38] An average of these values was applied to all other years.

- 1A4c: Agriculture/Forestry/Fishing/Fish Farms > Ag Energy Use
  - Distillate > CH_4, CO_2, N_2O
  - Kerosene > CH_4, CO_2, N_2O
  - Gasoline > CH_4, CO_2, N_2O
  - Ethanol > CH_4, CO_2, N_2O

[37] CARB 2000-2011 GHG Inventory.
[38] California Department of Food and Agriculture, California Agricultural Statistics 2008 Summary Report. Available at http://www.cdfa.ca.gov/statistics/PDFs/AgResourceDirectory2008/1_2008_OverviewSection.pdf

Emissions from the following categories are taken from the California state inventory and scaled to San Diego County using manufacturing data from the 2007 Economic Census.[39] More recent economic data was not available at the time of this project so that these values would be expected to somewhat overestimate emissions reductions that followed from the recent recession and that are reflected in the on-road transportation and electricity and natural gas sectors.

- 1A4a: Commercial/Institutional > Not Specified Commercial
    - Distillate > CH_4, CO_2, N_2O
    - Coal > CH_4, CO_2, N_2O
    - Kerosene > CH_4, CO_2, N_2O
    - Gasoline > CH_4, CO_2, N_2O
    - LPG > CH_4, CO_2, N_2O
    - Residual Fuel Oil > CH_4, CO_2, N_2O
    - Wood (wet) > CH_4, N_2O

Emissions from the following categories are taken from the California state inventory and scaled to San Diego County using annual population data from the US Census Bureau.[40]

- 1A4b: Residential > Household Use
    - Distillate > CH_4, CO_2, N_2O
    - Kerosene > CH_4, CO_2, N_2O
    - LPG > CH_4, CO_2, N_2O
    - Wood (wet) > CH_4, N_2O

Emissions from the following categories are taken from the California state inventory and scaled down to San Diego County using current and projected vehicle miles traveled from the 2008 California Motor Stock, Travel, and Fuel Forecast.[41]

- 1A3: Transport > Not Specified Transportation
    - LPG > CH_4, CO_2, N_2O
    - Residual Fuel Oil > CH_4, CO_2, N_2O

Emissions from the following categories are taken from the California state inventory and scaled down to San Diego County using data on purchased power.[42]

- 1B2: Oil and Natural Gas
    - Not Specified Industrial > Fugitives > Fugitive Emissions > CH_4
    - Pipelines > Natural Gas > Fugitives > Fugitive Emissions > CH_4, CO_2

- 1A1: Energy Industries > Pipelines
    - Natural Gas Pipelines > Natural Gas > CH_4, CO_2, N_2O
    - Non- Natural Gas Pipelines > Natural Gas > CH_4, CO_2, N_2O

[39] U.S. Census Bureau, 2007 Economic Census, available at https://www.census.gov/econ/census/.
[40] U.S. Census Bureau, QuickFacts for San Diego County. Available at http://quickfacts.census.gov/qfd/states/06/06073.html.
[41] California Department of Transportation. 2008 California Motor Stock, Travel, and Fuel Forecast. Available at http://www.dot.ca.gov/hq/tsip/smb/documents/mvstaff/mvstaff08.pdf
[42] FERC Form 1.

Emissions from the following categories are taken from the California state inventory and scaled down to San Diego County using manufacturing data from the 2007 Economic Census.[43]

- 1A2f: Manufacturing Industries and Construction > Non- Metallic Minerals > Stone, Clay, Glass, and Cement > Cement
  - Distillate > CH_4, CO_2, N_2O
  - LPG > CH_4, CO_2, N_2O
  - MSW > CH_4, CO_2, N_2O
  - Petroleum Coke > CH_4, CO_2, N_2O
  - Residual Fuel Oil > CH_4, CO_2, N_2O
  - Tires > CH_4, CO_2, N_2O

- 1A2k: Manufacturing Industries and Construction > Construction
  - Gasoline > CH_4, CO_2, N_2O

- 1A2m: Manufacturing Industries and Construction > Non-Specified Industry
  - Distillate > CH_4, CO_2, N_2O
  - Gasoline > CH_4, CO_2, N_2O
  - Kerosene > CH_4, CO_2, N_2O
  - LPG > CH_4, CO_2, N_2O
  - Petroleum Coke > CH_4, CO_2, N_2O
  - Residual Fuel Oil > CH_4, CO_2, N_2O

- 1B2: Oil and Natural Gas > Manufacturing
  - Chemicals and Allied Products > Fugitives > Fugitive Emissions > CH_4
  - Construction > Fugitives > Fugitive Emissions > CH_4
  - Electric and Electronic Equipment > Fugitives > Fugitive Emissions > CH_4
  - Food Products > Fugitives > Fugitive Emissions > CH_4
  - Fugitives > Fugitive Emissions > CH_4
  - Plastic and Rubber > Fugitives > Fugitive Emissions > CH_4
  - Primary Metals > Fugitives > Fugitive Emissions > CH_4
  - Pulp and Paper > Fugitives > Fugitive Emissions > CH_4
  - Storage Tanks > Fugitives > Fugitive Emissions > CH_4

5.1.2 CARB Categories Not Included

Several categories were included in CARB's statewide inventory, but not in our inventory for San Diego County. Emissions from the following categories were set to zero, because data from the US Census Bureau on 2011 Business Patterns in San Diego County indicated no economic activity for these categories.

- 1A1b: Petroleum Refining
  - Associated Gas > CH_4, CO_2, N_2O
  - Catalyst Coke> CH_4, CO_2, N_2O

[43] 2007 Economic Census.

  - Distillate> CH_4, CO_2, N_2O
  - LPG > CH_4, CO_2, N_2O
  - Petroleum Coke > CH_4, CO_2, N_2O
  - Refinery Gas > CH_4, CO_2, N_2O
  - Residual Fuel Oil > CH_4, CO_2, N_2O

- 1A1c: Manufacture of Solid Fuels and Other Energy Industries
  - Associated Gas > CH_4, CO_2, N_2O
  - Crude Oil > CH_4, CO_2, N_2O
  - Distillate > CH_4, CO_2, N_2O
  - Residual Fuel Oil > CH_4, CO_2, N_2O

- 1B2: Oil and Natural Gas > Manufacturing: Stone, Clay, Glass, and Cement: Fugitives > Fugitive Emissions > CH_4
- 1B2a: Oil > Petroleum Refining: Process Losses: Fugitives > Fugitive Emissions > CH_4
- 1B3: Other Emissions from Energy Production > In State Generation: Merchant Owned > Geothermal Power – Geothermal > CO_2
- 1B3: Other Emissions from Energy Production > In State Generation: Utility Owned > Geothermal power > CO_2

6.2 Limitations

The emissions values for this category are not calculated using actual fuel use data or modeled emissions data as in other categories. Rather, EPIC scaled down statewide totals using the ratio of relevant activity in San Diego County relative to the statewide totals. Though EPIC selected data sources to most accurately reflect the ratio of regional to statewide GHG emissions, these ratio values are not based on observed GHG emissions in San Diego County. Actual fuel data for the Other Fuels category would yield a more accurate estimate of emissions.

7 COGENERATION

Cogeneration is the process of combusting natural gas or other fuels to generate electricity and thermal energy that can be used in cooling or heating applications. The analysis requires the breakdown of emissions between those related to electricity and those related to thermal. The following sections summarized the method used to estimate emissions from Cogeneration and to allocate them between the electricity category and the Other-Thermal Cogeneration category.

7.1 Method Used to Estimate 2012 Emissions

For the purposes of the regional inventory, cogeneration is divided into categories of self-serve and utility purchased power. Self-serve represents the energy generated and consumed on site. Other cogeneration facilities generate electricity to sell to an electric utility. In some cases a combination of the two occurs: an on-site cogeneration facility consumes part of the electrical generation and sells part to an electrical utility. Another factor is the location of the cogeneration facility, whether in the region or outside the region.

To estimate emissions from the different possible cogeneration sources, two different data sets are required: total natural gas consumption in the SDG&E natural gas service territory[44] and the quantity of electricity SDG&E purchased on behalf of its customers from cogeneration sources.[45] Because these data sources are both incomplete and overlapping, and some aspects of the data are included in the emissions factor for electricity, a careful accounting is necessary.

7.1.1 Emissions from Total Natural Gas Consumption Data

EPIC received total natural gas consumption data from SDG&E[46] and the California Energy Commission (CEC).[47] SDG&E data included economic sectors and customer type (bundled or transportation only). CEC data included a breakdown of natural gas used for cogeneration. To calculate emissions from cogeneration, EPIC used total gas consumption data provided by the California Energy Commission (CEC) to determine the average percentage of cogeneration use compared to total gas consumption. EPIC then used this percentage to derive cogeneration gas consumption in the San Diego Region from natural gas data provided by San Diego Gas and Electric (SDG&E). Converting this natural gas quantity to emissions represents total emissions from cogeneration plants located within the San Diego region for both electricity and thermal energy, regardless of the disposition of electricity (consumed on site or sold to SDG&E).

Once cogeneration use had been multiplied by the greenhouse gas emissions factor for natural gas (0.0054 MMT CO_2e/therms), the resulting emissions were split into either the electric or thermal heat category by using a weighted average of the thermal/electric split for cogeneration facilities in the San Diego Region.[48]

7.1.2 Emissions from SDG&E Purchased Power Data

As described in Section 4, SDG&E purchased power was used to develop the overall emissions factor for electricity. A subset of purchased power is cogeneration. SDG&E purchases power from cogeneration facilities both inside and outside of the San Diego Region. Data for purchased power only provided electricity and does not take into account the thermal aspects of cogeneration. EPIC used U.S. EPA eGrid to determine the thermal emissions for each cogeneration plant that sold energy to SDG&E. From this calculation, it is possible to determine both electric and thermal emissions from facilities from which SDG&E purchased electricity that are located inside and outside the San Diego region.

7.1.3 Reconciliation of Both Data Sets

The emission estimates from total natural gas data capture in-region cogeneration but does not include emissions associated with plants outside the San Diego region. The purchased power data capture emissions only from plants that sell electricity to SDG&E and do not capture self-serve

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[44] Quarterly Fuel and Energy Report Data 2008-2012 for SDG&E. Natural Gas by Rate Code. Personal Communication with Andrea Gough, California Energy Commission Staff, email on 8-13-13. Note that SDG&E's natural gas service territory is San Diego County. Therefore, no adjustment is required to limit the analysis to San Diego County as with electricity.
[45] FERC Form 1.
[46] San Diego Gas & Electric data request. Personal communication with Dinah Willer, SDG&E Account Manager (Email December 30,2013)
[47] Quarterly Fuel and Energy Report Data 2008-2012 for SDG&E. Natural Gas by Rate Code. Personal Communication with Andrea Gough, California Energy Commission Staff (Email on 8-13-13).
[48] eGRID 2010.

emissions. Therefore it is necessary to reconcile results from both data sets to avoid under or double counting. Table 6 summarizes the distribution of cogeneration from each data source.

Table 7 Distribution of Cogeneration Emissions

Natural Gas Data

	Self-Serve	Sold to SDG&E
Electric	Emissions in Electric category	Emissions from in-region thermal emissions already in purchased power data. Subtract from emissions total from natural gas data.
Thermal	Emissions in Other: Cogen-thermal category	Emissions in Other: Cogen-thermal category

Purchased Power Data used for Emissions Factor for Electricity

	In-Region	Out-of-Region
Electric	Included in Electric Category via emissions factor for electricity. (Subtract from Natural Gas data emisisons total)	Included in Electric Category via emissions factor for electricity.
Thermal	Not included in emissions factor for electricity. Already accounted for in Natural Gas data.	Emissions in Other: Cogen-thermal category

7.2 Business-as-usual Projection

To project emissions from cogeneration, EPIC took the average ratio of natural gas consumption for cogeneration[49] for years 2010-2012 and the natural gas consumption total in the California Energy Commission 2015-2025 Energy Demand Forecast.[50] This ratio was then applied to the California Energy Commission 2015-2025 Energy Demand Forecast through 2025. These values were further projected to 2050 using the best-fit curve.

7.3 Differences From Previous Inventory

The main methodological difference between how emissions from the electricity category were calculated in previous and the current inventory is that EPIC developed a method to account for cogeneration that is sold to SDG&E, which is embedded in the emissions factor for electricity, separately from cogeneration that is produced in the region but consumed on site. Also, data from

[49] Quarterly Fuel and Energy Report Data 2008-2012 for SDG&E. Natural Gas by Rate Code. Personal Communication with Andrea Gough, California Energy Commission Staff (Email on 8-13-13).
[50] California Energy Demand 2015-2025 Forecast.

eGrid allowed more accurate separation of cogeneration emissions associated with electricity production and that associated with thermal energy.

8 INDUSTRIAL

Emissions from the industrial category result from the processing of materials to manufacture items such as mineral aggregate products, chemicals, metals, refrigerants, electronics, and other consumer goods. Additionally, gases with high global warming potential are used in air conditioning units and refrigeration, and in the manufacture of electronics, fire protection equipment, insulation, and aerosols. This category focuses on industrial processes that directly release carbon dioxide and other greenhouse gases by processes other than fuel consumption.

8.1 Method Used to Estimate 2012 Emissions

EPIC used the categories in the CARB state Greenhouse Gas Inventory[51] Industrial Category and scaled down statewide emissions based on ratio values from relevant manufacturing, transportation, population, and energy data in San Diego and the state.

8.1.1 CARB Categories Included

Emissions from the following CARB categories were calculated for San Diego County. As described in Section 6.1.1, the following categories are category numbers, subcategory numbers, headings, codes and fuel types used within each type of activity according to the CARB 2014 state inventory. Below are only those categories, subcategories, activities and fuel types causing emissions in the San Diego region, as evidenced by the existence of activity data for these categories in the San Diego region.

Emissions from the following categories are taken from the California state inventory and scaled to San Diego County using current and projected vehicle miles traveled from the 2008 California Motor Stock, Travel, and Fuel Forecast.[52]

- 2D1: Industrial Lubricant Use
  - Not Specified Industrial > Fuel consumption – Lubricants
  - Not Specified Transportation > Fuel consumption – Lubricants

- 2G4: Other Industrial Product- CO2, Limestone
  - Not Specified Industrial > CO2 consumption
  - Not Specified Industrial > Limestone and dolomite consumption
  - Not Specified Industrial > Soda ash consumption

Emissions from the following categories are taken from the California state inventory[53] and scaled down to San Diego County using manufacturing data from the 2006 and 2007 Economic Census.[54]

[51] CARB 2000-2012 GHG Inventory.
[52] California Department of Transportation. 2008 California Motor Stock, Travel, and Fuel Forecast. Available at http://www.dot.ca.gov/hq/tsip/smb/documents/mvstaff/mvstaff08.pdf.
[53] CARB 2000-2011 GHG Inventory.
[54] 2007 Economic Census.

- 2D3: Industrial Solvent Use
    - Solvents & Chemicals : Evaporative losses : Fugitives > Fugitive emissions

Emissions from the following categories are taken from the California state inventory and scaled to San Diego County using annual population data from the US Census Bureau.[55]

- 2E: Electronic Industry
    - Manufacturing : Electric & Electronic Equip. : Semiconductors & Related Products > Semiconductor manufacture > C2F6
    - Manufacturing : Electric & Electronic Equip. : Semiconductors & Related Products > Semiconductor manufacture > C3F8
    - Manufacturing : Electric & Electronic Equip. : Semiconductors & Related Products > Semiconductor manufacture > C4F8
    - Manufacturing : Electric & Electronic Equip. : Semiconductors & Related Products > Semiconductor manufacture > CF4
    - Manufacturing : Electric & Electronic Equip. : Semiconductors & Related Products > Semiconductor manufacture > HFC-23
    - Manufacturing : Electric & Electronic Equip. : Semiconductors & Related Products > Semiconductor manufacture > NF3
    - Manufacturing : Electric & Electronic Equip. : Semiconductors & Related Products > Semiconductor manufacture > SF6

- 2F: Product Uses as- Not Specified Commercial
    - Use of substitutes for ozone depleting substances > CF4
    - Use of substitutes for ozone depleting substances > HFC-125
    - Use of substitutes for ozone depleting substances > HFC-134a
    - Use of substitutes for ozone depleting substances > HFC-143a
    - Use of substitutes for ozone depleting substances > HFC-236fa
    - Use of substitutes for ozone depleting substances > HFC-32
    - Use of substitutes for ozone depleting substances > Other ODS substitutes

Emissions from the following categories are taken from the California state inventory and scaled down to San Diego County using data on purchased power.[56]

- 2G1b: Other Industrial Product- Electrical
    - Imported Electricity : Transmission and Distribution > Electricity transmitted
    - In State Generation : Transmission and Distribution > Electricity transmitted

[55] U.S. Census Bureau, QuickFacts for San Diego County. Available at http://quickfacts.census.gov/qfd/states/06/06073.html.
[56] FERC Form 1 and SDG&E.

8.1.2 CARB Categories Not Included

Emissions from the following categories were used in CARB's statewide inventory but set to zero in the regional inventory because Economic Census data from 2007 indicated no economic activity in San Diego County[57].

- 2A1: Manufacturing: Stone, Clay, Glass, and Cement: Cement > Clinker Production> CO_2
- 2A2: Manufacturing: Stone, Clay, Glass, and Cement: Lime > Lime Production> CO_2
- 2B2: Manufacturing: Chemical and Allied Products: Nitric Acid > Nitric Acid Production > N_2O
- 2H3: Petroleum Refining: Transformation > Fuel Consumption

8.2 Business-as-usual Projection

GHG emissions from 2012 to 2050 were projected using data from SANDAG on the projected changes in land use in the Industrial sector. EPIC determined the ratio of industrial activity in San Diego to that in California in 2012 and increased this ratio by the percentage change in land use between 2012 and 2020, 2025, 2035, and 2050.

8.3 Differences from Previous Inventory

The main difference between the emissions projection this time and previous 2012 projection is the use of SANDAG's Industrial sector land use data for the projection instead of a ratio based on the state. Statewide Industrial emissions increase much more significantly to 2050, which does not appear to match expected industrial land use patterns in the San Diego region.

8.4 Limitations

Industrial emissions and projections are not based on observed GHG emissions in San Diego County. Using actual data for San Diego sources of emissions would yield more accurate emissions levels. Also, while use of SANDAG's land use data for industrial could increase accuracy of these values, it is not clear whether emissions would increase because of the same or slightly expanded land use footprint.

9 CIVIL AVIATION

Eleven airports, including the region's primary commercial and international airport at Lindbergh Field, contribute to about 4% regional GHG emissions. However, only emissions from commercial aviation operations at the San Diego International Airport at Lindbergh Field are included in this inventory, as the majority of commercial flights depart from this airport. Greenhouse gas (GHG) emissions included in the civil aviation category result from the combustion of jet fuel and aviation gasoline used by commercial aircraft.

9.1 Method Used to Estimate 2012 Emissions

Because many airports have reported greenhouse gas emissions in accordance with the Airport Cooperative Research Program (ACRP), the ICLEI U.S. Community Protocol[58] recommends that

[57] 2007 Economic Census.
[58] ICLEI U.S. Community Protocol.

communities preparing regional greenhouse gas inventories use existing airport inventories for the Civil Aviation category.

The San Diego County Regional Airport Authority prepared an inventory for the San Diego International Airport based on 2008 data[59]. The inventory lists GHG emissions from several categories, including purchased electricity, employee transportation, and ground service vehicles. However, emissions from these categories are already captured in other categories of the inventory, so EPIC only included emissions from aircraft fuel use in the Civil Aviation category. As the airport's inventory is calculated from 2008 data, EPIC used passenger data from the San Diego International Airport[60], normalized with population data[61], to calculate 2012.

9.2 Business-as-usual Projection

EPIC also used passenger data from the San Diego International Airport[62], normalized with population data[63] to project emissions to 2050.

9.3 Differences from Previous Inventory

The previous inventories estimated greenhouse gas emissions from civil aviation by using jet fuel and aviation gasoline purchase data and aircraft passenger data. EPIC adopted a new methodology for the 2012 inventory to comply with the ICLEI U.S. Community Protocol for this category.

9.4 Limitations

Because the San Diego International Airport's GHG Inventory only includes GHG emissions from 2008, EPIC had to project emissions using historical passenger data. As trends in number of passengers may not be directly correlated to trends in GHG emissions, this method may not accurately allocate emissions to the Aviation sector.

10 OFF-ROAD

Off-road vehicles and equipment contribute approximately 3% of regional greenhouse gas emissions via fuel combustion in internal combustion engines. The off-road category includes the following equipment sub-categories: construction and mining equipment, industrial equipment, airport ground support, pleasure craft, recreational equipment, lawn and garden equipment, agricultural equipment, transport refrigeration units (TRU), military tactical support equipment, other portable equipment, and rail yard operations.

[59] San Diego County Regional Airport Authority Air Quality Management Plan, 2008. Available at http://www.san.org/sdcraa/airport_initiatives/environmental/air_quality.aspx.
[60] San Diego International Airport Historical Passenger Data. Available at http://www.san.org/sdia/at_the_airport/education/airport_statistics.aspx.
[61] SANDAG Series 13.
[62] San Diego International Airport Historical Passenger Data.
[63] SANDAG Series 13.

10.1 Method Used to Estimate 2012 Emissions

To the extent possible, EPIC followed the California Air Resources Board (CARB) methodology to calculate emissions from off-road equipment in San Diego County. In 2007, CARB released the OFFROAD model[64], which calculates emissions from all off-road sources. CARB is currently replacing the OFFROAD model with several category-specific models phased in over time. EPIC used CARB's updated models[65] to calculate GHG emissions for off-road categories when available. These categories include airport ground support, construction and mining equipment, and industrial equipment. For all other categories, the team used the OFFROAD model to calculate emissions.

10.2 Business-as-usual Projection

For off-road categories without an updated CARB model, the OFFROAD2007 model was used to calculate emissions for 2010, 2020, and 2040 for the San Diego Air Basin. Intermediate years were interpolated and values between 2040 and 2050 were projected using a best-fit curve. For some off-road categories, a new model was available, which calculated emissions to 2029. For these categories, emissions were then projected to 2050 using a linear forecast.

10.3 Differences from Previous Inventory

The previous inventory also relied on CARB's methodology to calculate emissions from off-road equipment. However, at that time, CARB had not yet developed any category-specific models, so calculations for all off-road categories were generated from the OFFROAD 2007 model.

10.4 Limitations

At the time that emissions from this sector were calculated, CARB's updated models for off-road equipment were not available. As a result, OFFROAD 2007 was used to calculate emissions from several off-road categories. Therefore, the methods used to calculate emissions from this sector may have since been revised and, thus, emissions reported here may either under- or over-estimate actual GHG emissions from the off-road category.

11 LAND USE & WILDFIRES

Land use and development influence regional greenhouse gas (GHG) emissions in several ways. First, vegetation cover can act to reduce GHG emissions through carbon sequestration, as growing plants take up carbon dioxide (CO_2). Second, when vegetation is displaced by development, not only is there a loss of a carbon sink, but decomposing plants also release CO_2 into the atmosphere. Additionally, during wildfires, burning vegetation emits CO_2, nitrous oxide (N_2O), and methane (CH_4). The amount of each gas emitted depends primarily on the ecosystem involved. The classes of vegetation and their relative cover in San Diego County are given in Figure 2.

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[64] California Air Resources Board OFFROAD2007 Model. Available at http://www.arb.ca.gov/msei/categories.htm#offroad_motor_vehicles.
[65] California Air Resources Board In-Use Off-Road Model. Available at http://www.arb.ca.gov/msei/categories.htm#offroad_motor_vehicles.

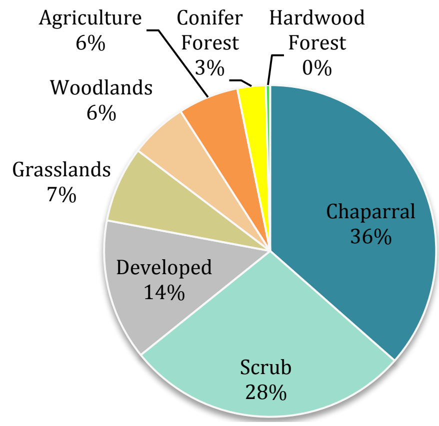

Figure 2 Relative vegetation cover in San Diego County

11.1 Method Used to Estimate 2012 Emissions and Business-as-Usual Projection: Land Use

To the extent possible, carbon uptake by vegetation was estimated using the methodology from the California Air Resources Board (CARB) Winrock Study[66], which relates land use changes to greenhouse gas emissions and quantifies carbon sequestration by vegetation type.

EPIC downloaded vegetation data for San Diego County as a GIS shapefile from SANDAG.[67] The data, originally categorized into 130 vegetation types by Holland Classification Code, was then reclassified into seven types to match the Winrock study: Scrub, Shrub (Chapparal), Hardwood Forest, Conifer Forest, Grasslands, and Woodlands. EPIC added the class “Scrub” to the Winrock classification to include ecosystems prevalent in San Diego County; all other classes appear in the Winrock study.

The effect of development on carbon sequestration by vegetation was quantified by analyzing land use GIS shapefiles from SANDAG for 2008, 2012, and 2050[68] to produce an output shapefile of vegetation available for carbon uptake in 2008, 2012, and 2050. Attributes labeled “open space park/preserve,” “park active,” “landscape open space,” “undevelopable natural area,” or “vacant/undeveloped land” were considered undeveloped; all other land use attributes were considered developed. For each year, the attributes considered “developed” were clipped out to produce shapefiles that represent undeveloped land in the County. Each of these shapefiles was then overlaid on the vegetation shapefile, and the vegetation shapefile clipped to match the areas of undeveloped land, producing maps of vegetation available for carbon uptake in 2008, 2012, and 2050. Finally, annual carbon uptake was calculated by multiplying the land cover area of each vegetation type by its appropriate uptake rate. Uptake by vegetation for intermediate years was interpolated linearly.

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[66] California Air Resources Board. Carbon Emission Factors Subworkgroup, 2010. Section 2. Available at http://www.arb.ca.gov/fuels/lcfs/workgroups/ewg/010511-final-rpt-carbon-emiss-factors.pdf.

[67] ECO_VEGETATION_CN shapefile from SANDAG Regional GIS Warehouse. Available at http://www.sandag.org/index.asp?classid=21&fuseaction=home.classhome.

[68] Land_Use_2008, LANDUSE_CURRENT, and LANDUSE_PLANNED shapefiles from SANDAG Regional GIS Warehouse. Available at http://www.sandag.org/index.asp?classid=21&fuseaction=home.classhome.

11.2 Method Used to Estimate 2012 Emissions and Business-as-Usual Projection: Wildfires

Fire burn perimeter data from SANDAG's website was overlaid on the vegetation shapefile in GIS to determine the area of each vegetation type burned by wildfires annually. Carbon dioxide and methane emissions from burned vegetation were then estimated using the method of Akagi et al. (2011).[69] Because SANDAG's fire perimeter data is only available through 2010, an average of emissions from wildfires from 1990 to 2010 was taken and held constant from 2012 to 2050.

12 WATER

Greenhouse gas (GHG) emissions from a community's water consumption result from electricity and natural gas use from supply and conveyance (upstream processes), treatment and distribution within the region, and end use. The magnitude of water emissions depend upon the source of the water, the distance and topography traversed in conveyance, treatment processes, and the amount and nature of the end use. Emissions presented in this category represent only those associated with upstream supply and conveyance. Emissions associated with other aspects of the water cycle are captured in the Electricity and Natural Gas categories and the data necessary to accurately break out water end use energy use from regional totals is not available.

12.1 Method Used to Estimate 2012 Emissions

To the extent possible, emissions from water consumption in San Diego County were estimated using the WW.14 method from the ICLEI U.S. Community Protocol.[70] The method considers each element of the water cycle (supply and conveyance, treatment and distribution) individually, using a community-specific energy consumed per unit of water for each process of the water system. A sum of the emissions from each process is then taken to estimate total GHG emissions from a community's water use.

To estimate gallons of water consumed in San Diego County per year, the reported annual per capita consumption for 2010[71] was multiplied by the regional population.[72] The result was then split into groundwater and surface water using the freshwater breakdown for San Diego County from the United States Geological Survey.[73] For upstream supply and conveyance emissions, surface water consumption was multiplied by an energy intensity value from the Navigant Consulting report, prepared for the CEC.[74] Emissions from groundwater extraction were calculated by multiplying groundwater consumption by the groundwater extraction energy intensity value from the California

[69] Akagi, S. K., Yokelson, R. J., Wiedinmyer, C., Alvarado, M. J., Reid, J. S., Karl, T., Crounse, J. D., and Wennberg, P. O., 2011. Emission factors for open and domestic biomass burning for use in atmospheric models, Atmos. Chem. Phys., 11, 4039-4072. Doi:10.5194/acp-11-4039-2011.
[70] ICLEI U.S. Community Protocol.
[71] Based on the estimated reported per capita consumption of 150 gallons in 2010. San Diego County Water Authority, from chart "Water Authority Service Area Water Use" at http://www.sdcwa.org/sites/default/files/images/water-management/WaterUse1990-2014.
[72] SANDAG Series 13.
[73] U.S. Geological Survey Estimated Use of Water in San Diego County, 2010. Available at http://ca.water.usgs.gov/water_use/index.html, doi:10.5066/F7KD1VXV.
[74] Navigant Consulting, Inc. 2006. Refining Estimates of Water-Related Energy Use in California. California Energy Commission, PIER Industrial/Agricultural/Water End Use Energy Efficiency Program. CEC-500-2006-118.

Public Utilities Commission for the Southern California.[75] The energy intensity for surface water treatment used to calculate emissions from water treatment was a Southern California-specific value from the U.S. Community Protocol.[76] Finally, emissions from groundwater and surface water conveyance and distribution were estimated by multiplying total water consumption by energy intensities available from a CEC study of 2006[77] and then by the emissions factor for electricity.[78]

12.2 Business-as-usual Projection

Business-as-usual emissions were estimated to 2050 using the SANDAG Series 13 population forecast, holding per-capita water consumption constant from 2012 to 2050.

12.3 Differences from Previous Inventory

The previous inventories did not break out the emissions associated with water as a separate category. They included GHG emissions from water treatment and distribution in the electricity and natural gas categories. In addition, upstream emissions from water supply and conveyance were not included in the previous inventories.

12 RAIL

The Rail category of the regional greenhouse (GHG) gas inventory includes both passenger and freight rail. Like many modes of transport, GHG emissions from both passenger and freight rail result from the combustion of fuels in internal combustion engines.

12.1 Method Used to Estimate 2012 Emissions

Detailed activity or fuel consumption data for rail transportation were not available within the timeframe of this project for San Diego County. Therefore, GHG emissions for the County were scaled from the California Air Resources Board (CARB) statewide inventory[79] to San Diego County, based on the number of support establishments for rail in the county and state.[80]

12.2 Business-as-usual Projection

Because GHG emissions from CARB's inventory were only available to 2011 at the time these values were calculated, emissions for 2012 to 2050 were projected linearly.

12.3 Differences from Previous Inventory

The previous inventory also scaled emissions from rail from the CARB statewide inventory to the San Diego region. However, the value used in the previous inventory to scale statewide emissions to the

[75] California Public Utilities Commission, Embedded Energy in Water Studies, Appendix G: Groundwater Energy Use. Available at http://www.cpuc.ca.gov/PUC/energy/Energy+Efficiency/EM+and+V/Embedded+Energy+in+Water+Studies1_and_2.htm
[76] ICLEI U.S. Community Protocol.
[77] Navigant Consulting, Inc. 2006. See also Adapted from Implications of Future Water Supply Sources for Energy Demands.
[78] EPIC derived emissions factor for electricity. See Section 4.1 for more information.
[79] CARB GHG Inventory 2000-2011.
[80] U.S. Census Bureau 2011 County Business Patterns (NAICS). Available at http://censtats.census.gov/cgi-bin/cbpnaic/cbpdetl.pl

County was based on data from the U.S. Economic Census on the "total sales, shipments, receipts, revenue, or business done by domestic establishments" for rail transportation.

12.4 Limitations

Because the rail category in CARB's statewide inventory is not separated into freight and passenger rail sub-categories, it was difficult to find a ratio value that would capture both of these activities. EPIC used the number of support establishments for rail in the county and state as a ratio value because it best captured both freight and passenger rail activities. However, it may not represent the exact ratio of all rail in the county compared to the state. Better data for this category would yield more accurate emissions estimates. Further, an estimate of GHG emissions based on fuel consumption from both freight and passenger rail would more accurately represent emissions from rail.

13 SOLID WASTE

Emissions from solid waste constitute about 5% of GHG emissions in the region. These emissions are a result of biodegradable, carbon-bearing waste decomposing in largely anaerobic environments, producing landfill gas composed of approximately 50% methane and 50% carbon dioxide. The water content of a landfill determines how fast the waste will decay, and, if water is unavailable, the waste will not decay. Therefore, a large portion of the carbon in the waste will not degrade under these conditions and will be sequestered as long as the landfill's anaerobic and low-moisture conditions persist. Consequently, the degradation process can take 5 to 50 years.

13.1 Method Used to Estimate 2012 Emissions

Solid waste emissions were estimated using method SW.4 from the ICLEI U.S. Community Protocol. This method uses disposed waste in a given year[81], the characterization of waste[82], and a default emission factor (0.06 MT CO_2e/wet short ton) from the U.S. EPA Waste Reduction Model (WARM)[83] to estimate emissions from the disposal of solid waste by the San Diego Region. Because a recent waste characterization study was not available for the City of San Diego or the Region, it was assumed that the City's characterization was the same as that reported in a 2008 statewide study for California. A 75% diversion rate is assumed in 2020 and beyond, as per EPA regulations[84], and a 55 % CH_4 capture rate is used, as recommended by the U.S. Community Protocol as the default value, increasing to 75% in 2020 and beyond, as reflected by best practice.[85]

[81] California Department of Resources Recycling and Recovery (CalRecycle) Disposal Reporting System (DRS). Available at http://www.calrecycle.ca.gov/DataCentral/.
[82] California Department of Resources Recycling and Recovery (CalRecycle). California 2008 Statewide Waste Characterization Study. Available at http://www.calrecycle.ca.gov/publications/Documents/General/2009023.pdf.
[83] U.S. EPA. Waste Reduction Model (WARM). Available at http://epa.gov/epawaste/conserve/tools/warm/index.html.
[84] AB 341 was amended in 2011 to read that it is state policy to achieve at least 75% diversion by 2020.
[85] LA County Solid Waste Management Department. Measuring Landfill Gas Collection Efficiency Using Surface Methane Concentrations, Huitric and Kong. Available at http://www.arb.ca.gov/cc/ccea/comments/april/huitric_kong.pdf.

13.2 Business-as-usual Projection

Per capita emissions rates for 2012 were used to project emissions out to 2050, based on SANDAG's population forecast.[86]

13.3 Differences from Previous Inventory

Method SW.4 differs from the previous inventory's methodology in two ways. First, method SW.4 estimates GHG emissions from waste disposed by San Diego County, regardless of whether or not the landfills are located inside or outside the County boundary. The previous inventory, on the other hand, used data from waste disposed in the 26 landfills in the county to estimate emissions from solid waste. Second, method SW.4 estimates future emissions resulting from solid waste disposed of in the inventory year. In contrast, the previous inventory used solid waste data from previous years (back to 1950) to estimate inventory year emissions.

13.4 Limitations

Since an updated waste characterization for San Diego County was not available when emissions from this category were calculated, a study from 2008 was used. Additionally, since an emissions factor was not available for each category reported in the study, a default emissions factor for mixed solid waste was used. Therefore, calculations that include more recent waste characterization in addition to emissions factors specific to each category of a waste may be more precise in allocating emissions to the Solid Waste sector.

14 WASTEWATER

The treatment of domestic wastewater produces methane (CH_4) and nitrous oxide (N_2O) emissions. This category estimate such emissions resulting from community-generated wastewater treatment.

14.1 Method used to Estimate 2012 Emissions

Due to lack of consistent data for wastewater treatment facilities in the San Diego Region, emissions from the treatment of wastewater were estimated using data from Point Loma Wastewater Treatment Plant in the City of San Diego and used as a proxy for other plants in the region. The Point Loma Wastewater Treatment Plant treats approximately 175 million gallons of wastewater per day[87], which are generated by more than 2.2 million residents, over half of the County's population.

In order to calculate emissions from wastewater, EPIC used GHG emission data from Point Loma Wastewater Treatment Plant as reported to the California Air Resources Board (CARB) in 2010.[88] Annual emissions were divided by gallons of wastewater processed at the plant in that year to estimate a typical CO_2e/gallon of wastewater processed in San Diego County.

[86] SANDAG Series 13.
[87] Point Loma Wastewater Treatment Plant Annual Report 2010, Section 3 Plant Operations. Available at http://www.sandiego.gov/mwwd/pdf/pm/2010plantoperations.pdf.
[88] Emissions from Point Loma Wastewater Treatment Plant from Report to CARB in 2010.

In order to obtain an estimate for total gallons of wastewater produced in San Diego County, EPIC multiplied ICLEI's value for per capita wastewater production in California (100 gallons/day)[89] by the regional population.[90] EPIC then multiplied the total gallons of wastewater produced by our estimate of typical CO_2e/gallon of wastewater processed to calculate total GHG emissions from wastewater treatment in the San Diego Region.

14.2 Business-as-usual Projection

The per capita wastewater production value for California (100 gallons/day) was multiplied by SANDAG's Series 13 population projection[91] to estimate emissions to 2050.

14.3 Differences from Previous Inventory

The previous inventory estimated emissions from wastewater using per capita emissions factors for nitrous oxide (N_2O) and methane (CH_4) provided by CARB.

14.4 Limitations

Due to lack of more specific information on the total amount of regional wastewater treatment and emissions, the Wastewater sector may somewhat underestimate regional emissions by using Point Loma treatment emissions as a proxy. The Point Loma Treatment Plant is not as energy intensive as more modern plants in the region, which treat to a higher level of purity before discharge. The Point Loma facility is permitted as a chemically enhanced advanced primary treatment facility while more modern plants treat to secondary levels, which require greater energy use.[92]

15 AGRICULTURE

Emissions from agriculture make up only a small portion of the County's greenhouse gas (GHG) inventory, as emissions from livestock are less than 1% of total regional GHG emissions. These emissions are broken into two categories: enteric fermentation and manure management. Enteric fermentation is a microbial fermentation process that occurs in the stomach of ruminant animals, producing methane that is released through flatulence and eructation. Manure management, on the other hand, is the process by which manure is stabilized or stored. Anthropogenic methane (CH_4) and nitrous oxide (N_2O) emissions result from livestock manure, and the amount of gas produced depends on the manure management system involved.

15.1 Method Used to Estimate 2012 Emissions

EPIC followed the ICLEI U.S. Community Protocol for Emissions from Domestic Animal Production within a Community (A.1 and A.2). Method A.1 addresses enteric fermentation from livestock

[89] ICLEI U.S. Community Protocol.
[90] SANDAG Series 13.
[91] SANDAG Series 13.
[92] EPIC Personal conversation with Encina wastewater treatment plant manager comparing the Encina treatment facility energy use with that of Point Loma, March 2015.

production. Methane emissions due to enteric fermentation are derived from the population[93] and emissions factors for each animal type.

Method A.2 addresses emissions from manure management. Emissions from manure management are derived from data on animal populations[94], animal characteristics, and manure management practices. Method A.2 is broken up into three sub-categories, including methane emissions from manure management (A.2.1), direct nitrous oxide emissions from manure management (A.2.3), and indirect nitrous oxide emissions from manure management (A.2.4).

15.2 Business-as-usual Projection

EPIC projected both enteric fermentation and manure management emission estimates to 2050 using a logarithmic decay model. First, EPIC calculated historical emissions from livestock to 2012, then used a logarithmic decay function to calculate emissions in subsequent years out to 2050. As livestock production in San Diego County is decreasing over time, this model produced a more reasonable result than a linear model.

15.3 Differences from Previous Inventory

While the previous inventory used a direct calculation method provided in the California Air Resources Board (CARB) statewide GHG inventory, the method used in the 2012 inventory relied on an equation from the U.S. Community Protocol. The two methods are similar, because they both use livestock population data to estimate GHG emissions.

15.4 Limitations

Because historical data showed a decrease in livestock population, using a linear projection to 2050 would cause emissions from agriculture to become negative. As such, an exponential decay function was used. This function may not accurately account for emissions from the Agriculture sector, but is more reasonable than a linear projection based on historical trends.

16 MARINE VESSELS

Emissions from marine vessels in San Diego County are largely attributed to the Port of San Diego, which serves as a transshipment facility for San Diego, Orange, Riverside, San Bernardino and Imperial Counties, northern Baja California, Arizona, and other areas east of California. The specific emissions included in the marine vessels category are broken into two sub-categories as follows:

- Ocean Going Vessels (OGV)—these include auto carriers, bulk carriers, passenger cruise vessels, general cargo vessels, refrigerated vessels (reefers), roll-on roll-off vessels (RoRo), and tankers for bulk liquids.
- Harbor Craft—these include tugboats, ferries, and commercial fishing vessels.

[93] National Agricultural Statistics Service. Available at http://quickstats.nass.usda.gov.
[94] National Agricultural Statistics Service.

16.1 Method Used to Estimate 2012 Emissions

Emissions from marine vessels in San Diego County were quantified based on the Port of San Diego's 2012 Maritime Air Emissions Inventory (June 2014).[95] The report provided estimates for emissions from both Harbor Craft and Ocean Going Vessels (OGV) for 2012.

16.2 Business-as-usual Projection

Since methodologies differed between the Port's 2006 and 2012 inventories, values for intermediate years were not interpolated. Instead, the 2012 values were held constant from 2012 to 2050.

16.3 Differences from Previous Inventory

In previous inventories, CARB provided emissions data from its 2007 statewide inventory, and those inventories were scaled to the San Diego region. Using the Maritime Air Emissions Inventory likely more accurately allocates emissions to the Marine Vessels sector, as it is based on local data.

16.4 Limitations

Due to lack of relevant data that could be used to project emissions to 2050, emissions were held constant from 2012 on. Therefore, the Marine Vessels sector likely does not include future business-as-usual trends.

17 REGIONAL GHG EMISSIONS PROJECTIONS

The Regional GHG Emissions Forecast (Table 2) includes the emission reductions that would result from adopted statewide policies and regulations in place in 2012. The forecast was calculated by first estimating the BAU projection for each emissions sector (described in sections 3 through 16), then subtracting the estimated GHG emissions reductions due to regulations. This describes the methods used to calculate these emissions reductions. The estimated reductions are based on the current implementation timeline for regulations, many of which do not currently extend beyond 2020 or 2025. Therefore, these emissions reductions are conservative estimates and the extension of current regulations and/or new future regulations would lead to additional reductions beyond what is estimated here.

17.1 Transportation

As noted in Section 3.1, the EMFAC 2014 emissions projections include the effects of the most recent Advanced Clean Cars program[96], which includes federal fuel economy standards for passenger cars and light-duty trucks applying to new vehicle model years through 2016, as well as California's ZEV III GHG regulation[97] for model years 2017-2025. The projection also accounts for the effects of SB 375, electric vehicle miles and one heavy duty truck regulation.

[95] Port of San Diego 2012 Maritime Air Emissions Inventory, June 2014. Available at https://www.portofsandiego.org/ordinances-a-resolutions/doc_view/6325-2012-maritime-air-emissions-inventory-report.html.
[96] CARB Advanced Clean Cars Program.
[97] CARB Zero Emission Vehicle (ZEV) Program.

To show the effects of other adopted statewide policies, EPIC estimated the emissions reductions from a) the Regulation to Reduce Greenhouse Gas Emissions from Vehicles Operating with Under Inflated Tires, b) the Low Carbon Fuel Standard, and c) Off-Model Measures calculated by SANDAG and provided by SANDAG.

- The expected reduction from The Regulation to Reduce Greenhouse Gas Emissions from Vehicles Operating with Under Inflated Tires[98] in 2020 was scaled from the state to the San Diego region using a ratio of vehicle miles traveled. The resulting reductions were held constant from 2020 to 2050.
- The reduction amounts from the Low-Carbon Fuel Standard[99] were based on an estimated intensity reduction as required by the regulation, 10% from 2011 to 2020. As such, emissions reductions were calculated by reducing emissions from the Transportation sector by 10% in 2020. This reduction was held constant to 2050.

17.2 Electricity

EPIC estimated emissions reduction values for the following policies.

- Renewable Portfolio Standard: this was held constant at 33% renewable energy in electricity supply from 2020 to 2050. The baseline year (2012) level was 15%.

- State Solar - Net metered: The projection to 2020 and 2035 was linear based on the net metering cap for SDG&E in 2017 of 607 MW, followed by multiplying the photovoltaic projection provided by the California Energy Commission[100] by the ratio of actual reported in December 2014[101] to CEC forecast for the years thereafter.
    - Programs and policies that encourage customer-sited distributed solar photovoltaics include the California Solar Initiative (and previously the Emerging Renewables Program), New Solar Homes Partnership, and Net Metering. California's current residential rate structure, an inclining block structure that charges a higher marginal rate as consumption increases, also encourages customers to install solar photovoltaics at their premises. In addition to state measures, a federal tax credit and accelerated depreciation also provide financial incentive for this technology.

- State Solar – Shared: The reductions associated with shared solar were kept fixed at the regulatory cap for shared solar in the SDG&E service territory of 59 MW for 2020, 2025, 2035 and 2050, as the Green Tariff Shared Renewables program (SB 43) allows up to 59 MW of solar to be installed in SDG&E territory under a pilot that lasts until January 1, 2019.[102]

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[98] California Air Resources Board, Tire Inflation Regulation. Available at http://www.arb.ca.gov/cc/tire-pressure/tire-pressure.htm.
[99] California Air Resources Board, Low-Carbon Fuel Standard Program. Available at http://www.arb.ca.gov/fuels/lcfs/lcfs.htm.
[100] Personal Communication with California Energy Commission Staff Asish Gautam, email October 22, 2013.
[101] San Diego Gas & Electric, Advice Letter 26890-E. Progress Towards the Net Energy Metering Transition Trigger Level in Compliance with Decision 14-03-041.
[102] State of California Public Utilities Commission, 2014. Decision Approving Green Tariff Shared Renewables Program for San Diego Gas and Electric Company, Pacific Gas and Electric Company, and Southern California Edison Company Pursuant to Senate Bill 43. Available at http://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M143/K989/143989599.PDF.

- Electricity Efficiency: Reductions were based on a study by Navigant for the California Public Utilities Commission for 2015-2025. These values were projected to 2050.[103]
    - The California Public Utilities Commission developed the Strategic Energy Efficiency Plan with detailed goals and targets for improvement in energy use among all sectors of the economy in California.[104] California has numerous policies to help to realize the long-term strategic goals in the Plan and to encourage energy efficiency, including standards for new buildings and appliances, programs administered by investor-owned utilities under the auspices of the California Public Utilities Commission, and specific requirements for commercial buildings to disclose energy use as required by AB 1103.

17.3 Natural Gas

Reductions from increased natural gas efficiency as a result of policies listed in Section 17.2 for electricity were projected through 2050 on the basis of a study on the potential of natural gas efficiency measures for the CEC.[105]

17.4 Wastewater

A capture rate of 98% was used for 2020, 2025, 2035 and 2050, considered reasonable as the literature suggests[106] that biogas capture systems for anaerobic lagoons are the simplest and easiest method to capture nearly all emissions from treatment. It is assumed that most wastewater treatment emissions will be captured by this or equivalent ways by 2020[107].

17.5 Solid Waste

Landfill waste diversion rate of 75% was used as the state goal for 2020 according to AB341.[108] A 75% capture rate was used for projections as the best-case scenario commonly used by the EPA.[109] These rates were held at 75% for the projection years through 2050.

17.6 Other CARB Measures

The following measures to address high GWP emissions are expected to have a GHG reduction impact in the San Diego region:

- H-1 Motor Vehicle A/C Refrigerant Emissions
- H-4 Remove High GWP use in Consumer Products

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[103] 2013 California Energy Efficiency Potential and Goals Study, Final Report. Available at http://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M088/K661/88661468.PDF.

[104] Engage 360, 2011. California Energy Efficiency Strategic Plan. Available at http://www.cpuc.ca.gov/NR/rdonlyres/A54B59C2-D571-440D-9477-3363726F573A/0/CAEnergyEfficiencyStrategicPlan_Jan2011.pdf.

[105] 2013 California Energy Efficiency Potential and Goals Study, Final Report.

[106] Global Methane Global Initiative, Table 1, https://www.globalmethane.org/documents/ww_fs_eng.pdf,.

[107] Requirement to implement 98% capture rate by 2020 has been set in the City of San Diego Climate Action Plan 2012 throughout its evolution since 2012, see http://www.sandiego.gov/planning/genplan/cap/pastmeetings.shtml for archived climate action plans as well as current 2015 draft City of San Diego Climate Action Plan, at http://www.sandiego.gov/planning/genplan/cap/. Communication with City of San Diego public works department staff has indicated since 2012 that this is reasonable and feasible.

[108] AB 341 Bill Text. Available at http://www.leginfo.ca.gov/pub/11-12/bill/asm/ab_0301-0350/ab_341_bill_20111006_chaptered.html.

[109] Huitric and Kong.

- H-6 Refrigerant Tracking/Reporting/Repair Deposit Program
- H-6 Leak Reduction and Recycling in Electrical Applications

CARB estimates the statewide reductions from these measures to be 0.2, 0.2, 4.9 and 0.1 MMT CO_2e in 2020[110]. These values were scaled to San Diego region as a ratio of similar activities in San Diego versus California. This came to about 8% average of the total state reduction in San Diego.

17.7 Effect of Cap and Trade

The Update to the Scoping Plan provides that about 23 MMT CO_2e will be reduced by the state Cap and Trade program statewide.[111] To estimate the San Diego region's portion of the total state's covered emissions, EPIC used the ratio of the San Diego region's covered emissions to statewide covered emissions based on reported data for 2013.[112] San Diego region's covered emissions under Cap and Trade was roughly 2% of the total covered emissions. Two percent of 23 MMT is approximately 0.5 MMT CO_2e, which was considered to be the share of cap and trade emissions reductions attributable to the San Diego region. This value was held constant through 2050.

[110] California Air Resources Board. Greenhouse Gas Reductions from Ongoing, Adopted, and Foreseeable Scoping Plan Measures, 2014. Available at http://www.arb.ca.gov/cc/inventory/data/tables/ar4_first_update_to_scoping_plan_2014-05-22.pdf.
[111] California Air Resources Board. First Update to the Climate Change Scoping Plan, 2013. Table 5, page 93. Available at http://www.arb.ca.gov/cc/scopingplan/2013_update/first_update_climate_change_scoping_plan.pdf.
[112] California Air Resources Board. 2013 GHG Facility and Entity Emissions. Available at http://www.arb.ca.gov/cc/reporting/ghg-rep/reported-data/ghg-reports.htm.

Looking Past 2035 – Possible Pathways for Additional Greenhouse Gas Emissions Reductions from Transportation

The Transportation Sector: Potential strategies to reduce greenhouse gas emissions under evaluation by state agencies

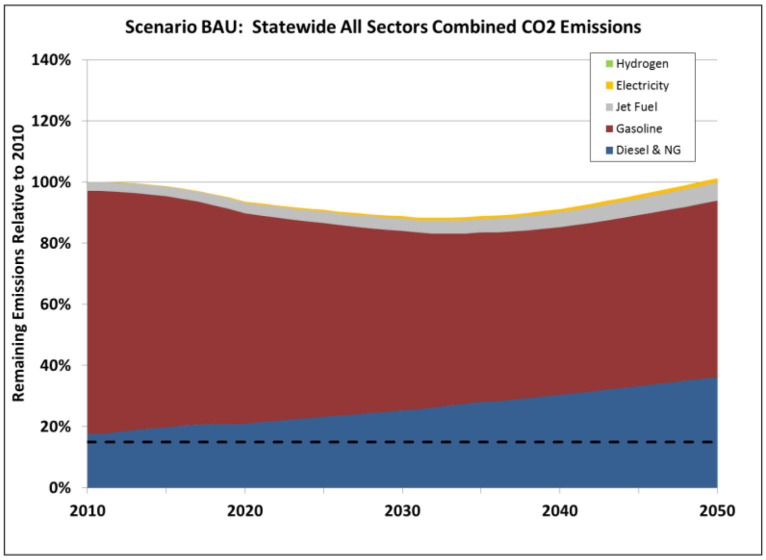
As referenced in Chapter 2, both ARB and Caltrans are evaluating potential strategies to meet statewide climate goals with a focus on the transportation sector. In 2012, ARB released a Draft Vision for Clean Air: A Framework for Air Quality and Climate Planning, which examines strategies to meet California's air quality and climate goals.[1] This framework presents scenarios that combine technology, energy, and efficiency assumptions that change over time. That is, the scenarios start with the benefits of existing programs and assume further improvements in efficiency as well as cleaner technology, fuels, and energy sources. According to ARB, these are ambitious assumptions that would require innovation, investment, incentives, and regulations to achieve. The scenarios provide a perspective on how a mix of technologies could be successful in helping the state meet its multi-pollutant goals. Any other mix of technologies and fuels achieving equivalent or better emissions reductions could be considered part of the scenario, but these are some achievable examples ARB has analyzed.

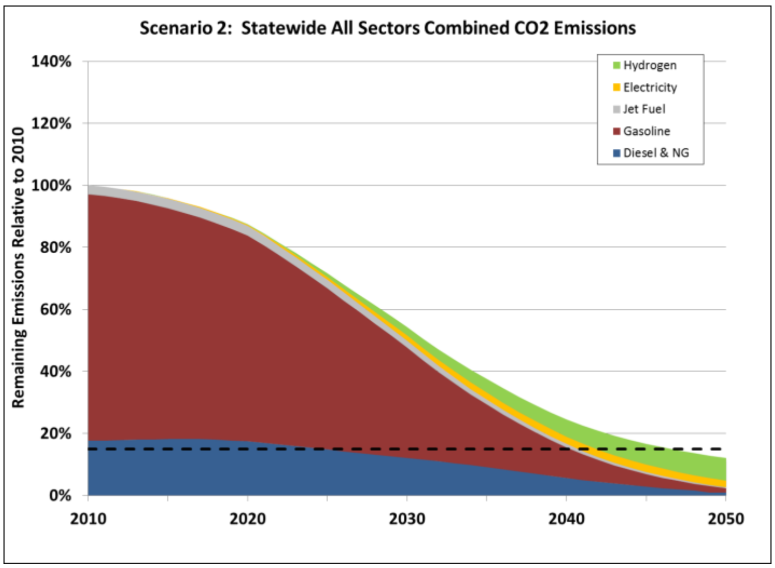
The ARB scenarios evaluated the following sectors of mobile sources: passenger vehicles, heavy-duty vehicles, freight and passenger locomotives, cargo handling equipment, commercial harbor craft, oceangoing vessels, off-road vehicles, and aviation. They are described below. The air quality goals used to develop Scenarios 2 and 3 are to achieve the federal ozone standards and Executive Order S-03-05's long-term goal to reduce the state's greenhouse gas emissions to 80 percent below 1990 levels for all sectors, not just transportation, by 2050. In 2012, Governor Brown issued Executive Order B-16-2012, which calls for the same state goal specifically for the transportation sector.[2]

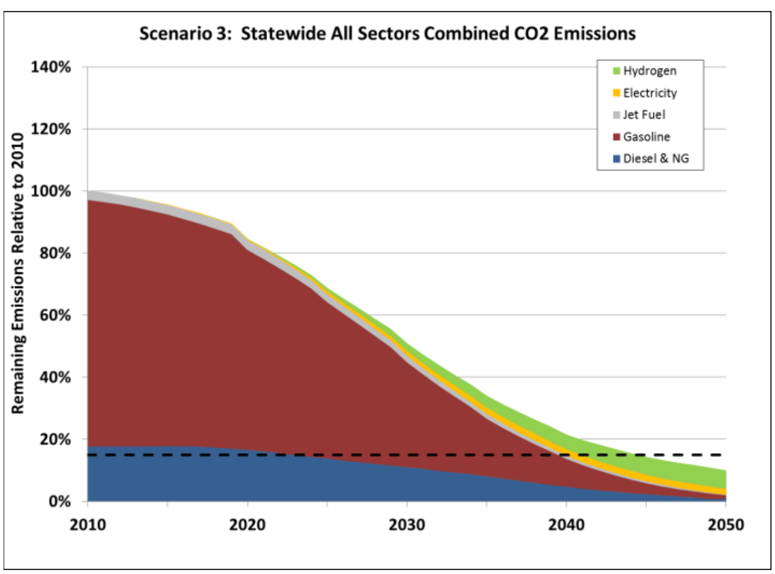
Scenario 1 (Business as usual or BAU) represents all current federal and state programs, including the Advanced Clean Car Program, the 33 percent renewables target from the California Renewable Portfolio Standard, and the Low Carbon Fuel Standard goal of 10 percent less carbon intensity by 2020.

Scenario 2 builds upon Scenario 1 and includes an aggressive phase-in of alternative fuel vehicles and zero-emission vehicles (plug-in electric, hydrogen fuel cell, and hybrid electric vehicles), as well as phased transition to sustainable fuels, such as hydrogen, electricity, and natural gas as transportation fuels (additional assumptions are made for heavy-duty trucks, port, rail, and aviation sectors).

Scenario 3 builds upon Scenarios 1 and 2 and includes cleaner near-term combustion based on more aggressive future nitrogen oxides emissions standards. It also assumes that land use and transportation system improvements would result in a 20 percent reduction in vehicle miles traveled (VMT) from 2050 Scenario 1 levels. Both Scenarios 2 and 3 assume that starting in 2040 all new auto sales will be of zero emission vehicles. Additional assumptions are made for other transportation sectors. The charts on the next page illustrate the results of the scenario analyses.[3] Both Scenarios 2 and 3 would achieve the 2050 greenhouse gas target of 80 percent below 1990 levels.







Source: California Air Resources Board, Draft Vision for Clean Air: A Framework for Air Quality and Climate Planning, Scenario Assumptions and Results, August 20, 2012.

ARB currently is developing an update to the Vision Scenario Planning modeling tool. A public workshop on Vision 2.0 was held in March 2015. ARB staff identified next steps as posting the updated model on the ARB website, developing scenarios for plans and programs, and briefing its board in the fourth quarter of 2015.[4]

As part of the development of the California Transportation Plan 2040 (CTP 2040), Caltrans also is using the ARB Vision framework to evaluate greenhouse gas emissions reductions from the transportation sector toward achieving California climate goals.[5] SB 391 requires Caltrans to analyze how to attain a statewide reduction of greenhouse gas emissions to 1990 levels by 2020, and 80 percent below 1990 levels by 2050. Therefore, the CTP 2040 includes analyses of transportation improvement strategies, fuels, and vehicle technologies that provide for the maximum feasible reductions in greenhouse gas emissions, as required under SB 391.

The Draft CTP 2040 includes three alternatives or scenarios to analyze the potential effectiveness of various packages of VMT and greenhouse gas emission reduction strategies, projects, and vehicle technologies. The alternatives are designed to show the greenhouse gas reductions that may be achieved by different mixes of transportation strategies and technology.

Alternative 1 starts with the Sustainable Communities Strategies from metropolitan planning organizations around the state, and the state modal plans (California Aviation System Plan, California Freight Mobility Plan, Interregional Transportation Strategic Plan, California State Rail Plan, and Statewide Transit).

Alternative 2 applies statewide transportation strategies designed to further reduce greenhouse gas emissions from the Sustainable Communities Strategies and state modal plans. The transportation strategies include pricing such as road user charges; transportation alternatives such as telecommute, work at home, increased carpooling and car sharing; mode shift as a result of doubling transit services and increasing transit speeds, doubling bike and walk shares; and operational efficiency (e.g., incident and emergency management, transportation system management [TSM] strategies). Many of these proposed strategies are viewed by Caltrans as aspirational and specific policies or regulations would need to be enacted to achieve the outcomes.

Alternative 3 includes all the Alternative 2 strategies plus additional aggressive vehicle and fuel technology strategies.

Because the CTP 2040 only includes the transportation sector, it assumed that the transportation sector 2020 greenhouse gas value calculated for Alternative 1 is the reference point for the 2050 greenhouse gas reductions. Greenhouse gas reductions were calculated based on VMT outputs for 2020 and 2040 using the EMFAC 2011 model. For the final CTP 2040, the new EMFAC 2014 model will be used. Alternative 3 is the only alternative that would achieve the 80 percent greenhouse gas emissions reductions below 1990 levels in 2050 according to the Caltrans analysis.

The scenario analyses conducted by both ARB and Caltrans show that substantial changes to vehicle fleets in California and a considerable transition to sustainable fuels will be needed to achieve 2050 greenhouse gas emission reduction goals.

A Subset of the Transportation Sector: Potential strategies to reduce greenhouse gas emissions from cars and light-duty trucks

The Regional Plan focuses on reducing greenhouse gas emissions from cars and light-duty trucks, as required by SB 375. SANDAG reviewed the assumptions included in the ARB Vision scenarios and the CTP 2040 to help develop a post 2035 scenario focused on carbon dioxide emissions reductions for cars and light-duty trucks for the San Diego region. This scenario uses the greenhouse gas emission reductions goals under Executive Orders S-03-05 and B-16-12 as long-term reference points.

Figure D.1

Total Projected Carbon Dioxide Emissions from Cars and Light-Duty Trucks for the San Diego Region

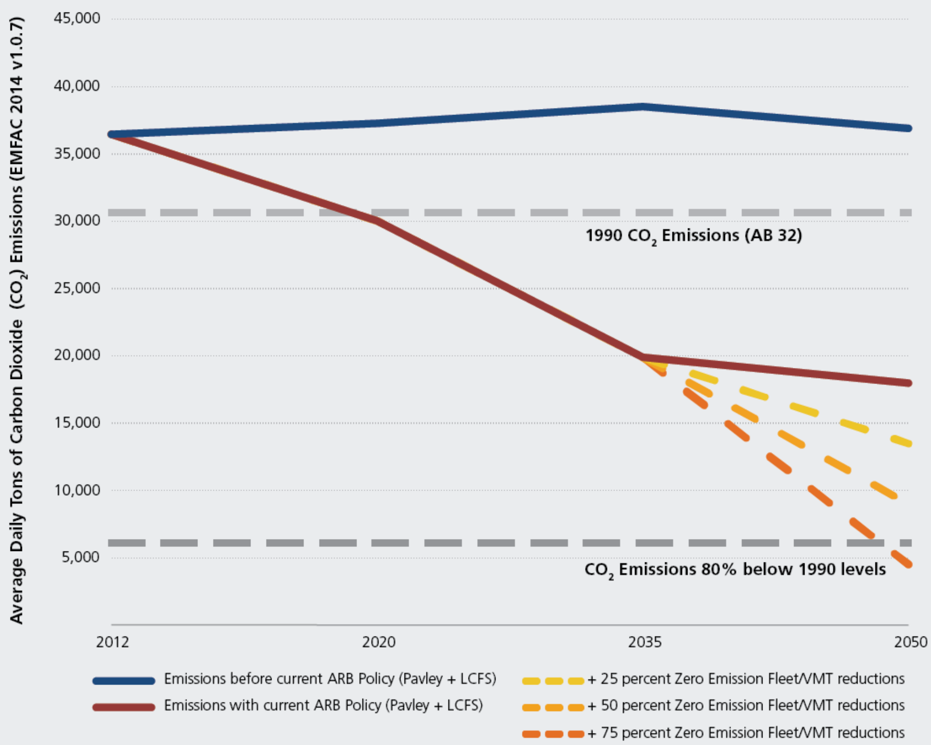


Figure D.1 illustrates the projected regional carbon dioxide (CO_2) emissions from cars and light duty trucks before current ARB Policy and with current ARB Policy (output from activity based model, which includes transportation demand and system management strategies) as well as additional TDM strategies (shared mobility services, vanpools, carpools), and the regional electric vehicle charger program. After 2035, additional TSM strategies are included (use of Managed Lanes by zero emission vehicles only as well as increased frequencies on highly productive *Rapid* routes using Managed Lanes to represent efficiencies due to implementation of automated guideways). The TDM and TSM strategies are included in the Regional Plan. Current ARB Policy includes the Advanced Clean Car Program (Pavley) and low carbon fuel standard (LCFS). In addition, as shown in Figure D.1, in dashed lines, a combination of varying levels of zero emission vehicle penetration and VMT reductions could further decrease emissions by 2050. Achieving the additional emission reductions would require substantial changes in state and federal policies or regulations, which are beyond the ability of SANDAG to implement.

While SANDAG may not be able to solely implement clean vehicle or fuel policies, there are a number of areas in which regional actions will influence and support greenhouse gas emissions reductions. The Regional Plan currently includes ambitious programs to incentivize vanpools, carpools, and shared mobility travel options. The TDM program includes consistent vanpool program growth through 2050 (more than 800 vanpools expected to operate by 2020, growing to more than 1,100 vanpools by 2035 and to more than 1,500 vanpools by 2050).

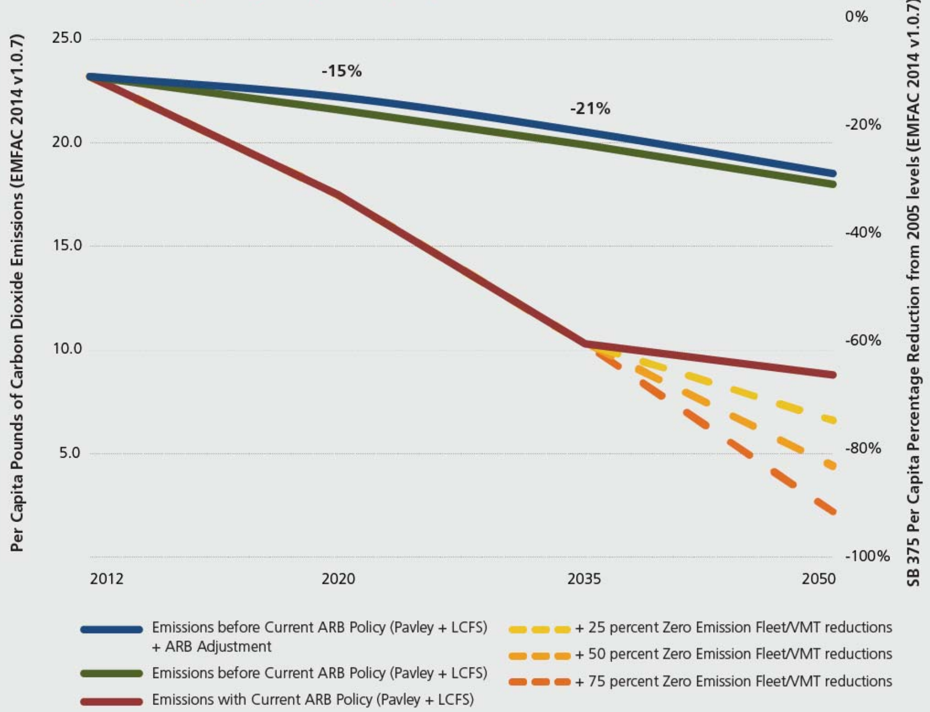
Nearly 500 carpools would be incentivized annually. Shared mobility adoption among residents within Smart Growth Opportunity Areas of the San Diego region also is forecasted to grow substantially through 2050. In 2020, it is assumed that approximately 50,000 adults residing in mixed-use transit corridors (69 or more persons per acre) will be active shared mobility members. In 2035, more than 145,000 adults residing in communities with densities comparable to community and town centers (55 or more persons per acre) are forecasted to be active shared mobility member. This figure is projected to grow to 225,000 adults in 2035 and 2050, respectively. Based on current research, active members of shared mobility services drive seven miles less per day.

The Regional Plan also currently includes ambitious measures to increase electric vehicle penetration. These regional measures will support statewide goals for cleaner vehicles and fuels. The Regional Charger Program would lead to carbon dioxide emissions reductions by extending the electric range of plug-in hybrid electric vehicles (PHEVs) and displacing the use of gasoline. Currently, PHEVs drive 30 percent of their miles in electric mode with the remaining miles in gasoline mode. The build-out of a robust electric vehicle charger network would allow PHEVs more opportunities to charge and increase the percentage of miles driven in electric mode. The Regional Charger Program forecasts that one charger for every five PHEVs would increase the percentage of electric miles from 30 percent to 41 percent. This would translate to 36,000 charging stations in 2035 and 44,000 charging stations in 2050. The build-out of the charger network would be accomplished through a combination of regional planning and incentives for the installation of publicly available Level 1 and Level 2 charging stations. Level 1 charging adds about 2 to 5 miles of range to an electric vehicle per hour of charging time, while Level 2 adds about 10 to 20 miles of range per hour of charging time.

The same potential scenario shown in Figure D.1 was analyzed on a per capita basis. Figure D.2 shows how per capita carbon dioxide emissions from cars and light duty trucks could be drastically reduced by applying various strategies as we head toward mid-century. Projected per capita CO_2 emissions from cars and light duty trucks before current ARB Policy and including the required ARB adjustment (+2 percent) would be reduced by 29 percent by 2050 (from 2005). Current ARB policies (Pavley and LCFS) would further reduce per capita emissions by more than 60 percent by 2050. As shown in Figure D.2, in dashed lines, and as discussed above, a combination of varying levels of zero emission vehicle penetration and VMT reductions could further decrease per capita emissions by 2050.

Figure D.2

Projected Carbon Dioxide Emissions for Cars and Light-Duty Trucks for the San Diego Region (per capita)



The ARB Draft Vision for Clean Air and Draft CTP 2040 scenarios envision how a 2050 goal of 80 percent below 1990 levels of greenhouse gas emissions for the transportation sector might be achieved, given a set of aggressive assumptions requiring improvements in vehicle and fuel technologies that would require major changes in state and federal policy and regulation beyond sole regional control. Using the ARB Draft Vision and Draft CTP 2040 frameworks, the SANDAG regional scenarios in Figures D.1 and D.2 show how an 80 percent reduction goal and even greater percentage reductions in total and carbon dioxide emmissions per capita for cars and light-duty trucks might be met by adding far more aggressive regional TSM measures, zero emission vehicle penetration, and VMT reduction. Regional programs will support future changes in state and federal policies and regulation toward achieving the statewide climate goals.

The Regional Plan sets forth ambitious but feasible TSM, electric vehicle, and other programs that can be implemented now and in the future to make progress toward achieving the state 2050 greenhouse gas emission reduction goal. These programs are aligned with, and help implement some of the aggressive statewide measures envisioned by the 2050 greenhouse gas reduction scenarios in the ARB Draft Vision and Draft CTP 2040.

Endnotes

[1] ARB Vision for Clean Air: A framework for Air Quality and Climate Planning, June 27, 2012 http://www.arb.ca.gov/planning/vision/docs/vision_for_clean_air_public_review_draft.pdf;

Vision for Clean Air: A Framework for Air Quality and Climate Planning Sacramento Vision Workshop August 22, 2012 http://www.arb.ca.gov/planning/vision/docs/staff_presentation_on_August_22_2012.pdf;

Scenario Assumptions and Results, August 20, 2012 http://www.arb.ca.gov/planning/vision/docs/draft_scenario_assumptions_and_results_appendix.pdf.

[2] Executive Order (EO) S-03-05 establishes the following greenhouse gas emission reduction targets for California: reduce greenhouse gas emissions to 2000 levels by 2010, to 1990 levels by 2020, and to 80 percent below 1990 levels by 2050. EO B-16-12 orders that California target for 2050 a reduction of greenhouse gas emissions from the transportation sector equaling 80 percent less than 1990 levels.

[3] According to ARB's Vision for Clean Air: A Framework for Air Quality and Climate Planning, published in 2012, to reduce greenhouse gas emissions by 80 percent below 1990 levels by 2050 is equivalent to an 85 percent reduction from today's levels. The dashed line illustrates the emissions reduction goal.

[4] ARB, Vision 2.0, http://www.arb.ca.gov/planning/vision/vision.htm.

[5] Caltrans, Draft California Transportation Plan 2040, March 2015.