California's Greenhouse Gas Emissions Inventory

A Compilation of Inventory Updates Since the 2016 Edition of the Inventory

Supplement to the Technical Support Document

CALIFORNIA AIR RESOURCES BOARD

Air Quality Planning and Science Division

Method Updates as of March, 2022

California's 2000-2015
Greenhouse Gas Emissions Inventory

2017 Edition

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State of California
Air Resources Board
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INTRODUCTION

Assembly Bill 1803 gave California Air Resources Board (ARB) the responsibility of preparing and updating California's greenhouse gas (GHG) inventory to track the State's progress in reducing GHG emissions. The GHG inventory is a critical piece, in addition to California Global Warming Solutions Act (AB 32) program data, in demonstrating the State's progress in achieving the 2020 statewide GHG target. The 2017 edition of California's GHG inventory covers emissions for 2000 through 2015 and includes inventory improvements and accounting method updates.

The GHG inventory was developed according to the *Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories* (IPCC Guidelines)(IPCC, 2006), which are the internationally recognized standard for developing national GHG inventories. Since the 2016 edition of the inventory (2000-2014 emissions), staff has made several improvements to inventory categories, emissions estimation methods, and data sources. This document provides a description of the inventory updates since the previous edition of the inventory.

Each release of the California inventory incorporates the latest available data sources and current scientific understanding of GHG emissions. The IPCC guidance for GHG inventories states that it is good practice to recalculate historic emissions when methods are changed or refined, when new source categories are included in the inventory, or when errors in the estimates are identified and corrected. Consistent with the IPCC Guidelines, recalculations are made to incorporate new methods or to reflect changes in statistical data supplied by other agencies for all years from 2000 to 2015, to maintain a consistent time-series of estimates within the inventory. Therefore, emission estimates for a given calendar year may be different between editions as methods are updated or if the data source agencies revise their data series.

In the sections to follow, a background on each updated category is presented followed by a description of the update. The sections in this document are organized by the hierarchical structure of IPCC inventory categorization (as shown in the Table of Contents). For reader's convenience, a table summarizing inventory updates organized by AB 32 Scoping Plan sector category is provided on the next page.

SUMMARY LIST OF UPDATES

Scoping Plan Sector Category	Description of Update	IPCC Category	Section Number In This Documentation
Industrial	Disaggregated oil & gas production fugitive emissions into three subcategories: production, processing, and storage fugitives	Energy	A.1
Industrial	Disaggregated natural gas pipeline/ transmission & distribution emissions into two subcategories to: storage fugitives and pipeline fugitives	Energy	A.2
Industrial (Excluded Category)	Updated petroleum seeps estimation with two studies on emissions from La Brea Tar Pits and Coal Oil Point	Energy (Excluded Category)	A.3
High GWP	Revised the refrigerant mix assumption for Transport Refrigeration Unit (TRU) based on new information	Industrial Processes and Product Use	B.1
High GWP	Updated the 2000-2010 time series for SF_6 emissions from electrical equipment based on an ARB survey	Industrial Processes and Product Use	B.2
Agriculture	Used the DeNitrification-DeComposition (DNDC) model to update N_2O emissions from synthetic fertilizers and crop residues	Agriculture, Forestry, and other Land Uses	C.1
Recycling and Waste	Updated the composting emission factor using California specific data in ARB's updated Compost Emission Reduction Factor (CERF)	Waste	D.1
NA	Incorporated GHG emissions from the exceptional natural gas leak event at Aliso Canyon	Energy	E.1

Interim Method for Addressing Temporary Data Unavailability During Data Transition

Scoping Plan Sector Category	Description of Update	IPCC Category	Section Number In This Documentation
Industrial	Updated the CO_2 consumption number to match USEPA's most recent estimates, and to ensure a consistent time series	Industrial Processes and Product Use	F.1
Industrial	Extrapolated parameter values for domestic wastewater based on previous years data	Waste	F.2

DESCRIPTION OF INVENTORY UPDATES

A. Energy

1. Oil & Gas Production Fugitive Emissions (IPCC 1B2): Disaggregate into Three Subcategories

1.1 Background

The existing categorization aggregates all the fugitive emission activities associated with the oil and gas production into a single category, process losses. This category is now expanded to include three new categories: Production, Processing, and Storage. ARB's Crude Oil and Natural Gas Industry Survey (ARB, 2007a), on which the data in this category was based, already delineated data into these three categories; therefore, disaggregating the GHG inventory using the same survey data is straightforward. This inventory update does not change the emission estimation methodology, but it is simply reporting emissions at a greater level of detail.

1.2 Estimation Methodology

The methodology has not changed, only the categories were expanded to provide more detail.

2. Natural Gas Transmission and Distribution Fugitive Emissions (IPCC 1B2b): Disaggregate into Two Subcategories

2.1 Background

The existing categorization aggregates all the fugitive emission activities associated with natural gas transmission and distribution into a single category, natural gas pipelines fugitives. This category is now re-labeled as natural gas transmission and distribution to represent the broader natural gas delivery system, and is expanded to include two new categories: natural gas storage fugitives and natural gas pipeline fugitives. ARB's natural gas transmission and distribution survey (ARB, 2007b), on which the data in this category is based did not provide enough detail for this disaggregation; therefore, staff used the Mandatory GHG Reporting Regulation (MRR) (ARB, 2016a) data to break the storage emissions out from the total. The total aggregated emissions do not change, but they are now reported under two categories of finer detail.

2.2 Estimation Methodology

The MRR program collects emissions data on both storage and pipeline leaks from the natural gas industry. The emissions reported for storage were divided by the total emissions reported for the fugitive emissions from the natural gas transmission, distribution and storage to obtain the percentage of emissions associated with storage. Fractions attributed to storage were calculated from the MRR dataset for each year from 2011to 2015, and were applied to the existing total fugitive emissions to obtain an estimate for storage emissions. The rest of the emissions were then assigned to the pipeline fugitive category. For the back years 2000-2010, for which MRR does not have data, the 3-year average of 2013-2015 was used as the surrogate for the percent associated with storage. Staff has chosen to use the data for 2013-2015 instead of the data for 2011-2013 to estimate 2000-2010 emissions because the later years are considered more robust as the reporting program matured over time.

3. Petroleum Gas Seeps Fugitive Emissions (IPCC 1B2)(Excluded Emissions): Update with Two Studies on Emissions from La Brea Tar Pits and Coal Oil Point

3.1 Background

In the previous editions of the inventory, the petroleum seeps emission estimates were taken from the California Emission Inventory Database And Reporting System (CEIDARS)(ARB's inventory database for criteria pollutants). The Total Organic Gas reported for this category was speciated into methane and used as an estimate for seep emissions. In CEIDARS, this data is reported by the local air quality districts and not updated regularly. In this edition of the inventory, emission estimates from studies on the two largest seeps in the state, Coal Oil Point and The La Brea Tar Pits, were used to augment the estimate from CEIDARS. Petroleum seeps are considered a natural emission source and is classified as "excluded" emissions (that are tracked in the inventory but are not used to compare against California's 2020 emission limit).

3.2 Estimation Methodology

The studies each provided a single year emission estimate for the seep under analysis. Since there are no data available for other years, it is assumed that the estimate for a single year is representative of all years. The seeps emissions in all likelihood do fluctuate over time, but it is assumed that the fluctuations will be small and not more significant than the inherent uncertainties of the estimates. The study of the La Brea Tar Pits (Jeong, 2013) was conducted in 2010 and estimated the annual methane emissions at 1.5 $MMTCO_2e$. The study of Coal Oil Point (MMS OCS, 2003) was conducted in

1996 and estimated the methane emissions at 0.7 $MMTCO_2e$. The petroleum seeps category in the GHG inventory is now the sum of the emissions from these 2 studies and the estimate from CEIDARS.

B. Industrial Processes and Product Use

1. Product uses as Substitutes for Ozone Depleting Substances (IPCC 2F): Update the Refrigerant Mix Assumption for Transport Refrigerated Units (TRU)

1.1 Background

The emissions from refrigerant use in the transport sector include road transport refrigeration units (TRU) used in trailers over 25 feet in length, single unit trucks 11 to 25 feet in length, and vans less than 11 feet in length. Before 1994, no HFCs were used as refrigerants in TRUs; the refrigerants used were CFC-12 and R-502 (a blend of CFC-115 and HCFC-22), both of which are ozone-depleting substances (ODS). Due to the global phase-out of ODS required by the Montreal Protocol, beginning in 1995 new TRU units were manufactured using HFC refrigerants. The two refrigerants used in new units were HFC-134a (GWP of 1430), and R-404A (GWP of 3922), a blend of the following HFCs: HFC-143a (52%), HFC-125 (44%), and HFC-134a (4%).

In the 2016 and prior editions of the ARB GHG inventory, the assumption for TRUs built beginning in 1994 through the present was that 76% used HFC-134a and 24% used R-404A as the refrigerant, with a weighted average GWP of 2028. Emission factor assumptions are routinely reviewed and updated when necessary, and it was discovered that the given refrigerant usage assumptions for TRUs may have been applicable to European road transport, but did not reflect TRUs in California or the U.S. Multiple data sources were consulted[1], resulting in the update described below.

1.2 Model Update

Beginning in the 2017 edition of the GHG inventory, the refrigerant mix assumption for TRU built in 1994 through the present has been updated to 10% using HFC-134a and 90% using R-404A as the refrigerant, with a weighted average GWP of 3673. The updated GWP is 80% greater than the previous weighted average. HFC emissions in $MMTCO_2e$ from this sector are therefore also 80% greater than previously estimated.

[1] Schwarz, et. al., 2011; UNEP, 2015; 2011; Kwon, 1998; Carrier, 2015; Green Cooling Initiative, 2016; HDT, 2012; Michineau, et al., 2012; Racplus, 2013; Refrigerant HQ, 2014; Thermo King, 2016

2. <u>Sulfur Hexafluoride from Use of Electrical Equipment (IPCC 2G1b): 2000-2010 Data Update</u>

2.1 Background

Sulfur hexafluoride (SF_6) gas is used by the electric power industry in gas-insulated substations, circuit breakers, and other switchgear because of its dielectric strength and arc-quenching characteristics. Fugitive emissions of SF_6 are the result of leaks through seals of gas-insulated substations and switchgear. SF_6 can also be released during equipment installation and servicing.

2.2 Data Update

In the previous editions of the inventory, SF_6 emissions from gas-insulated switchgear (GIS) for years 2000-2010 were calculated by scaling the national emissions in the U.S. Environmental Protection Agency (USEPA) GHG inventory down to California level using the California-U.S. ratio of electricity generation. In this edition, the 2000-2010 time series was updated to include 2008 California-specific data compiled in a survey conducted by ARB in 2009 (ARB, 2009). The 2008 number estimated from the survey results is directly used in the GHG inventory and used as an anchor point for adjusting the estimates for other years in the 2000-2010 time series. The 2000-2010 emission trend from the previous inventory edition is mapped to the updated 2008 number. This update does not change the emission numbers for 2011-2015, as they are directly reported to ARB through the Regulation for Reducing Sulfur Hexafluoride Emissions from Gas Insulated Switchgear program (ARB 2007c).

C. Agriculture, Forestry and Other Land Use

1. <u>Nitrous Oxide from Soil Management - Synthetic Fertilizer and Crop Residue (IPCC 3C4): A Tier 1 and Tier 3 Hybrid Approach</u>

1.1 Background

Nitrous oxide (N_2O) emissions from soils are primarily produced through microbial-mediated processes of nitrification and denitrification, and are subject to controls of many soil environmental factors. Nitrogen (N) input from fertilizer, manure, and crop residue into soils can lead to increased N availability for nitrification and denitrification, therefore resulting in N_2O emissions released into the atmosphere. The agricultural soil management category in the GHG inventory includes estimates of direct and indirect N_2O

emissions from synthetic fertilizer, organic fertilizer, manure application, and crop residues returned on croplands.

Past editions of the inventory used an IPCC Tier 1 approach based on default emission factors to estimate emissions from these soil management activities. In this edition, the methodology for direct N_2O emissions from crop residues and synthetic fertilizer used on croplands without manure application has been updated to a Tier 1 and Tier 3-hybrid approach employing a process-based model, DeNitrification-DeComposition (DNDC). The methodology for other soil management activities remains unchanged from the previous inventory editions; and these include the use of organic fertilizer on croplands, dairy croplands receiving manure application (where synthetic fertilizer may be used in conjunction with manure), and organic farms (which may use a combination of organic and manure fertilizer), as well as indirect N_2O emissions from any type of croplands. In addition, with the availability of a new data source, staff updated the synthetic fertilizer application rates for dairy croplands although the calculation methodology remains unchanged from the previous inventory editions (i.e., Tier 1 approach). The table below summarizes methodologies for specific soil management activities used in this edition.

Table 1. Summary of methodologies used to calculate direct N2O emissions for specific soil management activities.

Soil Management Activity	Non-Organic Cropland without Manure Application	Dairy Cropland with Manure Application	Organic Farms
Organic Fertilizer	Tier 1 (no change in method)	Tier 1 (no change in method)	Tier 1 (no change in method)
Synthetic Fertilizer	DNDC	Tier 1 (no change in method but updated application rates)	NA
Crop Residues	DNDC	Hybrid Tier 1 & 3 (updated crop residues using DNDC)	Hybrid Tier 1 & 3 (updated crop residues using DNDC)
Manure Application	NA	Tier 1 (no change in method)	Tier 1 (no change in method)

1.2 Methodology for Synthetic Fertilizer and Crop Residues on Cropland without Manure Application

DNDC Model

The DNDC model (Li et al., 1992; Li, 2000) is a process-based soil biogeochemical model developed for quantifying GHG emissions, and has been extensively evaluated against datasets of N_2O fluxes that were measured worldwide (e.g., Gilhespy et al., 2014; Giltrap et al., 2010) and in California (Li et al., 2013). DNDC accounts for both natural factors and farming management practices (FMPs) affecting N_2O emissions from soils. DNDC simulations of N_2O emissions from California croplands have been tested against field N_2O emissions from typical cropping systems in California. The tests showed that DNDC was capable of predicting observed seasonal and annual total N_2O emissions from typical California cropping systems and the model's performance was better than the Tier 1 approach. Therefore, the new hybrid methodology provides a better estimate of direct N_2O emissions from synthetic fertilizer and crop residue.

DNDC consists of two components. The first component, which consists of the soil climate, crop growth and decomposition sub-models, predicts soil temperature, moisture, pH, redox potential and substrate concentration distribution (e.g. ammonium, nitrate, dissolved organic carbon) based on ecological drivers (e.g., climate, soil, vegetation and anthropogenic activity). The second component, which consists of the nitrification, denitrification and fermentation sub-models, predicts carbon and nitrogen gases fluxes (such as carbon dioxide, N_2O, and methane) based on soil environmental variables.

N_2O Emission Calculation

DNDC was used to estimate direct N_2O emissions from croplands without manure application by linking the model with a California-specific database containing data on weather, crop types and areas, soil properties, as well as farming management practices. The total cropland areas simulated ranged between 2.591×10^6 and 3.159×10^6 ha from 2000 to 2015, representing an average of 92% of total California croplands (ranged from 90% to 93%). Four scenarios of irrigation methods (i.e., flooding, sprinkler, drip, and subsurface drip) were included in the model to reflect the diverse irrigation management practices in California (Orang et al., 2008; Tindula et al., 2013). For each individual year, DNDC was run for three consecutive years to initialize the model to allow the distribution of carbon and nitrogen speciation in soil to match closely to field conditions. The results for the third year were taken as the emission estimate for that individual year. These results represent direct emissions from synthetic fertilizer and crop residues. However, we used 3-year rolling average of emission estimates, as described in the next section, to represent emissions of a given inventory year.

In the previous editions, N_2O emissions from crop residues returned to soil were only calculated for 13 crops, six of which were adjusted for crop residue burning. The amounts of N inputs from crop residues of the 13 crops were calculated using default crop yields and N contents of above- and below-ground residues; and the conversion of crop residue N to N_2O was calculated using the IPCC default emission factor. DNDC produced N inputs from crop residues for 53 crops. The DNDC-derived N_2O emissions from crop residues were further adjusted for crop residue burning for the six crops by subtracting the portion of N that was released to the atmosphere by burning, instead of being returned to the soil.

Three-Year Rolling Average

Besides farm management practices, a primary driver of N_2O emissions from microbial-mediated process of nitrification and denitrification is the timing and the amount of precipitation, which can lead to high year-to-year variability in emissions. Since DNDC accounts for farming management practices as well as natural factors, N_2O emissions estimated by DNDC may also exhibit large variability from year to year due to weather conditions. To better track emission trend due to changes in farm management practices over time, without large year-to-year variability driven by natural forces, 3-year rolling average of annual DNDC outputs is used to represent emissions in this category in the inventory.

1.3 Synthetic Fertilization Application Rates for Dairy Croplands and Organic Farms

Due to lack of comprehensive data on manure application in cropland at this time, N_2O emissions from dairy croplands that receive manure application are still calculated using the Tier 1 approach based on the IPCC default emission factors. In previous inventory editions, croplands with or without manure application were not differentiated, and the same synthetic fertilizer application rates (which vary by crop type) were used regardless of whether the cropland receives manure. In this edition, synthetic fertilizer application rates for dairy croplands are updated based on the 2013 Annual Dairy Reports obtained from the Regional Water Quality Control Boards (RWQCB, 2014). Staff surveyed data from 127 randomly selected dairy farms in the 2013 Annual Dairy Reports, representing at least 10% of the reports submitted for each county, and compiled the updated synthetic fertilizer application rates for dairy croplands. Table 2 summarizes the new synthetic N fertilizer rates used for dairy croplands.

Table 2. Updated synthetic fertilizer rate in dairy croplands

Crop	Synthetic Fertilizer Rate (lbs N/acre)
Almonds	0
Corn, grain	160
Corn, silage	41
Cotton	62
Grapes, all	0
Hay, alfalfa	11
Hay, (excl alfalfa)	2
Fruit, other	54
Nuts, other	0
Oats	6
Sorghum	4
Wheat, winter	27

Synthetic fertilizer rates for croplands in organic farms were assumed to be zero per organic certification requirement.

1.4 Methodology for Crop Residues on Dairy Croplands and Organic Farms

N_2O emissions from N input in crop residues returned to soil in dairy croplands and organic farms were calculated using a hybrid approach. The amounts of N inputs in crop residues produced from DNDC for croplands without manure application were adopted for the croplands in dairy and organic farms with the assumption that crops in those croplands normally receive sufficient N application to support full plant growth. However, the conversion of crop residue N to N_2O emissions was still calculated using the IPCC default emission factor as in previous editions.

1.5 Data Sources

To simulate N_2O emissions using DNDC, a California-specific database was created. The input information contained in the database include: (1) daily meteorological data, (2) land area of different crop types, (3) soil properties, and (4) farming management practices. These data were collected and organized for each county.

Meteorological data. Daily meteorological data were derived from weather data produced by the DAYMET model (Thornton et al., 2015).

Crop areas. Statewide crop total areas were obtained from the U.S. Department of Agriculture's (USDA's) National Agricultural Statistics Service

(NASS), Quick Stats (USDA, 2016a). County level crop area data were also from NASS Quick Stats for census years. For non-census years, statewide totals were allocated to the counties for each crop, based on the fraction of total cropland area in each county with respect to the statewide total cropland area, as interpolated from census years prior to 2012, or from the California Department of Food and Agriculture's (CDFA) California Agricultural Statistics reports after 2012 (CDFA, 2013-2016).

Croplands with manure application were not simulated by DNDC, and their acreages were therefore removed from the crop area used in the DNDC modeling. County dairy cropland areas were estimated from the dairy Geographic Information System (GIS) files obtained from the Regional Water Quality Control Boards (RWQCB, 2015). The dairy crop data (type of crops and planted areas) in dairy croplands were derived from 127 dairy farms sampled from 2013 Annual Dairy Reports (RWQCB, 2014). The organic farm areas and associated crops were obtained from the University of California- Davis reports on "Statistical Review of California's Organic Agriculture" (UCD, 2007-2013), and were also not modeled in DNDC.

Soil data. Soil data were collected from USDA's Soil Survey Geographic Database (SSURGO) database (USDA, 2016b). Key soil data, including bulk density, clay content, soil organic carbon content and pH, were compiled. The SSURGO map units were overlaid with the regions of agricultural landuse developed by the Land Use Surveys of the California Department of Water Resources (CDWR, 2014) and the area-weighted means of the four soil properties were calculated for each county. The area-weighted means of the soil properties were used as "representative" soil values for simulating N_2O emissions for the inventory.

Farming management data. Farming management data, including planting and harvest dates, tillage, fertilization, irrigation, and residue management, were developed for the crops largely from open literature, surveys, as well as personal communications with researchers, growers, and University of California Cooperative Extension staff. There was no discernable trend in N fertilizer application rates in the past 25 years, so we used static N application rates for 2000 to 2015 (Rosenstock et al., 2013; UCD, 2015). Irrigation methods for the crops were assumed to change overtime per the CDWR's Statewide Irrigation Methods Surveys (CDWR, 2015). The four irrigation methods modeled were surface gravity irrigation, sprinkler irrigation, surface drip, and subsurface drip. Fractions of irrigation methods for each crop were developed using linear interpolation for 2000 to 2010 and extrapolation for 2011 to 2015.

1.6 Changes in Estimates

Compared to the Tier 1 approach, the emission estimates obtained using the hybrid methodology are more dynamic, related closely to the environmental and farming management variables. In previous inventory editions, direct N_2O emissions from synthetic fertilizer and crop residue calculated using Tier 1 approach were relatively constant over time due to the use of a constant emission factor. In contrast, the N_2O emissions based on the hybrid methodology showed an overall decreasing trend from 2000 to 2015, which was primarily due to: (1) reductions in cropland area and associated N inputs from synthetic fertilizer and crop residue; (2) lowered N_2O emission rate per unit N input due to large-scale changes in irrigation management practices that moved from flood irrigation towards sprinkler and drip irrigation; and (3) the use of the updated synthetic fertilizer rates for dairy and organic farming croplands.

D. Waste

1. **<u>Composting of Organic Waste (IPCC 4B): Updated Compost Emission Factor</u>**

1.1 Background

Composting of organic waste such as food scraps, yard trimmings, branches, leaves, grass, and organic municipal solid waste, is common in California as a way to divert such waste from landfills. Composting is a controlled decomposition process that destroys pathogens in the waste material, reduces its volume greatly and yields a stable organic-rich soil-like mixture called compost. This section pertains to emissions from industrial-scale composting facilities and does not include small-scale backyard composting. These industrial facilities predominantly use a process called windrow composting, in which large amounts of organic waste undergo decomposition in long rows. The windrows are actively managed (e.g. shredding, aeration, watering, etc.) to maximize the aerobic decomposition of the organic feedstock. During the composting process, a large fraction of the degradable organic carbon (DOC) in the waste material is converted into carbon dioxide. However, studies have indicated that some anaerobic pockets occur in the piles where methanogenic bacteria produce some methane, and some nitrous oxide is emitted as the byproduct of nitrifying or denitrifying bacteria.

1.2 Compost Emission Reduction Factor (CERF) Update

The ARB's Compost Emission Reduction Factor (CERF) was updated in March of 2016 (ARB, 2016b). This edition of the inventory utilizes information from the updated CERF, including the fugitive emissions from composting and the CH4 and N2O emission factors. The previous emission factors (4.1 gCH_4/kg feedstock and 0.09 gN_2O/kg feedstock) did not incorporate California-specific studies and were based on information that is now outdated. The new emission factors used in this inventory edition (1.96 gCH_4/kg feedstock and 0.075 gN_2O/kg feedstock) are the averages of 3 studies from IPCC and 3 additional California-specific studies. A more detailed description of the revised CERF and the referenced studies can be found in the CERF report (ARB, 2016b).

E. Other Emissions

1. <u>Natural Gas Fugitive Emissions (IPCC 1B2b): ARB's Estimation for the Aliso Canyon Leak Event</u>

1.1 Background

On October 23, 2015, Southern California Gas (SoCalGas) informed the State of a natural gas leak at its Aliso Canyon natural gas storage facility. The leak was caused by an uncontrolled breach in the natural gas storage infrastructure and occurred outside the envelope of instruments put in place to measure the flow of natural gas at the facility. On February 11, 2016, SoCalGas temporarily controlled the leak by injecting mud from a relief well intersecting the bottom of the leaking well. A permanent seal of the well was announced by The Department of Conservation, Division of Oil, Gas, and Geothermal Resources (DOGGR) on February 18, 2016. To quantify the methane release rate from the Aliso Canyon gas leak, state agencies, in collaboration with scientific experts, relied on existing and new methane measurements in the Los Angeles basin. The data include ambient measurements around the well site, at nearby air monitoring towers, and using airplanes, as well as data from remote sensing and satellites. These measurements allow for an estimation of the leak's cumulative emissions.

1.2 Categorization of Emissions

The Aliso Canyon natural gas leak released 1.96 $MMTCO_2e$ of methane emissions during calendar year 2015 and an additional 0.52 $MMTCO_2e$ in 2016. Because this is a one-time event, and its emissions will be fully mitigated in future years according to legal settlement, these emissions are presented alongside but tracked separately from routine inventory data. In this edition of the GHG inventory, a new "Other Emissions" category has been added to the inventory data tables to house the exceptional Aliso Canyon leak event. The 2017 edition of the inventory includes the portion of emissions released in 2015, while the portion released in 2016 will be included the 2018 edition of the inventory.

1.3 Estimation Methodology

A collaborative effort between several different project teams utilized a suite of various methodologies in order to produce the best estimation. The full detailed report, which describes these methodologies, can be found at https://www.arb.ca.gov/research/aliso_canyon/aliso_canyon_methane_emissions-arb_final.pdf

INTERIM METHOD DURING DATA TRANSITION

The ARB utilizes data from several data sources in calculating California GHG emissions. Occasionally, a data source agency may go through administrative changes or experience other delays in data compilation; and as a result, the data needed for ARB to calculate emissions may not be available at the time of GHG inventory compilation. In other instances, a data source agency may begin revising statistical data using an improved method but could not complete the entire time series in one year, resulting in an artificial change in emissions numbers without an actual change in emissions. In these situations, ARB staff uses data extrapolation techniques to temporarily fill in the data gaps until revised data become available in future inventory cycles. The following sections describe the interim methods used in this inventory edition that are not permanent updates to the inventory, but are expected to be revised once the data become available.

F. Interim Method

1. Carbon Dioxide Consumption (IPCC 2G4a): Interim Emission Estimation

1.1 Background

Carbon dioxide (CO_2) is used in a variety of processes including food processing, carbonated beverages, and refrigeration. The CO_2 used in these applications is eventually released to the atmosphere, thus is a source of GHGs. California CO_2 consumption data is estimated from the USEPA GHG inventory (USEPA, 2015a) and scaled the national emissions to California using population ratio. USEPA is in the process of updating the national CO_2 consumption emission estimates, but had not completed updating older years in the time series at the time California's inventory was compiled. Therefore, staff used an interim emission quantification methodology to estimate CO_2 consumption emissions for the older years.

1.2 Interim Emission Estimation Methodology

The USEPA has completed the update for national CO_2 consumption emissions for years 2010-2015, but has not yet back-calculated the remainder of the 2000-2009 time series. The change in emission estimation method in the middle of the time series led to a significant disparity between emission levels prior to 2010 and those since 2010, an artifact of method update that does not represent an actual change in emissions. California's GHG inventory used USEPA's updated 2010-2015 numbers and scaled it to California using population ratio, consistent with previous editions. However, to address the artificial emission increase due to a change in method, the 2000-2009 emissions are adjusted by mapping the emission trend from the previous inventory edition to the revised 2010 number in the interim. When the USEPA completes the update to years prior to 2010, ARB will revise the emission estimate for these years.

2. Domestic Wastewater (IPCC 4D1): Extrapolated parameter values based on previous years data

2.1 Background

Methane emissions from wastewater are estimated from the volume of wastewater generated, organic loading in wastewater (measured in biochemical oxygen demand (BOD) or chemical oxygen demand (COD)), and percentage of wastewater that is centrally treated (aerobic or anaerobic systems), anaerobically digested or treated in septic systems. Methane is emitted from wastewater when it is treated in anaerobic conditions. Nitrous oxide is emitted as the result of the nitrification and denitrification processes, which take place at wastewater treatment plants, but also in the water bodies where effluent is discharged.

2.2 Data Extrapolation

The California GHG inventory has been using a mixture of California-specific data when available, supplemented with national data scaled to the California population, in the domestic wastewater calculations. All of the parameter data come from USEPA, which compiles data on a yearly basis. Some of the 2015 data were not available at the time the inventory was compiled, so the data were extrapolated. The parameters extrapolated were:

- CA population served by biological denitrification
- Protein consumption rate
- Sewage sludge N not entering aquatic environment
- Proportion anaerobic
- Proportion anaerobic with primary treatment
- Proportion anaerobic without primary treatment
- Proportion aerobic
- Proportion aerobic with primary treatment
- Proportion aerobic without primary treatment
- Wastewater flow to plants with anaerobic digesters.

All of these parameters were showing linear trends, so a first-order extrapolation was performed to estimate the 2015 value.

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California's 2000-2016
Greenhouse Gas Emissions Inventory
2018 Edition

Inventory Updates Since the 2017 Edition of the Inventory

Supplement to the Technical Support Document

CALIFORNIA
AIR RESOURCES BOARD

Air Quality Planning and Science Division

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Introduction

Assembly Bill 1803 gave California Air Resources Board (CARB) the responsibility of preparing and updating California's greenhouse gas (GHG) inventory to track the State's progress in reducing GHG emissions. The GHG inventory is a critical piece, in addition to data from various California Global Warming Solutions Act (AB 32) programs, in demonstrating the State's progress in achieving the statewide GHG targets established by AB 32 (reduce emissions to the 1990 levels by 2020) and Senate Bill 32 (SB 32) (reduce emissions to at least 40% below the 1990 levels by 2030). The 2018 edition of California's GHG inventory covers emissions for 2000 through 2016 and includes inventory improvements and accounting method updates.

The GHG inventory was developed according to the Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories (IPCC Guidelines)(IPCC, 2006), which are the internationally recognized standard for developing national GHG inventories. Since the 2017 edition of the inventory (2000-2015 emissions), staff has made improvements to emissions estimation methods and incorporated new data sources. This document provides a description of the inventory updates since the previous edition of the inventory.

Each release of the California inventory incorporates the latest available data sources and emission quantification methodology. The IPCC guidance for GHG inventories states that it is good practice to recalculate historic emissions when methods are changed or refined, when new source categories are included in the inventory, or when errors in the estimates are identified and corrected. Consistent with the IPCC Guidelines, recalculations are made to incorporate new methods or to reflect changes in statistical data supplied by other agencies for all years from 2000 to 2015, to maintain a consistent time-series of estimates within the inventory. Therefore, emission estimates for a given calendar year may be different between editions as methods are updated or if the data source agencies revise their data series.

In the sections to follow, a background on each updated category is presented followed by a description of the update. In some cases, a model used for estimating emissions in the GHG inventory has been updated, but the way the model is utilized in the compilation of the GHG inventory has not changed. Though this type of update is not considered a change in methodology, for completeness, this document provides an overview of the model update and points readers to other technical documentations for more details.

The inventory category code associated with the hierarchical structure of IPCC inventory categorization is shown in the sub-heading title of each section. The sections are presented in the order of IPCC inventory category codes.

Description of Inventory Updates

1. In-State Electricity Generation (IPCC 1A1a): Incorporate Biomethane Data for 2011 and 2012

1.1 Background

CARB's Regulation for the Mandatory Reporting of Greenhouse Gas Emissions (MRR) program collects data on the amount of biomethane supply purchased by in-state power plant operators (CARB, 2017a). Biomethane purchases displace fossil natural gas combustion emissions. Biomethane quantities reported to the MRR program by power plant operators were first incorporated into the 2016 edition of the GHG inventory, starting with data for the 2013 and 2014 calendar years. Since then, each edition of the inventory incorporates an additional year of biomethane data (e.g., the 2017 edition included data for 2015, and the 2018 edition includes data for 2016). In the 2018 edition, staff went further back in time to incorporate biomethane data for 2011 and 2012. This inventory update does not affect emissions quantification for 2013-2016.

1.2 Data and Method

The biomethane quantities reported to the MRR program for calendar years 2011 and 2012 are used to displace the total natural gas combusted by in-state power plants in 2011 and 2012. All methodology, data sources, and emissions classification are the same as in previous inventory editions documented in the 2016 edition of the Technical Support Document (CARB, 2016).

2. Imported Electricity (IPCC 1A1ai): Add Energy Imbalance Market Outstanding Emissions

2.1 Background

Under AB 32, CARB must account for statewide GHG emissions, including all emissions resulting from the generation of electricity delivered to and consumed in California, whether that electricity is generated in-state or imported to California to serve California load. The Energy Imbalance Market (EIM) of the California Independent System Operator (CAISO) is a real-time market to manage transmission congestion and optimize procurement of energy to balance supply and demand for the combined CAISO and EIM footprint. EIM Outstanding Emissions are calculated by CARB staff to address emissions leakage and ensure full and accurate accounting of GHG emissions from imported electricity under EIM. EIM Outstanding Emissions were quantified in the latest version of the MRR regulation that became effective January 1, 2018, and therefore were not previously captured under MRR or the statewide GHG inventory.

2.2 Emissions Calculation Method and Data Source

EIM Outstanding Emissions are calculated using information reported to the MRR program and the default emissions factor pursuant to section 95111(h) of the MRR regulation (CARB, 2017a).

3. On-Road Transportation (IPCC 1A3b): Incorporate Updated EMFAC Model

3.1 Background

CARB's on-road mobile vehicles emission inventory model EMFAC was updated in December 2017 (EMFAC2017)(CARB, 2017b). The entire 2000-2016 time series for the on-road transportation category is calculated following the same methodology as in previous editions of the statewide GHG inventory, but the 2018 edition uses the latest model, EMFAC2017. Several major updates differentiate EMFAC2017 from its predecessor, EMFAC2014. The technical documentation of EMFAC2017 (CARB, 2017c) has more details. An overview of the model updates is presented in the next section.

3.2 Model Updates

Latest vehicle registration data from the California Department of Motor Vehicle (DMV) and International Registration Plan (IRP) were used to update vehicle population and improve fleet characterization. Extensive on-road and chassis dynamometer emissions testing of both light and heavy duty vehicles better informs in-use emissions. Activity profiles include the latest California Household Travel Survey (2010-2012) for light duty vehicles as well as data from the most recent Heavy Duty Activity Data Collection (2016). Two new modules have been added, one for transit and another for calculating GHGs. The new GHG module uses fuel data from the California Board of Equalization, the California Energy Commission, and the MRR program. The GHG module uses emission factors and heat contents consistent with the MRR program for CO_2, and CARB's vehicle surveillance program (VSP) data for CH_4 for light duty vehicles. For N_2O, it uses data from VSP for gasoline vehicles and CARB's Cross California Portable Emission Measurement System (PEMS) for heavy duty vehicles. Additionally, Zero Emission Vehicle compliance assumptions for the Advanced Clean Cars program have been updated, and the Federal Phase 2 GHG Standards for Medium-Heavy and Heavy-Heavy Duty Vehicles was included.

3.3 Change in Emissions

There is no change in the way the EMFAC model is used in the compilation of the statewide GHG inventory. See the existing Technical Support Document (CARB, 2016) for a description of the on-road transportation methodology. However, as the entire 2000-2016 time series is calculated using the latest model EMFAC2017, there are notable differences in the emission estimates for 2000-2015, especially for nitrous oxide (N_2O). Using EMFAC2017, diesel combustion N_2O emissions in 2015 are now 3.8 times higher than if EMFAC2014 was used. The difference in gasoline combustion N_2O emissions in 2015 varies by vehicle type, and ranges from 31% to 83% higher using EMFAC2017. Comparing the total on-road N_2O emissions for same calendar year between the two versions of the model, EMFAC2017 outputs are 1.9 to 2.8 $MMTCO_2e$ higher than using EMFAC2014. Methane emissions also increased as a result of the model updates. For example, the 2015 emissions in the 2018 edition is approximately 0.08 $MMTCO_2e$ higher than the 2017 edition.

4. Ocean-Going Vessel Emissions (IPCC 1A3d): Model Update

4.1 Background

Ocean-going vessels (OGV) are a significant source of emissions around California ports and coastal shipping lanes. CARB's OGV model was used for analyzing the impacts of the CARB fuel rule amendments, providing updates for the State Implementation Plan, and providing activity data for calculating emissions in the CARB GHG inventory. CARB staff made updates to the OGV model in 2013 and 2016. More detail information about the OGV model updates can be found on CARB program webpage at: https://www.arb.ca.gov/msei/ordiesel.htm (CARB, 2014). An overview of the model updates are described in the next section.

The use of the OGV model in the CARB statewide GHG inventory is the same as The use of the OGV model in the CARB statewide GHG inventory is the same as documented in the previous edition of the Technical Support Document (CARB, 2016). By using the latest model in the 2018 edition of the GHG inventory, the updates made to the OGV model are now reflected in the inventory.

4.2 Model Updates

In 2013, CARB staff reviewed more recently available economic forecast data and updated the growth rates for the interim timeframe (2006-2012) and the long-term timeframe (2013 and beyond) in the OGV model. Updates to the long-term growth factors specific to each California port were made to container ships, auto ships, tankers, and cruise ships. For container ships, auto ships, and tankers, the growth factor updates are based on output from the Federal Highway Administration's (FHWA) Freight Analysis Framework (FAF) model. For cruise ships, the updates are based on the 2011 Cruise Market Update by the San Diego Unified Port District. The growth factors for year 2013 and onward are applied to 2006 base year activity and emissions.

For the interim timeframe covering years 2006-2012, updates to the growth factors were made using publicly available activity data from several data sources. For auto ships and tankers, data from the Maritime Transportation Administration were used. Growth factors were derived from trends in total tonnage delivered to specific ports in California by either auto ships or tanker ships from 2006 to 2011; and for 2012, growth factors were derived from the FAF model. For cruise ships, data from San Diego Unified Port District's Cruise Market Update were used. Growth factors were derived from trends in total passengers served from 2006 to 2012. For container ships, 20-feet equivalent units (TEU) throughput data from the Ports of Los Angeles/Long Beach and the Port of Oakland were used. Growth factors were derived from trends in TEU throughput as reported by each of the ports from 2006 to 2012. For the other vessel types (i.e. bulk, general cargo, reefer, and roll-on/roll-off ships), updated growth factors were derived from container ships growth rates from one of three container ship ports: Ports of Los Angeles/Long Beach, Port of Oakland, and Port of San Diego.

In 2016, minor technical improvements were made to the OGV model to align the timeframe of input data with the model structure for 2016 and earlier years. Other changes that do not impact the years covered by the 2018 edition of statewide GHG inventory (2000-2016) include incorporation of more recent data to inform future projections beyond 2016.

5. Rice Cultivations (3C7): Update to Tier 3 Methodology Using DNDC

5.1 Background

There were over 220,000 hectares (ha) of rice paddy in California in 2016, comprised of approximately 3% of the State's harvested cropland (USDA, 2017). Because of the unique requirement of flooding for rice growth, rice paddy is a significant source of methane (CH_4) emissions in the State. Methane is produced from rice paddy through methanogenesis, a process that breaks down soil organic matter (SOM) into CH_4 under anaerobic conditions where oxygen is restricted. The CH_4 emission rate from rice soil is therefore driven by two principal variables: the amount of SOM available and the redox potential (or Eh value), a parameter that measures the degree of oxygen deficiency in soil. Any factors that influence either of these variables would change CH_4 fluxes. The redox potential in rice paddy fluctuates normally between -300 and +600 mV, depending on the water regime. Methane emissions, however, occur only within the narrow range of soil redox potential between -150 mV and -300 mV (Wang et al., 1993; Yu, 2011).

Water regime (or flooding pattern) and crop residue management are the two most important management factors that affect CH_4 fluxes. Other management practices, such as fertilizer application, tillage, and rice cultivar, can also play a role. The most common practices for rice management in California involve wet seeding, continuous flooding during rice growing season and incorporation of rice straw into the soil followed by winter flooding. Besides rice management practices, other environmental factors such as soil type and weather, especially temperature, can affect CH_4 emissions as well.

In the previous edition of CARB's GHG inventory, methane emissions from rice paddy were estimated using default emission factors derived from California-specific studies. In this edition, staff upgraded the methodology to a process-based modeling approach using the geochemical model DeNitrification-DeComposition (DNDC)(Li et al., 1992; Li, 2000). With this updated methodology, effects of all environmental and management factors were captured in estimating CH_4 emissions from California rice cultivation. DNDC is already used for estimating N_2O emissions from agricultural soil management in cropland receiving no manure applications in California.

5.2. Methodology

DNDC Model

The DNDC model (Li et al., 1992; Li, 2000) is a process-based computer simulation model of carbon (C) and nitrogen (N) biogeochemistry and was developed for quantifying carbon sequestration and GHG emissions in agroecosystems. The core of DNDC modeling consists of microbe-mediated biochemical processes dominating carbon- and nitrogen-cycling in agroecosystems. DNDC has been evaluated against CH_4 emissions data in California rice systems with an R^2=0.85 between measured and predicted values (Simmonds, et al., 2015). A full description of the DNDC scientific basis and processes, including all equations involved, is available at the model host site (UNH, 2016).

Methane Emission Calculations

Methane emissions from rice cultivation were calculated by linking the DNDC model with a California-specific database containing spatial and temporal information on weather, crop, soil, and rice management practices in California. Model parameters calibrated for the rice cultivar M206 in Simmonds et al. (2015) were used for the simulation because of the broad adaptation of M206 in the entire rice growing region in California (California Rice Research Board, 2016). For each given year, DNDC was run for three consecutive years, allowing the distribution of carbon and nitrogen speciation in soil to match closely to field conditions. The CH_4 emissions of the third year were then used as the emission estimate for that year. To alleviate year-to-year variability in emissions due to weather conditions, 3-year rolling average of emission estimates was used as the final inventory estimate for a given inventory year.

Rice straw burning is a practice that has been used as a method to control pests in certain rice fields. Rice straw burning reduces SOM available for decomposition and thus reduces methane emissions from the rice fields. To account for effects of rice straw burning on methane emissions, DNDC simulations were performed separately for fields with and without straw burning and a weighted mean of emission estimates was taken based on the percentage of rice acreages subject to burning. For detailed information on the acreage of rice fields burned over time, please refer to Section III.D of the full Technical Support Document (CARB, 2016c).

5.3 Data Sources

The DNDC database contained California-specific information on (1) daily meteorological records, (2) land area of rice cultivation, (3) soil properties, and (4) farming management practices. The data were organized at the county level.

The daily meteorological data were obtained from the DAYMET model (Thornton et al., 2015). Rice cultivation areas were obtained from the U.S. Department of Agriculture's (USDA's) National Agricultural Statistics Service (NASS), Quick Stats (USDA, 2017) prior to 2012 or the California Department of Food and Agriculture's (CDFA) California Agricultural Statistics reports after 2012 (CDFA, 2013-2017). Soil data, including bulk density, clay content, soil organic carbon content and pH, were compiled from the USDA's Soil Survey Geographic Database (SSURGO) database (USDA, 2016). The SSURGO map units were overlaid with the regions of agricultural land use developed by the Land Use Surveys of the California Department of Water Resources (CDWR, 2014) on ArcMap, and the area-weighted means of the four soil properties were calculated for each county and were used as "representative" soil values in DNDC modeling. Farming management data, including planting and harvest dates, tillage, fertilization, irrigation, and crop residue management, were developed from open literature sources such as the Cost and Return Studies of UC Davis (UCD, 2015) and Rosenstock et al. (2013).

5.4 Change in Emissions

Overall, the new methodology using DNDC modeling reduced CH_4 emission estimates from rice cultivation by 8.5% compared to the estimates using default emission factors. Changes in the emission estimates are attributable to two sources: the acreage increase due to inclusion of wild rice and the methodology change. Emissions from wild rice, which comprised about 3% (2.1-3.8% over 2000-2016) of the total rice acreage in the state, were not use in the previous edition, but were included in the current inventory edition.

Interim Method During Data Transition

The CARB utilizes data from several data sources in calculating California GHG emissions. Occasionally, a data source agency may experience delays in data compilation due to various reasons; and as a result, the data needed for CARB to calculate GHG emissions may not be available at the time of inventory compilation. In other instances, a data source agency may begin revising statistical data using an improved method but could not complete the entire time series in one year, resulting in an artificial change in emissions numbers without an actual change in emissions. In these situations, CARB staff temporarily fills in the data gaps by either using the previous year value as a placeholder or employing data extrapolation techniques until revised data become available in future inventory cycles. This section describes the interim methods used in this inventory edition that are not permanent changes to inventory methodology, but that are expected to be revised once the data become available.

1. Miscellaneous Fuel Combustion (Multiple Categories, IPCC 1A1-4)

1.1 Background

The CARB GHG inventory uses fuel use data from the U.S. Energy Information Administration (EIA) for certain fuel combustion categories. The EIA completes fuel use estimates for 50 states each year, but some of the data are not updated until 18 months after the end of a calendar year; and therefore, are not available in time for CARB's annual inventory compilation. These fuel use categories include: liquefied petroleum gas (LPG), coal, and wood fuel use not reported to the MRR program; certain diesel fuel use activities in non-road categories that are not captured by CARB's off-road mobile source model; and natural gas use in pipeline pressurization and on-road uses. CARB staff temporarily filled in data gap with placeholder values until these data are updated in the following year.

1.2 Interim Emission Estimation Methodology

For 2015 EIA fuel use data that were not available in time for the compilation of CARB's 2017 edition of the GHG inventory, staff had temporarily filled in 2014 values as placeholders. EIA has made these 2015 fuel data available since that time. In the 2018 edition of the GHG inventory, staff updated the 2015 emissions using the 2015 fuel data that are now available from EIA. Because EIA did not released 2016 data in time for the compilation of the 2018 edition of the inventory (covering 2000-2016 emissions), staff temporarily filled 2016 values with 2015 values as placeholders in the 2018 edition.

2. Lubricant Use (IPCC 2D1)

2.1 Background

The CARB GHG inventory uses data from the EIA for lubricant uses in the industrial and transportation sectors. The EIA completes fuel use estimates for 50 states each year, but some of the data are not updated until 18 months after the end of a calendar year, and therefore, are not available in time for CARB's annual inventory compilation. CARB staff temporarily filled in data gap with placeholder values until these data are updated in the following year.

2.2 Interim Emission Estimation Methodology

For 2015 EIA lubricant data that were not available in time for the compilation of CARB's 2017 edition of the GHG inventory, staff had temporarily filled in 2014 values as placeholders. EIA has made 2015 data available since that time. In the 2018 edition of the GHG inventory, staff updated the 2015 emissions using the 2015 data that are now available from EIA. Because EIA did not released 2016 data in time for the compilation of the 2018 edition of the inventory (covering 2000-2016 emissions), staff temporarily filled 2016 values with 2015 values as placeholders in the 2018 edition.

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CALIFORNIA AIR RESOURCES BOARD

Air Quality Planning and Science Division

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A. Introduction

Assembly Bill 1803 gave California Air Resources Board (CARB) the responsibility of preparing and updating California's greenhouse gas (GHG) inventory to track the State's progress in reducing GHG emissions. The GHG inventory is one piece, in addition to data from various California Global Warming Solutions Act (AB 32) programs, in demonstrating the State's progress in achieving the statewide GHG targets established by AB 32 (reduce emissions to the 1990 levels by 2020) and Senate Bill 32 (SB 32) (reduce emissions to at least 40% below the 1990 levels by 2030). The 2019 edition of California's GHG inventory covers emissions for 2000 through 2017 and includes inventory improvements and accounting method updates.

The GHG inventory was developed according to the Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories (IPCC Guidelines)(IPCC, 2006), which are the internationally recognized standard for developing national GHG inventories. Since the 2018 edition of the inventory (2000-2016 emissions), staff has made improvements to emissions estimation methods and incorporated new data sources. This document provides a description of the inventory updates since the previous edition of the inventory.

Each release of the California inventory incorporates the latest available data sources and emission quantification methodology. The IPCC guidance for GHG inventories states that it is good practice to recalculate historic emissions when methods are changed or refined, when new source categories are included in the inventory, or when errors in the estimates are identified and corrected. Consistent with the IPCC Guidelines, recalculations are made to incorporate new methods or to reflect changes in statistical data supplied by other agencies for all years from 2000 to 2016, to maintain a consistent time-series of estimates within the inventory. Therefore, emission estimates for a given calendar year may be different between editions as methods are updated or if the data source agencies revise their data series.

In the sections to follow, a background on each updated category is presented followed by a description of the update. In some cases, a model used for estimating emissions in the GHG inventory has been updated, but the way the model is utilized in the compilation of the GHG inventory has not changed. Though this type of update is not considered a change in methodology, for completeness, this document provides an overview of the model update and points readers to other technical documentations for more details.

The inventory category code associated with the hierarchical structure of IPCC inventory categorization is shown in the sub-heading title of each section.

B. Description of Inventory Updates

B.1 Imported Electricity (IPCC 1A1ai): Align emission factors with CARB's Mandatory Reporting Program

B.1.1 Background

Under AB 32, CARB must account for statewide GHG emissions, including all emissions resulting from the generation of electricity delivered to and consumed in California, whether that electricity is generated in-state or imported to California to serve California load. CARB's Regulation for the Mandatory Reporting of Greenhouse Gas Emissions (MRR) program collects data on the amount of electricity (in megawatt-hour (MWh)) imported from out-of-state power plants (CARB 2018). To determine emissions for each out-of-state power plant, CARB's MRR program calculates facility-specific emissions-per-MWh factors derived from two sources pursuant to the MRR: (1) facility-reported data collected by the U.S. Environmental Protection Agency (US EPA) GHG Reporting Program (GHGRP) for power plants that are subject to the GHGRP (US EPA 2018); and (2) facility-reported data collected by the U.S. Energy Information Administration (EIA) (EIA 2019) for power plants that are not subject to GHGRP. In this update, staff have aligned the inventory with the MRR requirements to provide greater consistency between these two data sets.

B.1.2 Data and Method

For the data for calendar years 2011 and forward, the GHG inventory now uses both the imported megawatt-hour amounts and the associated emissions reported to the MRR program. Each specified import designated as a first deliverer is categorized individually in the GHG inventory, and shows the amount of power delivered to California (in kWh) from that specified import as well as the associated emissions of CH_4, N_2O, and CO_2 (separated into anthropogenic and biogenic components). These values come directly from MRR. For 2010 and prior years, imported electricity data remain unchanged from previous editions of the inventory.

B.2 Residential Post-Meter Natural Gas Leaks (IPCC 1B1): Previously-Unquantified Emission Source

B.2.1 Background

Estimates of methane (CH_4) emissions from leaks in the natural gas transmission and distribution system are included in the annual GHG inventory. However, these estimates only include leaks up to the customer meter. Leaks that occur after the customer meter have not been previously quantified due to lack of data. A recent study funded by the California Energy Commission (CEC) and conducted by the

Lawrence Berkeley National Laboratory (CEC 2018) gathered data on post-meter CH_4 emissions from single-family homes around California. This study estimates statewide mean methane emissions from residential natural gas consumption using measurements of inactive, house leakage (pipe-fitting leaks and combustion appliance pilot light flames) and, separately, a subset of operating combustion appliances in 75 California homes that participated in energy efficiency retrofit programs.

The measurements show inactive house emissions mostly near the limit of detection but with a small number of emissions above 10 grams of methane per day. Pilot lights were found to be potentially significant contributors to inactive emissions. Similarly, measurements of combustion efficiency for operating appliances show a majority of values near zero but with small detected emissions from stovetops and water heaters that are also fit with gamma distributions. One exception is forced air furnaces, which were considered low emitters. The team also found that emissions from pilot lights likely constitute a significant fraction of inactive house emissions, and flames in domestic water heaters dominate emission during steady operation state.

B.2.2 Data and Method

The study produced an estimate of about 2,539 grams of CH4 per house. This estimate combined with the data on statewide housing units (DOF 2000-2019) generated the estimates of emissions for each year. The number of housing units in California each year is multiplied by the post-meter leak estimate of 2,539 grams of CH4 per house. A new inventory category is created in the 2019 edition of the GHG Inventory for post-meter natural gas leaks.

B.3 Ozone-Depleting Substance Substitutes (IPCC 2F): Data Updates

B.3.1 Background

Emissions of ozone depleting substances (ODS) substitutes occur when they are released into the atmosphere (e.g., from fire extinguishers or aerosol cans) or when they leak out of equipment such as refrigerators and air conditioning units. Estimating these emissions is difficult because the sources are diffuse and the emissions occur over the equipment lifetime.

Emissions from the use of ODS substitutes in California are calculated using a model based on California-specific research and regulatory data reported to CARB under the refrigerant management program (RMP). This model is consistent with IPCC Tier 2 methodology criteria (IPCC 2006) and is documented in full detail in the ODS substitutes technical support document (CARB 2016). CARB's ODS substitutes model relies on a variety of input data sources. These include internal CARB research, CARB-funded consultant surveys, models, and regulatory data reported under the RMP. A full description of the model inputs and data can be found in (CARB 2014) and in the external documentation technical support document (CARB 2016).

B.3.2 Data and Method

No updates were made to the calculation methodology in the 2019 GHG inventory edition. The updates included in this inventory edition include two data input updates outlined below.

First, the proportion of HFC-134a to R-404A used in transport refrigeration units (TRU's) was updated. Previously, the model assumed that 76% of California's TRU's were using HFC-134a and 24% were using R-404a as the refrigerant, with a weighted average GWP of 2,028. It was discovered that the given refrigerant usage assumptions for TRU's may have been applicable to Europe, but did not reflect California's TRU refrigerant usage (Carrier 2015, Kwon 1998). In this version of the inventory, the refrigerant mix assumption for TRU's built in 1994 through the present has been updated to 10% using HFC-134a and 90% using R-404A as the refrigerant, with a weighted averaged GWP of 3,673. This change has raised the emissions from this sector, measured in CO_2e.

Second, the consumer products aerosol propellant ODS substitutes emissions estimates were updated using the most recently available data results from the CARB "Final 2013, 2014, and 2015 Consumer & Commercial Product Survey Data Summaries", which was completed on April 2, 2019 (CARB 2019a). The previous emissions estimates had been based on projected emissions from the 2006 Consumer & Commercial Products & Aerosol Coasting Products Survey (CARB 2009). The previous data source was outdated and replaced by more recent data to improve current and projected emissions estimates.

Although the estimated mass of emissions in 2017 increased in the consumer product aerosol propellant emissions sector by 17% from 5.2 million pounds to 6.1 million pounds, overall GHG emissions (measured in CO_2e) decreased by 36% from 0.70 MMT CO_2e to 0.45 MMT CO_2e. The reduction in CO_2e despite the increase in mass of emissions is due to an updated model assumption; the amount of HFC-134a (GWP = 1,430) propellant was reduced by approximately half and replaced with the use of HFO-1233ze (GWP = 1) as a result of US EPA HFC prohibitions that became effective in January of 2016 (US EPA 2016).

B.4 Cattle Enteric Fermentation Update (IPCC 3A1a)

B.4.1 Background

Enteric fermentation is a digestive process in ruminant animals such as cattle. Microbes in the digestive tract, or rumen, decompose and ferment food, producing methane as a by-product.

The US EPA models enteric fermentation emissions using many detailed assumptions about groups of states that are aggregated into sub-national regions. (US EPA 2019) The US EPA's modeling results forms the basis for California's livestock enteric fermentation GHG Inventory. One notable challenge has been identifying how diets fed to California cattle differ from surrounding states in US EPA's regional assumptions. Different diets result in different enteric fermentation methane emissions. CARB funded research to improve enteric fermentation emission estimates.

B.4.2 Data and Method

Researchers in University of California- Davis estimated that California cattle, on average, emit roughly 5% less methane than has been assumed in US EPA's regional estimates (Appuhamy & Kebreab 2018; CARB 2019b). California cattle diets also vary seasonally and annually based on many variables, including availability and price of feedstuffs. CARB staff plans to continue to refine enteric fermentation emissions estimates by exploring feed data specific to each calendar year in the future inventory. In the meantime, the livestock GHG Inventory will assume that California cattle as a whole emit 5% less methane for every calendar year in the inventory.

B.5 Miscellaneous Data Corrections (IPCC 1A1ai, 1A2f, 2A1)

In the 2019 edition of the inventory, CARB staff made minor data corrections to several parts of the inventory. These include:

- Reviewing the cement sector calculations to refine and improve fuel quantity, heat capacity, clinker production and the biogenic CO2 fraction; and
- Ensuring in-state electricity generation emissions aligned between the inventory and MRR.

As the result of these data corrections, some emissions and fuel data for the same calendar year may be slightly different between the 2019 edition and 2018 edition of the inventory.

C. Interim Method during Data Transition

The CARB utilizes data from several data sources in calculating California GHG emissions. Occasionally, a data source agency may experience delays in data compilation due to various reasons; and as a result, the data needed for CARB to calculate GHG emissions may not be available at the time of inventory compilation. In other instances, a data source agency may begin revising statistical data using an improved method but could not complete the entire time series in one year, resulting in an artificial change in emissions numbers without an actual change in emissions. In these situations, CARB staff temporarily fills in the data gaps by either using the previous year value as a placeholder or employing data extrapolation techniques until revised data become available in future inventory cycles. This section describes the interim methods used in this inventory edition that are not permanent changes to inventory methodology, but that are expected to be revised once the data become available.

C.1 Crop Cultivation Acreage Data (IPCC 3C4 – 5)

C.1.1 Background

California has a large agricultural sector which cultivated nearly 3 million hectares of cropland in 2016 (NASS 2018). Most of this acreage is cultivated with applications of synthetic, nitrogen-based fertilizer. Such large scale addition of nitrogen into soils has greatly increased nitrogen availability for microbial processes such as nitrification and denitrification, which result in emissions of the greenhouse gas (GHG) nitrogen dioxide (N_2O). N_2O emissions are considered direct when they occur on the soils that received a nitrogen fertilizer application and are considered indirect when the applied nitrogen is either volatilized to the atmosphere or leached into waterbodies, where it is released as N_2O. In order to estimate these emissions, crop acreage data is needed.

In 2019, the 2017 National Agricultural Statistics Service (NASS) census data of crop acreages was not released in time to generate the estimates of direct and indirect N_2O emissions prior to inventory publication. CARB staff performed an analysis to determine the amount of variation in inter-annual State crop acreage and found that year-to-year variation was small, with maximum inter-annual variation over the 2000-2016 period being ±7% (USDA 2018). Since inter-annual variation is small, staff chose to use the 2016 crop acreage as a placeholder in the modeling process to generate the 2019 edition of the greenhouse gas inventory. All other data inputs and methods were performed as documented in the Inventory Update Documentation (CARB 2017a).

C.1.2 Interim Emission Estimation Methodology

Since the inter-annual variation of crop acreage is small and the overall contribution of direct and indirect N_2O emissions from managed soils to the Statewide inventory is also small (less than 2% of the inventory), staff chose the method of assuming that crop acreage was static from 2016-2017. Other model inputs, including meteorological data, were updated in the model runs for the 2019 inventory edition. Excluding crop acreage data, DNDC was run as is outlined in the 2017 edition of CARB's GHG Inventory Methodology Update Document (CARB 2017a) with input data for the inventory year 2017.

C.2 Livestock Population Data (IPCC 3A)

C.2.1 Background

The USDA Census of Agriculture ("Census") (USDA 2019) was not yet available when California's livestock GHG Inventory was being calculated for 2017. The Census occurs once every 5 years, and is the most comprehensive and accurate single data set for California livestock.

C.2.2 Interim Emission Estimation Methodology

Since the Census occurs only once every 5 years, CARBs existing methodology for non-Census years is carried forward into 2017. The 2020 edition of the GHG Inventory will reflect the most recent Census data for 2017.

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California's 2000-2018 Greenhouse Gas Emissions Inventory 2020 Edition

Inventory Updates Since the 2019 Edition of the Inventory

Supplement to the Technical Support Document

CALIFORNIA AIR RESOURCES BOARD

Air Quality Planning and Science Division

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Table of Contents

A. Introduction

Assembly Bill (AB) 1803 gave the California Air Resources Board (CARB) the responsibility of preparing and updating California's greenhouse gas (GHG) inventory to track the State's progress in reducing GHG emissions. The GHG inventory is one piece, in addition to data from various California Global Warming Solutions Act (AB 32) programs, in demonstrating the State's progress in achieving the statewide GHG targets established by AB 32 (reduce emissions to 1990 levels by 2020) and Senate Bill 32 (SB 32) (reduce emissions to at least 40 percent below 1990 levels by 2030). The 2020 edition of California's GHG inventory covers emissions for 2000 through 2018 and includes inventory improvements and accounting method updates.

The GHG inventory was developed according to the Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories ("IPCC Guidelines") (IPCC 2006), which is the internationally recognized standard for developing national GHG inventories. Since the 2019 edition of the inventory (2000-2017 emissions), CARB staff has made improvements to emissions estimation methods and incorporated new data sources. This document provides a description of the inventory updates since the previous edition of the inventory.

Each release of the California inventory incorporates the latest available data sources and emission quantification methodology. The IPCC guidance for GHG inventories states that it is good practice to recalculate historic emissions when methods are changed or refined, when new source categories are included in the inventory, or when errors in the estimates are identified and corrected. To maintain a consistent time-series of estimates within the inventory and consistent with the IPCC Guidelines, recalculations are made to incorporate new methods or to reflect changes in statistical data supplied by other agencies for all years from 2000 to 2018. Therefore, emission estimates for a given calendar year may be different between editions as methods are updated or if the data source agencies revise their data series.

The 2020 edition of the GHG Inventory has expanded the level of detail provided to the public for activity data underlying the GHG emissions. Beginning with this year's inventory, the quantities of heat contained in combusted fuels (in units of British Thermal Units (btu)) will be provided in spreadsheet format to allow for a common comparison between fuels, in addition to physical fuel quantities (e.g., gallons and standard cubic feet) that were already provided in the previous editions. In previous years, the Documentation Index website (CARB 2019a) has included data for imported electricity from GHG-emitting resources. Starting this year, the amount of imported hydro, solar, wind, and nuclear electricity (in Terawatt-hour (TWh) unit) will also be provided in the Documentation Index website.

In addition, CARB is releasing a report on upstream emissions of California's natural gas consumption pursuant to AB 2195. AB 2195 requires CARB "to quantify and publish annually the amount of greenhouse gas emissions resulting from the loss or release of uncombusted natural gas to the atmosphere and emissions from natural gas flares during all processes associated with the production, processing, and transporting of natural gas imported into the state from out-of-state sources." Most of the emissions quantified in the AB 2195 report occurred outside of California borders; and therefore, are not added to the GHG Inventory total.

In the sections to follow, background information on each updated category is presented followed by a description of the update. The inventory category code associated with the hierarchical structure of IPCC inventory categorization is shown in the sub-heading title of each section.

B. Description of Inventory Updates

B.1 Imported Electricity (IPCC 1A1ai): Adjust the Disaggregation of Facility-Reported CO_2e Emissions into CO_2, CH_4, and N_2O

B.1.1 Background

Under AB 32, CARB must account for statewide GHG emissions, including all emissions resulting from the generation of electricity delivered to and consumed in California, whether that electricity is generated in-state or imported to California to serve California load. CARB's Regulation for the Mandatory Reporting of Greenhouse Gas Emissions (MRR) program collects data on the amount of electricity (in megawatt-hours (MWh)) imported from out-of-state power plants (CARB 2019b). To determine emissions for each out-of-state power plant, CARB's MRR program uses resource-specific emissions-per-MWh factors reported for each import from a specified source. Four cases exist in which the import is not from a single, specified source: unspecified imports, asset controlling suppliers (ACS), multi-jurisdictional retail providers (MJRP), and the California Independent System Operation (CAISO) Energy Imbalance Market (EIM) outstanding emissions. In each of these four cases, power is coming from a group or system of multiple power sources. MRR does not require the reporting of individual pollutant emission factors for these four cases; rather, a single emission factor is reported in units of carbon dioxide equivalent (CO_2e) without individual GHGs. In accordance with the framework laid out in the IPCC Guidelines, the GHG Inventory needs to report each pollutant individually and disaggregate the emissions reported for these four cases. In this update, staff has modified the method for disaggregating the reported CO_2e emissions into individual pollutants using assumptions and emission factors consistent with MRR for 2008 and later years.

B.1.2 Data and Method

For 2008 and later year data, the GHG inventory uses a single method to disaggregate CO_2e emissions reported to the MRR program for the above mentioned four cases. The method uses the default emission factors for the combustion of natural gas as published in Table C-1 of Title 40 of the Code of Federal Regulation (CFR) Part 98 (40 CFR 98) (CARB 2019c) that is incorporated by reference in the MRR rule text (CARB 2019d). The default natural gas emission factors are used to determine the percentage of the total CO_2e emissions attributed to each gas: methane (CH_4), carbon dioxide (CO_2), and nitrous oxide (N_2O). These percentages are then applied to the reported CO_2e emissions for each of the four cases to disaggregate their emissions from a single CO_2e value into three individual values for CH_4, CO_2, and N_2O.

No methodological change was made to data for years before MRR started to collect data. For 2007 and earlier year data, pollutants were estimated individually, and there was not a need to disaggregate CO_2e into the three gases.

B.2 Transportation (IPCC 1A3): Use Biodiesel and Renewable Diesel Data from the Low Carbon Fuel Standard Program

B.2.1 Background

In the previous edition of the GHG Inventory, staff used the statewide biodiesel and renewable diesel volume data from the California Energy Commission (CEC 2015). CEC estimates fuel volumes by conducting transportation energy balance analysis using a combination of diesel blend data from the California Department of Tax and Fee Administration (CDTFA), CEC's internal accounting of fuel imports and exports, and diesel production data from the Petroleum Industry Information Reporting Act (PIIRA). CEC started tracking, analyzing, and compiling data on these fuels before the Low Carbon Fuel Standard (LCFS) was implemented; and therefore, CEC has more years of data than LCFS. Starting this year, CEC is incorporating most of the LCFS data for 2011 and onward. With this CEC change, the GHG Inventory is now directly referencing LCFS data for 2011 and more recent years (LCFS 2020). For 2010 and prior years data, GHG Inventory continues to use data obtained from CEC (CEC 2015).

B.2.2 Data and Method

Starting with the 2020 edition of the GHG Inventory, the GHG Inventory is using biodiesel and renewable diesel volumes collected by the LCFS program for 2011 and later years (LCFS 2020), and continuing to use CEC data for 2010 and prior years (CEC 2015). Besides the change in activity data source, there is no change to methodology for calculating GHG emissions.

B.3 Industrial (IPCC 1B2aiii): Add Sorbent CO_2 Emissions to the Manufacturing Sector and Commercial Cogeneration Facilities

B.3.1 Background

Non-combustion CO_2 emissions result from the use of sorbent materials to scrub acid gases out of the exhaust of various industrial and power producing processes. This process releases CO_2 as a product of the chemical reaction that removes the acid gases. The MRR program has been collecting sorbent CO_2 emissions since the 2011 data year. The previous editions of the GHG Inventory have already incorporated acid gas emissions for the following three categories of facilities that report emissions to MRR: merchant-owned in-state power plants, industrial Combined Heat & Power (CHP, or cogeneration) facilities, and refineries & hydrogen production facilities. For the 2020 edition, additional MRR sorbent CO_2 data for the manufacturing sector and commercial CHP facilities have been processed and provided for inclusion in the GHG Inventory.

B.3.2 Data and Method

In addition to the sorbent CO_2 emissions already included in the previous inventory editions, MRR sorbent CO_2 data for the manufacturing sector and commercial CHP facilities are now also included (CARB 2019b). The additional emissions are small, representing only 0.005 $MMTCO_2e$ of emissions (in 2017 value) that were not previously quantified in prior editions of the GHG Inventory. The additional data are incorporated in the GHG Inventory in the same manner as other MRR sorbent CO_2 data in previous inventory editions. No new or modified methods are used.

However, the IPCC Guidelines (IPCC 2006) recommends that corresponding updates be applied to the entire time series to ensure data consistency over time. Therefore, staff employs an estimation technique to extend these additional emissions back in time. For years before MRR started to collect data (2000-2010), the GHG Inventory uses the three-year average of 2011-2013 emissions for each sector for which these emissions are reported. This three-year average is then used to estimate the sector-specific emissions from this source for years 2000-2010.

B.4 Agriculture (IPCC 3A1ai & 3A2ai): Revise Estimation of Dairy Cattle Population

B.4.1 Background

Methane emissions from dairies are calculated using dairy population by cattle type and emission factors that are embedded in models used in the U.S. Environmental Protection Agency's (USEPA) Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2012 (USEPA 2014). CARB uses the U.S. Department of Agriculture's (USDA) Census of Agriculture (USDA 2020) for California's milk cow population in Census years: 2007, 2012, and 2017, or every 5 years. In the previous inventory editions, for intervening years between the 5-year Census, staff estimated dairy population by proportionally scaling the dairy population data from the California Department of Food and Agriculture's (CDFA) Dairy Statistics Annual (CDFA 2019) to match the 5-year Census numbers. However, CDFA is no longer publishing the Dairy Statistics Annual after the 2017 version was released in 2019. Therefore, staff must find an alternate method of estimating annual dairy population.

B.4.2 Data and Method

Without California-specific dairy cattle population data for 2018, staff uses the long-term trend in existing USDA 5-year Census data (USDA 2020) to extrapolate dairy population for 2018. The USDA 5-year Census data shows a long-term average annual statewide decline of approximately 0.5 percent in milk cow populations. Staff applies this long-term average decline rate to 2017 data to estimate the 2018 milk cow population. The GHG inventory plans to use this estimation method for future years until a more reliable dataset becomes available.

B.5 Miscellaneous Data Updates (IPCC 1A1ai, 1A2f, 2A1)

In the 2020 edition of the inventory, CARB staff made minor updates to several parts of the inventory. These updates include:

- Merge "Pacific Northwest" and "Pacific Southwest" into one unspecified electricity imports category to be consistent with MRR.
- Use the version of the 40 CFR 98 Table C-1 (CARB 2019c) that is currently incorporated by reference in the MRR rule text (instead of the most current version used by the USEPA) to be consistent with MRR.
- For cement industry fuel calculations, scale fuel combustion CO_2 by fuel type at the facility-level, instead of the sector-level as was done for the 2019 edition.
- Recategorize some custom fuels based on additional supplemental information about the heat content of the custom fuels.
- Use Useful Thermal Output (UTO) data from the U.S. Energy Information Administration (EIA) (EIA 2020) to attribute total emissions from cogeneration units to electricity and UTO for 2011-2018.
- Minor data corrections are also made to amount of electricity for EIM, landfill waste decay rates, and ocean-going vessel data.

As a result of these minor updates and data corrections, some emissions and fuel data for the same calendar year may be slightly different between the 2020 edition and 2019 edition of the inventory.

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California's 2000-2019 Greenhouse Gas Emissions Inventory 2021 Edition

Inventory Updates Since the 2020 Edition of the Inventory

Supplement to the Technical Support Document

CALIFORNIA AIR RESOURCES BOARD

Air Quality Planning and Science Division

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A. Introduction

Assembly Bill (AB) 1803 gave California Air Resources Board (CARB) the responsibility of preparing and updating California's greenhouse gas (GHG) inventory to track the State's progress in reducing GHG emissions. The GHG inventory is one piece, in addition to data from various California Global Warming Solutions Act (AB 32) programs, in demonstrating the State's progress in achieving the statewide GHG targets established by AB 32 (reduce emissions to the 1990 levels by 2020) and Senate Bill 32 (SB 32) (reduce emissions to at least 40% below the 1990 levels by 2030). The 2020 edition of California's GHG inventory covers emissions for 2000 through 2018 and includes inventory improvements and accounting method updates.

The GHG inventory was developed according to the Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories ("IPCC Guidelines")(IPCC 2006), which are the internationally recognized standard for developing national GHG inventories. Since the 2020 edition of the inventory (2000-2018 emissions), staff have made improvements to emissions estimation methods and incorporated new data sources. This document provides a description of the inventory updates since the previous edition of the inventory.

Each release of the California inventory incorporates the latest available data sources and emission quantification methodology. The IPCC guidance for GHG inventories states that it is good practice to recalculate historic emissions when methods are changed or refined, when new source categories are included in the inventory, or when errors in the estimates are identified and corrected. Consistent with the IPCC Guidelines, recalculations are made to incorporate new methods or to reflect changes in statistical data supplied by other agencies for all years from 2000 to 2019, to maintain a consistent time-series of estimates within the inventory. Therefore, emission estimates for a given calendar year may be different between editions as methods are updated or if the data source agencies revise their data series.

The 2020 edition of the GHG Inventory expanded the level of details provided to the public for activity data underlying the GHG emissions. From the 2020 edition and onward, the quantities of heat contained in combusted fuels (in units of British Thermal Units (btu)) will be provided in spreadsheet format to allow for a common comparison between fuels, in addition to physical fuel quantities (e.g., gallons and standard cubic feet) that were already provided in the previous editions. The kilowatt-hours (kWh) quantities of imported hydro, solar, wind, and nuclear electricity will also be provided in the Documentation Index website (CARB 2019a).

In addition, CARB is releasing a report on upstream emissions of California's natural gas consumption pursuant to AB 2195. AB 2195 requires CARB "to quantify and publish annually the amount of greenhouse gas emissions resulting from the loss or release of uncombusted natural gas to the atmosphere and emissions from natural gas flares during all processes associated with the production, processing, and transporting of natural gas imported into the state from out-of-state sources." Most of the emissions quantified in the AB 2195 report occurred outside of California borders; and therefore, are not added to the GHG Inventory total.

In the sections to follow, a background on each updated category is presented followed by a description of the update. The inventory category code associated with the hierarchical structure of IPCC inventory categorization is shown in the sub-heading title of each section.

B. Description of Inventory Updates

B.1 Imported Electricity (IPCC 1A1ai): ACS/MJRP Reported CO_2e Emissions Disaggregation into CO_2, CH_4, and N_2O

B.1.1 Background

Section B.1 of the Inventory Updates published for the 2020 edition of the GHG Inventory (CARB 2020) discussed four cases of electricity imports that are not from a single, specified source: unspecified imports, asset controlling suppliers (ACS), multi-jurisdictional retail providers (MJRP), and California Independent System Operator (CAISO) Energy Imbalance Market (EIM) outstanding emissions. For these four cases, pursuant to MRR, emissions are reported in carbon dioxide equivalent (CO2e) rather than individual pollutants. As of the 2020 edition of the GHG Inventory, the CO2e emissions were disaggregated to individual pollutants using default natural gas combustion emission factors for all four of these cases.

In the 2021 edition of the GHG Inventory, the disaggregation of CO2e emissions to individual pollutants has been updated for ACS and MJRP emissions using supplemental reported data for these resource types.

B.1.2 Data and Method

Pursuant to MRR, system-wide emission factors are calculated for an ACS/MJRP based on their net imports and net generation. These net values are calculated as emissions and MWh from the following categories:

Facility-Owned Generation + Specified Purchases + Unspecified Purchases – Specified Sales

For each of these categories, an ACS/MJRP may have generation or transactions from multiple resources. Each of these resources has CARB-established emission factors for total CO2e, CO2, CH4, and N2O. For each resource in each category, emissions are calculated as:

Resource Emissions = MWh × Transmission Loss Factor (TL) × Emission Factor (EF)

Emissions are then summed for all resources in each category. For example, total facility-owned generation emissions equal the sum of emissions from each facility-owned resource. Similarly, generation is summed for all resources in each category.

The system emission factor is calculated as:

System Emission Factor = Sum of System Emissions (MTCO2e) / Sum of System MWh

The system emission factor is calculated as a single CO2e factor for MRR reporting. Starting with the 2021 edition of the GHG Inventory, system emission factors for ACS/MJRPs are calculated individually for CO2, CH4, and N2O using the reported, CARB-specified emission factors for each pollutant for each resource. These calculations follow the same method as described for the system CO2e emission factor, but with reported emissions for each individual pollutant replacing reported CO2e emissions.

There are a few instances where emissions are reported only in CO2e for a given resource transaction reported by an ACS/MJRP. The first is when an ACS/MJRP manually enters an emission factor rather than using a CARB-specified emission factor for a given resource; manual emission factors are entered in CO2e only. The second is when an ACS/MJRP reports unspecified purchases, for which the default unspecified imports emission factor of 0.428 MTCO2e/MWh is used. In both cases, the CO2e emissions are disaggregated using default natural gas combustion emission factors as described in section B.1 of the 2020 edition Inventory Updates document (CARB 2020).

B.2 Off-Road Gasoline and Ethanol Fuel Use (IPCC 1A2k, 1A2m, 1A3a, 1A3dii, 1A4a, 1A4c): Hold the 2019 values the same as 2018

B.2.1 Background

CARB accounts for on-road gasoline and ethanol fuel use using California Department of Tax and Fee Administration (CDTFA) publicly reported net taxable volumes (CDTFA 2021). This reported volume only includes gasoline and ethanol subject to taxation for use on highways and roads. Any volumes used for non-road or off-road purposes is not reported by CDTFA, as the agency is concerned only with on-road uses subject to taxation.

CARB staff estimate the off-road use of gasoline and ethanol with a fuel balance. MRR holds the full reported amount of gasoline and ethanol used in California. Staff takes this MRR total value and deducts the CDTFA on-road amount to obtain the off-road amount.

B.2.2 Data and Method

For 2019, staff found that CDTFA’s total gasoline and ethanol volume for on-road was greater than the verified MRR total gasoline and ethanol volume, which includes both on-road and off-road uses. CARB staff are looking into this discrepancy and will work with CDTFA to reconcile these data sets. In the interim, CARB will use the 2018 estimate of off-road total gasoline and ethanol in the 2020 version of the inventory as the 2019 estimate in the 2021 version; the on-road gasoline and ethanol volumes in the 2021 inventory continue to come from CDTFA data. Once the datasets are reconciled, off-road gasoline and ethanol will be updated for all applicable years.

B.3 Miscellaneous Data Updates (IPCC 1A1aii, 1B1, 1B4)

In the 2021 edition of the inventory, CARB staff made minor updates to several parts of the inventory. These updates include:

- Use Useful Thermal Output (UTO) data from the U.S. Energy Information Administration (EIA)(EIA 2021) to attribute total emissions from cogeneration units to electricity and UTO for 2019.
- Match emissions data as reported in MRR but continue to use engineering judgment to estimate missing fuel data.

As the result of these minor updates and data corrections, some emissions and fuel data for the same calendar year may be slightly different between the 2021 edition and 2020 edition of the inventory.

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