California Environmental Protection Agency

Air Resources Board

2015 Edition

Methodology for Projecting California's Methane Emissions

Technical Support Document

State of California
Air Resources Board
Air Quality Planning and Science Division

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Disclaimer

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INTRODUCTION

An emission projection estimates expected future emission levels based on current emissions, expected regulatory implementation, and other technological, social, economic, and behavioral patterns. Emission projection analysis assists the Air Resources Board (ARB) in demonstrating progress toward meeting the emission limits set forth by legislations. This document describes the methodology and data used for projecting methane emissions in support of the Short-Lived Climate Pollutant (SLCP) Strategy developed pursuant to Senate Bill 605 (Lara, Chapter 523, Statutes of 2014). This edition of emission projection utilizes best available information as well as fuel and energy demand forecast at the time when the analysis was conducted in mid-2015.

In this edition of emission projection, the Business-As-Usual (BAU) scenario represents incorporation of all existing measures identified in the First Update to AB 32 Scoping Plan ("the 2014 Scoping Plan")(ARB 2014), as well as Assembly Bill 1493 Clean Car Standards ("Pavley I") and Senate Bill 107 Renewable Portfolio Standards (RPS) of 20%.[1] The emission projection uses the average statewide greenhouse gas (GHG) emissions for 2009-2011 as the base year. Using a three year average dampens variations that may make a given year unsuitable for use as the basis for projection analysis. For example, using a hot and dry year with higher power consumption and less hydroelectric power generation as the base year would skew the projected emissions associated with power generation.

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[1] Note that the BAU scenario in this emission projection is different from the BAU scenario in previous versions of GHG emission projection that are still available on GHG emission inventory program webpage (http://www.arb.ca.gov/cc/inventory/data/bau.htm). Previous versions were developed in support of the original Assembly Bill 32 (AB 32) Scoping Plan in 2008 and the First Update to AB 32 Scoping Plan in 2014. BAU in previous version represents a scenario where AB 32 measures did not exist. In this version, the BAU scenario assumes that AB 32 measures have been implemented, but none of the measures proposed in the SLCP Strategy are implemented.

I. Overview of the General Approach

The general approach for projecting future emissions consists of multiplying base year emissions by sector- or activity-specific growth factors. The calculation uses the following general equations:

Projected 20XX Emissions = Base Year Emissions x 20XX Growth Factor

20XX Growth Factor = Projected 20XX Activity Level / Base Year Activity Level

Activity level data can be a variety of quantitative parameters ranging from fuel consumption, livestock population, electricity demand or generation, amounts of materials used, production data, to human population. While some activity level data are parameters explicitly used in the emission calculation equations for inventorying current and past year emissions, some activity data for future emission projection are surrogates that are known to correlate with emissions.

In general, the above equation is used to project hypothetical baseline emissions first, then as a second step, the effects of policy and regulations are accounted with additional adjustments. The hypothetical baseline represents emissions before laying the effects of Scoping Plan measures over the projection, and it serves as an interim step in estimating BAU emissions. Emission reduction profile of each climate program is developed and overlaid on top of the baseline projection to generate other scenarios for planning analyses. The impact of each regulation and policy can thus be seen independent of others, and the combined impacts of all such efforts can also be displayed.

A. Base Year Emissions

The base year is usually the average of emissions of three recent years taken from the state-wide GHG emission inventory. This composite approach for base year emissions can level out fluctuations from unpredictable events that might otherwise over- or under-estimate energy demand in a particular year. For example, drought conditions in a particular year may reduce the amount of hydroelectric power available, causing an increase in the use of fossil fuel power generation and an increase in GHG emissions, which can over-estimate future emissions.

For this edition of the emission projection, the 2009-2011 average is chosen because it spans a low and a high hydropower year, and is the most recent consecutive 3-year period that does not mix years with and without the San Onofre Nuclear Generating Station (SONGS), a zero-GHG generation source that was shut down in 2012. (To avoid mixing years that contain anomalous factors that lead to substantial differences in the emissions that make up the base year, the next 3-year period that could be considered would be 2012-2014, three contiguous years without SONGS. However, this option will not be available until the GHG emission inventory is updated to include years out to 2014.) Staff conducted analysis of the different base year options and found that projection is not sensitive to the choice of base year. The 2030 projection differs by no more than 1 million metric ton of CO_2 equivalent ($MMTCO_2e$) (or 0.2%) among the different base year options.

B. Growth Factor

Growth factors are sector- and fuel-specific ratios derived from various forecasted data sources. They are applied to individual sectors, subsectors, or emission categories for a comprehensive estimate of total state-wide emissions in the forecasted years. There are 4 general categories of growth factors: activity level parameter, growth surrogate, extrapolation, and no growth. The following subsections provide an overview of the use of these types of growth factors. Section II, Description of Projection, describes emission projection calculations by sector in more detail.

Activity Level Parameter

The most common type of growth factor is forecasted activity level parameters that are used directly in the equations for estimating GHG emissions. For example, in the annual state-wide GHG emission inventory, fuel use quantity is used directly in the equations to calculate emissions from fuel combustion activities. Projected fuel use quantity estimated for a future year can be used to estimate the projected GHG emissions in the corresponding future year.

For sectors and subsectors whose emissions are driven by fuel combustion (on-road gasoline and diesel, rail, aviation gasoline, jet fuel, and natural gas), growth factors are derived primarily from the energy demand model used by the California Energy Commission (CEC) for their biennial Integrated Energy Policy Report (IEPR) (CEC 2015). The IEPR establishes future demand for electricity, natural gas, and transportation fuels. It accounts for economic drivers such as disposable income, fuel prices, and consumer preferences. The IEPR demand forecast provides Low, Mid, and High demand cases. The Mid demand case is used for standard GHG emission projection.

For the off-road mobile sectors (ships; harborcraft; equipment used in construction, oil drilling, and industrial activities; and airport ground support equipment), off-road mobile source inventory models developed by ARB (ARB 2011b) provide the forecast for future fuel consumption, from which GHG emissions are calculated.

Emissions from dairy livestock are estimated based on cattle population. Future cattle population forecast developed by the Food and Agricultural Policy Research Institute (FAPRI) (FAPRI Various) is used in GHG emission projection.

Fugitive emissions from landfills are estimated using a first-order decay model developed by ARB, with waste deposition data as model input. The waste deposition forecast from CalRecycle (CalRecycle 2015) and future population projection (CADOF 2014) are used as the activity level data input in the landfill emissions model.

Growth Surrogate

Growth factors can be derived from growth surrogates when no direct activity level data are available. Surrogates are chosen because they closely align with the category being grown and are known to share a similar growth trend with emissions or activity level.

Except for landfill, which is projected using forecasted activity level data, in general fugitive emissions are projected using the growth surrogates found in the ARB's California Emissions Projection Analysis Model (CEPAM) (ARB 2015), ARB's emission forecast system for criteria pollutants.

Extrapolation

When both parameters and surrogates are lacking, extrapolation is used to forecast emissions. For example, emissions from the combustion of associated gas used in oil and gas fields is a category in which extrapolation is used. Because associated gas is a byproduct of oil production, which follows a historical trend of gradual decline, extrapolation is considered a reasonable predictor of future supply and use.

No Growth Assumption

Emissions of certain categories are not expected to increase in the future. In which case, a no growth assumption is used. For example, stationary fuel combustion of non-natural gas fuels are not expected to increase due to the stringent local air district rules that limit new combustion sources to using only natural gas fuel. It is assumed that the existing sources will remain and no new ones will be added. Imported electricity is also assumed to remain constant due to constrained transmission capacity and restrictions on new long-term contracts with coal-fired power plants. This represents a conservative assumption, as these sources are likely to be replaced with cleaner natural gas or other sources with fewer emissions.

C. Data Source for Growth Factors

Data sources required for emission projection include reports issued by other State agencies, the forecasting system used by ARB for projecting future emissions of criteria pollutants, and outputs from source-specific models. Table 1 provides a summary of the data sources.

Table 1. Data Sources for Growth Factors

Forecasted Parameter	*Data Source for Deriving Growth Factor*	*Emission Sources*
Electricity Demand	2012 IEPR (CEC 2015) and ARB electricity generation profile calculation	Electricity generation and cogeneration (in-state, imported)
Transportation Fuel Demand	2011 IEPR (CEC 2015)	Gasoline, ethanol, diesel, jet fuel, and natural gas
	2009 IEPR (CEC 2015)	aviation gasoline and propane
Natural Gas Demand	2013 IEPR (CEC 2015)	Refineries, commercial and residential fuel use, stationary fuel combustion
Off-Road Fuel Use	ARB Off-Road In-Use Fuel & Marine Inventory Model (ARB 2010, ARB 2011b, ARB 2011a)	Off-road activity, construction & mining equipment, ships and harborcraft
Associated Gas Combustion	Extrapolated from historic trend	Oil & gas extraction
Landfill Emissions	ARB landfill emissions calculation; CalRecycle's waste deposition projection (CalRecycle 2015)	Landfills
Dairy Population	2015 Food & Agriculture Policy Research Institute (FAPRI) (FAPRI Various)	Enteric fermentation and manure management
Other Agriculture & Fugitive Emissions	California Emissions Projection Analysis Model (CEPAM) (ARB 2015)	Wastewater, non-dairy agriculture sources, recreational boats, fugitive emissions from various sectors
High GWP Gas Emissions	ARB Model (Gallagher, Zhan et al. 2013)	High GWP gases

D. Emission Reductions from AB 32 Measures

Various GHG reduction measures are designed to achieve certain levels of GHG reductions at specific years. Calculating projected emissions to account for reduction measures is done in 2 steps. Staff first estimates the amount of reductions that a measure is expected to achieve in each year, then develops control factors that are multiplied by the growth factors to obtain final projected emissions.

Control factors are developed using the following general equation:

20XX Control Factor = 1 – [20XX Reduction from Measure / 20XX Baseline Emission Forecast For All Categories Affected by Measure]

To calculate projected emissions incorporating implementation of existing reduction measures (the BAU case), the control factors are used in concert with the growth factors for the hypothetical baseline. The BAU forecast uses the following general equation:

20XX BAU Emissions = Base Year Emissions x 20XX Growth Factor x 20XX Control Factor

II. Description of Projection Method by Sector

Emission estimates for future years are developed using projected future energy demand, fuels required to meet the energy demand, specific emission forecasting models or estimates that directly estimate future emissions (such as CEPAM, ARB's Landfill Estimate, and the High GWP Gas Model), or other surrogates. The following sub-sections describe the emission forecast method for each sector.

A. Electricity Generation and Cogeneration

In-state and imported electricity generation projection is based on the CEC's IEPR Electricity Demand Forecast (CEC 2013). To determine emissions from the electricity demand, staff first generates an electricity supply profile that approximates the mix of electricity generation sources needed to meet the future demand. In developing the supply profile, staff assumes that there is no increase in electricity generation from non-natural gas fuels such as coal, coke, diesel, and liquefied petroleum gas (LPG) over time. This is a reasonable assumption given that stringent local air district regulations effectively prohibit permitting of new sources using non-natural gas fuels. Natural gas fueled electricity generation is the only way to meet the standards for new sources. While existing non-natural gas generation will likely decline, replaced by newer, more efficient natural gas or renewable generation sources, the conservative case is to assume that they remain constant.

The remaining demand is assumed to be met through renewable sources, imported electricity, and new or existing natural gas generation. Although imports from fossil sources will likely decline, replaced by imports from cleaner plants or renewables, emissions from electricity imports are conservatively assumed to not increase over time. It is in recognition of the foreseen lack of new long-term increases in interstate transmission capacity that constrains transmission capacity to existing levels. Increased efficiency is expected from in-state natural gas generation as additional combined-cycle power plants with lower GHG emissions are developed. Any remaining demand not met by the above sources is assumed to come from new in-state natural gas power plants.

The BAU scenario incorporates 3 reduction measures identified in the 2014 Scoping Plan: 1) Electricity Energy Efficiency and Conservation 2) Renewable Portfolio Standard (RPS) of 33%, and 3) California Solar Initiative (CSI). The impact of Cap-and-Trade is layered in the end, keeping the emissions below the cap.

RPS has no impact on the demand; it only reduces the emissions associated with the choice of power supply to meet the demand. On the other hand, energy efficiency reduces demand by reducing the amount of power needed to accomplish the same end uses, and CSI reduces demand on the grid by generating local (often rooftop) solar power to supply end uses. After calculating the BAU emissions for all the sectors covered by Cap-and-Trade, if the emissions summed across covered sectors are above the cap level, emissions of each covered sector are reduced proportionally to meet the cap.

The RPS increases the percentage of retail sales from renewable sources from 20% in 2012 to 33% by 2020. After 2020, renewable portfolio is held constant at 33%. Emission reductions increase proportionally as retail electricity sales continue to grow based on the IEPR demand forecast even if renewable portfolio is held constant at 33%. The demand reduction of CSI is held constant at its 2020 level out to 2030. The percent reduction in demand attributed to electricity energy efficiency is maintained at the 2020 level for years after 2020. Similarly, mass emissions reductions increase proportionally as the demand grows based on the IEPR demand forecast, since the fixed percentage of 2020 will apply to a larger growing demand.

B. Transportation

Projection of transportation emissions relies on different approaches depending on the source category and fuel. Emissions from on-road use of gasoline and diesel begin with fuel demand forecasts from the IEPR (CEC 2013). Future ethanol percentages in gasoline are held constant at base year levels (approximately 10 percent). Likewise, future renewable or bio-diesel volumes are held constant at base year levels. Pavley I is incorporated into the baseline because it is independent of AB 32. Pavely I has been incorporated into the IEPR forecast.

ARB developed category-specific inventory models for off-road mobile sources. These ARB models (ARB 2010, ARB 2011b, ARB 2011a) are used for diesel and residual oil use in ocean-going vessels (OGVs) and commercial harborcraft (CHC) as well as off-road mobile equipment used in the construction & mining, oil drilling, industrial sources, and airport ground support.

Emissions from gasoline use in recreational boats rely on outputs of fuel consumption from CEPAM (ARB 2015), the system used by ARB staff to forecast criteria pollutants. CEPAM was used for estimating future emissions from recreational boats as it provides more specific estimates for this category than are otherwise available from the IEPR (CEC 2013).

Estimates of demand for other non-road fuel use, including gasoline, diesel, jet fuel, aviation gasoline, propane, and natural gas rely on the IEPR forecast (CEC 2013). This includes emissions from trains, aircraft, and other off-road equipment not already covered above.

The BAU scenario incorporates 7 reduction measures identified in the 2014 Scoping Plan: 1) Pavley II (Advanced Clean Cars), 2) Low Carbon Fuel Standard (LCFS), 3) Sustainable Communities Strategy (SB 375), 4) Tire Pressure Program, 5) Ship Electrification, 6) Heavy Duty Aerodynamics, and 7) Medium/Heavy Hybridization. The impact of Cap-and-Trade is layered in the end, keeping the emissions below the cap. After calculating the BAU emissions for all the sectors covered by Cap-and-Trade, if the emissions summed across covered sectors are above the cap level, emissions of each covered sector are reduced proportionally to meet the cap.

Of the 7 reduction measures included in the BAU scenario, 6 of them achieve reductions by reducing fuel consumption. Only LCFS achieves reductions by changing the carbon footprint of fuel use. Currently, most of the reductions from LCFS occur out of state, as most of the feedstock crop is grown and the biofuel is produced out of state. However, for the purpose of this emission projection analysis, it is assumed that LCFS reductions are attributable to the AB 32 emission limit and are equivalent to in-state reductions. The framework for accounting for LCFS reductions will continued to be evaluated in the upcoming Scoping Plan process.

The Advanced Clean Cars measure sets specified reduction levels based on what it is expected to achieve in 2021-2030. For the reductions of other measures in the 2021-2030 timeframe, it is assumed that they maintain the percent reduction achieved in 2020. The mass emissions reductions are expected to increase proportionally as emissions are forecasted to grow.

C. Commercial and Residential

Emissions from the commercial and residential sectors consist predominantly of natural gas use from smaller combustion sources, including small boilers, water heaters, and appliances. Emissions from this sector rely on the IEPR forecast of natural gas demand.

The consumption of fuels in the commercial and residential sectors other than natural gas, including biomass (wood), diesel, propane, and gasoline, is assumed to remain constant. Combustion emissions associated with these fuels are very small relative to natural gas combustion emissions.

The BAU scenario incorporates 2 reduction measures identified in the 2014 Scoping Plan: 1) Energy Efficiency and Conservation (Natural Gas) and 2) Solar Hot Water and Efficiency (AB 1470). The impact of Cap-and-Trade is layered in the end, keeping the emissions below the cap. After calculating the BAU emissions for all the sectors covered by Cap-and-Trade, if the emissions summed across covered sectors are above the cap level, emissions of each covered sector are reduced proportionally to meet the cap.

Both of these Scoping Plan measures achieve reductions by reducing fuel consumption, either through reduced demand as the result of energy efficiency or conservation, or due to replacing natural gas device with solar device.

For reductions in the 2021-2030 timeframe, it is assumed that all measures maintain the percent reduction they achieved in 2020 out to 2030.

D. Industrial

The IEPR demand forecast (CEC 2013) is used for projecting emissions from industrial facilities using natural gas, including a portion of the emissions from refineries and hydrogen plants. Consumption of non-natural-gas fuels is assumed to remain constant because no new sources burning non-natural gas fuels are expected to be permitted under the stringent air district regulations. Growth factors for fugitive sources, such as wastewater treatment plants, are derived from the CEPAM forecasting system (ARB 2015).

Some fuels used by industrial facilities require a different approach to estimate their emissions. Associated gas is a byproduct of oil production. Future emissions from the combustion of associated gas are estimated by extrapolating the historical emission trend spanning 1990 to the base year. This forecasting approach reflects the limited and declining supply of associated gas in the State. For cement plants, coal is the primary fuel. Coal consumption is not expected to increase. Clinker production emissions from cement plants are correlated with fuel combustion, and are also not expected to see a significant change into the future.

Cap-and-Trade is the only measure directly targeting the industrial sector. Cap & Trade is applied to keep the emissions from covered sectors under the Cap. Any reduction this necessitates is distributed, pro-rata, across the covered sectors.

E. Landfill and Composting Facility

Landfill emissions are projected based on forecast of waste deposition in California landfills developed by CalRecycle (CalRecycle 2015). Waste deposition information is then used to determine future methane generation from landfills statewide. The landfill emissions projection uses the same model as the annual GHG emission inventory. The composition of future waste and landfill control efficiency are assumed the same as that of the base year.

The BAU scenario incorporates the Landfill Methane Control Measure, the only reduction measure identified in the 2014 Scoping Plan affecting this sector. This measure achieves reductions by improving the methane capture through the existing landfill gas collection system and requiring certain landfills to install a gas collection system. Landfills that are able to demonstrate compliance with ARB landfill regulation are assumed to achieve 80% collection efficiency by 2020 and going out to 2030.

F. Other Fugitive and Area Sources

For a number of categories, growth factors are derived from ARB's criteria emissions forecasting system, CEPAM. CEPAM is deemed the best available data source for deriving growth factors if no other forecasting studies specific to these emitting activities are available. CEPAM growth factors are based on many data sources (e.g. population, economic output, construction) ranging from state-wide to local Air District and county level data. The following inventory categories use CEPAM growth factors:

- Gasoline fuel combustion (recreational watercraft & agricultural mobile equipment)
- Agricultural burning emissions
- Industrial fugitive emissions (process losses, evaporative losses, and storage tank losses)
- Pipeline fugitive losses (natural gas pipelines)
- Petroleum seeps

- Wastewater treatment fugitive emissions

The BAU scenario incorporates the effect of Cap-and-Trade on gasoline fuel consumption. Cap & Trade is applied to keep the emissions from covered sectors under the cap. Any reduction this necessitates is distributed, pro-rata, across the covered sectors. There is no other reduction measure directly affect these categories.

G. Agriculture

Forecasted emissions from agriculture are based on projected demand of fuel use, projected farming activities, and livestock population projection. Emissions from natural gas and diesel fuel use rely on IEPR demand forecasts (CEC 2013). Future emissions from dairy livestock activities (enteric fermentation and manure management) are estimated using FAPRI's 2015 forecasts of livestock population in 2014-2024 (FAPRI Various). They are held constant after 2025. All other agricultural activity emissions are assumed to remain constant into the future.

The BAU scenario incorporates the impacts of Cap-and-Trade on natural gas and diesel fuel consumption. Cap & Trade is applied to keep the emissions from covered sectors under the cap. Any reduction this necessitates is distributed, pro-rata, across the covered sectors. There is no other reduction measure directly affect this sector.

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