Appendix A Greenhouse Gas Inventory Methodology and 2030 Reduction Target Pathway

AECOM
300 California Street
San Francisco, CA 94104
www.aecom.com

415.796.8100 tel
415.796.8200 fax

Appendix A – Greenhouse Gas Inventory Methodology and 2030 Reduction Target Pathway

PART I – GHG INVENTORY METHODOLOGY

This section presents the calculation methodologies, data sources, and assumptions used to prepare the 2015 GHG inventory. It is organized by emissions sector and subsector. The intent of this section is to provide documentation to guide preparation of future annual inventories to maintain direct comparisons from one year to the next.

Wherever necessary, the project team used the following global warming potential (GWP) factors from the UN International Panel on Climate Change (IPCC) Fifth Assessment Report to convert various greenhouse gases into carbon dioxide equivalent units (CO_2e):

- CO_2 = 1
- CH_4 = 28
- N_2O = 265

STATIONARY ENERGY

Residential Buildings (I.1), Commercial & Institutional Buildings and Facilities (I.2), Manufacturing Industries & Construction (I.3), and Agriculture, Forestry and Fishing Activities (I.5)

The Residential, Commercial/Institutional, Industrial, and Agriculture/Forestry/Fishing subsectors includes the use of electricity and natural gas by these building types or activities within the city boundary.

I.1.1 – FUEL COMBUSTION

Data Sources
Table 1 identifies the sources for fuel consumption activity data and emissions factors. Long Beach Gas & Oil Department (LBGO) provided aggregated natural gas activity data, and an LBGO-specific emissions factor was used to calculate emissions.

Table 1: Stationary Fuel Consumption Data Sources

Description	Source	Units
Natural Gas Consumption by End-Use Category	LBGO[1]	therms / year
Natural Gas – Emission Factor	LBGO[2]	MT / therm

[1] City of Long Beach, 2015. Greenhouse Gas Report to California Air Resources Board
[2] ibid

Calculation Methodology

LBGO provided annual natural gas consumption data within the city boundary by end use category (e.g., residential, commercial and institutional, industrial).

The natural gas activity data was multiplied by an LBGO-specific emissions factor for carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) after standardizing units to calculate total emissions as metric tons of carbon dioxide equivalent (MT CO_2e).

Assumptions

No natural gas use was identified for the agriculture/forestry/fishing subsector. If this type of activity did occur within the City in 2015, the corresponding natural gas use was likely incorporated within the commercial or industrial data from LBGO.

I.1.2 – Electricity

Data Sources

As shown in Table 2, Southern California Edison (SCE) provided electricity consumption data for 2015 sorted by rate category, and a 2015-specific emissions factor.

Table 2: Residential Electricity Data Sources

Description	Source	Units
Electricity Consumption by Rate Category (residential and non-residential)	SCE	kWh / year
SCE – Emissions Factor	SCE	MT / MWh
Estimates of the proportion of non-residential electricity consumption by sector (commercial, industrial, and agricultural)	SCE	percent

Calculation Methodology

SCE provided activity data by rate category (residential and non-residential) but was unable to break down non-residential electricity consumption into sub-categories due to aggregation requirements to protect data privacy. Instead, SCE provided the estimated proportion of non-residential electricity consumption by sector (commercial, industrial, and agricultural) based on historic energy usage.

The project team used this information to calculate estimates of electricity consumption by sector for 2015. The resulting electricity consumption values were multiplied by the SCE emission factors for CO_2, CH_4, and N_2O after standardizing units to calculate total emissions as MT CO_2e.

Assumptions

The project team calculated commercial energy consumption from total non-residential energy consumption based on an estimate provided by SCE based on historic energy usage. This method assumes that the proportion of non-residential electricity consumption attributable to the commercial sector in 2015 is similar to historic patterns.

This subsector includes emissions identified as agriculture based on the SCE information used to allocate the total non-residential electricity data. If energy use was erroneously allocated to agricultural activity within the city boundary, there would be no net change to total electricity emissions results as SCE provided activity data describing total non-residential electricity use; allocation to different end uses (e.g., commercial, industrial) was performed to follow GPC guidance as closely as possible.

Energy Industries (I.4)

The Energy Industries subsector includes the combustion of natural gas and other stationary fuels by energy-related industrial facilities within the city boundary that are engaged in petroleum refining and electricity generation activities, although the latter is not included in the Basic reporting framework (see note in I.4.4 below).

I.4.1 Emissions from Fuel Combustion

Data Sources

Table 3 shows the data sources for activity data and direct emissions reporting used to estimate emissions in this subsector. For the Thums gas and oil field, activity data on fuel consumption was collected from the EPA Flight Database for diesel and natural gas. Data for the Tidelands facility (also called the West Wilmington Field) was not available in the EAP Flight Database, so the project team referred to the CARB industrial emissions database, which provided direct emissions data but not activity data for specific fuel types or uses/activities.

Table 3: Emissions from Fuel Combustion at Refineries

Description	Source	Units
Emissions by GHG from operations at the Thums gas and oil field by fuel type and source	EPA Flight Database[3]	MT / year
Emissions from the Tidelands facility (fuel supplier CO2e)	CARB[4]	MT CO_2e / year
Natural Gas – Emission Factors	EPA[5]	MT / scf
Diesel – Emission Factors	EPA[6]	MT / gallon

Calculation Methodology

Activity data for fuel consumed at the Thums facility was provided in the EPA database and multiplied by corresponding emissions factors from the EPA. For the Thums facility, emissions data from the EPA Flight Database was broken out by greenhouse gas, fuel type, and source.

Activity data for the Tidelands facility was unavailable and the project team used emissions data from the CARB industrial database instead. This information was not broken out by fuel type. The project team inferred that the emissions were from natural gas combustion and back calculated natural gas activity data using the EPA natural gas emissions factor.

Assumptions

Emissions for the Tidelands facility were reported in the CARB industrial database as fuel-supplier emissions and emitter emissions. For purposes of the community inventory, the fuel-supplier emissions were assumed to represent natural gas provided to the facility by SCE since LGBO reported that it does not supply natural gas to the Tidelands facility. This would make the natural gas consumed at Tidelines an additional volume of natural gas from that reported by LBGO and represented elsewhere in the

[3] US Environmental Protection Agency (EPA), 2015. Facility Level Information on Greenhouse Gases Tool (FLIGHT). Available: <https://ghgdata.epa.gov/ghgp/main.do#>
[4] California Air Resources Board, 2015. Annual Summary of 2015 Greenhouse Gas Emissions Data Reported to the California Air Resources Board. Available: < https://ww2.arb.ca.gov/mrr-data>
[5] US Environmental Protection Agency (US EPA), 2015. Emissions Factors for Greenhouse Gas Inventories. Available: <https://www.epa.gov/sites/production/files/2015-11/documents/emission-factors_nov_2015.pdf>
[6] ibid

inventory (e.g., I.1, I.2, I.3), meaning the inclusion of this emissions source is not double-counting emissions reported elsewhere in the inventory. In the absence of additional information on what caused the emitter emissions, the project team assumed they resulted from process emissions (e.g., equipment leaks, pneumatic devices, etc.) at the Tidelands facility. These emissions are reported in subsector I.8.

I.4.4 Emissions from Energy Generation Supplied to the Grid

Emissions from energy generation supplied to the grid are reported as a territorial emissions source and not included in the Basic or Basic+ reporting frameworks. However, the City of Long Beach has calculated this emissions source to provide a more complete analysis of emissions sources in the city. The data sources and methodology for these calculations are provided below.

Note also that this sector includes emissions associated with waste incineration at the Southeast Resources Recovery Facility (SERRF) – these emissions are reported here and not in solid waste (III.3) because the waste is incinerated to produce electricity that is consumed by SCE customers. SCE electricity consumed by residents and businesses in Long Beach is already included in the Stationary Energy sector under I.1.2, I.2.2, and I.3.2.

Data Sources

Table 4 shows the source of activity data and emissions factors used in this subsector. In most cases, facility-level emissions data was gathered from the EPA Flight Database, CARB, and other sources. Emissions in this subsector represent fuel use at facilities engaged in electricity generation and co-generation activities.

Table 4: Energy Generation Data Sources

Description	Source	Units
Natural gas combustion for electricity generation from LBGO	LGBO	therms / year
Landfill gas combustion for electricity generation at Haynes facility	EPA Flight Database[7]	scf / year
Natural gas combustion for electricity generation from SoCalGas at Haynes facility	EPA Flight Database[8]	mmbtu / year
Natural gas combustion for electricity generation from SoCalGas at AES Alamitos facility	EPA Flight Database[9]	MT CO_2 / year
MSW combustion from SERRF for electricity generation	EPA Flight Database[10]	MT CO_2e / year
MSW combustion from SERRF for electricity generation	City of Long Beach[11]	tons of MSW / year (2015)
Natural gas combustion for electricity generation from SoCalGas at NRG Energy	CARB[12]	MT CO_2e / year

[7] US Environmental Protection Agency (EPA), 2015. Facility Level Information on Greenhouse Gases Tool (FLIGHT). Available: <https://ghgdata.epa.gov/ghgp/main.do#>
[8] ibid
[9] ibid
[10] ibid
[11] 2015 waste incineration volume is confidential data. Personal communication between Al Foley at City of Long Beach and Joshua Lathan of AECOM on September 6, 2017.
[12] California Air Resources Board, 2015. Annual Summary of 2015 Greenhouse Gas Emissions Data Reported to the California Air Resources Board. Available: < https://ww2.arb.ca.gov/mrr-data>

Description	Source	Units
Natural Gas – Emission Factor	LBGO[13]	MT / therm
Natural Gas – Emission Factor	EPA[14]	MT / scf

Calculation Methodology

The project team used facility-level emissions data reported in the EPA Flight Database and the EPA natural gas emissions factor to back calculate activity data for natural gas consumed for electricity generation at the AES Alamitos facility (operated by SoCalGas). The project team used activity data directly reported in the EPA Flight Database for natural gas consumed for electricity generation at the Haynes facility (operated by SoCalGas). The project team used facility-level emissions data reported in the EPA Flight Database and the EPA landfill gas emissions factor to back calculate landfill gas activity data used in electricity generation at the Haynes facility.

The project team used emissions data reported by CARB and the EPA natural gas emissions factor to back calculate activity data for natural gas used in electricity generation at the NRG Energy facility.

LBGO provided activity data and an emissions factor for natural gas used in electricity generation at LBGO facilities.

The project team derived a per ton emissions factor to calculate emissions from electricity generation at the SERRF facility. The emissions factor was calculated based on 2015 SERRF emissions reported in the EPA FLIGHT database divided by a known volume of waste incinerated at SERRF in 2015. This calculation provided an estimated emissions factor expressed as MT CO_2e/metric ton of incinerated waste. The emissions factor was multiplied by activity data representing the total waste from Long Beach incinerated at the SERRF facility in 2015 to calculate MT CO_2e.

Fugitive Emissions from Oil and Natural Gas Systems (I.8)

The Fugitive Emissions subsector includes emissions resulting from activities at the City's Thums and Tidelands oil and natural gas facilities.

I.8.1 Oil and Gas Well Fugitive Emissions

Data Sources

Data on emissions for the Thums and Tidelands facilities were obtained from the sources listed in Table 5 below.

Table 5: Oil and Gas Well Fugitive Emissions Data Sources

Description	Source	Units
Emissions from the Thums facility by source and type	EPA Flight Database[15]	MT / year
Emissions from the Tidelands facility (emitter CO_2e)	CARB[16]	MT CO_2e / year

[13] City of Long Beach, 2015. Greenhouse Gas Report to California Air Resources Board
[14] US Environmental Protection Agency (US EPA), 2015. Emissions Factors for Greenhouse Gas Inventories. Available: <https://www.epa.gov/sites/production/files/2015-11/documents/emission-factors_nov_2015.pdf>
[15] US Environmental Protection Agency (EPA), 2015. Facility Level Information on Greenhouse Gases Tool (FLIGHT). Available: <https://ghgdata.epa.gov/ghgp/main.do#>
[16] California Air Resources Board, 2015. Annual Summary of 2015 Greenhouse Gas Emissions Data Reported to the California Air Resources Board. Available: < https://ww2.arb.ca.gov/mrr-data>

Calculation Methodology
Emissions data for the Thums facility broken out by greenhouse gas and by emissions source was obtained from the EPA Flight Database. The project team converted emissions from CO_2 and CH_4 into MT CO_2e for each source. Flaring was reported separately from leaks from atmospheric tanks, compressors, and other equipment. Note that fuel combustion associated with the Thums facility is reported in I.4.1.

Emissions data for the Tidelands facility were not available in the EPA Flight Database. Instead, emissions data presented in MT CO_2e were obtained from the CARB industrial database and recorded directly in the CIRIS inventory file.

TRANSPORTATION

On-Road Transportation (II.1)

The on-road transportation subsector includes exhaust-related GHG emissions from on-road vehicles operating within the City of Long Beach. The City's on-road transportation emissions are estimated using outputs from the Southern California Association of Governments (SCAG) origin-destination travel model. The outputs used in the inventories were developed to align with the origin-destination methodology, which allocates vehicle trips and their corresponding vehicle miles traveled (VMT) to cities based on the starting and ending point of each trip. Under this methodology, a city would include VMT occurring within its boundaries based on the following distribution:

- **Internal-Internal trips**: 100% of trips that start and end in the city are included
- **Internal-External and External-Internal trip**: 50% of trips that start or end in the city are included
- **External-External trips**: Trips that do not start or end in the city (i.e., pass through travel) are excluded

II.1.1 Fuel Combustion from On-road Transportation

Data Sources
Table 6 shows the sources for VMT data and vehicle fuel emissions factors used in this subsector. City-specific data on vehicle trips was collected from the SCAG travel demand model and was further analyzed with data outputs from the California Air Resources Board (ARB) mobile source emissions model (EMFAC) to estimate emissions factors by vehicle type.

Table 6: On-road Transportation Data Sources

Description	Source	Units
Daily VMT by Vehicle Class, Fuel Type, and Speed Bin for the City of Long Beach (2012 and 2016)	SCAG Regional Travel Demand Model[17] (run by AECOM)	VMT / day
VMT and Fuel Consumption by Vehicle Type, Fuel Type, and Speed Bin for the South Coast Air Basin	California Air Resources Board EMFAC2014 Web Database[18]	VMT / day gallons / year

[17] Southern California Association of Governments, 2011. Transportation Demand Models. Available: <http://www.scag.ca.gov/DataAndTools/Pages/TransportationModels.aspx>
[18] California Air Resources Board. EMFAC2014 Web Database, v1.0.7. Available: <https://www.arb.ca.gov/emfac/2014/>

Description	Source	Units
Emission Rates by Pollutant by Vehicle Type, Fuel Type, and Speed Bin for the South Coast Air Basin	California Air Resources Board EMFAC2014 Web Database[19]	grams / mile

The project team developed VMT estimates for the city using the SCAG Regional Travel Demand model. As the model does not generate outputs for 2015, the project team used outputs for 2012 and 2016 to interpolate VMT values for 2015. Daily VMT values were converted to annual values using an annual traffic conversion factor of 347.

Per the origin-destination methodology, all VMT associated with internal-internal trips were included in the inventory, and 50% of VMT from internal-external and external-internal trips were included in the inventory. All external-external trips were omitted from the inventories.

Fuel consumption and emissions factors for 2015 were obtained from ARB's mobile emissions model, EMFAC. EMFAC2014 was the current EPA-approved version of the EMFAC model at the time of inventory analysis, and is a mobile source emissions model for California that provides daily VMT, fuel consumption (gallons/day), and emissions factors (grams/mile), by air basin, vehicle type, operational year, and speed bin.

Outputs from the SCAG travel demand model and EMFAC2014 were provided in 5 mph speed bins. Although both datasets used in this analysis were separated into vehicle categories, the vehicle types in EMFAC2014 model are different (and more granular) than the vehicle classes in the SCAG model. To apply fuel efficiency and emission rate data from EMFAC2014 to the city-specific VMT data from the SCAG model, the project team assigned vehicle types from EMFAC2014 to the vehicle classes in the SCAG model according to the classifications shown in Table 7.

Table 7: Vehicle Category Reclassification

SCAG Model Vehicle Class	EMFAC2014 Vehicle Type
Light Duty Vehicles	LDA
Light Duty Trucks	LDT1, LDT2, LHDT1, LHDT2
Medium Duty Trucks	MDV
Heavy Duty Trucks	T6 (all subtypes), T7 (all subtypes except T7 Ag)
Not Included	All Other Buses, MH, Motor Coach, OBUS, PTO, SBUS, T7 Ag

Note: Several vehicle types from EMFAC2014 (i.e., All Other Buses, MH, Motor Coach, OBUS, PTO, SBUS, T7 Ag) were excluded from the fuel efficiency and pollutant emission rate calculations because they did not apply to the vehicle classes in the SCAG model. However, this approach had no impact on annual VMT calculations because VMT values were generated from the SCAG model, as opposed to EMFAC2014.

[19] ibid

Calculation Methodology

Calculating Fuel Mix of VMT by Vehicle Class

VMT from vehicles in the same vehicle class that consume different fuel types are recorded separately in the final inventory and have different emissions factors applied. The SCAG model does not distinguish between fuel type, so it was necessary for the project team to determine the proper ratio of VMT driven by gasoline, diesel, and electric vehicles in each vehicle class. VMT ratios by vehicle class and fuel type were calculated from the EMFAC2014 outputs at the Air Basin level, and then applied to the city-specific VMT data to allocate the SCAG VMT data by vehicle fuel type. Once separated, emissions from diesel and gasoline vehicles were calculated as Scope 1 emissions in this section using the same method.

Emissions associated with electric vehicles were not calculated under this subsector. Because SCE did not provide activity data specifically on electric vehicle charging, electricity consumption associated with electric vehicles is assumed to be embedded in residential and commercial electricity consumption from SCE, which is reported in inventory sectors I.1.2 and I.2.2.

Fuel Consumption by Vehicle Class by Speed Bin

Fuel efficiencies were calculated using EMFAC2014 data by dividing daily VMT by daily fuel consumption for each combination of vehicle type and speed bin. To convert the fuel efficiency values from EMFAC2014 to SCAG vehicle classes, the project team averaged the fuel efficiency values of each EMFAC2014 vehicle type within a SCAG vehicle class (see Table 7 for vehicle type comparisons across models). The results were then multiplied by VMT values to generate annual gallons of fuel consumed by vehicle class by speed bin.

Emissions by Vehicle Class by Speed Bin

Emissions factors in grams per mile for CO_2, N_2O, and CH_4 were calculated by vehicle class by speed bin using EMFAC2014 emissions rate data. EMFAC2014 provides emissions rates for a variety of pollutants and greenhouse gases, including CO_2, NO_X (all nitrous oxides) and TOG (total organic gases, including CH_4). The project team isolated CH_4 and N_2O using methods recommended by CARB.[20] Methane was isolated by multiplying TOG emissions factors for both gas and diesel by 0.0408. For gasoline, N_2O was isolated by multiplying NO_X emissions rates by 0.0416. For diesel, N_2O was calculated by summing the total daily gallons of diesel consumed by vehicle class by speed bin, multiplying each value by 0.3316 to calculate the total grams of N_2O emitted, and then dividing the results by daily VMT to arrive at emissions factors in grams per mile for each vehicle class and speed bin. Next, the speed bin and vehicle class-specific emissions factors were multiplied by annual VMT in each speed bin/vehicle class combination to generate emissions in metric tons for 2015 for each of the three greenhouse gases.

Composite Activity Data and Emissions Rates by Fuel Type

Individual emissions factors for all vehicle types and speed bins were combined into weighted emissions factors for each greenhouse gas that represent all vehicle classes and speed bins weighted by VMT within the city. That is, emissions factors for vehicle classes that represent a higher percentage of VMT were weighted according to their relative VMT proportion and within vehicle classes; emissions factors for speed bins that represent a higher percentage of VMT were also weighted according to their relative VMT proportion.

Finally, VMT for all vehicle classes were summed (gasoline and diesel separately) resulting in a total annual VMT activity value for each fuel type, to which the composite emissions factors for each

[20] California Air Resources Board, 2013. Frequently Asked Questions. Available: <https://www.arb.ca.gov/msei/emfac2011-faq.htm#emfac2011_web_db_qstn07>

greenhouse gas were applied to calculate annual emissions for each greenhouse gas. As elsewhere in the inventories, the individual greenhouse gases were converted to CO_2e using GWP coefficients from the IPCC 5th Assessment.

Assumptions

The SCAG Transportation Demand Model does not calculate VMT for urban buses by speed bin, but instead outputs them as an aggregate value. All calculations described above (fuel efficiencies, emission rates, etc.), when performed on the urban buses vehicle class, were not carried out individually by speed bin. Therefore, calculations for the urban bus category are less granular and may have a higher margin of error.

The SCAG Travel Demand Model does not separate urban bus VMT by trip type. For all other vehicle classes, the model separates internal-internal trips, internal-external and external-internal trips, and external-external trips. Although it is recommended by ARB and the GPC to include all internal-internal trips, 50% of internal-external trips, and exclude all external-external trips, for urban buses this distinction was not possible, and instead all VMT from urban buses were included in the inventories. Therefore, VMT and the corresponding emissions from urban buses are likely over-estimated in the inventory as it relates to the city's responsibility for urban bus emissions per the origin-destination methodology.

Railways (II.2)

The Railways subsector includes the use of electricity and diesel fuel to operate passenger rail and freight rail services within the city.

II.2.1 Fuel Combustion from Railway Transportation

Data Sources

Table 8 presents the data sources used to estimate railway fuel consumption and fuel emissions factors. The calculations used a combination of track length and route schedules, with emissions factors for different locomotive types.

Table 8: Diesel Consumption from Rail Transportation Data Sources

Description	Source	Units
Freight Rail Routes	Caltrans GIS Data Library[21]	GIS Data
National Diesel Locomotive – Emissions Factor	US EPA Emissions Factors for Locomotives[22]	grams / gallon
Energy Density of Diesel by Locomotive Type	US EPA Emissions Factors for Locomotives[23]	Brake horsepower hour / gallon
Energy Consumption of Locomotives by Service Provider in the South Coast Air Basin	Port of Long Beach Air Emissions Inventory[24]	MWh

[21] California Department of Transportation (Caltrans), 2013. California Rail Network. Available: <http://www.dot.ca.gov/hq/tsip/gis/datalibrary/>
[22] US Environmental Protection Agency (US EPA), 1997. Emissions Factors for Locomotives. Available: <nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P1001Z8C.TXT>
[23] ibid

Description	Source	Units
Total BNSF Fuel Use by Locomotive Type	BNSF[25]	gallons
Total Union Pacific Fuel Use by Locomotive Type	Union Pacific[26]	gallons

Calculation Methodology

The most detailed activity data available for Union Pacific and BNSF trains operating in the city was provided by the South Coast Air Basin and expressed as energy consumption of locomotives by operator. These values were converted to gallons of diesel and then downscaled from the air basin level to the City of Long Beach.

The energy densities of diesel locomotives depend on locomotive type (long haul/freight vs. switching), so the first step in this process was to calculate the total fuel use of each operator by locomotive type. Fuel use by locomotive type was converted to energy consumption by locomotive type using energy density data from US EPA. From this, the system-wide ratio of line-haul energy consumption to switching energy consumption was calculated for each operator and then applied to the air basin-level energy consumption data. This allowed the different energy densities for locomotive types to be applied to more accurately convert energy consumption to gallons of diesel consumed by each operator within the air basin.

Caltrans GIS data of freight rail lines was used to determine the percent of the air basin's freight rail network mileage that is located within the city. This ratio was used to downscale the total gallons of diesel consumed at the air basin level to the city. Finally, default national emissions factors for diesel from the US EPA were used to estimate emissions in CO_2e.

Assumptions

Default national emission factors for diesel locomotives from EPA were used to estimate emissions. This assumes that locomotive fleets operating within the City of Long Beach emit at rates similar to the national average.

II.2.2 Electricity Consumed in the City for Railways

Data Sources

Table 9 presents the data sources for railway electricity use and emission factors. Electricity consumption data was provided by LA Metro, and electricity emissions factors were collected from utility companies that provide electricity to the Blue Line.

[24] Port of Long Beach, 2015. Annual Air Emissions Inventory. Available: <http://polb.com/civica/filebank/blobdload.asp?BlobID=13555>

[25] BNSF Railway Company, 2015. Class I Railroad Annual Reports. Available: <http://www.bnsf.com/about-bnsf/financial-information/pdf/14R1.pdf>

[26] Union Pacific Railroad, 2013-2017. Class I Railroad Annual Reports. Available: <https://www.up.com/cs/groups/public/@uprr/@investor/documents/investordocuments/pdf_uprr_r-1_03312015.pdf>

Table 9: Electricity Consumption from Rail Transport Data Sources

Description	Source	Units
Metro Rail Route Lines GIS Data	LA Metro GIS Data[27]	GIS
Electricity Consumption of Metro Rail by Line by Utility	LA Metro	MWh
LADWP – Emissions Factor	LADWP	lbs / MWh
SCE – Emissions Factor	SCE	t / MWh

Calculation Methodology
Activity data for the entire Metro Railway system was provided by transit line and electric utility company. To isolate electricity consumed within the city, the project team used Metro Rail GIS data to calculate the ratio of the Blue Line that is within the city limits. This ratio was multiplied by total electricity consumption for the Blue Line, and the results were summed by electricity utility provider. Utility-specific emissions factors were then applied to convert from MWh to CO_2e.

Assumptions
The method of isolating Long Beach-specific electricity consumption from system-wide consumption assumes that energy use is uniform across all portions of a transit line.

Waterborne Navigation (II.3)

The Waterborne Navigation subsector includes the consumption of diesel fuel to operate harbor craft and oceangoing vessels hoteling as a result of activity at the City's port. Note that the City estimated waterborne navigation emissions in its total inventory but did not include this source within the jurisdictional inventory that is evaluated in the CAAP; see CAAP Chapter 5 for further detail on this distinction.

II.3.1 – Fuel Combustion for Waterborne Navigation Occurring in the City

Data Sources
As shown in Table 10, the Port of Los Angeles Air Emissions Inventories provided the activity data and emissions factor data to calculate emissions in this subsector.

Table 10: Waterborne Navigation Data Sources

Description	Source	Units
Emissions by Vessel Type (Oceangoing vessels - hoteling, oceangoing vessels – transit and maneuvering, and harbor craft)	Port of Long Beach Air Emissions Inventory 2015[28]	MT CO_2e / year

[27] Los Angeles Metropolitan Transportation Authority (LA METRO), 2017. LA Metro Rail GIS. Available: <https://developer.metro.net/introduction/gis-data/download-gis-data/>
[28] Port of Long Beach, 2015. Annual Air Emissions Inventory. Available: < http://polb.com/civica/filebank/blobdload.asp?BlobID=13555>

Calculation Methodology
The Port of Long Beach annual Air Emissions Inventories provide estimates of GHG emissions in MT CO_2e split into oceangoing vessels (hoteling), oceangoing vessels (transit and maneuvering), and harbor craft.

These emissions estimates were calculated by the Port of Long Beach based on methodologies described in detail in the Port's 2015 Air Emissions Inventory. The project team used these emissions estimates directly in the City's inventory. Oceangoing vessels – transit and maneuvering are not included in the Basic reporting framework but are included in the Basic+ inventory results provided in the CAAP.

Assumptions
All harbor craft emissions were included as Scope 1, assuming that the majority of harbor vessel operations occur within the city limits. For purposes of the community emissions inventory, all 'transit' and 'maneuvering' operation-related emissions were allocated to Scope 3 assuming most of these operations occur outside the city limits. This assumption has no impact on the CAAP analysis since all waterborne vessel emissions were excluded from the jurisdictional inventory for GHG target analysis purposes.

Aviation (II.4)

The Aviation subsector includes emissions associated with the operations of ground service equipment and generators at Long Beach Airport. Note that emissions associated with transboundary airplane trips are not included in the Basic reporting framework and are therefore not included here. Emissions associated with electricity or natural gas consumption are not included here because they are already captured in the SCE and LBGO activity data recorded in I.2.

II.4.1 Emissions from Fuel Combustion for Aviation Occurring in the City

Data Sources
Table 11 presents the sources for activity data and emissions factors used to calculate emissions associated with ground service equipment and generators. Activity data from Long Beach Airport was combined with a regional off-road diesel emissions factor and a national EPA aviation gasoline emissions factor.

Table 11: Aviation Emissions Occurring Inside the City Data Sources

Description	Source	Units
Fuel consumption by fuel and equipment type	Long Beach Airport	gallons
Aviation Gasoline – Emissions Factor	EPA[29]	MT / gallon
Off-road Diesel – Emissions Factor	California Air Resources Board Off-road Model	MT / gallon

Calculation Methodology
The activity data provided by Long Beach Airport for diesel and aviation gasoline was multiplied by corresponding emissions factors to convert gallons of fuel consumed to MT CO_2e.

[29] US Environmental Protection Agency (US EPA), 2015. Emissions Factors for Greenhouse Gas Inventories. Available: <https://www.epa.gov/sites/production/files/2015-11/documents/emission-factors_nov_2015.pdf>

Off-road Transportation (II.5)

The Off-road Transportation subsector includes emissions associated with off-road vehicles and equipment used in construction, transport refrigeration, light commercial, industrial, and lawn and gardening operations.

Data Sources

Data for construction, light commercial, industrial, and lawn and gardening equipment were obtained from the California Air Resources Board OFFROAD2007 model, which provides county-level emissions factors for off-road equipment.[30] OFFROAD2007 uses multiple factors and indicators to estimate and project off-road equipment activity levels. This includes, but is not limited to population, statewide rules and regulations, academic studies, growth forecasts, existing ARB reporting systems (e.g., Diesel Off-Road On-Line Reporting System [DOORS]), and non-compliance estimates.[31] Activity data from OFFROAD2007 is provided separately for gasoline, diesel, and LPG in gallons per year (gal/yr).

Calculation Methodology

To scale the results of OFFROAD2007 from county-level emissions data to values more representative of emissions generated within the city, the project team collected demographic indicators from the American Communities Survey (ACS) 2011-2015 5-Year Estimates for both the City of Long Beach and the County of Los Angeles.[32,33] These values were used to generate multipliers for converting county-level values to city-level values. ACS data includes a breakdown of the number employees by job sector within a given geography. Job sector-specific multipliers were generated from employment data to improve the precision of the calculations, where possible. For emissions sources that are not job sector-specific, such as lawn and gardening equipment, the project team applied a multiplier based on population. For example, in 2015, 4.7% of the County's manufacturing jobs were located within the City of Long Beach, so the countywide industrial equipment emissions value generated by OFFROAD2007 was multiplied by 0.047 to estimate industrial equipment emissions in the city. Table 12 shows the demographic indicators used to downscale the county-wide OFFROAD2007 emissions.

Table 12: County to City Multiplier Sources by Off-road Equipment Class

Off-road Equipment Class	Multiplier Source (ACS 5-Year Estimates)
Industrial Equipment	Employees in the Manufacturing Sector
Light Commercial Equipment	Employees in the Wholesale Trade and Retail Trade Sectors
Transport Refrigeration Units	Population
Lawn and Garden Equipment	Population
Construction and Mining Equipment	Population

[30] CARB. 2006 (December). Off-Road Emissions Inventory. Available: <http://www.arb.ca.gov/msei/offroad/offroad.htm>.
[31] Additional information regarding the assumptions and factors used to estimate OFFROAD activity levels can be found at: <http://www.arb.ca.gov/msei/categories.htm>
[32] U.S. Census Bureau, 2009-2013, 2010-2014, 2011-2015, 2012-2016, and 2013-2017 American Community Survey 5-Year Estimates. Selected Economic Characteristics (Table DP03). Available: <https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ACS_16_5YR_DP03&prodType=table>
[33] U.S. Census Bureau, 2009-2013, 2010-2014, 2011-2015, 2012-2016, and 2013-2017 American Community Survey 5-Year Estimates. Total Population (Table B01003). Available: <https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ACS_16_5YR_B01003&prodType=table>

The downscaled activity data for gasoline, diesel, and LPG consumption were then multiplied by their corresponding emissions factors from the OFFROAD2007 model to convert gallons of fuel consumed to MT CO_2e.

WASTE

Solid Waste Disposal (III.1)

The Solid Waste Disposal subsector includes methane emissions that occur as a result of the anaerobic decomposition of waste disposed in landfills. Emissions in this sector were calculated using the methane commitment method described in the GPC.

Data Sources

The project team obtained solid waste disposal data from City staff. The data included short tons of solid waste generated within the city organized by the final waste processing facilities used in 2015. Waste processing facilities included multiple landfills throughout California, incineration facilities, and use of alternative daily cover (ADC).

Landfill methane capture efficiency rates were collected from the EPA FLIGHT database, where reported, and were otherwise assumed to be 75% at landfills where no EPA FLIGHT data was available. The result is different methane capture rates used in the emissions calculations based on where the city's waste was sent. Data for total waste disposed to landfills is provided in Table 13. The landfill methane capture rates are provided in Table 14.

Table 13 – Waste Disposed by Waste Type

Landfill Facility	Disposal Type	Short Tons
American Avenue Disposal Site	Landfill	0.02
Kettleman Hills - B18 Nonhaz Co-disposal	Landfill	0.9
Lamb Canyon Sanitary Landfill	Landfill	0.9
Chemical Waste Management, Inc. Unit B-17	Landfill	2.1
Lancaster Landfill and Recycling Center	Landfill	46.4
Victorville Sanitary Landfill	Landfill	85.2
Savage Canyon Landfill	Landfill	107.5
San Timoteo Sanitary Landfill	Landfill	781.5
Antelope Valley Public Landfill	Landfill	858.9
McKittrick Waste Treatment Site	Landfill	1,479.8
Mid-Valley Sanitary Landfill	Landfill	2,923.8
Chiquita Canyon Sanitary Landfill	Landfill	3,352.4
Simi Valley Landfill & Recycling Center	Landfill	12,495.2
Azusa Land Reclamation Co. Landfill	Landfill	21,124.2
Prima Deshecha Sanitary Landfill	Landfill	22,503.5

A

APPENDIX A

Landfill Facility	Disposal Type	Short Tons
Olinda Alpha Sanitary Landfill	Landfill	26,645.0
El Sobrante Landfill	Landfill	30,330.2
Sunshine Canyon City/County Landfill	Landfill	57,267.5
Frank R. Bowerman Sanitary Landfill	Landfill	97,700.1
Subtotal	**Landfill**	**277,704.9**
Lancaster Landfill and Recycling Center	ADC	443.5
Simi Valley Landfill & Recycling Center	ADC	908.8
Antelope Valley Public Landfill	ADC	1,206.2
El Sobrante Landfill	ADC	128,994.4
Subtotal	**ADC**	**131,552.9**
Commerce Refuse-To-Energy Facility	Incineration	436.8
Southeast Resource Recovery Facility (SERRF)	Incineration	196,599.5
Subtotal	**Incineration**	**197,036.3**

Source: City of Long Beach 2017

Table 14 – Waste Disposed by Waste Type

Landfill Facility	Methane Collection Rate	Source
American Avenue Disposal Site	75.00%	Default assumption
Kettleman Hills - B18 Nonhaz Co-disposal	75.00%	Default assumption
Lamb Canyon Sanitary Landfill	74.00%	EPA FLIGHT
Chemical Waste Management, Inc. Unit B-17	75.00%	Default assumption
Lancaster Landfill and Recycling Center	75.00%	Default assumption
Victorville Sanitary Landfill	74.83%	EPA FLIGHT
Savage Canyon Landfill	75.00%	EPA FLIGHT
San Timoteo Sanitary Landfill	75.00%	Default assumption
Antelope Valley Public Landfill	75.00%	Default assumption
McKittrick Waste Treatment Site	75.00%	Default assumption
Mid-Valley Sanitary Landfill	76.68%	EPA FLIGHT
Chiquita Canyon Sanitary Landfill	75.00%	Default assumption
Simi Valley Landfill & Recycling Center	74.90%	EPA FLIGHT
Azusa Land Reclamation Co. Landfill	75.00%	Default assumption
Prima Deshecha Sanitary Landfill	75.00%	Default assumption
Olinda Alpha Sanitary Landfill	75.00%	Default assumption
El Sobrante Landfill	74.87%	EPA FLIGHT

Landfill Facility	Methane Collection Rate	Source
Sunshine Canyon City/County Landfill	87.65%	EPA FLIGHT
Frank R. Bowerman Sanitary Landfill	75.00%	Default assumption

Calculation Methodology

The equations and inputs associated with the methane commitment methodology are presented below, followed by additional data items used to estimate the city's solid waste emissions.

The project team applied equations 8.1, 8.3, and 8.4 from the GPC (shown on the following pages).

Equation 8.1: Degradable organic carbon (DOC)

DOC = (0.15 x A) + (0.2 x B) + (0.4 x C) + (0.43 x D) + (0.24 x E) + (0.15 x F) + (0.39 x G) + (0.0 x H) + (0.0 x I) + (0.0 x J) + (0.0 x K)	
A	= Fraction of solid waste that is food
B	= Fraction of solid waste that is garden waste and other plant debris
C	= Fraction of solid waste that is paper
D	= Fraction of solid waste that is wood
E	= Fraction of solid waste that is textiles
F	= Fraction of solid waste that is industrial waste
G	= Fraction of solid waste that is rubber and leather
H	= Fraction of solid waste that is plastics
I	= Fraction of solid waste that is metal
J	= Fraction of solid waste that is glass
K	= Fraction of solid waste that is other, inert waste

Source: Default carbon content values sourced from IPCC Waste Model spreadsheet, available at: http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_2_Ch2_Waste_Data.pdf
Note: GPC Equation 8.1 includes factors A-F; AECOM added factors G-K using the default DOC content in % of wet waste from the same IPCC Waste Model spreadsheet referenced in the source above.

A

APPENDIX A

Equation 8.3: Methane commitment estimate for solid waste sent to landfill

CH_4 emissions =

$MSW_x \times L_0 \times (1-f_{rec}) \times (1-OX)$

Description		**Value**
CH_4 emissions	= Total CH4 emissions in metric tons	Computed
MSW_x	= Mass of solid waste sent to landfill in inventory year, measured in metric tons	User input (see Table 13)
L_0	= Methane generation potential	See Equation 8.4 Methane generation potential
f_{rec}	= Fraction of methane recovered at the landfill (flared or energy recovery)	User input (see Table 14)
OX	= Oxidation factor	0.1 for well-managed landfills; 0 for unmanaged landfills

Source: Adapted from *Revised 1996 IPCC Guidelines for National Greenhous Gas Inventories*

The project team used the following values in Equation 8.3 for the city's calculations:

- MSW_x = see Table 13
- f_{rec} = see Table 14
- OX = 0.1

Equation 8.4: Methane generation potential, L_0

L_0 =

$MCF \times DOC \times DOC_F \times F \times 16/12$

Description		**Value**
L_0	= Methane generation potential	Computed
MCF	= Methane correction factor based on type of landfill site for the year of deposition (managed, unmanaged, etc., fraction)	Managed = 1.0 Unmanaged (≥ 5 m deep) = 0.8 Unmanaged (<5 m deep) = 0.4 Uncategorized = 0.6
DOC	= Degradable organic carbon in year of deposition, fraction (tons C / tons waste)	See Equation 8.1
DOC_F	= Fraction of DOC that is ultimately degraded (reflects the fact that some organic carbon does not degrade)	Assumed equal to 0.6
F	= Fraction of methane in landfill gas	Default range 0.4-0.6 (usually taken to be 0.5)
16/12	= Stoichiometric ratio between methane and carbon	n/a

Source: *IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (2000)*

The project team used the following values in Equation 8.4 for the city's calculations:

- MCF = 1.0
- DOC_F = 0.6
- F = 0.5

Waste Characterization

The project team estimated landfill waste composition for the 2015 GHG inventory based on CalRecycle's statewide waste characterization studies. The 2015 inventory results are based on CalRecycle's *2014 Disposal-Facility-Based Characterization of Solid Waste in California* report. Per the 2014 report, CalRecycle's side-by-side analysis of the 2008 and 2014 study results identified an unexpected anomaly in the distribution of waste per sector (i.e., residential, commercial, and self-hauled). The report states that CalRecycle was obtaining additional data to verify the 2014 report results. In the interim, the 2014 report presents two sets of data: one reflecting the 2014 calculated sector percentages, and the other based on the 2008 report sector percentages. The project team averaged the reported results for use in the GHG inventory.

The CalRecycle study estimates the percentage of different materials in California's waste stream. The project team referred to Table 7: Composition of California's Overall Disposed Waste Stream to determine the distribution of waste by the material types included in Equation 8.1. Table 15 shows the results of this data sorting,

Table 15: Waste Characterization – Selected Materials Categories

Material	2008 Sector Percentages	2014 Sector Percentages	2008 and 2014 Average	Material Categories/Sub-types from CalRecycle Reports[1]
Paper	18.1%	18.5%	18.3%	Paper category plus Gypsum Board sub-type from Inerts and Other category
Textiles	5.6%	5.8%	5.7%	Textiles and Carpet sub-types from Other Organic category
Food	16.5%	18.1%	17.3%	Food sub-type from Other Organic category
Garden and Park	10.6%	11.8%	11.2%	Leaves and Grass, Prunings and Trimmings, Manures, and Remainder/Composite Organics sub-types from Other Organic category
Wood	15.5%	13.6%	14.6%	Lumber sub-type from Inerts and Other category and Branches and Stumps sub-type from Other Organic category
Rubber and Leather	0.1%	0.1%	0.1%	Tires sub-type from Special Waste category
Plastics	10.4%	10.4%	10.4%	Plastic category
Metal	3.1%	3.1%	3.1%	Metal category
Glass	2.5%	2.5%	2.5%	Glass category

Material	2008 Sector Percentages	2014 Sector Percentages	2008 and 2014 Average	Material Categories/Sub-types from CalRecycle Reports[1]
Other	17.7%	16.1%	16.9%	Electronics category, Household Hazardous Waste (HHW) category, Mixed Residue category, Inerts and Other category (minus Lumber and Gypsum Board sub-types), and Special Waste category (minus Tires sub-type)
Total [2]	**100.1%**	**100.0%**	**100.1%**	

[1] *2014 Disposal-Facility-Based Characterization of Solid Waste in California,* CalRecycle 2015. Prepared by Cascadia Consulting Group. Available online at: <http://www.calrecycle.ca.gov/Publications/Documents/1546/20151546.pdf>. Adapted by AECOM 2017.

[2] Totals do not sum to 100% due to rounding in the CalRecycle report.

Assumptions

Use of the CalRecycle waste characterization report assumes that waste generated in the city has a similar composition to waste generated in the state as a whole. The project team conservatively assumed that 100% of ADC waste was green waste and allocated the tonnage to the Garden and Park material category and corresponding DOC factor. It is likely that some or all of the ADC waste was inert materials that would not decompose to generate landfill emissions, and therefore the city's solid waste emissions could be lower than estimated in the inventory. New ADC tracking data provided by CalRecycle that was unavailable during inventory preparation can be used in future inventories to better understand the portion of the city's ADC waste that includes green waste.

Incineration and Open Burning (III.3)

The Incineration and Open Burning subsector (referred to as incineration elsewhere in this report) includes carbon dioxide, methane, and nitrous oxide emissions that result from the incineration of waste at the Commerce Refuse-to-Energy Facility, which is located outside the city limits. Emissions from the Southeast Resource Recovery Facility (SERRF), which is located within Long Beach, are calculated and reported separately in the Emissions from Energy Generation Supplied to the Grid subsector (I.4.4).

Data Sources

The project team obtained data on waste incineration from staff at the Long Beach Environmental Services Bureau. The data provided included short tons of solid waste incinerated at one of two incineration facilities (i.e., Commerce Refuse-to-Energy Facility and Southeast Resource Recovery Facility [SERRF]).

Table 16: Wastewater Incineration Data Sources

Description	Source	Units
Emissions from waste incinerated at the SERRF facility	EPA Flight Database[34]	MT / year
Total municipal solid waste incinerated at the SERRF facility	City of Long Beach[35]	st / year
Municipal solid waste from Long Beach incinerated at the Commerce facility	CalRecycle[36]	st / year

Calculation Methodology

Waste incineration facility emissions factors were calculated based on 2015 SERRF emissions reported in the EPA FLIGHT database divided by a known volume of waste incinerated at SERRF in 2015. This calculation provided an estimated emissions factor expressed as MT CO_2e/metric ton of incinerated waste. This emissions factor was multiplied by activity data representing the total waste from Long Beach incinerated at the Commerce facility in 2015 to calculate MT CO_2e for this subsector in lieu of a Commerce facility-specific emissions factor.

Assumptions

Waste incineration emissions factors could vary among the two incineration facilities. The data needed to estimate different incineration emissions factors was not publicly available at the time of inventory preparation, and incineration represents a minor emissions source in the City's total inventory so the project team does not believe this data gap would have a material impact on inventory results. Further, the Commerce facility was closed in 2018 and will not appear in future city inventories.

Wastewater Treatment and Discharge (III.4)

The Wastewater Treatment and Discharge subsector includes nitrous oxide emissions from the portion of wastewater going to the LB Water Reclamation Plant that is generated by Long Beach (III.4.1) and nitrous oxide and methane emissions from the portion of wastewater going to the Joint Water Pollution Control Plant (located in Carson, CA) that is generated in Long Beach (III.4.3).

Data Sources

Table 17 presents the sources for activity data used to calculate wastewater emissions.

Table 17: Wastewater Sector Emissions Activity Data Sources

Description	Source	Units
Daily nitrogen load from effluent discharge for the Long Beach Water Reclamation Plant	LACSD[37]	kg nitrogen / day
Daily nitrogen load from effluent discharge for the Joint Water Pollution Control Plant	LACSD[38]	kg nitrogen / day
Service populations for the Long Beach Water Reclamation	LACSD[39]	population

[34] US Environmental Protection Agency (EPA), 2015. Facility Level Information on Greenhouse Gases Tool (FLIGHT). Available: <https://ghgdata.epa.gov/ghgp/main.do#>
[35] 2015 waste incineration volume is confidential data. Personal communication between Al Foley at City of Long Beach and Joshua Lathan of AECOM on September 6, 2017.
[36] CalRecycle, 2015. CY 2015 Electronic Annual Reporting.
[37] Sanitation Districts of Los Angeles County (LACSD), 2015. Long Beach Water Reclamation Plant NPDES Annual Monitoring Report.
[38] Los Angeles County Sanitation Districts (LACSD), 2015. Joint Water Pollution Control Plant NPDES Annual Monitoring Report.

Description	Source	Units
Plant and Joint Water Pollution Control Plant		served
Percentage of Long Beach population served by each plant	Long Beach Water Department[40]	percent
Volume of digester gas produced at the Joint Water Pollution Control Plant; methane content of biogas; details on onsite or offsite use	LACSD[41]	cubic feet / year

Calculation Methodology

Wastewater generated in the city is treated by two wastewater treatment plants: the Long Beach Water Reclamation Plant and the Joint Water Pollution Control Plant. Both plants treat wastewater from other cities as well, so only a portion of the emissions associated with these plants is attributable to Long Beach.

GHG emissions from both plants occur in the form of N_2O from nitrogen loads in treated effluent discharge and nitrification/denitrification processes during treatment. Furthermore, the Joint Water Pollution Control Plant also produces digester gas, the incomplete combustion of which (onsite or offsite) results in CH_4 emissions.

The project team received data on daily nitrogen loads from effluent discharge, which were used to estimate N_2O emissions using a standard equation from the ICLEI Local Government Operations Protocol (LGOP). Similarly, data on the population served by each treatment facility were used in a separate standard equation from the LGOP to estimate emissions from nitrification/denitrification processes.

Data on total biogas generation and the corresponding methane content at the Joint Water Pollution Control Plant were used in a standard LGOP equation to estimate fugitive methane emissions. All standard equations contain default conversion factors and other constants such as days per year, which are specified in the LGOP.

As emissions were initially calculated at the facility scale for both treatment plants, and the service population of the plants includes communities outside of Long Beach, emissions were downscaled to the city using a ratio of total City of Long Beach-specific service population to the total service population.

Assumptions

As the treatment process at the Long Beach Water Reclamation Plant is aerobic, no methane emissions are assumed to be generated at that facility.

[39] Los Angeles County Sanitation Districts (LACSD), 2012. Clearwater Program Master Facilities Plan.
[40] Estimates provided by Jinny Huang from Long Beach Water Department via phone on December 28, 2017.
[41] Los Angeles County Sanitation Districts (LACSD), 2015. Joint Water Pollution Control Plant NPDES Annual Monitoring Report.

PART II – 2030 REDUCTION TARGET PATHWAY

The CAAP evaluated a 2030 GHG target that was established to demonstrate consistency with the state's adopted 2030 GHG target (i.e., 40% below 1990 levels by 2030), and CAAP actions were defined to demonstrate a feasibly reduction pathway toward target achievement. While the CAAP does also include a 2045 carbon neutrality goal and high-level estimates of the City's potential progress toward that the goal, this appendix focuses on describing the assumptions and calculation methodology used to demonstrate 2030 target achievement in the CAAP.

Table 18 summarizes the GHG reductions by action that provide the City's pathway to 2030 target achievement. The remainder of this section provides quantification details for each action listed below to document assumptions related to action implementation and sources of information to support future CAAP monitoring and updates. GHG reductions have been rounded to the nearest tens value and the green highlighted values within each action section correspond to the GHG reductions shown in the table below. The CAAP reflects the sector-level reductions total shown here.

Table 18 – Quantified CAAP Actions

CAAP Action	2030 GHG Reductions (MT CO_2e/yr)
BUILDING + ENERGY ACTIONS	**247,700**
BE-1 Provide access to renewably generated electricity	188,960
BE-2 Increase use of solar power	3,880
BE-6 Perform municipal energy and water audits	13,120
BE-8 Implement short-term measures to reduce emissions related to oil and gas extraction	41,740
TRANSPORTATION ACTIONS	**30,480**
T-1 Increase the frequency, speed, connectivity and safety of transit options	5,230
T-4 Implement the Port of Long Beach Clean Trucks Program	25,250
WASTE ACTIONS	**85,070**
W-1 Ensure compliance with state law requirements for multifamily and commercial property recycling programs	45,340
W-3 Partner with private waste haulers to expand organic waste collection community-wide	39,730
TOTAL CAAP REDUCTIONS	**363,250**

Some action quantification methodologies refer to the demographic forecasts used to estimate the city's BAU emissions scenario. The relevant demographic information is documented in Table 19.

Table 19 – City of Long Beach Demographic Forecasts

	2012	2015	2016	2020	2030	2035
Population	466,255	468,911	469,796	478,346	480,424	481,463
Employment	153,154	155,402	156,900[1]	165,800	172,297	175,546
Service Population	619,409	624,312	626,696	644,146	652,721	657,009

Notes:
Service population = population + employment
Values for 2012, 2016, 2020, and 2035 provided to AECOM by City of Long Beach, Table LU-8: Population, Household and Employment Growth
Values for 2015 and 2030 interpolated
[1] Employment data is for 2017

CLEAN ELECTRICITY GRID OPTIONS

The general quantification approach used to evaluate emissions reductions from actions that would reduce electricity use or offset it with carbon-free energy sources is presented in the section below.

Overarching Methodology

The CAAP evaluated the GHG reduction potential that would result from implementation of SCE's commitment to provide 80% carbon-free energy by 2030, as well as the additional net emissions reductions that would occur from voluntary participation in SCE's Green Rate program.

Potential emissions reductions were estimated according to the following equation:

Emissions Reduction = (Business-as-Usual Emissions) – (Mitigated Scenario Emissions)

The primary inputs supporting calculations for the above equation include activity data (e.g., MWh of electricity use) and emissions factors (e.g., MT CO_2e/MWh). Each component of the equation is described below.

BUSINESS-AS-USUAL (BAU) EMISSIONS SCENARIO

Activity Data

BAU emissions were calculated based on the 2030 electricity activity data forecasts that underpin the CAAP's GHG emissions forecasts. These were developed for three subsectors: residential, commercial, and industrial electricity accounts. 2030 forecasts were calculated using growth indicators to estimate how the 2015 base year inventory might change by the CAAP's 2030 target year. Residential activity data was projected using city population forecasts and the commercial and industrial activity data was projected using city employment forecasts. Population and employment forecast information was collected form the SCAG 2016 Regional Transportation Plan/Sustainable Community Strategy and provided to AECOM by the City of Long Beach in August 2018 (see Table 19). CAAP action BE-6 separately estimates the GHG reduction potential from a City commitment to purchase renewable electricity for all municipal accounts by 2030. The community inventory did not separately evaluate municipal GHG emissions, however the City did prepare a 2015 municipal operations inventory from which municipal electricity activity data was collected for purposes of evaluating GHG reduction potential. This activity data was subtracted from the communitywide electricity data for commercial accounts provided by SCE in order to avoid double counting emissions reduction potential. Table 20 presents the city's 2015 and 2030 electricity activity data.

Table 20 – Electricity Activity Data

Energy Sub-sector	2015 (MWh)	2030 (MWh)
Residential	813,346	833,316
Commercial	678,407	872,200
Municipal	108,264	108,264
Industrial	1,409,718	1,562,987

Note: Values are rounded; for purposes of community emissions planning, no activity data growth was assumed for municipal electricity accounts from 2015-2030.

Emissions Factor

In the CAAP forecasts, BAU emissions were calculated using an estimated SCE 2030 electricity emissions factor that assumes compliance with the state's Renewables Portfolio Standard (RPS). The RPS requires SCE to procure 60% RPS-eligible sources by 2030. In the CAAP 2015 base year, SCE's electricity came from the energy source mix shown in Table 21. The project team estimated a 2030 mix that assumes compliance with the RPS requirements (i.e., 60% eligible renewable sources), with the remainder of energy provided by unspecified sources of power. This scenario represents a conservative estimate based on the 2015 energy mix by allocating the full 40% of non-RPS energy to the potentially highest emissions option in use in the 2015 base year. It is a conservative approach in that it results in an estimated emissions factor that is greater (i.e., more carbon intensive) than other scenarios could provide. For example, if SCE maintains its large hydroelectric and nuclear power sources through 2030 and provides 60% RPS-eligible energy sources, then only 32% of energy would need to come from unspecified sources.

Table 21 – SCE Electricity Mix

Energy Source	2015 SCE Power Mix (Actual)[1]	2030 SCE Power Mix (Estimated)[2]
Eligible Renewable	25%	60%
Coal	-	-
Large Hydroelectric	2%	-
Natural Gas	26%	-
Nuclear	6%	-
Other	-	-
Unspecified Sources of Power	41%	40%
Total	**100%**	**100%**

Source:
[1] California Energy Commission. 2015 SCE Power Content Label.
[2] Estimated by AECOM.

At the time of emissions forecast analysis, an unspecified energy source emissions factor of 0.428 MT CO_2e/MWh was collected from the California Air Resources Board[42] to evaluate the estimated 2030 SCE emissions factor. When applied to the estimated energy mix shown above, the resulting weighted emissions factor for SCE's estimated 2030 electricity portfolio is 0.1712 MT CO_2e/MWh, as shown in Table 22.

[42] CARB Unofficial Electronic Version of the Regulation for the Mandatory Reporting of Greenhouse Gas Emissions. Available online: https://ww3.arb.ca.gov/cc/reporting/ghg-rep/regulation/mrr-2018-unofficial-2019-4-3.pdf?_ga=2.85289563.330032031.1594773045-55257910.1560365597

Table 22 – 2030 Estimated Electricity Emissions Factor

Energy Sources	2030 Energy Mix	Emissions Factor ($MT\ CO_2e/MWh$)	$MT\ CO_2e/MWh$
Eligible Renewable	60%	0	0
Unspecified Sources of Power	40%	0.428	0.1712
Total	**100%**	**-**	**0.1712**

The estimated 2030 emissions factor was combined with the estimated 2030 activity data to calculate the BAU electricity emissions scenario (see Table 23).

Table 23 – 2030 BAU Electricity Emissions Scenario

Energy Sub-sector	2030 (MWh)	2030 Emissions Factor ($MT\ CO_2e/MWh$)	2030 BAU Emissions ($MT\ CO_2e$)
Residential	833,316	0.1712	142,664
Commercial	763,936	0.1712	130,786
Municipal	108,264	0.1712	18,535
Industrial	1,562,987	0.1712	267,583
Subtotal	**3,268,504**		**559,568**

MITIGATED EMISSIONS SCENARIO

The mitigated scenario was developed with participation estimates and/or goals for the different electricity focused CAAP actions to calculate what amount of future electricity demand would be achieved in a manner that differs from the BAU scenario. The calculations and assumptions are presented below.

BE-1 PROVIDE ACCESS TO RENEWABLY GENERATED ELECTRICITY

SCE-Provided 2030 Electricity Emissions Factor

In September 2020, SCE provided City staff with its estimated 2030 electricity emissions factor that aligns with the utility company's long-term carbon free energy source commitments. The 2030 factor provided by SCE has a lower emissions intensity (i.e., $MT\ CO_2e/MWh$) than the 2030 emissions factor used in the BAU emissions forecast analysis presented in the previous section. The result is that if SCE does achieve its proposed 2030 electricity factor, the City will experience even greater electricity emissions reductions than currently estimated in the BAU scenario. The net additional reductions from use of this new 2030 emissions factor were calculated based on the difference between the 2030 BAU forecast scenario and one in which SCE does achieve its proposed 2030 emissions factor.

PARTICIPATION ASSUMPTIONS

Because this scenario was analyzed as an alternative to the current BAU emissions forecast scenario, this action was quantified to assume that all Long Beach SCE customers would receive electricity with the provided 2030 emissions factor, unless they participate in the SCE Green Rate program or a solar PV installation program. Therefore, participation in this action is assumed to be 100%.

Emissions Factors

SCE provided City staff with a proposed replacement 2030 electricity emissions factor of 0.1192 MT CO_2e/MWh, which is referenced throughout the remainder of this section.

SCE Green Rate Program

For purposes of the CAAP analysis, a scenario was evaluated in which the City of Long Beach encourages voluntary participation in the existing SCE 100% Green Rate program through which residential and commercial electricity customers fund solar energy development with 100% of their energy use. Participation in this program would provide a net GHG reduction beyond implementation of SCE's 80% carbon-free commitment described above.

Participation Assumptions

A review of the Sacramento Municipal Utility District's (SMUD) 2017 Annual Report[43] shows that 74,000 customers participated in the Greenergy program that provides 100% renewable electricity (comparable to SCE's 100% Green Rate program). The report notes that SMUD had 628,952 customer contracts in 2017 and 1,500,000 total customers. The report is unclear if the Greenergy participation reference to 74,000 customers uses that term in the same way as the total customer metric is reported, or if it more closely reflects the number of customer accounts. The different interpretations result in a Greenergy participation rate in 2017 that ranges from 4.9% to 11.8%.

For purposes of the CAAP, voluntary participation in the SCE Green Rate program was assumed to reach 10% by 2030 for residential and commercial customers (industrial customers were not included in this assumption). This could either be viewed as an approximate doubling of participation in SMUD's comparable program from 2017 (which would provide a decade of CAAP implementation to achieve that participation rate) or achieving slightly less participation than SMUD experienced in its comparable program in 2017.

Based on the stated participation assumptions above, Table 24 shows the resulting 2030 electricity demand by sub-sector and SCE rate program option.

Table 24 – Energy Demand Estimate by SCE Rate Option

Energy Sub-sector	2030 (MWh)	SCE Green Rate Participation	SCE Green Rate Energy Demand (MWh)	SCE Non-Green Rate Energy Demand (MWh)
Residential	833,316	10%	83,332	749,985
Commercial	763,936	10%	76,394	687,543
Municipal	108,264	0%	-	108,264
Industrial	1,562,987	0%	-	1,562,987

Emissions Factors

As described above, the assumption is that participation would be in the 100% Green Rate program, which has an emissions factor of 0.0 MT CO_2e/MWh. The portion of electricity demand that is not covered by the 100% Green Rate program (as shown in Table 24) would be provided by SCE at its committed 2030 electricity rate of 0.1192 MT CO_2e/MWh.

[43] SMUD, *2017 SMUD Annual Report*. Available online: https://www.smud.org/-/media/About-Us/Reports-and-Statements/2017-Annual-Report/2017-Annual-Report.ashx

MITIGATED SCENARIO EMISSIONS

The combination of activity data shown in Table 24 with the emissions factors described above result in the mitigated scenario emissions shown in Table 25.

Table 25 – Mitigated Scenario Electricity Emissions

Energy Sub-sector	SCE Green Rate Energy Demand (MWh)	SCE 100% Green Rate Emissions Factor (MT CO_2e/yr)	SCE Non-Green Rate Energy Demand (MWh)	SCE Non-Green Rate Emissions Factor (MT CO_2e/yr)	Total Emissions (MT CO_2e/yr)
Residential	83,332	0.0	749,985	0.1192	89,408
Commercial	76,394	0.0	687,543	0.1192	81,964
Municipal	-	0.0	108,264	0.1192	12,906
Industrial	-	0.0	1,562,987	0.1192	186,328
Subtotal	**159,725**	**-**	**3,108,779**	**-**	**370,605**

The estimated reduction resulting from implementation of this action is calculated based on the difference between the BAU and mitigated scenarios and total approximately 188,960 MT CO_2e/yr (see Table 26).

Table 26 – Emissions Reduction

Energy Sub-sector	BAU Scenario Emissions (MT CO_2e/yr)	Mitigated Scenario Emissions (MT CO_2e/yr)	Emissions Reductions (MT CO_2e/yr)
Residential	142,664	89,408	53,256
Commercial	130,786	81,964	48,822
Municipal	18,535	12,906	5,628
Industrial	267,583	186,328	81,256
Total	**559,568**	**370,605**	**188,960**

Note: Total reduction value has been rounded for use in the CAAP.

BE-2 Increase Use of Solar Power

PARTICIPATION ASSUMPTIONS

Based on a review of Google's Project Sunroof dashboard, the City of Long Beach currently has 1,469 roofs with solar PV installations and a maximum coverage potential of 91,992 roofs (see Table 27). Therefore, approximately 2% of candidate roofs currently have solar. Project Sunroof also estimates that the average system size in Long Beach is 6.8 kW DC with 476 square feet of coverage, producing 10,400 kWh AC per year.

Table 27 – Long Beach Solar PV Data

	Value	Unit
Maximum Coverage Potential	91,992	Roofs
Existing Coverage	1,469	Roofs
% Current Coverage	2%	% of candidate roofs
Per Roof Estimates	6.8	kW DC
Average System Size	476	sq ft
Average Electricity Generation	10,400	kWh AC per year

Source: Google Project Sunroof for City of Long Beach, accessed February 2020

This action assumes that 5% of Long Beach's candidate roofs will have solar installations by 2030; or approximately double the current coverage. This means that more than 3,100 new solar systems would be installed, generating approximately 32,500 MWh of carbon-free electricity (see Table 28). To avoid double counting emissions reductions, this value of carbon-free electricity can be compared to the amount of electricity demand estimated in 2030 that will not be provided through the SCE Green Rate program (see Table 25). The net additional carbon-free energy provided through action BE-2 is approximately 1% of that total remaining energy demand.

Table 28 – Solar Action Implementation Assumptions

	Value	Unit
Roof Coverage by 2030	5%	%
New Installations	3,131	New Roofs
Generation per roof	10,400	kWh AC per year
Total Generation per year	32,562,400	kWh AC per year
Total Generation per year	32,562.40	MWh
BAU Scenario Electricity EF	0.1192[1]	MT CO_2e/MWh
Mitigated Electricity EF	0	MT CO_2e/MWh

[1] This emissions factor corresponds to the SCE 2030 commitment to provide 80% carbon-free electricity; see Action BE-1 description for further information.

EMISSIONS FACTORS

The electricity generated from solar PV systems is a carbon-free energy source for community CAAP planning purposes. The energy provided by these systems would offset purchases of SCE electricity. As shown above, Action BE-1 already estimates the GHG reductions associated with implementation of SCE's 80% carbon-free commitment by 2030. Therefore, this action is calculated to show the net marginal GHG reductions that result from avoiding using of SCE's 2030 electricity.

MITIGATED SCENARIO EMISSIONS

This action would provide net GHG reductions totaling 3,880 MT CO_2e/yr, as shown in Table 29.

Table 29 – Emissions Reduction

Action Electricity Generation (MWh)	BAU Scenario Emissions (MT CO_2e/yr)	Mitigated Scenario Emissions (MT CO_2e/yr)	Emissions Reductions (MT CO_2e/yr)
32,562	3,880	-	**3,880**

BE-6 Perform municipal energy and water audits

PARTICIPATION ASSUMPTIONS

Energy Efficiency
The City regularly takes action to implement energy efficiency improvements as part of standard business operations. The Public Works Department provided information on the primary electricity savings from efficiency improvement programs implemented since 2015, which were quantified for inclusion in the CAAP GHG reduction estimates:

- Street and park light retrofits – 1,538,927 kWh/yr
- Houghton Community Center window upgrades – 295 kWh/yr

The Public Works Department also committed to a reduction in natural gas use within City buildings and facilities of 5% below 2015 base year levels by 2030.

Renewable Energy Development
Public Works staff also provided information on the City's solar PV development programs, including use of power purchase agreements to implement additional solar installations. Table 30 shows the solar installation capacities evaluated in this CAAP action; this table also includes a 1 MW commercial solar program planned for installation by the Energy Department at Pier A West.

Table 30 – Municipal Solar Development Projects

Solar Location	kW Size
ECOC	238.5
Main Health Dept. Building	656
Public Works Yard	668
East Division Police Sub-Station	176
LBGO Headquarters	851
Airport Parking Garage (Lot B)	736
City Place Lot A	216
City Place Lot B	280
City Place Lot C	150
Pike Parking Structure	539
Aquarium Parking Structure	524
Convention Center	2,800
Pier A West	1,000
Total	**8,834.5**

The project team used the PV Watts calculator estimate the approximate electricity generation potential of the City's solar projects shown above. The calculation was performed using the default assumptions within the calculator based on the Long Beach Airport Garage location. Based on these assumptions, the City's 8,834.5 MW of solar development could generate 14,50,584 kWh/yr.

In addition to the solar development projects listed above, the Public Works Department is implementing two battery storage projects totaling 1,685 MWh of storage, and the Energy Department is evaluating and piloting gravity well potential energy storage systems at wellbore sites within the City's oil fields. Neither of these additional actions were included within this action evaluation but could demonstrate additional GHG reduction potential in future CAAP updates.

100% Carbon-Free Electricity

In CAAP action BE-1, the City has committed to purchasing 100% renewable electricity for all municipal accounts by 2030. The GHG quantification shown here assumes that all remaining municipal electricity demand following energy efficiency programs and solar development projects will be offset through participation in the SCE Green Rate program. Note that the action BE-1 quantification inputs above do not include municipal participation in the Green Rate program. GHG reductions related to 100% renewable municipal electricity are included here to illustrate all municipal energy reductions together.

Table 31 summarizes the BAU and mitigated scenario inputs for this action. The municipal energy demand is based on the City's 2015 municipal operations GHG inventory and assumes for CAAP action planning purposes that municipal energy demand does not increase in the future; municipal emissions are represented in inventory sector I.2, as described in Part I of this appendix, and therefore their potential emissions growth was included within the commercial sector energy growth forecasts.

Table 31 – BAU and Mitigated Scenario Inputs

BAU Scenario Energy Demand					
	Value	**Units**	**Emissions Factor**	**Unit**	**MT CO_2e**
Electricity	108,264	MWh	0.1192	MT CO_2e/MWh	12,906
Natural Gas	787,878	therms	0.00532	MT CO_2e/therm	4,190
Subtotal	-	-	-	-	17,097
Mitigated Scenario - Energy Savings					
	Value	**Units**	**Emissions Factor**		**MT CO_2e**
			BAU	**Mitigated**	
Solar Development	14,508	MWh/yr	0.1192	-	1,729
Energy Efficiency - electricity	1,539	MWh/yr	0.1192	-	183
Energy Efficiency - natural gas	39,394	therms	0.0053	-	210
Renewable Electricity Purchase	92,217	MWh/yr	0.1192	-	10,993
Subtotal					**13,116**

Emissions Factors

To avoid double counting with GHG reductions estimated in action BE-1, the electricity savings and solar development potential were multiplied by the SCE 2030 emissions factor that corresponds to its 80% carbon-free energy commitment. The natural gas emissions factor was derived from the 2015 municipal operations GHG inventory, dividing natural gas emissions by reported therms consumption.

Mitigated Scenario Emissions

Table 32 shows the mitigated scenario emissions and allocates the GHG reductions to energy efficiency, solar energy development, and carbon-free electricity purchases.

Table 32 – Mitigated Scenario Emissions by Source

Reductions Source	MT CO_2e
Energy Efficiency	393
Solar PV Development	1,729
Carbon-free Electricity Purchase	10,993
Subtotal	**13,116**

BE-8 Implement short-term measures to reduce emissions related to oil and gas extraction

PARTICIPATION ASSUMPTIONS

The Long Beach Energy Resources Department anticipates a decrease in oil production of 20% below 2018 production volumes by 2030 due to depletion. In 2018, 11,158,706 barrels of oil (bbl) were produced in the city. This commitment would result in a 2030 production volume of 8,926,965 bbl.
The CAAP emissions forecasts had assumed that 2018 production levels would remain constant based on year-over-year production declines. This was a conservative approach in that production has already been decreasing, but the forecasts did not assume continued declines beyond the last year for which empirical data was available at the time of analysis (i.e., 2018).

EMISSIONS FACTORS

To estimate GHG reductions associated with decreased oil production, the project team calculated a per barrel emissions factor based on the 2015 GHG inventory oil industry emissions divided by the 2015 production volume. The emissions sub-sectors included in this analysis include I.4.1 and I.8.1 (see Part I of this appendix for further information).

MITIGATED SCENARIO EMISSIONS

Table 33 shows the inputs used to quantify this action.

Table 33 – Oil and Gas Emissions per Barrell

	Value	Unit
2015 Oil Production	13,321,018	bbl
2015 Oil-related Emissions	249,139	MT CO_2e/yr
2015 Emissions per Barrel	0.019	MT CO_2e/bbl
2030 Oil Production – BAU	11,158,706	bbl
2030 Oil Production – Mitigated	8,926,965	bbl
2030 Oil Production Reduction	2,231,741	bbl
2030 GHG Reductions	**41,740**	**MT CO_2e/yr**

T-1 Increase the frequency, speed, connectivity and safety of transit options

PARTICIPATION ASSUMPTIONS

This action assumes that implementation of transit system and ridership improvements will result in a 1% VMT reduction below 2030 BAU levels for light duty vehicles (gas and diesel).

Emissions Factors

Reductions from this action were calculated using the same methodology used to estimate GHG emissions for sub-sector II.1 On-Road Transportation. The project team re-ran the emissions forecast calculations based on VMT values that included a 1% reduction in gas and diesel VMT for light duty vehicles. Refer to Part I of this appendix for further detail on the on-road emissions quantification methodology.

Mitigated Scenario Emissions

As with the electricity actions described above, GHG reductions from this action were calculated as:

Emissions Reduction = (Business-as-Usual Emissions) – (Mitigated Scenario Emissions)

See Table 34 for outputs from this on-road emissions model analysis. This action is estimated to result in reductions of approximately 5,230 MT CO_2e/yr.

Table 34 – Action Quantification Inputs

	Value	Unit
VMT Reduction – LDV – gas and diesel	1	1%
2030 BAU – LDV Gasoline	2,390,410,729	VMT/yr
2030 BAU – LDV Diesel	25,468,434	VMT/yr
2030 BAU – LDV Gasoline and Diesel	522,835	MT CO_2e/yr
2030 Mitigated – LDV Gasoline	2,366,506,622	VMT/yr
2030 Mitigated – LDV Diesel	25,213,750	VMT/yr
2030 Mitigated – LDV Gasoline and Diesel	517,607	MT CO_2e/yr
Reduction	**5,228**	**MT CO_2e/yr**

T-4 Implement the Port of Long Beach Clean Trucks Program

Participation Assumptions

This action is based on implementation results for the Port of Long Beach Clean Trucks Program. The Clean Air Action Plan estimates GHG reductions from this action could range from 10-46% in 2031. The project team conservatively estimated the low-end of this range for use in quantifying GHG reductions.

The 2015 CAAP inventory did not have granular enough information from the on-road travel model to isolate VMT associated with Port truck activity. The project team used the diesel heavy-duty vehicle (HDV) on-road category as a proxy for Port trucking activity. The ratio of HDV VMT from the Port's 2015 Air Emissions Inventory was compared to the CAAP on-road VMT data to help scale the emissions reduction estimates. As shown in Table 35, the comparison of HDV VMT in these two inventories shows the Port value is approximately 8.2% lower than that assumed based on the community-wide on-road inventory. Since this action is quantified as a reduction in future GHG emissions, the community-wide diesel HDV emission were extracted from the on-road emissions inventory and normalized by multiplying by -8.2%. A 10% reduction in the 2030 diesel HDV emissions was then calculated to estimate the reduction potential of this action.

EMISSIONS FACTORS
The calculations were based on the emissions from the CAAP GHG inventory and forecasts. See Part I of this appendix for further information on how on-road emissions were calculated.

Table 35 – Action Quantification Inputs

	VMT	MT CO_2e/yr	
		2015	2030
Port Inventory - Diesel HDV on-road emissions	151,857,117	256,283	-
Community Inventory - Diesel HDV on-road emissions	164,234,998	230,181	274,876
Ratio (Port/Community Inventory)	-8.2%	-	-8.2%
Scaled Diesel Emissions (Estimate of Port's diesel HDV emissions in community inventory)	-	-	252,471
Clean Trucks Program – GHG Reduction Potential	-	-	10%
GHG Reductions	-	-	**25,250**

ADDITIONAL PORT EMISSIONS CONSIDERATIONS
In addition to the Clean Trucks Program quantified above, the Port of Long Beach has committed to achieve 100% emissions-free cargo handling equipment (CHE) by the year 2030. The city's 2015 GHG inventory estimated off-road vehicle and equipment emissions based on ARB's OFFROAD model (the most up to date program at the time), which did not include emissions associated with CHE. ARB's current offroad emissions model, Orion, does include CHE emissions, so future GHG inventories can accurately reflect this emissions source. The Port's 2015 Air Emissions Inventory estimated that CHE emissions totaled nearly 127,000 MT CO_2e/yr. The Port's ongoing GHG reduction actions will serve to fully reduce this emissions source by the 2030 CAAP target year.

The Port will also implement ARB's Ocean-Going Vessels At-Berth Regulation that will result in reduced fuel use by certain vessel types when at-berth in the Port of Long Beach. ARB has estimated that implementation of this regulation will result in emissions reduction totaling approximately 100,500 MT CO_2e/yr at the Port of Long Beach

Neither of these GHG reduction values is included in the CAAP's target achievement pathway because they both represent emissions sources that are not included in the city's jurisdictional production inventory. However, both actions demonstrate the ongoing commitment of the Port of Long Beach to identify and implement programs and actions that will reduce GHG emissions and improve local air quality.

T-5 Develop an Electric Vehicle Infrastructure Master Plan

Long Beach Airport is implementing programs to increase use of electric ground service equipment (GSE) to reduce emissions from gasoline- and diesel-powered equipment. Sufficient data was unavailable during CAAP development to estimate potential future reductions from these efforts. However, the Airport's 2031 BAU Emissions Inventory report estimates emissions from GSE will total approximately 2,559 MT CO_2e/yr. Future CAAP updates will monitor implementation of vehicle and equipment electrification programs citywide to understand if additional GHG reductions are occurring beyond those currently estimated within this appendix.

Solid Waste Calculations

The solid waste actions are calculated based on the methane commitment methodology equations described in the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC), and replicated in Part I of this appendix. Specifically, the calculations follow Equation 8.3, and use the same default factors as described in Part I. The methodological descriptions of the actions included below describe the process for calculating other inputs needed in the GPC equation. Please refer to Part I of this appendix for a full description of the methane commitment method and its corresponding equations and default assumptions.

The solid waste disposal data from 2015 was used to estimate landfill disposal amounts by facility in 2030 (see Table 36). AECOM used the 2015 disposal data shown in Table 14 and converted from short tons to metric tons for use in the preceding equations. The rate of disposal, expressed as metric tons per service population (MT/SP), where service population is residents plus employees, was calculated based on 2015 values, and held constant to estimate future disposal values in the emissions forecasts.

Table 36 – Landfill Waste Disposal Forecasts

Year	Short Tons (ST)	Metric Tons (MT)	Service Population (SP) [3]	MT/SP [4]
2015	409,258 [1]	371,273 [2]	624,312	0.595
2030	-	388,167 [5]	652,721	0.595

Source: AECOM 2018

Notes: Service population (SP) = population and jobs

[1] See Table 13, landfill plus ADC volume

[2] 1.0 short ton = 0.9072 metric tons

[3] See Table 19 for demographic data sources

[4] Calculated for 2015 as MT/SP, and held constant for 2030

[5] Calculated as SP * (MT/SP)

For CAAP action planning purposes, the volume of waste disposal was further disaggregated into single-family residential, multi-family residential, commercial, and ADC. Table 37 shows the breakdown by land use type and treatment destination. The project team used the CalRecycle Waste Characterization Web Tool – Residential Waste Stream Data Export tool to evaluate the contribution of single-family and multi-family waste in Long Beach (values shown in Table 37). Single-family residential waste collected in the city is sent to SERRF for incineration; multi-family residential waste is sent to regional landfills as shown in Table 13. The project team then derived the commercial portion of the waste stream by subtracting the multi-family residential value from the total volume sent to landfills in 2015.

Table 37 – Landfill Waste by Type and Destination

CalRecycle Land Use Splits	Tons (ST)	Tons (MT)	Destination	Landfill Waste Ratio
Single-family Residential	71,963	65,284	SERRF	-
Multi-family Residential	49,413	44,827	landfill	12%
Commercial	228,292	207,103	landfill	56%
ADC	131,553	119,343	landfill - ADC	32%
Total (non SFR city hauled)	409,258	371,273	-	100%

The corresponding landfill waste ratio was applied to the total 2030 disposal forecast (see Table 36). Table 38 shows the modeled 2030 disposal tonnage by land use and type for use in the CAAP action quantification.

Table 38 – 2030 Landfill Waste Estimates

Land Use Splits	Disposal Value (landfill or ADC)	Units
Multi-family Residential	46,867	tons (MT)
Commercial	216,527	tons (MT)
ADC	124,773	tons (MT)
Total	388,167	tons (MT)

W-1 Ensure compliance with state law requirements for multifamily and commercial property recycling programs

PARTICIPATION ASSUMPTIONS

This action would increase paper and cardboard recycling in the multi-family residential and commercial waste streams to reduce waste in these categories 75% below the 2030 estimated levels.

EMISSIONS FACTORS

To model emissions reductions, separate multi-family residential and commercial hypothetical landfill profiles were developed. This allowed each CAAP action to be applied differently based on land use type. The same methane commitment calculation inputs were used as described in Part I of this appendix. A weighted landfill methane collection factor was calculated based on the estimated 2030 waste disposal volume by landfill facility and the methane collection rates shown in Table 14. The resulting weighted methane collection rate was 77.61% for landfills that received Long Beach waste in 2015.

MITIGATED SCENARIO EMISSIONS

Tables 39 and 40 show the modeled 2030 multi-family and commercial landfill emissions by waste type based on the methane commitment methodology calculations described in Part I. The total landfill waste weight by composition correspond to the values shown in Table 38. This action would divert 75% of the paper/cardboard waste tonnage away from landfills, and therefore avoid 75% of these estimated future emissions. Reductions would total 7,461 MT CO_2e/yr from the multi-family sector, and 37,873 MT CO_2e/yr from the commercial sector; total reductions from this action are estimated to be approximately 45,340 MT CO_2e/yr.

Table 39 – 2030 Multi-family Residential Landfill Emissions

Waste Type	Landfill Waste Composition (Weight)	DOC Content in Waste	GHG Emission (Methane)	GHG Emission (MT CO_2e)
Paper/Carboard	11,019	40.0%	355	9,949
Textiles	3,785	24.0%	73	2,050
Food	11,609	15.0%	140	3,931
Garden and Park	5,268	20.0%	85	2,378
Wood	2,228	43.0%	77	2,163
Rubber and Leather	0	39.0%	0	0
Plastics	5,162	0.0%	0	0
Metal	1,657	0.0%	0	0
Glass	1,402	0.0%	0	0
Other	4,736	0.0%	0	0
Total	**46,867**		**731**	**20,470**
W-1 Paper/Cardboard Reduction				
75%				**7,461**
W-3 Food / Garden and Park / Wood Reduction				
75%				**6,354**

Table 40 – 2030 Commercial Landfill Emissions

Waste Type	Landfill Waste Composition (Weight)	DOC Content in Waste	GHG Emission (Methane)	GHG Emission (MT CO_2e)
Paper/Carboard	55,930	40.0%	1,803	50,498
Textiles	9,751	24.0%	189	5,282
Food	53,648	15.0%	649	18,164
Garden and Park	25,225	20.0%	407	11,388
Wood	15,409	43.0%	534	14,956
Rubber and Leather	48	39.0%	2	42
Plastics	26,210	0.0%	0	0
Metal	7,662	0.0%	0	0
Glass	4,910	0.0%	0	0
Other	17,732	0.0%	0	0
Total	**216,527**		**3,583**	**100,330**
W-1 Paper/Cardboard Reduction				
75%				**37,873**
W-3 Food / Garden and Park / Wood Reduction				
75%				**33,381**

W-3 Partner with private waste haulers to expand organic waste collection community-wide

PARTICIPATION ASSUMPTIONS

This action would increase organic waste diversion in the multi-family residential and commercial waste streams to reduce waste in these categories 75% below the 2030 estimated levels.

Note that a similar action is included in the CAAP for single-family residential waste (action W-2). However, single-family waste is processed at SERRF and its corresponding GHG emissions are excluded from the CAAP for GHG target achievement purposes (see Part I of this appendix for further information on this). Therefore, GHG reductions are not estimated for W-2 since the corresponding emissions are not included in the jurisdictional production inventory.

EMISSIONS FACTORS

The same approach to action quantification as described in W-1 was taken for this action.

MITIGATED SCENARIO EMISSIONS

Tables 39 and 40 included above with action W-1 also highlight the reductions associated with this action. Each table shows a GHG reduction value from diverting 75% of the food, garden and park, and wood waste tonnages away from landfills, therefore avoiding 75% of these estimated future emissions. Reductions would total 6,354 MT CO_2e/yr from the multi-family sector, and 33,381 MT CO_2e/yr from the commercial sector; total reductions from this action are estimated to be approximately 39,730 MT CO_2e/yr.