APPENDIX C

VOC EMISSIONS, GALLON LIMITS AND EMISSIONS AVOIDED METHODOLOGY

A. Summary

The proposed volatile organic compound (VOC) limit for the Photovoltaic Coatings category is 600 grams per liter (g/l). The use of Photovoltaic Coatings is projected to cause a one-time release of VOC emissions in air districts where the coating would potentially be applied to uncoated solar modules. This appendix describes the assumptions and methodology used in the proposed 2020 SCM emissions analysis, which includes estimates of the VOC emissions from using Photovoltaic Coatings; the proposed volume limits; and the estimated greenhouse gas and criteria pollutant emissions avoided from the increased electricity generated by coated solar modules.

B. Calculating VOC Content of Coatings

The terms VOC Regulatory and VOC Actual are used in architectural coatings rules. The VOC Regulatory of a coating/colorant is equivalent to the term "VOC, less water and exempts." The VOC Actual is equivalent to the term "VOC, including water and exempts."

The VOC Regulatory calculates the VOC less exempts and water. It subtracts the volume of water and the volume of exempt compounds from the volume of material in the denominator. The calculation was derived to express the VOC emitted per volume of coating solids to eliminate the effect of dilution. Dilution with water or exempt solvents would reduce the VOC-to-paint-volume ratio while maintaining a constant VOC-to-paint/adhesive-solids ratio. This is important because those materials are applied at a certain film thickness so dilution would result in a larger volume of the material being applied to achieve the same film thickness. For conventional solvent based products with no exempt compounds, the two values are the same.

For waterborne coatings and coatings containing exempt compounds, the VOC Regulatory is always higher than the VOC Actual. For all coating categories except the Low Solids coatings category and the proposed Photovoltaic Coating category, the limits are VOC Regulatory. Low Solids coatings are regulated based on VOC Actual, as well as the proposed Photovoltaic Coatings. VOC emissions are always calculated based on the VOC Actual.

The following equations are used to determine VOC Actual and VOC Regulatory content of an architectural coating.

$$VOC_{Actual} = \frac{W_{vm} - W_w - W_e}{V_c}$$

(Also known as Material VOC)

$$VOC_{Regulatory} = \frac{W_{vm} - W_w - W_e}{V_c - V_w - V_e}$$

(Also known as Coating VOC)

$$VOC_{Regulatory\ \ (Low\ Solids)} = \frac{W_{vm} - W_w - W_e}{V_c}$$

Where:

W_{vm} = Total weight of volatile materials (VOC+water+exempt compounds) in the coating, in grams
W_w = Weight of water in the coating, in grams
W_e = Weight of exempt compounds in the coating, in grams
V_c = Total volume of the coating, in liters
V_w = Volume of water in the coating, in liters
V_e = Volume of exempt compounds in the coating, in liters

For coatings with low solids content (like Photovoltaic Coatings) the VOC Actual and the VOC Regulatory Low Solids are the same.

C. Methodology for VOC Emissions

Assumptions

CARB staff used the following assumptions to calculate VOC emissions, gallon limits, and emissions avoided:

- For eight of the nine districts, the district's CEQA threshold is in tons per day (TPD). This threshold cannot be exceeded by emission increases from Photovoltaic Coatings. San Joaquin Valley APCD is the only district where a CEQA threshold is in tons per year (TPY). This is reflected in the "VOC Emissions" and "Gallon Limits" calculations.
- When determining "VOC Emissions" and "Gallon Limits", staff assumed a coverage rate of 0.014 liters/meter squared.
- When determining "VOC Emissions" and "Gallon Limits", staff used the proposed Photovoltaic Coatings VOC limit of 600 g/l
- When determining "Emissions Avoided", staff assumed solar sites operate on average 2,231 hours per year. This assumption was determined through 2018 GIS data from the California Energy Commission (CEC).
- When determining "Emissions Avoided", staff assumed a 2017 California overall GHG emission factor of 0.22 metric tons carbon dioxide equivalent per megawatt hour.

CARB staff used the following data provided by one of the major solar coating manufacturers to estimate district VOC emissions, gallon Limits and statewide emissions avoided from GHG and criteria pollutants.

Table C-1 shows data for solar sites within the nine impacted districts where staff believes there is potential for Photovoltaic Coatings to be applied.

Table C-1
Potential Solar Sites for Photovoltaic Coatings

Air District	Solar Project Name[1]	MW (DC)[1]	Module Surface Area (meters squared)[1]	Number of Modules[1]
Antelope Valley AQMD	Sierra	22.5	0.72	256,800
Antelope Valley AQMD	Antelope Valley Phase 1	255.4	0.72	3,114,560
Antelope Valley AQMD	Antelope Valley Phase 2	61.7	0.72	685,440
Antelope Valley AQMD	Alpine Solar	92.4	0.72	1,087,000
Eastern Kern APCD	Rosamond	38.8	0.72	430,556
Eastern Kern APCD	Catalina	143.2	0.72	1,591,111
Imperial Valley APCD	ISEC South Phase 1	26.5	0.72	353,440
Imperial Valley APCD	ISEC South Phase 2	145.8	0.72	1,943,893
Imperial Valley APCD	Mount Signal Solar	265.8	0.72	3,120,000
Imperial Valley APCD	ISEC West Solar	182.3	0.72	2,278,750
Imperial Valley APCD	Calipatria	22.1	1.23	130,000
Imperial Valley APCD	Solar Gen 2	194	0.72	2,425,000
Imperial Valley APCD	Campo Verde	184	0.72	2,300,000
Mojave Desert AQMD	Blythe Solar	27.3	0.72	341,250
Mojave Desert AQMD	McCoy	325	0.72	2,888,904
Mojave Desert AQMD	Desert Stateline	392	0.72	3,200,000
Monterey Bay ARD	California Flats	169	0.72	1,502,230
Sacramento Metro AQMD	Bruceville Phase 1	1.2	0.72	15,195
Sacramento Metro AQMD	Bruceville Phase 2	20.7	0.72	258,323

Air District	Solar Project Name[1]	MW (DC)[1]	Module Surface Area (meters squared)[1]	Number of Modules[1]
Sacramento Metro AQMD	Boessow	3.7	0.72	45,630
Sacramento Metro AQMD	Point Pleasant	1.2	0.72	15,210
Sacramento Metro AQMD	Kost	3.7	0.72	45,630
Sacramento Metro AQMD	Dillar	11.3	1.94	39,600
Sacramento Metro AQMD	Bruceville	18.8	1.94	66,000
Sacramento Metro AQMD	Kammerer	18.8	1.94	66,000
Sacramento Metro AQMD	McKenzie	18.8	1.94	132,000
San Joaquin Valley APCD	Avenal Solar Phase 1	7.7	1.42	60,000
San Joaquin Valley APCD	Avenal Solar Phase 2	49.9	1.42	390,000
San Joaquin Valley APCD	Kansas South Solar	27.1	1.63	113,280
San Joaquin Valley APCD	Regulus	81.6	1.95	247,273
San Joaquin Valley APCD	Redwood	100	0.72	1,111,000
San Joaquin Valley APCD	Lost Hills - Blackwell	45.5	0.72	505,555
San Joaquin Valley APCD	North Star	61.5	0.72	750,000
San Luis Obispo County APCD	Topaz	715	0.72	8,437,200
Santa Barbara APCD	Cuyama	40	0.72	472,011

1. This data is provided by Pellucere Technologies Inc.

Table C-2 shows the district totals for the facilities listed in Table C-1.

Table C-2
District Totals for Potential Photovoltaic Coatings Sites

Air District	MW[1]	Weighted Average Module Surface Area (meters squared)[1]	Number of Modules[1]
Antelope Valley AQMD	432	0.72	5,143,800
Eastern Kern APCD	182	0.72	2,021,667
Imperial Valley APCD	1,021	0.73	12,551,083
Mojave Desert AQMD	744	0.72	6,430,154
Monterey Bay ARD	169	0.72	1,502,230
Sacramento Metro AQMD	98	1.26	683,588
San Joaquin Valley APCD	373	0.95	3,177,108
San Luis Obispo County APCD	715	0.72	8,437,200
Santa Barbara APCD	40	0.72	472,011

1. This data is provided by Pellucere Technologies Inc. The total megawatts per district may not equal the sum of megawatts in a district from Table C-1 due to rounding.

The following equations were used to determine the district weighted average module surface area in meters squared.

Equation 1:

$$\textbf{Project Weighted Average Module Surface Area } (m^2) = \text{Module Surface Area at Project} * \frac{\text{Number of Modules at Project Site}}{\text{Number of Modules in Air District}}$$

(Note: All these variables are from Table C-1)

Equation 2:

$$\textbf{District Weighted Average Module Surface Area } (m^2) = \Sigma \text{ Project Weighted Average Module Surface Area}$$

(Note: Values are from results of Equation 1)

Example Eastern Kern Weighted Average Module Surface Area Calculation

Table C-3
Eastern Kern APCD Module Surface Area and Number of Modules

Air District	Solar Project Name	Module Surface Area[1] (m^2)	Number of Modules[1]
Eastern Kern APCD	Rosamond	0.72	430,556
Eastern Kern APCD	Catalina	0.72	1,591,111

1. The values for module surface area and number of modules are from table C-1.

$$Rosamond\ Weighted\ Average\ Surface\ Area\ (m^2) = (0.72) * \frac{430{,}556}{2{,}021{,}667} = \mathbf{0.15}$$

$$Catalina\ Weighted\ Average\ Surface\ Area\ (m^2) = (0.72) * \frac{1{,}591{,}111}{2{,}021{,}667} = \mathbf{0.57}$$

$$Eastern\ Kern\ APCD\ Weighted\ Average\ Surface\ Area\ (m^2) = 0.15 + 0.57 = \mathbf{0.72}$$

Table C-4 shows the total potential VOC emissions if all projects identified to date are completed in each air district and the corresponding CEQA Threshold.

Table C-4
Potential Project VOC Emissions and CEQA Thresholds by Air District

Air District	Potential Project VOC Emissions (tons)	CEQA Threshold (TPD)
Antelope Valley AQMD	34	0.0685
Eastern Kern APCD	13	0.0685
Imperial Valley APCD	84	0.0685
Mojave Desert AQMD	43	0.0685
Monterey Bay ARD	10	0.0685
Sacramento Metro AQMD	8	0.0325
San Joaquin Valley APCD[1]	28	N/A
San Luis Obispo County APCD	56	0.0685
Santa Barbara APCD	3	0.0685

1. The San Joaquin Valley APCD does not have an applicable daily CEQA limit, its applicable limit is an annual CEQA threshold of 10 TPY.

The following equations were used to determine the total VOC emissions in a district.

Equation 3:

$$\textbf{Total Surface Area } (m^2) = \text{Total Number of Modules} * \text{Weighted Average Module Surface Area } (m^2)$$

(Note: All these variables are from Table C-2)

Equation 4:

$$\textbf{Total Volume } (l) = \text{Total Surface Area } (m^2) * \text{coverage rate } \left(\frac{l}{m^2}\right)$$

(Note: Total Surface Area (m^2) is from Equation 3. The coverage rate is from CARB staff's assumptions)

Equation 5:

$$\textbf{Total Emissions } (\textbf{tons}) = \frac{\text{Total Volume } (l) * \text{VOC Limit } \left(\frac{g}{l}\right)}{\text{Conversion Factor } \left(\frac{g}{ton}\right)}$$

(Note: Total Volume is from Equation 4. The VOC limit is from CARB staff's assumptions. Conversion Factor is 907,185)

Example Eastern Kern VOC Emission Calculation

$$\textbf{Total Surface Area } (m^2) = 2{,}021{,}667 * 0.72\ (m^2) = \mathbf{1{,}455{,}600}$$

$$\textbf{Total Volume } (l) = 1{,}455{,}600\ (m^2) * 0.014\ \left(\frac{l}{m^2}\right) = \mathbf{20{,}378}$$

$$\textbf{Total Emissions } (\textbf{tons}) = \frac{20{,}378\ (l) * 600\ \left(\frac{g}{l}\right)}{907{,}185\ \left(\frac{g}{ton}\right)} = \mathbf{13}$$

D. Methodology for Gallon Limits and Equivalent Megawatts

CARB staff used an approach similar to the one used to calculate VOC emissions to calculate equivalent megawatts and volume limits.

Table C-5 shows equivalent megawatts and the number of modules that can be coated and volume in gallons per district based on corresponding CEQA Threshold from table C-4.

Table C-5
Equivalent Daily Megawatts, Number of Modules and Volumes per District

Air District	Daily MW	Daily Number of Modules	Daily Volume (Gallons)
Antelope Valley AQMD	0.9	10,274	27.4
Eastern Kern APCD	0.9	10,275	27.4
Imperial Valley APCD	0.8	10,200	27.4
Mojave Desert AQMD	1.2	10,274	27.4
Monterey Bay ARD	1.2	10,275	27.4
Sacramento Metro AQMD	0.4	2,777	13
San Joaquin Valley APCD[1]	3.4	27,399	101.3
San Luis Obispo County APCD	0.9	10,275	27.4
Santa Barbara APCD	0.9	10,274	27.4

1. San Joaquin Valley APCD has a daily and annual gallon limit. The annual values are 1,139,621 modules coated per year and volume of 3,994 gallons/year based on CEQA Threshold of 10 TPY.

The differences in daily megawatts for districts with the same daily volume limit found in Table C-5 is due to variations in solar module technologies. For instance, the capacity and surface area of a module used in one district is different than what is used in another. Therefore, this will result in different daily megawatts even though the daily volume limit is the same.

The following equations were used to calculate equivalent megawatts and number of modules that can be coated per district based on corresponding CEQA Threshold in TPD.

Equation 6:

$$\boldsymbol{Volume\ (l)} = \frac{CEQA\ Threshold\ (TPD) * Conversion\ Factor\ \left(\frac{g}{ton}\right)}{VOC\ Limit}$$

(Note: CEQA Threshold is from Table C-4. The VOC limit is from CARB staff's assumptions. Conversion factor is 907,185)

(Multiply the volume by 0.26417 gallons per liter to convert liters to gallons if desired)

Equation 7:

$$\textbf{Total Surface Area } (\boldsymbol{m^2}) = \frac{Volume\ (l)}{Coverage\ Rate\ \left(\frac{l}{m^2}\right)}$$

(Note: Volume is from Equation 6. The coverage rate is from CARB staff's assumptions)

Equation 8:

$$\textbf{Number of Modules} = \frac{Total\ Surface\ Area\ (m^2)}{Weighted\ Average\ Module\ Surface\ Area\ (m^2)}$$

(Note: Total Surface Area (m^2) is from Equation 7. Weighted Average Module Surface Area (m^2) is from Table C-2)

Equation 9:

$$\textbf{Daily Equivalent Megawatts } (\boldsymbol{MW_e}) = \frac{CEQA\ Number\ of\ Modules}{Number\ of\ Modules} * Megawatts$$

(Note: CEQA Number of Modules is from Table C-5. Number of Modules and Megawatts are from Table C-1)

Example Eastern Kern Daily Number of Modules Calculation

$$\textbf{Volume } (\boldsymbol{l}) = \frac{0.0685\ TPD * 907{,}185\ \left(\frac{g}{ton}\right)}{600\ \left(\frac{g}{l}\right)} = \mathbf{103.57}$$

$$\textbf{Total Surface Area } (\boldsymbol{m^2}) = \frac{103.57\ \frac{l}{day}}{0.014\ \frac{l}{m^2}} = \mathbf{7{,}397.88}$$

$$\textbf{Number of Modules} = \frac{7397.88\ m^2}{0.72\ m^2} = \mathbf{10{,}275}$$

$$\textbf{Daily Equivalent Megawatts } (\boldsymbol{MW_e}) = \frac{10{,}275}{2{,}021{,}667} * 182 = \mathbf{0.9}$$

Table C-6 shows the gallon limits and equivalent yearly megawatts. Through discussions with manufacturers, staff assumed 150 coating days per year. These values are rounded down from the values in Table C-5. The objective of rounding down is to make sure that the proposed gallon limits do not exceed a district's CEQA Threshold.

Table C-6
Proposed Daily Gallon Limits and Equivalent Megawatts

Air District	Daily Volume Limit (Gal)	Equivalent MW Coated Annually[2]
Antelope Valley AQMD	27.0	128
Eastern Kern APCD	27.0	137
Imperial Valley APCD	27.0	123
Mojave Desert AQMD	27.0	176
Monterey Bay ARD	27.0	171
Sacramento Metro AQMD	12.5	58
San Joaquin Valley APCD[1]	100.0	131
San Luis Obispo County APCD	27.0	129
Santa Barbara APCD	27.0	129

1. An annual volume limit of 3,900 gallons per year is applicable in the San Joaquin Valley APCD. The annual equivalent megawatts are shown in Table C-6.
2. Data from a major Photovoltaic Coating manufacturer shows 170 to 210 viable coating days, staff assumed 150 coating days per year.

E. Methodology for Emissions Avoided

Staff took the following steps to determine the emissions avoided over 10 years from power plants through a three percent energy gain from Photovoltaic Coatings:

1. Retrieve data from the California Energy Commission (CEC). Data included California energy generation and capacity from all sources excluding renewable energy sources such as wind, hydro, solar, geothermal and nuclear. Separate data was taken only for solar photovoltaic (PV). The data year used is 2017 (CEC, 2019).

2. Retrieve data from CARB criteria pollutants inventories. Criteria Pollutants analyzed include carbon dioxide (CO_2), nitrogen oxides (NO_x), sulfur oxides (SO_x), particulate matter with particle size of 10 microns or less (PM_{10}), particulate matter with particle size of 2.5 microns or less ($PM_{2.5}$), volatile organic compounds (VOC) and carbon monoxide (CO). The data year used is 2017 (CARB, 2020).

3. Retrieve the California greenhouse gas (GHG) emission factor. The emission factor used is 0.22 metric ton carbon dioxide equivalent per

megawatt hour . This is for the overall GHG intensities. Total electricity emissions (sum of in-state generation and imports) divided by the sum of tc($\frac{MT\ CO_2e}{MWh}$)Wh consumed in California and MWh exported out of California. Transmission and distribution losses are not represented in the consumption number (CARB, 2018b; CARB, 2019b).

4. Calculate a CARB emission factor for the criteria pollutants and GHG in pounds per megawatt hour using the collected data in steps 1-3.

5. Calculate the tons for GHG and criteria pollutants over a 10-year period.

Step 1: Data Collected from CEC

Table C-7 shows the total energy generated and capacity from CEC collected data. The first three columns (from left to right) show the total generated energy and capacity from all California electricity sources. The remaining three columns are total generated energy and capacity from all California solar photovoltaic sites. As mentioned previously, these values exclude renewable energy sources such as wind, hydro, solar, geothermal and nuclear.

Table C-7
Generated Energy and Capacity from California Energy Source

Generated GWh Overall	Capacity MW Overall	Hours Operated Overall	Solar PV Generated GWh	Solar PV Capacity MW	Solar PV Operated (Hours)
96,187	44,036	2,184	21,895	9,812	2,231

(CEC, 2019)

The following equation was used to calculate average hours operated.

Equation 10:

$$\boldsymbol{Hours\ Operated} = \frac{Energy\ Generated}{Capacity} * \frac{1{,}000\ MW}{GW}$$

(Note: All variables are from Table C-7)

Step 2: Data Collected from CARB Criteria Pollutants Inventory

Table C-8 shows the total criteria pollutants from CARB's California Emissions Inventory Development and Reporting System (CEIDAR). Staff believes there are potential 3,774 MW in California from solar photovoltaic (PV) modules that can be coated with Photovoltaic Coatings. Based on data provided by the coating manufacturers, modules coated with a Photovoltaic Coating can achieve three to four percent in energy gains. Staff used three percent energy gain to estimate the potential emissions avoided. Three percent of 3,774 MW is 113 MW.

Table C-8
CARB Total Criteria Pollutant Emissions

Criteria Pollutant	NO_x (Tons)	SO_x (Tons)	PM_{10} (Tons)	$PM_{2.5}$ (Tons)	VOC (Tons)	CO (Tons)
CEIDARS	8,703.6	695.7	2,197.7	2,075.4	1,454.3	15,701.5
3% PV Adjusted (Equation 11)	22.8	1.8	5.8	5.4	3.8	41.2

(CARB, 2020)

- Through discussions with coating manufacturers, staff assumed 3,774 MW from solar PV modules are eligible for Photovoltaic Coatings. An energy gain of three percent is used. Three percent of 3,774 MW is 113 MW.
- The top row shows the totals for criteria pollutants from California Emissions Inventory Development and Reporting System (CEIDAR). The top row is not emissions avoided from the 3,774 MW. The bottom row are values calculated using equation 11. They will be used to determine an emission factor for calculating emissions avoided.

The remaining example calculations will use a 3% energy gain of 113 MW in the equations.

Equation 11:

$$\boldsymbol{Criteria\ Pollutant\ 3\%\ PV\ Adjusted\ (Tons)} =$$

$$Total\ Criteria\ Pollutant\ Tons * \frac{3\%\ of\ Total\ PV\ Potential\ MWh}{Total\ MWh\ From\ Energy\ Sources}$$

(Note: Total Criteria Pollutant Tons is from Table C-8. 3% of Total PV Potential MWh is calculated from Tables C-7 and C-8. Total MWh from Energy Sources is calculated by values from Table C-7.)

Example NO_x Adjusted Tons Calculation

$$\boldsymbol{NO_x\ 3\%\ PV\ Adjusted\ (Tons)} = 8703.6\ Tons * \frac{113\ MW * 2231\ Hrs}{44{,}036\ MW * 2{,}184\ Hrs} = \mathbf{22.8}$$

Step 3: Data Collected from CARB GHG Inventory

Table C-9 shows the 2014 - 2017 CARB GHG in-state, imports and overall emissions factors in metric tons carbon dioxide per megawatt hour. For this analysis, staff used the most recent data year of 2017 overall emission factor of 0.22 $\left(\frac{MT\ CO_2e}{MWh}\right)$

Table C-9
2014-2017 CARB GHG Emission Factors

Parameter	2014 (MT CO_2e/ MWh)	2015 (MT CO_2e/ MWh)	2016 (MT CO_2e/ MWh)	2017 (MT CO_2e/ MWh)
In-State[1]	0.25	0.25	0.20	0.18
Imports	0.35	0.33	0.26	0.25
Overall[2]	0.31	0.29	0.24	0.22

(CARB, 2018b; CARB, 2019b)

1. In-state electricity emissions and MWh generation include commercial-scale power plants, on-site generation for on-site use, cogeneration emissions attributed to electricity generation, in-state generated electricity exported out of state, and rooftop solar.
2. Total electricity emissions (sum of in-state generation and imports) divided by the sum of total MWh consumed in California and MWh exported out of California. Transmission and distribution losses are not represented in the consumption number.

Step 4: Calculate CARB Emission Factors for Criteria Pollutants in Pounds per Megawatt Hour

Table C-10 shows the calculated CARB emission factors in pounds per megawatt hour for the criteria pollutants and GHG.

Table C-10
CARB Criteria Pollutant and GHG Emission Factors

NO_x (lb/MWh)	SO_x (lb/MWh)	PM_{10} (lb/MWh)	$PM_{2.5}$ (lb/MWh)	VOC (lb/MWh)	CO (lb/MWh)	CO_2 (lb/MWh)
0.18	0.01	0.05	0.04	0.03	0.33	484

The following equations were used to calculate emission factors in pounds per megawatt hour for criteria pollutants and GHG.

Equation 12 (used for criteria pollutants):

$$\textbf{Emission Factor}\left(\frac{\boldsymbol{lb}}{\boldsymbol{MWh}}\right) = \frac{3\%\ PV\ Adjusted\ (tons)}{3\%\ of\ Total\ PV\ Potential\ MWh} * \frac{Pounds}{Ton}$$

(Note: 3% PV Adjusted (tons) is from Table C-8. 3% of Total PV Potential MWh is calculated from Tables C-7 and C-8. Multiply 2000 pounds to convert to US tons)

Equation 13 (used for GHG):

$$\textbf{Emission Factor}\left(\frac{\boldsymbol{lb}}{\boldsymbol{MWh}}\right) = 0.22\ \frac{MT\ CO_2e}{MWh} * \frac{Pounds}{Metric\ Ton}$$

For both Equation 12 and 13, multiply 2200 pounds to convert to metric tons.

Example NO_x Emission Factor Calculation

$$\textbf{Emission Factor}\left(\frac{\boldsymbol{lb}}{\boldsymbol{MWh}}\right) = \frac{22.8\ tons}{113\ MW\ *\ 2231\ Hrs} * \frac{2000\ lb}{Ton} = \mathbf{0.18}$$

Step 5: 10 Year Emissions Avoided from GHG and Criteria Pollutants

Table C-11 shows the calculated CARB emissions avoided for criteria pollutants and GHG. GHG is in metric tons whereas criteria pollutants are in US tons.

Table C-11
Emissions Avoided

Fuel Type	CO_2 (Metric Tons)	NO_x (Tons)	SO_x (Tons)	PM_{10} (Tons)	$PM_{2.5}$ (Tons)	VOC (Tons)	CO (Tons)
California Electricity Mix	554,627	227	13	63	50	38	416

- Reflects emissions avoided from GHG and criteria pollutants for power plant over a 10-year period.
- Assumes 3% (~113 MW equivalent) increase Photovoltaic capacity due to the application of the coatings.
- California electricity mix is derived from GHG and criteria pollutant inventories, and California Energy Commission electricity generation data. (CARB, 2018b; CARB, 2019b; CARB, 2020; CEC, 2019; CEC, 2020)

The following equations were used to calculate the emissions avoided from GHG and criteria pollutants.

Equation 14:

$$\boldsymbol{Emissions\ Avoided\ (Tons)} =$$

$$3\%\ of\ Total\ PV\ Potential\ MWh * Emission\ Factor\ \left(\frac{lb}{MWh}\right) * \frac{Tons}{lb} * 10\ Years$$

(Note: 3% of Total PV Potential MWh is calculated from Tables C-7 and C-8. Emission Factor is from Table C-10. Divide by 2000 pounds to convert to US tons.)

Divided 2200 pounds to convert to metric tons.

Example NO_x 10 Year Emissions Avoided Calculation

$$Emissions\ Avoided\ (Tons) = 113\ MW * 2231\ Hrs * 0.18 \frac{lb}{MWh} * \frac{Tons}{2000\ lbs} * 10\ Yrs$$
$$= \mathbf{227}$$

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