An Evaluation of the Effectiveness, Efficiency, and Equity of California’s Cap-and-Trade Program

Raphael Yolson Louis
University of San Francisco, rlouis@dons.usfca.edu

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This Master's Project

An Evaluation of the Effectiveness, Efficiency, and Equity of California’s Cap-and-Trade Program

by Raphael Louis

is submitted in partial fulfillment of the requirements for the degree of:

Master of Science in Environmental Management

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Raphael Louis       Date       Stephanie A. Siehr       Date
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List of Acronyms

ACC……………………………………………………………………………….. Advance Cars Program
CARB……………………………………………………….California Air Resource Board
CCES…………………………………………………….Center For Climate and Energy Solution
CCI…………………..………………………………………………………………California Climate Investment
CEC………………………………………………………….. California Energy Commission
CI………………………………………………………………............. Carbon Intensity
COP……………………………………………………..Compliance Offset Protocol
ECE…………………………………………………………..California Energy Commission
EITE………………………………………………………………..Emissions Intensive and Trade Exposed
EIA ………………………………………………………….Energy Information Administration
EPA …………………………………………………………Environmental Protection Agency
ETS……………………………………………………………………..Emission Trading System
GHG …………………………………………………………………..Greenhouse gas
IEA …………………………………………………………..The International Energy Agency
IPCC …………………………………………………….. Intergovernmental Panel on Climate Change
MVR……………………………………………………………………..Monitoring, Reporting and Verification
MTCO2e ……………………………………………..Metric tons of carbon dioxide equivalent
MW………………………………………………………………........... Megawatt
SDG ………………………………………………………………..Sustainable Development Goals
SWOT..............................................................Strengths, Weaknesses, Opportunities, Threats
Key Term Definition
Banking: the holding of compliance instruments from one compliance period for sale or surrender in a future compliance period (CARB, 2017).

Business-as-Usual Scenario: set of conditions reasonably expected to occur within the offset project boundary without the financial incentives provided by offset credits. It also considers all current laws and regulations and current economic and technological trends (CARB, 2017).

Environmental Effective (for the purpose of this research): Meeting the specific GHG emission target within the set deadline (Narassimhan et al. 2018).

Economic Efficient (for the purpose of this research): Incentivizing GHG reduction while maintaining a relatively low abatement cost (Narassimhan et al. 2018).

Greenhouse Gas (GHG): are gases in the atmosphere that absorb infrared (heat), slowing or preventing the loss of heat to space. These gases include: (carbon dioxide (CO2), methane (CH4), nitrogen trifluoride (NF3), nitrous oxide (N2O), sulfur hexafluoride (SF6), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and other fluorinated greenhouse gases).

Greenhouse Effect: warming of the surface and lower atmosphere of the planet that is caused by the GHG gas that convert infrared radiation into heat (Merriam-webster, 2022).

GHG Emissions: the release of greenhouse gases from sources and processes in a facility, including the combustion of transportation fuels such as natural gas, petroleum products, and natural gas liquids. In the context of offsets, "emissions" means the release of greenhouse gases into the atmosphere from sources and processes within an offset project boundary.

Entity: a person, firm, association, organization, partnership, business trust, corporation, limited liability company, company, or government agency (CARB, 2017).

Equity (for the purpose of this research): promoting fairness through stakeholder engagement and investments in underserve communities (Narassimhan et al. 2018).

Fossil Fuel: are fuels extracted from decomposing plants and animals. These fuels include natural gas, petroleum, coal, or any form of solid, liquid, or gaseous fuel derived from such
material to create useful heat (National Geographic Society, 2022).

Offset Project: all equipment, materials, items, or actions that are directly related to or have an impact upon GHG reductions, project emissions, or GHG removal enhancements within the offset project boundary (CARB, 2017).

Price Ceiling: The maximum fixed price at which allowances, and price ceiling units would be available for sale to covered entities in the program (CARB, 2017).
Abstract
California’s Cap-and-Trade program establishes an aggregate limit on GHG emissions while empowering the regulated firms with flexibility in complying with the emissions reduction mandates. This research conducted three analyses to determine if California’s carbon Cap-and-Trade program is effective at meeting its GHG goals, economically efficient, and promotes environmental equity throughout communities within California. First, the SWOT analysis investigated the Cap-and-Trade program features to determine the importance of each of the features within the program. It showed that California’s Cap-and-Trade program’s main threats are leakages, lack of partnerships, and long-term political will. Nevertheless, the program’s features strive to promote environmental effectiveness, economic efficiency and social equity. Furthermore, the complementary policy analysis explored the extent of the state’s other climate policies in reducing emissions relative to California's Cap-and-Trade program. It found that the complementary policies are the primary drivers of GHG emission reduction in California. In addition, the comparative analysis discussed the similarities and differences between California’s Cap-and-Trade program with the Regional Greenhouse Gas Initiative (RGGI). This analysis showed that California’s Cap-and-Trade program is more environmentally ambitious, economically efficient, and socially equitable than the RGGI because of its ambitious goals and coverage scope. In sum, these analyses supported the hypothesis that California’s Cap-and-Trade program is effective, efficient, and equitable. Future research should investigate potential strategies that CARB could use to influence other states in implementing a similar Cap-and-Trade program to further mitigate GHG emissions.
1. Introduction

In the last decades, Energy production and consumption fueled the rapid industrialization that provided better living standards to citizens throughout the developed world. Today, energy continues to be necessary to fuel daily necessities, including creating electricity for appliances and powering vehicles. However, the unsustainable management of resources for developing our modern world has given birth to one of the world's greatest challenges this century, climate change (National Research Council, 2011). The Intergovernmental Panel on Climate Change (IPCC) published its Fifth Assessment Report to conclude that human activity has warmed the planet (IPCC, 2013). The combustion of fossil fuels has led to an increase in greenhouse gas (GHG) in the atmosphere (IPCC, 2013). Today, fossil fuels contribute to 80 percent of the world's energy consumption (International Energy Agency, 2019).

GHG emission in the atmosphere can contribute to the greenhouse effect, which is the phenomenon where greenhouse gases in the atmosphere trap solar radiation to warm the planet. The GHG emission from continuous combustion of fossil fuels, including natural gas, petroleum, and coal, creates an excess amount of GHG emissions in the atmosphere, which trap infrared radiation and further warm the planet. The scientific community has reported multiple times that the planet is approaching a tipping point where continuous positive feedback loops of the greenhouse effect will dramatically accelerate climate change and threaten our existence (Knight et al., 2017). According to the Environmental Protection Agency (EPA), some impacts associated with the warming of the planet include but not limited to sea level rise, elevated ocean acidity, habitat loss, extreme weather events, shifts in ecosystem characteristics, and increased adverse effects on human health and well-being (EPA, 2017).

Coal is most carbon intense emission source in the energy sector, follow by petroleum and natural gas (Coleman and Dietz, 2019). According to the Energy Information Administration (EIA) U.S. energy-related carbon dioxide (CO2) emission was at 5,130 million metric tons (Mmt) in 2019 which is a 15 percent decrease from the 6,003 Mmt in 2007 (EIA, 2019). That year, fossil fuel combustion for energy accounted for 74% because of an increase energy from renewable sources including wind and solar, which required no fuel cost (EIA, 2019). Moreover, emissions from coal, natural gas and petroleum dropped by 14.6 percent, 3.3 percent, 0.8 percent, respectively. Despite this relative decrease in the CO2 emission, specially from
combusting coal, fossil fuels remain persistent in being favorable in the global energy market compared to available renewable energy (Mulvey et al., 2015; Fankhauser, 2017). Some scientists argued that the corporate dependency on fossil fuels likely correlated with the high subsidies available in the market (Kitson et al., 2011). As consumption demands continue to surge, shifting to a low-carbon future may require effective transitional policy and a halt to the massive fossil fuel subsidies for energy production.

In recent decades, many global initiatives and conversations addressing the GHG emission crisis worldwide have bear hope for the future. Many government entities are investing and researching programs that mitigate GHG emission and sustain the growing energy needs of the developed world. In addition, scientists, entrepreneurs, and policymakers are challenged to rethink the current manufacturing and industrial systems and design more effective policies to preserve the natural environment and life (Mourdghaffari et al., 2020).

1.1. Recent Climate Policy in the United States

In 2015, the United States joined the Paris Agreement which is a legally binding international treaty to keep global warming to less than 1.5 degrees Celsius above the temperature benchmark set before the Industrial Revolution (IPCC, 2011), encouraging entities to reach the global peaking of greenhouse gas emissions by mid-century (Banks, 2021). President Obama and the EPA presented the Clean Power Plan as an Executive Order to demonstrate the United States' commitment to the Paris agreement. The order was the first to address climate issues and significantly reduce carbon and methane pollution from power plants (Cornell, 2021). It introduced strong standards for power plants and customized goals for states around the country. The customized goals take each state's energy mix into account but ensure consistency across the nation and that all states are accountable.

On February 9, 2016, the Supreme Court suspended any enforcement of the Clean Power Plan due to lower court rules involving pending lawsuits. However, the plan hit the courts in Washington again on September 27, 2016, where many states argued that the federal government overstepped its authority by further regulating the energy industry, which is a significant portion of the US economy (Besco, 2018). Most of the states involved in the lawsuits use coal as their primary source of electric power generation, which would subject them to a 32% emission
reduction by 2030. The Paris Agreement went into effect on November 4, 2016, the same day Donald Trump won the electoral vote in the United States 2016 presidential election. However, in June 2017, the Trump Administration announced its plan to pull out of the agreement on November 4, 2020, as soon as it is legally permissible. Later in October 2017, President Trump repealed the Clean Power Plan, eliminating any direct GHG emission policies on the federal level.

In February 2021, the United States officially rejoined the Paris agreement to initiate national action toward global climate solutions. President Biden initiated a 50%-52% below 2005 levels by 2030 national GHG emission reduction target. His Administration also formed a centralized executive committee to identify and coordinate climate related actions and issued directives with a view toward decisions that support meeting the Administration’s GHG reduction targets (US Congress, 2021).

Many states in the US have successfully established climate policies to reduce their statewide carbon footprint on the environment (Chyong et al., 2020). According to the Center for Climate and Energy Solutions, 20 states and the District of Columbia have set GHG emissions targets, 13 states have passed some carbon price policy, and 39 states and DC have a renewable portfolio standard. Since these states implemented their climate policies, GHG emission in the US has gradually declined (EPA 2018). For example, CO2 emissions were at a historic high of 6131 million metric tons in 2007 but declined to 820.1 million metric tons in 2016, which was an estimated 13 percent decline (EPA 2018). The electricity sector which is one of the most polluting sectors in the US showed a 25 percent decline from its high in 2007 to 2016 (EPA, 2018). The Energy Information Administration (EIA) further investigated the GHG emissions declined in the electricity sector and reported that the total electricity consumption during that period increased by 1.4 percent (EIA, 2018). This indicates that the climate regulation in place to decarbonize the electric sector has reduced GHG emissions even with the increase in demand for electricity.

1.2. California’s Cap-and-Trade Program

Arguably, the most notable climate policy in the US is California's Cap-and-Trade program. A Cap-and-Trade program limits/caps the amount of emissions that companies can
emit while creating a market for companies to trade permits. First, each governing entity sets a cap for GHG emissions based on the amount they would like to reduce. Next, firms that emit more greenhouse gasses than the number of allowances they possess must adjust through government-approved means to comply with the program. Over time, a government-appointed entity reduces the “Cap” and the total number of permits available in the market to induce more emission reduction. As the state reduces those permits, it creates a scarcity that forces the functioning of the Cap-and-Trade program.

California's Cap-and-Trade program is a multisector program that has a legislative history dated as follows:

- In 2005, the California legislative branch acknowledged the state's negative contribution to greenhouse gas production and introduced the Global Warming Solutions Act of 2006, also known as Assembly Bill 32 (AB32).
  - Conceptually, AB 32 is an umbrella policy that combines a variety of regulatory initiatives to reach California's aggregated emissions target. The bill assigned California Air Resources Board (CARB) the responsibility for identifying, determining, and planning the specific policies for achieving these targets.
- In 2006, the legislative branch established AB 32. CARB began researching and analyzing regulations to lower California's overall GHG emissions to 1990 levels by 2020.
- In 2008 it established the first scoping plan, which included a wide variety of regulations intended to help meet the state goals. These regulations include but are not limited to the Renewable Portfolio Standard (RSP) for retail electricity sales; the Low Carbon Fuel Standard (LCFS) to reduce the carbon intensity of transportation fuel; and the Advance Car Program, which includes Low Emission Vehicle (LEV) and Zero-Emission Vehicles (ZEV).
- By January 2011, it adopted a scoping plan for achieving the maximum technologically feasible and economically efficient GHG reductions.
- In 2012, the Cap-and-Trade program regulations to achieve the 2020 goals within the power industry were officially initiated and enforced.
- In 2013, it targeted large industries such as cement producers and energy generators.
• In 2015, the program expanded to regulate the sales of fuels and natural gas for the automotive transportation sector.

• In 2017, the California Legislature upgraded AB 32’s goal to reduce GHG emissions by 40% below 1990 levels by 2030. Additionally, AB 197 requires CARB regulation that results in direct emission reductions at large stationary sources and mobile sources.

• In 2018, then-Governor Jerry Brown signed an executive order that set a new goal for the state 80% reduction from 1990 levels by 2050.

CARB is required to design regulations, including the Cap-and-Trade program, to promote equity, minimize costs, and maximize overall GHG emission reduction in California (CARB, 2019). The program regulates GHG gases, including carbon dioxide (CO2), methane (CH4), nitrogen dioxide (N2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF6), nitrogen trifluoride (NF3), and other fluorinated greenhouse gases (CARB, 2022). CARBs initiated the Cap, the maximum amount of allowable emissions in California in units of metric tons of carbon dioxide equivalents (MTCO2eq) in 2008. Then CARB allocated a certain number of "allowances" or "credits" to different facilities within each sector. The credits then serve as units of emissions and determine the amount that a regulated entity is allowed to emit within a specific timeframe.

1.3. Research Questions and Hypothesis

This paper aims to better understand how effective the established California Cap-and-Trade program is at reducing GHG emissions within its covered boundaries. It also explores how economically efficient it is at achieving its set GHG emission reduction target. In addition, it studies how CARB promotes equity within the framework of the program. The main question of this study is: How effective, efficient and equitable is California's Cap-and-Trade program at reducing GHG emissions to address the climate crisis? This study also explores some sub-questions to better answer the main question. These questions include: what are the strengths, weaknesses, opportunities, and threats associated with the features that constitute the program? How does the complementary policy contribute to emission GHG reduction in California? How does California's Cap-and-Trade program environmentally, economically, and socially compares to the other United States emission trading system (ETS), the Regional Greenhouse Gas Initiative (RGGI)? The aim is to understand the California Cap-and-Trade program and provide
recommendations for improving the program.

The study also formulated three hypotheses as a standard to answer the main question. The first hypothesis is that if California’s Cap-and-Trade program is meeting its target caps within its set deadlines, then the program is effective. The second hypothesis is that if abatement costs are low relative to the cost of allowances, then the program is efficient. The third hypothesis is that if California’s Cap-and-Trade promotes stakeholder engagement and invests in underserved communities, then it is equitable.

2. Methodology

As previously stated, the scope of this research is the state of California. The study design includes a literature review section and three forms of analysis. The literature review will provide useful information on CARB, background peer reviewed research on California’s Cap-and-Trade program, and significance of this study to the literature. The study will conduct three different analyses: a SWOT Analysis, a Complimentary Policy Analysis, and a Comparative Analysis. Each of these analyses will pursue a better understanding of how California’s Cap-and-Trade program contribute to GHG emission reduction effectiveness, economic efficiency and social equity. The SWOT analysis will be conducted to assess the features of California's Cap-and-Trade program. It will provide argument about each features’ contribution to the strength, weakness, opportunity, and threat to the program’s ability to accomplish its mission. The complimentary policy analysis will assess the complimentary policies under the AB32. It will analyze their contribution to the GHG emission reduction in California.

The comparative analysis will be used to compare the California Cap-and-Trade program with the Regional Greenhouse Gas Initiative (RGGI) ETS in the US. This analysis will note the similarities and differences in environmental effectiveness, economic efficiency, and social equity of these two US-based EST programs. The result summary section will recap the main findings of the study. The recommendation section provides different initiatives that CARB may imply to improve the Cap-and-Trade program. The data, graphs and tables will be obtained from the US Environmental Protection Agency (EPA), Energy Information Administration (EIA) California Air Resources Board (CARB), and peer review articles explored throughout the study.

In the context of this study, economic efficiency is defined as incentivizing GHG
reduction while maintaining a relatively low abatement cost; environmental effectiveness is simply defined as the ability of the program to meet its targeted GHG emission reduction within each specific deadline. Social equity is defined as promoting fairness through stakeholder engagement and investments in underserve communities.

3. Literature review

Many researchers have studied GHG emissions and their effect on the climate to better understand, mitigate, and adapt to climate change. Due to the collective agreements among researchers on the negative impact of GHG emissions on the environment, California's Cap-and-Trade program was established to reduce GHG emissions within and prevent or reduce their contribution to climate change. CARB is the California State agency that collects and analyzes data on GHG emissions in California. As one of the major contributors to climate policy literature, CARB details how California's Cap-and-Trade program influences the state's economic activity and GHG emissions and develops scoping plans to improve the program and incentivizes firms to comply to achieve the state's emissions reductions goals. While most of CARB's analyses are focused on monitoring change in GHG emissions throughout the state, it provides limited quantitative argument on the current influence of California's Cap-and-Trade program on GHG emissions reduction (CARB, 2017).

Beyond CARB, some studies analyze the design of specific climate policies, their associated carbon market price, and generated revenue to define the effectiveness of an emissions trading system (ETS) (Narasimhan et al., 2018). However, their result also failed to quantify how much emissions reduction can be attributed to the specific climate policy. Some other researchers use econometrics to assess the reduction of GHG emissions in RGGI states (Murray and Manil, 2015). The main finding was that the decline in natural gas prices and the recession were the cause of lower emissions in RGGI states.

Cullenward (2014) conducted one unique study on potential leakage in California's carbon market based on individual companies' behavior. His findings showed that a significant amount of GHG emissions were not being subjected to compliance under California's climate policies but simply transferred to another state. Out-of-state power plants were generating large amounts of California's electricity, but those GHG emissions were not being reported to CARB.
These power plants strategically reshuffled the resources in their portfolios to reduce their in-California emissions and limit their compliance with California's Cap-and-Trade and other climate policies. As a result, these entities did not report more than 59 million tons of GHG emissions in California. Although Cullenward's arguments seem ambiguous because his study included a small sample size of six out-of-state coal power plants and only three of which had a long-term contract canceled and moved to a bothering state, it set the precedent study of how leakage can be a threat to California's Cap-and-Trade program. Furthermore, this study contributed to CARB's decision to expand coverage to GHG emissions from imported electricity.

Furthermore, Wara (2014) argued that although California's Cap-and-Trade program gained much attention due to its broad scope and apparent success, California's other climate policies have been more effective at reducing emissions. He illustrated California's climate policies as a form of the dinner menu, where the "main course" section includes renewable portfolio standards, vehicle tailpipe emissions standards, and low carbon fuel standards; and California's Cap-and-Trade program is "dessert." Wara further highlighted that CARB's 2014 Scoping Plan estimates that the "main course" policies will contribute to 71 percent of the AB 32 reductions requirement, while 29 percent will come from Cap-and-Trade.

Cullenward and Coghlan (2016) supported Wara's analysis that California's Cap-and-Trade program does not have the most significant influence on GHG emission reduction. They confirmed that California's Cap-and-Trade program accounted for less than a third of total emissions reduction as predicted in CARB's 2008 and 2014 scoping plan models. They expressed that the program disregarded resource shuffling, where "electricity importers preferentially swap out higher-emitting resources and replace them with lower-emitting resources." Their article also further supports Cullenward's (2014) argument that California electric utilities used this mechanism to escape compliance with the Cap and other policies, resulting in emissions leakage.

In another article on designing effective climate policy, Carlson (2012) discussed how complementary policies to California's Cap-and-Trade program can constrain and limit its effectiveness. California's Cap-and-Trade program is meant to reduce greenhouse gas emissions at the lowest overall price by letting emitters decide how to meet their obligations to comply with
the Cap most effectively (Carlson, 2012). However, the mandated emissions reductions through complementary policies such as renewable portfolio standards and energy efficiency standards reduce the compliance flexibility of the California Cap-and-Trade program in allowing the market to find the cheapest reductions.

Resnik and colleagues (2018) argue that when it comes to environmental policymaking, theories of justice can be in conflict. He then concluded that using the concept of accountability for reasonableness to environmental justice, general agreement on the reasonable process may serve as acceptable to ease policymaking. Nuriel Moghavem (2018) further discussed that California's Cap-and-Trade program embodied accountability for reasonableness in its development. His findings suggest that the program is a living policy that values new evidence, such as scientific data. Furthermore, Yoomto et al. 2019 argue that greenhouse gases will be reduced to a lower extent and utility will decrease less if mitigation policies are only imposed on large companies. All these findings further inquire about close monitoring of California's Cap-and-Trade program to ensure its success in achieving its mission.

4. SWOT Analysis

Since the California Cap-and-Trade contains many feature layers, it is important to understand how each of the features within the program to determine the best improvement recommendation. This SWOT analysis of the program assesses the features within the program to highlight its strengths, weaknesses, opportunities, and threats as they relate to the environmental effectiveness, economic efficiency, and social equity of the program.

4.1. Regulation Coverage

California's Cap-and-Trade program covers the power and industrial sectors starting in January 2013. Then it expanded to cover natural gas and transportation fuels in January 2015. That year, the program covered around 450 entities, including in-state and imported electricity generators, petroleum and natural gas distributors and refineries, and manufacturing facilities that emit 25,000 metric tons of CO2e/year or more (CARB, 2019). In 2019, CARB reported a coverage of 419 million metric tons of CO2e emission into the atmosphere that year, with 41 percent from the transportation sector, 14 percent from electrical power plants, and 24 percent from industrial factories (figure 1). In total, California's Cap-and-Trade program covers roughly
85% of California's GHG emissions (CARB, 2019). The rest of the GHG emissions, which may be indirectly covered or not covered under the Cap, came from commercial and residential buildings, agriculture, and natural events like wildfires.

Figure 1. Percent Emission in California for each economic sector in 2019. (Source: CARB 2019)

4.1.1. **Strength**

4.1.1.1. **GHG Emission Reduction Certainty**

In the last decades, California has experienced the effects of the global warming trend through wildfires, drought, and heatwaves (Schnell and Prather, 2017). These events created the incentive for the California government to address the unsustainable use of resources to ensure the next generation’s survival by taking ambitious measures to discontinue excessive amounts of GHG emissions within its borders and beyond. The program is concrete evidence of California’s initiative to reduce GHG and keep firms environmentally conscious of how GHG emissions impact the environment. According to CARB, California’s Cap-and-Trade program provide certainty that emission is being reduced to the set limit as all the covered entities comply (CARB, 2017). This certainty in reduction makes the program more favorable to politicians than other climate regulations such as carbon tax (Raymond, L., 2019).
4.1.1.2. Balance Power Paradigms

Furthermore, California's Cap-and-Trade program has two significant power paradigms: a Command Strategy vs. Market-based Strategy (CARB). Under the Command Strategy, CARB sets the "cap," which is the maximum level of emissions from the covered sectors of the economy. As CARB updates the "Cap," covered entities must obtain and surrender allowances for each unit of pollution they emit. One may argue that this authority to limit overall GHG emissions is a positive influence towards mitigating the evident impact of the pollution throughout the state. The market-based strategy paradigm, on the other hand, promotes cost-effective reduction to sustain stable economic growth. The market dictates a price for GHG emissions, which creates a financial incentive for entities to implement the least costly emission reduction activities (Taylor, 2017). Covered entities can reduce emission or purchase ("Trade") allowances to comply with the program. Covered entities that choose not to reduce their emissions must purchase allowances from the government or other entities with a surplus of allowances. These interworking in the system ensures that the overall GHG emission emissions are met by the set deadline while allowing the market to find the most cost-efficient method of reducing emissions.

4.1.2. Weakness

4.1.2.1. Noncovered GHG Emission

Although the Cap-and-Trade program applies to many polluters, it does not cover GHG emissions in all industries and sectors. For example, it does not cover commercial and residential buildings, agriculture, and natural events like wildfires. CARB acknowledged this weakness in the program and expressed its challenges with quantifying the GHG emissions from these sources (CARB, 2015). The lack of available technology in the market also makes it tough. As a result, one may wonder whether the emission from the uncovered sources may rise enough to sign as the emission from the covered sectors continues to decrease. Additionally, will California be able to attain carbon neutrality if the program does extend to all the uncovered GHG emissions?
4.1.3. Opportunity

4.1.3.1. Business Investments

One of the California Cap-and-Trade program's goals is to induce sustainable business investments to efficiently reduce GHG emissions. CARB's intention was that the earlier that firms start to innovate successfully, the better their chances at reducing their GHG emission as the deadlines close in. Consequently, building the program in such a way provides companies time and flexibility to devise their plan on how to best reduce their emissions (Wachs and Engel 2020). Additionally, firms that have most successfully planned their transition from the use of historic polluting resources such as fossil fuels have the opportunity to incentivize investors to invest in their sustainable visions. Furthermore, some of the sectors of long-term investment, according to CARB, are the electrification of industry, transportation, and heating. These entities are the most pollution sectors to reduce or eliminate GHG emissions under California's Cap-and-Trade program (Sugiyama, 2012). new business development as well as investments and makes way for more job availability.

4.1.4. Threat

4.1.4.1. Leakage

Leakage is a phenomenon that is resulted from firms, electric utilities, in particular, physically relocating production to a neighboring state in response to the Cap-and-Trade program but continues to sell power into California's GHG regulated market. As unregulated firms sell their power to the state, their GHG emissions essentially leak out from under the Cap (Potts, 2006; CARB, 2017). This strategy undermines the mission of the program as the energy imports could be dirtier than the local products they are replacing. For instance, instead of complying with the Cap and other policies by reducing emissions, a firm such as a coal power plant could move its GHG-emitting activities to other states where policies are less stringent to avoid compliance. While their emissions in California seem to have declined, their overall emissions have not. Therefore, CARB should incorporate solutions to mitigate leakage as it promotes sustainability.
4.1.4.2. Unfounded Legal Challenges

Some stakeholders, including the oil industry, have had an enormous influence on the program design and risks of underperformance underperform. The California Chamber of Commerce has also disapproved of implementing the Cap-and-Trade program and has filed several lawsuits. In 2012, they filed a lawsuit claiming that cap-and-trade was unconstitutional and should not be implemented. In late June 2017, the suit was defeated due to a lack of support in the California legislature, and the program was declared legally permissible (Ashton, 2017). However, that same year, the oil refiners, including Exxon, tried to pursue further legal loopholes to repeal the program. Consequently, one may argue that these influential entities may not stop fighting as targets become more intense (Ashton, 2017).

4.1.4.3. Allowance Allocations

Under California's Cap-and-Trade program, an allowance is a legal permit of one metric ton of CO2e (MTCO2e) of emission. Allowances are introduced into the system either by auction or through direct (free) allocation. In the first trading period, CARB calculated allocations based on each industry's three-year moving-average output benchmark. Electrical distribution utilities (EDUs), large industrial facilities, and natural gas suppliers (NGOs) received free, partial, or no allocation of allowances. From the second trading period (2013–2017), CARB used a mix of free allocations, auctioning, and fixed price allowance sales for different sectors. Allowances are allocated to industrial facilities based on annual output and sector-specific emissions intensity factors; and EDUs receive allowances based on their long-term procurement plan; and NGS allowance allocations are based on the previous year's sales (CARB, 2019).

In general, allowances are set at about 90% of the average annual statewide emission cap, and allowance distribution declines over time in proportion to the annual decline in the total Cap (Abbot & Lormon, 2021). CARB allocates free allowances to specific energy-intensive and trade-exposed (EITE) industries based on how much of their product (not GHG emissions) they produce in California. The more they produce in California, the more free allowances they receive. This strategy is intended to prevent emissions leakage. As allowances become scarcer, their cost value increases, encouraging firms to find ways to reduce emissions in the most cost-effective before the set deadline.
CARB also holds two allowance auctions quarterly for participating firms. The first auction type, which CARB referred to as Current Auctions, offers current and previous year vintages. The second type of auction, which CARB refers to as Advance Auctions, offers vintages of the subsequent calendar years. Entities may submit bids in a single-round, sealed-bid auction format. Allowances are awarded to entities starting with the highest bids respectively until all available allowances are exhausted. CARB sets a designated number of allowances from each compliance period budget into the Allowance Price Containment Reserve (APCR) to reduce the risk of higher than expected allowance prices. In 2012, the assembly bill initiated the first auction reserve price at a $10-per-metric ton price floor and set it to rise each year at a rate of 5% in addition to the cost of inflation. In 2022, vintage allowances skyrocketed from $17.80 to $29.15, which is about a 40% increase from 2021 (figure 2).

![Quarterly California cap-and-trade auction prices](image)

Figure 2. Quarterly California Cap-and Trade auction Prices. Prices are for the current vintage allowances sold in each auction (Source: EIA 2022).

In 2013, the initial Cap was set to 162.8 million metric tons of carbon dioxide equivalents (MMT CO2eq), 2% below forecasted emissions from 2012, regulating the large industry and electric energy generators (figure 3). Then in 2015, it increased to 394.5 MMT CO2eq as the program expanded to cover transportation fuels and natural gas. However, the allowance budget continues to decline annually by around 3%. The 2020 limit was 334.2 MMT CO2eq, and the 2030 limit is 200.5 MMT CO2eq (CARB, 2018). According to CARB, Electric Distribution Utilities (EDUs) accounted for approximately 45% of the allowance allocation, while industrial
allocation and natural gas suppliers accounted for 31% and 24% of the total direct allocations, respectively, in 2021 (Table 1).

Figure 3. Allowance Allocation Budget. The Cap during the period 2013-2030 and how industrial allowance allocation compares to industrial emissions for facilities in California (CARB, 2028).
Table 1. Vintage 2021 Allowance Allocation by Entity Type and Industrial Sector. (Source: CCES, 2021)

<table>
<thead>
<tr>
<th>Entity Type</th>
<th>Industrial Sector</th>
<th>Vintage 2021 Allocated Allowances</th>
<th>Percent of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical Distribution Utilities</td>
<td></td>
<td>73,106,879</td>
<td>45%</td>
</tr>
<tr>
<td>Natural Gas Suppliers</td>
<td></td>
<td>39,254,946</td>
<td>24%</td>
</tr>
<tr>
<td>Industrial and Other$^1$</td>
<td>Refining and Hydrogen Production</td>
<td>29,944,669</td>
<td>18%</td>
</tr>
<tr>
<td>Industrial and Other$^1$</td>
<td>Cement, Lime, Clay, Gypsum</td>
<td>8,159,023</td>
<td>5%</td>
</tr>
<tr>
<td>Industrial and Other$^1$</td>
<td>Oil and Gas Production</td>
<td>7,325,544</td>
<td>4%</td>
</tr>
<tr>
<td>Industrial and Other$^1$</td>
<td>Miscellaneous$^2$ Industrial and Other</td>
<td>6,265,868</td>
<td>4%</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>164,056,929</td>
<td>100%</td>
</tr>
</tbody>
</table>

4.1.5. **Strength**

4.1.5.1. **Total Allowable Emissions**

Free allocation of allowances has many economic benefits for firms and customers alike. As mentioned earlier, natural gas and electrical utilities receive all or partial free allowances with the expectation that the value of allowances must be used to benefit ratepayers and achieve greenhouse gas emissions reductions. Although the strength of this strategy is counter-intuitive, the argument is rather logically consistent with the notion that the decrease in free allowances will promote GHG reduction emissions while minimizing the economic harm to the California economy. Eventually, the continuous decrease in free allowances through time induces a reduction of GHG emissions within facilities in the covered sectors. According to CARB, the program’s track record shows great success in reducing the number of allowances available in the market in the past years (figure 2). If the total allowable emission continues to decrease and targets are being met as CARB intends, one may conclude that California is making practical advancements toward its carbon-neutral economy.

4.1.5.2. **Allowance Cost Containment**

To reduce allowance price volatility, CARB implemented an allowance price
containment feature that includes a price floor and a price ceiling. The price floor limits the allowance prices from falling below the established threshold. If necessary, CARB can remove allowances from circulation whenever the floor price is reached, thereby preventing prices from falling further than the price floor (Stocking, 2012). The price ceiling is only applicable if at least one of California's covered entities or an opt-in covered entity does not have sufficient eligible compliance instruments in their holding and compliance accounts for the following compliance surrender deadline. The price ceiling also acts as a prevention mechanism to mitigate investors' affinity for risks in low-carbon investments and secure their distribution of potential payoffs for high carbon investments. The price ceiling truncates that distribution, limiting the upside of low-emissions investments, while the price floor limits the downside of these same investments (Dinan, 2010; Stocking, 2012).

Furthermore, the allowance containment reserve can reduce permit prices if they become excessively high. CARB reserves 4% of all allowances to allow this adjustment (figure 2). This containment reserve and the price floor are two tools that allow CARB to stress emission reductions. Until 2022, carbon prices in California's cap-and-trade system have never been particularly high. Although the price has not reached the EPA's average price of carbon which is currently $46, the allowance prices have nearly doubled at the beginning of 2022. One may argue that if allowance prices continue to drastically increase, cost of abatement may be more favorable for most companies covered under the program.

4.1.6. Weaknesses

4.1.6.1. Equilibrium Costs of abatement

A potential challenge of California's Cap-and-Trade market is its inability to maintain a balanced carbon price that's high enough to motivate individual companies to invest in real GHG reductions rather than just buying credits without creating a shock in the market (CARB, 2018). Since the market system determines the price of allowances, it can create unpredictability in the carbon market for all parties involved in the program (Budget, 2018). For example, when the carbon market has a strong demand for allowances, it creates excess permits in the carbon market; and vice-versa, when the carbon market has a weak demand for allowances, it creates reduced permits in the allowance market. Hence, it may be challenging for firms to budget GHG
emission expenses and predict the allowance's final costs. This challenge results in large industrial firms and oil producers preparing for worst-case scenario pricing for their goods and services.

4.1.6.2. Historically Cheap Allowances

Allowances in California have yet to reach the EPA’s estimated social cost of CO2e emission. The EPA estimated the social cost of carbon emissions at $42 per metric ton in early 2017 (US Environmental Protection Agency 2017). It went from under $12 in 2014 to $14.40 in 2017 (figure 2). Although an increased investor interest in carbon allowances has recently increased the cost of a carbon permit in California to about $29 (figure 2), the program is not yet mitigating as efficiently as it should in comparison to the EPA social carbon price. Some scientists argued that the banking system of the program may also have had a significant influence on allowance prices. Wara (2022) estimates that roughly 300 million tons of allowances are banked to satisfy compliance obligations in the coming years. In practical terms, actual CO2 reductions are unlikely to fall as steeply as the program’s emissions cap if firms accumulate allowances.

4.1.6.3. Environmental Justice Gap

Some scientists are concerned that the same market forces resulting in allocative efficiency may also be altering the difference in pollution concentrations experienced between disadvantaged and other communities (Banzhaf, Ma, and Timmins, 2019; Currie, Voorheis and Walker, 2020). Although the program has improved the pollution concentration gap between disadvantaged and other communities from sample facilities to fall, the environmental justice gap remains (Tessum et al., 2019). Furthermore, market-based environmental policies such as California’s Cap-and-Trade do not address environmental justice concerns directly. They mainly focus on allocative efficiency rather than distributional objectives (Sheriff, 2022). Consequently, equity concerns may remain a relevant issue with the California Cap-and-Trade program.

4.1.7. Opportunity

4.1.7.1. Revenue Management

For covered entities, each additional unit of emissions carries an opportunity cost. One
more unit of pollution either reduces the number of allowances the covered firm can sell or raises the number of allowances the firm must purchase to remain in compliance. Thus, the allowance market is a source of revenue for private firms as well as government entities. Since the beginning of the program, it has generated about 19 billion dollars of total revenue (California Climate Investment, 2022). These revenues are deposited into the state's Greenhouse Gas Reduction Fund (GGRF) and then appropriated to state agencies to implement programs that further reduce greenhouse gas emissions, mitigate ratepayer costs, innovate energy efficiency and develop renewable energy. In September 2016, the California Air Resources Board reported that the GGRF had invested $4 billion in sustainable communities and clean transportation, $503 million in energy efficiency and clean energy, and $765 million in natural resources and waste diversion (CARB, 2017). In 2018, $284 million was invested in community air protection (CARB, 2017). Moreover, CARB is required by law to invest 35 percent of all allowance revenues in environmentally disadvantaged and low-income communities (Center For Climate and Energy Solution, 2020). The investment expands the reach of the program and will continue to provide a safety net for the state's sustainable development goals.

4.1.8. Threat

4.1.8.1. Market-based Uncertainties

Some experts argue that market-based compliance is a tool because industrial facilities are only encouraged to assess the best approach for their circumstances and are not strictly required to reduce onsite emissions, which may be more environmentally profitable. A recent study showed that more than half of the facilities covered under the Cap-and-Trade program increased their in-state emissions during the program's first three years (Cushing 2018). One may argue that the freedom to pursue other options for compliance may negate or slow down the program's push toward a carbon zero economy. For example, some firms may find that purchasing carbon credits or investing in offsets projects may cost less than a shift from fossil fuels. Since the allowance prices have a lower impact on these firms, they lack the incentive to switch to renewables or become innovative.

Cheap allowance purchases in the carbon market can negatively influence firms' affinity for GHG emission reduction. When allowances are valued at low prices, they diminish the
incentive for facilities to reduce GHG emissions (DeVore 2017). Additionally, emission banking can have the same effect when banked emission credits roll over into auctions experiencing surplus. One may argue that if cheap allowances persist due to economic downturns, firms may have less incentive to reduce their GHG emission to the mandated Cap and beyond. Furthermore, emission reduction may become slower than intended, and the California targets may not continue to stay on schedule to reach the 2045 carbon neutrality goal.

4.2. Compliance Flexibility

CARB provides firms with tools to increase their flexibility to comply with the Cap-and-Trade program. These tools include Banking, Offset projects, and Compliance Period. All these tools are accessible to all firms within all the covered sectors to facilitate their compliance with California's Cap-and-Trade program.

4.2.1. Banking

Under the California Cap and Trade program, entities can purchase allowances and "bank" them later. CARB allows entities to "bank" their excess allowances to increase their ability to comply in future years. Banking also protects firms from price volatility associated with variation in the market. The covered firms can "bank" allowances from the past toward the present emissions period, but it does not allow them to borrow allowances from the future (CARB, 2021).

4.2.2. Offset

Firms can also invest in "offset" projects that reduce or sequester carbon within us and its. These projects, which are outside of the industrial, energy, and transportation sectors, allow entities to receive one metric ton of CO2 equivalent to one "offset" credit for emission reductions. These offset projects should increase the net reduction as the California Cap-and-Trade program expands to emissions that are not sourced under the Cap and have no compliance obligations. These compliance offsets must also be within the framework of the CARB-approved Compliance Offset Protocol (COPs). They can also be obtained using a linked jurisdiction project or an approved sector-based crediting program (CARBs, 2018).

The five CARB-approved offset compliance protocols are U.S. Forest Projects

4.2.3. Compliance Period (CP)

California's Cap-and-Trade has 3-year compliance periods, with a partial surrender obligation due each year. The last compliance period, its Third Compliance Period (CP3), began on January 1, 2018, and ended on December 31, 2020. CP3 included two annual compliance obligation deadlines and one Full Period Compliance Obligation (FPCO) deadline, similar to the last two. The deadlines were set up as follows: November 1, 2019, for 2018 emissions, November 2, 2020, for 2019 emissions, and November 1, 2021, for the FPCO deadline. CP4 will follow the same format for the period starting on January 1, 2021, and ending on December 31, 2023 (CARB, 2018).

4.2.4. Strength

4.2.4.1. Allowance Elasticity

Banking makes allowances more elastic because "bank" allowances do not expire. Consequently, companies can use their allowances in the present or future as they need them. This tool has been proven useful mainly to EDUs, which are often challenged to meet compliance obligations during years of increased energy demand due to annual variations in the market and unexpected events like extreme heat or cool weather. The banking tool allows them to be more prepared when those circumstances arise. Firms, however, are limited in their total allowances available for "banking" and cannot submit future year allowances for compliance with a previous year. In addition, a company's "bank" allowance limits are based on the overall allowance budget of the facility. These limitations reduce companies' reliance on allowances and promote GHG reductions.

4.2.4.2. Cap Expansion

Offset projects are a great tool that companies can use to expand the program's reach and
reduce GHG emissions. In 2008, firms initially could reduce up to 8% of total compliance obligation through offset options. In 2021, offset options reduced significantly to 4% and will remain so till 2025. According to CARB, this decline incentivizes companies to continue to innovate and mitigate more GHG emissions. Between 2026 to 2030, CARB plans only to allow 6% of total compliance obligation to come from offsets. This increase offers flexibility to firms to continue to broaden the reach of the California Cap-and-Trade program and helps promote equity and cost-efficient overall emissions reduction as the carbon cap reaches its lowest point.

4.2.5. Weakness

4.2.5.1. Offset Scope

Currently, the offset projects are limited to emissions-reduction projects in the United States and the city of Quebec. CARB plans to further limit the scope of offset projects to just projects within the program's jurisdiction, meaning within its state borders and the city of Quebec (CARB, 2020). Additionally, firms' offset projects are currently restricted to projects in five areas: forestry, urban forestry, dairy digesters, destruction of ozone-depleting substances, and mine methane capture (CARB, 2021). Consequently, firms may be limited in their accessibility to offset credit which may be crucial to their cost-effective compliance strategy. CARB should approve more offset protocols to increase the diversity of projects and the ability of firms to comply.

4.2.5.2. Equity in Minority Communities

Many environmental groups advocate that offset projects can jeopardize local communities’ livelihoods and create loopholes for further emissions (Bourke, 2021). For example, some offset projects, including planting new forests, require land and space. Stakeholders, particularly indigenous lands and environmental advocates, fear that “land-grabs” will put the security of their livelihoods and cultures at risk. Thomas Joseph of the Hoopa Valley Tribe in California described this involvement as an act of colonization. He stated, “Just like the US government has taken land from us and colonized us, now companies are trying to do the same thing: carbon markets are a further act of colonization. (Bourke, 2021)”
4.2.6. Opportunity

4.2.6.1. Project Diversity

CARB should continue creating more protocols to expand the area in which projects can be developed (CARB, 2019). As more protocols are introduced, more opportunities for the program extend and reach uncovered areas. The new protocols may also provide more solutions to the program’s ability to deal with hotspots and environmental equity. Furthermore, project diversity may create more opportunities for firms to engage with at-risk communities and invest in them through education, community development, and cultural preservation.

4.2.6.2. Innovation Driver

Furthermore, offset can create space for CARB to continue to drive innovation to remain on track in achieving its set Cap targets (CARB, 2017). It is evident that in recent years, electricity from wind and utility-scale solar continues to be cheaper than any conventional energy technology, even without government subsidies and despite the continued decline in the cost of natural gas electricity. As CARB continues to reduce subsidies for fossil fuels and support more investment in improving solar photovoltaic cells, more efficient batteries, small modular nuclear reactors, and nascent technologies that use fossil fuels without emitting CO2. The sooner the state con reaches its goal of carbon neutrality, the more economic and environmental benefits may follow.

4.2.7. Threat

4.2.7.1. Offset Project Efficiency

Carbon sequestration from offset projects, including tree planting, is often extremely difficult to calculate and monitor (Haya et al., 2020). Many corporate offset projects aimed at capturing carbon have typically chosen to plant fast-growing, monoculture forests, which can have a significant impact on endemic species. Research shows that mixed, native forests capture more carbon, preserve wildlife, and promote a healthy ecosystem (Hulvey, 2013). CARB should continue to be vigilant with the environmental cost and benefit of entities' offset projects.
4.2.7.2. Environmental Advocators Affinities

Some environmental justice advocates found the program lacks equity as a primary intent. The lawsuit, “Association of Irritated Residents v. California Air Resources Board,” claimed that CARB did not adequately consider alternatives to a Cap-and-Trade, like carbon taxes that do not create additional localized hotspots (Takade, 2013). In 2012, the court ruled that CARB did not “disregard the law or act arbitrarily or capriciously in adopting the scoping plan” (California Courts of Appeal, 2012). Despite this defeat, the lawsuit remained a topic of consideration. Assemblymember Cristina Garcia, chair of the Committee on Natural Resources, advocated for a better focus on local air quality and environmentally disadvantaged communities. She introduced assembly bill (AB) 378, which incorporated this focus into the extension of the cap-and-trade program. However, lobbying from fossil fuel companies such as Chevron plummeted the bill. If these disagreements on the effectiveness of the program continue to develop and communities require stronger government involvement through carbon tax which guaranty environmental equity, then California’s Cap-and-Trade program may be threatened.

4.3. Emissions Reporting and Verification

CARB provides entities within the different sectors with detailed instructions on collecting and submitting the appropriate monitoring documentation to support the reporting and verification process. Through the mandatory reporting (MR) of GHG Emissions, CARB requires facilities and entities with more than 10,000 metric tons of carbon dioxide equivalent (MTCO2e) of combustion and process emissions to submit an annual GHG emissions data report. Additionally, CARB grants accredited third-parties authority to verify reports from facilities and entities that emit more than 25,000 MTCO2e.

- Offset projects must be permanent to prevent a reversal of the avoided emissions. For example, methane flaring in livestock digester projects permanently converts methane to carbon, a less dangerous greenhouse gas.
- Offset projects must be a direct reduction within a confined project boundary. For instance, recycling activities are not eligible for offset credit because recycling activities do not have a direct GHG reduction at the recycling facility.
Offset projects must be conservatively quantified to ensure that only real reductions are credited. CARB requires entities to provide a sound foundation and understanding of the underlying quantification for all sources, sinks, and reservoirs within a project boundary. The net change from implementing a project represents its actual reduction for issuing credit and allows CARB to verify and enforce GHG reduction within transparent monitoring and measurement requirements of the Compliance Offset Protocol.

Offset projects must be additional and different from any reduction required through regulation or action that would have otherwise occurred under the California Cap and Trade program. Firms must avoid investing in projects that are already widely used or reducing projects from out-of-state sources that would be covered. For example, projects such as installing solar panels are not eligible for offsets as the actual emission reductions are associated with power generation and all electricity generation under the Cap-and-Trade Program. Similarly, a company's offset project for cleaner vehicle fleets would not qualify for offset because transportation fuels are covered in the program.

4.3.1. **Strength**

4.3.1.1. Independent Verification

CARB reporting verification process has significant importance in the good functioning of California's Cap-and-Trade program. CARB works closely with independent market monitoring analytics to monitor auctions as well as the holding and trading of compliance instruments for the Cap-and-Trade Program. CARB's reliance on accredited third-party entities and stakeholders to verify emissions helps create accountability for GHG emitters and reduces report bias in the system (CARB 2017). Though all reports are scientifically subjected to some margin of error, the involvement of a third party in the verification process reduces the bias and potential bribery.

4.3.2. **Weakness**

4.3.2.1. Misreporting/ Margin of errors

Although CARB requires a third-party verification for GHG emissions, misreporting may remain possible. For instance, some policy analysts are critical of offset projects because it is
difficult to discern whether a credited reduction indeed constitutes a reduction relative to what would have been the case under business as usual or relative to what would have occurred if provisions for offsets had not been in place (Wara and Victor, 2019). In addition, one can argue that tracking greenhouse gas outputs from sources under the program may also prove challenging at times since technologies may malfunction. Consequently, verification should be well established in frequency to reduce the associated margin of error as much as possible.

4.3.3.  *Opportunity*

4.3.3.1.  Stakeholders Engagement

Stakeholder engagement can be used as a tool to increase the pressure on industries to internalize the social costs of carbon emissions. CARB should continue to provide firms the platforms to disclose their risks under climate change and their initiatives to mitigate greenhouse gas emissions to major investors, along with financial regulators (Guardian, 2019). These reports would also inform consumers and businesses that overtime compliance will become more and more expensive, so they will need to look for additional ways to reduce their emissions. Additionally, the reporting and verification procedure may create space for concerned stakeholders to pressure companies on their internal actions to mitigate GHG emissions (Cal. Super. Ct., 2009).

4.3.4.  *Threat*

4.3.4.1.  Public Misinformation

In general, the spread of misinformation can have a severe threat to public interests as it can create a political atmosphere that does not support California’s Cap-and-Trade program (Pierre and Neuman, 2021). Stakeholders, including politicians and environmental advocates, can use misinformation as a tool to reduce public support and prevent the program from continuing its mission; thus, CARB should implement countermeasures to reduce misinformation and propaganda. For example, Keith McCoy, a senior Exxon lobbyist in Washington, was caught on tape in June describing the company’s campaign to cloud the science. He stated, “Did we aggressively fight against some of the science? Yes,” (Pierre and Neuman, 2021). Consequently, CARB should devise solutions to minimize the extent to which
entities can participate in misinforming on matters of critical value.

4.4. Compliance Enforcement

To enforce the Cap-and-Trade program, CARB does not allow firms to bank all their annual free allowances. Instead, it requires firms to use at least 30% of their yearly free allowances to cover the previous year’s emissions (CARB, 2017). Additionally, firms must provide allowances and offsets to cover emissions from the entire compliance period. Furthermore, if a firm misses a deadline or falls short of compliance, that firm is required to surrender four allowances for every metric ton not covered in time. CARB has the authority to file suits against any trading involving a manipulative device, a corner of or an attempt to corner the market, fraud, attempted fraud, or false or inaccurate reports. CARB also welcomes stakeholder engagement with regulated firms by establishing an emission accounting process and provides the public the option to comment or voice their opinions at meetings.

4.4.1. Strength

4.4.1.1. Enforcement Mechanism

Enforcement mechanisms are essential to maintain the fruitful functionality of the Cap-and-Trade program's mission to achieve 200.5 million tons in 2030. Therefore, it is fitting for CARB to create strict penalties, including requiring firms to turn in four allowances per ton of excess GHG emitted if they miss the set allowance deadline. In addition, this strategy creates a positive incentive for participating firms to comply with the deadlines. For example, if the facility emitted 30 tons of carbon dioxide above its allowed GHG emission and failed to purchase the extra credit before the compliance deadline, it would be required to purchase 120 allowance credits as a penalty to cover its late compliance (CARB, 2019). Additionally, requiring facilities to use a minimum of their allowances each year ensure that firms do not all their bank which may affect the Cap.

4.4.2. Weakness

4.4.2.1. Firm Specific Emissions Reductions

Some scientists are increasingly worried that the program may allow some of California's
biggest polluters to conduct business as usual and even increase their emissions. A study showed that California's oil and gas industry saw an increase of 3.5% in carbon emissions since the program began in 2013 (Lisa Wong, 2019). Furthermore, Marathon Petroleum and Chevron refineries were consistently the largest polluters in the state. The study also showed that combustion vehicles were also rising. With these results, one may argue that the enforcement mechanism may not be as effective in reducing greenhouse gas as one would presume. Additionally, CARB filed a multi-million-dollar lawsuit against Volkswagen in 2017. The company cheated on the emissions report and was lawfully reprimanded.

4.4.2.2. Resource Shuffling

According to CARB, resource shuffling happens when a seller of energy in California modifies its sales portfolio to report lower or no-emission electricity in California while reporting electricity associated with higher greenhouse gas ("GHG") emissions in other states without GHG limits. This attitude in reporting weakens the program's success and undermines the significance of the threat of climate change. Although California's carbon market is generally seen as a model climate policy, this assertion may become inaccurate if CARB continues to credit utilities for shifting legacy coal contracts to their unregulated neighbors. It would mean that the Cap-and-Trade program relies on resource shuffling to generate compliance on paper, causing a false appearance of emissions reductions and lacking real climate benefits.

4.4.3. Opportunity

4.4.3.1. Technological Innovation

California's Cap-and-Trade program offers incentives for firms to fund research and development of technology that uses less energy or a different, less-polluting fuel. This invention of new technology benefits society because other entities will adopt the new technology and magnify the emissions reduction. The more GHG reduction technologies available in the market, the more opportunities entities will have to reduce their emissions without further spending on allowances or the necessity to exit the market. The most significant benefits presented by reduced carbon emissions are long-term, such as stabilizing ecosystems/agriculture and reducing the frequency of natural disasters, and are difficult to compute. One may argue that the more cost-effective it may be for companies to invest in clean technology, the more the emission they
may be incentivized to reduce.

4.4.3.2. Stakeholder Engagement

CARB schedules several meetings per year with stakeholders and the general public, allowing them to participate in the rulemaking or rule modification. The stakeholders and the public have the opportunity to learn and comment on the program's rule modifications to help assess its effectiveness in achieving its goal (CARB, 2022). Additionally, this creates an opportunity for consumers to play a role in improving the health of our planet. Consumers can also join in creating positive changes by becoming informed about which organizations are making an effort to stay in compliance. Informed consumers can choose to support firms with intentional initiatives to reduce their GHG emissions. However, suppose a company is not making evident progress in complying with the terms of the program. In that case, consumers can choose to purchase products from their competitors who are reducing their GHG emissions.

4.4.4. Threat

4.4.4.1. Giant Lobbying

Lobbying has been one of the main threats against the California Cap and Trade Program. Environmentalists and regulated parties alike have challenged the CARB’s enforcement and implementation of the Cap-and-Trade Program in court. Although the oil industry has been slowly declining in recent decades, with California recently shifted from third to sixth in the ranks of oil-producing states, the oil industry still has an outsized influence on climate policies (Bourke, 2022). For example, 17 Democrats who argued against Garcia’s legislation received $1.2 million in campaign donations from the oil, gas, and labor industries (Mulkern, 2017). The fossil fuel industry has a seemingly enormous influence on moderate democrats because of their economic position. The cap-and-trade program was ultimately extended by AB 398 and supported by Garcia. However, she continues to advocate for stricter protections for marginalized communities beyond the required 25% investment of revenue. Without more political support, the program may be weakened and environmental justice.

4.4.4.2. Air Pollution Hotspots

Although polluting facilities are aware that GHG emission reductions could bring about
significant air quality and health benefits for California's disadvantaged residents, upgrades at the most polluting facilities are often more expensive because they are old. As a result, the polluting facilities in those communities tend to buy carbon credits and keep emitting their air pollutants (Adelman, 2013). A recent study shows that California’s cap-and-trade program has yet the enforcement mechanism to yield localized improvements in environmental equity (Cushing, 2018). Additionally, some firms argue that the effectiveness of the California Cap-and-Trade program should not be analyzed based on the hotspots because the Cap is statewide, and GHG emission is a worldwide issue.

4.5. EST Linking and Partnership

In recognition of California's climate leadership and engagement with other jurisdictions, AB 32 encourages CARB to consult with the federal government and other nations to identify the most effective strategies and methods to reduce GHGs. In addition, CARB manages GHG control programs and facilitates the development of integrated and cost-effective regional, national, and international GHG reduction programs. However, CARB struggles to influence the implementation of regulations over geographic jurisdiction beyond the markets its firms operate.

This jurisdiction challenge is particularly true for the electricity industry, where California is highly integrated with other markets in the western grid and car manufacturing industries beyond its borders. However, CARB has been linking its ETS with other justifications. CARB's process includes initiating a public process to amend the Cap-and-Trade Regulation and vetting compliance instruments of other emission trading systems (EST). Additionally, the party linking with the California Cap-and-Trade program must reciprocally approve all the compliance instruments and obligations to maintain a similar context and framework.

California's Cap-and-Trade program is currently only linked to Québec emission trading EST. The Quebec linking process was initiated in Mai 2012, after CARB released a proposed amendment to the legislative branch. The legislature enacted Senate Bill 1018, which granted the office of the governor of California the authority to decide whether CARB may take action to approve the linkage with another EST. In February 2013, Governor Edmund G. Brown Jr. received a request for linkage with the Québec Cap-and-Trade System from CARB. In April 2013, the governor issued its SB 1018 findings and required CARB to prepare a linkage
readiness report. In October 2013, CARB, in liaison with the governor, approved the proposed amendments to the Cap-and-Trade Regulation.

On January 1, 2013, CARB recognized the Quebec ETS instruments as both parties, CARB and the Government of Québec, pursued a non-binding agreement expressing their intentions to continue consulting and coordinating with each other related to their adopted linkage. In November 2013, CARB submitted the linkage readiness report to the governor as requested. In January 2014, California's Cap-and-Trade Program officially linked with Québec's Cap-and-Trade System. Later on, Ontario linked with the California Cap-and-Trade program, but it departed from the linked carbon market soon after. Nevertheless, California and Québec continued to maintain the operation, integrity, and stringency of their linked Cap-and-Trade program and market (Government of Canada, 2016).

4.5.1. Strength

4.5.1.1. Jurisdiction Extension

Linking California's Cap-and-Trade program with Quebec furthers California's climate ambition, enhances liquidity, provides cost containment for covered entities and consumers, and sets a model for other jurisdictions to reduce emissions (CARB, 2018). Since climate change is a global issue, policy experts argue that the current CARB's linking initiatives with other emissions pricing programs yield more significant abatement efforts (Government of Canada, 2016). Furthermore, they argue that linked ETS possess cross-jurisdictional abatement efforts that yield further cost reductions beyond stand-alone programs.

4.5.2. Weakness

4.5.2.1. Number of ETS Partnerships

California's Cap-and-Trade program only has one ETS link with the city of Quebec. As the only state in the western united states with a Cap-and-Trade program, it lacks partnership with its neighboring states, which is essential for long-term benefits to further reduce GHG emissions and prevent leakage. Many states do not want to establish an ETS like California's ambitious program because of the uncertainty of the associated economic cost. A worst-case
study by California's manufacturers (who generally oppose the program) estimated that AB 32 could cost California $135.8 billion by 2020 in both direct and indirect costs (Andrew Chang & Company 2012). Nevertheless, linking would be beneficial in furthering the GHG emission reduction initiative.

4.5.3. **Opportunity**

4.5.3.1. **Global ETS Prototype**

The IPCC concluded that the world must decrease the net carbon dioxide emission by nearly 50% by 2030 to maintain much of the planet's livability (The Nobel Prize, 2018). The only way that cap and trade systems work globally is if every country participates in programs within the same context and framework (Gleckman, 2014). Some societies may decide to be very strict, while others might offer leniency, but the goal is to reach carbon neutrality soon. California is the fifth-largest economy globally, and the success of its ETS may prove to be an incentive for other government entities. As California's Cap-and-Trade program obtains more success with its ambitious goals, it may become a prototype for other states and countries. The more countries adopt the California Cap-and-Trade program's context and framework; the more emissions may be reduced globally. In addition, California will be able to promote the technologies and infrastructure required to meet the collective climate goal and foster a sustainable, clean energy economy.

4.5.4. **Threat**

4.5.4.1. **Unregulated global GHG emission**

California's reductions will not prevent these long-term harms unless they spur global change in carbon emission patterns. Without more partnership and linking, the California vision for a carbon-neutral economy may not be successful. Its efforts may result in what the British economist William Forster Lloyd referred to as the Tragedy of the commons. It is a theory of economic behavior whereby some activity has diverging incentives for individual actors and society. For example, the burden of climate change applies to all entities regardless of their status. However, the main benefactors of GHG emissions are industrialized entities. If, in an effort to reduce the climate burden, an industrialized entity chooses to reduce its GHG
emissions. In doing so, they may only gain a negligible reduction in the cost of climate change because each actor's emissions contribution is minuscule compared to society's aggregate GHG emissions. The net benefit of participating in GHG-emitting activities would be more logical than the net benefit of not participating in them.

This Scenario can apply to California and its relationship with neighboring states and other government entities that are not under a similar context and framework of the Cap-and-Trade program. Furthermore, If its neighboring states and countries continue to permit high pollution levels, then GHG emissions may spill out into the atmosphere every year. After all, there is only one common atmosphere.

5. Analysis of Complementary GHG Policies

Table 2. Summary of the Complimentary policy analysis (Raphael Louis, 2022).

<table>
<thead>
<tr>
<th>Policy Type</th>
<th>Objective</th>
<th>Highlight</th>
<th>Policy Date</th>
</tr>
</thead>
</table>
| Renewable Standard Portfolio (RPS)      | Reduce GHG emissions in the electricity sector through the implementation of GHG emissions reductions planning targets in the Integrated Resource Plan (IRP) process. | • 25 % by 2017  
• 33 % by 2021  
• 60 % by 2030 | 2002         |
| Advance Car Program (LEV to ZEV)        | Reduce GHGs and other pollutants from the transportation sector through transition to zero emission, cleaner transit systems and reduction of vehicle miles traveled. | • 1.5 million by 2025 (ZEV)  
• 4.2 million by 2030 (ZEV) | 2012         |
| Low Carbon Fuel Standard (LCFS)         | Transition to cleaner/less polluting fuels that have a lower carbon intensity. | • 20 % reduction by 2030 | 2009         |

Some scientists argue that because the overall Cap and number of allowances in circulation determine overall emissions introducing a complimentary GHG-reducing policy might not yield any further reductions in overall emissions (Goulder and Stavins, 2012). The demand for emissions allowances would fall to the extent that the complimentary policy would be the primary driver of reductions in emissions. Consequently, the price of allowances would fall until all the allowances in circulation are again demanded. In an extreme of cases, the Cap-and-Trade program could be rendered ineffective because allowance prices could fall to zero. An exact result of this argument was observed under the US SO2 trading program, where federal regulations mandated reductions in SO2 emissions beyond the Cap in place, and SO2 allowances
prices settled near-zero (Chan et al. 2012).

Additionally, other outside factors may have played a role in GHG reduction. According to CARB, the largest reductions in greenhouse gas production have been during the recession in 2008-2009 before the Cap-and-Trade program went into effect (figure 4). In 2019, total GHG emissions in California decreased by approximately 7.1 million metric tons of CO2e, or 1.6 percent, compared to 2018 (Figure 4). In 2016, total GHG emissions in California decreased by approximately 20.7 million metric tons of CO2e, or 4.8 percent, compared to 2015 (Figure 4). Emission from sources covered under the Cap-and-Trade program decreased by approximately 16.4 million metric tons of CO2e, or 4.8 percent" (CARB, 2017). The 2017 scoping plan reported that "in 2014, total GHG emissions were 443.5 million metric tons of CO2 equivalent (MMTCO2e), a decrease of 2.8 MMTCO2e compared to 2013. This represents an overall decrease of 9.4% since peak levels in 2004." It remains unclear if the recession was the catalyst for emission reductions or if it is a result of the established climate policy in California. Moreover, the scope of the climate crisis and public pressure for solid regulations on fossil fuel companies have risen exponentially in the last decade (Bourke, 2022). With these arguments, one can agree that GHG emissions reductions are only partially a result of California's Cap-and-Trade program.

Figure 4. California Total GHG Emission (Raphael Louis, 2022; Data Source: CARB, 2021).
Nevertheless, California's Cap-and-Trade program met its 1990 emission levels by the 2020 emission target in 2016, 4 years before its deadline. Even with its effectiveness in reaching this last target, more than double their effort maybe be required to reach the 2030 GHG emission reduction target (CARB, 2017). CARB’s 2017 Climate Change Scoping Plan reaffirmed the Cap-and-Trade program’s role in emissions reduction as complementary, despite its prominence. It stated that “the Cap-and-Trade program is designed to fill the gap in the required emissions reductions over and above what is achieved by the prescriptive measures” (CARB, 2017). However, the scoping plan predicts an increased role for the Cap-and-Trade program in reducing emissions and reaching the 2030 target (CARB, 2017). CARB showed that the Cap-and-Trade program would become more effective are reducing GHG emissions, accounting for a reduction of 236 million metric tons of CO2e, or 38 percent of the total reduction (Figure 5).

Figure 5. CARB’s Predicted Cumulative GHG Reduction Estimate for different AB32 Climate Change Initiatives (Source: CARB, 2017).

Although California’s Cap-and-Trade met its initial benchmarks to 20% below 1990 by 2020 in 2016, the complementary emissions-reduction policies may have played a more substantial role in this outcome. California needs to more than double its yearly emissions cuts to be on track to meet the 2030 GHG emission target (CARB, 2021). California's battle against
GHG emissions in the transportation and energy sector focuses on three regulations in addition to the Cap-and-Trade program: the Low Carbon Fuel Standard (LCFS), the Advance Car program, and the Renewables Portfolio Standard (RPS). With the limitation on understanding the net impact of an ETS on overall emissions reduction (Hood, 2013), this section of the study seeks to investigate the “prescriptive measures” in the AB32 and their contribution to GHG emission reduction in California.

5.1. Renewable Portfolio Standards

The renewable portfolio standard (RSP) was initiated in 2002, requiring all electricity retail sellers in California to source an initial 20 percent of their electricity from renewable sources by 2017 (SB 1078). The RPS’s objective is to increase renewable power standards for each utility’s procurement of electricity consumed in California and establish a trading system for the renewable energy credit. Various technologies are eligible to count towards the standard, including solar PV, solar thermal, wind, hydroelectricity, bioenergy, and geothermal. In the last decades, California’s mandated RSP proved to reduce GHG emissions and help increase renewables in the energy market. One may argue that without the mandated RSP, electricity firms would be less likely to invest in their renewable source and reduce GHG emissions voluntarily.

In 2008, Governor Arnold Schwarzenegger signed an executive order that increased the target to 33% by 2021 (CEC, n.d). In addition to this Renewables Portfolio Standard, the California Legislature also passed the Emergency Economic Stabilization Act in 2008. This provided $18 billion in incentives for renewable energy and energy efficiency (.). In 2015, the RSP mandate increased to a 50% target by 2030 (SB 350). In 2017, the California Energy Commission (CEC) estimated that 29 percent of California’s electricity comes from renewable sources (CEC, 2018). In 2018, the California senate upgraded its 2030 target to 60% 2030 and required all of California’s electricity to come from free carbon sources by 2045.

Peer-reviewed articles show that the establishment of RSPs and their subsidies lead to lower allowance prices in the cap-and-trade market, increasing the incentive to innovate and create lower-cost compliance alternatives (Carlson, 2012). Moreover, the price of installing, maintaining, and operating renewable energy technologies at a utility scale has also declined.
dramatically (Lazard, 2017). Lazard's study shows a continued decline in the cost of generating electricity from alternative energy technologies. For example, he highlighted that wind has been less expensive than coal or natural gas on a per megawatt/hour (MWh) basis since 2011. He also demonstrated how the cost of solar has also dropped and is now only slightly higher than wind energy. Consequently, he concluded that despite the continued decline in the cost of natural gas electricity, electricity from wind and utility-scale solar continues to be cheaper than any conventional energy technology, even without government subsidies. It is hard to argue against the role RSPs have played in changing the EDUs.

5.2. Low Carbon Fuel Standard (LCFS)

As mentioned before, the transportation industry accounts for 40 percent of the GHG emissions in California (CARB, 2016). The Low Carbon Fuel Standard (LCFS) is one of the leading players in California’s active measures to reduce greenhouse gas (GHG) emissions from the transportation sector. CARB initiated LCFS in 2008 under AB 32, approved in 2009 to require petroleum fuel importers, refiners, and wholesalers to reduce the carbon intensity in the fuel pool while providing a range of low-carbon and renewable alternatives to achieve air quality benefits. California’s LCFS has stricter vehicle tailpipe emissions and mileage standards than required by the federal government.

LCFS is based on the principle that each fuel has "life cycle" greenhouse gas emissions, including CO2, CH4, N2O, and other GHG contributors. By assessing the GHG emission life cycle associated with a given fuel's production, transportation, and consumption, CARB can obtain a carbon intensity (CI) score for each fuel. Based on the calculated CI, CARB creates a yearly declining CI benchmark for transportation fuel providers. In doing so, CARB creates an LCFS credit market where fuel above or below the benchmark generates credits or deficits. CARB defined credit as dollars per metric ton of avoided carbon dioxide equivalent (CO2e) emissions (CARB, 2021). Entities below the CI benchmark must meet their compliance obligation by purchasing their missing credits from another regulated party with excess credit.

The LCFS complements the state’s emissions reduction and clean transportation programs, such as Cap-and-Trade and the Advanced Clean Cars Program. Since its implementation in January 2011, LCFS carbon intensity across transportation fuels consumed in
California rose from 6.1 percent to 8.5 percent in 2017 (Berkley, 2022). The reduction to the mixing of regular fuel with ethanol, biodiesel, and renewable diesel fuels. Furthermore, fuel producers have also taken steps toward decreasing their fuels’ carbon intensity (Berkley, 2022). As a result, gasoline and other petroleum-based transportation were 10 percent less carbon-intensive in 2020 than the 2010 baseline (CARB, 2016). California’s current commitment is to reduce CI by 20 percent by 2030 (CARB, 2018).

5.3. Advanced Clean Cars Program (ACC)

The Advanced Clean Cars Program (ACC), which CARB introduced in 2012, is also at the forefront of California’s GHG emission reduction initiatives. It builds upon previous efforts to control smog-causing, harmful health pollutants and GHG emissions from passenger vehicles. It complements the other policies to reduce GHG emissions by improving vehicle technology, reducing fuel consumption, and increasing transportation mobility options. The ACC program has two distinct efforts that contribute to emission reductions: the Low-Emission Vehicle (LEV) regulation and Zero-Emission Vehicles (ZEV).

In 1990, the EPA and National Highway Traffic Safety Administration (NHTSA) established LEV as a national program to harmonize GHG and fuel economy standards. In 2004, CARB adopted LEV, requiring manufacturers to reduce criteria pollutants like carbon monoxides and nitrogen oxides from light and medium-duty vehicles in 2009 through 2016 model years (CARB, 2012). In 2012, CARB amended LEV, requiring manufacturers to produce new passenger vehicles that emit 75 percent less in criteria pollutants and 40 percent less in GHG emissions in 2025 compared to 2012 model year vehicles (CARB 2019). In 2019, Governor Newsom reached an agreement with major automakers, including Ford, BMW and Honda, to proactively adopt the modified version of this GHG standard despite conflict with the EPA over their validity under the Clean Air Acts. These car manufacturers plan to use engine and emission control advancements, wider application of advanced hybrid technology, and greater use of robust and lighter materials.

Through the ACC program, CARB also incentivizes firms to invest in Zero Emission Vehicle (ZEV) to achieve the state's long-term GHG emission reduction goals. ZEV regulation mandated a 4.5 percent increase in the number of vehicles available for sale that do not emit any
exhaust, including battery-electric, hydrogen fuel cell, and plug-in hybrid electric vehicles after 2018. The new mandate requires a 22% increase in ZEV production after 2025 (CARB, 2022). Moreover, CARB estimated that a minimum of 8 percent of ZEV with technologies including full battery-electric, hydrogen fuel cell, and plug-in hybrid-electric vehicles will be sold in 2025. To further the ZEV commitment, Governor Newsom announced his statewide plan for 100 percent sales of zero-emission light-duty vehicles by 2035 (CARB, 2020).

Although the implementation of the ACC program has produced cars that are significantly cleaner today than a decade ago, the EPA reported that California’s air quality still struggles to improve (EPA 2017). According to CARB, the number of cars on the road and the distance that drivers are traveling continue to significantly increase, causing LEV production to be insufficient for GHG reduction (CARB, 2019). CARB argued that ZEVs and plug-in hybrid electric vehicles are significantly lower-emitting than LEVs. Therefore, ZEV regulation may prove beneficial moving forward in reducing GHG emissions in the transportation sector.

6. Comparative Analysis

There are two official ETS in the United States: California's Cap-and-Trade initiative and the Regional Greenhouse Gas Initiative (RGGI). Many national and international governments acknowledge California as a global leader in climate-change policy due to its ambitious carbon-reduction targets. California adopted and designed its Cap-and-Trade program with more robust administrative and regulatory structures suitable for handling unique opportunities and constraints (See SWOT) while improving and avoiding the flaws within the ETS before it. To best understand the effectiveness of California's Cap-and-Trade Program, this analysis compares these two ETS based on environmental effectiveness, economic efficiency, and social equity. The following table provides the framework for paring the two ETS (PMR and ICAP, 2016):
<table>
<thead>
<tr>
<th>Overall Assessment</th>
<th>ETS Attributes</th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environmental Effectiveness</td>
<td>Coverage of Key Emitting Sectors</td>
<td>ETS fits into overall climate policy with many sectors unregulated.</td>
<td>ETS fits into overall climate policy with some additional carbon mitigation policies; significant EITE exemptions.</td>
<td>ETS fits into overall climate policy covering all sectors with minimal EITE exemptions; or EITE coverage under an alternative policy.</td>
</tr>
<tr>
<td>Emission Cap to Cover Emission</td>
<td>Cap set equal or higher than the covered Business As Usual (BAU) emission levels at the beginning of a compliance period without further decrease over time.</td>
<td>Cap set less than the covered BAU emission levels at the beginning of a compliance period with some decrease over time.</td>
<td>Cap set less than the covered BAU emission levels at the beginning of the compliance period with definite decrease over time.</td>
<td></td>
</tr>
<tr>
<td>Stringency of Cap</td>
<td>No annual tightening of cap.</td>
<td>Circumstantial decreases in emissions cap.</td>
<td>Pre-determined annual tightening of emissions cap.</td>
<td></td>
</tr>
<tr>
<td>Economic Efficiency</td>
<td>Abatement Cost</td>
<td>High allowance price without Emission Entity and Trade Expose (EITE) included.</td>
<td>Low/moderate allowance prices without EITE included.</td>
<td>Low to moderate allowance prices with EITE included.</td>
</tr>
<tr>
<td>Raised Revenue</td>
<td>No revenue raised. Net expense for the government administering the ETS and firms to comply with ETS.</td>
<td>Some revenue raised through auctions. Covers administrative costs and MRV transaction costs.</td>
<td>Significant revenue generated to spend on additional environmental goals; Revenues to alleviate the social and economic burden of an ETS.</td>
<td></td>
</tr>
<tr>
<td>EITE earmarking</td>
<td>No revenue raised; EITE sectors get allocations for free; EITE sectors also</td>
<td>Revenue used to reduce the burden of EITE sectors in addition to free</td>
<td>Revenue used to reduce the burden of EITE sectors without free</td>
<td></td>
</tr>
<tr>
<td>Social Equity</td>
<td>Stakeholder engagement with regulated firms only prior to the beginning of a period. No option for public to play a role in the rule making process.</td>
<td>Stakeholder engagement with regulated firms through the establishment of emissions accounting process; Use of consistent schedule post ETS establishment or whenever a change in rules is necessary. No option for public comments.</td>
<td>Stakeholder engagement with regulated firms through the establishment of emissions accounting process; Use of a consistent schedule post ETS establishment or whenever a change in rules is necessary. Option for public to voice their opinions at meetings or comments.</td>
<td></td>
</tr>
<tr>
<td>---------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>And Outcomes</td>
<td>No correlation between rule modification/change outcomes and stakeholder recommendations. Evidence of Stakeholder fatigue.</td>
<td>Rule modification/change outcomes follow stakeholder recommendations. Evidence of disagreement among stakeholders on the outcome.</td>
<td>Clear correlation between rule modification/change outcomes and stakeholder recommendations. Overall agreement within stakeholders about the outcome.</td>
<td></td>
</tr>
<tr>
<td>Stakeholder Engagement</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td># of meetings per period or comments received</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rainfall</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

| Green earmarking | No additional green spending.                                                                                                      | Smaller share of revenue used for green spending.                                                                                       | Bigger share of revenue used for green spending.                                                                                                   |
| Earmarking for distributional equity | No money allocated to assist low-income communities.                                                                                   | Smaller share of revenue used to assist low-income communities.                                                                          | Bigger share of revenue allocated to assist low-income communities.                                                                                     |
6.1. Regional Greenhouse Gas Imitative (RGGI)

According to the Center for Climate and Energy Solution (2019), RGGI was presented in 2005 and formally required fossil fuel power plants with a capacity of 25 megawatts or greater to obtain an allowance for each ton of carbon dioxide they emit annually starting in 2009. Currently, the program regulation is linked within 11 states: Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, Vermont, and Virginia. RGGI states account for about one-sixth of the US population and one-fifth of the nation's GDP (EIA, 2021). Fossil fuels are the primary source of electricity production in most of these states. Each of these states agreed to adopt individual shares of the overall GHG emission cap and establish their own state-level carbon dioxide emissions budgets in accordance with the Model Rule (MR). The Model Rule serves as a regulatory blueprint for each member state. It identifies methods and standards for quarterly carbon dioxide allowance auctions and parameters for tracking the acquisition and transfers of carbon dioxide allowances.

As the yearly cap decrease, power plants within each state in the RGGI are required to comply through purchasing allowances from quarterly auctions, other generators within the region, or offset projects. The different government entities established RGGI, Inc. as the nonprofit that oversees, regulates, and administers auctions for carbon dioxide emissions allowances. At the auctions, participating power plant owners submit confidential bids, which then inform the price of allowances. RGGI, Inc. established guidelines to ensure the auctions run effectively and facilitate trading and secondary market purchases between participants. RGGI spend its allowance revenues in four areas: catalyzing clean, equitable transportation, promoting blue carbon in coastal habitats, enhancing urban forests, and improving New Jersey Green Bank. The states collectively generated a 48 percent decrease in emissions between the 2006–2008 period and the 2016–2018 period (Figure 6).
Figure 6. The RGGI Carbon emission and yearly Cap (source: RGGI, 2022).

6.2. Environmental Effectiveness

Table 3. Summary of the comparative analysis of the environmental effectiveness between RGGI and California’s Cap-and-Trade program (Raphael Louis, 2022).

<table>
<thead>
<tr>
<th></th>
<th>Key Polluters Coverage</th>
<th>Initial Emission Cap to Cover Emission</th>
<th>Current Emission Cap to Cover Emission</th>
<th>Stringency of Cap</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RGGI ETS</strong></td>
<td>Low</td>
<td>Low (20% with some additional mitigation policies, transportation sector not covered; only CO2 covered)</td>
<td>High (50% below Initial Business As Usual)</td>
<td>Medium (2.5% constant annual decrease)</td>
</tr>
<tr>
<td><strong>California’s Cap-and Trade</strong></td>
<td>High</td>
<td>Medium (9% above covered emission)</td>
<td>Medium (about 15% below Initial Business As Usual)</td>
<td>High (3% annual decrease for 2020 target, 5% annual decrease for 2030 Targets)</td>
</tr>
</tbody>
</table>
RGGI does not have as large a GHG reduction sectoral scope as California's Cap-and-Trade system. It only covers fossil fuel power plants with a capacity greater than 25 megawatts, leaving emissions-intensive sectors, including transportation, unregulated (Ramseur, 2017). Moreover, the EIA reported that the RGGI covers only about 20% of its jurisdiction's total CO2 emissions, which is not as ambitious and stringent as California's coverage. RGGI, Inc, the leading agency that oversees the program, set the initial emissions cap at 188 million tons in 2005; meanwhile, their reported emission was only 124 million tons when the program took effect in 2009 (figure 5). Fortunately, RGGI had established a price floor that kept allowance prices from falling to near zero. However, RGGI authorities had to permanently remove about 23% of the total allowances from the market after the first compliance period to set a 44% lower cap in the next compliance period with an annual reduction of 2.5% (Ramseur, 2017; EIA 2022). RGGI states are currently pursuing their 30 percent below 2020 levels by 2030. Meanwhile, their last emission report shows that the states are collectively emitting 96 million tons of CO2 (RGGI, 2022).

Some studies argue that both California's Cap-and-Trade program and RGGI can are not the sole influencer on GHG emissions reductions. The presence of complementary policies, including the EPA power plant regulations, renewable portfolio standard (RPS), economic recession, and lower natural gas prices, are the driving force of GHG emissions in both programs. However, other studies show that RGGI's state's total emissions from 2009 to 2012 could have been 24% higher in the absence of the ETS program (Murray & Maniloff, 2015). Instead, CO2 emissions in the electricity sector dropped 35% between 2009 and 2014 (CERES, 2015; figure 6).

California’s Cap-and-Trade has better environmental performance than RGGI, with complete coverage of large emitting sectors, including the transportation and electricity sector. California’s Cap declined by 3 percent through 2020 and is decreasing by 5 percent through 2030 (CARB, 2022). California’s emissions were 9 percent below the Cap during the initial 2013 compliance period (Camuzeaux, 2015). Unfortunately, both RGGI and California remain partially dependent on imported power, which threatens the programs’ environmental benefits and integrity.
6.3. Economic Efficiency

Table 4. Summary of the comparative analysis of the economic efficiency between RGGI and California’s Cap-and-Trade program (Raphael Louis, 2022).

<table>
<thead>
<tr>
<th></th>
<th>Cost of Abatement</th>
<th>Revenue Raised</th>
<th>EITE Allocation</th>
<th>Green Earmarking</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RGGI</strong></td>
<td>High ($13 per allowances in 2022)</td>
<td>High ($6 billion in for 2009 to 2022)</td>
<td>N/A</td>
<td>High (up to 81% of revenue has been allocated to energy efficiency, clean &amp; renewable energy and greenhouse gas abatement efforts.)</td>
</tr>
<tr>
<td><strong>CA Cap-and-Trade</strong></td>
<td>Low ($29 per allowance in 2022)</td>
<td>High ($19 billion in revenue from 2012 to 2022)</td>
<td>Medium/High (Receive free allowances, which is measured through emissions intensity and trade exposure and sector-specific benchmarks, to mitigate leakage risk and facilitate firms’ transition.)</td>
<td>Medium (25% revenue is required by law to be used for green spending.)</td>
</tr>
</tbody>
</table>

Tracking revenue generation and use in an ETS helps further corroborate how a system strives to balance the social, economic, environmental, and political needs that arise from implementing a carbon pricing policy (Narasimhan et al. 2018). Since the program began, RGGI states have experienced a net gain in economic growth, increased jobs, and long-run electricity cost reductions in most states (RGGI, 2022). According to the Center for Climate and Energy Solution, between 2009–and 2017, RGGI states saw a net economic benefit of $4.7 billion from the cap-and-trade program (CCES, 2018). In 2021, RGGI reported a total of $6.7 billion in revenue since the program’s initiation in 2009. Participating states are required to use at least 25% consumer benefit or strategic energy purpose (RGGI Inc., 2010). In practice, RGGI states allocated 42% for energy efficiency programs, 11% for bill assistance to low-income residents,
9% for GHG abatement, 8% for renewable energy development, 8% for state budget reductions, 4% for program administration, and 1% for RGGI management between 2009 and 2014 (Ramseur, 2017). RGGI also projected a net effect of 30,200 jobs available between 2009 and 2025 (Hibbard, Okie, Tierney, & Darling, 2015).

Although RGGI has a lower marginal cost of abatement than California’s Cap and Trade program, the EPA determined that RGGI is less economically efficient than California’s Cap-and-Trade program (PMR & ICAP, 2016). The low marginal abatement cost is not the best indicator of RGGI’s economic performance because it covers only the entities that are easiest to mitigate while pushing more costly sectors out of the system to be regulated through alternative means. Additionally, RGGI has a history of overallocation of allowances or hoarding of allowances by firms from a previous compliance period (RGGI, 2017). According to EIA, their allowance emission price was at $6 in 2019 and closed at a record-high $13 per ton in 2022. This jump in allowance prices caused electricity prices in some states, including Vermont and New Hampshire, to significantly increase (RGGI, 2022). The high regional electric prices resulted in a 12 percent drop in goods production and a 34 percent drop in the production of energy-intensive goods (EIA, 2022).

In California, current allowances in 2022 reached $28.60 per ton, up from $17 a ton at the end of 2019. Even with the free allowance allocation incorporated in the market, raised revenue added up to 19 billion dollars in 2022 (CARB, 2022). CARB uses about 25 percent of all allowance revenues towards green projects and other GHG reduction initiatives (Narassimhan et al, 2018).

6.4. Social Equity

Table 5. Summary of the comparative analysis of the social equity between RGGI and California’s Cap-and-Trade program (Raphael Louis, 2024).
RGGI ETS | High (Quarterly meetings.) | N/A | High (At least 25% of revenue must be allocated for ‘consumer benefit’– no explicit low-income provisions.)
---|---|---|---
CA Cap-and-Trade | High (Yearly official and periodic unofficial meetings) | Medium (56% of the survey responses supported the program) | High (A minimum of 35% of the proceeds be invested in projects that are located within and benefiting individuals living in disadvantaged communities.)

The effects of GHG emissions are reflected through long-standing patterns of inequality and racism in communities (Environmental Group Food and Water Watch, 2019). As a result, these communities often shoulder an outsized share of the climate burden as they are vulnerable to greater risks from heat waves, floods, and other climate-related impacts. Additionally, the harmful pollutants produced from fossil fuel facilities have become collateral in these communities (EPA, 2015). These pollutants, which include particulate matter, nitrogen, sulfur oxides, and toxic substances like benzene, have caused significant health problems ranging from respiratory disorders to reproductive problems to cancer ((Environmental Group Food and Water Watch, 2019). Consequently, stakeholder engagement, public opinion, and earmarking for distributional equity are important to achieve an equitable Cap-and-Trade program.

More positively, California schedules stakeholder meetings and public town halls when a rule change is proposed and receives public comments on the rule changes. California's ETS has received significant public support, with 54% of the state's residents favoring the program even if it raised consumer prices (Baldassare, Bonner, Kordus, & Lopes, 2016). In addition, CARB is required to allocate 35% of the total allowance revenue to minority communities to help mitigate the impacts of climate change within those communities (CARB, 2019). CARB allocated this revenue in response to environmental advocates demand for environmental equity in minority communities.

RGGI conducts regular quarterly stakeholder meetings and receives public comments on major rule changes. There is some evidence that the RGGI may have fared better in building constituency support for the full auctioning of allowances when compared to California (Rabe,
RGGI and its state constituents regularly framed the auction process as delivering significant benefits to both the environment and the economy, while there are claims that California equivocated over its plans for using auction revenues and alienated stakeholders in the process (Rabe, 2016). Each state in the RGGI uses its budget allowance revenue budget differently. Some states reinvest significantly, such as Virginia, using 95 percent of ESTs revenue towards communities threatened by recurrent flooding sea-level rise (45 percent) and energy efficiency programs for low-income individuals (50 percent). However, only 25 percent of RGGI revenues are required to be allocated towards customer benefits - with no explicit low-income provisions (RGGI, 2022).

7. Conclusion and Recommendation

CARB’s goal is to ensure that California’s program contributes to effectively and efficiently reducing emissions of GHG to combat the existential threat of climate change. Through analysis of government reports and the literature review, this paper finds that the California Cap-and-Trade program is a popular climate policy due to its ambitious scope and targets. The program creates strict limits on the amount of allowable GHG emission while providing significant compliance flexibility mechanisms for firms to maintain economic efficiency and promoting equity through stakeholder engagement and revenue allocation to underserve communities. The SWOT analysis suggests that CARB has a challenging task of formulating the program’s features to guarantee effectiveness, efficiency, and equity. So far, the main threats to the program are leakage, lack of partnership, and long-term political will.

The complementary policy analysis affirms that while California's Cap-and-Trade program does promote free-market principles while limiting the overall state emission of GHG, it did not achieve its GHG emission reduction targets without the complementary policies established under AB 32. Moreover, it showed that the complementary policies are the primary drivers of GHG emissions reduction in California because the implementation of the complementary regulations is more specific and enforceable. However, CARB estimated a high contribution of the program in the feature.

The comparative analysis shows that California's Cap-and-Trade program is more environmentally effective and economically efficient than the RGGI. Environmentally,
California's Cap-and-Trade program is more stringent and covers more sectors than the RGGI (Narasimhan et al., 2018). Economically, California's Cap-and-Trade program performs more efficiently than RGGI, with over 19 billion dollars in revenue, while pushing companies to reduce emissions (CARB, 2022). Social equity within both programs is moderate because both programs are developed in the open, using publicly accessible data. Both EST programs support new relevant evidence and arguments, including scientific data, expert opinion, and moral arguments. However, some studies suggest that RGGI promotes social equity better than California's Cap-and-Trade program (Rabe, 2016).

In sum, these analysis findings show that California’s Cap-and-Trade is executing emission reduction an while creating a market that raises additional funds to further its sustainability initiatives. California’s commitment to addressing climate change is a national and international inspiration for climate action. The research supported that California’s Cap-and-Trade program has effectively met its targets while promoting economic ease on the market so far. In addition, the program makes a moderate amount of room to include stakeholders and public participation. Since the findings supported all three hypotheses, the research concluded that California’s Cap-and-Trade is effective, efficient, and equitable.

Nevertheless, CARB can improve the program to maintain its effectiveness, efficiency, and equity. To this end, this research provides these recommendations for CARB to better improve its Cap-and-Trade Program:

7.1. Leakage Prevention Through Linking and Partnership

CARB should continue to work more effectively in resolving the issue of leakage. CARB should devise more attention to expanding its Cap-and-Trade program's ambition and framework through linking. This expansion to other regions would facilitate a reduction in leakage within the program. Ideally, CARB should continue influencing it neighboring states and Mexico, to establish a similar Cap-and-Trade program, which would significantly decrease leakage and contract shuffling.

7.2. Reduce Allowance Price Volatility

Moreover, CARB should continue to work more on pursuing strategies that strengthen
the allowance prices. To maximize GHG emission reduction, the allowance prices should be high enough to compel firms and stakeholders to change their behavior. Beyond the price floor and ceiling, CARB allowance prices should include the cost of each additional ton of GHG emitted and their potential future damages. Although an allowance price equilibrium may be hard to reach under the Cap-and-Trade program, it is nevertheless worth pursuing. Additionally, CARB should decrease the percent of free allowances it allocates to the electric utilities and large industries to drive emission reduction further.

7.3. Oversight and Evaluation Through increase stakeholders engagement

Although there have not been too many cases of lack of compliance, CARB should set more effective oversight and evaluation of the Cap-and-Trade program to maintain the integrity of the program. To that end, CARB should continue to rely on experts, including academic researchers, environmental justice groups, and economists, to provide ongoing guidance to the administration and the Legislature and help evaluate GHG emission reduction and how revenue is spent. Additionally, CARB should continue to strengthen public engagement through mediums such as social media to better hold companies accountable for their emissions.

7.4. Future Research

Further research should explore the compliance enforcement and administrative costs and the micro-influence of California's Cap-and-Trade program. These studies should look at how individual firms are behaving within the compliance boundaries and how their individual behavior benefits them and society. Additionally, CARB and the scientific community should better understand the administrative cost of California's Cap-and-Trade program and the cost of compliance to the firms. This understanding will help better estimate how much of a price increase in allowances is needed to favor the ideal percent of emission reduction within the specific deadlines.

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