Technical Appendix

1. GHG and CAP/HAP Emission Calculation

This appendix describes the methodologies used for estimating greenhouse gases (GHG) and criteria air pollutants/hazardous air pollutants (CAP/HAP) emission reductions associated with implementation of South Coast AQMD's INVEST CLEAN Project. The Project includes four specific GHG reduction measures:

- Measure 1 - Charging Infrastructure Deployment Incentive Program
- Measure 2 - Battery Electric Truck Deployment Incentive Program
- Measure 3 - Battery Electric Cargo Handling Equipment Deployment Incentive Program
- Measure 4 - Battery Electric Locomotive Pilot Program

A. General Methodologies

The following general methodologies were used for estimating GHG and CAP/HAP emission reductions for all four measures:

1) GHG emissions reductions were calculated based on the estimated activity levels (e.g., vehicle miles traveled, operating hours, fuel consumption) of baseline vehicles and equipment, estimated electricity consumption for battery electric (BE) units, and the corresponding GHG emission factors for electricity generation. The overall methodology is consistent with the methodologies used in the available tools (e.g., AFLEET CFI[1,2]). The upstream GHG emission reductions for diesel fuel production and refining were also calculated based on the total gallons of diesel fuel and the corresponding GHG emission factor.

2) GHG emissions reductions were estimated for three GHG namely CO_2, CH_4, and N_2O and were reported in metric tons of CO_2-equivalent (CO_2e) emissions reductions based on the global warming potential values listed in Table 1.

Table 1. Global Warming Potential[3]

GHG	CO_2	CH_4	N_2O
GWP	1	28	265

3) The estimated electricity consumption for battery-electric units for all four measures were adjusted by: 1) overall charging efficiency representing the charger efficiency (grid to charger loss) and the battery charging efficiency (battery charging loss), and 2) transmission and distribution grid loss based on EPA's eGrid estimates for Western Power Grid (i.e., 5.1%).[4] The charging efficiency was based on the EPA's study which came up with an average combined charging efficiency of 85% for estimating electricity consumption for battery-powered electric vehicles and plug-in hybrid electric

[1] Alternative Fuel Life-Cycle Environmental and Economic Transportation (AFLEET) for Charging and Fueling Infrastructure (CFI) Emissions, https://afleet.es.anl.gov/infrastructure-emissions/

[2] Argonne National Laboratory, Well to Wheels Analysis of Energy Use and Greenhouse Gas Emissions of PHEV, 2010. Well-To-Wheels Energy and Greenhouse Gas Analysis of Plug-In Hybrid Electric Vehicleshttps://afdc.energy.gov/files/pdfs/argonne_phev_evaluation_report.pdf

[3] CPRG Program Implementation Grants - General Competition Notice of Funding Opportunity, Appendix B, https://www.epa.gov/system/files/documents/2024-01/cprg-general-competition-correction.pdf

[4] U.S. EPA's eGrid, Western Power Grid, https://www.epa.gov/egrid/frequent-questions-about-egrid#What%20is%20Grid%20Gross%20Loss

vehicles and is also reflected in AFLEET tools for on-road vehicles. However, with further developments in battery and charging technologies, the charging efficiency is expected to continue to improve resulting in lower overall GHG emissions from electricity consumption in future years.

4) The GHG electricity generation emission factors for 2030 and later years, used in these calculations, reflect the implementation of California's Renewable Portfolio Standard (RPS) Program which requires 60% renewables by 2030 and 100% carbon fee by 2045. The 2030 GHG emission factors represent the weighted average of emission factors for utilities in Los Angeles and Orange counties, which were used for years 2030 to 2044. The 2045 (and later) GHG emission factors were set to zero because of RPS Program requirements.[5] The EPA's GHG emission factors for the Western California electrical utility subregion were used for years 2025 to 2029.[6]

5) A project life was assumed for each measure to conservatively estimate the future GHG emissions reductions associated only with the CPRG incentive funding for these measures although emission reductions will continue as the new ZE units will be replaced with newer ZE units in the future. For heavy-duty trucks, heavy-duty truck chargers, and cargo handling equipment, the project life was assumed to be 10 years based on anticipated vehicle/equipment life. For switcher locomotives a 20-year project life was assumed.

6) The annual and cumulative GHG emissions reductions for each measure, and for all four measures combined, are calculated for two periods: 2025 to 2030 and from 2025 to 2050.

7) The methodology for estimating co-benefits of these measures in reducing CAP/HAP emissions is also based on estimated activity level (e.g., vehicle miles traveled, operating hours, fuel consumption) and the corresponding emission factors. The co-benefits emission reductions were estimated for NOx, PM2.5 and diesel particulate matter (DPM) for each measure in terms of short tons per year for year 2030.

8) Detailed GHG and CAP/HAP emission reductions calculations and calculation formulas for all four measures are provided in the GHG and CAP/HAP Emission Reductions Calculations Spreadsheet attached to this application.

B. Specific Methodologies

The following sections describe the specific methodologies for estimating GHG and CAP/HAP emissions reductions for each measure:

1. Measure M1: Charging Infrastructure Deployment Incentive Program

This measure is the construction or expansion of zero emission charging infrastructure in the two MSAs listed in the Workplan. Infrastructure projects are critical in supporting the deployment of zero emission equipment. A ranking system will be developed to prioritize disadvantaged communities, small fleets,

[5] Priority Climate Action Plan - The Los Angeles-Long Beach-Anaheim, CA Metropolitan Statistical Area, March 2024 (Table B.18) https://www.epa.gov/inflation-reduction-act/priority-climate-action-plans-states-msas-tribes-and-territories

[6] EPA's 2024 GHG Emission Factor HUB, Table 6 for Electricity (CAMX WECC California Subregion) https://www.epa.gov/climateleadership/ghg-emission-factors-hub

charging site control, shared sites, and public charging projects. The number of charging units under this measure is assumed as shown in Table 2:

Table 2. Assumed Number of Chargers for Measure M1

Year	2025	2026	2027	2028	2029	2030
Number of Chargers		480	480	60		

The methodology for estimating GHG emission reductions for this measure is based on the assumed number of chargers deployed each year, charger power capacity, and percentage charger utilization rate. The projected annual electricity consumption, annual mileage, and number of battery-powered trucks were then calculated in conjunction with the corresponding GHG emission factors. Class 8 heavy duty trucks are the vehicles using the chargers under this measure. The projected annual truck miles and projected number of trucks are used in conjunction with the corresponding emission factors (i.e., g/mile, g/truck) to calculate GHG and CAP/HAP emission reductions using the methodology described in the next section for Measure G2: On-Road Heavy Duty Vehicles. The projected annual electricity consumption is used in conjunction with the electricity GHG emissions factors to calculate the electricity GHG emissions.

The charger power capacity and electricity consumption rate for trucks are assumed to be 250 KW and 2 KWh/mile (Class 8 truck data) based on information from ZE truck manufacturers. The utilization rate of chargers is assumed to be 20% for the first year of deployment, 2026 and increasing to a conservative maximum rate of 60% for 2028 and later years based on experience with existing chargers and the anticipated level of utilization.

The annual and cumulative GHG emissions reductions for this measure for 2025 to 2030 and 2025 to 2050 periods are provided in Tables 3 and 4 below.

Table 3. GHG Emission Reductions for Measure M1 for 2025 to 2030 (metric tons CO_2e)

Year	2025	2026	2027	2028	2029	2030
Annual	0	137,020	549,382	877,326	879,354	984,096
Cumulative	0	137,020	686,402	1,563,727	2,443,082	3,427,178

Table 4. GHG Emission Reductions for Measure M1 for 2025 to 2037 (metric tons CO_2e)

	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
Annual	0	137,020	549,382	877,326	879,354	984,096	984,096	984,096	984,096	984,096	984,096	984,096	984,096
Cumulative	0	137,020	686,402	1,563,727	2,443,082	3,427,178	4,411,274	5,395,370	6,379,466	7,363,562	8,347,658	9,194,734	9,629,448

Table 4. GHG Emission Reductions for Measure M1 for 2038 to 2050 (metric tons CO_2e), continued

	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Annual	984,096	984,096	984,096	984,096	984,096	984,096	984,096	1,202,846	1,202,846	1,202,846	1,202,846	1,202,846	1,202,846
Cumulative	9,736,219	9,840,960	9,840,960	9,840,960	9,840,960	9,840,960	9,840,960	10,059,711	10,278,461	10,497,212	10,715,962	10,934,712	11,153,463

The 2030 CAP/HAP emissions reductions for this measure are provided in Table 5.

Table 5. CAP/HAP Emission Reductions for Measure M1 (short tons/yr)

	2030
NOx	1,289
PM2.5	18
DPM	19

2. Measure M2: Battery Electric Freight Vehicles Deployment Incentive Program

This measure would incentivize the decarbonization of goods movement operations by increasing the use of ZE heavy duty long-haul trucks. This Measure would grant either the replacement or conversion of a heavy-duty diesel truck used to move goods with a CARB-certified zero emission technology. The number of ZE trucks for this measure is shown in Table 6:

Table 6. Number of Heavy-Duty Trucks for Measure M2

Truck Class	2025	2026	2027	2028	2029	2030
Class 8 Diesel Trucks		30	40			
Class 4 Diesel Trucks		179	194			
Class 5 Diesel Trucks		179	194			

The methodology for estimating the annual GHG emission reductions for this measure is based on the number of trucks, estimated activity level in terms of the annual vehicle miles traveled (VMT) and GHG emission factors (i.e., CO_2, CH_4, and N_2O) derived from CARB's EMFAC2021 Model[7] in terms of grams per mile for running exhaust and grams per truck for truck idling.

The estimated annual VMT for Class 8 heavy-duty trucks is based on the historical data for projects funded under the Prop 1B program. For Class 4 and Class 5 trucks, the average annual miles for the 2011 to 2017 model years from EMFAC2021 were used. The composite emission factors for running exhaust in grams per mile and for idling in grams per truck per day for CO_2, CH_4, and N_2O for the 2025 to 2030 calendar years were derived from CARB's EMFAC2021 Model assuming 2010 to 2017 model years trucks for Class 8 trucks and 2011 to 2017 model years for Class 4 and 5 trucks (no 2010 model year Class 4 and 5 trucks after 2025 in EMFAC model).[8] The assumption the truck model years is based on the selection of oldest model years that comply with the 2010 heavy-duty truck engine standards as of January 1, 2023[9] and will still be operating after 2025. The 2030 composite emission factors were used for GHG emissions reductions after 2030 since the GHG emission factors don't change much by year in EMFAC2021 Model. The number of operating days for trucks is assumed to be 312 days per year based on EMFAC2021 Model.

The methodology for estimating GHG emissions from the electricity consumption for battery-powered trucks is based on the annual MWh of electricity associated with these trucks, which is calculated based on the estimated annual VMT, estimated electricity consumption for battery-powered trucks (i.e., KWh/mile) and corresponding GHG emissions factors for electricity generation adjusted for the assumed charging efficiency and transmission and distribution grid loss.

The annual VMT for electric-powered trucks are assumed to be the same as those of the replaced diesel trucks. The electricity consumption for battery-powered trucks were assumed to be 2 KWh/mile for Class 8 trucks and 0.7 KWh/mile for Class 4 and 5 trucks based on information from ZE truck manufacturers.[10] With continued battery technology improvements, the electricity consumption rate of

[7] EMFAC2021 Model, https://arb.ca.gov/emfac/emissions-inventory/e263cdd9de130c5e61759e36d202a9e6bbe4a24e

[8] To calculate the weighted-average composite emission factors in grams per mile, EMAFC 2021 Model was run in the Emissions Output mode for these model year trucks to determine the corresponding running exhaust emissions and VMT.

[9] California Truck and Bus Regulation https://ww2.arb.ca.gov/our-work/programs/truck-and-bus-regulation

[10] Volvo Electric Trucks https://www.volvotrucks.us/trucks/vnr-electric/

ZE trucks is expected to continue to decrease resulting in overall lower GHG emission from these trucks. The annual and cumulative GHG emissions reductions for this measure for 2025 to 2030 and 2025 to 2050 periods are provided in Tables 7 and 8 below.

Table 7. GHG Emission Reductions for Measure M2 for 2025 to 2030 (metric tons CO_2e)

	2025	2026	2027	2028	2029	2030
Annual	0	6,955	14,987	14,865	14,769	15,814
Cumulative	0	6,955	21,943	36,808	51,577	67,391

Table 8. GHG Emission Reductions for Measure M2 for 2025 to 2050 (metric tons CO_2e)

	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
Annual	0	6,955	14,987	14,865	14,769	15,814	15,814	15,814	15,814	15,814	15,814	15,814	15,814
Cumulative	0	6,955	21,943	36,808	51,577	67,391	83,205	99,019	114,833	130,647	146,461	155,320	156,146

Table 8. GHG Emission Reductions for Measure M2 for 2025 to 2050 (metric tons CO_2e), continued

	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Annual	15,814	15,814	15,814	15,814	15,814	15,814	15,814	18,186	18,186	18,186	18,186	18,186	18,186
Cumulative	157,096	158,140	158,140	158,140	158,140	158,140	158,140	160,512	162,883	165,255	167,626	169,998	172,369

The overall methodology for estimating CAP/HAP emission reductions for this measure is the same as the GHG emission reductions methodology described earlier. The composite emission factors for NOx, PM10 and PM2.5 for running exhaust in grams per mile and for idling in grams per truck per day were extracted from EMFAC2021 Model for the year 2030. The number of trucks in 2030 were based on the cumulative number of trucks from 2025 to 2030. The 2030 CAP/HAP emissions reductions for this measure are provided in Table 9.

Table 9. CAP/HAP Emission Reductions for Measure M2 (short tons/year)

	2030
NOx	17
PM2.5	0.2
DPM	0.2

3. <u>Measure M3: Battery Electric Cargo Handling Equipment Deployment Program</u>

This measure reduces emissions associated with goods movement by the replacement or conversion of cargo handling equipment (CHE) used at warehouses, inland/dry ports, railyards or freight facility center within the California trade corridors. Eligible types of equipment for conversion or replacement are diesel-powered rubber-tired gantry (RTG) cranes or existing diesel yard trucks and lifts, including forklifts, side handlers, top picks or reach stackers. For calculation purpose, yard trucks and top handlers are assumed as shown in Table 10.

Table 10. Number of CHE for Measure M3

	2025	2026	2027	2028	2029	2030
Yard Tractors		18	16			
Top Handlers		14	12			

The methodology for estimating the annual GHG emission reductions associated with the replaced cargo handling equipment is based on the estimated activity level in terms of the annual operating hours, average engine size, and load factor as well as the corresponding GHG emission factors in terms of grams per KWh of CO2, CH4, and N2O.

The annual operating hours and engine size (HP) for yard tractors and top handlers were based on the latest actual reported data for such equipment operating at the Ports of Los Angeles and Long Beach.[11] The load factors for these equipment are based on CARB's CHE documentation.[12] The GHG emission factors in grams per KWh were derived from EPA's GHG emission factors for diesel fuel and for the industrial/commercial off-road equipment (Kg or grams per gallon)[13], diesel off-road equipment fuel consumption rate and diesel fuel density. The diesel off-road equipment brake-specific fuel consumption rate used in these calculations was assumed to be 0.367 lbs/bhp-hr for diesel engines greater than 100 hp.[14] Diesel fuel density was assumed at 7 lbs per gallon.

The methodology for estimating GHG emissions from the electricity consumption associated with the operation of battery-powered CHE is based on the annual KWh of diesel equipment (calculated based on engine size, annual operating hours and load factor) converted to electricity consumption in MWh (calculated based on diesel fuel heat content and estimated KWh per gallon for offroad diesel equipment[15]) in conjunction with the corresponding GHG emissions factors for electricity generation adjusted for the assumed charging efficiency and estimated transmission and distribution grid loss.

The annual and cumulative GHG emissions reductions for this measure for 2025 to 2030 and 2025 to 2050 periods are provided in Tables 11 and 12 below.

Table 11. GHG Emission Reductions for Measure M3 for 2025 to 2030 (metric tons CO_2e)

	2025	2026	2027	2028	2029	2030
Annual	0	7,179	13,409	13,409	13,409	13,825
Cumulative	0	7,179	20,588	33,996	47,405	61,230

Table 12. GHG Emission Reductions for Measure M3 for 2025 to 2050 (metric tons CO_2e)

	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
Annual	0	7,179	13,409	13,409	13,409	13,825	13,825	13,825	13,825	13,825	13,825	13,825	13,825
Cumulative	0	7,179	20,588	33,996	47,405	61,230	75,056	88,881	102,706	116,531	130,357	137,003	137,420

Table 12. GHG Emission Reductions for Measure M3 for 2025 to 2050 (metric tons CO_2e), continued

	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Annual	13,825	13,825	13,825	13,825	13,825	13,825	13,825	14,711	14,711	14,711	14,711	14,711	14,711
Cumulative	137,836	138,253	138,253	138,253	138,253	138,253	138,253	139,139	140,024	140,910	141,796	142,681	143,567

The methodology for estimating CAP/HAP emission reductions from battery-powered CHE is based on the estimated average emission rate for each CHE type (yard tractors and top handlers) in terms of tons per year of NOx, PM2.5, and PM10 which was calculated for the oldest model years of CHE operating in 2030 based on CARB's OFFROAD2021 Model[16] (i.e., 2017 and older model years).

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[11] 2022 Air Emission Report for Port of Los Angeles (Table 5.1)
https://www.portoflosangeles.org/environment/air-quality/air-emissions-inventory
2022 Air Emissions Report for Port of Long Beach (Table 4.5)
https://polb.com/environment/air#emissions-inventory

[12] CARB 2022 Cargo Handling Equipment Documentation (Table 6)
https://ww2.arb.ca.gov/sites/default/files/2023-08/2022CHEInventory.pdf

[13] EPA's 2024 GHG Emission Factor HUB (Table 2 for diesel fuel; Table 5 for Industrial/Commercial non-road vehicles) https://www.epa.gov/climateleadership/ghg-emission-factors-hub

[14] EPA's Exhaust and Crankcase Emission Factors for Nonroad Compression-Ignition Engines in MOVES2014b; July 2018 Document Display | NEPIS | US EPA

[15] Based on diesel equipment fuel consumption rate of 0.367 lbs/hp-hr and diesel fuel density of 7 lbs/gal

[16] CARB's OFFROAD2021 Model https://arb.ca.gov/emfac/offroad/emissions-inventory/1c89220b7b52edd1aa5c253103ead65c6f617ab2

The number of CHE in 2030 were based on total number of CHE replaced from 2025 to 2030. The average emission factors for NOx, PM10 and PM2.5 in tons per year were calculated for each CHE type based on the average engine size, annual operating hours and load factors in conjunction with CARB's zero-hour emission factors and deterioration rates for the oldest model years (i.e., 2010 to 2017) of yard trucks and top handlers (container handling equipment) categories in CARB's OFFROAD2021 model for the year 2030. The selection of the oldest model years in the OFFROAD2021 Model was intended to provide a representative pool of replaced CHE covered in this measure. The 2030 CAP/HAP emissions reductions for this measure are provided in Table 13.

Table 13. CAP/HAP Emission Reductions for Measure M3 (short tons/year)

	2030
NOx	24.1
PM2.5	1.2
DPM	1.1

4. Measure M4: Battery Electric Locomotives Pilot Program

This measure is the replacement or repower of Class 1 to 3 diesel fueled freight locomotives domiciled in the South Coast Air Basin. Types of locomotives eligible are Switchers, Medium Horsepower (MHP), and Line Haul. Upgrading locomotives is capital intensive. Providing incentive funding would encourage the purchase of advanced technology as a replacement. Upgrade of locomotive provides the highest GHG emission reductions since many of them are still equipped with very large and uncontrol engines, and locomotives have a long service life. The number of ZE switcher locomotives for this measure is shown in Table 14.

Table 14. Number of Switcher Locomotives for Measure M4

	2025	2026	2027	2028	2029	2030
Switcher Locomotives			4	14		

The methodology for estimating the annual GHG emission reductions associated with the replaced switcher locomotives is based on the activity level in terms of the estimated annual diesel fuel consumption per locomotive and EPA's GHG emission factors for switcher locomotives.[17]

The average annual diesel fuel consumption for switcher locomotives operating at railyards was estimated to be 75,000 gallons per switcher based on the reported data for Class I switchers in 2017. [18]

The methodology for estimating GHG emissions from the electricity consumption associated with the operation of battery-electric switchers is based on the annual MWh of electricity that is calculated based on the estimated annual diesel fuel consumption, EPA's fuel conversion factor for switcher locomotives (15.2 hp-hr/gal)[19], and the corresponding GHG emissions factors for electricity generation adjusted for the assumed charging efficiency (i.e., charger efficiency and battery charging efficiency).

[17] EPA's 2024 GHG Emission Factor HUB (Table 2 for diesel fuel; Table 5 for locomotives), https://www.epa.gov/climateleadership/ghg-emission-factors-hub

[18] CARB's Methodology for Battery Electric Switcher Usage Pattern, https://ww2.arb.ca.gov/resources/fact-sheets/yes-california-grid-can-handle-electrification-all-switchers-all-railyards

[19] EPA's 2009 Technical Highlights Emission Factors for Locomotives (Table 3)

Since the annual diesel fuel consumption for switchers used in these calculations also includes idling operations, the estimated GHG emission reductions are conservative for battery-powered switcher locomotives as the electricity consumption for idling for these units is very small.

The annual and cumulative GHG emissions reductions for this measure for 2025 to 2030 and 2025 to 2050 periods are provided in Tables 15 and 16 below.

Table 15. GHG Emission Reductions for Measure M4 for 2025 to 2030 (metric tons CO_2e)

	2025	2026	2027	2028	2029	2030
Annual	0	0	2,835	12,755	12,755	14,130
Cumulative	0	0	2,835	15,590	28,345	42,476

Table 16. GHG Emission Reductions for Measure G4 for 2025 to 2050 (metric tons CO_2e)

	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
Annual	0	0	2,835	12,755	12,755	14,130	14,130	14,130	14,130	14,130	14,130	14,130	14,130
Cumulative	0	0	2,835	15,590	28,345	42,476	56,606	70,737	84,867	98,997	113,128	127,258	141,389

Table 16. GHG Emission Reductions for Measure G4 for 2025 to 2050 (metric tons CO_2e), continued

	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Annual	14,130	14,130	14,130	14,130	14,130	14,130	14,130	17,053	17,053	17,053	17,053	17,053	17,053
Cumulative	155,519	169,650	183,780	197,911	212,041	226,172	240,302	257,355	274,409	288,627	292,925	297,223	300,146

The methodology for estimating CAP/HAP emission reductions from switcher locomotives is based on the estimated annual fuel consumption, EPA's fuel conversion factor for switchers in terms of hp-hr/gal, and EPA's emission factors for switcher locomotives at Tier level[20] in terms of grams per hp-hr for NOx, PM10 and PM2.5.

For the purpose of estimating CAP/HAP emissions benefits for this measure, it is assumed that all replaced switchers will be Tier 0 switchers locomotives since significant number of these units still operate at railyards in California, as documented in CARB's 2022 emissions inventory for switcher locomotives.[21] The 2030 CAP/HAP emissions reductions for this measure are provided in Table 17.

Table 17. CAP/HAP Emission Reductions for Measure M4 (short tons/year)

	2030
NOx	285.0
PM2.5	9.2
DPM	10.0

For detailed emissions calculations, please refer to the GHG and CAP/HAP Emission Reductions Calculations Spreadsheet attached to this application.

[20] EPA's 2009 Technical Highlights Emission Factors for Locomotives (Table 2)
[21] CARB's 2022 Class 1 Switcher Rail Yard Emissions Inventory (Figure 6) https://ww2.arb.ca.gov/our-work/programs/msei/road-categories/road-diesel-models-and-documentation

2. Jobs Estimation Calculator

Background

Estimating job creation from targeted investment is critical to understanding project impact. However, estimating this impact is challenging. Typically, economic models are used to describe relationships, test various scenarios, and understand optimal outcomes. However, existing models (including Argonne National Laboratory's JOBS EV and the Bureau of Economic Analysis RIMS II, among many) do not meet project specific needs, exist in an accessible format, and/or fit project constraints. Therefore, a custom jobs estimation calculator was created to better understand impacts from this project and inform decisions.

The developed Calculator combines existing research on the EV industry and supply chains with insider EV market knowledge. While this calculator is not an economic model, it uses insights from prior economic modeling to create a tool to understand, explore, and estimate the relationship between investment and job creation.

Methods

The Calculator requires users to input specific number of EV equipment into the model. The number of equipment is multiplied by market cost, job multipliers, and regional distribution of EV supply chain jobs to give users a comprehensive assessment of job creation based on investment.

$$\left(Number\ of\ Equipment * \ Cost\ per\ Unit * \frac{Median\ Direct\ Jobs}{\$1\ Invested}\right) + \left(Number\ of\ Equipment * \ Cost\ per\ Unit * \frac{Median\ Indirect\ \&\ induced\ Jobs}{\$1\ Invested}\right) = Total\ Jobs\ Created$$

Total jobs created are then broken down into eight (8) regions, to better describe the distribution of investment.

Equipment Costs

Equipment costs for medium-duty EVs (MDEV), heavy-duty EVs (HDEV), DC fast chargers (DCFC), level 2 chargers (L2), battery electric storage systems (BESS), solar microgrids, electric locomotives, and cargo-handling equipment are based on the average cost of specific equipment based on information from manufacturers, previous projects, and publicly available data.

Job Multipliers

The job creation estimates are based on job multipliers created from reports from EDF[22] and PERI.[23]

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[22] Environmental Defense Fund. (2024). U.S. Electric Vehicle Manufacturing Investments and Jobs: Characterizing the Impacts of the Inflation Reduction Act after 18 Months. https://www.edf.org/sites/default/files/2024-03/EDF_US_EV_Manufacturing_Investments_Spring2024.pdf

[23] Pollin, R., Chakraborty, S., & Wicks-Lim, J. (2021). Employment impacts of proposed us economic stimulus programs: Job creation, job quality, and demographic distribution measures. Political Economy Research Institute. https://peri.umass.edu/publication/item/1397-employment-impacts-of-proposed-u-s-economic-stimulus-programs

Based on the EDF's recent analysis, $185.6 billion in investments was associated with 194,500 created/retained jobs. This translates to 1.05 jobs created per $1 million invested. Additionally, the EDF estimated that indirect and induced jobs were +7 for each direct EV manufacturing job and +2.5 for each direct EV battery job.

Another report, from Pollin et al. (2021) from PERI, estimated job creation from public investment. Based on this report, for every $1 million invested in high-efficiency autos, one can expect 1.4 direct jobs and 7.2 indirect and induced jobs, for a total of 8.6 jobs. The report also found 3.8 direct jobs and 7.5 indirect/induced jobs for every million invested in solar energy.

The Calculator uses the median of these two reports to determine a jobs multiplier for every dollar invested in the specific type of equipment (EV general, EV batteries, or solar).

Regional Distribution

To determine regional distribution of jobs, the total jobs created are multiplied using a regional distribution multiplier, determined from the comprehensive assessment of EV supply chain from Turner (2024)[24].

$$Total\ Jobs\ Created * \frac{Regional\ Number\ of\ Supply\ Chain\ Sites}{All\ EV\ Supply\ Chain\ Activity} = Regional\ Distribution\ of\ Jobs$$

[24] Turner, J. M. (2024). US and Canada Electric Vehicle Supply Chain Map. Charged: A History of Batteries and Lessons for a Clean Energy Future. Retrieved from https://www.charged-the-book.com/na-ev-supply-chain-map[1]