California's 2000-2017 Greenhouse Gas Emissions Inventory 2019 Edition

Inventory Updates Since the 2018 Edition of the Inventory

Supplement to the Technical Support Document

CALIFORNIA
AIR RESOURCES BOARD

Air Quality Planning and Science Division

August 2019

Table of Contents

TABLE OF CONTENTS **2**

A. Introduction 3

B. Description of Inventory Updates 4

B.1 Imported Electricity (IPCC 1A1ai): Align emission factors with CARB's Mandatory Reporting Program *4*

B.2 Residential Post-Meter Natural Gas Leaks (IPCC 1B1): Previously-Unquantified Emission Source *4*

B.3 Ozone-Depleting Substance Substitutes (IPCC 2F): Data Updates *5*

B.4 Cattle Enteric Fermentation Update (IPCC 3A1a) *6*

B.5 Miscellaneous Data Corrections (IPCC 1A1ai, 1A2f, 2A1) *7*

C. Interim Method during Data Transition 8

C.1 Crop Cultivation Acreage Data (IPCC 3C4 – 5) *8*

C.2 Livestock Population Data (IPCC 3A) *9*

References 10

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.

References

Appuhamy & Kebreab 2018. Characterizing California-specific Cattle Feed Rations and Improve Modeling of Enteric Fermentation for California's Greenhouse Gas Inventory. Available at: https://ww3.arb.ca.gov/research/apr/past/16rd001.pdf

CARB 2009. Results of the 2006 Consumer & Commercial Products & Aerosol Coating Products Survey. Available at: https://www.arb.ca.gov/consprod/regact/2006surv/2006surv.htm

CARB 2014. Gallagher, G., T. Zhan, Y.-K. Hsu, P. Gupta, J. Pederson, B. Croes, D. R. Blake, B. Barletta, S. Meinardi, P. Ashford, A. Vetter, S. Saba, R. Slim, L. Palandre, D. Clodic, P. Mathis, M. Wagner, J. Forgie, H. Dwyer and K. Wolf (2014). High-Global Warming Potential F-gas Emissions in California: Comparison of Ambient-Based versus Inventory-Based Emission Estimates, and Implications of Refined Estimates. Environmental Science & Technology, 48(2): 1084-1093.

CARB 2016. Emission Inventory Methodology and Technical Support Document for California's High Global Warming Potential Gases Emission Inventory, April 2016. Available at: www.arb.ca.gov/cc/inventory/slcp/doc/hfc_inventory_tsd_20160411.pdf

CARB 2017a. California's 2000-2015 Greenhouse Gas Emissions Inventory: Inventory Updates Since the 2016 Edition of the Inventory. 2017 Edition. Available at: https://www.arb.ca.gov/cc/inventory/pubs/reports/2000_2015/ghg_inventory_00-15_method_update_document.pdf

CARB 2018. California Air Resources Board. Data reported to CARB Mandatory Reporting Regulation for 2009 to 2017. Available at: https://www.arb.ca.gov/cc/reporting/ghg-rep/reported-data/ghg-reports.htm

CARB 2019a. Final 2013, 2014, and 2015 Consumer & Commercial Products & Aerosol Coating Products Survey, April 2, 2019. Available at: https://www.arb.ca.gov/consprod/regact/2006surv/2006surv.htm

CARB 2019b. Personal communication between Kevin Eslinger, CARB, and UC Davis Professor Ermias Kebreab regarding CARB-funded enteric research, Characterizing California-specific Cattle Feed Rations and Improve Modeling of Enteric Fermentation for California's Greenhouse Gas Inventory.

Carrier 2015. Carrier Transicold Pursues Natural Refrigerant Technology for Transport Refrigeration Applications. Accessed on October 6, 2015 at: https://www.carrier.com/truck-trailer/en/north-america/news/news-article/carrier_transicold_pursues_natural_refrigerant_technology_for_transport_refrigeration_applications.aspx

CEC 2018. Natural Gas Methane Emissions from California Homes. California Energy Comission. Available at: https://www.energy.ca.gov/publications/displayOneReport.php?pubNum=CEC-500-2018-021.

DOF 2000-2019. E-5 and E-8 Population and Housing Estimates for Cities, Counties, and the State, 2000 - 2019. California Department of Finance. Available at: http://www.dof.ca.gov/Forecasting/Demographics/Estimates/

EIA 2019. Form EIA-923 detailed data with previous form data (EIA-906/920). Available at: https://www.eia.gov/electricity/data/eia923/

IPCC 2006. 2006 IPCC Guidelines for National Greenhouse Gas Inventories, National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T., and Tanabe K. (eds.), IGES, Japan. Available at: http://www.ipcc-nggip.iges.or.jp/public/2006gl/.com

Kwon 1998. Practical Considerations Regarding R-404A and POE Lubricant Used in Transport Refrigeration Systems. S.L. Kwon. Internations Refrigeration and Air Condidtioning Conference, Paper 386. Available at: http://docs.lib.purdue.edu/iracc/386

NASS 2018. National Agricultural Statistics Service – Quick Stats. Available at: http://quickstats.nass.usda.gov/.

USDA 2019. United States Department of Agriculture - Census of Agriculture - 2017. https://www.nass.usda.gov/AgCensus/

US EPA 2016. Significant New Alternatives Policy (SNAP) Program Rule 20, "Prohibition on the use of certain high-GWP HFCs as alternatives". Federal register docket number EPA-HQ-OAR-2014-0198. Accessed online on May 14, 2019. Available at: https://www.govinfo.gov/content/pkg/FR-2015-07-20/pdf/2015-17066.pdf

US EPA 2018. Greenhouse Gas Reporting Program (GHGRP). Data for 2010-2017. Data available at: https://www.epa.gov/ghgreporting

US EPA 2019. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2017 - Methodology for Estimating CH4 Emissions from Enteric Fermentation – Cattle Enteric Fermentation Model. Annex 3, Part B, Section 3.10 pp A-249 – A-272. https://www.epa.gov/sites/production/files/2019-02/documents/us-ghg-inventory-2019-annex-3-additional-source-or-sink-categories-part-b.pdf