Appendix B: 2016 Greenhouse Gas Emissions Inventory for the San Diego Region

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Introduction

The San Diego Association of Governments (SANDAG) contracted the Energy Policy Initiatives Center (EPIC) at the University of San Diego (USD) to estimate the 2016 greenhouse gas (GHG) emissions for the San Diego region. GHG emissions estimates were included in San Diego Forward: The 2021 Regional Plan (2021 Regional Plan) and its associated Environmental Impact Report (EIR). This appendix summarizes the methodologies and data used to conduct this analysis.

To the extent possible, EPIC followed the same methods used in developing the 2012 GHG emissions inventory for San Diego Forward: The 2015 Regional Plan.[1] The 2016 GHG inventory includes 15 categories of emissions calculated based on the U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions and California Air Resources Board (CARB) California statewide GHG inventory methodology.

Overview of the Appendix

This appendix includes the following sections:

- **Background** provides common background sources and assumptions used for the inventory.
- **Summary of Results** provides the results of the 2016 GHG inventory.
- **Method to Calculate Emissions Inventory by Category** includes subsections that cover the methods used to develop the inventory.

Background

Greenhouse Gases

The primary GHGs included in this document are carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O); others are included where data is available. Each GHG has a different capacity to trap heat in the atmosphere, known as its global warming potential (GWP), which is normalized relative to CO_2 and expressed in carbon dioxide equivalents (CO_2e). The 100-year GWPs reported by the Intergovernmental Panel on Climate Change (IPCC) are used by CARB to estimate GHG emissions inventories statewide.[2] The GWPs in this document, provided in Table B.1, are from the IPCC Fourth Assessment Report (AR4).[3]

[1] SANDAG: San Diego Forward: 2015 Regional Plan (2015).
[2] CARB: Current California GHG Emission Inventory Data. 2000–2018 GHG Inventory (2020 Edition).
[3] IPCC Fourth Assessment Report: Climate Change 2007: Direct Global Warming Potentials (2013).

Table B.1: Global Warming Potentials Used in the Regional Greenhouse Gas Inventory

Global Warming Potentials Used in the Regional Greenhouse Gas Inventory	
Greenhouse Gas	**Global Warming Potential**
Carbon dioxide (CO_2)	1
Methane (CH_4)	25
Nitrous oxide (N_2O)	298
Difluoromethane (HFC-32)	675
1,1,1,2-Tetrafluoroethane (HFC-134a)	1,430
Pentafluoroethane (HFC-125)	3,500
1,1,1-Trifluoroethane (HFC-143a)	4,470
Carbon tetrafluoride (CF_4)	7,390
Octafluoropropane (C_3F_8)	8,830
1,1,1,3,3,3-Hexafluoropropane (HFC – 236fa)	9,810
Octafluorocyclobutane (C_4F_8)	10,300
Hexafluoroethane (C_2F_6)	12,200
Fluoroform (HFC-23)	14,800
Nitrogen trifluoride (NF_3)	17,200
Sulfur hexafluoride (SF_6)	22,800

Source: IPCC 2013.

Demographics

SANDAG estimates and forecasts population, housing, and employment for the San Diego region. The demographic estimates for 2016 are provided in Table B.2.[4]

Table B.2: Demographic Estimates in the San Diego Region

Demographic Estimates in the San Diego Region				
Year	**Population**	**Jobs**	**Manufacturing Jobs***	**Housing Units**
2016	3,287,280	1,646,419	109,234	1,182,983

* Manufacturing jobs are included in jobs.

2016 population and housing data are estimates.

Source: SANDAG 2020, 2021.

[4] 2016 population and housing are from the SANDAG Demographic & Socio-Economic Estimates (August 19, 2020, Version). SANDAG Data Surfer, accessed on December 10, 2020. Other estimates are based on SANDAG Series 14 Growth Forecast, provided by SANDAG staff to EPIC, March 29, 2021.

Rounding of Values in Tables and Figures

Rounding is used only for the final GHG values within the tables and figures throughout the document. Values are rounded to the nearest integer of a higher order of magnitude. Values are not rounded in the intermediary steps in the actual calculation. Because of rounding, some totals may not equal the exact values summed in any table or figure.

Summary of Results

Table B.3 provides a summary of the 2016 GHG inventory in the San Diego region.

Table B.3: Summary of 2016 Greenhouse Gas Inventory

Summary of 2016 Greenhouse Gas Inventory	
Greenhouse Gas Emissions (Million Metric Tons [MMT] CO_2e)	
Emissions Category	**2016**
Passenger Cars and Light-Duty Vehicles	10.4
Electricity	5.3
Natural Gas	3.1
Industrial	2.1
Heavy-Duty Trucks and Vehicles	1.8
Other Fuels	1.1
Off-Road Transportation	0.62
Solid Waste	0.59
Water	0.24
Aviation	0.21
Rail	0.11
Wastewater	0.07
Agriculture	0.05
Marine Vessels	0.05
Soil Management	0.05
Total	**26**

MMT – million metric tons.
SAFE Rule – Federal Safer Affordable Fuel-Efficiency Vehicles Rule, April 2020.
Source: EPIC, USD 2021.

The previous 2012 GHG inventory included the following land use and development influences on the regional inventory: (1) carbon sequestration from vegetation cover, (2) carbon emissions from vegetation displaced by development, and (3) carbon emissions from vegetation burning due to wildfires. This inventory excludes emissions and sequestration estimates from

vegetation and follows CARB's approach to track statewide GHG emissions from anthropogenic activities not including the GHG flux associated with carbon stocks in California's natural and working lands[5] and wildfire emissions. This is because wildfires are part of Earth's carbon cycle and it is difficult to determine how much of the wildfire emissions are from anthropogenic activities.[6, 7]

Method to Calculate Emissions Inventory by Category

On-Road Transportation – Passenger Car and Light-Duty Vehicles

The passenger car and light-duty vehicles emissions category is the largest contributor of GHG emissions in the San Diego region, accounting for about 40% of total GHG emissions in the 2016 inventory. Tailpipe GHG emissions from on-road transportation are the result of fuel combustion (i.e., gasoline, diesel, natural gas) from mobile vehicles on freeways, highways, and local roads. The vehicle classes included in this emissions category are passenger cars and light-duty vehicles. The GHG emissions from other on-road vehicles are accounted for in the subsection titled *On-Road Transportation – Heavy-Duty Trucks and Vehicles*.

Method Used to Estimate 2016 Emissions

EPIC used EMFAC2017, CARB's on-road mobile sources model, to estimate the on-road transportation emissions for passenger cars and light-duty vehicles.[8] SANDAG provided the input file to run EMFAC2017 under custom mode, as well as the output file containing all emissions results.[9] The input file, from SANDAG's activity-based model (ABM14.2.2), includes vehicle miles traveled (VMT) on an average weekday by EMFAC vehicle categories and fuel types. The output file, from an EMFAC2017 custom model run, provides CO_2 emissions in tons per weekday for each vehicle category and each fuel type. This passenger car and light-duty vehicles emissions category covers the GHG emissions from EMFAC2017 vehicle classes LDA, LDT1, LDT2, and MDV.[10]

To convert the emissions output from tons of CO_2 per weekday to metric tons of CO_2e per year, EPIC used the weekday-to-year conversion factor and CO_2-to-CO_2e (CO_2, CH_4, and N_2O) conversion factor for each EMFAC vehicle category, based on statewide GHG inventory assumptions and EMFAC2017 default run results, respectively.[11] The weekday-to-annual conversion factors for LDA, LDT1, LDT2 and MDV are all 347 weekdays per year;

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8 CARB: Mobile Source Emissions Inventory. EMFAC2017.
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8 CARB: Mobile Source Emissions Inventory. EMFAC2017.
9 Files provided by SANDAG staff, October 6, 2021.
10 LDA: passenger cars; LDT1: light-duty trucks with gross vehicle weight rating (GVWR) less than 6,000 lbs and equivalent test weight (ETW) no larger than 3,750 lbs; LDT2: light-duty trucks with GVWR less than 6,000 lbs and ETW between 3,750 and 5,750 lbs; and MDV: medium-duty trucks with GVWR between 6,000 and 8,500 lbs.
11 This approach is recommended by CARB EMFAC staff. Personal communication, January 27, 2020.

the CO_2 to CO_2e conversion factors range from 1.01 for gasoline LDT2 to 1.05 for diesel LDA.[12] The key inputs and results are shown in Table B.4.

Table B.4: Key Inputs and 2016 Greenhouse Gas Emissions from On-Road Transportation – Passenger Cars and Light-Duty Vehicles

Key Inputs and 2016 Greenhouse Gas Emissions from On-Road Transportation – Passenger Car and Light-Duty Vehicles	
VMT (miles per weekday)*	78,987,431
CO_2 Emissions (tons per weekday)**	32,605
Conversion Factor (tons CO_2 per weekday to MT CO_2e per year)	319
GHG Emissions (MT CO_2e)	10,404,317
GHG Emissions (MMT CO_2e)	**10.4**

* SANDAG ABM14.2.2 VMT.

** EMFAC2017 model run with custom VMT inputs from ABM14.2.2.

Passenger car and light-duty vehicles are EMFAC2017 vehicle classes LDA, LDT1, LDT2, and MDV.

Source: CARB 2016, 2017; SANDAG 2021; EPIC, USD 2021.

On-Road Transportation – Heavy-Duty Trucks and Vehicles

The on-road transportation heavy-duty trucks and vehicles category accounts for 7% of total GHG emissions in the 2016 inventory. Vehicle classes included in this category are taken from EMFAC2017.[13]

Method Used to Estimate 2016 Emissions

EPIC used the same method to estimate emissions from this category and the on-road transportation passenger cars and light-duty vehicles category, with an EMFAC2017 model run of VMT from SANDAG ABM14.2.2 and tons of CO_2 per weekday to MT CO_2e per year conversion. The key inputs and results are shown in Table B.5.

[12] The weekday-to-year conversion factors are based on CARB's California's 2004–2014 Greenhouse Gas Emission Inventory Technical Support Document, 2016 Edition, accessed March 23, 2020. The CO_2-to-CO_2e conversion factors are based on EMFAC2017 default 2016 emissions run for San Diego region by vehicle category and fuel type, January 14, 2020, model run.

[13] Vehicle classes are all except LDA, LDT1, LDT2, and MDV as shown in EMFAC2017 Technical Documentation, Table 6.1-1.

Table B.5: Key Inputs and 2016 Greenhouse Gas Emissions from On-Road Transportation – Heavy-Duty Trucks and Vehicles

Key Inputs and 2016 Greenhouse Gas Emissions from On-Road Transportation – Heavy-Duty Trucks and Vehicles	
VMT (miles per weekday)*	4,834,783
CO_2 Emissions (tons per weekday)**	5,866
Conversion Factor (tons CO_2 per weekday to MT CO_2e per year)	300
GHG Emissions (MT CO_2e)	1,761,445
GHG Emissions (MMT CO_2e)	**1.8**

* SANDAG ABM14.2.2 VMT.

** EMFAC2017 model run with custom VMT inputs from SANDAG.

Heavy-duty trucks and vehicles are EMFAC2017 vehicle categories except LDA, LDT1, LDT2, and MDV. Conversion factors are different for each vehicle class.

Source: CARB 2016, 2017; SANDAG 2021; EPIC, USD 2021.

Off-Road Transportation

The off-road transportation category includes the following subcategories by equipment type: construction and mining equipment, cargo handling equipment, industrial equipment, airport ground support, pleasure craft, recreational equipment, lawn and garden equipment, agricultural equipment, transport refrigeration units, military tactical support equipment, and other portable equipment. The GHG emissions from off-road equipment fuel combustion account for 2% of total emissions in the 2016 inventory.

Method Used to Estimate 2016 Emissions

CARB released the OFFROAD ORION model in 2017 and the SORE model in 2020.[14] The ORION 2017 model generates off-road equipment emission data by county, vehicle category, vehicle type, horsepower (HP), and fuel type. SORE 2020 is a standalone Microsoft Access model that generates emission data for off-road vehicles with engines less than or equal to 25 HP. EPIC used ORION 2017 to generate 2016 regional off-road emissions for HP greater than or equal to 25. For the vehicles with HP equal to 25, data may overlap with SORE 2020 results. EPIC used SORE 2020 results for the overlapping vehicles because SORE 2020 is the latest and most recently updated model. Pleasure crafts and recreational vehicles are subcategories in ORION 2017; however, no San Diego regional data were available. EPIC used CARB's pleasure craft model, PC2014, and recreational vehicle model, RV 2018, to generate the emission data for the respective subcategories.[15] Like SORE 2020, both these models are standalone Microsoft Access models.

Table B.6 shows the different databases used to generate the emissions for the different vehicle subcategories.

[14] CARB: ORION 2017 and SORE 2020 Small Off Road Engine model.

[15] CARB: PC2014 Pleasure Craft model and RV 2018 Recreational Vehicle model.

Table B.6: Databases Used to Estimate Off-Road Emissions

Databases Used to Estimate Off-Road Emissions	
Databases/Models	**Vehicle Subcategories**
ORION 2017, SORE 2020	Agriculture
ORION 2017, SORE 2020	Airport Ground Support
ORION 2017, SORE 2020	Cargo Handling Equipment
ORION 2017, SORE 2020	Construction and Mining
ORION 2017, SORE 2020	Industrial
SORE 2020	Lawn
ORION 2017, SORE 2020	Light Commercial
ORION 2017	Military Tactical Support
PC2014	Pleasure Crafts
ORION 2017	Portable Equipment
RV 2018	Recreational Vehicles
ORION 2017, SORE 2020	Transportation Refrigeration Unit

Source: CARB: ORION 2017, SORE 2020, PC2014 Pleasure Craft model, RV 2018 Recreational Vehicle model; EPIC, USD 2020.

The key inputs and 2016 GHG emissions are shown in Table B.7.

Table B.7: Key Inputs and 2016 Greenhouse Gas Emissions from Off-Road Transportation

Key Inputs and 2016 Greenhouse Gas Emissions from Off-Road Transportation	
Subcategories	**GHG Emissions (MMT CO_2e)**
Agriculture	0.010
Airport Ground Support	0.017
Cargo Handling Equipment	0.002
Construction and Mining	0.204
Industrial	0.097
Lawn	0.052
Light Commercial	0.071
Military Tactical Support	0.022
Pleasure Crafts	0.066
Portable Equipment	0.068
Recreational Vehicles	0.003
Transportation Refrigeration Unit	0.008
Total	**0.62**

Source: CARB: ORION 2017, SORE 2020, PC2014 Pleasure Craft model, RV 2018 Recreational Vehicle model; EPIC, USD 2020.

Rail

The rail category includes GHG emissions from both passenger and freight rail resulting from the combustion of fuels in internal combustion engines. Emissions from rail contribute to 0.4% of total emissions in the 2016 inventory.

Method Used to Estimate 2016 Emissions

Detailed activity or fuel consumption data for rail were not available for the San Diego region. EPIC scaled the emissions from the CARB statewide inventory to the San Diego region, based on the ratio of 2016 County Business Pattern establishments for support activities for rail transportation to that of the state.[16]

Because the rail category in CARB's statewide inventory is not separated into freight and passenger rail subcategories, EPIC used the number of support establishments for rail in the San Diego region to capture both freight and passenger rail activities. However, it may not represent the exact ratio of all rail in the region compared to the state. The most

[16] CARB: CARB Greenhouse Gas Emission Inventory – Query Tool, accessed on October 25, 2020. U.S. Census Bureau: 2016 County Business Patterns, accessed on October 25, 2020. The NAICS Code for rail transportation support activities is 4882.

recent 2018 County Business Pattern data do not show any data on support establishments for rail transportation for the San Diego region; therefore, the method used in this appendix may be limited. Table B.8 shows the key inputs and 2016 GHG emissions from rail.

Table B.8: Key Inputs and 2016 Greenhouse Gas Emissions from Rail

Key Inputs and 2016 Greenhouse Gas Emissions from Rail	
Support Activities for Rail Transportation in California	78
Support Activities for Rail Transportation in San Diego Region	4
Total Rail Emissions in California (MMT CO_2e)	2.17
Total Rail Emissions in San Diego (MMT CO_2e)	**0.11**

Support Activities for Rail Transportation: NAICS 4882. Industries under NAICS 4882 provide services that support rail transportation.

Source: EPIC, USD 2020.

Electricity

GHG emissions from electricity use in the San Diego region account for 20% of total emissions in the 2016 inventory.

Method Used to Estimate 2016 Emissions

To estimate GHG emissions from grid-supply electricity use, EPIC adjusted the 2016 electricity sales with transmission and distribution losses and multiplied the adjusted sales by the electricity emission factor, expressed in pounds of CO_2e per megawatt-hour (lbs CO_2e/MWh).

The local utility, San Diego Gas & Electric (SDG&E), provided the 2016 San Diego regional electricity sales by bundled and Direct Access (DA) supply for each customer class. The San Diego regional electricity sales account for electricity sales to all local jurisdictions, including military bases and tribal reservations.[17] The transmission and distribution loss factor, 0.082, is the loss estimate for the entire SDG&E service territory (larger than the San Diego region) and accounts for the difference between electricity generated for load and electricity sales.[18]

SDG&E and electric service providers (ESPs) for DA customers have different power mixes in their electricity supplies. The SDG&E 2016 bundled emission factor, 527 lbs CO_2e/MWh, was calculated using Federal Energy Regulatory Commission Form 1 data, the California Energy Commission (CEC) Power Source Disclosure Program data on SDG&E-owned and purchased power, and EPA's Emissions and Generating Resource Integrated Database (eGRID) on specific power plant emissions. EPIC's technical working paper, "Estimating Annual Average Greenhouse Gas Emission Factors for the Electricity Sector: A Method for Inventories," describes the detailed method to calculate the SDG&E bundled electricity

[17] Electricity sales data provided by SDG&E to EPIC, August 16, 2018.

[18] Loss factor is from CEC Energy Demand 2019 Forecast. For each forecast cycle, utilities provide the estimates, which remain relatively stable. Personal communication with CEC staff. March 23, 2020.

emission factor.[19] The DA emission factor, 836 lbs CO_2e/MWh, is a default taken from the California Public Utilities Commission Decision 14-12-037.[20]

Two adjustments are made to the emissions estimate based on grid-supply electricity:

- Emissions associated with electricity use at water treatment plants in the San Diego region were allocated to the water category and removed from the electricity category. The method used to identify electricity use at water treatment plants is discussed in the *Water* section of this appendix B.
- Emissions associated with natural gas used for on-site self-serve electric generation, mostly attributed to co-generation plants, were removed from the natural gas category and allocated to the electricity category. EPIC used the CEC Quarterly Fuel and Energy Report (QFER) Power Plant Owner Reporting database, U.S. Energy Information Administration (EIA) Form 923 data, and the 2016 SDG&E Power Source Disclosure Program to identify the self-serve electric generation plants.

With the adjustments, the key inputs and results are shown in Table B.9.

Table B.9: Key Inputs and 2016 Greenhouse Gas Emissions from Electricity

Key Inputs and 2016 Greenhouse Gas Emissions from Electricity	
Electricity Sales – Bundled (MWh)	14,482,332
Electricity Sales – Direct Access (MWh)	3,360,561
Transmission and Distribution Loss Factor	1.082
SDG&E Electricity Emission Factor (lbs CO_2e/MWh)	527
Direct Access Electricity Emission Factor (lbs CO_2e/MWh)	836
GHG Emissions (MT CO_2e)	5,121,950
GHG Emissions Associated with Electricity for Water Treatment – Excluded (MT CO_2e)	–58,925
GHG Emissions Associated with Natural Gas Used at On-Site Self-Serve Electric Generation – Added (MT CO_2e)	204,014
GHG Emissions (MT CO_2e)	5,267,039
GHG Emissions (MMT CO_2e)	**5.3**

Source: CEC 2020; SDG&E 2018; EPIC, USD 2020.

[19] EPIC: Estimating annual average greenhouse gas emission factors for the electric sector: a method for inventories (2016), accessed May 7, 2020.

[20] D.14-12-037, December 18, 2014, in Rulemaking 11-03-012 (filed March 24, 2011). The recommended emission factor is 0.379 MT CO_2e/MWh (836 lbs CO_2e/MWh).

Natural Gas

The combustion of natural gas for building end use accounts for 12% of total emissions in the 2016 inventory. This category calculates emissions from building end use natural gas for purposes other than electric generation, not for utility-level electric generation (UEG) and not for on-site self-serve electric generation, as they are accounted for under the electricity category. However, emissions associated with natural gas use for heat output from any of the co-generation plants are captured in this category.

Method Used to Estimate 2016 Emissions

To estimate GHG emissions from metered natural gas end use, EPIC multiplied the metered natural gas sales by a constant natural gas emission factor.

SDG&E provided the 2016 San Diego regional natural gas sales by customer class. The San Diego regional natural gas sales are sales to all local jurisdictions, including military bases and tribal reservations. The natural gas use for UEG purposes, either at co-generation or electric generation plants, is excluded.[21] However, certain co-generation plants may have dual purposes that generate electricity use for both on-site use and sales to the utility. EPIC used the natural gas emission factor, 0.00545 MT CO_2e per therm, based on CARB's statewide inventory data.[22]

Three adjustments are made to the emissions estimate based on natural gas sales:

- Emissions associated with natural gas used at on-site self-serve electric generation, mostly co-generation plants, were removed from this category and allocated to the electricity category. EPIC used the CEC QFER Power Plant Owner Reporting database, EIA Form 923, and the 2016 SDG&E Power Source Disclosure Program to identify the self-serve electric generation plants.
- Emissions associated with natural gas used for utility electric sales at dual-purpose (both on-site use and utility sales) co-generation plants were removed from this category because they are already accounted for in the electricity emission factor calculation. The method to identify the plants is the same as above.
- Emissions associated with heat output from utility-level co-generation plants were estimated separately and added to this category. This natural gas use is not captured in the SDG&E natural gas sales. EPIC assumed that excess heat output was sold by the plants for other use (e.g., to another industrial customer nearby). The method to identify the plants is the same as above.

With these adjustments, the key inputs and results are shown in Table B.10.

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21 Natural gas sales data provided by SDG&E, August 16, 2018.

22 CARB: Documentation of California's Greenhouse Gas Inventory (11th Edition), accessed March 23, 2020. The natural gas emission factor is also used in CARB Mandatory GHG Reporting and is the same under each customer class (e.g., residential, commercial).

Table B.10: Key Inputs and 2016 Greenhouse Gas Emissions from Natural Gas

Key Inputs and 2016 Greenhouse Gas Emissions from Natural Gas	
Natural Gas Sales (therms)	585,460,937
Natural Gas Emission Factor (MT CO_2e/therm)	0.00545
GHG Emissions (MT CO_2e)	3,192,578
GHG Emissions Associated with Heat Output from Utility-Level Co-Generation Plants – Included (MT CO_2e) (1)	118,239
GHG Emissions from Natural Gas used to Generate Electricity for Sales to Utility – Excluded (MT CO_2e)* (2)	−3,593
GHG Emissions from Natural Gas Used at On-Site Self-Serve Electric Generation – Excluded (MT CO_2e) (3)	−204,014
Total Adjustment (MT CO_2e) (1+2+3)	−89,369
GHG Emissions (MT CO_2e)	3,103,209
GHG Emissions (MMT CO_2e)	**3.1**

* Does not include power plants generating electricity for utility sales only.

Source: CARB 2019; SDG&E 2018; EPIC, USD 2020.

Industrial

Emissions from GHGs with high GWPs used in industrial processes and the processing of materials to manufacture items (e.g., mineral aggregate products, chemicals, metals, refrigerants, electronics, and other consumer goods) account for 8% of total emissions in the 2016 inventory. GHGs with high GWPs are used in air conditioning units and refrigeration, as well as in the manufacturing of electronics, fire protection equipment, insulation, and aerosols. This category focuses on industrial processes that directly release CO_2 and other GHGs with high GWPs (i.e., SF_6, C_2F_6, C_3F_8, CF_4, C_4F_8, HFC-23, NF_3, HFC-125, HFC-134a, HFC-143a, HFC-236fa, HFC-32) by processes other than fuel consumption.

Method Used to Estimate 2016 Emissions

Similar to the method used in the other fuels category, EPIC scaled down the industrial emissions in the CARB statewide GHG inventory to the San Diego region based on the San Diego region to state ratio relevant to each economic sector.[31]

The following are the IPCC category numbers, subcategory numbers, headings, codes, and fuel types used within each type of activity in the statewide inventory. Only those categories, subcategories, activities, and fuel types causing emissions in the San Diego region are shown:

- 2D1: Industrial Lubricant Use
  - Not Specified Industrial > Fuel Consumption – Lubricants > CO_2
  - Not Specified Transportation > Fuel Consumption – Lubricants > CO_2
- 2D3: Industrial Solvent Use
  - Solvents & Chemicals: Evaporative Losses: Fugitives > Fugitive Emissions > CO_2

- 2E: Electronic Industry
  - Manufacturing: Electric & Electronic Equip.: Semiconductors & Related Products > Semiconductor Manufacture > C_2F_6
  - Manufacturing: Electric & Electronic Equip.: Semiconductors & Related Products > Semiconductor Manufacture > C_3F_8
  - Manufacturing: Electric & Electronic Equip.: Semiconductors & Related Products > Semiconductor Manufacture > C_4F_8
  - Manufacturing: Electric & Electronic Equip.: Semiconductors & Related Products > Semiconductor Manufacture > CF_4
  - Manufacturing: Electric & Electronic Equip.: Semiconductors & Related Products > Semiconductor Manufacture > HFC-23
  - Manufacturing: Electric & Electronic Equip.: Semiconductors & Related Products > Semiconductor Manufacture > NF_3
  - Manufacturing: Electric & Electronic Equip.: Semiconductors & Related Products > Semiconductor Manufacture > SF_6
- 2F: Product Uses as – Not Specified Commercial
  - Use of Substitutes for Ozone-Depleting Substances > CF_4
  - 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 Ozone-Depleting Substances Substitutes
- 2G1b: Other Industrial Product – Electrical
  - Imported Electricity: Transmission and Distribution > Electricity Transmitted > SF_6
  - In State Generation: Transmission and Distribution > Electricity Transmitted > SF_6
- 2G4: Other Industrial Product – CO_2, Limestone
  - Not Specified Industrial > CO_2 Consumption > CO_2
  - Not Specified Industrial > Limestone and Dolomite Consumption > CO_2
  - Not Specified Industrial > Soda Ash Consumption > CO_2

EPIC used different ratios to scale down the activities above to the San Diego region. Table B.11 shows the ratios used and their values in 2016.

Table B.11: Key Inputs and 2016 Greenhouse Gas Emissions from Industrial

Key Inputs and 2016 Greenhouse Gas Emissions from Industrial				
Economic Sector/Industry	**Basis for Ratio Value**	**California (MMT CO_2e)**	**Ratio Value**	**San Diego Region (MMT CO_2e)**
Industrial Lubricant and Limestone Use	San Diego manufacturing sector employees/ California manufacturing sector employees	1.93	9%	0.17
Industrial Lubricant Use – Not Specified Transportation (Lubricant, ODS)	San Diego VMT/California statewide VMT	5.55	9%	0.51
Industrial Solvent Use – Solvents and Chemicals	San Diego manufacturing sector employees/ California manufacturing sector employees	0.79	9%	0.07
Electronic Industry – Semiconductor Manufacture	San Diego semiconductor manufacturing sector employees/California semiconductor manufacturing sector employees	0.16	7%	0.01
Not Specified Residential (ODS)	San Diego total residential units/California total residential units	3.17	9%	0.27
Not Specified Commercial (ODS)	San Diego total employees/California total employees	11.9	9%	1.01
Imported Electricity – Transmission and Distribution	San Diego purchased electricity/California purchased electricity	0.03	11%	0.004
In State Generation – Transmission and Distribution	San Diego in-county electricity generated/ California in-state electricity generated	0.07	3%	0.002
Total GHG Emissions (MMT CO_2e)		**24**	**N/A**	**2.1**

ODS – Emissions from use of substitutes for Ozone-Depleting Substances.
Source: 2016 County Business Patterns; SANDAG ABM14.2.2 VMT; EMFAC2017 statewide on-road emission inventory; SANDAG demographic data; EPIC, USD 2021.

Emissions from the following categories were included in CARB's statewide inventory but not in the 2016 regional inventory because Economic Census data indicated no economic activity in the San Diego region.[32] The categories are:

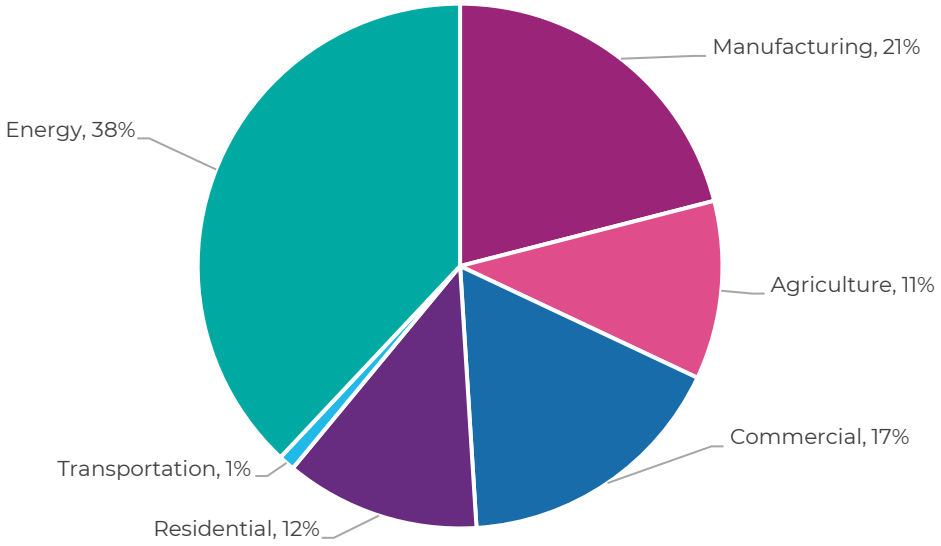
- 2A1: Manufacturing: Stone, Clay, Glass, and Cement: Cement > Clinker Production > CO_2
- 2A2: Manufacturing: Stone, Clay, Glass, and Cement: Lime > Lime Production > CO_2
- 2B2: Manufacturing: Chemical and Allied Products: Nitric Acid > Nitric Acid Production > N_2O
- 2H3: Petroleum Refining: Transformation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

Other Fuels

The Other Fuels category accounts for 4% of total emissions in the 2016 inventory. These fuels include distillate (other than in power production), kerosene, gasoline (other than in transportation), liquefied petroleum gas (LPG), residual fuel oil (other than in power production), and wood (wet).

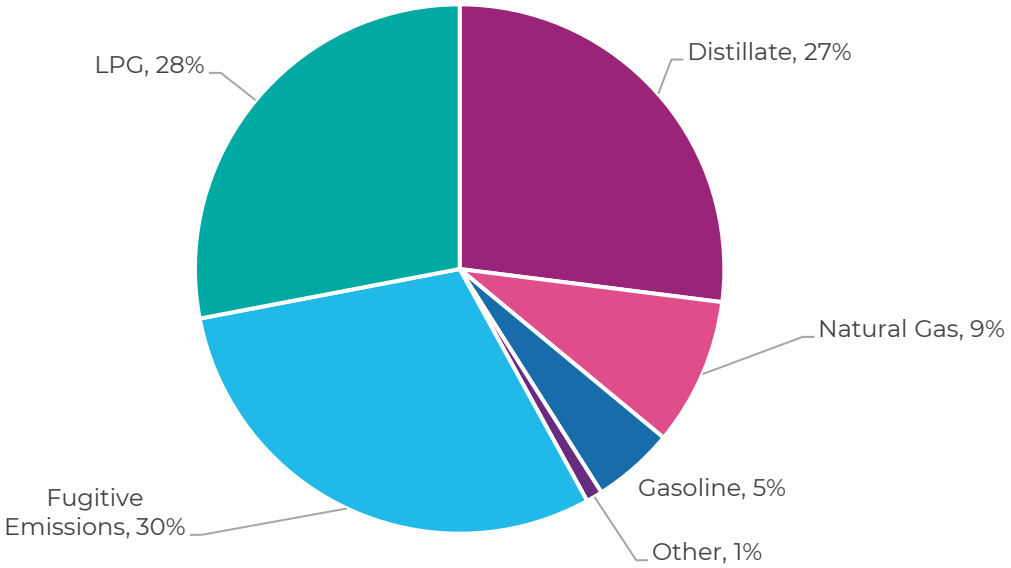
Emissions from this category are divided into the following economic sectors, according to the CARB statewide GHG inventory: agriculture, commercial, residential, transport, energy, and manufacturing. The relative distribution of emissions by economic sector is provided in Figure A.1 and by fuel type in Figure A.2.

Figure B.1: Relative Distribution of 2016 Greenhouse Gas Emissions from Other Fuels by Economic Sectors



Source: EPIC, USD 2020.

Figure B.2: Relative Distribution of 2016 Greenhouse Gas Emissions from Other Fuels by Fuel Type



Source: EPIC, USD 2020.

Method Used to Estimate 2016 Emissions

The GHG emissions from the CARB statewide inventory were the basis of the regional estimates.[23] EPIC scaled down the statewide emissions by economic sector to the San Diego region based on whether a particular category had any economic activity in the San Diego region using relevant economic, population, employment, or transportation data. Therefore, not all of CARB's statewide emissions from these economic sectors are included in the 2016 regional inventory.

CARB uses the IPCC category and subcategory names and codes, as specified in the IPCC 2006 Guidelines for GHG Inventories, to be consistent with the EPA national inventory. Below are only those IPCC categories, subcategories, activities, and fuel types with GHG emissions in the San Diego region, based on economic activity data in the San Diego region.

CARB agriculture sector: EPIC scaled down the emissions from the following categories to San Diego region using the 2016 ratio of the revenue generated by agricultural activities in the San Diego region to the statewide agricultural revenue.[24]

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

[23] CARB Greenhouse Gas Emission Inventory – Query Tool for years 2000 to 2017 (12th edition), accessed on May 25, 2020.
[24] California Department of Food & Agriculture: California Agricultural Statistics Review, 2016–2017. accessed May 28, 2020.

- Kerosene > CH_4, CO_2, N_2O
- Gasoline > CH_4, CO_2, N_2O
- Ethanol > CH_4, CO_2, N_2O

CARB commercial sector: EPIC scaled down the emissions from the following categories to the San Diego region using the 2016 ratio of the number of employees in the San Diego region's manufacturing sector to the statewide manufacturing sector.[25]

- 1A4a: Commercial/Institutional > Not Specified Commercial
  - Distillate > 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

CARB residential sector: EPIC scaled down the emissions from the following categories to the San Diego region using the 2016 ratio of the San Diego regional population to the statewide population.[26]

- 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

CARB transportation sector: This category included the emissions from LPG fuel combustion. EPIC scaled down the emissions from the following categories to the San Diego region using the 2016 ratio of San Diego regional VMT to statewide VMT.[27]

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

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25 2016 County Business Patterns, accessed on May 30, 2020. The 2012 North American Industry Classification System (NAICS) Code for manufacturing Sector is 31-33.

26 San Diego demographic data are shown in Table A.2. Statewide population projections are from California Department of Finance, accessed on May 30, 2020.

27 San Diego regional 2016 VMT are provided in Table A.4 and Table A.5. California statewide VMT is from EMFAC2017, accessed on June 1, 2020.

CARB energy sector: This category included the emissions from the transmission and distribution of electricity (e.g., fugitive and fuel combustion emissions from natural gas pipelines used for electric generation, non-natural gas pipelines and natural gas storage). EPIC scaled down the emissions from the following categories to the San Diego region using the 2016 ratio of total establishments for transmission and distribution activities in the San Diego region to the statewide establishments for the same activities.[28]

- 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

CARB manufacturing sector: EPIC scaled down the emissions from the following categories to the San Diego region using the 2016 ratio of the number of employees in the San Diego region's manufacturing sector and the statewide manufacturing sector.[29]

- 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

[28] 2016 County Business Patterns, accessed on May 30, 2020. The 2012 NAICS Code for Electric Power Generation, Transmission and Distribution is 2211.

[29] 2016 County Business Patterns, accessed on May 30, 2020. The 2012 NAICS code for manufacturing sector is 31-33.

    - 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

Several categories were included in CARB's statewide inventory, but not in this 2016 regional inventory, because 2016 business patterns in data for the San Diego region indicated no economic activities under these categories. The categories are:

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

The key inputs and results are shown in Table B.12.

Table B.12: Key Inputs and 2016 Greenhouse Gas Emissions from Other Fuels

Key Inputs and 2016 Greenhouse Gas Emissions from Other Fuels	
Economic Sectors Associated with Other Fuels*	**2016 Emissions (MMT CO_2e)**
Agriculture	0.12
Commercial	0.20
Residential	0.13
Transportation	0.01
Energy	0.44
Manufacturing	0.24
Total GHG Emissions	**1.1**

* Economic sectors used in CARB statewide GHG inventory.

Source: California Agricultural Statistics Review 2016–2017; 2016 County Business Patterns; SANDAG ABM14.2.2 VMT; EMFAC2017 statewide on-road emission inventory; EPIC, USD 2020.

Solid Waste

Emissions from solid waste are a result of biodegradable, carbon-bearing waste decomposing in largely anaerobic environments and producing landfill gas. The degradation process can take 5 to 50 years. Emissions from solid waste contribute to 2% of total emissions in the 2016 inventory.

Method Used to Estimate 2016 Emissions

EPIC estimated the emissions from solid waste using method SW.4 from the ICLEI U.S. Community Protocol.[30] The emissions are based on the disposed waste in a given year, the characterization of the waste stream, and emissions factor of each type of waste. Because a waste characterization study for the entire region was not available, EPIC used the waste characterization studies from the cities of Chula Vista, Oceanside, and San Diego to estimate the waste composition in the region.[31] The solid waste emission factors, MT CO_2e per short ton of waste by type, are from the EPA Waste Reduction Model (WARM).[32] Table B.13 shows the waste composition derived and the corresponding emission factors.

[30] ICLEI: U.S. Community Protocol Appendix E, accessed in May 2020.

[31] The City of Chula Vista and the City of Oceanside's waste characterization studies were provided by the jurisdictions. Personal communication. City of San Diego Waste Characterization Study.

[32] U.S. EPA Waste Reduction Model (WARM) Version 15.

Table B.13: Estimated San Diego Region Solid Waste Composition

Estimated San Diego Region Solid Waste Composition		
Type of Waste	**Percentage of Total Composition***	**Landfill Methane Without Recovery (MT CO_2e/Short Ton)**
Paper	17%	2.12
Plastic	9.9%	0
Glass	1.9%	0
Metal	3.5%	0
Organics	40.4%	1.03
Electronics	0.8%	0
Inerts and Other	21.2%	0.07
Household Hazardous Waste	0.2%	0
Special Waste	2.9%	0
Mixed Residue	2.1%	0

* The composition was derived from the waste composition of the City of Chula Vista, City of Oceanside, and City of San Diego.

Source: EPIC, USD 2020.

The 2016 emissions from solid waste are provided in Table B.14.

Table B.5: Key Inputs and 2016 Greenhouse Gas Emissions from Solid Waste

Key Inputs and 2016 Greenhouse Gas Emissions from Solid Waste	
Total Waste Disposal (short tons)	3,317,216
Mixed Waste Emission Factor (MT CO_2e/short ton)*	0.79
Landfill Gas Capture Rate	0.75
Oxidation Rate	0.10
Total GHG Emissions (MMT CO_2e)	**0.59**

* Weighted average from Table X.26.

Source: EPIC, USD 2020.

Water

The GHG emissions from energy associated with upstream supply and conveyance, and treatment of water account for 1% of total emissions in the 2016 inventory. This category does not include emissions associated with electricity used for water distribution and water end use (e.g., water heating at homes). The emissions from energy used for water distribution and water end use are captured in the electricity and natural gas categories, discussed in previous sections.

Method Used to Estimate 2016 Emissions

The San Diego County Water Authority (SDCWA) is the water wholesaler for the San Diego region. SDCWA imports raw and treated water on behalf of its 24 member agencies. The raw water sources, from the State Water Project and Colorado River, vary year by year depending on water availability; therefore, the energy needed to supply and convey water differs as well. The latest available upstream energy intensity, in kWh per acre-foot of water, is from the average of fiscal years 2013 and 2014 in the SDCWA 2015 Urban Water Management Plan. EPIC calculated the GHG emissions from upstream water supply by multiplying the water supplies with their respective energy intensities and the California average electricity GHG emission factor in 2016.[33] The upstream emissions are shown in Table B.15.[34]

Table B.15: 2016 Upstream Emissions from Water Supply

2016 Upstream Emissions from Water Supply		
Water Source	**Imported Treated Water**	**Imported Raw Water**
Water Demand (acre-feet)	138,312	282,726
Energy Intensity (kWh/acre-foot)*	1,862	1,817
California Average Electricity Emission Factor (lbs CO_2e/MWh)**	530	530
Upstream GHG Emissions (MT CO_2e)		185,411

* Includes water conveyance from the State Water Project and Colorado River to Metropolitan Water District and SDCWA system. The difference between energy intensity for treated and raw water is the water treatment energy intensity.

** eGRID 2016 CAMX subregion emission factor.

Source: EPIC, USD 2020.

SDCWA has its own water treatment plant (WTP), Twin Oaks WTP, and many SDCWA member agencies have their own WTPs as well. Member agencies that do not have WTPs may purchase treated water from other member agencies or from SDCWA. For example, the City of San Diego and the City of Del Mar are member agencies of the SDCWA, but the City of San Diego provides water treatment service for the City of Del Mar. Local water treatment energy intensity depends on water sources, treatment level, capacity, and efficiency of the WTP. For example, brackish groundwater requires advanced treatment, such as reverse osmosis, to remove the salinity in the water, so its treatment has a higher energy intensity than surface water treatment with conventional methods. Table B.16 below shows the WTPs in the San Diego region, the water treated, and the associated

[33] SDCWA 2016: Urban Water Management Plan 2015, Metropolitan Water District of Southern California, Urban Water Management Plan 2015. The Western Electricity Coordinating Council CAMX (eGRID Subregion) emission rate from eGRID was used as representative of the average California electricity emission rate for upstream electricity. U.S. EPA. eGRID 2016 Edition, released February 15, 2018, accessed June 29, 2018.

[34] 2016 water source and demand for each SDCWA member agency were provided by SDCWA staff to EPIC, October 23, 2018.

electricity use for water treatment in 2016.[35] EPIC calculated the GHG emissions from water treatment by multiplying the electricity used for water treatment with SDG&E 2016 electricity GHG emission factor.

Table B.16: 2016 Emissions from Local Water Treatment

2016 Emissions from Local Water Treatment				
Water Treatment Plant	**Plant Operator**	**Water Treated (Acre-Feet)**	**Water Treatment Energy Intensity (kWh/Acre-Foot)**	**Water Treatment Electricity Use (kWh)**
R.M. Levy WTP	Helix WD	42,767	58	2,493,844
R.E. Badger Filtration Plant	Santa Fe ID	12,685	44	558,346
Combined Miramar, Otay, and Alvarado WTP*	City of San Diego	163,823	56	9,151,144
Escondido-Vista WTP	Escondido + Vista ID	30,678	47	1,441,875
David C. McCollum WTP	Olivenhain MWD	21,301	142	3,018,745
Richard A. Reynolds Ground Water Desalination Facility	Sweetwater Authority	1,855	1,174	2,178,583
Robert A. Perdue WTP	Sweetwater	13,347	141	1,879,760
Lester J. Berglund WTP	City of Poway	10,329	208	2,150,666
Robert A. Weese WFP	City of Oceanside	11,878	29	348,546
Mission Basin Groundwater	City of Oceanside	2,997	1,257	3,766,499
Twin Oaks Valley WTP	SDCWA	79,538	33	2,661,602
Carlsbad Desalination Plant**	SDCWA	45,107	4,397	198,335,919
Total Water Treatment Electricity Use (kWh)				227,985,529
SDG&E Electricity Emission Factor (lbs CO_2e/MWh)				527
Transmission and Distribution Loss Factor				1.082
Local Treatment GHG Emissions (MT CO_2e)				58,925

ID: irrigation district; WD: water district; WFP: water filtration plant; WTP: water treatment plant.

* The electricity use and energy intensity include both water treatment and conveyance from nearby reservoirs for City of San Diego WTPs and both water extraction and treatment for Sweetwater Authority's brackish water desalination plant. The data associated with water treatment cannot be separated out.

** The water treated at the plant includes SDCWA wholesale water and local supply for individual SDCWA member agencies that have separate contracts with the plant. The energy intensity is the high efficiency estimate from the Plant's Environmental Impact Report (2008).

[35] Data were collected by EPIC from 2018 to 2020 for the development of SANDAG's 2016 and 2018 "ReCAP Snapshots" (greenhouse gas inventory and Climate Action Plan monitoring reports prepared for local jurisdictions).

Source: EPIC, USD 2020.

Combining the upstream and local emissions, the total 2016 emissions from water are shown in Table B.17.

Table B.17: 2016 Greenhouse Gas Emissions from Water Supply, Treatment, and Distribution

2016 Greenhouse Gas Emissions from Water Supply, Treatment, and Distribution	
Upstream GHG Emissions (MT CO_2e)	185,411
Local Treatment GHG Emissions (MT CO_2e)	58,925
Total (Upstream + Local) GHG Emissions (MT CO_2e)	244,337
Total (Upstream + Local) GHG Emissions (MMT CO_2e)	**0.24**

Source: EPIC, USD 2020.

Wastewater

The GHG emissions from domestic wastewater treatment account for 0.3% of total emissions in the 2016 inventory. This category presents emissions from community-generated wastewater treated at centralized wastewater treatment plants and on-site septic systems. Emissions associated with the energy used to collect and treat wastewater are not included in this category but are included in the electricity and natural gas category.

Method Used to Estimate 2016 Emissions

In 2019, SANDAG, in collaboration with local jurisdictions, prepared the 2016 Regional Climate Action Planning Framework (ReCAP) Snapshots to assist local jurisdictions with monitoring community-wide GHG emissions and Climate Action Plan (CAP) implementation.[36] EPIC calculated the 2016 community-wide GHG emissions inventories for 16 (out of 19) jurisdictions in the San Diego region and used the wastewater emissions from these 16 GHG inventories directly in this category.

The City of Coronado postponed preparation of a ReCAP Snapshot due to the ongoing CAP development; however, 2016 wastewater flow was collected during the data-collection process. The GHG emissions shown in Table A.18 for Coronado include wastewater flow from military bases in Coronado to the Point Loma Wastewater Treatment Plant (WWTP). Depending on the boundary determined in the future Coronado CAP, the wastewater emissions estimated here may differ from those calculated under the CAP.

The City of San Diego and the unincorporated County of San Diego (the County) report community-wide GHG emissions separately under their own CAP monitoring processes. The 2016 wastewater emissions from the City of San Diego are taken directly from its

[36] SANDAG: Climate Action. November 2019 ReCAP Snapshots (with 2016 GHG Emissions Inventories).

2019 CAP Annual Report.[37] For the County, EPIC estimated the 2016 wastewater emissions using its 2014 (CAP baseline year) wastewater emissions and population increase.[38] The key inputs and 2016 wastewater emissions are show in Table B.18.

Table B.18: Key Inputs and 2016 Greenhouse Gas Emissions from Wastewater

Key Inputs and 2016 Greenhouse Gas Emissions from Wastewater	
Local Jurisdiction	**2016 Wastewater Emissions (MT CO_2e)**
Carlsbad	2,972
Chula Vista	2,577
Coronado	260
Del Mar	87
El Cajon	1,161
Encinitas	1,916
Escondido	4,986
Imperial Beach	353
La Mesa	734
Lemon Grove	260
National City	656
Oceanside	5,751
Poway	1,140
San Diego*	21,257
San Marcos	2,915
Santee	584
Solana Beach	619
Vista	3,207
Unincorporated County of San Diego**	21,583
Total	73,014
Total (MMT CO_2e)	**0.07**

* 2016 emissions reported in the City of San Diego CAP 2019 Annual Report.

** Estimated based on 2014 wastewater emissions reported in the County of San Diego CAP Appendix A (21,183 MT CO_2e), 2014 population (498,159), and 2016 population (507,555).

All wastewater emissions are from SANDAG November 2019 ReCAP Snapshots (with 2016 GHG Emissions), except City of San Diego and County of San Diego.

Source: SANDAG 2019, EPIC, USD 2020

[37] City of San Diego CAP: 2019 Annual Report Appendix (2020), accessed November 2, 2020.

[38] County of San Diego CAP Appendix A: 2014 Greenhouse Gas Emissions Inventory and Projections (2017), accessed May 20, 2020.

Civil Aviation

The GHG emissions from commercial aviation operations account for 1% of total emissions in the 2016 inventory. The San Diego International Airport (SAN) and McClellan-Palomar Airport (CRQ) are the only airports in the San Diego region in 2016 with scheduled commercial flights services, while other airports operate on a private and on-demand basis.[39] Because 99% of commercial passengers in the San Diego region are covered by SAN and CRQ, this category does not include the GHG emissions associated with aviation operations at other municipal airports in the San Diego region.[40] GHG emissions in this category are from combustion of jet fuel and aviation gasoline used by commercial aircrafts.

Method Used to Estimate 2016 Emissions

EPIC used the aircraft emissions reported in the SAN 2016 GHG Emissions Inventory (SAN GHG Inventory)—developed by the San Diego County Regional Airport Authority—and CRQ 2016 Emissions Inventory—developed for the CRQ Master Plan Program Environmental Impact Report (PEIR). The aircraft emissions in the SAN GHG Inventory are calculated based on the Airport GHG Emissions Management Guidance Manual and include emissions from aircraft start up, take off, and up to mixing height (3,000 feet).[41] The aircraft emissions in CRQ 2016 Emissions Inventory include emissions from fuel combustion and emissions from auxiliary power units.[42]

The 2016 aircraft emissions were 213,353 (0.2 MMT CO_2e), with 95% from SAN aircraft emissions and 5% from CRQ aircraft emissions.

Agriculture

GHG emissions from livestock (from enteric fermentation and manure management) are included in this category. Enteric fermentation is a microbial fermentation process that occurs in the stomach of ruminant animals, producing CH4 that is released through flatulence and eructation. Manure management is the process by which manure is stabilized or stored. CH4 and N2O emissions result from livestock manure, and the amount of gas produced depends on the manure management system involved. The agriculture category contributes to 0.2% of total emissions in the 2016 inventory.

Method Used to Estimate 2016 Emissions

EPIC followed the ICLEI U.S. Community Protocol for Emissions from Domestic Animal Production within a Community (A.1 and A.2) to calculate the emissions from agriculture.[43] Method A.1 addresses enteric fermentation from livestock production. CH4 emissions due

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[39] Airports with scheduled commercial flights follow Federal Aviation Administration (FAA)'s FAR Part 139 rules. On-demand basis refers to aviation operators allowed under FAA rules to accept paying passengers (FAR Part 135 operators).

[40] FAA: Passenger Boarding (Enplanement) and All-Cargo Data for U.S. Airports, CY 2016. Airports included are SAN, CRQ, Miramar MCAS, North Island NAS, Montgomery-Gibbs, Brown Field, and Gillespie Field.

[41] San Diego County Regional Airport Authority: 2016 Greenhouse Gas Emissions Inventory (October 16, 2018), provided by Airport Authority staff to EPIC, August 7, 2018.

[42] CRQ Master Plan Update PEIR: Appendix H – Climate Change Technical Report (2018).

[43] ICLEI: U.S. Community Protocol for Emissions from Domestic Animal Production within a Community, accessed August 3, 2020.

to enteric fermentation are derived from the livestock population and emission factors for each animal type. Method A.2 addresses emissions from manure management. Emissions from manure management are derived from data on animal populations, animal characteristics, and manure management practices. Method A.2 is broken up into three subcategories, including CH4 emissions from manure management (A.2.1), direct N2O emissions from manure management (A.2.3), and indirect N2O emissions from manure management (A.2.4).

All the emission factors and other factors used for the calculations were taken from the ICLEI protocol. Table B.19 shows the factors used to calculate the agriculture emissions.

Table B.19: Factors Used to Calculate Greenhouse Gas Emissions from Agriculture

Factors Used to Calculate Greenhouse Gas Emissions from Agriculture							
	Dairy Cattle	**Other Cattle, Including Calves**	**Beef Cattle**	**Sheep**	**Goats**	**Swine**	**Horses**
Methane Emissions from Enteric Fermentation (A.1)							
Enteric Fermentation Emission Factor (kg CH_4/head/year)	147	54	100	8	5	1.5	18
Methane Emissions from Manure (without anaerobic digester) (A.2.1)							
Percentage Dry Lot	0	0.11	1	0.5	0.5	0	0.5
Percentage Pasture	0	0	0	0.5	0.5	0.2	0.5
Percentage Liquid Slurry	0.2	0.09	0.01	0	0	0.07	0
Percentage Daily Spread	0.1	0.01	0	0	0	0	0
Percentage Solid Storage	0.09	0	0	0	0	0	0
Percentage Anaerobic Lagoon	0.6	0.21	0	0	0	0.43	0
Percentage Dip Pit	0	0.58	0	0	0	0.27	0
Volatile Solid (VS) (kg/animal/year)	2,025	1,252	1,259	0	0	0	0
Average VS (kg/day/1,000 kg animal mass)	0	0	0	8.3	9.5	5.4	6.1
Typical Animal Mass	0	0	0	25	64	39	450

Factors Used to Calculate Greenhouse Gas Emissions from Agriculture							
	Dairy Cattle	**Other Cattle, Including Calves**	**Beef Cattle**	**Sheep**	**Goats**	**Swine**	**Horses**
Max CH_4 Producing Capacity per Pound of Manure (m^3 kg VS)	0.24	0.17	0.33	0.36	0.17	0.48	0.33
Methane Conversion Factor Pasture	0.015	0	0	0.015	0.015	0.015	0.015
Methane Conversion Factor Dry Lot	0	0.015	0.015	0.015	0.015	0	0.015
Methane Conversion Factor Liquid Slurry	0.34	0.35	0.43	0	0	0.33	0
Methane Conversion Factor Daily Spread	0.005	0.005	0	0	0	0	0
Methane Conversion Factor Solid Storage	0.04	0	0	0	0	0.04	0
Methane Conversion Factor Anaerobic Lagoon	0.73	0.75	0	0	0	0.73	0
Methane Conversion Factor Dip Pit	0	0.35	0	0	0	0.33	0
Direct Nitrous Oxide Emissions from Manure (A.2.3)							
Daily Rate of Kjeldahl Nitrogen Excreted (kg N/animal/year)	156	54.7	52.3	0.45	0.45	0.54	0.25
Direct N_2O Emission Factor Dry Lot	0	0.03	0.02	0.03	0.03	0	0.03
Direct N_2O Emission Factor Pasture	0	0	0	0	0	0	0

Factors Used to Calculate Greenhouse Gas Emissions from Agriculture							
	Dairy Cattle	**Other Cattle, Including Calves**	**Beef Cattle**	**Sheep**	**Goats**	**Swine**	**Horses**
Direct N_2O Emission Factor Daily Spread	0	0	0	0	0	0	0
Direct N_2O Emission Factor Solid Storage	0.005	0	0	0	0	0.005	0
Direct N_2O Emission Factor Liquid/Slurry	0.005	0.08	0.005	0	0	0.08	0
Direct N_2O Emission Factor Dip Pit	0	0.002	0	0	0	0.002	0
Direct N_2O Emission Factor Anaerobic Lagoon	0	0	0	0	0	0	0
Indirect Nitrous Oxide Emissions from Manure (A.2.4)							
Frac Gas, Pasture*	0	0	0	0	0	0	0
Frac Gas, Liquid/Slurry	26	26	26	0	0	26	0
Frac Gas, Daily Spread	10	10	0	0	0	0	0
Frac Gas, Dry Lot	0	23	23	23	23	0	23
Frac Gas, Solid Storage	27	0	0	0	0	45	0
Frac Gas, Anerobic Lagoon	43	43	0	0	0	58	0
Frac Gas, Dip Pit	0	24	0	0	0	34	0
Frac Runoff/Leach, Pasture**	0	0	0	0	0	0	0
Frac Runoff/Leach, Daily Spread	0	0	0	0	0	0	0
Frac Runoff/Leach, Solid Spread	0	0	0	0	0	0	0
Frac Runoff/Leach, Liquid/Slurry	0.8	0.8	0	0	0	0.8	0
Frac Runoff/Leach, Anaerobic Lagoon	0.8	0.8	0	0	0	0.8	0

Factors Used to Calculate Greenhouse Gas Emissions from Agriculture							
	Dairy Cattle	**Other Cattle, Including Calves**	**Beef Cattle**	**Sheep**	**Goats**	**Swine**	**Horses**
Frac Runoff/Leach, Dry Lot	0	3.9	3.9	3.9	3.9	0	0
Frac Runoff/Leach, Dip Pit	0	0	0	0	0	0	0

* Frac Gas – Nitrogen lost through volatilization.

** Frac Runoff/Leach – Nitrogen lost through runoff and leaching.

Source: ICLEI 2013; EPIC, USD 2020.

Marine Vessels

The GHG emissions from marine vessels in the San Diego region 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, as well as northern Baja California and Arizona. The GHG emissions from marine vessels account for 0.2% of total emissions in the 2016 inventory.

The emissions are from the following two subcategories:

- **Ocean-Going Vessels (OGV):** These include auto carriers, bulk carriers, passenger cruise vessels, general cargo vessels, refrigerated vessels (reefers), roll-on roll-off vessels, and tankers for bulk liquids.
- **Commercial Harbor Craft (CHC):** These include tugboats, towboats, pilot boats, work boats, ferries, and sports and commercial fishing vessels.

The emissions from OGV or CHC beyond the Port of San Diego's landside and waterside boundary (24 nautical miles from the coastline) are not included in the 2016 inventory.

Method Used to Estimate 2016 Emissions

EPIC used the OGV and CHC emissions reported in the Port of San Diego 2016 Maritime Air Emissions Inventory.[44] The 2016 emissions are shown in Table B.20.

[44] Port of San Diego 2016 Maritime Air Emissions Inventory (2018), accessed May 8, 2020. Other emissions from the 2016 Port of San Diego inventory, e.g., cargo handling equipment, locomotives, and on-road vehicles, are included in "Other categories" of this regional inventory.

Table B.60: 2016 Greenhouse Gas Emissions from Marine Vessels

2016 Greenhouse Gas Emissions from Marine Vessels	
Vessel Type	**2016 Emissions**
OGV (MT CO_2e)	22,500
CHC (MT CO_2e)	25,500
Total GHG Emissions (MT CO_2e)	48,000
Total GHG Emissions (MMT CO_2e)	**0.05**

Source: Port of San Diego, 2018.

Soil Management

Emissions from synthetic fertilizer use and crop residue or soil management contribute to 0.2% of total emissions in the 2016 inventory. The emissions are broken into two subcategories: farm emissions and non-farm emissions. The farm emissions account for the emissions due to agricultural soil management activities, such as synthetic fertilizers used for cultivation purposes to enhance the soil's nutrients and emissions due to crop residue. The non-farm emissions account for synthetic fertilizers used for residential or commercial purposes.

Farm emissions due to agricultural synthetic fertilizer use include direct N_2O emissions, indirect N_2O emissions, and CO_2 emissions from urea and lime application. The non-farm emissions only include direct N_2O and indirect N_2O emissions. The N_2O emissions from crop residues are due to the nitrogen content in the residue.

Method Used to Estimate 2016 Emissions

EPIC followed the IPCC method to calculate the direct and indirect N_2O and CO_2 emissions from managed soils.[45] The IPCC method calculates emissions from manure management, fertilizer application, and agricultural activities. Because the emissions from manure management are accounted for in the agriculture category, this section does not include these emissions.

To calculate the direct and indirect N_2O emissions from fertilizer applications for both farm and non-farm activities, EPIC multiplied the tonnage used by the nitrogen content of each synthetic fertilizer.[46] The nitrogen content of each fertilizer is based on the specific chemical content.[47] If the specific chemical content of a fertilizer is not given,

[45] IPCC: N_2O Emissions from Managed Soils and CO_2 Emissions from Urea and Lime Application, accessed on August 2, 2020.

[46] California Department of Food & Agriculture: 2016 Fertilizing Materials Tonnage Report, accessed on August 3, 2020.

[47] International Fertilizer Association: Fertilizer Converter, accessed on August 3, 2020. This database provides information on the nitrogen content percentage by weight of a given fertilizer.

code 97 fertilizer with a 25-15-17 Nitrogen-Phosphorous-Potassium (NPK) composition is used.

The farm use soil management has N_2O emissions from crop residue and from crop burning activities. Because the San Diego region does not have agricultural burning activities in 2016, EPIC only considered the emissions due to crop residue. Among the crops that have nitrogen content in their residue, only oats/hay are grown in the San Diego region. EPIC calculated the emissions from crop residue using the total nitrogen content in the crop residue based on the acres of crop cultivated.[48] The CO_2 emissions from urea application and from liming are based on the total quantities of urea and lime applied and their respective emission factors.[46] Table B.21 shows the key inputs and results for the soil management emissions.

Table B.21: Key Inputs and 2016 Greenhouse Gas Emissions from Soil Management

Key Inputs and 2016 Greenhouse Gas Emissions from Soil Management	
Total Nitrogen in Farm Use Synthetic Fertilizers (tons)	3,013
Total Nitrogen in Non-Farm Use Synthetic Fertilizers (tons)	5,247
N_2O Emitted per Unit of Nitrogen (kg N_2O-N/kg N)	0.01
N_2O Emitted per Unit of Nitrogen Volatilized (kg N-N_2O/kg NH_3- N + NO_x-N volatilized)	0.01
N_2O Emitted per Unit of Nitrogen Leached/Runoff (kg N_2O-N/kg N leaching/runoff)	0.0075
Total Area of Oats Harvested (acres)	2,100
Total Nitrogen in Crop (Oats/Hay) Residue (kg N)	7,990
Amount on Lime Applied (tons)	216
Carbon Content of Lime (ton C/ton of lime)	0.125
Amount of Urea Applied (tons)	559
Carbon Content of Urea (ton C/ton of urea)	0.2
Direct N_2O Emissions from Farm Activities – Synthetic Fertilizers and Crop Residue (MMT of CO_2e)	0.013
Direct N_2O Emissions from Non-Farm Activities – Synthetic Fertilizer (MMT of CO_2e)	0.022
Indirect N_2O Emissions from Farm Activities – Synthetic Fertilizers and Crop Residue (MMT of CO_2e)	0.004
Indirect N_2O Emissions from Non-Farm Activities – Synthetic Fertilizer (MMT of CO_2e)	0.007
CO_2 Emissions from Farm Urea Applications (MMT CO_2e)	4×10^{-4}

[48] California Department of Agriculture Weights & Measures: 2016 County of San Diego Crop Statistics and Annual Report, accessed on August 4, 2020.

Key Inputs and 2016 Greenhouse Gas Emissions from Soil Management

CO_2 Emissions from Farm Lime Applications (MMT CO_2e)	1×10^{-4}
Total Farm Emissions (MMT CO_2e)	0.02
Total Non-Farm Emissions (MMT CO_2e)	0.03
Total GHG Emissions from Soil Management Sector (MMT CO_2e)	**0.05**

Source: County of San Diego 2016; International Fertilizer Association IPCC 2006; EPIC, USD 2020.