

Technical Appendix

The following emission reductions will result from CPRG implementation grant funding. All of the proposed measures will be 100% grant funded by the CPRG implementation grant.

San Joaquin Regional Transit District (San Joaquin RTD) will use the grant funding to replace thirteen buses. San Joaquin RTD currently uses Model Year 2010, 2012, and 2013 diesel-electric hybrid buses. These thirteen buses are reaching the end of their useful lives and will be replaced with eleven Model Year 2023 diesel-electric hybrid buses under Transportation Measure 1 and two fuel cell electric buses (FCEBs) under Transportation Measure 2.

Measure 1: Hybrid Electric Bus Acquisition; Sector: Transportation

Since the buses use the same fuel, the upstream emissions (emissions associated with producing the fuel) between the Model Year 2010 and Model Year 2022 buses are assumed to be the same. The Model Year 2022 buses are assumed to be more efficient and to have lower tailpipe emissions. As a result, the deployment of Model Year 2022 buses will reduce overall emissions.

CALSTART calculated emissions reductions by using California Air Resources Board's Emission Factors (EMFAC) Model. CALSTART used the 2021 version of the model to calculate the emission rates (grams per mile) for Model Year 2010 and Model Year 2022 buses. EMFAC was used to calculate emissions rates for carbon dioxide (CO₂), carbon monoxide (CO), oxides of nitrogen (NO_x), particulate matter – 10 microns or less (PM₁₀), and particulate matter – 2.5 microns or less (PM_{2.5}). EMFAC was programmed with the following assumptions:

- Output: On road Emission Rates
- Model Version: EMFAC 2021 v1.0.2
- Subarea: San Joaquin
- Season: Annual
- Vehicle Category: Urban Bus
- Speed: Aggregate
- Fuel: Diesel (includes diesel-electric hybrid buses)

EMFAC produced the following emission rates:

Pollutant	MY 2010 Emission Rates	MY 2022 Emission Rates
CO ₂ (g/mile)	1,435.891	1,026.025
CO (g/mile)	0.086856	0.0581
NO _x (g/mile)	0.423101	0.280411
PM ₁₀ (g/mile)	0.154044	0.140417
PM _{2.5} (g/mile)	0.055196	0.049867

San Joaquin RTD's fleet currently accumulates approximately 56,575 miles per year per bus. The buses have an expected life of 12 years, meaning that each bus is expected to drive 678,900 miles over its lifetime. Based on these assumptions, the lifetime tailpipe emissions produced by eleven Model Year 2010 buses and eleven Model Year 2022 buses were calculated.

The lifetime emissions reductions for the eleven diesel-electric hybrid buses are displayed below:

Pollutant	MY 2010 Lifetime Emissions	MY 2022 Lifetime Emissions	Lifetime Emissions Reductions
CO2 (short tons)	8578.47	6129.80	3,366.92
CO (pounds)	1,426.99	954.55	472.44
NOx (pounds)	6,951.29	4,606.98	2,344.31
PM10 (pounds)	2,530.85	2,306.96	223.89
PM2.5 (pounds)	906.84	819.28	87.56

The annual reductions in criteria pollutant emissions (in pounds) are displayed in the table below:

Bus Type	CO (lbs.)	NOx (lbs.)	PM10 (lbs.)	PM2.5 (lbs.)	VOC (lbs.)
Diesel-Electric Hybrid Bus	219.25	644.74	26.69	4.24	22.98

Total Emissions Reductions:

Emission Reductions	GHG (short tons)	CO (lbs.)	NOx (lbs.)	PM10 (lbs.)	PM2.5 (lbs.)	VOC (lbs.)
Diesel-Electric Buses	3,366.92	472.44	2,344.31	223.89	87.56	-

Measure 2: Hydrogen Bus Pilot; Sector: Transportation

The fuel cell electric buses (FCEBs) are replacing diesel-electric hybrid buses; thus, the emissions reductions constitute the difference between emissions from diesel-electric hybrids buses and FCEBs.

CALSTART calculated the emissions reductions that were associated with these replacements. To estimate the wells- to-wheels emissions reductions, CALSTART used Argonne National Laboratory's Alternative Fuel Life-Cycle Environmental and Economic Transportation (AFLEET) Tool. AFLEET calculates greenhouse gas (GHG), particulate matter (PM), oxides of nitrogen (NOx), and volatile organic compound (VOC) emissions for CNG and battery electric buses.

AFLEET uses data from Argonne National Laboratory's Greenhouse gases, Regulated Emissions, and Energy use in Technologies (GREET) model to calculate the well-to-pump emissions associated with each type of fuel. The tailpipe emissions are calculated using data from the Environmental Protection Agency's Motor Vehicle Emission Simulator (MOVES).

AFLEET can be programmed with custom parameters to generate emissions calculations. CALSTART programmed AFLEET with the following assumptions:

- Vehicle Type: Transit Bus
- State: California
- Diesel-Electric Hybrid Bus Fuel Economy: 5.84 miles per diesel gallon equivalent¹
- FCEB Fuel Economy: 7.5 miles per diesel gallon equivalent
- Source of Hydrogen: Central Plant SMR (Off-Site)
- Annual Mileage per Bus: 56,575 per year

All other parameters were left with the default values. Based on these parameters, AFLEET calculated the annual emissions that will be generated by two hybrid-electric buses and two FCEBs.

AFLEET calculated that a fleet of two diesel-electric hybrid buses will produce 265.8 short tons of GHG emissions per year, whereas a fleet of two FCEBs will produce 215.1 short tons of GHG emissions per year. This represents an annual savings of 50.7 short tons per year, which is a 19% decrease. Over the 12-year life of the bus, this represents a savings of 608.4 short tons.

AFLEET was also used to calculate criteria pollutants emissions reductions. AFLEET examined carbon monoxide (CO), oxides of nitrogen (NOx), particulate matter – 10 micrometers (PM10), particulate matter – 2.5 micrometers (PM2.5), and volatile organic compounds (VOC).

The annual reductions in criteria pollutant emissions (in pounds) are displayed in the table below:

Bus Type	CO (lbs.)	NOx (lbs.)	PM10 (lbs.)	PM2.5 (lbs.)	VOC (lbs.)
FCEB	0.00	0.00	25.44	3.24	0.00

Over the 12-year life of the bus, emission reductions for the Fuel Cell Electric Buses are as follows:

Emission Reductions	CO (lbs.)	NOx (lbs.)	PM10 (lbs.)	PM2.5 (lbs.)	VOC (lbs.)
Lifetime Emission Reductions	2630.95	7736.91	14.97	11.97	275.71

¹<https://blog.ucsusa.org/jimmy-odea/electric-vs-diesel-vs-natural-gas-which-bus-is-best-for-the-climate>

Percent Reduction	100%	100%	4.7%	23.5%	100%
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Total Emissions Reductions

Emission Reductions	GHG (short tons)	CO (lbs.)	NOx (lbs.)	PM10 (lbs.)	PM2.5 (lbs.)	VOC (lbs.)
Fuel Cell Electric Buses	608.40	2,630.95	7736.91	14.97	11.97	275.71

According to the [U.S. Department of Energy](#), hydrogen fuel cell buses emit only water vapor and warm air with a 100% reduction of petroleum. According to the [U.S. Department of Transportation](#), a single zero emission bus has a reduction potential of 1,690 tons of CO₂e over its 12-year lifetime.

Measure 4: City Hall Solar Installation & Energy Efficiency Upgrades; Sector: Energy

According to a 2019 energy audit and solar capacity study for the project, the total electrical consumption of the new city hall towers is 1,070,882 kWh and 545.1 kW DC of solar photovoltaics was proposed to be installed on parking shade structures to serve the new city hall and the parking lot lights. Using the NREL [PVWatts](#) Calculator: 1 kW DC System Size is about 1,632 kWh/year for Stockton, CA.

Using the International Council for Local Environmental Initiatives (ICLEI)'s Commercial Energy Reduction Strategies: Increased Commercial Solar Photovoltaic calculator, it is projected that there will be cumulative total of 37 metric tons/year reduction of CO₂e. This calculator uses the Intergovernmental Panel on Climate Change (IPCC) 5th Assessment 100 Year Values. The increased solar capacity was calculated to be 656 kW Installed Capacity/Year and the generation potential used the PVWatts calculation of 1,632 kWh/kW Installed Capacity. It was projected that for a start year of 2025 and end year of 2026 prior to the reduction there was an estimated output of 108,487 metric tons CO₂e. With the reduction measure in place, that output went down to 108,450 metric tons CO₂e.

These calculations do not account for changes in energy and solar capacity projections for the year 2024 nor the proposed additional solar photovoltaics on a larger parking lot and for potential rooftop solar on both towers of the new city hall.

Measure 5: Household Appliance Decarbonization; Sector: Energy

Using the International Council for Local Environmental Initiatives (ICLEI)'s Residential Low Income Weatherization Programs calculator, for 100 homes serviced each year, there will be cumulative total of 77 metric tons/year reduction of CO₂e. This calculator uses the IPCC 5th Assessment 100 Year Values. For electricity savings per home per year, the calculator used the default "CEC CEC. 2005 Options for Energy Efficiency in Existing Buildings CEC-400-2005-039-

CMF" value of 271 kWh/home/year. For gas saving per home per year, the calculator used the default "CEC CEC. 2005 Options for Energy Efficiency in Existing Buildings CEC-400-2005-039-CMF" value of 72 Therms/home. It was projected that for a start year of 2025 and end year of 2026 prior to the reduction there was an estimated output of 209,216 metric tons CO₂e. With the reduction measure in place, that output went down to 209,139 metric tons of CO₂e.