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CEC Staff Recommended 1990 Greenhouse Gas Emission Baseline for Building Decarbonization Assessment

Assembly Bill 3232 (Friedman, Chapter 373, Statutes of 2018) mandates the Energy Commission to assess the potential for the state to reduce greenhouse gas (GHGs) emissions in the state's residential and commercial building stock by at least 40 percent below 1990 levels by January 1, 2030. Energy Commission staff must develop the GHG baseline for this Building Decarbonization Assessment (Assessment) that is due to the Legislature at the end of 2020.

Table 1: Choice set and Energy Commission staff's recommendation of possible GHG emissions to include in the baseline for the AB 3232 Building Decarbonization Assessment

Type or source of emissions	Reported for buildings in CARB inventory?	In CEC AB 3232 baseline?
Core building emissions		
✓ Fuel combustion (natural gas and other fuels)	Yes	**Yes**
✓ Refrigerants and other high-GWP gases	Some; not for 1990 & not for ozone-depleting substances (ODS)	**Yes**; only ODS substitutes
Methane emissions from natural gas infrastructure leaks		
• Production	No	No
• Transmission and distribution	No	No
• Meter	No	No
✓ Behind-the-meter leaks ("post-meter natural gas leaks")	Residential; not for 1990 & pending for commercial sector	**Yes**
Electricity emissions		
• Count in 1990 baseline	No	No
✓ Account for incremental emissions from the increased loads from fuel substitution activities	--	**Yes**

Table 1 reports which GHG emissions the Energy Commission plans to include in the GHG baseline. Staff organized the choice set of possible emissions to consider into three categories: core building emissions, methane emissions from natural gas infrastructure

leaks, and electricity emissions. As noted in the middle column, not all GHG emissions are reported exclusively for the residential and commercial sectors in the California Air Resources Board (CARB) inventory or reported for the 1990 base year (CARB 2007; CARB 2019a; CARB 2019b).

Table 1 presents which GHG emissions the Energy Commission plans to consider in the baseline when assessing the feasibility of meeting the 2030 GHG reduction target. There are four sub-categories to consider when assessing methane emissions from natural gas infrastructure leaks. Only behind-the-meter leaks are reported for the residential sector in the CARB inventory, and are included in the baseline for the residential and commercial buildings sector for now. The other three categories either are attributed to another sector or are not currently reported in the inventory. Similarly, since electricity generation is reported as its own sector in the CARB inventory, Energy Commission staff had to decide the best means to account for and assess these emissions for the Assessment.

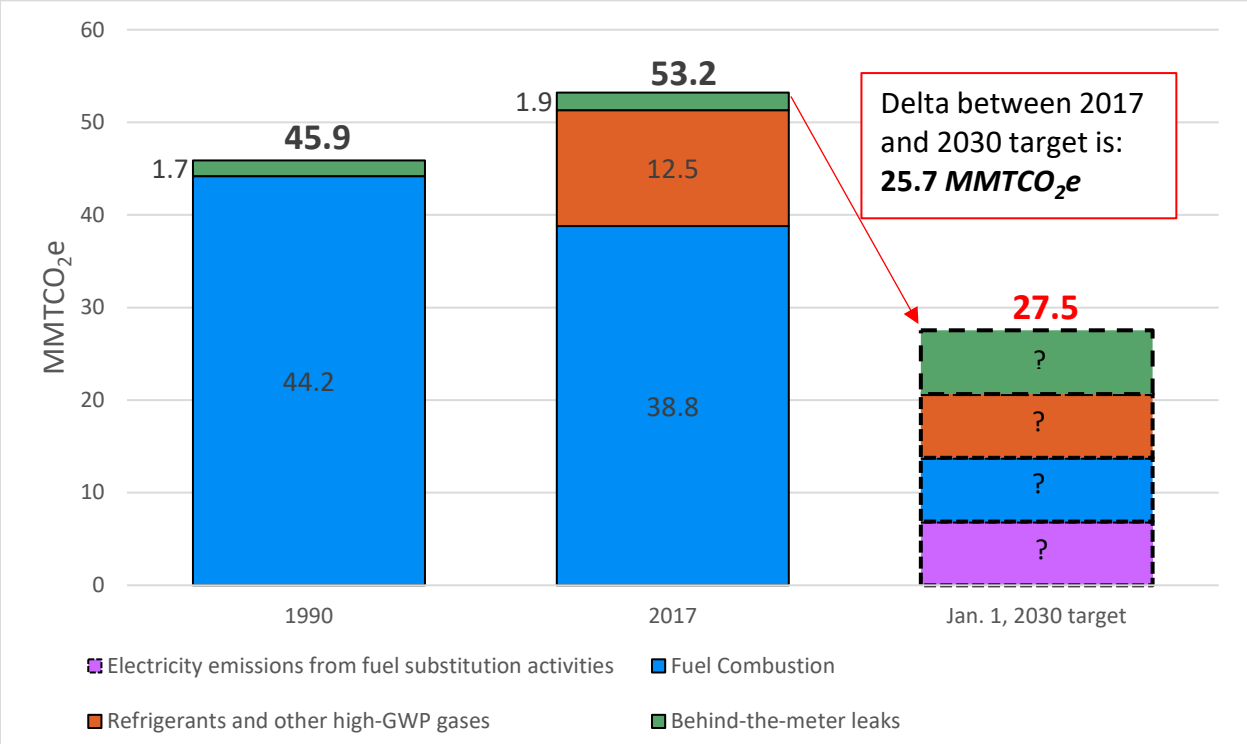
It is important to note that emissions from electric generation attributed to residential and commercial sectors will still be tracked for the Energy Commission's Integrated Energy Policy Report (IEPR) proceeding and the strategies to reduce all electricity emissions from buildings (e.g., the GHG reduction potential from demand flexibility strategies) will be assessed as part of the Building Decarbonization Assessment's abatement cost curve analysis. By not including 1990 electricity emissions in the baseline, only the incremental emissions from the increased electric loads from fuel substitution activities will be assessed for achieving the 2030 goal. The date these incremental emissions will begin accruing will be set based on the Energy Commission's fuel substitution modeling assumptions, likely 2020 or 2021. Although counterintuitive, staff did not include electricity emissions in 1990 since, based on staff analysis and as discussed below, including these emissions would have resulted in much fewer emissions that need to be abated from 2017 levels by the residential and commercial sector to achieve the 2030 target (11.2 versus 25.7 MMTCO2e). As such, the included GHG emissions in Table 1 produce an aggressive target to assess in a short time horizon.

Overview of AB 3232 Building Decarbonization Assessment Baseline

This staff analysis presents an overview of the AB 3232 Building Decarbonization Assessment baseline; the background, decision framework, and methodology (if applicable) of how to account for each emission category in the baseline mentioned in Table 1; and a thorough discussion of the decision for why only a portion of electricity emissions will be assessed in the report. A discussion and numerical table detailing the 1990 Building Decarbonization Assessment baseline concludes the analysis.

Based on CARB GHG inventory (CARB 2007; CARB 2019a; CARB 2019b) and Energy Commission staff analysis, Figure 1 illustrates the AB 3232 Building Decarbonization Assessment baseline, the 2017 GHG emissions, and the total aggregate emissions needed to achieve the 40 percent reduction January 1, 2030 target. The quantities for the January 1, 2030 target are reported as question marks to show that the amount of each emissions at that time are ambiguous, but the sum of all emissions must at least reach the 27.5 MMTCO2e target. The final report will provide a more comprehensive assessment of the potential magnitude of these emissions at the 2030 target. Staff argues that these emissions best capture the GHG emissions reduction potential from the residential and commercial buildings sector, namely fuel substitution activities (i.e., technology switching from natural gas to electrical appliances).[1]

Figure 1 -- Simplified illustration of the AB 3232 Building Decarbonization Assessment baseline and the 2030 target for residential and commercial buildings of 27.5 MMTCO2e (40% reduction from 45.9 MMTCO2e)



As can be seen in Figure 1, total emissions increased between 1990 and 2017. Although fuel combustion emissions decreased, emissions from refrigerants and other High Global Warming Potential (high-GWP) gases significantly increased. As discussed in the refrigerant and other high-GWP gases section below, the 1987 Montreal Protocol and the exclusion of ozone-depleting substances from the CARB inventory emissions

[1] Fertilizer emissions are not included since they are outside the scope of fuel substitution.

explains this anomaly. A 40 percent reduction from 1990 levels, 45.9 MMTCO2e, results in a 2030 target of 27.5 MMTCO2e emissions' a 25.7 MMTCO2e gap compared to 2017 levels. Note that because the AB 3232 deadline is January 1, 2030 ("the 2030 target"), the last full year of the Energy Commission's baseline assessment is 2029. This target date assumption is similar to what was done for the Energy Commission's Senate Bill 350 analysis of doubling energy efficiency savings by 2030 (CEC 2017).

Notice the bottom box area for the January 1, 2030 target representing the electricity emissions from fuel substitution activities. Although not included in the 1990 baseline estimation, electricity emissions are accounted only for those emissions that result from the increased loads from building electrification (i.e., fuel substitution from natural gas to electric appliances). The discussion below provides staff's reasoning for this approach. However, electricity emissions are still tracked and will be embedded in the report when assessing abatement costs for all GHG reduction activities.

CARB inventory and GHG baseline emission estimation methodology

The methodologies of estimating the magnitude of GHG emissions from residential and commercial buildings rely on CARB's GHG emissions inventory. Staff assessed only those emissions included in the inventory. The methodology staff used to estimate the level of emissions included in the baseline is presented in the emission's corresponding section below. CARB has two emissions inventory time series with different assumptions (CARB 2007; CARB 2019a; CARB 2019b). Table 2 reports how Energy Commission staff bridged the two inventories into one continuous time series as reported in Figures 1, 2, and 3. Staff's methodology consisted of developing ratios that were applied to the inventory to estimate the emissions attributable to the residential and commercial sectors or applied current methodologies to previous years. All emissions (CO_2, CH_4, N_2O, etc.) are reported in millions tonnes carbon dioxide equivalent. Note that Energy Commission staff used the 2000-2017 inventory for reporting years 2000-2004 and only accounted for the emissions included in CARB's inventory.

In Table 2, all categories with "CARB" are taken straight from the CARB inventory. "CEC est." were values estimated by Energy Commission staff in consultation with CARB staff, and "TBD" are values with temporary non-zero placeholders of 1.0 since the data for those emissions are pending. For fugitive emissions, any cell with "--" designates emissions not included in the inventory or AB 3232 baseline but are emissions that could be included in the baseline for the final Building Decarbonization Assessment. The "n.a." in the fuel substitution row reflects that these emissions from the incremental loads from fuel substitution activities are not applicable and cannot be accounted for in previous years. Figure 1 reports the simplified view of 1990 and 2017 emission levels and the corresponding 2030 target. Figure 2 reports the time series if electricity

emissions were in included in the 1990 baseline, while Figure 3 reports the complete time series of the baseline. Table 3 at the end of this analysis reports the numerical values used in Figures 1, 2, and 3.

Table 2 Assumptions in developing and partitioning the AB 3232 GHG emissions baseline and 1990-2017 time series using the CARB GHG emissions inventory

	1990-2004 Inventory		2000-2017 Inventory	
	Residential	**Commercial**	**Residential**	**Commercial**
Core building emissions				
Fuel combustion	CARB	CARB	CARB	CARB
Refrigerants and other high-GWP gases	CEC est.	CEC est.	CARB	CARB
Methane emissions				
Natural gas production	--	--	--	--
Transmission and distribution^	--	--	--	--
Meter	--	--	--	--
Behind-the-meter leaks	CEC est.	TBD	CARB	TBD
Electric generation (not in 1990 baseline)				
Res. and Comm. Buildings	CEC est.	CEC est.	CEC est.	CEC est.
Fuel substitution	n.a.	n.a.	n.a.	n.a.

^ As described in the transmission and distribution section below, staff would estimate ("CEC est.") the magnitude of these emissions for all years if these emissions were to be included in the final AB 3232 Building Decarbonization Assessment report.

The sections below provide staff's reasoning for the inclusion of which emissions to include in the AB 3232 Building Decarbonization Assessment baseline and the methodology staff used to estimate the level of emissions for the corresponding emission category. As stated above, the baseline could evolve and be updated to include non-zero amounts of methane emissions from natural gas infrastructure leaks. Any updates to the baseline will be through the combined direction of the California Public Utilities Commission (CPUC) and CARB and will be discussed, if necessary, at a forthcoming staff workshop.

Core building emissions

Core building emissions capture almost all "direct emissions" that occur at a building site. With the exception of refrigerants and other high-GWP for years 1990-2014, the

estimates for the residential and commercial sectors are taken directly from the CARB inventory. Staff omitted emissions from "residential use of nitrogen fertilizer on turf" since they are outside the scope of fuel substitution. Staff also omitted "fuel storage" since these emissions are negligible and are not counted in the 1990-2004 inventory. Staff has the greatest confidence in the acceptability of including these core building emissions for the Assessment.

Fuel combustion

All fuel combustion emissions for the residential and commercial sectors from all fuel sources were taken directly from both CARB inventories. No additional computations were made. As seen in Table 3, and Figures 1 and 3, the abatement of these emissions are the largest set of emissions attributed to the residential and commercial sector and are the primary focus of the Assessment. As can be seen in Figure 1, over half of these emissions must be reduced to meet the 2030 target.

Fuel combustion emissions methodology:
Total emissions that are reported in the CARB inventory as "fuel combustion" for the residential and commercial sectors; values taken directly from both the 1990-2004 and 2000-2017 inventories.

Refrigerants and other high-GWP gases

Refrigerant emissions and other high-GWP gases (i.e., emissions from the use of substitutes for ozone depleting substitutes) are included in this assessment, while ozone depleting substances (ODS), which are other high-GWP gases, are not. As mentioned above, ODS such as chlorofluorocarbons (CFCs) and halons were banned in the 1987 Montreal Protocol and are not counted in the CARB inventory (CARB tracks these emissions separately). Emissions from ODSs have decreased significantly since 1990 while use of substitutes for ODSs, which are accounted in the ARB inventory, continue to grow (CARB 2019, p16). Staff excluded ODSs from the baseline to maintain consistency with the CARB inventory.

Refrigerant emissions and other high-GWP gases for the residential and commercial sectors are directly reported in the 2000-2017 inventory (CARB 2019a). However, these emissions are not reported for any sector ("Not Specified") in the 1990-2004 inventory (CARB 2007). Staff used the 5-year average of the ratio of residential and commercial emissions compared to other sectors for years 2000-2005. These years were chosen since these emissions noticeably increase over time and these years are sampled closer to the 1990-2004 inventory. However, note that 1990 had a substantially low value for emissions from this category, use of substitutes for ozone depleting substitutes, at 0.37

$MMTCO_2e$ across all sectors. Any change of assumptions would have a negligible effect in magnitude of the 1990 baseline estimate.

According to CARB staff analysis, HFC emissions are the fastest growing GHG emissions and are expected to increase to roughly 30 MMTCO2e under business as usual assumption without HFC regulations. Even with current CARB HFC regulations in place, they will still increase to roughly 20 MMTCO2e by 2030. CARB and CEC staff agree that emission sources should include HFCs used as refrigerants in space cooling since they are becoming one of the largest source of HFC emissions and also fast growing with more air conditioners being installed as a result of warming impacts. In addition, with fuel substitution activities, new sources of hydrofluorocarbons ("HFCs") would be added in heat pumps for space heating, water heating, and clothes drying. Given these emerging trends, Energy Commission staff recognizes that these emissions seen in Figures 1 and 3 will be significant in the assessment and will likely require the other source of emissions, particularly fuel combustion emissions, to be reduced significantly more to reach the 2030 target.

Staff may consider CARB's recommendation of using 2013 as a baseline for these emissions. Using this recommendation would make the analysis consistent with the baseline for Senate Bill 1383 (Lara, Chapter 525, Statutes of 2016), which calls for a 40 percent reduction of HFCs by 2030 from 2013 levels.

Refrigerants and other high-GWP gases emissions methodology:

- For years 2000-2017, values taken directly from "use of substitutes for ozone depleting substitutes (ODS)" for the residential and commercial sectors.
- "Use of substitutes for ODS" are not reported for residential and commercial sector in the 1990-2004 inventory; sectors were "not specified" for these years. Staff estimated the 5-year average of the ratio of residential and commercial emissions using the years 2000-2005 in the 1990-2004 inventory, 0.109 and 0.235, respectively, to the reported "not specified" sector values for the years 1990-1999.

Methane emissions from natural gas infrastructure leaks

Methane emissions from natural gas infrastructure leaks have emerged to become a major concern as a source of GHG emissions. Methane is a powerful greenhouse gas and is 25 times more effective than carbon dioxide at trapping heat over a 100-year period. The California Methane Survey, funded partly by CARB and the Energy Commission, conducted over several months spanning from 2016 and 2018, found that just 10 percent of the point sources were responsible for 60 percent of the total methane emissions detected (Duren et al. 2019). The researchers found that less than

0.2 percent of infrastructure in the state (based on a survey of 272,000 facilities and components) are responsible for 34-46 percent of total methane emissions in California.

Staff has categorized the source of these methane emissions leaks into four categories of where they occur along the natural gas infrastructure:

- Production
- Transmission and distribution
- Meter
- Behind-the-meter leaks

Beginning in 2019, CARB reports the methane emissions from behind-the-meter leaks for the residential sector. As explained below, Staff applied the same estimation methodology for the residential sector for the interim years 1990-2000 and have a non-zero placeholder for commercial behind-the-meter methane emissions until forthcoming research by the Energy Commission can update these values. CARB staff has stated that they intend to use the research results and add commercial behind-the-meter methane emissions in future inventory updates.

The other source categories of methane emissions---production, transmission and distribution, and meter---are not reported for the residential and commercial sectors in the CARB inventory. Staff would need to estimate non-zero values for how much of those emissions are attributed to the commercial and residential sectors and how much building decarbonization efforts would affect those values. Further complicating the estimation of a baseline for these emissions, the CARB inventory only reports leaks from the natural gas infrastructure from natural gas produced in the state and excludes the out-of-state gas leaks. This reporting gap is problematic. According to the *2019 California Gas Report Supplement*, a report California gas and electric utilities are required to report to the CPUC per Decision D.95-01-039, in 2018 California imported about 89 percent of its natural gas from other states (California Gas and Electric Utilities 2019, page 16). As such, the scope, volume, and global warming potential (GWP) of methane emissions are an emerging issue and there are still significant uncertainties in the level of methane emissions (CEC 2019). Assumptions of the 20-year GPW versus the 100-year GWP and the percent leakage rate can have a large impact on the 2030 target.

However, the tracking and abatement potential of these emissions are being addressed by other agencies and statutes. For example, Senate Bill 1371 (Leno, Chapter 525, Statutes of 2014) gives the CPUC authority to regulate and enforce intrastate gas pipeline transportation and pipeline facilities so to abate and monitor the system-wide methane leaks. Given the data uncertainty of the leakage rate and scope of these

emissions, staff has concerns of attributing these emissions to 1990 levels as well as specifying non-zero values that will not be in congruence with the CARB GHG inventory. As such, these reported emissions in the Building Decarbonization Assessment baseline should be considered as a lower bound estimate.

The baseline could evolve to include these other category of emissions, but staff would require substantial evidence of the magnitude of these emissions as well as have the CPUC and CARB provide direction to include these emissions. If necessary, staff will welcome a future staff workshop to discuss adapting the baseline to include the omitted emissions categories or to update existing data and methodologies of the included baseline emissions.

Production

The CPUC accounts for production emissions with their building decarbonization work. Production emissions may decrease if there is a significant decrease in demand for natural gas from the building sector which will result in decrease need for production. Energy commission staff has concerns of expanding the scope of analysis to this extent given the uncertainty of emissions mentioned above. Further, staff has concerns that when extending the scope of analysis to this level, the assessment will need to consider the impact building decarbonization will have on global competitive markets. For example, the latent demand (i.e., global demand) for natural gas may not change from California's building decarbonization policies. Producers may instead sell natural gas to out-of-state markets while not impacting their level of production and resulting rate of methane leaks.

Staff does not have proposed methodology to attribute these emissions to residential and commercial buildings.

Transmission and Distribution

To get attribution values for residential and commercial sectors, staff calculated the share of historical California natural gas consumption across sectors using historical consumption data that dates back to 1990 reported in the California Energy Commission's 2019 Preliminary Forecast (CEC 2019a). Staff considered using the data from the Energy Information Administration (EIA 2019), but their data does not report consumption for years 1990 to 1997. Staff applied the associated sector percentages to the transmission and distribution emissions to estimate these methane emissions associated with the residential and commercial sectors. Staff also considered using the CARB's Fuel Combustion Data (CARB 2019b), but preferred to use the Energy Commission's data since these data are used as an input in the CARB inventory. No available data exists on the linear or non-linear relationship of how fuel substitution activities impacts the rate of these emissions.

Transmission and distribution emissions methodology (Currently not applied to AB 3232 baseline):

- The California Energy Commission's 2019 Preliminary Forecast (CEC 2019a) reports annual statewide natural gas consumption by sector beginning in 1990. The user can create attribution ratios for the residential and commercial sectors and apply them to the reported fugitive emissions:
  - For years 2000-2017, use the Industrial/Transmission and Distribution/Natural Gas Pipelines/Fugitives emissions category in the 2000-2017 inventory (CARB 2019a).
  - For years 1990-1999, use the Industrial/Pipelines/Gas/Fugitives emissions category in the 1990-2004 inventory (CARB 2019b).
- Staff currently does not have a recommended methodology to account for the out-of-state emissions from the transmission and distribution system.

Meter

Quantifying the extent of methane emissions from meters is an emerging research area. A CARB-sponsored study at Pacific Gas and Electric surveyed residential meters in the Bay Area to investigate the extent of leaks.[2]

The reduction of these direct emissions can be tracked in the assessment by accounting for the reduction of residential and commercial meters. But at this time, staff are not including these emissions in the baseline because of the lack of data and a methodology that is in congruence with the CARB GHG inventory.

Behind-the-meter leaks

Residential

The 2019 edition of the ARB inventory includes residential post-meter leakage (CARB 2019a) based on a recent study by the Energy Commission (CEC 2018). Staff consulted with CARB staff to apply the same methodology (CARB 2019c, pp 5-6) to the 1990-1999 reporting years using Department of Finance housing estimates (DOF 1990-2000; DOF 2000-2010).

Energy Commission staff noticed a difference in their estimates, but learned that the reported inventory relied on a different vintage of data. The differences are negligible compared to the total emissions in the baseline. But to be consistent with ARB's

[2] Presentation by François Rongere of Pacific Gas and Electric, "Methane Emissions from Gas Residential Meter Set." January 2019. https://www.cpuc.ca.gov/uploadedFiles/CPUC_Website/Content/Safety/Risk_Assessment/Methane_Leaks/11%20-%20Meter%20Set%20Emissions_Jan2019%20PGE.pdf. Accessed 11/13/2019.

inventory, the values from the 2000-2017 inventory are used. However, staff notes that ARB's analysis for 1990 uses the same Total Housing Units input value which implies that any updates will likely not change the 1990 baseline estimate for this emissions category. Staff expects these emissions to be updated as more information becomes available.

Residential behind-the-meter leaks estimation methodology:

- For years 2000-2017, staff used the values in the CARB inventory reported as Residential/Household Use/Natural Gas Consumption/Fugitives
- For years 1990-2000 staff used the methodology reported in CARB's technical support document (CARB 2019c, pp 5-6) using the Department of Finance statewide housing unit estimates for those corresponding years (DOF 1990-2000; DOF 2000-2010). The methodology assumes a constant annual leakage rate, where 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.

Commercial

Energy Commission staff currently has a study investigating the rate of emissions from this sector. The pending results will affect how staff will handle the AB 3232 baseline. Since data is not available and that staff expects that these emissions are greater than those from the post-meter rates from the residential sector, staff has assigned a non-zero 1.0 placeholder for each year. These values will be updated once the report has been finalized and after consultation from CARB since this category will be added in subsequent updates of the inventory. Staff expects this report to be published in early 2020 and to have updated estimates for the final Building Decarbonization Assessment.

Commercial behind-the-meter leaks estimation methodology:
For years 1990-2017, a non-zero placeholder value of 1.0 is placed until a forthcoming Energy Commission research study on the extent of behind-the-meter leakage in commercial buildings is released spring 2020. CARB staff and Energy Commission staff expects that the research results will inform the methodology for estimating the extent of these emissions which will also result in the creation of a new commercial behind-the-meter leaks category in forthcoming editions of the CARB GHG inventory.

Electricity emissions

As can be seen in Figure 2 and at the bottom of Table 3, when including emissions from the electric generation sector that are attributable to residential and commercial

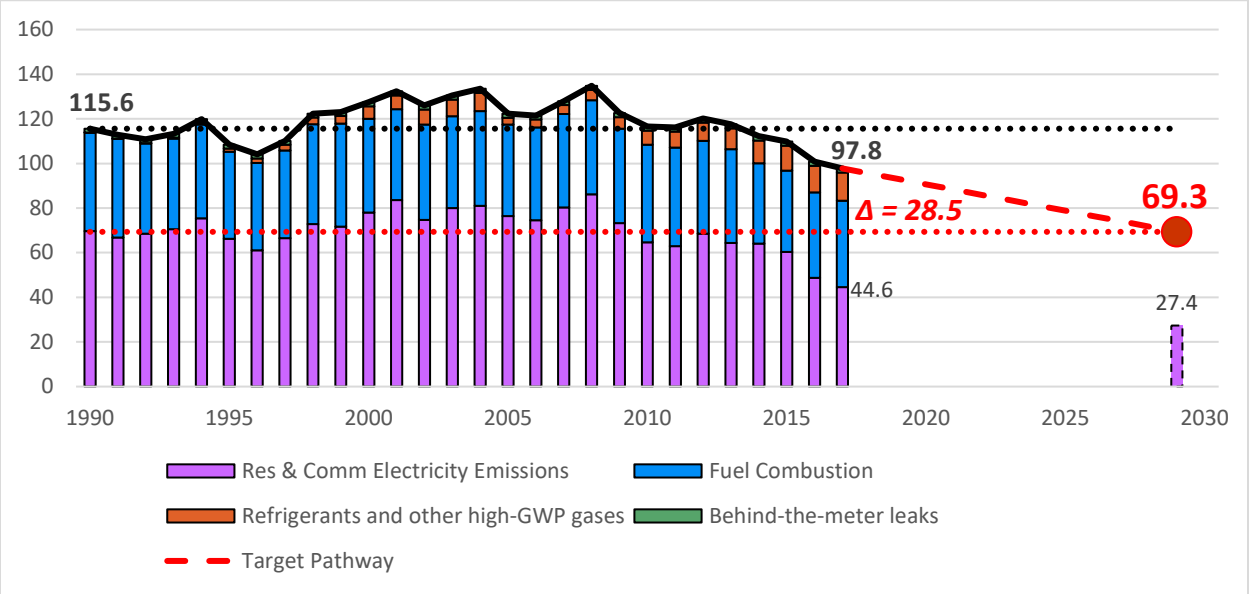
buildings, the 1990 baseline is roughly 2.5 times greater (115.6 compared to 45.9 $MMTCO_2e$). But the inclusion of these emissions shows that the emissions reported for 2017 have already been reduced by 15.4 percent from 1990 levels. Moreover, its 2017-2029 gap to meet its 2030 target is almost equivalent to the gap if the recommended baseline 2030 is used, 28.5 compared to 25.7 $MMTCO_2e$, despite the increase in scope of GHG reduction opportunities.

Even though the inclusion of electric generation emissions would benefit the assessment by expanding the scope of GHG emission reduction activities to consider such as demand-side management policies (e.g., energy efficiency and load flexibility programs), this expansion in scope conflicts with other existing GHG emission reduction activities that are not occurring in the buildings sector. And given existing energy and energy efficiency policies, namely Senate Bill 100 (De León, Chapter 312, Statutes of 2018; SB 100), which requires an aggressive improvement of the renewable portfolio standard, it suggests that the these emissions are on track in reaching the 69.3 $MMTCO_2e$ emissions target without requiring much overall action from the buildings sector.[3] Moreover, a "business as usual" scenario from existing demand-side management policies such as the doubling energy efficiency goal set out by Senate Bill 350 (De León, Chapter 547, Statutes of 2015) increases the likelihood of achieving this alternative target. As such, staff argues that an assessment that includes electricity emissions in the 1990 baseline rather than the only accounting for those electricity emissions resulting from fuel substitution activities, would result in an assessment that would not make the reduction of fuel combustion emissions the primary focus---even though these emissions are significant in magnitude and natural gas consumption is forecasted to increase over time (see CEC 2019a).

Energy Commission staff consulted with CARB staff in developing the AB 3232 baseline recommendation. CARB staff had similar concerns Energy Commission staff had regarding the inclusion of electricity generation emissions in the baseline, and recommended focusing greenhouse gas emission reductions of fuel combustion, refrigerants and other high-GWP gases. Staff kept this recommendation in mind as well as having an objective of creating a baseline consistent with the CARB's inventory while not report any conflicting information.

Figure 2 GHG emissions by emissions category (1990-2017) and 2030 target -- including electricity generation emissions attributed to residential and commercial buildings (million tonnes of CO2 equivalent---MMTCO2e)

[3] See also Executive Orders S-03-05, B-30-15, and B-55-18.



Establishing an acceptable GHG emissions baseline that measures emissions attributed to buildings is inherently problematic since the CARB's inventory does not have a category of *total* (fuel combustion and electricity end-use) emissions for California's residential and commercial building stock. Lumping emissions across sectors can create problems when assessing greenhouse gas reduction performance ex post. For example, since CARB will continue to report gross values of Residential and Commercial emissions, when CARB reports 2030 GHGs in 2032, that reporting will likely *not* show a 40% reduction in emissions in those specific sectors, especially if the state does not engage in fuel substitution activities given the forecasted increase in natural gas demand (CEC 2019a). There is thus a need to examine the net reductions of emissions across sectors categorized in the inventory while controlling for the GHG emission reduction activities occurring outside the scope of the buildings sector.

Staff's analysis suggests that the alternative baseline that includes electricity generation emissions in the 1990 baseline would result in much fewer emissions that need to be abated compared to the Staff's recommended baseline. As can be seen in the year 2029 in Figure 2 and shown at the bottom of Table 3, electricity emissions attributed to the residential and commercial sectors are forecasted to decrease by 17.2 $MMTCO_2e$ based on the Energy Commission's 2019 Preliminary Integrated Energy Policy Report (IEPR) California Energy Demand Forecast (CEC 2019b; see analysis assumptions at the bottom of Table 3). As the grid gets cleaner because of the increased renewable portfolio standard in 2030, staff's analysis suggests that only 11.2 $MMTCO_2e$ remains to be abated by the buildings sector. This 11.2 $MMTCO_2e$ is significantly smaller than the 25.7 $MMTCO_2e$ 2017-2029 gap using the recommended baseline approach. And as stated above, staff projects that residential and commercial natural gas consumption

will increase over the same time horizon (CEC 2019a). This juxtaposition of future outcomes reinforces staff's recommendation of omitting electricity generation emissions from the 1990 baseline calculation and the resulting 2030 target setting.[4] But as discussed, electricity emissions resulting from fuel substitution activities will be accounted for in the assessment.

Staff argues that the recommended baseline and GHG emissions accounting method of including increased electricity emissions from fuel substitution activities in the assessment provides the most focused and rigorous approach for reducing net GHG emissions given the CARB's categorization of emissions. The benefit of this recommended approach is that it controls for the potential of shifting emissions across sectors and helps the state assess the potential for cost effectively reducing total greenhouse gas emissions from buildings by an amount consistent with Senate Bill 32 (Pavley, Chapter 249, Statutes of 2016), the statewide greenhouse gas reduction mandate of 40 percent below 1990 levels by 2030. Since SB 100 was passed at the same time as AB 3232, the Assessment will complement the work of achieving the 2045 carbon neutral target, but the Assessment will primarily focus on the time horizon of achieving the 2030 target. Staff will also address and track the GHG emissions reduction potential when including electric generation emissions, but it will not be the primary focus of the Building Decarbonization Assessment.

Staff will rely on Energy Commission's existing tools and models with consultation from CARB, CPUC, and the California Independent System Operator to project and track the GHG emissions impacts from fuel substitution activities. Staff will reach out to other agencies regarding the assumptions of greenhouse gas emission intensities from fuel substitution activities.

[4] Staff considered doing a similar analysis using the data from the 2019 Integrated Resource Planning proceeding (CPUC 2019, pp 95--96). In their assessment, they assume a GHG planning target range for the electric sector of 30–53 $MMTCO_2$ for 2030. But given the different underlying assumptions, staff preferred to the IEPR forecast approach even though staff believes the ultimate conclusion and recommendation would remain the same.

Proposed methodology for estimating the incremental emissions from the increased loads from fuel substitution activities:

- Energy Commission staff are developing a modeling tool that can assess various scenarios of the GHG reduction potential of fuel substitution activities and energy efficiency measures that can assessed compared to the AB 3232 baseline.
- The tool will provide outputs of hourly loads and GHG intensities. Staff can use these outputs to assess the potential GHG reduction possibilities of these emissions from demand side management programs, particularly demand flexibility strategies.

Methodology for estimating the emissions from electric generation attributed to all residential and commercial buildings (not in AB 3232 baseline):

- For all years in the inventory, staff estimated the GHG emission attribution of the residential and commercial sector using the annual sum of imports and in-state electricity generation in the CARB inventory. These reported emissions from the inventory includes transmission and distribution in the electricity generation sector.
- Using the Energy Commission's Form 1.1b (CEC 2019b) statewide electricity sales by sector (GWh), which reports annual sales for each sector beginning in 1990, staff estimated annual attribution percentages that can be applied to the summed electricity generation emissions. Note that electricity sales by sector equals consumption minus self-generation. Similar to the transmission and distribution methodology, staff relied on in-house Energy Commission and did not use an alternative source like the Energy Information Administration (EIA 2018) or the CARB's Fuel Combustion Data (CARB 2019b).
- Staff currently are only using the residential and commercial categories in Form 1.1.b for the attribution. Staff is considering adjusting the attribution ratios by adding TCU (Transportation, Communication, and Utilities) and Streetlighting as part of the commercial sector.

Discussion and summary of baseline

The Building Decarbonization Assessment must assess the feasibility of reducing GHG emissions from the residential and commercial sector by 40 percent from 1990 levels by 2030. As seen in Table 1, the scope of GHG emissions categories attributed to the

residential and commercial sectors can vary. Given that the legislation does not explicitly state which baseline to use, Energy Commission staff had to decide using this choice set from Table 1 of which emissions to include in the baseline. Although it may appear counterintuitive, the discussed approach of not including electricity generation emission in the 1990 baseline results in a more aggressive target to assess. Such an assessment paired with the report's abatement cost analysis will help guide policy in targeting the least-cost strategies of reducing GHG emissions from the residential and commercial sectors compared to other GHG reduction strategies.

Staff has the least confidence with the methane emissions from natural gas infrastructure leaks. Although there ought to be a non-zero attribution for some of these emissions categories, staff does not have the confidence in the precision of attributing these values to the CARB inventory or attributing the rate of reduction of these emissions from fuel substitution activities. The scope and estimates of all emissions in the baseline could change as more verifiable data becomes available. Staff welcomes input from stakeholders and agencies and would be willing to discuss revising the baseline at a future workshop. As such, the baseline could be revised before the final Building Decarbonization Assessment report.

Figure 3 AB 3232 Building Decarbonization Assessment baseline GHG emissions by emissions category (1990-2017) and 2029 target---millions tonnes of CO2 equivalent---MMTCO2e)

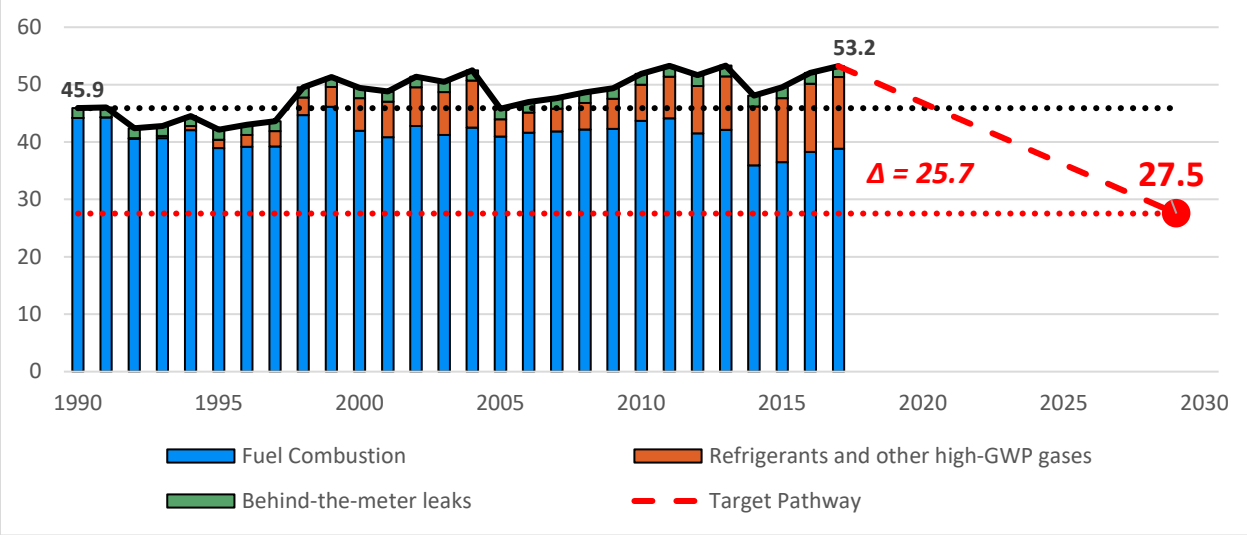


Figure 3 summarizes the 1990-2017 time series of the Building Decarbonization Assessment baseline emissions and the pathway to the 2030 target. Table 3 below reports the numerical emissions values for 1990 and 2017. Staff assumes that the 27.5 $MMTCO_2e$ target includes the emissions in the baseline in addition to the emissions created from the increased electricity generation due to any fuel substitution activities

(As illustrated in Figure 1). The 2030 target is a benchmark for aggregate emissions reduction and does not prescribe how much reduction is required from each emissions source. This approach implies that to achieve the AB 3232 target, these emissions and any resulting emissions from the expansion of electric generation due to fuel substitution must be reduced by more than 40 percent from 1990 levels by 2030.

As seen in Figure 3, there were 53.2 $MMTCO_2e$ emissions for 2017, which is greater than the 1990 baseline, 45.9 $MMTCO_2e$---much of this increase is attributed to the increase in refrigerants and other high-GWP gases, particularly HFCs emissions.[5] Not only is the gap to achieve the 2030 goal larger compared to 1990 levels, the preliminary 2019 California Energy Demand Mid Demand Case Forecast projects statewide residential and commercial natural gas consumption to *increase* 2.2 percent from 2017 to 2030[6], with much of the increase occurring within the commercial sector (CEC 2019a). This recommended baseline provides both a more focused approach in reducing emissions from natural gas fuel combustion, and provides a more aggressive approach in assessing the least-cost way of reducing these emissions. Reducing these emissions, particularly the need to significantly reduce fuel combustion emissions by over half compared to 2017 levels, will incur substantial costs. Staff argues that focusing on these emissions provides the best means of assessing the costs and feasibility of reducing these emissions and of prioritizing fuel substitution and GHG emissions reduction activities.

[5] Ozone Depleting Substances (ODSs) were banned in the 1987 Montreal Protocol and are not counted in the ARB inventory; emissions from ODSs have decreased significantly since 1990 while ODS substitutes, which are accounted in the ARB inventory, continue to grow (CARB 2019, p16).
[6] According to the forecast, natural gas consumption will increase from 6,455 MM Therms in 2017 to 6,549 in 2030; this increased consumption conflicts with California's statewide GHG reduction mandates for 2030.

Table 3 AB 3232 Baseline GHG Emissions for 1990 and 2017 – Reported in million tonnes of CO2 equivalent, $MMTCO_2e$

AB 3232 Emissions Category[a]	1990	2017	*Jan 1, 2030 Target*	*2017-2029 Delta*
Total Fuel Combustion	**44.18**	**38.81**		
Natural gas	38.83	35.36		
Other fuels	5.35	3.45		
Residential Fuel Combustion	*29.74*	*25.11*		
Natural gas	*27.74*	*23.62*		
Other fuels	*2.00*	*1.49*		
Commercial Fuel Combustion	*14.44*	*13.70*		
Natural gas	*11.08*	*11.75*		
Other fuels	*3.35*	*1.95*		
Refrigerants and other high-GWP gases	**0.01**	**12.52**		
Residential	0.00	3.54		
Commercial	0.01	8.98		
Methane emissions from natural gas infrastructure leaks	**1.71**	**1.89**		
Production	--	--		
Transmission and distribution	--	--		
Meter	--	--		
Post-meter natural gas leaks				
Residential	0.71	0.89		
Commercial	1.00	1.00		
AB 3232 Baseline Total	**45.90**	**53.22**	**27.54[b]**	**25.68**
Difference compared to 1990		*(+7.32)*	*(18.36)*	
Res & Comm Electricity Emissions	69.68	44.55		
AB 3232 Baseline Total + Res & Comm Elec. Emissions	115.58	97.77	69.35	28.42
Difference compared to 1990		*(-17.81)*	*(46.23)*	
CEC staff analysis[c] • **2019 Preliminary IEPR Res & Comm Electricity Sales GHG Emissions Forecast for 2029:** 27.35 $MMTCO_2e$ (a 17.2 reduction) • **2029 Remaining Emissions To Be Abated To Achieve Goal (= 28.4 - 17.2):** 11.2 $MMTCO_2e$				

[a] Estimates were rounded from nearest hundredths. The methodological assumptions are stated at the end this document.

[b] The 2030 target assumes that any electricity emissions resulting from fuel substitution activities will be accounted for when comparing to the 1990 baseline.

[c] Assumes a 0.14 MT/MW annual average GHG intensity for 2030 (based on CEC staff's 2019 IEPR hourly fuel substitution analysis). This analysis is based on the 2019 IEPR Preliminary Forecast (CEC 2019b) for 2029 of electricity sales by sector (equals consumption minus self-generation); projected 2029 electricity sales for residential are 89,907 GWh and 105,460 GWh for commercial.

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