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# Analysis of Successful Policy Implementation in California

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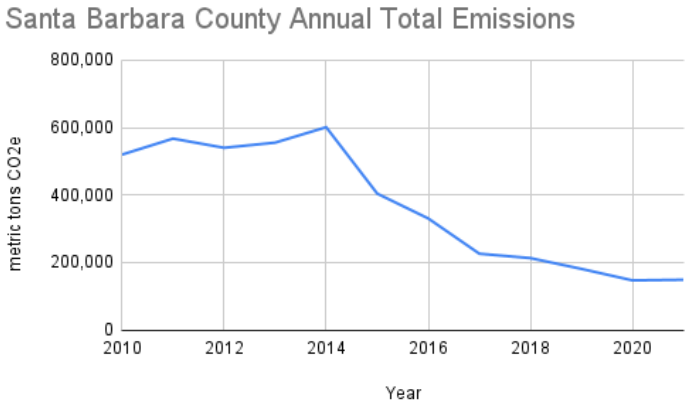
# 1 Abstract

With increasing greenhouse gas emissions rates, governments bear the responsibility of responding promptly with appropriate mitigation measures. The serious threat of anthropogenic climate change calls for the need for immediate action. California policies such as Assembly Bill 32 and Senate Bill 375 target greenhouse gas emissions across industries while focusing on minimizing the harm from anthropogenic climate change. Our research includes looking at the emission levels of our surrounding counties; Santa Barbara, San Luis Obispo, Ventura, and Kern which portray a downwards trend. We looked into policy to determine if it made a positive impact, or if the changes were due to other factors. Our research found several valuable insights into cleaner transportation initiatives, local energy production, and better land management strategies.

# 2 Background

Years of climate science confirms the threat of anthropogenic climate change. Where natural climate change are the usual cycles we observe over decades, human-caused or anthropogenic climate change alters these cycles.[34] Negative aspects of anthropogenic climate change arise from the accumulating greenhouse gas emissions in the atmosphere. As radiation from the sun approaches Earth, shortwave radiation passes through the atmosphere and is reflected off the surface as long-wave radiation. Some of this radiation is absorbed by greenhouse gasses in the lower atmosphere.[43] An accumulation of greenhouse gasses can then disrupt the natural climate cycles and amplify natural disasters. As the severity and number of amplified natural disasters increase, governments at all levels have a responsibility to respond with appropriate mitigation and adaptation policies. Mitigation policy focuses on stabilizing the greenhouse gasses in our atmosphere and adaptation policy focuses on preventing or minimizing the harm from anthropogenic climate change.[34] The state of California has passed several different bills to focus on greenhouse gas emissions and combat climate change in a variety of ways. One such law was Assembly Bill 32 (AB 32), The Global Warming Solutions Act of 2006. The law outlined the process for industry within the state to begin reporting emissions and set climate goals for the next 50 years.[33] Following AB 32, other legislation like Senate Bill 375 focused on the transportation sector's greenhouse gas emissions which contributed to 40 percent of emissions at the time.[10] The bill was the foundation for several programs counties later created to support clean vehicle initiatives. Our research began by looking at the emission levels of our surrounding counties; Santa Barbara, San Luis Obispo, Ventura, and Kern. We discovered a downward trend that can be seen in the figures below. We looked into policy to determine if policy made a positive impact, or if the changes were due to other factors. Our research found several valuable insights into cleaner transportation initiatives, local energy production, and better land management.

The following graphics detail the total annual emissions from the four focus counties. The emission data is gathered from the EPA "FLIGHT" tool and measured in CO2 equivalents. Most detail a downward trend that is explored in the discussion section. After, the following graphs depict the annual emissions per capita of each county. The population had little affect on the trend, but the metric tons of CO2 equivalents were mostly low with the notable exception of Kern County. The last set of graphs detail the different gas emissions for each county. Methane and nitrogen dioxide are more potent green house gases, but are still vastly less responsible for the total emissions compared to carbon dioxide. The data is measured in carbon dioxide equivalents, so fewer metric tons of the other gasses were released, but their equivalent effect is displayed.


Santa Barbara County Annual Total Emissions
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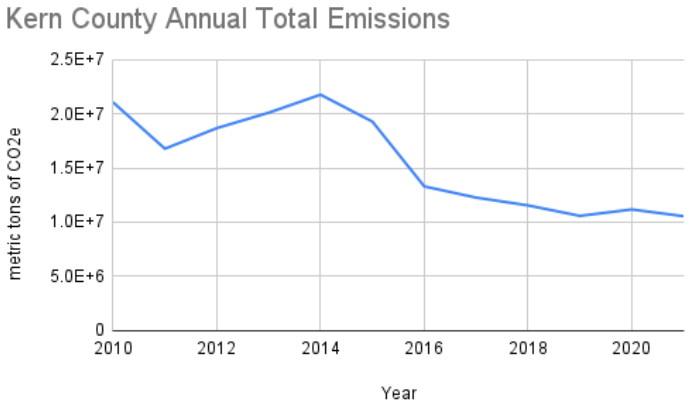
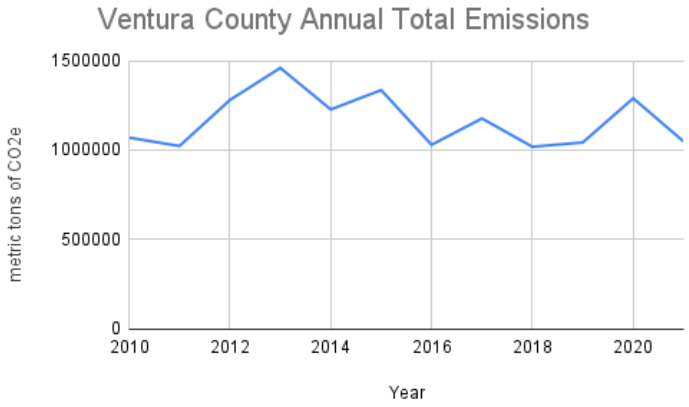
600,000
400,000
200,000
0
metric tons CO2e
2010
2012
2014
2016
2018
2020
Year


Kern County Annual Total Emissions
2.5E+7
2.0E+7
1.5E+7
1.0E+7
5.0E+6
0
metric tons of CO2e
2010
2012
2014
2016
2018
2020
Year


Ventura County Annual Total Emissions
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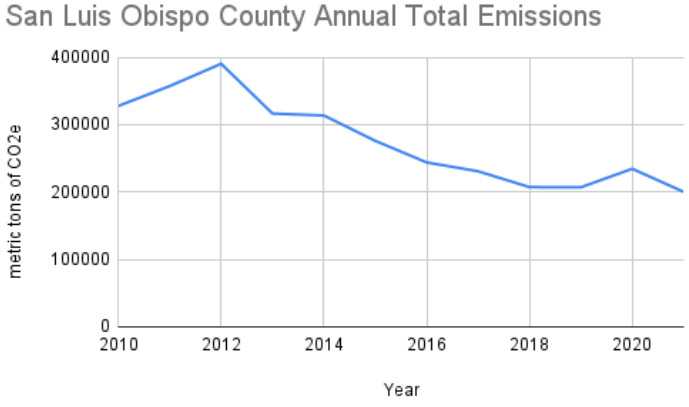
1000000
500000
0
metric tons of CO2e
2010
2012
2014
2016
2018
2020
Year


San Luis Obispo County Annual Total Emissions
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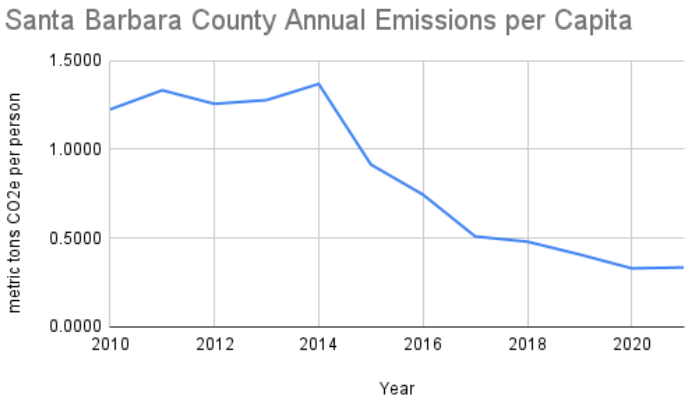
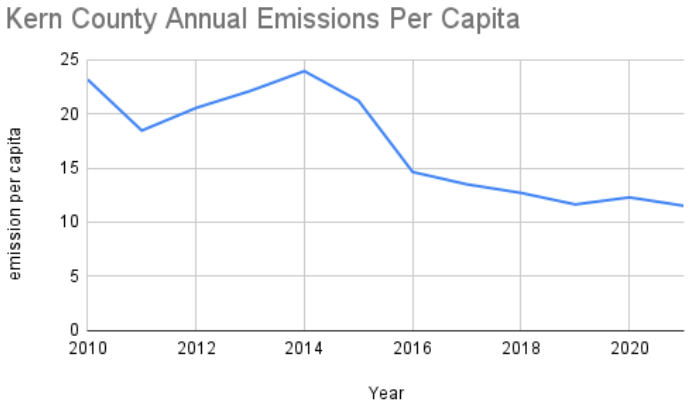
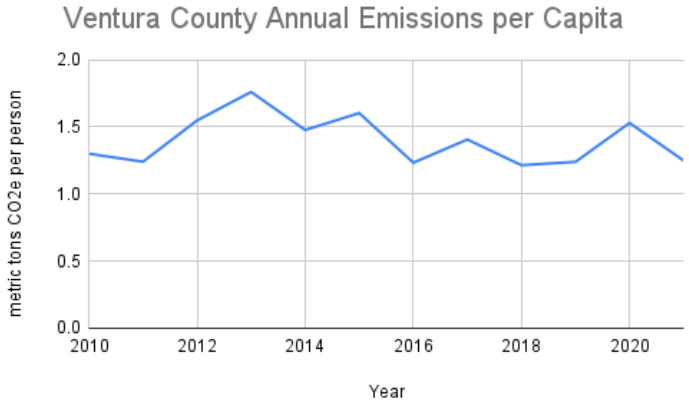
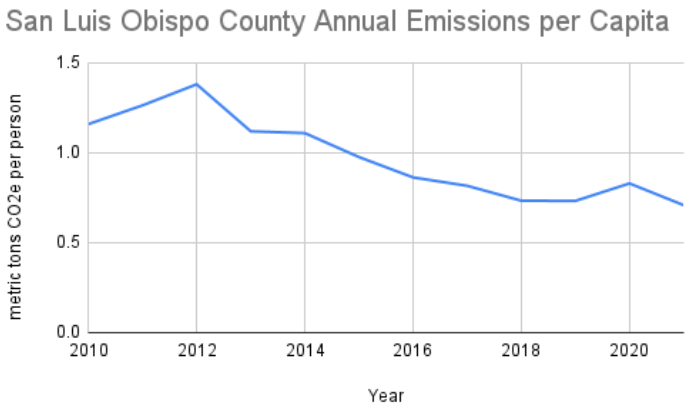
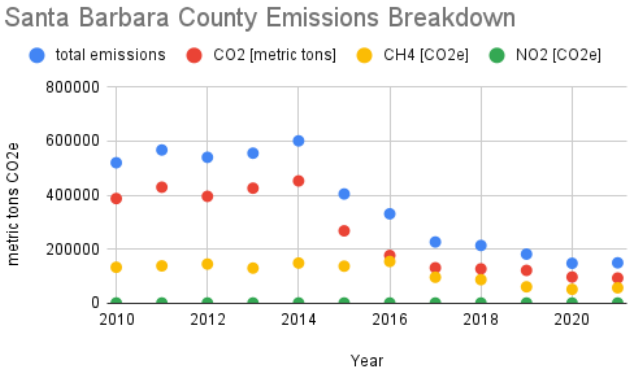
300000
200000
100000
0
metric tons of CO2e
2010
2012
2014
2016
2018
2020
Year

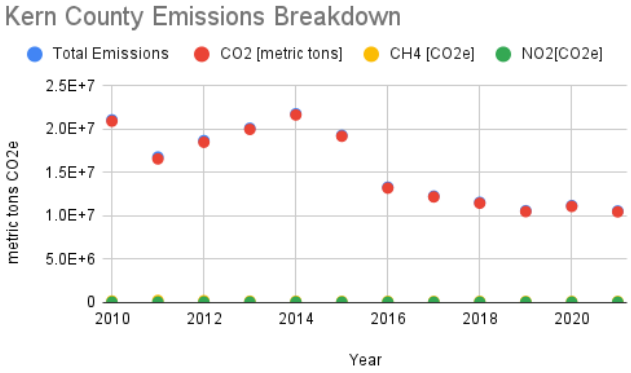

Santa Barbara County Annual Emissions per Capita
1.5000
1.0000
0.5000
0.0000
metric tons CO2e per person
2010
2012
2014
2016
2018
2020
Year

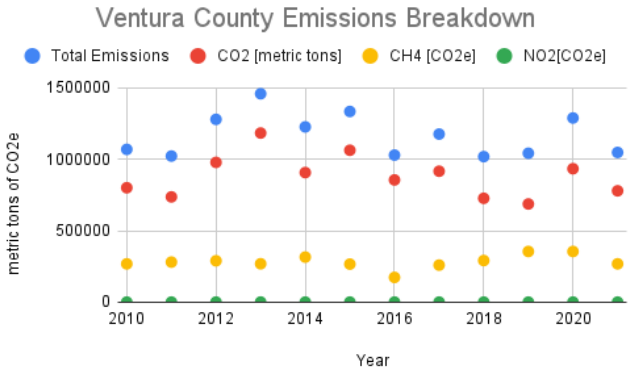

Kern County Annual Emissions Per Capita
25
20
15
10
5
0
emission per capita
2010
2012
2014
2016
2018
2020
Year

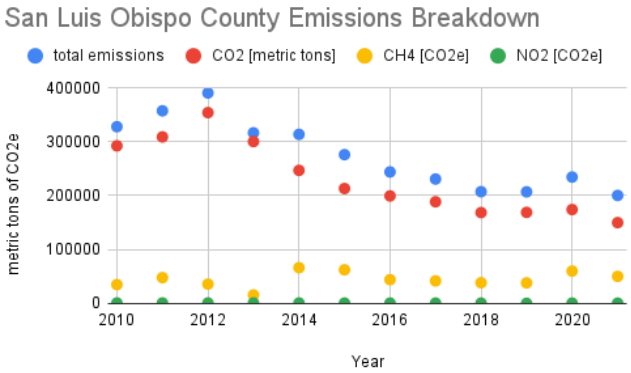

Ventura County Annual Emissions per Capita
2.0
1.5
1.0
0.5
0.0
metric tons CO2e per person
2010
2012
2014
2016
2018
2020
Year


San Luis Obispo County Annual Emissions per Capita
1.5
1.0
0.5
0.0
metric tons CO2e per person
2010
2012
2014
2016
2018
2020
Year




# 3 Transportation Policy

The transportation sector of California is an excellent area for policy implementation because it is responsible for roughly half of the state's greenhouse gas emissions.[16] The transportation sector includes personal use vehicles, public transport, private fleet trucking companies, as well as public service

vehicles. Current policies include rebate and voucher programs that create incentives for private, public, and personal clean air vehicles.

## 3.1 Clean Vehicle Rebate Program

The Clean Vehicle Rebate Program, CVRP, is the largest clean vehicle initiative in the state of California. The Clean Vehicle Rebate Program wants to promote the adoption of zero-emission vehicles while educating the public on new technology innovations in the transportation sector. CVRP works closely with the California Air Resources Board, California Energy Commission, as well as vehicle manufacturers.

Currently, the program has processed over 1 billion dollars in rebates since it began in 2010, benefitting over 450,000 rebate recipients. CVRP has also attended more than 1,000 events to educate and promote the use of zero-emission vehicles. Of all the approved and processed rebates, roughly 68 percent were for Battery electric vehicles, 29 percent were for plug-in hybrid vehicles, and 3 percent were for fuel-cell vehicles and other types of qualifying vehicles. The rebate program tends to work best in areas where commutes are common.[36]

The Clean Vehicle Rebate Program has shown the best implementation in the San Francisco and Los Angeles areas. Los Angeles County has 139,093 rebates totalling in 335,117,199 dollars. Likewise, Santa Clara County currently has 59,816 rebates totalling in 139,158,922 dollars. Northern California shows little to no involvement in the program, which will be a goal to analyze how effective the project would be if implemented in these areas. For example, Modoc County has only had one rebate since the program began in 2010.[36]

Based on information provided by CVRP, responses from the community demonstrate that the initiative is positive. The majority of respondents claim the rebate program was either very or extremely important in their decision to purchase a zero-emission vehicle.[41] Likewise, since 2013 the majority of respondents claim they replaced their current vehicle as opposed to adding it as an alternative means of transportation. The overall positive response to the rebate program gives an optimistic view for incorporating the project in areas that do not already implement the rebate program.[42]

## 3.2 Clean Truck and Bus Vouchers

The Clean Truck and Bus Voucher program, HVIP, aims to benefit disadvantaged communities by supplying alternative transportation for the low-income households. HVIP funds the purchase of zero-emission trucks, buses, and the necessary infrastructure to fuel or charge these alternative vehicles. The funds provided to the program go to public and private manufacturers of heavy-duty trucks and bus fleets. Currently, over 30 manufacturers participate in the HVIP initiative including Kenworth, Peterbilt, Ford, and Volvo.[26]

As of the end of 2022, over 800 million dollars have been allocated to the program, which helped fund over 11,000 clean vehicles. 64 percent of these projects have directly benefited disadvantaged communities and low-income households. The Clean Truck and Bus Voucher program has brought about an estimated reduction of nearly 1 billion metric tons of CO2 equivalence across 4,400 projects. These vouchers tend to work best when implemented in disadvantaged areas as well as areas that rely on the shipment of goods to or from a certain area.[26]

Similar to the Clean Vehicle Rebate Program, HVIP is most effective in the Los Angeles area and Bay Area of California. Los Angeles County has 4,664 vouchers totaling 327 million dollars. Looking at the entire Los Angeles area, there are a total of 7,757 vouchers with funding over half a billion dollars. Although not nearly as effective, Bay Area counties have roughly 1,700 vouchers totaling over 100 million dollars of funds.[27] The Bay Area has less agriculture than the surrounding counties of Los Angeles, therefore less of a need to transport goods via trucks. The biggest agricultural counties include Fresno and Kern which would be areas that could benefit the most from HVIP, but currently do not have the most involvement in the voucher program.

The Clean Truck and Bus Voucher program is tricky to navigate because California has a wide range of diversity in how the transportation system operates. In some areas, many people rely on the public transit system such as the Bay Area and Los Angeles. On the contrary, rural areas do not have the proper situation to effectively set up a useful public transit system. These areas include counties such

as Modoc and Shasta. Unfortunately, it would be difficult to incorporate the necessary infrastructure to have a lasting impact on the clean bus and truck industry in these areas.

### 3.3 Other Policies

Other important policies in California include the Executive Order N-79-20, requiring all new vehicles sold in California to be zero-emission vehicles by 2035.[12] In the Clean Air Act, Section 209, California is authorized to set stricter vehicle emissions standards than the federal standards.[46]

Therefore, this Executive order would require manufacturers and dealerships to transition to creating zero-emission vehicles, in turn requiring the public to purchase new vehicles that would reduce the emissions throughout the transportation sector. These stricter policies allow California to take larger steps in correcting carbon emissions.

Similarly, the Advanced Clean Cars II Rule restricts manufacturers to start the zero-emission vehicle ramp-up with the 2026 model. The regulation also tightens emissions from gasoline vehicles. The Advanced Clean Cars II is meant to enforce the executive order. To date, 17 other states have adopted California's prior zero-emission vehicle program, requiring car manufacturers to produce and deliver more low and zero-emitting vehicles.[5] Requiring all vehicle manufacturers to start making EV's provides an optimistic future for more EV's on the road.

The Electric Vehicle Charging Standards policy is also important because it standardizes charging requirements. Charging vehicles will be more accessible, straight-forward, and membership free.[25] Easier charging will hopefully motivate more consumers to purchase EV's. These policies reinforce new technical standards to support the future of more electric vehicles on the road in the state of California. It is very important to acknowledge the transportation sector with continued pushes toward net-zero emissions because half of California's emissions are produced by vehicles. These regulations put on manufacturers are an important step toward fully zero emissions.

### 3.4 Comparisons Between Electric Vehicles (EV's) and Traditional Gas-Powered Vehicles

Currently in the state of California, there are roughly 14 million registered vehicles on the road. According to McKinsey and Company, electric vehicles have twice the amount of emissions as a typical internal combustion engine during the manufacturing process. The embedded emissions due to the manufacturing of any vehicle chassis is responsible for between 5 and 10 metric tons of CO2 equivalents. Electric vehicles emit another 7 metric tons of CO2 equivalents to manufacture the lithium ion battery, totalling in between 12 and 17 metric tons of CO2 per electric vehicle. A typical internal-combustion vehicle emits 5 to 10 metric tons of CO2 equivalents during the manufacturing stage.[44]

The national average distance traveled in any vehicle is around 12,000 miles every year. The average gasoline vehicle emits around 24 lbs per gallon of gasoline depending on the year, make, and model. The national average gasoline efficiency is estimated to be 22 miles per gallon. Given these estimates, an average internal-combustion vehicle will emit about 5.9 metric tons of CO2 equivalents per year. These values are all assumptions made by the US Department of Energy.[6] These emissions are in addition to the initial 5 to 10 metric tons of CO2 equivalents due to manufacturing.

$$\frac{12,000mi}{year}\frac{1gal}{22mi}\frac{24lbs(CO_2e)}{1gal}\frac{1mton}{2204.6lbs} = \frac{5.9mton}{year}$$

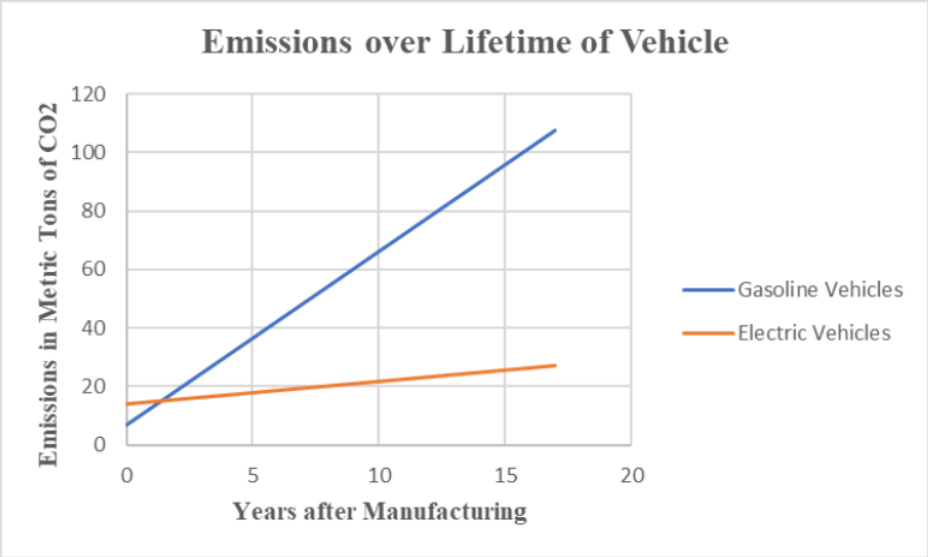
Although there are not direct emissions on a fully electric vehicle, there are indirect emissions associated with charging due to the electricity source. The majority of power across California is provided via a grid of mixed sources so it is very difficult to attribute a certain level of emissions to the charging of an electric vehicle. With that being said, nearly 51 percent of energy produced in California is attributed to non-renewable sources.[7] For simplicity's sake, this can be modeled by saying half of electric vehicles carry some amount of indirect emissions while driving and the other half do not. As of 2019, battery electric vehicles have a distance of about 3.6 miles per kW-hour of charge.[6] Given statistics on California provided by the annual Electric Power Report,[18] the average emissions from generated electricity in the state of California is as follows:

$$\frac{4507500 mtons CO_2}{197165000 MWh} \frac{1 MWh}{1000 kWh} = \frac{0.00023 mton CO_2}{kWh}$$

Indirect emissions for EV's can be calculated as follows:

$$\frac{12,000 mi}{year} \frac{1 kWh}{3.60 mi} \frac{0.00023 mton CO_2}{kWh} = \frac{0.762 mton CO_2}{year}$$

Comparing the lifetime emissions of each of these cars and using these estimates, it would take roughly one year of driving an EV to have a lower carbon footprint when compared to a typical gasoline vehicle. Conventional gasoline vehicles emit roughly 4 times the amount of CO2 over the course of 17 years when compared to EV's. The lifetime emissions of each type of vehicle can be seen below in the graph based on the calculations of annual emissions and manufacturing emissions.




Estimates show that there are over 900,000 electric vehicles [8] and roughly 13 million conventional gasoline vehicles [40] on the road in the state of California. Given these values, each year gasoline cars emit nearly 77 million metric tons of CO2e per year[D] whereas electric vehicles emit close to 340 thousand metric tons of CO2e per year[E]. Gasoline cars are responsible for a disproportionate amount of CO2 emissions even when considering the amount of vehicles on the road. Hypothetically, if the Clean Vehicle Rebate Program was able to take another half a million gasoline cars off the road by replacing them with electric vehicles, emissions due to cars would decrease by nearly 3 million metric tons of CO2e per year when considering the given assumptions. Perspectively, that is roughly equivalent to decommissioning roughly 15 power plants given annual emissions of 200 thousand metric tons of CO2e for each plant.

Emissions by Conventional Cars on the road today

$$13,000,000 cars \frac{5.9 mtons CO_2}{year} = 76,700,000 \frac{mtons CO_2}{year}$$

Emissions by Electric Vehicles on the road today

$$450,000 cars \frac{0.762 mtons CO_2}{year} = 342,900 \frac{mtons CO_2}{year}$$

$Total\ Emissions = 76,700,000 + 342,900 = 77042900 \frac{mtons CO_2}{year}$

Reduced Emissions of Conventional Cars due to Improved Effectiveness of CVRP

$$12,500,000 cars \frac{5.9 mtons CO_2}{year} = 73,750,000 \frac{mtons CO_2}{year}$$

Increased Emissions of EV's due to Improved Effectiveness of the Clean Vehicle Rebate

$$700,000 cars \frac{0.762 mtons CO_2}{year} = 533400 \frac{mtons CO_2}{year}$$

$Total\ Emissions = 73,750,000 + 533,400 = 74,283,400 \frac{mtons CO_2}{year}$

$Total\ Emissions\ Reduced\ by\ Switching\ to\ EV's = 77,042,900 - 74,283,400 = 2,759,500 \frac{mtons CO_2}{year}$

Although electric vehicles emit twice as much CO2 than regular gasoline vehicles during manufacturing, it is clear that EV's are drastically better for the environment when looking at the lifetime emissions of each type of vehicle. Switching from conventional gasoline vehicles to EV's are making huge impacts in lowering the overall emissions of the transportation sector.

To gain a better perspective on the effectiveness of the Clean Vehicle Rebate Program, it is important to look at a year by year basis for the surrounding Santa Barbara area. Initially, there were only roughly 800 rebates in the first 3 years of the program. The 800 vehicle rebates allowed for a decrease of roughly 4,000 metric tons of CO2e in the surrounding Santa Barbara year, proving to be not very effective in the early years of the rebate program. However, in the year of 2014, the program began to improve community involvement, where also 1,400 rebates were claimed and over a decrease in 8,000 metric tons of CO2e was observed. On its own, this is not a huge achievement, but the amount of rebates grows each year, leading to a substantial difference in emissions due to vehicles on the road. The Following table shows the number of rebates each year between 2014 and 2023 followed by the amount of emission reductions the rebates were able to achieve.

**Table: Yearly Analysis of CVRP in Kern, San Luis Obispo, Santa Barbara, and Ventura Counties**

| Year | Number of Rebates | Reduction in Emissions ($MTCO_2e$) |
|---|---|---|
| 2014 | 1,468 | 8,661.2 |
| 2015 | 1,543 | 9,103.7 |
| 2016 | 1,568 | 9,251.2 |
| 2017 | 1,795 | 10,590.5 |
| 2018 | 2,990 | 17,641 |
| 2019 | 2,958 | 17,452.2 |
| 2020 | 1,809 | 10,673.1 |
| 2021 | 2,268 | 13,381.2 |
| 2022 | 1,758 | 10,372.2 |
| 2023 (as of July) | 1,208 | 7,127.2 |
| **Total (2014 - Present)** | 19,365 | 114,253.5 |

The surrounding Santa Barbara area is responsible for roughly 4 percent of all rebates in the state of California. Although this is not a significant amount when looking at the entire state, these 4 counties were still able to contribute to the removal of 114,253.5 metric tons of CO2e over the course of nearly a decade. For perspective, that is equivalent to the decommission of a single petroleum and natural gas processing facility, specifically it would be like decommissioning the Aera Energy Alberta Finley Shale facility in Kern County. Although this does not sound significant, any step closer to zero-emissions is a step in the right direction. Unfortunately, the majority of transportation emissions are due to trucks transporting goods throughout the state. The Clean Truck and Bus Voucher program does not see nearly the same level of involvement in the surrounding areas of Santa Barbara. Likewise, it is quite difficult to attribute a certain level of emission reductions to a voucher because it is much harder to know how many

vehicles each voucher is responsible for funding. There is also a much wider range of distances traveled between vehicles funded by the program since it encompasses both public and private transportation applications.

It is important to note that these calculations are not fully inclusive, as it does not consider the plug-in hybrid vehicles that contribute both charging and limited exhaust emissions. More extensive considerations can be made in advocating for more electric vehicles, but these general calculations demonstrate the overarching need to transition to electric transportation as it can have significant effects on the total emissions in the state of California. These calculations are also meant to give insight into how the rebate and voucher programs can have immense impact on reducing emissions while having a rough idea of what transitioning to EV's will look like in California. The calculations do not fully articulate the total emissions of the transportation sector and are based on assumptions such as emissions due to charging, distance traveled every year, gas mileage, and number of vehicles on the road.

# 4 Renewable Energy Projects and Policy

The analysis and quantification of greenhouse gas emissions play a pivotal role in evaluating the true environmental benefits of renewable energy projects. This section of the report dives into the comprehensive assessment of greenhouse gas emissions related to the operation of a solar farm. Through examination of emission factors, energy production data, and life-cycle considerations, a nuanced understanding of the environmental impact of solar farms will be provided.

## 4.1 Solar Farm Analysis

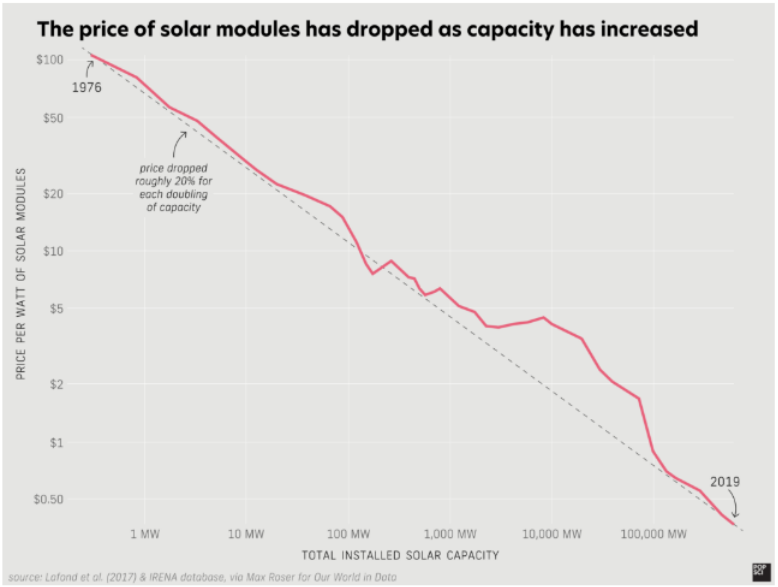
Through photovoltaic technology, solar panels generate electricity by harnessing sunlight's energy through the photovoltaic effect. An electric current is created when photons from the sun interact with the semiconductor materials within the panels. Regarding greenhouse gasses, solar panels contribute to a notably reduced carbon footprint compared to fossil fuel-based energy sources thanks to their emission-free electricity generation. However, an in-depth analysis of life-cycle emissions must include the entire trajectory from manufacturing to disposal. Emissions do occur during the production of raw materials, transportation, assembly of components, installation, and end-of-life management.[31]

Naturally, comparing generated emissions from solar panels to generate emissions from other sources of power puts into perspective the amount of greenhouse gas emissions saved by using solar panels. In particular, solar panel emissions will be compared to natural gas and coal plants. For a life cycle, greenhouse gas emissions are about 0.97 lb CO2 eq/kWh, 2.26 lb CO2 eq/kWh, and 0.088 lb CO2 eq/kWh for natural gas plants,coal plants, and solar panels respectively.[31] A vast majority of these emissions for natural gas and coal plants emerge during operational processes, about 98 percent, while for solar panels only about 21 to 26 percent occur during this time. As expected, about 60 to 70 percent of emissions occur during upstream processes and 5 to 20 percent occur during downstream processes for solar panels.

Using these estimates for greenhouse gas emissions, the total amount of emissions generated by natural gas plants and coal plants can be compared with solar panel emissions in order to determine how many emissions are saved by solar panels. In order to accomplish this, some assumptions will need to be made regarding solar panels. For a solar panel in California, about 400 W [31] per panel represents the average power output under optimal conditions. 2000 solar panels per acre [28] provides a reasonable density for the installation. A 20 percent efficiency[31] assumption will account for the fact that not all sunlight energy can be converted into electricity. Finally, California has an average peak sunlight duration of 5.5 hours.[48] Using these estimates for calculations, 1 acre of solar panels in a solar farm should produce about 320,000 kWh with 28,000 lbs of CO2 eq of Emissions a year, or about 12.7 MTon. For a natural gas plant producing 320,000 kWh in a year, it is estimated that it would produce 310,000 lbs of CO2 eq, or about 140 MTon, with coal plants producing over double this amount. Therefore, about 127.3 MTon of CO2 eq emissions will be saved in 1 year by 1 acre of solar panels in California if it were to replace 320,000 kWh worth of energy production of a natural gas plant. Continuing, applying these calculations to a singular solar panel, about 160 kWh will be produced per year, producing about 14.16 lb of CO2 eq emissions. A natural gas plant would produce about 155.2 lb of CO2 eq emissions every 160 kWh, meaning a singular solar panel would save about 141 lb of CO2 eq emissions. With the average American driving about 14,000 miles per year,[9] it would take about 77 of these solar panels to

offset CO2 eq emissions [14] of 1 year of transportation for a non-electric vehicle. In summary, comparing greenhouse gas emissions from solar panels to those from other power sources highlights the substantial environmental benefits of solar energy, making them a vital part of a greener future.

Overtime, solar panels have emerged as a compelling economic option. The cost of renewable energy has plummeted in the last decade, mainly due to the capacity of photovoltaic technology increasing as well as government incentives driven by environmental concerns.[38] As solar technology continues to advance, not only are solar panels an environmentally conscious choice but also an increasingly attractive economic proposition. It is now estimated that electricity from fossil fuels cost between 5 and 17 cents per kWh,[37] while solar energy costs an average of 3 to 6 cents per kWh,[37] and is trending downwards. However, there are still several challenges and factors contributing to the reliance on natural gas plants and other conventional energy sources. The biggest challenges with solar energy revolve around reliance on sunlight, as solar energy might not always align with peak energy demand periods.[15] This concern requires energy storage solutions or backup power sources to ensure a consistent energy supply, with large-scale and cost-effective energy storage solutions still being in development. Another concern revolves around replacing the current existing energy infrastructure, such as natural gas plants, which will require substantial investments in new grid upgrades which can be costly. There are also several geopolitical and lobbying considerations that must be taken into account, as fossil fuel industries have established economic influence in certain regions, influencing energy policies in the area. In order to address these issues, a large investment would be required in order to achieve a 100 percent renewable electricity grid.[1] While this number is extremely difficult to quantify, one estimate states it would require at least 5.7 trillion dollars of investment [2] and a 43 to 286 percent increase on the average American electric bill. In 2017, the average monthly electric bill was 111 dollars, so about 576 to 3,882 more spent on electricity per year per residence in the United States if this large investment was made to achieve 100 percent renewable energy by 2030. According to a survey conducted in 2019, on average Americans are willing to pay an additional 16.25 dollars per month [51] for renewable energy. It is evident that achieving a goal of 100 percent renewable energy will greatly rely on robust federal assistance to overcome initial costs, encourage adoption, and drive the necessary infrastructure and policy changes.




Ethical concerns surrounding large-scale-energy production are also very important to consider when comparing fossil fuels to renewable energy sources such as solar and wind. For instance, coal's health impacts and use of forced labor in coal mining are associated with exploitation of workers, adding to concerns about human rights violations associated with these energy sources. The extraction of these resources often involves hazardous working conditions for laborers in mines and drilling operations, leading to injuries and even fatalities. Moreover, the combustion of fossil fuels heavily contributes to air pollution, which not only harms human health but also disproportionately affects disadvantaged communities. These fossil fuel heavy resources are major contributors to climate change, leading to more frequent and severe weather events, intensifying food and water scarcity, and displacing vulnerable populations.

In the pursuit of sustainable energy solutions, the United States has implemented a range of influential policies [39] aimed at increasing the utilization of solar panels and solar farms. The Federal Investment Tax Credit (ITC), provides a tax benefit for installing residential, commercial, and utility-scale solar. Through the ITC, solar installations have steadily increased due to the reduced upfront costs of solar panel projects. Similarly, the Modified Accelerated Cost Recovery System (MACRS) reduces the income subject to federal taxes for solar project owners. There is also the Public Utilities Regulatory Act (PURPA) which can mandate that utilities purchase energy from solar and other qualifying facilities. California specifically has recently put a policy into place requiring all new homes and low-rise apartment buildings to include solar panels as a standard feature.[32] Overall, the Solar Mandate for New Homes in California demonstrates the state's commitment to sustainable energy, placing a great deal of importance on integrating renewable energy solutions into everyday life to address both environmental and economic concerns.

## 4.2 Calculations

Here are the calculations for what one acre of solar panels produces in greenhouse gas emissions. *Given assumptions stated earlier*,

$$\frac{2000 panels}{acre}\frac{400W}{panel}\frac{5.5 sunlight}{day} \times 0.2 = 880\frac{kWh}{day}$$

$$\frac{880kWh}{day}\frac{365 days}{year} = 321,200\frac{kWh}{year}$$

$$\frac{321,200kWh}{year}\frac{0.088 lbsCO_2E}{kWh} = \frac{28,300 lbsCO_2E}{year}$$

Here are the calculations for what a natural gas plant produces to produce the same amount of energy.

$$\frac{321,200kWh}{year}\frac{0.97 lbsCO_2E}{kWh} = \frac{311,600 lbsCO_2E}{year}$$

*So the emissions reduced through solar use is...*

$$311,600 - 28,300 = 283,300\frac{lbsCO_2E}{year}$$

## 4.3 Community Choice Aggregates

Along with solar panels, Community Choice Aggregation, or CCA, has emerged as a powerful movement. CCA programs allow local governments to purchase energy for the community while partnering with electricity distributors such that the consumer has an active choice in what energy they receive. CCA programs allow the consumer to receive a choice of stock electricity from a distributor, mixed renewable and stock electricity, or fully renewable electricity. Each of these options vary in prices with the fully renewable option costing slightly more. Distributors such as Pacific Gas and Electric (PGE) and SoCal Edison (SCE) are the main partners for such projects. CCA programs allow the consumer to have a choice in energy source, which is beneficial because it allows them to take an active control over their personal emissions. Providing these clean energy options with competitive and stable electricity rates, CCAs significantly reduced the carbon footprint associated with electricity generation at an affordable cost. Currently, CCAs are authorized in 10 states with about 4.7 million customers and roughly 13 billion kWh of electricity purchased,[45] displaying that there is a large demand of Americans who are willing to spend a little more for cleaner electricity.

Community choice aggregation has benefits as well as some disadvantages. The purchase power of the consumer is higher, which creates more leverage and can potentially lower the cost of electricity. With more competition, this allows a greater opportunity for local renewable energy to begin to grow. Unfortunately, there are administrative costs associated with CCAs that can potentially make the electricity cost a little more than what is expected. Similarly, some CCAs employ an opt-in policy which means that a customer must actively sign up for the program to gain the benefits of the program. Opting into the program requires an extra step for the consumer, which means some will not want to go through the hassle of signing up. Opt-out policies are much more effective because the consumer would need to

actively seek out leaving the program.[1.]

Currently, the Central Coast Community Energy aggregation (3CE) provides choices for Santa Cruz County, San Benito County, Monterey County, parts of San Luis Obispo County, and most of Santa Barbara County. The seven cities in the County of San Luis Obispo joined 3CE in 2018 and are all working toward carbon free energy by 2030.[4] Ventura County joined the Clean Power Alliance (CPA) in 2018 with an opt-out policy. Evidence suggests that the CPA program is responsible for over 7 billion pounds of GHG emissions prevented by the community choosing clean energy source options to power their homes.[24] The city of Santa Barbara belongs to the Santa Barbara Clean Energy CCA, which is a new locally controlled energy provider as of 2021. The rest of Santa BarbaraCounty is partnered with 3CE, joining in 2021. Kern County does not actively participate in any CCAs, but as of 2019, the Kern County Administrative Center was looking at the feasibility for CCA participation. Among the many arguments for CCAs in Kern County, local accountability is the primary benefit of establishing a CCA program. [4.]

Each of these CCAs operate independently from one another, but all function with the same premise. The main goal of each program is to reduce emissions through a greater involvement of renewable sources. CCAs also provide more benefits than just reducing emissions, as implementing CCA programs also yield economic benefits. The involvement of CCAs means that revenue is kept locally. CCA programs often reinvest aggressively to pursue renewable energy projects to continue to offset the cost of electricity by having more options for renewable energy. For example, a 10 megawatt solar project was constructed by the Marin Clean Energy CCA, which has helped power about 3,400 homes while also creating jobs with a 50 percent local hiring requirement. Implementation of more CCAs as well as continuing investments into local benefits is proven to be an effective way to reduce emissions and better the community.[4.]

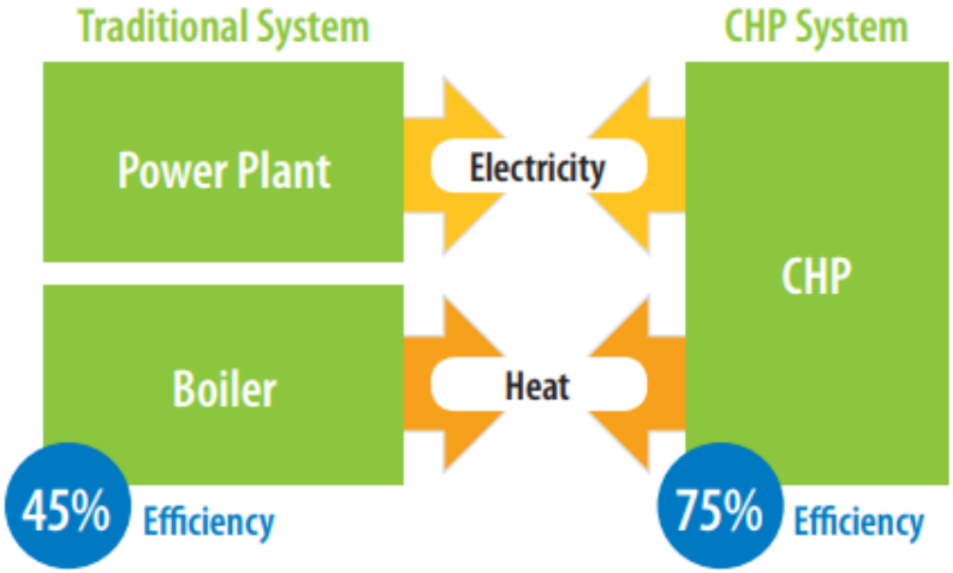
## 4.4 End User Energy Saving Technology

Accompanying new renewable energy sources and CCA programs, end user energy saving technology designed for consumers of energy are rapidly being developed and deployed in locations such as homes, industries, and businesses to allow individuals or groups to reduce their overall energy consumption and use energy more efficiently.

LED, or Light Emitting Diode, lighting is a significant advancement in energy-efficient lighting technology. LED lighting uses less than 80 percent of energy compared to the standard bulb, while lasting over 20 times longer.[22] The efficiency of this source of illumination considerably helps lower carbon emissions as less electricity is overall required for the same amount of lighting, lowering greenhouse gasses and pollutants released for this energy process. LEDS are safer as they are much cooler, easier to install, and sturdier.[20]

Next, Energy Management Systems are a broad and rapidly growing technology acting as software tools which monitor and analyze energy use, saving electricity consumers valuable cash on their electric bills while also saving energy and reducing emissions.[21] Several different aspects are implemented within these systems to increase energy efficiency. A large emphasis is placed on saving energy when it is not needed, as lighting and HVAC is left on overnight or in unoccupied rooms frequently, using an extremely large amount of energy. Outdoor air is used for cooling when possible, lights are dimmed in response to available daylight, and preventing heating and cooling simultaneously are a few other features possible with an Energy Management System. More advanced controls allow you to analyze trends of energy data or to use alarms to report failures or energy wasting, allowing the consumer to use their energy as efficiently as possible.[19]

Cogeneration, or combined heat and power, has also become more efficient over time thanks to new advanced equipment supporting better waste management and flexibility with fuels. In these processes, one single fuel source can be used to produce both electrical and thermal energy. Through this process, a cogeneration system is much more efficient than a standard power plant, where thermal energy is wasted. Today, cogeneration systems hover around 70 to 80 percent efficiency while most traditional power plants are around 40 percent efficient. To put into perspective, the NIH Cogen plant operated in Sweden since 2004 is estimated to save the NIH about 5 million dollars annually, with the energy savings equaling about 5,000 households a year with 58,000 tons of carbon dioxide emissions reduced a year as well.




Due to the economical and environmental promises, California has adopted several policies to help encourage the adoption of these renewable technologies. Property Assessed Clean Energy Finance Programs, or PACE, allow homeowners and businesses to finance the up-front cost of renewable energy installations and pay the cost back over a set time period. Energy Upgrade California is a similar initiative which offers energy assessments for homeowners and building owners. Incentives and rebates are offered to offset the cost of energy-efficient upgrades as well as several financing options including support for low-income households. This program maintains a network of certified contractors who specialize in energy-efficient upgrades and renovations, allowing property owners to upgrade their energy infrastructure with ease. Time-of-Use pricing is also becoming increasingly popular in California, incentivizing consumers to shift energy-intensive activities to off-peak hours, where electricity demand is the lowest. Time-of-Use electricity prices are higher at peak hours and lower at off-peak hours, promoting usage of electricity which is cleaner overall increasing energy efficiency. The reduced stress on the electrical grid and the reduced need to generate electricity from carbon-intensive sources result in a decrease in greenhouse gas emissions.[50]

# 5 Waste Management

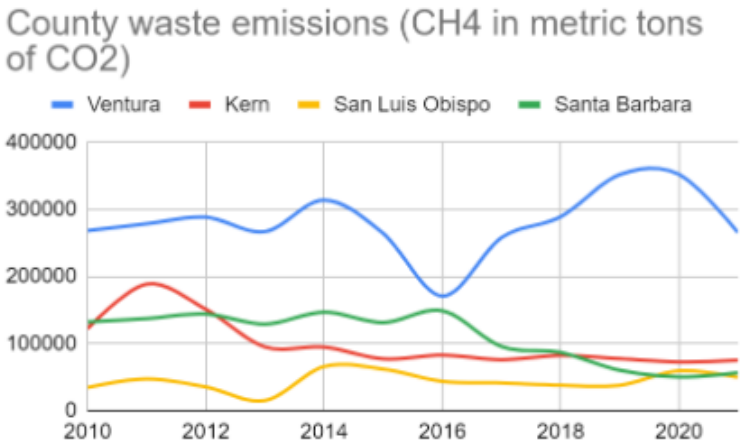
Policy is an extremely important factor in reducing landfill greenhouse gas emissions through diversion and reduction of organic waste, especially since half of landfill materials is made up of organics. During their decomposition process, organic material releases methane making up 20 percent of California's total methane emission located at landfills. [13]

To reduce these emissions, California has implemented SB 1383, the Short-Lived Climate Pollutant Reduction Act which primarily focuses on the reduction of methane from organic waste in landfills. This law mandates a 40 percent methane reduction by 2030, establishing targets to reduce 50 percent of organic waste disposal by 2020 and a 75 percent reduction by 2025. It also sets a statewide edible food recovery program that aims to rescue at least 20 percent of edible food.

## 5.1 Landfill Emissions Data

As per recent data recovered from EPA's FLIGHT program Ventura County has been reporting the highest values of greenhouse gas emissions for the past 10 years. This responds to an average emissions per capita of 0.32 for this past reporting period. The emissions reached an all time minima in 2016 due to undergoing expansion plans on 2 of their 3 landfills. Following the completion of this expansion project emissions reached an all time peak in 2019 when the facilities started operating at maximum capacity again.

The following graphic details the emissions data of landfills in the four focus counties.




Recently, Kern County has been the second highest emitting County of those surveyed which reached its peak emissions in 2011 and has been upholding a consistent downwards trend since then. Their most recent emissions per capita came out to 0.08 which is the lowest of the countries surveyed. Kern is also the highest populated County of our 4 counties of interest which leads to them having a lower than average trash per person consumption.

During 2021 Santa Barbara and San Luis Obispo counties have reported similar emission values with respective emission per capita values of 0.64 (SB) and 0.17 (SLO). San Luis Obispo has been consistently reporting less than 10,000 metric tons of carbon dioxide equivalent (MMTCO2e) of methane which is due to them only having one reporting facility. Santa Barbara County has been sustaining an overall downwards trend for the past decade with occasional peaks. It is important to note that Santa Barbara County has one of the highest trash per person consumption and emissions per capita while having the lowest population of the counties surveyed. This is due to the high volume of trash produced by the tourism industry which is very large in comparison to other counties.

## 5.2 Policy Compliance Programs

Starting January 1st 2022 SB1383 went into effect. To ensure compliance each County has set certain programs and policies into effect which will be outlined in the following section:[47]

1. Recycling and Market Development Zone Program:

   The main way to reduce landfill emissions is landfill diversion. One tactic to encourage that is the new Recycling and Market Development Zone Project (RMDZ) which encourages businesses to use materials from waste streams in the manufacturing of their products. In return the business owner is eligible to receive a low interest loan, technical assistance, and free product marketing. The zones of this program cover 88,000 square miles of California, creating a new local market and initiative for landfill diversion in these areas.[12] This program is available to help fuel new businesses as well as expand existing ones while combining recycling with economic development. Among the counties participating are Ventura, Kern, Santa Barbara, and San Lus Obispo.

2. Food Recovery Program (FRP):

   SB1383 requires 20 percent edible food recovery by 2025 which otherwise would be sent to landfills, to be redistributed to feed people in need. This law sets out to save landfill space and lower methane emissions due to organic waste. To achieve this goal commercial business and households have to both undergo fundamental habit changes. For commercial businesses they are separated into 2 tiers. Tier 1 businesses have more produce, fresh groceries and shelf stable food. An example of these would be any whole food vendors or grocery stores. Tier 2 businesses are those who have a surplus of more prepared foods such as restaurants, cafeterias, and hotels. Kern County mandates all types of commercial edible food generators (tier 1 and 2) to have a written agreement or contract with a food recovery organization to donate any surplus edible foods. Santa Barbara County has a food recovery network that works by having a list of food recovery organizations that are willing to work with retail food businesses. This network is setup by the Less is More[30] staff who work with solid waste staff to connect donors to recipients. To help business and donor organizations with

this increased workload and effort, CalRecycle had set up a Food Waste Prevention and Rescue Grant Program.[11] They are set to help establish new or expanding existing food waste prevention projects.

3. Compost Rebate Program

   To encourage recycling of organic sand landfill diversion, San Luis Obispo counties Integrated Waste Management Authority (SLO IWMA) has enforced a Compost Rebate Program which incentivises the use of compost instead of chemical fertilizer. In return users are eligible to receive a rebate for the compost material cost. Composting is the process of "recycling food and other organic waste" [17] to produce a natural soil fertilizer that improves soil health, recycles nutrients, and mitigates the impacts of droughts. This process emits less short lived pollutants than the manufacturing of chemical fertilizers and recycles organic material such as food and landscape waste. The Rebate program set out by San Luis Obispo County mandates that compost eligible for rebate had to be purchased from a preapproved SB1383 complaint facility. Rebate is also only possible for the price of the compost material and does not include any transportation or application costs. Rebate is also only available for program participants that purchase between 20 to 3,000 tons of compost per year.

4. ReSource Center

   One of the first landfills in California to become SB 1383 compliant has been Tajiguas landfill home to the groundbreaking landfill technology housed in their ReSource center. This center is built up of 3 components.

   The first being the Material Recovery Facility, MRF, which is a specialized plant that intakes all landfill received materials and separates them using several techniques such as optical identification. It is able to remove up to 80 percent of organics from landfilled materials as well as separate and categorize recycling by type such as hard cardboard, glass, metals, or thin plastics. Thi technology is much more accurate than trusting consumers in their trash separation which leads to higher organics and recyclables recovery rates and less landfilled material which reduces landfills greenhouse gas emissions.

   The next component of the center is the anaerobic digestion facility (ADF) which intakes all sorted out organic waste. These are set in anaerobic pods for 28 days while being turned regularly then treated and sent back to a pod for 28 more days. All greenhouse gasses emitted during the organics decomposition process in those anaerobic pods are captured and treated to send them to a cogeneration facility to generate electricity. It is currently estimated that enough electricity is generated by these systems to cover all electrical demands of the resource center as well as 4000 extra households. All excessively produced electricity is added to the grid. The leftover "slur" from this process is treated in an onsite composting facility and the final compost product is donated to a local avocado ranch to be used as natural fertilizer.

   The last component is the landfill itself which all materials not sorted out by the MRF are sent to after being finely shredded. All new additions to the landfills happen in organized thin layers and are covered with mulch to seal the top.

## 5.3 Average MRF Recovery Calculations

$$1000\frac{BTU}{ft^3CH_4} \times 35.3147\frac{ft^3CH_4}{m^3CH_4} \times \frac{1}{0.657}\frac{m^3CH_4}{kgCH_4} \times \frac{1}{25}\frac{kgCH_4}{kgCO_2} = 2150.06\frac{BTU}{kgCO_2}$$

$$2150.06\frac{BTU}{kgCO_2} \times 101.6\frac{tonsorganics}{dq} \times 40\frac{kgCO_2}{tonsorganics} = 8737835.056\frac{BTU}{day} = 2560.8\frac{kWh}{day}$$

*Given average household energy consumption is* $20\frac{kWh}{day}$ *in California* MRF generates enough energy for 128 households.

## 5.4 Waste Management Conclusion

Considering recent waste emission trends in California which have been unsteady with a slight downwards trend, more action needed to be taken in order to stop the steadily approaching climate change

effects. SB 1383 is a great statewide program which offers incentives, support, and realistic goals to reduce greenhouse gas emissions in the waste management industry by specifically targeting the main pollution cause which is organic waste. However no clear proven supporting conclusion can be drawn over the efficacy rates of SB1383 since this law only got activated in January 2022 and last greenhouse gas emissions data available on EPA's flight database was published regarding 2021 emissions. In theory SB1383 will reduce emissions tremendously, however there is no data available proving the current efficacy of the changes implemented.

# 6 Results and Conclusion

In the policy implementation of the four focus counties, the success in California policy comes from the synergy in State and County goals. Statewide, rebate programs like the CVRP gave counties the oversight to implement rebates for cleaner vehicle incentives specific for their county needs. These specific county rebates could couple well with statewide mandates like the Advanced Clean Cars II Rule and the increase in charging stations. Major stakeholders in the community are addressed by these comprehensive actions that would otherwise hurt communities if the synergetic policy was not adopted. California also continues to adopt new clean technology like solar farms. Solar panels provide more local power that decreases the reliance on fossil fuels. As the investments into renewable energy like solar farms in Kern county continue, the fossil fuel based power plants that reach their expiration date are discontinued and not renewed or replaced. Our focus counties supported the growth by introducing cleaner power options for consumers to choose from which would help sustain the new solar farm installations. State policy in landfill management also showcases the beneficial synergy from state standards and county support. Senate Bill 1383 set high standards for waste management and San Luis Obispo county set up an integrated waste management authority to help enforce a compost rebate program. Santa Barbara set up a food recovery network to link retail food businesses with food donation organizations. Kern county mandated that all commercial food retailers have a contract with a food recovery organization to donate surplus food. All these counties worked within state standards to create successful local policies fit for their needs. In conclusion, a strong state policy that mandates clear standards coupled with support programs to help counties enforce these standards yields successful reduction in greenhouse gas emissions.

# References


1. AAF. “What It Costs to Go 100 Percent Renewable.” Accessed September 30, 2023. https://www.americanactionforum.org/research/what-it-costs-go-100-percent-renewable/.
2. AAF. “What It Costs to Go 100 Percent Renewable.” Accessed September 30, 2023. https://www.americanactionforum.org/research/what-it-costs-go-100-percent-renewable/.
3. AAF. “What It Costs to Go 100 Percent Renewable.” Accessed September 30, 2023. https://www.americanactionforum.org/research/what-it-costs-go-100-percent-renewable/.
4. “About 3CE - Central Coast Community Energy,” June 19, 2022. https://3cenergy.org/about-us/, https://3cenergy.org/about-us/.
5. “Advanced Clean Cars II | California Air Resources Board.” Accessed September 30, 2023. https://ww2.arb.ca.gov/our-work/programs/advanced-clean-cars-program/advanced-clean-cars-ii.
6. “Alternative Fuels Data Center: Data Sources and Assumptions for the Electricity Sources and Fuel-Cycle Emissions Tool.” Accessed September 30, 2023. https://afdc.energy.gov/vehicles/electric_emissions_sources.html.
7. “Alternative Fuels Data Center: Emissions from Electric Vehicles.” Accessed October 21, 2023. https://afdc.energy.gov/vehicles/electric_emissions.html.
8. “Alternative Fuels Data Center: Maps and Data - Electric Vehicle Registrations by State.” Accessed September 30, 2023. https://afdc.energy.gov/data/10962.
9. “Average Miles Driven per Year in the U.S. (2022).” Accessed September 30, 2023. https://www.thezebra.com/resources/driving/average-miles-driven-per-year/.
10. “Bill Text - SB-375 Transportation Planning: Travel Demand Models: Sustainable Communities Strategy: Environmental Review.” Accessed September 30, 2023. https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=200720080SB375.
11. California, State of. “Food Waste Prevention and Rescue Grant Program.” CalRecycle Home Page. Accessed September 30, 2023. https://calrecycle.ca.gov/climate/grantsloans/foodwaste/.
12. ———. “Recycling Market Development Zone (RMDZ) Program.” CalRecycle Home Page. Accessed September 30, 2023. https://calrecycle.ca.gov/rmdz/.
13. “California’s Short-Lived Climate Pollutant Reduction Strategy - CalRecycle Home Page.” Accessed September 30, 2023. https://calrecycle.ca.gov/organics/slcp/.
14. Center for Sustainable Systems. “Carbon Footprint Factsheet.” Accessed September 30, 2023. https://css.umich.edu/publications/factsheets/sustainability-indicators/carbon-footprint-factsheet.
15. Center for Sustainable Systems. “Photovoltaic Energy Factsheet.” Accessed September 30, 2023. https://css.umich.edu/publications/factsheets/energy/photovoltaic-energy-factsheet.
16. Commission, California Energy. “Transforming Transportation.” California Energy Commission. California Energy Commission, current-date. https://www.energy.ca.gov/about/core-responsibility-fact-sheets/transforming-transportation.

17. “Composting 101,” July 20, 2020. https://www.nrdc.org/stories/composting-101.
18. “Electric Power Annual 2021 - U.S. Energy Information Administration.” Accessed September 30, 2023. https://www.eia.gov/electricity/annual/.
19. Energy.gov. “Energy Management Systems: Maximizing Energy Savings (Text Version).” Accessed October 9, 2023. https://www.energy.gov/scep/energy-management-systems-maximizing-energy-savings-text-version.
20. Energy.gov. “LED Lighting.” Accessed October 9, 2023. https://www.energy.gov/energysaver/led-lighting.
21. Energy.gov. “Property Assessed Clean Energy Programs.” Accessed October 9, 2023. https://www.energy.gov/scep/slsc/property-assessed-clean-energy-programs.
22. Fenwick, Sophie. “LED Lighting Significantly Reduces Carbon Footprint.” *Energy Saving Lighting* (blog), April 8, 2021. https://www.energysavinglighting.org/led-lighting-significantly-reduces-carbon-footprint/.
23. “Generating Methane Gas From Manure.” Accessed October 21, 2023. https://extension.missouri.edu/publications/g1881.
24. “Homepage - Clean Power Alliance.” Accessed October 21, 2023. https://cleanpoweralliance.org/.
25. House, The White. “FACT SHEET: Biden-Harris Administration Announces New Standards and Major Progress for a Made-in-America National Network of Electric Vehicle Chargers.” The White House, February 15, 2023. https://www.whitehouse.gov/briefing-room/statements-releases/2023/02/15/fact-sheet-biden-harris-administration-announces-new-standards-and-major-progress-for-a-made-in-america-national-network-of-electric-vehicle-chargers/.
26. Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project | California HVIP. “Home.” Accessed September 30, 2023. https://californiahvip.org/.
27. Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project | California HVIP. “Impact.” Accessed September 30, 2023. https://californiahvip.org/impact/.
28. “Is Five Acres Enough for a Solar Farm? | Coldwell Solar.” Accessed September 30, 2023. https://coldwellsolar.com/commercial-solar-blog/is-five-acres-enough-for-a-solar-farm/.
29. Less Is More. “Home.” Accessed October 21, 2023. https://lessismore.org/.
30. Less Is More. “Santa Barbara County Regional SB 1383 Food Recovery Plan.” Accessed September 30, 2023. https://lessismore.org/materials/santa-barbara-county-regional-sb-1383-food-recovery-plan/.
31. “Life Cycle Assessment Harmonization.” Accessed September 30, 2023. https://www.nrel.gov/analysis/life-cycle-assessment.html.
32. Lozanova, Sarah. “California Solar Mandate.” GreenLancer, March 17, 2022. https://www.greenlancer.com/post/california-solar-mandate.

33. “Mitigation and Adaptation | Solutions – Climate Change: Vital Signs of the Planet.” Accessed September 30, 2023. https://climate.nasa.gov/solutions/adaptation-mitigation/.
34. “Natural vs Anthropogenic Climate Change - Energy Education.” Accessed September 30, 2023. https://energyeducation.ca/encyclopedia/Natural_vs_anthropogenic_climate_change.
35. Powell, Jerry. “Sortation by the Numbers.” *Resource Recycling News* (blog), October 1, 2018. https://resource-recycling.com/recycling/2018/10/01/sortation-by-the-numbers/.
36. “Rebate Map | Clean Vehicle Rebate Project.” Accessed September 30, 2023. https://cleanvehiclerebate.org/en/rebate-map.
37. “Solar Energy vs. Fossil Fuels | ConsumerAffairs®,” June 26, 2023. https://www.consumeraffairs.com/solar-energy/solar-vs-fossil-fuels.html.
38. “Solar Power Got Cheap. So Why Aren’t We Using It More? | Popular Science.” Accessed September 30, 2023. https://www.popsci.com/story/environment/cheap-renewable-energy-vs-fossil-fuels/.
39. SolSmart. “Solar Energy Toolkit: The Federal and State Context: Policies Affecting Solar Energy Development.” Accessed September 30, 2023. https://solsmart.org/resource/the-federal-and-state-context-policies-affecting-solar-energy-development.
40. Statista. “U.S.: Total Number of Cars by State.” Accessed September 30, 2023. https://www.statista.com/statistics/196010/total-number-of-registered-automobiles-in-the-us-by-state/.
41. Tableau Software. “CVRP EV Consumer Survey_ENG_LIVE.” Accessed September 30, 2023. https://public.tableau.com/views/CVRPEVConsumerSurvey_ENG_LIVE/Impacts?:embed=y&:showVizHome=no&:host_url=https%3A%2F%2Fpublic.tableau.com%2F&:embed_code_version=3&:tabs=yes&:toolbar=yes&:animate_transition=yes&:display_static_image=no&:display_spinner=no&:display_overlay=yes&:display_count=yes&:language=en-US&publish=yes&:loadOrderID=0.
42. Tableau Software. “CVRP Rebate Statistics_ENG_LIVE.” Accessed September 30, 2023. https://public.tableau.com/views/CVRPRebateStatistics_ENG_LIVE/RebateStatistics?:embed=y&:showVizHome=no&:host_url=https%3A%2F%2Fpublic.tableau.com%2F&:embed_code_version=3&:tabs=yes&:toolbar=yes&:animate_transition=yes&:display_static_image=no&:display_spinner=no&:display_overlay=yes&:display_count=yes&:language=en-US&publish=yes&:loadOrderID=0.
43. “The Earth’s Radiation Budget - NASA Science.” Accessed September 30, 2023. https://science.nasa.gov/ems/13_radiationbudget/.
44. “The Race to Decarbonize Electric-Vehicle Batteries | McKinsey.” Accessed September 30, 2023. https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/the-race-to-decarbonize-electric-vehicle-batteries.

45. US EPA, OAR. “Community Choice Aggregation.” Overviews and Factsheets, January 13, 2022. https://www.epa.gov/green-power-markets/community-choice-aggregation.
46. “Vehicle Emissions California Waivers and Authorizations | US EPA.” Accessed September 30, 2023. https://www.epa.gov/state-and-local-transportation/vehicle-emissions-california-waivers-and-authorizations.
47. Ventura County Public Works Agency. “Organic Waste Recycling (SB1383).” Accessed September 30, 2023. https://www.vcpublicworks.org/wsd/iwmd/sb1383-slcp/.
48. Watt, The Green. “Average Peak Sun Hours By State (+ 50 State Winter, Summer Averages).” *The Green Watt* (blog), February 11, 2023. https://thegreenwatt.com/average-peak-sun-hours-by-state/.
49. “What Is a Materials Recovery Facility (MRF)? | Rubicon,” August 8, 2019. https://www.rubicon.com/blog/materials-recovery-facility/.
50. “What It Costs to Go 100 Percent Renewable - AAF.” Accessed September 30, 2023. https://www.americanactionforum.org/research/what-it-costs-go-100-percent-renewable/.
51. “Who Is Willing to Pay More for Renewable Energy? - Yale Program on Climate Change Communication.” Accessed September 30, 2023. https://climatecommunication.yale.edu/publications/who-is-willing-to-pay-more-for-renewable-energy/.