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| Date: | August 21, 2018 |
| To: | Allison Wood, San Diego Association of Governments |
| From: | Brenda Hom and Poonam Boparai |
| Subject: | **SANDAG Electric Vehicle Off-Model Calculator Methodology for SCS Compliance – 2019 San Diego Forward: The Regional Plan** |
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The San Diego Association of Governments (SANDAG) tasked Ascent with preparing a carbon dioxide (CO2) emissions calculator for regional electric vehicle (EV) programs that would be considered “off-model” greenhouse gas (GHG) reduction strategies in San Diego Forward: The 2019-2050 Regional Plan (2019 Regional Plan). The 2019 Regional Plan is SANDAG’s third Regional Transportation Plan and Sustainable Communities Strategy (RTP/SCS) pursuant to Senate Bill (SB) 375.

SB 375, signed into law in 2008, aligns regional transportation planning efforts and land use and housing allocation with overall State GHG reduction goals. Assembly Bill (AB) 32 (2006) and Executive Order (EO) S-3-05 (2005) established targets for the State to reduce its GHG emissions to 1990 levels by 2020 and 80 percent below 1990 levels by 2050. SB 32, signed in 2016, set an intermediate target of reducing statewide emissions to 40 percent below 1990 levels by 2030. Given that transportation accounts for nearly 40 percent of the state’s emissions, the efforts in SB 375 to reduce regional transportation-related emissions are key to supporting the State’s GHG reductions goals. (California Air Resources Board [CARB] 2017, 2018a).

SB 375 requires metropolitan planning organizations (MPOs), such as SANDAG, to adopt an SCS or Alternative Planning Strategy, showing land use allocation in each MPO’s Regional Transportation Plan. The California Air Resources Board (CARB), in consultation with the MPOs, provides each affected region with reduction targets for GHGs emitted by passenger cars and light trucks in their respective regions for 2020 and 2035. SANDAG serves as the MPO for San Diego county and adopted San Diego Forward: The 2015 Regional Plan in October 2015. In March 2018, CARB adopted the Target Update for the SB 375 targets tasking SANDAG to achieve a 15 percent and a 19 percent per capita reduction in CO2 emissions from 2005 levels by 2020 and 2035, respectively (CARB 2018b).

In order to ensure that the emissions reductions are solely attributed to MPO actions, CARB sets a number of stipulations in its recommended SB 375 SCS GHG reduction methodology. CARB recommends that MPOs use a post-processed set of vehicle emissions factors in CARB’s EMissions FACtor (EMFAC) model that prevent MPOs from taking credit from improving State and federal vehicle efficiency standards to achieve the assigned targets. This stipulation generally leads MPOs to reduce emissions by reducing vehicle miles traveled (VMT) through land use and transportation planning strategies. Although planning efforts may account for the majority of CO2 emission reductions under SB 375, CARB allows for the inclusion of “off-model” strategies where MPOs can take emissions reductions credit for transportation programs and other activities that are not fully captured in the regional transportation model, such as SANDAG’s Activity Based Model (ABM) (CARB 2011). The “off-model” strategy programs may include transportation demand management (TDM) and EV programs, which are not generally correlated with land use planning. The “off-model” quantification of the emissions reductions from SANDAG’s EV programs under the 2019 Regional Plan is the subject of this memorandum.

#### 2019 Regional Plan EV Off-Model Approach

##### Background and Purpose

An exhaustive evaluation of the California passenger vehicle market and technology conducted by CARB found that the GHG emission standards currently in place for model years 2022-2025 are readily feasible at or below the costs estimated in 2012 when the Advanced Clean Cars Program standards were adopted with support from automakers. Continuing on the path to meeting the 2025 standards will deliver significant clean-air and public health benefits for Californians and cost-savings for consumers. The Midterm Review of Advanced Clean Cars Program report confirmed that the previously adopted package of GHG standards and technology-forcing zero emission vehicle standards are appropriate. The report indicated that existing programs in California will add at least 1 million zero emission vehicles on its roads and highways by 2025. CARB staff’s analysis found that conventional technology to achieve these standards is moving at a faster pace than originally expected, and that achieving these vehicle emission limits is feasible, and will result in cost-savings for consumers. In the report, CARB also recommended that California make a major push to develop new post-2025 standards while working with automakers, federal regulators and partner states to further develop the market for electric cars. CARB projects that the zero emission market will see more than 20 new electric and plug-in model introductions with greater driving range at mass-market prices and more choices of body styles, brands, and consumer utility in the next few years (CARB 2017a).

To establish a 2030 target as recommended by CARB, EO B-48-18 was signed by Governor Brown in January 2018. The EO directs all State entities to work with the private sector to have at least 5 million zero emission vehicles on the road by 2030, as well as install 200 hydrogen fueling stations and 250,000 electric vehicle charging stations by 2025. It specifies that 10,000 of the electric vehicle charging stations should be direct current fast chargers. Therefore, the trend in the State is towards a higher number of zero emission vehicles based on CARB’s analysis and the direction in EOs. It is anticipated that the State and individual regions can significantly exceed the projected number of zero emission vehicles in EMFAC given the right mix of regulations, incentives, infrastructure, public-private partnerships, and education and outreach campaigns. This analysis provides the reductions SANDAG can expect based on proposed EV programs under the 2019 Regional Plan.

In preparation for development of the EV off-model calculator, Ascent reviewed methods used by other MPOs in California, including the Association of Bay Area Governments (ABAG) and Metropolitan Transportation Commission (MTC), Southern California Association of Governments (SCAG), and Sacramento Area Council of Governments (SACOG). In 2013, MTC was one of the first MPOs to develop an EV off-model methodology that accounted for specific EV incentive programs (CARB 2014). MTC used the same approach again in 2017 for Plan Bay Area 2040 (MTC 2017). SCAG’s 2016 RTP/SCS adopted MTC’s EV methodology to develop their off-model calculations (SCAG 2015). SACOG used the difference in EV market penetration forecasts between two versions of EMFAC (EMFAC2011 and EMFAC2014) to calculate EV off-model reductions relative to EMFAC2011 (SACOG 2015).

The EV programs considered by SANDAG for the 2019 Regional Plan would be most similar to MTC’s approach, which quantified CO2 reductions from a regional EV charger program and a vehicle incentive program. The regional charger program would increase the percentage of electric vehicle miles travelled (eVMT) in the region by extending the electric range of plug-in hybrid electric vehicles (PHEV) through the addition of public chargers. The vehicle incentive program would encourage faster turnover of gasoline passenger vehicles to battery electric vehicles (BEV) and PHEVs through rebates relative to default vehicle populations in EMFAC. Similar to MTC, SANDAG is considering a Regional EV Charger Program (RECP) and Vehicle Incentive Program (VIP) as part of 2019 Regional Plan to increase the share of eVMT and plug-in electric vehicle (PEV) population in the region.

In reviewing MTC’s approach and recent EV studies released by governmental and non-governmental research groups, Ascent found that a number of assumptions used in prior calculators could be expanded upon and better substantiated. Recent EV research include new charging infrastructure studies specific to California and the SANDAG region. Thus, Ascent updated MTC’s approach to include these studies to allow for further variability and substantiation of the assumptions and data used in the calculations. The resulting calculator replaces the EV off-model methodology used in San Diego Forward: The 2015 Regional Plan.

It should be noted that PHEVs and BEVs are herein referred together as PEVs. PEVs and hydrogen fuel cell electric vehicles are together referred to as zero emission vehicles (ZEVs).

The purpose of this EV off-model calculator is to estimate the CO2 reductions and costs associated with implementation of SANDAG’s proposed RECP and VIP. The estimated reductions would contribute towards meeting SB 375 regional CO2 reduction targets for 2020 and 2035, updated by CARB in March 2018 (CARB 2018). This calculator expands upon MTC’s EV off-model methodology and applies a similar methodology to calculate emission reductions from SANDAG’s proposed version of the RECP and VIP. MTC’s approach was first developed as part of Plan Bay Area, MTC’s 2013 Metropolitan Transportation Plan and Sustainable Communities Strategy (MTP/SCS). At that time, data and studies related to EV charging, travel, and market behavior were limited because PEVs had only been mass produced for three years in the U.S., starting with the 2011 Chevrolet Volt. SANDAG’s EV off-model calculator for 2019 Regional Plan takes advantage of more recent research on the EV market and EV travel and charging behavior, including studies specific to California and the San Diego region.

Recent policies, research, studies, and models used to develop the 2019 Regional Plan EV off-model calculator include:

* EO B-16-12 and EO B-48-18, which set a target of 1.5 million ZEVs and 5 million ZEVs in the State by 2025 and 2030, respectively.
* SB 350, which calls for a 50 percent renewable mix for the state’s electricity grid by 2030;
* *California Plug-In Electric Vehicle Infrastructure Projections: 2017-2025,* published by the California Energy Commission (CEC) in March 2018, which includes projections of the PEV vehicle fleet mix, charger inventory, and charging demand by county that would achieve the 1.5 million ZEV statewide target by 2025 established in EO B-16-12 (CEC 2018);
* *Plug-in Electric Vehicle Market Growth Analysis*, prepared by the Center for Sustainable Energy (CSE) for SANDAG in March 2018, which forecasts PEV sales in the San Diego region based on historical PEV sales trends in the area (CSE 2018);
* Electric Vehicle Infrastructure Projection Tool (EVI-Pro), released in early 2018 by the National Renewable Energy Laboratory’s (NREL) and CEC, which estimates the public charging infrastructure needed to support a targeted PEV mix by 2025 for various regions across the state by county. Although this tool is not publicly available at this time, NREL and CEC released a web-based data viewer that summarizes the results of the tool for California, including anticipated charger counts and charger loads. The results of EVI-Pro were used to develop projections in CEC’s *California Plug-In Electric Vehicle Infrastructure Projections: 2017-2025* report. (NREL 2018a, NREL 2018b);
* EMFAC2017, released in late 2017 by CARB, which updates the statewide vehicle population, emissions, and VMT forecasts by fuel type, vehicle class, and other factors, accounting for adjusted ZEV forecasts that are generally more conservative than previously assumed in EMFAC 2014 (CARB 2017b). EMFAC2017 also accounts for a minimum regulatory compliance scenario under the ZEV mandate in the State’s Advanced Clean Cars Program. This mandate requires vehicle manufacturers to produce an increasing number of ZEVs for model years 2018 through 2025.

SANDAG’s EV off-model approach is the first among the MPOs to use CEC’s EVI-Pro’s region-specific results to account for how changes to the targeted PEV population would affect the recommended number of chargers needed under the RECP. EVI-Pro uses real-world travel data from mass market consumers to determine the charging infrastructure needed for residential, workplace, and public areas under a variety of scenarios (Alternative Fuels Data Center [AFDC] 2018). CEC’s EVI-Pro runs also accounted for charger densities, driving and charging simulations, sensitivities to fuel costs, and range anxiety. This included a fuel price sensitivity analysis that used a cost-minimization algorithm to determine the demand for chargers (e.g., the number of Level 2 chargers vs. direct current fast chargers needed to meet the demand from EVs in 2025). Ascent used the average charging demand results from CEC’s study, between the high and low fuel charging price scenarios. EVI-Pro’s results are limited to forecast years through 2025, which anticipate a maximum PEV share of 4.3 percent of the light-duty fleet in the SANDAG region. In comparison, under EO B-16-12 and EO B-48-18, the targeted statewide EV population mix is approximately five percent by 2025 and 16 percent by 2030.

##### Key Methods and Assumptions

SANDAG’s EV Off-Model includes the following key methods and assumptions used in the model’s calculations. The differences from MTC’s approach resulted in a more complex calculator, but also one that accounts for San Diego-specific factors.

* CO2 reductions from the RECP were based on difference between the total eVMT provided by a targeted regionwide number of non-residential chargers and the eVMT anticipated in EMFAC forecasts for a given milestone year. The targeted number of chargers, calculated using a San Diego-specific PEV-to-charger ratio estimated by the CEC, would be equal to the sum of all existing chargers as of 2018 and any new chargers added starting from 2018. Although the installation of new chargers could be due to both the RECP and other utility- or State-level incentives, it is assumed that the GHG reductions associated with EV growth anticipated in EMFAC2017 are only attributed to the State-level incentives.

These chargers were assumed to charge both BEVs and PHEVs. The eVMT provided to each type of vehicle per charger by non-residential charger type (e.g., public vs. workplace) reflect the findings and assumptions in CEC’s 2018 study and EVI-Pro runs.

* CO2 reductions from the VIP were based the difference between the targeted EV population for a given milestone year and the EV population anticipated in EMFAC2017 forecasts. Average VMT and eVMT per vehicle per day were based on EMFAC2017 defaults, which varies by calendar year and vehicle type.

Other assumptions include:

* Chargers have a 90 percent charging efficiency (i.e., the percentage of energy drawn from the electricity grid by the charger that is taken up by the electric vehicle battery);
* Level 2 and Direct Current (DC) Fast Chargers would be rated at 6.6 kilowatt (kW) and 105 kW starting in 2025;
* PHEVs would not have the ability to use DC Fast Charging;
* EVs have an efficiency of 0.225 kilowatt-hours (kWh) per mile; and
* The San Diego Gas and Electric (SDG&E) electricity emission factor would range from 0.196 to 0.172 metric tons of CO2 (MT CO2) per MWh based the utility’s current renewable mix and the renewable mix required under SB 350 by 2030.

These assumptions, except for the SDG&E emission factor, are consistent with those used in CEC’s EVI-Pro runs for the San Diego region. CEC did not calculate emissions in their report, so no utility emission factors were used. Regardless, the calculator allows the user to adjust these inputs and assumptions in light of evolving research. Other specific assumptions used in the calculator are detailed in the rest of this memorandum.

##### Model Inputs

The calculator is set up such that the user can input basic program assumptions for the regional charger and vehicle incentive programs (RECP and VIP) for each milestone year (2020, 2025, 2030, 2035, and 2050). Default assumptions included in the background calculations for RECP and VIP can also be changed by the user, if necessary. For each program, the user can choose a target scenario based on preprogrammed inputs or choose a custom target scenario. SANDAG’s chosen scenario should reflect the desired exceedance above EMFAC2017 EV forecasts in order to appropriately assign GHG reduction credits and incentive costs to SANDAG efforts.

###### Scenarios

The tool allows the user to select a different forecast scenario for either the RECP or VIBP to determine the total charger or PEV population that SANDAG hopes to achieve under those programs. The preprogrammed inputs include full and partial iterations of three preset scenarios based on State EV targets under EO B-16-12 (State Targets), CEC’s EV forecast in EVI-Pro (CEC forecasts), and EV forecasts anticipated in CSE’s market study (CSE forecasts). For example, the user can select the full CEC forecast scenario or a 70 percent CEC forecast scenario, which scales down the PEV and charger targets that would have occurred under the CEC forecast scenario by 70 percent. The following describe the three preprogrammed scenarios and the custom scenario option in the tool.

* **State Targets:** The State Targets under EO B-16-12 to achieve 1.5 million EVs by 2025 and 5 million EVs by 2050 were apportioned to the SANDAG region based on the ratios between the EV population in SANDAG and the state as a whole, as modeled by EMFAC2017.
* **CEC Forecast**: The CEC’s forecast scenario is based on what the CEC anticipates the PEV population will be like for the SANDAG region in order to meet State Targets for 2025, accounting for a variety of economic and organizational factors. The model assumes that the CEC forecast trends would continue past 2025.
* **CSE Forecast:** The CSE Forecast scenario is based on either a linear or second-order polynomial trend of the PEV population in SANDAG based on historical sales. The second-order polynomial forecast is currently the preferred CSE Forecast scenario per SANDAG staff, though the user has the option to change the trend assumption in the background calculations.
* **Custom Inputs:** The model also allows the user to input custom charger or PEV population targets or custom scenarios based on a chosen fraction of either the State Targets or the CEC forecasts.

###### Regional Electric Vehicle Charger Program

The RECP CO2 calculations require the user to select a target scenario of the number of PEVs to be supported by the charger program. This calculator utilizes CEC’s results from EVI-Pro to calculate a PEV-to-charger ratio for each charger destination type (e.g., workplace, public) that is characteristic of the SANDAG region’s EV charging behavior. This provides a recommended number of chargers needed to support the targeted PEV population. Alternatively, the model allows the user to decide on the specific number of chargers to be installed under the program based on fiscal or administrative limitations. The number of average active hours of charging per charger specific to each PEV type and charger type was calculated from CEC’s EVI-Pro model results.

With respect to program costs, the user can input the average capital and administrative costs associated with each new charger funded or incentivized by the program. The average costs can be varied or remain constant over time depending on how SANDAG designs the program.

###### Vehicle Incentive Program

Similar to the RECP calculations, the VIP calculations require the user to either select a target PEV scenario or choose a custom targeted number of vehicles that would be incentivized under the program. If a custom target is chosen, the user can input the number of BEVs or PHEVs that would be incentivized by each milestone year starting with 2020. Once the number of PEVs is selected, the calculator utilizes the average VMT per PEV per day and the default PHEV utility factor (UF) used in EMFAC2017 to estimate the total eVMT associated with VIP. The PHEV utility factor (UF) is defined as the percent of PHEV VMT that is electric. To estimate the CO2 reductions, the total eVMT from the population of EVs under the VIP is subtracted by the eVMT from population of EVs in EMFAC business-as-usual (BAU) forecasts. The additional eVMT under the VIP is assumed to offset emissions from equivalent gasoline light-duty vehicles (LDV).

With respect to program costs, the user can input the average capital and administrative costs associated with each vehicle incentive. The average costs can be varied or remain constant over time depending on how SANDAG designs the program.

###### Comparison to State Targets

The calculator allows for the user to evaluate how SANDAG’s EV program contributes to the overall per-capita CO2reduction targets under SB 375 and how the resulting PEV populations compares to the San Diego region’s share of the State’s EV targets under EO B-16-12 and B-48-18. Once SANDAG adopts its Series 14 regional growth forecast, the forecasted population and daily VMT can be input into the calculator for each milestone year. To calculate the per-capita CO2 reductions associated with the EV off-model calculations, total daily reductions from both programs are divided by SANDAG’s forecasted population. To evaluate how SANDAG’s EV programs would help achieve the State’s EV targets, SANDAG’s total EV population and eVMT under both EV programs are compared to SANDAG’s LDV population and VMT, respectively, for each milestone year.

#### SANDAG EV Off-Model Methodology

SANDAG’s EV off-model calculator quantifies the CO2 reductions attributable to SANDAG’s EV programs that go beyond the reductions that would occur under current State legislation. The calculator quantifies CO2 reductions associated with implementation of the RECP and VIP for the milestone years 2020, 2025, 2030, 2035, and 2050. These years have been selected primarily to be consistent with the milestone years set in AB 32, SB 32, and SB 375. The tool allows the user to adjust program targets (e.g., number of chargers, vehicles incentivized) and other assumptions to calculate the CO2 reductions relative to a BAU forecast. The BAU forecast of PEV and eVMT growth is based on historical vehicle sales data and assumed regulatory compliance with the State’s ZEV mandate, as modeled in EMFAC2017. This approach allows CO2 reductions to be attributed only to SANDAG’s actions rather than being attributed to both State and SANDAG actions.

Both the RECP and VIP calculators use the same assumptions for EV efficiency, electricity emissions factors, gasoline-equivalent vehicle emission factors, and average miles travelled per day per vehicle by vehicle type. Emissions associated with eVMT are based on the average EV efficiency (measured in kWh per mi) and SDG&E’s electricity emissions factor (measured in grams [g] of CO2 per kWh). For future milestone years, the electricity emissions factors are adjusted to be consistent with the targets set by the Renewables Portfolio Standard and SB 350 (i.e., 33 percent renewable by 2020 and 50 percent renewable by 2030). For equivalent gasoline LDVs, emission factors were modeled in EMFAC2017 for the SANDAG region for each milestone year. EMFAC2017 web database was used to obtain the emission factors, rather than using the desktop version to run EMFAC with the post-processed SB 375 analysis option. The SB 375 analysis option in EMFAC is typically used to determine the emissions reductions associated with VMT reductions in future years under a given transportation plan, so that MPOs do not rely on increasing vehicle efficiencies to meet the regional SB 375 CO2 reduction targets. However, for the purposes of assigning CO2 reductions to the proposed EV programs, it is more conservative to compare EV emissions to more efficient gasoline vehicles with lower emission factors than to compare EV emissions to gasoline vehicles with higher emission factors that would have been assumed under the SB 375 analysis option.

##### Regional Electric Vehicle Charger Program

Under the RECP, SANDAG would continue to expand the public EV charging infrastructure in the San Diego region to support and incentivize the growing PEV population in the region. Chargers alone do not reduce CO2 emissions. However, the public EV charging infrastructure allows for the PEV population to grow by making it easier and more convenient for PEV drivers to charge their vehicles. The relationship between the charging infrastructure and the PEV population and travel behavior has been a primary study focus for several research groups, including various universities, national laboratories, and state agencies. However, until recently, this research has been limited to the behavior of early PEV adopters.

As the State prepares for greater adoption of PEVs to fulfill its climate goals, SANDAG’s RECP calculator utilizes CEC’s recent EVI-Pro modeling to account for travel and charging behavior that is more representative of mainstream drivers in the San Diego region (CEC 2018:1). As stated previously, the EVI-Pro data viewer was used to estimate the number of chargers needed to support a given PEV population, accounting for San Diego-specific estimates of the PEV fleet mix, access to home charging, and other factors. The resulting PEV-to-charger ratio is the basis for both the CO2 reduction and cost estimates related to the RECP. Based on CEC’s results, Ascent calculated a ratio of one charger for approximately every eight to 10 PEVs, depending on the targeted PEV population. The ratios were also categorized by charger type: workplace Level 2, public Level 2, and public DC Fast Chargers. The trend in how this ratio changes with respect to the supported PEV population is shown in Figure 1.



Note: Adapted from CEC’s results from EVI-Pro for the San Diego Region, consistent with results in “California Plug-In Electric Vehicle Infrastructure Projections: 2017-2025 Future Infrastructure Needs for Reaching the State’s Zero Emission-Vehicle Deployment Goals.” (CEC 2018). [[1]](#footnote-1)

Figure 1 PEV-to-Charger Ratio vs. PEV Population for the San Diego Region

Figure 1 shows the PEV-to-charger ratio between the 2017 and 2025 PEV population in the San Diego region, according to the CEC’s EVI-Pro assumptions. For 2025, CEC estimates that SANDAG’s fair share of PEVs to meet the 2025 goals under EO B-16-12 is 110,227 PEVs. In contrast, EMFAC2017 forecasts that the SANDAG region would have 61,378 PEVs by 2025, almost half of the State’s 2025 target. Ascent assumes that the linear trend between 2017 and 2025 would continue past 2025. As such, the equations shown in Figure 1 are used to calculate the number of workplace, public Level 2, and public DC Fast Chargers needed to support a given PEV population. SANDAG’s goal under the RECP is to meet the charger demand under a selected PEV population scenario.

CO2 reductions from implementation of the RECP are based on the sum of CO2 reductions from the effects of the additional chargers on BEV and PHEV travel activity. This is because charging behavior differs between BEV and PHEV drivers. While BEV drivers may experience range anxiety due to a limited presence of chargers, BEVs primarily charge at home and all miles associated with BEV driving are electric. On the other hand, PHEV drivers have the option of travelling further using gasoline after their electric-only range has been exhausted and a nearby charger is unavailable (It should be noted that no diesel PHEVs are currently on the market). However, the increased availability of chargers could allow PHEV drivers to extend their electric-only range, resulting in a greater percentage of eVMT across all miles driven. Equations 1 through 3 are used to calculate the CO2 reductions from BEVs and PHEVs under the RECP for a given milestone year.

Where:

ERECP = Emissions reductions associated with implementation of RECP (MT CO2)

EBEV\_RECP = Emissions reductions associated with BEVs under the RECP (MT CO2)

EPHEV\_RECP = Emissions reductions associated with PHEVs under the RECP (MT CO2)

###### BEV CO2 Reductions

CO2 reductions from BEVs are based on the difference between emissions from charging associated with the eVMT provided to BEVs under the RECP compared to the eVMT from BEVs anticipated by EMFAC. Any additional eVMT from the RECP is assumed to offset equivalent gasoline LDV VMT. Thus, for a given milestone year, BEV emission reductions from the RECP are based on Equation 2.

Where:

EBEV\_RECP = Emissions reductions from additional BEV eVMT from chargers operating under the RECP scenario compared to EMFAC forecasts (MT CO2)

VMTBEV\_RECP = eVMT associated with the electricity provided by chargers to BEVs under the RECP (mi/day)

VMTBEV\_EMFAC = eVMT associated with all BEV VMT under EMFAC2017 forecasts (mi/day)

EFGas = Emissions factor per mile associated with gasoline LDVs in the SANDAG region, as modeled in EMFAC2017 (g CO2/mi). Based on the four EMFAC vehicle categories included in the model’s SB 375 analysis option (passenger cars [LDA], light duty trucks with an estimated total weight less than 3,750 pounds [LDT1], light duty trucks with an estimated total weight less between 3,751 and 5,750 pounds [LDT2], and medium duty trucks [MDV]).

FEEV = Fuel economy of electric vehicles (kWh/mi) (e.g., 0.225 kWh/mi)

EFE = Electricity emission factor (g CO2/kWh)

The product of FEEV and EFE is the emission factor of EVs in grams per mile.

VMTBEV\_RECP is the eVMT provided to BEVs by all chargers in the SANDAG region including those associated with RECP that would been installed after 2019. VMTBEV\_EMFAC is the product of the BEV population and the average daily VMT per EV, as modeled in EMFAC2017. Although EMFAC2017 does not output EVs by PEV types, the BEV population forecasts were based on 1) manufacturer ZEV sales requirements under the state’s ZEV mandate and 2) 2016 BEV populations assumed in EMFAC2017, which were requested directly from CARB (Long, pers. comm., 2018a). These forecast assumptions are shown in Table 1 for all ZEVs. This approach was used because EMFAC2017 uses historical vehicle populations through calendar year 2016 and regulation-based EV projections for years after 2016.

| Table 1 EMFAC2017 ZEV Forecast and Regulatory Compliance Assumptions | | | |
| --- | --- | --- | --- |
|  | PHEV | BEV | FCV |
| 2016 Population in SANDAG | 7,417 | 10,105 | 7 |
| Sectors | Percent of New ZEV Sales | | |
| Model Year | PHEV | BEV | FCV |
| 2017 | 73% | 19% | 8% |
| 2018 | 78% | 19% | 4% |
| 2019 | 67% | 26% | 6% |
| 2020 | 63% | 28% | 8% |
| 2021 | 60% | 29% | 10% |
| 2022 | 59% | 29% | 12% |
| 2023 | 58% | 29% | 14% |
| 2024 | 57% | 28% | 15% |
| 2025+ | 57% | 26% | 17% |
| Notes: EMFAC2017 uses the same future ZEV sales requirements as assumed in EMFAC 2014.  EMFAC = EMission FACtor model; ZEV = zero emission vehicle; SANDAG = San Diego Association of Governments; PHEV = plug-in hybrid electric vehicle; BEV = battery electric vehicle; FCV = fuel cell vehicle.  Source: Long, pers. comm., 2018a, CARB 2015: Table 3.3-7 | | | |

VMTBEV\_RECP is calculated from the total number of chargers, active charging time for BEVs per charger, and EV fuel economy as shown in Equation 3.

Where:

VMTBEV\_RECP = eVMT associated with the electricity provided by chargers to BEVs under the RECP

i = charger type (e.g., Level 2 or DC Fast Charger)

Ci = Cumulative number of charging plugs or plugs by type installed under RECP (plugs).

Hi\_BEV = Active hours charged by charger type, per charger plug, per day associated with BEVs (hours/plug)

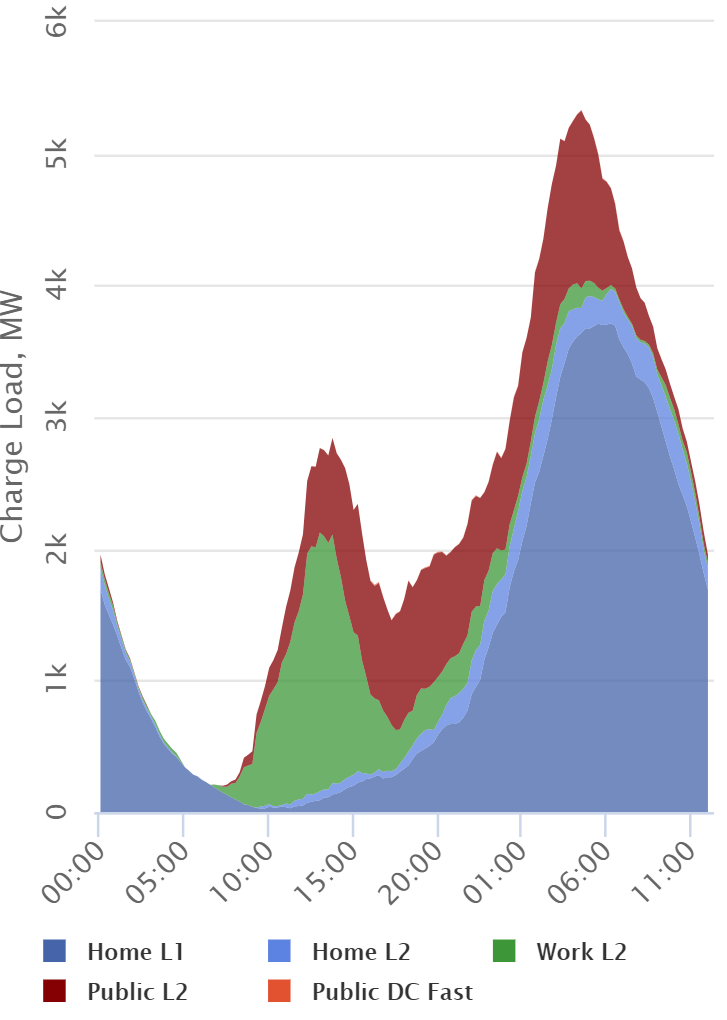
Pi = Power rating of charger type (e.g., 6.6 kW for Level 2 chargers or between 55 and 105 kW for DC Fast Chargers)

ηcharger = Charger efficiency (e.g., 90 percent)

FEEV = Fuel economy of electric vehicles (kWh/mi) (e.g., 0.225 kWh/mi)

Ci is calculated from the charging plug-to-PEV ratio from EVI-Pro (See Figure 1). The active charging referred to in Hi is distinct from charging time, because a car may still be plugged in but not actively charging because the car may have completed or stopped charging. For Hi, the default charging activity assumes workplace chargers actively charge BEVs for three hours and PHEVs for eight hours per day per charger, across multiple vehicles over the course of a day. Public chargers are assumed to charge BEVs for one hour per day per charger and PHEVs for 10 hours per day per charger. These charging times are consistent with the understanding that PHEVs would need to charge more frequently due to their smaller range compared to BEVs. Pi, ηcharger, and FEEV are consistent with those used in CEC’s EVI-Pro runs statewide.

The default Hi values given above are calculated from charger load results from CEC’s EVI-Pro runs for the SANDAG region (NREL 2018b). The charger load results show how much power, in MW, is drawn from each charger destination type (e.g., public level 2, workplace level 2, and public DC fast charger) over a 24-hour period, as shown in Figure 2.



Source: NREL 2018a. Note that Public DC Fast charger loads are imperceptible in this figure due to very small loads in comparison to other charger types.

Figure 2 Power Load by Charger Destination Type over a 24-hour Period for SANDAG in 2025

The area under the curve by each charger type is equal to the daily electricity demand for all chargers in the SANDAG region in 2025, under CEC’s target scenario in their 2018 infrastructure report (CEC 2018). Dividing the total energy delivered (in MWh) by the average charger power rating (in kW) gives the average hours charged by charger type. Ascent further disaggregated the charging hours by PEV type using the charger demand profile by PEV type assumed in CEC’s modeling (CEC 2018: Figure 4.5). This methodology to calculate the charging hours was recommended by CEC (Bedir, Pers. Comm., 2018).

###### PHEV CO2 Reductions

For CO2 reductions from PHEVs, the approach differs from the BEV calculations because the chargers affect the overall electric UF of PHEVs. Depending on the charger assumptions, the chargers would increase the amount of eVMT provided to PHEVs. Dividing the eVMT provided by the chargers by the PHEV VMT assumed in EMFAC would result in a higher UF relative to EMFAC defaults, potentially beyond the maximum UF for PHEVS. The maximum UF for PHEVs, assuming access to charging is widely available, is 80 percent according to a 2017 NREL study and the San Diego 2025 PEV fleet mix [NREL 2017: Figure 26]. MTC used this approach of comparing UFs to assign CO2 reductions to the MTC’s RECP and estimated a UF of 80 percent with additional chargers.

However, PHEV UF assumed under the RECP is inextricably connected with the assumptions used to estimate reductions from the VIP. This is because the VIP has the potential to increase overall PHEV VMT by increasing the number of PHEVs in the region. This affects the calculation of the PHEV UF under the RECP because the UF is calculated by dividing PHEV eVMT provided under the RECP by the total PHEV VMT. Thus, the calculations are set up to avoid double counting reductions from PHEVs from the two programs. This approach is detailed in Equations 4 through 7.

Where:

EPHEV\_RECP = Emissions reductions associated with PHEVs under the RECP (MT CO2)

EPHEV\_EMFAC = Emissions from PHEVs and Gasoline LDVs as forecasted in EMFAC2017 (MT CO2)

EPHEV\_SANDAG = Emissions from PHEVs that would occur under the RECP and VIP (MT CO2)

EPHEV\_VIP = Emissions reductions from PHEVs that would occur under the VIP only (MT CO2)

The overall PHEV daily VMT, regardless of fuel types, is assumed to be equal for both EPHEV\_EMFAC and EPHEV\_SANDAG (See Figure 3). EPHEV\_VIP is calculated in Equation 10. The PHEV-related VMT (VMTPHEV\_SANDAG) under both programs is assumed to be equal to the product of 1) the total number of PHEVs anticipated under the VIP and 2) average daily VMT per gasoline LDV assumed in EMFAC2017. The PHEV population target under the VIP needs to be greater than or equal to EMFAC forecasts to achieve applicable reductions. The VIP CO2 reductions from PHEVs are subtracted from the total in Equation 4 to avoid double counting.



(For demonstration purposes only. Relative values are subject to EV Off-Model calculator inputs and assumptions.)

Figure 3 Comparison of PHEV VMT by Fuel Type between SANDAG EV Programs and EMFAC2017 Defaults

Each bar in Figure 3 adds up to daily PHEV VMT anticipated under both the RECP and VIP. It is assumed that any PHEV VMT beyond EMFAC’s PHEV VMT forecasts would offset gasoline LDV VMT, as shown in the light gray bar in Figure 3. Applying the default EMFAC gasoline LDV emission factors to the difference in PHEV VMT results in the emissions reductions associated with both SANDAG programs.

Equation 5 describes how EPHEV\_EMFAC is calculated.

Where:

EPHEV\_EMFAC = Emissions from PHEVs and Gasoline LDVs as forecasted in EMFAC2017 (MT CO2)

VMTPHEV\_VIP = Daily VMT associated with PHEVs under the VIP (mi/day)

VMTPHEV\_EMFAC = Daily VMT associated with PHEVs under EMFAC2017 (mi/day)

UFEMFAC = Default PHEV Utility Factor assumed in EMFAC2017 (%).

EFGas = Emissions factor per mile associated with gasoline LDVs in the SANDAG region, as modeled in EMFAC2017 (g CO2/mi). Based on EMFAC vehicle categories LDA, LDT1, LDT2, and MDV.

EFEV = FEEV \* EFE (g CO2/mi) (See Equation 2)

VMTPHEV\_VIP is the product of the total PHEV population under VIP and the average daily miles per gasoline LDV, as modeled in EMFAC2017. Because EMFAC’s user interface does not separate VMT by PEV type, VMTPHEV­\_EMFAC is the product of the PHEV population and the average daily gasoline VMT per LDV, as modeled in EMFAC2017. As with BEVs, EMFAC2017 does not output vehicle populations by PEV types. Thus, the EMFAC PHEV population forecasts were calculated based on 1) manufacturer ZEV sales requirements under the State’s ZEV mandate (see Table 1) and 2) 2016 PHEV populations assumed in EMFAC2017, which were requested directly from CARB (Long, pers. comm., 2018a). See Table 1 for EMFAC’s ZEV forecast assumptions.

UFEMFAC was based on data obtained directed from CARB. CARB provided PHEV UF assumptions for each model year (MY) starting with MY 2018. Prior to MY 2018, EMFAC assumes all PHEVs have a UF of 40 percent, which was the assumption used in MTC’s EV off-model calculator. For EMFAC2017, however, CARB increased the UF assumptions for future model years to account for increasing electric range of available PHEVs (Long, pers. comm., 2018b). EMFAC2017 UF assumptions by model year are summarized in Table 2. These assumptions were applied to the PHEV population mix in EMFAC to calculate a weighted average UFEMFAC that accounts for the different UFs across model years for a given calendar year.

| Table 2 EMFAC2017 PHEV Utility Factor Assumptions | |
| --- | --- |
| Model Year | PHEV UF |
| Pre-2018 | 40% |
| 2018 | 46% |
| 2019 | 47% |
| 2020 | 48% |
| 2021 | 50% |
| 2022 | 55% |
| 2023 | 56% |
| 2024 | 58% |
| 2025+ | 59% |
| Notes: UF assumptions apply statewide. EMFAC = EMission FACtor model; PHEV = plug-in hybrid electric vehicle; UF = utility factor.  Source: Long, pers. comm., 2018b | |

Equation 6 describes how EPHEV\_RECP is calculated.

Where:

EPHEV\_SANDAG = Emissions from PHEVs as anticipated under 2019 Regional Plan scenarios with the implementation of the off-model programs (MT CO2)

VMTPHEV\_VIP = Daily VMT associated with PHEVs under the VIP (mi/day)

UFRECP = PHEV utility factor associated with charger scenario under the RECP. Limited to be between UFEMFAC and a maximum of 80 percent. (%)

EFGas = Emissions factor per mile associated with gasoline LDVs in the SANDAG region, as modeled in EMFAC2017 (g CO2/mi). Based on EMFAC vehicle categories LDA, LDT1, LDT2, and MDV.

EFEV = FEEV \* EFE (g CO2/mi) (See Equation 2)

UFRECP is the calculated PHEV UF associated with the charging scenario under the RECP, as shown in Equation 7.

Where,

eVMTPHEV\_RECP = eVMT associated with the electricity provided by chargers to PHEVs under the RECP

VMTPHEV\_VIP = Daily VMT associated with PHEVs under the VIP (mi/day)

eVMTPHEV\_RECP is the eVMT provided to PHEVs by all chargers in the SANDAG region including those associated with RECP. eVMTPHEV\_RECP is calculated identically to Equation 3, with the exception of Hi. In the case of PHEVs, Hi refers to the active hours charged by charger type per plug per day associated with PHEVs.

##### Vehicle Incentive Program

Under the VIP, SANDAG would offer incentives for drivers to replace older gasoline passenger vehicles with equivalent PEVs. While SANDAG could consider incentivizing FCVs in addition to PEVs, this calculator only accounts for reductions associated with incentives for PEVs due to the relatively small FCV population forecast and limited amount of existing infrastructure. The VIP would increase the share of PEVs among the LDA fleet in the San Diego region. It is assumed that the VIP would not increase or decrease overall VMT in the San Diego region anticipated under 2019 Regional Plan.

The CO2 reductions associated with the VIP are essentially a comparison of the new eVMT that would occur from the additional BEVs and PHEVs incentivized under the program beyond EMFAC forecasts. The calculation of CO2 reductions from VIP are reflected in Equations 8 through 10. Similar to Equation 1, the emissions reductions from VIP are the sum of the emissions reductions from BEVs and PHEVs under the program.

Where:

EVIP = Emissions reductions associated with implementation of VIP (MT CO2)

EBEV\_VIP = Emissions reductions associated with BEVs under the VIP (MT CO2)

EPHEV\_ VIP = Emissions reductions associated with PHEVs under the VIP (MT CO2)

###### BEV CO2 Reductions

CO2 reductions from BEVs are based on the difference between emissions from charging associated with the eVMT of the BEVs incentivized under the VIP compared to the eVMT from BEV anticipated by EMFAC. Any additional eVMT from the VIP is assumed to offset equivalent gasoline LDV VMT. Similar to Equation 2, BEV emission reductions from the VIP are based on the following equation.

Where:

EBEV\_VIP = Emissions reductions from the BEV population under VIP compared to EMFAC forecasts (MT CO2)

VMTBEV\_VIP = eVMT associated with all BEVs including those incentivized under the VIP (mi/day)

VMTBEV\_EMFAC = eVMT associated will all BEV VMT under EMFAC2017 forecasts (mi/day)

EFGas = Emissions factor per mile associated with gasoline LDVs in the SANDAG region, as modeled in EMFAC2017 (g CO2/mi). Based on EMFAC vehicle categories LDA, LDT1, LDT2, and MDV.

FEEV = Fuel economy of electric vehicles (kWh/mi) (e.g., 0.225 kWh/mi)

EFE = Electricity emission factor (g CO2/kWh)

Because both Equations 2 and 9 calculate reductions relative to EMFAC-forecasted VMT, BEV emissions reductions from VIP (EBEV\_VIP) are assumed to be independent of the BEV reductions from RECP (EBEV\_RECP). VMTBEV\_VIP is the product of the targeted BEV population under VIP and the average daily miles per vehicle for EVs as modeled in EMFAC2017. VMTBEV\_EMFAC, EFGas, FEEV, and EFE are the same values used in Equation 2.

###### PHEV CO2 Reductions

For emission reductions from PHEVs, the approach is similar to Equation 6 with an added complication behind the UF assumption.

Where:

EPHEV\_VIP = Emissions from PHEVs as anticipated under the VIP (MT CO2)

VMTPHEV\_VIP = Daily VMT associated with PHEVs under the VIP (mi/day)

UFVIP = PHEV utility factor assumed for VIP (%)

EFGas = Emissions factor per mile associated with gasoline LDVs in the SANDAG region, as modeled in EMFAC2017 (g CO2/mi). Based on EMFAC vehicle categories LDA, LDT1, LDT2, and MDV.

EFEV = FEEV \* EFE (g CO2/mi) (See Equation 2)

VMTPHEV\_VIP is the product of the targeted PHEV population under VIP and the average daily miles per vehicle for gasoline LDVs as modeled in EMFAC2017. To be conservative and to avoid circular arguments, UFVIP is assumed to be equal to the UF assumed under EMFAC2017 (UFEMFAC).

##### Incentive Costs

To estimate the cumulative incentive program costs to SANDAG, the user can input SANDAG’s incentive costs per charger or vehicle and percent-based administrative costs (e.g., five percent of all vehicle incentives) for each milestone year. For the RECP, the user can choose SANDAG’s average incentive cost per workplace charger, public L2 charger, and public DC Fast Charger. For the VIP, the user can choose SANDAG’s average incentive cost per BEV and PHEV. The total cost of each program would be based on the per-unit incentives multiplied by the associated new chargers or PEV populations as of 2018, as calculated from the EV off-model calculator for each milestone year. The calculated costs are cumulative, because the tool calculates the cumulative number of new chargers and PEVs as of 2018 associated with the RECP and VIP. Thus, the input costs per unit should reflect the average cost across all new chargers or vehicle incentivized since 2018.

##### Results

##### After testing the EV Off-Model calculator, SANDAG has selected the following scenarios to estimate GHG reductions and costs associated with EV programs that would be implemented under the 2019 Regional Plan. For the RECP, SANDAG anticipates that they would incentivize enough chargers to meet **80 percent** of the PEV population anticipated in CEC’s forecast. For the VIP, SANDAG anticipates that they would incentivize enough vehicles to meet **70 percent** of the PEV population anticipated in CEC’s forecast. Once the scenarios are selected, the tool calculates the profile and population of the chargers and vehicles needed to meet each scenario. The results from the tool for each program are shown below. SANDAG did not select any changes to model default assumptions, such as charger kW ratings.

###### Regional Electric Charger Program

##### **Selected Scenario:** 80 Percent of CEC Forecasts

Under the selected scenario, SANDAG would incentivize up to 26,000 new non-residential chargers by 2050, as shown in Table 3. The assumed average incentive costs per charger are shown in Table 4. As mentioned above, Table 4 shows the average cost across all new chargers incentivized at the start of the RECP. Table 5 shows the total program costs and GHG reductions by milestone year.

| Table 3 Total Non-Residential Chargers Incentivized under RECP | | | | | |
| --- | --- | --- | --- | --- | --- |
|  | 2020 | 2025 | 2030 | 2035 | 2050 |
| Workplace Level 2 Chargers | 461 | 3,027 | 5,248 | 7,450 | 13,937 |
| Public Level 2 Chargers | 646 | 1,085 | 2,402 | 3,648 | 7,010 |
| Public DC Fast Chargers | 229 | 1,056 | 1,889 | 2,727 | 5,276 |
| **Total Non-Residential Chargers** | **1,335** | **5,168** | **9,539** | **13,825** | **26,223** |
| Notes: DC = direct current  Source: Modeled by Ascent Environmental in 2018 | | | | | |

| Table 4 Non-Residential Charger Incentive Costs | | | | | |
| --- | --- | --- | --- | --- | --- |
|  | 2020 | 2025 | 2030 | 2035 | 2050 |
| Average Cost per Workplace Charger | $350 | $350 | $350 | $350 | $350 |
| Average Cost per Public Level 2 Charger | $500 | $500 | $500 | $500 | $500 |
| Average Cost per Public DC Fast Charger | $700 | $700 | $700 | $700 | $700 |
| Percent of Costs Associated with Administration | 5% | 5% | 5% | 5% | 5% |
| Average Cost per Charger1 | $501 | $485 | $485 | $485 | $485 |
| Notes: DC = direct current  1 Based on the charger population distribution shown in Table 3.  Source: Modeled by Ascent Environmental in 2018 | | | | | |

| Table 5 Regional Electric Charger Program Costs and Greenhouse Gas Emissions Reductions | | | | | |
| --- | --- | --- | --- | --- | --- |
|  | 2020 | 2025 | 2030 | 2035 | 2050 |
| Cumulative Program Cost ($) (Rounded) | $700,000 | $2,500,000 | $4,600,000 | $6,700,000 | $12,700,000 |
| Net Daily Emission Reduction (MT CO2/day)1 | 107 | 158 | 174 | 206 | 371 |
| Net Annual Emission Reduction (MT CO2/year) 1 | 39,236 | 57,768 | 63,350 | 75,035 | 135,481 |
| Cumulative Emissions Reduced from start of program (MT CO2)1 | 39,236 | 242,510 | 302,797 | 345,964 | 1,578,869 |
| Cost per MT CO2 reduced ($/MT CO2) | $18 | $10 | $15 | $19 | $8 |
| Average Annual Emission Reduction per charger1 (MT CO2/charger) | 29.4 | 11.2 | 6.6 | 5.4 | 5.2 |
| Notes: L2 = Level 2, DC = direct current, MT CO2 = metric tons of carbon dioxide  1 Relative to EMFAC2017 Forecasts  Source: Modeled by Ascent Environmental in 2018 | | | | | |

##### Implementation of SANDAG’s RECP would reduce emissions by 63,350 MT CO2 in 2030 and 135,481 MT CO2 in 2050 beyond EMFAC2017 forecasts. This would result from the installation of 26,000 chargers by 2050 in the SANDAG region. Based on the per-charger costs shown in Table 4, implementation of the RECP would require a total of $12.7 million in funding by 2050. These estimates assume that chargers installed during this time would operate through 2050. Costs are not adjusted for inflation.

###### Vehicle Incentive Program

##### **Selected Scenario:** 80 Percent of CEC Forecasts

Under the selected scenario, SANDAG would incentivize approximately 87,000 PEVs by 2050, as shown in Table 6. The assumed average incentive costs per vehicle are shown in Table 7. As mentioned above, Table 7 shows the average cost across all new PEVs incentivized since start of the VIP. Table 8 shows the total program costs and GHG reductions by milestone year.

| Table 6 Cumulative Plug-in Electric Vehicles Incentivized under VIP by Milestone Year | | | | | |
| --- | --- | --- | --- | --- | --- |
|  | 2020 | 2025 | 2030 | 2035 | 2050 |
| BEVs | 9,218 | 14,206 | 18,463 | 27,228 | 90,048 |
| PHEVs | 7,110 | 12,597 | 12,970 | 12,970 | 12,970 |
| Total PEVs | 16,328 | 26,803 | 31,432 | 40,031 | 86,704 |
| Notes: BEV = battery electric vehicle; PHEV = plug-in hybrid electric vehicle; PEV = plug-in electric vehicle  Source: Modeled by Ascent Environmental in 2018 | | | | | |

| Table 7 Vehicle Incentive Costs | | | | | |
| --- | --- | --- | --- | --- | --- |
|  | 2020 | 2025 | 2030 | 2035 | 2050 |
| Average Incentive per BEV ($/vehicle) | $1,000 | $1,000 | $1,000 | $1,000 | $1,000 |
| Average Incentive per PHEV ($/vehicle) | $700 | $700 | $700 | $700 | $700 |
| Average Incentive per Vehicle ($/vehicle) | $853 | $830 | $823 | $826 | $857 |
| Percent of Costs Associated with Administration | 5% | 5% | 5% | 5% | 5% |
| Average Cost per Vehicle Incentive1 ($/vehicle) | $896 | $871 | $864 | $867 | $900 |
| Notes: BEV = battery electric vehicle; PHEV = plug-in hybrid electric vehicle  1 Based on the charger population distribution shown in Table 6.  Source: Modeled by Ascent Environmental in 2018 | | | | | |

| Table 8 Vehicle Incentive Program Costs and Greenhouse Gas Emissions Reductions | | | | | |
| --- | --- | --- | --- | --- | --- |
|  | 2020 | 2025 | 2030 | 2035 | 2050 |
| Cumulative Program Cost ($) (Rounded) | $14,900,000 | $24,200,000 | $28,900,000 | $38,100,000 | $104,100,000 |
| Net Daily Emission Reduction (MT CO2/day)1 | 146 | 216 | 211 | 237 | 502 |
| Net Annual Emission Reduction (MT CO2/year) 1 | 53,279 | 78,862 | 76,879 | 86,616 | 183,202 |
| Cumulative Emissions Reduced from start of program (MT CO2)1 | 53,279 | 330,353 | 389,354 | 408,739 | 2,023,637 |
| Cost per MT CO2 reduced ($/MT CO2) | $280 | $177 | $64 | $80 | $194 |
| Average Annual Emission Reduction per vehicle1 (MT CO2/charger) | 3.3 | 2.9 | 2.4 | 2.2 | 2.1 |
| Notes: L2 = Level 2, DC = direct current, MT CO2 = metric tons of carbon dioxide  1 Relative to EMFAC2017 Forecasts  Source: Modeled by Ascent Environmental in 2018 | | | | | |

##### Implementation of SANDAG’s VIP would reduce emissions by 76,879 MT CO2 in 2030 and 183,202 MT CO2 in 2050 beyond EMFAC2017 forecasts. This would result from incentivizing up to nearly 87,000 PEVs by 2050. Based on the vehicle incentive costs shown in Table 7, implementation of the VIP would require a total of $104 million in funding by 2050.

###### Both Programs

As shown in Tables 9 and 10, implementation of both programs would result in a reduction of 140,230 MTCO2 in 2030 and 318,368 MT CO2 in 2050 beyond EMFAC2017 forecasts. Implementation of both programs would cost approximately $117 million by 2050. While the RECP is more cost effective in terms of GHG reductions compared to the VIP, as shown in Tables 5 and 8….

| Table 9 Electric Vehicle Program Cumulative Costs | | | | | |
| --- | --- | --- | --- | --- | --- |
|  | 2020 | 2025 | 2030 | 2035 | 2050 |
| Regional Electric Charger Program | $700,000 | $2,500,000 | $4,600,000 | $6,700,000 | $12,700,000 |
| Vehicle Incentive Program | $14,900,000 | $24,200,000 | $28,900,000 | $38,100,000 | $104,100,000 |
| Total Cumulative Cost | $15,600,000 | $26,700,000 | $33,500,000 | $44,800,000 | $116,800,000 |
| Source: Modeled by Ascent Environmental in 2018 | | | | | |

| Table 10 Electric Vehicle Program Greenhouse Gas Emissions Reductions | | | | | |
| --- | --- | --- | --- | --- | --- |
|  | 2020 | 2025 | 2030 | 2035 | 2050 |
| Daily | | | | | |
| Regional Electric Charger Program (MT CO2/day) | 107 | 158 | 174 | 206 | 371 |
| Vehicle Incentive Program (MT CO2/day) | 146 | 216 | 211 | 237 | 502 |
| Combined Daily Reductions (MT CO2/day) | 253 | 374 | 384 | 443 | 873 |
| Combined Daily Reductions (lb CO2/day) | 558,794 | 825,256 | 846,997 | 976,384 | 1,924,864 |
| Annual | | | | | |
| Regional Charger Program (MT CO2/year) | 39,236 | 57,768 | 63,350 | 75,035 | 135,481 |
| Vehicle Incentive Program (MT CO2/year) | 53,279 | 78,862 | 76,879 | 86,616 | 183,202 |
| Combined Annual (MT CO2/year) | 92,515 | 136,630 | 140,230 | 161,651 | 318,683 |
| Cumulative Emissions Reductions (MT CO2) | 92,515 | 572,863 | 692,151 | 754,703 | 3,602,506 |
| Cost per MT CO2 reduced ($/MT CO2) | $169 | $47 | $48 | $59 | $32 |
| Notes: lb CO2 = pounds of carbon dioxide, MT CO2 = metric tons of carbon dioxide  1 Relative to EMFAC2017 Forecasts  Source: Modeled by Ascent Environmental in 2018 | | | | | |

Table 11 shows the calculation of the reductions per capita, using the same methodology used in SANDAG’s 2015 Regional Plan, where total daily emissions reductions in pounds per day are divided by the forecasted population. The result is divided by the 2005 baseline emissions per capita to calculate an additional percent reduction in per capita emissions that would be applied to the per-capita reductions calculated under SANDAG’s main transportation model for the 2019 Regional Plan.

| Table 11 Per-Capita Reductions from the 2019 Regional Plan Electric Vehicle Programs | | | | | |
| --- | --- | --- | --- | --- | --- |
|  | 2020 | 2025 | 2030 | 2035 | 2050 |
| Combined Daily Reductions (lb CO2/day) | 558,794 | 825,256 | 846,997 | 976,384 | 1,924,864 |
| SANDAG Population under the 2019 Regional Plan | 3,435,713 | 3,575,041 | 3,714,370 | 3,853,698 | 4,068,759 |
| 2005 Baseline Emissions per capita (lb CO2/person) | 26 | | | | |
| Reduction per capita from EV programs (lb CO2/person) | 0.16 | 0.23 | 0.23 | 0.25 | 0.47 |
| Additional Percent per capita reduction | 0.6% | 0.9% | 0.9% | 1.0% | 1.8% |
| Notes: L2 = Level 2, DC = direct current, lb CO2 = pounds of carbon dioxide  1 Relative to EMFAC2017 Forecasts  Source: Modeled by Ascent Environmental in 2018 | | | | | |

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NREL. *See* National Renewable Energy Laboratory

##### Personal Communications

Bedir, Kadir. Air Pollution Specialist. California Energy Commission, Sacramento, CA. July 6, 2018. – call with Brenda Hom of Ascent Environmental regarding questions on how to estimate charging hours associated with different PEVs and charger destination types.

Long, Jeffrey. Staff Air Pollution Specialist. Mobile Source Analysis Branch, Air Quality Planning and Science Division, California Air Resources Board, El Monte, CA. June 25, 2018a – email to Brenda Hom of Ascent Environmental with a breakdown of the ZEV population by ZEV type and model year through 2017 for the month of October 2016 in the SANDAG region, as modeled in EMFAC2017; June 8, 2018b – email to Brenda Hom of Ascent Environmental with the assumed utility factor for PHEVs in EMFAC2017 by model year.

1. EVI-Pro should not be confused with EVI-Pro Lite, a simplified version of EVI-Pro, was not used in this analysis (AFDC 2018). Although EVI-Pro Lite is a publicly available version of EVI-Pro, it does not include many of the assumptions embedded in CEC’s California-specific runs. In comparisons between EVI-Pro and EVI-Pro Lite, the latter substantially underestimates the number of DC Fast Chargers in the San Diego region. EVI-Pro Lite also requires the user to input the PEV fleet mix and level of access to home charging, whereas CEC already uses data specific to the San Diego region to support those assumptions. [↑](#footnote-ref-1)