T-30. Use Cleaner-Fuel Vehicles

GHG Mitigation Potential

100%

Up to 100% of GHG emissions from on-road vehicles

Co-Benefits (icon key on pg. 34)

Climate Resilience

Using cleaner-fuel vehicles increases transportation resilience by providing a wider range of available vehicles if other fuels (like gasoline) become unavailable.

Health and Equity Considerations

While most cleaner fuels reduce both GHG and criteria air pollutants, a few may increase criteria pollutant emissions. The most prominent example of this is biodiesel, which generally results in higher NO_x emissions, but lower PM emissions compared to diesel.

Measure Description

This measure requires use of cleaner-fuel vehicles in lieu of similar vehicles powered by gasoline or diesel fuel. Cleaner-fuel vehicles addressed in this measure include electric vehicles, natural gas and propane vehicles, and vehicles powered by biofuels such as composite diesel (blend of renewable diesel, biodiesel, and conventional fossil diesel), ethanol, and renewable natural gas.

The full GHG emissions impact of cleaner fuels depends on the emissions from the vehicle's tailpipe as well as the emissions associated with production of the fuel (sometimes termed "upstream" emissions). For example, tailpipe GHG emissions from renewable natural gas are identical to tailpipe GHG emissions from conventional natural gas; the GHG benefits of renewable natural gas come from the fact that it is produced from biomass. Similarly, BEVs have zero tailpipe emissions, but properly accounting for their GHG impacts requires quantifying the emissions associated with the electricity generation needed to charge the vehicle's batteries.

Subsector

Clean Vehicles and Fuels

Locational Context

Non-applicable

Scale of Application

Project/Site or Plan/Community

Implementation Requirements

See measure description.

Cost Considerations

Capital costs to purchase cleaner fuel vehicles are high. Fueling infrastructure may be required, which will add to the upfront cost of transitioning to cleaner fuel vehicles. Fuel costs and savings compared to gasoline and diesel will vary depending on the type of fuel and market conditions. It is feasible to expect reduced fuel costs from cleaner fuels with an increased market and overall fuel cost savings over the life of the vehicle fleet.

Expanded Mitigation Options

If using electric vehicles, pair with Measure T-14 to ensure that electric vehicles have sufficient access to charging infrastructure.

GHG Reduction Formula

California has a well-defined process for quantifying the GHG emissions impacts of cleaner-fuel vehicles by virtue of the state's Low Carbon Fuel Standard (LCFS) program. An emissions calculation that considers both vehicle tailpipe and upstream fuel production emissions is sometimes referred to as a "well-to-wheels" analysis (A3 below). An emissions calculation that considers only vehicle tailpipe emissions is referred to as a "tank-to-wheels" analysis (A1 and A2 below).

The convention for project analysis under CEQA typically employs a hybrid approach. For natural gas, propane, and biofuels vehicles, the CEQA analysis quantifies only tailpipe emissions and does not seek to capture differences in emission associated with fuel production. However, for electric vehicles, CEQA analyses typically account for emissions associated with electricity generation (A1 and A2 below).

$$A1 = B \times \frac{(D \times E \times F \times G) - C}{C}$$

$$A2 = B \times \frac{(D \times E \times F \times G \times H) + \left(C \times \frac{1}{I} \times (1 - H)\right) - C}{C}$$

$$A3 = B \times \frac{J - K}{K}$$

GHG Calculation Variables

ID	Variable	Value	Unit	Source
Output				
A1	Percent reduction in GHG emissions from on-road vehicle emissions for BEVs	0–100	%	calculated
A2	Percent reduction in GHG emissions from on-road vehicle emissions for PHEVs	0–64	%	calculated
A3	Percent reduction in well-to-wheels GHG emissions from cleaner fuels or vehicle technologies	0–100	%	calculated
User Inputs				
B	Percent of vehicle fleet being converted to cleaner fuels	1–100	%	user input
C	Emission factor for existing (conventional fuel) vehicle	[ ]	g CO_2e per mile	CARB 2020a
Constants, Assumptions, and Available Defaults				
D	BEV efficiency	Table T-30.1	kWh per mile	see note

ID	Variable	Value	Unit	Source
E	Carbon intensity of local electricity provider	Tables E-4.3 and E-4.4	lb CO_2e per MWh	CA Utilities 2021
F	Conversion from lb to gram	454	g per lb	conversion
G	Conversion from kWh to MWh	0.001	MWh per kWh	conversion
H	Percent of PHEV miles in electric mode	46	%	CARB 2020a
I	Ratio of average hybrid vehicle mpg to comparable gasoline vehicle mpg	1.5	unitless	see below
J	Well-to-wheels emission factor for cleaner vehicle/fuel	Table T-30.2	g CO_2e per mile	CARB 2020a, 2020b, 2020c; U.S. DOE 2021
K	Well-to-wheels emission factor for existing (conventional fuel) vehicle	Table T-30.2	g CO_2e per mile	CARB 2020a, 2020b, 2020c; U.S. DOE 2021

Further explanation of key variables:

- (A1 or A2) – Use of these equations is appropriate for a typical CEQA project analysis, which considers tailpipe GHG emissions and, for electric vehicles, electricity generation emissions.
- (A3) – Use of this equation is appropriate for a user interested in a well-to-wheels analysis for all fuel types. The user should determine the appropriate emission factors for the conventional fuel and cleaner fuel.
- (C) – The user should run EMFAC to output GHG emission factors (CO_2, CH_4, and N_2O) for the existing (conventional fuel) vehicles. The EMFAC run should be based on project-specific values for the region, project year, season, vehicle category, model year, speed, and fuel type (gasoline, diesel, or a weighted average).[15] To determine the CO_2e emission factor of the conventional fuel vehicle, the emission factors for CO_2, CH_4, and N_2O from EMFAC should be multiplied by the corresponding 100-year GWP values (1, 25, and 298, respectively) from the IPCC's Fourth Assessment Report (IPCC 2007) and then summed.
- (E) – GHG intensity factors for major California electricity providers are provided in Tables E-4.3 and E-4.4. If the project study area is not serviced by a listed electricity provider, or the user is able to provide a project-specific value (i.e., for a future year not referenced in Tables E-4.3 and E-4.4), the user should use that specific value in the GHG calculation formula. If the electricity provider is not known, users may elect to use the statewide grid average carbon intensity.
- (H) – Based on the EMFAC2017 model (v1.0.3), 46 percent of miles traveled by PHEVs in California are in electric mode (eVMT), with 54 percent in gasoline mode (CARB 2020a).

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[15] There are many different combinations of input variables a user could specify in EMFAC to result in a unique emission factor output. This report does not attempt to consolidate a standardized group of emission factor output into a database table for the user to refer to. It is recommended the user run EMFAC to obtain project-specific results.

- (I) – Assumes that a PHEV operating in gasoline mode is similar to a gasoline hybrid (non-plug-in) vehicle. A typical gasoline hybrid vehicle has 50 percent higher fuel economy (mpg) than a comparable gasoline vehicle, based on a comparison of the gasoline and hybrid Toyota Camry and Corolla models (U.S. DOE 2021).
- (J and K) – The average California values for fuel efficiency, energy density, and carbon intensity of typical vehicle and fuel types are provided in Table T-30.2 (CARB 2020a, 2020b, 2020c; U.S. DOE 2021). Table T-30.2 also provides the well-to-wheels emission factor, which can be calculated based on the product of the fuel efficiency, energy density, and carbon intensity. If the user can provide a project-specific value, then the user should replace in the GHG calculation formula one or more of these values that produces the emission factor.
- (D) – BEV energy efficiency varies by vehicle type. The average California values are provided in Table T-30.1 in Appendix C. If the user can provide a project-specific value, they should replace the default in the GHG reduction formula. BEV energy efficiency can be calculated as:

$$\text{BEV efficiency (kWh per mile)} = \frac{L}{M \times N}$$

Where,

- (L) – Gasoline to electricity conversion. Users can assume 33.7 kWh per gallon of gasoline, which is a standard conversion factor used by U.S. EPA and U.S DOE (U.S. EPA 2021).
- (M) – Fuel economy (mpg) of a comparable gasoline vehicle. Users can obtain this from Table T-30.2.
- (N) –EER for an electric vehicle. Users can assume 3.4, which is the EER established by CARB for electric vehicles as stated in the LCFS regulation. (CARB 2020b).

GHG Calculation Caps or Maximums

Measure Maximum

($A1_{max}$) The GHG reduction from the use of BEVs is capped at 100 percent, which assumes that 100 percent of the fleet would be converted (B) and that the local electricity provider is powered 100 percent by renewables and thus has a carbon intensity of zero (E).

($A2_{max}$) The GHG reduction from the use of PHEVs is capped at 64 percent, which assumes that 100 percent of the fleet would be converted (B) and that the local electricity provider is powered 100 percent by renewables and thus has a carbon intensity of zero (E).

($A3_{max}$) For a well-to-wheels analysis, the GHG reduction from the use of electric vehicles is capped at 100 percent, which assumes that the local electricity provider is powered 100 percent by renewables and thus has a carbon intensity of zero (L). Note that the maximum percent reduction for all other cleaner vehicles and fuels presented in Table T-30.2 will not reach this maximum.

Subsector Maximum

Same as (A_{max}). Measure T-30 is the only measure at the Plan/Community scale within the Clean Vehicles and Fuels subsector.

Example GHG Reduction Quantification

The user reduces vehicle emissions by avoiding the use of conventional fuels in place of cleaner fuels or vehicle technologies. In this example, a municipality that sources their electricity from an electricity provider powered 100 percent by renewables (E) is converting half of their fleet of gasoline light duty automobiles to BEVs (B). The user has run EMFAC for their county, vehicle category, and project year, and determined the fleet emission factor to be 400 g CO_2e (C). The user would reduce GHG emissions from the existing fleet by 50 percent.

$$A1 = \mathbf{50\%} \times \frac{\left(0.33\,\frac{\text{kWh}}{\text{mi}} \times 0\,\frac{\text{lb CO}_2\text{e}}{\text{MWh}} \times 454\,\frac{\text{g}}{\text{lb}} \times 0.001\,\frac{\text{MWh}}{\text{kWh}}\right) - \mathbf{400\,\frac{g\ CO_2e}{mi}}}{\mathbf{400\,\frac{g\ CO_2e}{mi}}} = -50\%$$

Quantified Co-Benefits

Improved Local Air Quality

(O1) – The use of BEVS in lieu of conventional vehicles would decrease local criteria pollutants. The percent reduction is equal to (B). Electricity supplied by statewide fossil-fueled or bioenergy power plants will generate criteria pollutants. However, because these power plants are located throughout the state or outside the state, electricity consumption from vehicles charging typically will not generate localized criteria pollutant emissions on the project site or roadways traveled by the electric vehicles.

(O2) – The percent reduction in local criteria pollutants from use of PHEVs in lieu of conventional vehicles (A2) is equal to $(B \times A2_{max})$. See $(A2_{max})$ above, which assumes (E) is set to zero to nullify eVMT activity and vehicle fleet conversion (B_{max}) is set to 100 percent. $(A2_{max})$ is multiplied by the actual conversion of the vehicle fleet (B) to adjust the percent reduction calculated from $(A2_{max})$. Electricity supplied by statewide fossil-fueled or bioenergy power plants will generate criteria pollutants. However, because these power plants are located throughout the state or outside the state, electricity consumption from vehicles charging typically will not generate localized criteria pollutant emissions.

(O3) – For a well-to-wheels analysis, the fuels produced by facilities within and outside of California will generate criteria pollutants. Because these facilities are dispersed, offsite of the project/site or plan/community, fuel production typically will not generate localized criteria pollutant emissions. Therefore, only the tank-to-wheels (i.e., tailpipe) portion of the vehicle criteria pollutant emissions should be quantified. For BEVs and PHEVs, this can be done using the methodologies described above (O1 and O2, respectively). For vehicles fueled by diesel, biodiesel, renewable diesel, and natural gas, the criteria pollutant emission factor can be outputted by EMFAC (see C). The criteria pollutant reductions from use of gasoline hybrid or flex fuel vehicles cannot be readily quantified within EMFAC as these fuel types are not inputs the user can specify.

Fuel Savings (Increased Electricity)

(P1 and Q1) – The use of BEVs in lieu of conventional vehicles would decrease vehicle fuel consumption and increase electricity use. The percent reduction in fuel use (P1) is equal to (B). The absolute increase in electricity use can be calculated using the below formula (Q1).

(P2 and Q2) – The use of PHEVs in lieu of conventional vehicles would decrease vehicle fuel consumption and increase electricity use. The percent reduction in fuel use (P2) is equal to $(B \times A2_{max})$. The absolute increase in electricity use (Q2) is equal to $(H \times Q1)$.

(P3 and Q3) – For gasoline, gasoline hybrid, flex fuel, diesel, biodiesel, renewable diesel, and natural gas, the percent reduction in fuel use of the existing (conventional fuel) vehicle is equal to (B). The absolute increase in the cleaner fuel/vehicle energy can be calculated using the below formula (P3).

BEV Electricity Use Increase Formula

$$Q1 = B \times D \times R$$

Electricity Use Increase Calculation Variables

ID	Variable	Value	Unit	Source
Output				
Q1	Increase in electricity from electric vehicles	[ ]	kWh per year	calculated
User Inputs				
R	Average annual VMT of all vehicles in fleet	[ ]	miles per year	user input
Constants, Assumptions, and Available Defaults				
	None			

Further explanation of key variables:

- Please refer to the GHG Calculation Variables table above for definitions of variables that have been previously defined.

Cleaner Vehicle Energy Use Increase Formula

$$P3 = B \times R \times \frac{S}{T}$$

Cleaner Vehicle Energy Use Increase Variables

ID	Variable	Value	Unit	Source
Output				
P3	Increase in vehicle fuel use in fleet	[ ]	megajoules (MJ)	calculated
User Inputs				
	None			
Constants, Assumptions, and Available Defaults				
S	Energy density for cleaner fuel/vehicle	Table T-30.2	MJ per gal	CARB 2019, 2020a, 2020b, 2020c; U.S. DOE 2021
T	Fuel efficiency for cleaner fuel/vehicle	Table T-30.2	mpg	

Further explanation of key variables:

- (S and T) – The average California values for fuel efficiency and energy density of typical vehicle and fuel types are provided in Table T-30.2 (CARB 2019, 2020a, 2020b, 2020c; U.S. DOE 2021). If the user can provide a project-specific value, then the user should replace in the fuel use reduction formula one or more of these values that produces the energy consumption value (MJ).
- Please refer to the GHG Calculation Variables table above for definitions of variables that have been previously defined.

Sources

- California Air Resources Board (CARB). 2019. *LCFS Pathway Certified Carbon Intensities.* Available: https://ww2.arb.ca.gov/resources/documents/lcfs-pathway-certified-carbon-intensities. Accessed: January 2021.
- California Air Resources Board (CARB). 2020a. *EMFAC2017 v1.0.3*. August. Available: https://arb.ca.gov/emfac/emissions-inventory. Accessed: January 2021.
- California Air Resources Board (CARB). 2020b. *Unofficial electronic version of the Low Carbon Fuel Standard Regulation.* Available: https://ww2.arb.ca.gov/sites/default/files/2020-07/2020_lcfs_fro_oal-approved_unofficial_06302020.pdf. Accessed: January 2021.
- California Air Resources Board (CARB). 2020c. *California Climate Investments Quantification Methodology Emission Factor Database and Documentation.* August. Available: https://ww2.arb.ca.gov/resources/documents/cci-quantification-benefits-and-reporting-materials. Accessed: January 2021.
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- U.S. Department of Energy (U.S. DOE). 2021. *Fuel Economy Datasets for All Model Years (1984-2021)*. January. Available: https://www.fueleconomy.gov. Accessed: January 2021.
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