Forest Carbon and Climate Program
Department of Forestry
MICHIGAN STATE UNIVERSITY

State Cap-and-Trade Programs

November 2023

Graham Diedrich (MSU FCCP)

Introduction

In its most recent report, the Intergovernmental Panel on Climate Change (IPCC) warned that without immediate and deep emission reductions, limiting the worst effects of global warming by preventing average global temperatures from rising above 1.5°C will not be possible (IPCC, 2022). Following publication of this report, IPCC Chair Hoesung Lee claimed that humanity is "at a crossroads," with the "tools and know-how required to limit warming" and "secure a livable future" (IPCC, 2022).

One of the mechanisms to achieve emission reductions, increasingly supported by economists, policymakers, and industry leaders, is known as "cap-and-trade." The goal of a cap-and-trade program is to reduce greenhouse gas (GHG) emissions as a market-friendly alternative to traditional command and control regulatory policies. Different cap-and-trade markets vary in which GHGs are applicable, as well as other design elements discussed below.

The first cap-and-trade program in the U.S. was introduced through 1990 amendments to the Clean Air Act, which created a tradable permits market for sulfur dioxide emissions (EDF, 2018). Since then, several state-led cap-and-trade programs have been created, most of which focus on limiting and reducing GHG emissions. In 2003, the Regional Greenhouse Gas Initiative (RGGI) was formed amongst a handful of northeastern states. California passed its cap-and-trade legislation in 2013, while Oregon and Washington established programs in 2021 (starting in 2022 and 2023 respectively).

This paper describes the basic design elements of a cap-and-trade program, including linkages to forest offset projects. Following this are detailed looks at the RGGI, California, Oregon, and Washington programs. Finally, forest and climate change implications of, as well as criticisms levied against, cap-and-trade systems are discussed.

Basic Design

A cap-and-trade system has two main components. A government (or another facilitating administrator) sets an emissions cap and issues a quantity of emission allowances credits. Covered entities must hold sufficient allowances to account for the GHG emissions they produce. Entities can buy and sell allowances from each other based on their need. This supply and demand dynamic establishes a market price for carbon (C2ES, n.d.). In theory, cap-and-trade incentivizes those that can reduce their emissions for less than the price of an allowance to do so sooner so that they can profit from selling their allowances on the market. Figure 1 demonstrates the basic design of a cap-and-trade market. In this example, the allowance limit applies to Business A and Business B. Because Business A is out of compliance, it must purchase Business B's remaining allowance credits.

Other key design elements are highlighted in Table 1. In some markets, there are sectors (e.g., agriculture, forestry, landfills) not covered by the cap. If allowed, GHG emission reductions from these uncovered sources can be sold to covered entities in the form of a carbon offset credit. This provides an alternative to trading and selling allowances. Instead, entities with emissions beyond the cap can simply "offset" their excess emissions by purchasing credits from unregulated sectors.

Figure 1. Basic Design of Cap-and-Trade

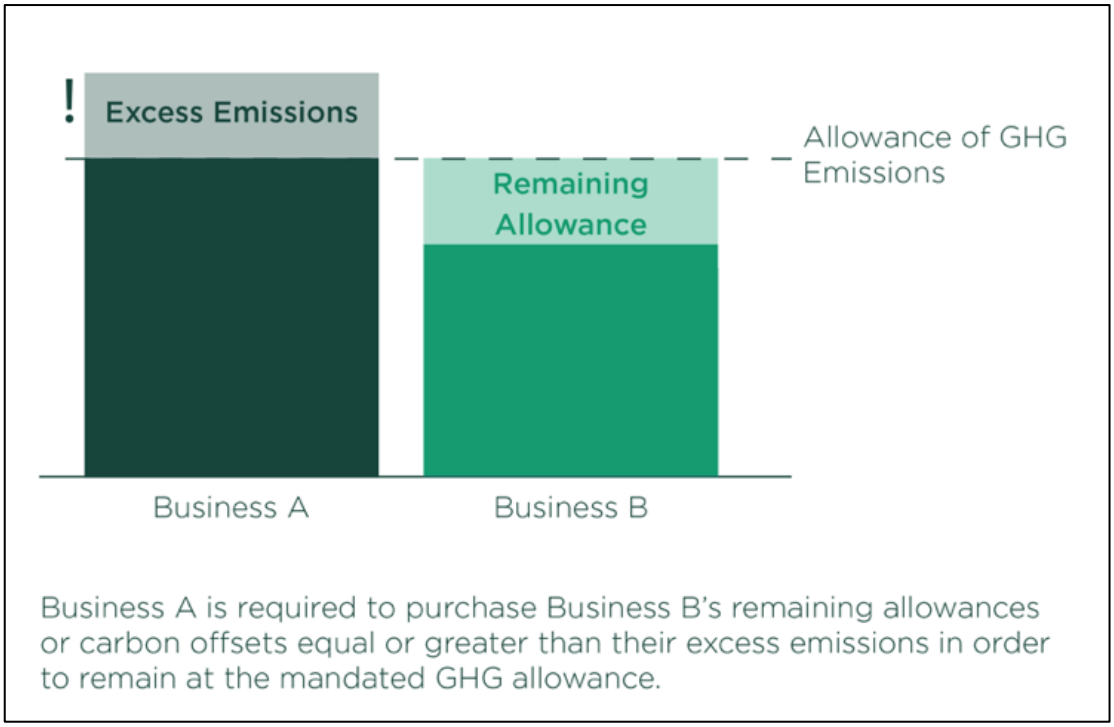


Table 1. Other Design Elements

Offset	A reduction or removal of emissions which compensates for emissions produced elsewhere
Target	The level of emissions reduction required by a specific date, compared to a specified baseline year
Compliance Period	The predetermined timespan in which entities must surrender a percentage of allowances
Banking	The ability to submit permits issued in one year to account for emissions in later years
Borrowing	The ability to use permits for future years in the current year
Distribution	Allowances are typically distributed freely, at quarterly auctions, or using a mix of both

Forest Offset Projects

Forest offset projects are planned sets of activities that increase carbon sequestration or prevent the loss of carbon stored in a forest landscape, when compared to a baseline or counterfactual in which project activities are absent. Offset credits are awarded based on the difference between the additional carbon stored in forests due to these planned

activities compared to the amount stored in a business as usual (BAU) scenario used as a baseline.

There are four primary project activity types accepted by registries when establishing a forest carbon project. As Table 2 demonstrates, actions fall under the categories of afforestation, reforestation, avoided conversion, and improved forest management.

Table 2. Types of Forest Offset Activities

Activities	Description
Afforestation	Establishing a forest on land not previously forested
Reforestation	Restoring tree cover on land not at optimal stocking levels
Avoided Conversion	Preventing the conversion of forestland to non-forest, must have demonstrably high likelihood of tree and carbon loss
Improved Forest Management	Activities to maintain or increase carbon stocks

In general, improved forest management can be achieved either through sequestering additional carbon by increasing the number of trees or improving forest health, or through maintaining current carbon stocks by avoiding BAU forest management activities that result in emissions.

Defining Credits and Offsets

Forest carbon credits are generated from forest offset projects that reduce the amount of carbon dioxide in the atmosphere, either through sequestration or avoided emissions. Each credit reflects a set, quantified amount of carbon and other GHGs. These credits are used in the marketplace as a means to offset carbon emissions and provide proof of an offset purchase.

A forest carbon credit is usually measured as one metric ton of carbon dioxide equivalent (Mt CO_2-e) which has not been released into the air or is newly stored due to the activities discussed previously. These credits can be purchased to offset emissions produced by another sector, such as energy production. For example, if a power plant is permitted to emit no more than 2 million metric tons of carbon annually but ends up emitting 2.5 million metric tons, they will need to purchase 0.5 million credits in a carbon marketplace to offset these extra emissions.

The terms *credit* and *offset* are often used interchangeably because they both refer to the same unit: one metric ton of CO_2-e stored or avoided which is equivalent to one carbon credit that can be used to offset one metric ton of emitted GHG.

Credit Generation

Credits are generated according to established guidelines, which have been developed to provide transparency and trust to all parties involved in carbon trading markets. These

verification systems ensure all stated emission reductions have truly occurred, are sustainable reductions, and that all participants follow the same guiding methodology. Examples include the Verified Carbon Standard (VCS) Program and the Gold Standard (GS).

Some standards incorporate environmental, socio-economic, and cultural benefits. These can be built into the carbon offset standard itself, as is the case with the Gold Standard. Alternatively, where carbon offset standards lack these requirements, project developers may consider using additional standards such as the Climate, Community, and Biodiversity (CCB) Standards, which focus on social, environmental, and biodiversity impacts. Project developers may elect to use CCB to demonstrate the additional positive impacts of their project activities.

For emission reductions to count towards the accumulation of carbon credits, they must be real, verifiable, additional, enforceable, quantifiable, and permanent. **Error! Reference source not found.** outlines each of these concepts in further detail.

Table 3. Emission Reduction Requirements for Carbon Credits

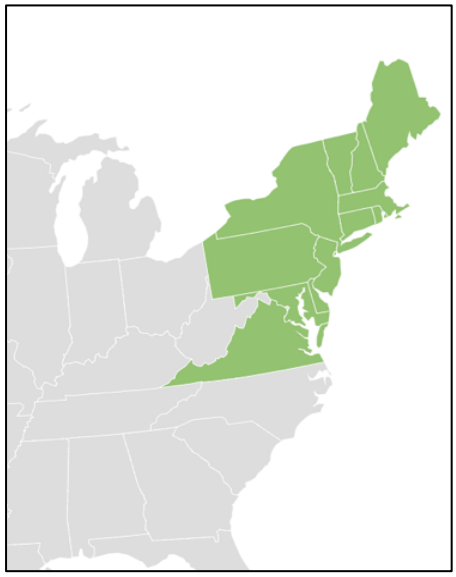
Requirement	Description
Real	Emissions measured accurately and not double-counted by any other projects
Verifiable	Clear monitoring and measurement requirement in place to allow auditors to assess and assert an emission reduction has occurred
Additional	Reductions would not have taken place without intervention in a business as usual (BAU) scenario
Enforceable	Ability for verifying auditors to investigate reductions
Quantifiable	Measurable, credible, and replicable emission reductions
Permanent	A guarantee that emissions cannot re-enter the atmosphere for specified number of years

Regional Greenhouse Gas Initiative

In 2003, governors from Connecticut, Delaware, Maine, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, and Vermont began to discuss the creation of a cap-and-trade market focused on carbon dioxide emissions from power plants (RGGI, n.d.-a). This was the first step in creating what would become the 12-state Regional Greenhouse Gas Initiative, also known as RGGI.

In 2005, seven of these states (Connecticut, Delaware, Maine, New Hampshire, New Jersey, New York, and Vermont) signed a memorandum of understanding, leading to the publication of a Model Rule in 2006 (RGGI, n.d.-a). The Model Rule provided individual states with

Figure 2. RGGI States



instructions on how to develop the regulatory and/or statutory proposals necessary to implement RGGI.

The first RGGI compliance period began in 2009. At that time, the initiative included ten members: Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, and Vermont. However, in 2011, New Jersey withdrew from the regional market. The state resumed participation in 2020 (RGGI, n.d.-a). Virginia and Pennsylvania became members in 2021 and 2022 respectively (RGGI, n.d.-a).

Design Elements

RGGI relies on a web of state regulations and statutes, composed of individual trading programs in each participating state. Based on the RGGI Model Rule, each state limits CO_2 emissions from power plants, issues allowances, and facilitates participation in regional auctions (RGGI, n.d.-b).

Emissions Cap

The regional emissions cap applies to power plants sized 25 megawatts or greater in all twelve RGGI states, except for New York which applies the emissions cap to power plants sized 15 megawatts or greater. Per the RGGI Model Rule, an adjusted cap is also provided to account for banked allowances accumulated during the previous compliance period (RGGI, 2018). An adjusted cap has been provided for every period following 2011. Each allowance is equivalent to a measure of carbon. RGGI uses the smaller American short ton (2000 lbs.) rather than the larger metric ton (2204.6 lbs.), where one allowance is equal to one short ton of CO_2.

By design, the RGGI cap is intended to decrease over time relative to the number of participating states. During the years that RGGI included ten participating states, the cap decreased from 188 million allowances in the years 2009–2011 to an adjusted cap of 74 million in 2020. The adjusted cap was increased to 100 million in 2021 to account for the entry of Virginia (RGGI, n.d.-b).

In 2022, the cap was 156,828,784 allowances, with an adjusted cap of 137,738,454 (RGGI, n.d.-b). This cap applied to the region as a whole, rather than as an individual limit per RGGI state, and included twelve states with Pennsylvania as the newest member. However, due to a court injunction in Pennsylvania that temporarily prevents the state from participating, the cap for the remaining eleven states was lowered to 116,112,784 CO_2 allowances with an adjusted cap of 97,022,454 (RGGI, n.d.-b).

Distribution of Allowances

Each RGGI state distributes allowances through separately-held quarterly auctions (RGGI, 2021a). In addition, all RGGI members (other than Virginia and Delaware) have set-aside programs permitting states to hold onto allowances which can be retired, allocated, or distributed in outside auctions (RGGI, 2021b). In the most recent auction, held on September 7, 2022, the clearing price for the entirety of the RGGI market was $13.45 per allowance (RGGI, 2022).

Banking and Borrowing

Covered entities may bank allowances, without limitation, until the allowances are used to satisfy compliance or transferred to another account (RGGI, 2018). However, RGGI does

not allow borrowing. Regulated entities are restricted to using allowances granted during the current year or those banked from previous years and are prohibited from using future allowances to satisfy compliance requirements (RGGI, 2018).

Offsets

Offsets can be used to satisfy up to 3.3% of a regulated entity's compliance obligation (RGGI, n.d.-c). However, some RGGI states do not accept applications for offset projects, such as Massachusetts, New Hampshire, Rhode Island, and Virginia (RGGI, n.d.-c). Among the eight states that do allow offsets, six (Delaware, Maine, Maryland, New Jersey, New York, and Vermont) do not accept sulfur hexafluoride, end-use efficiency, and afforestation offset projects (RGGI, n.d.-c).

One of the five offset project categories permitted under the RGGI Model Rule is forestry and afforestation (RGGI, n.d.-d). Eligible project types include reforestation, improved forest management, and avoided conversion. To ensure offset allowances represent permanent sequestration capacity, RGGI states require a legally binding permanent conservation easement that is "perpetual in duration" (RGGI, n.d.-d). The process for quantifying net GHG reductions is as follows:

1. Estimate baseline onsite carbon stocks
2. Estimate baseline carbon in harvested wood products
3. Determine actual onsite carbon stocks
4. Determine actual carbon in harvested wood products
5. Calculate the offset project's primary effect
6. Quantify the offset project's secondary effects
7. Calculate total net GHG reductions and GHG removal enhancements

To facilitate this process, RGGI provides annual monitoring, calculation, and sampling worksheets for the qualified holder of an offset project (RGGI, n.d.-d).

As of November 2022, there is only a single RGGI offset project: a landfill methane capture facility located in Maryland (RGGI, n.d.-e). This is may be due to an over-allocation of permits relative to emissions, meaning regulated entities lack any incentive to use offsets instead of traditional allowances (Burgert, 2008).

California Cap-and-Trade

In the state of California, a cap-and-trade program was introduced in 2012 and implemented in 2013 by the California Air Resources Board, or CARB (CARB, 2015). Since then, the cap-and-trade program has become the centerpiece of the state's carbon neutrality goals (CARB, n.d.-a).

Design Elements

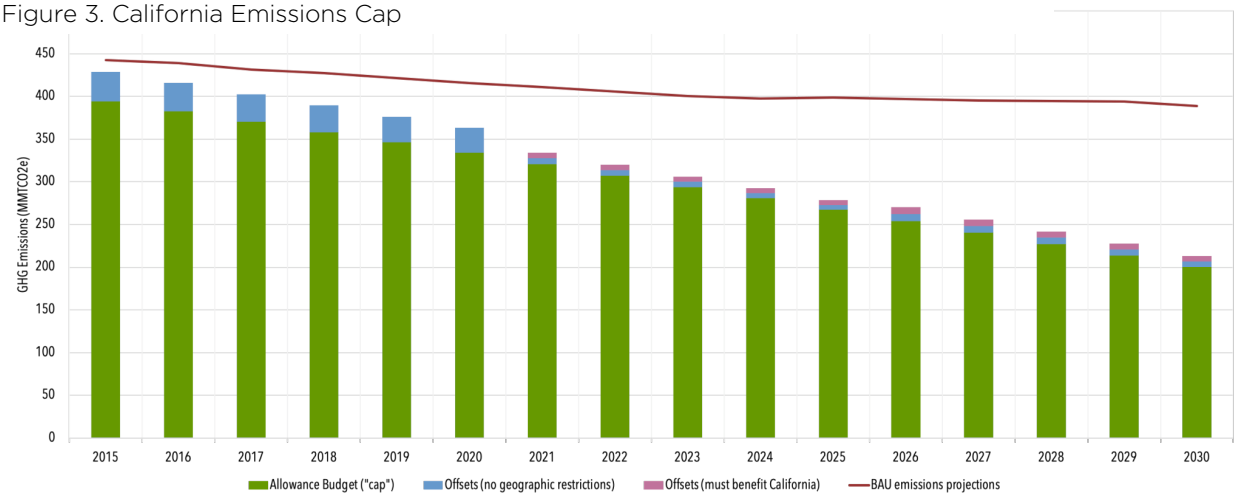
California cap-and-trade establishes a declining limit on CO_2 emissions, applying to entities involved in electricity generation, large industrial activities, and fuel supply (University of California Center for Law, Energy & the Environment, n.d.). In total, there are approximately 450 covered entities making up more than 80% of statewide emissions (CARB, n.d.-b). CARB is tasked with implementing, monitoring, and enforcing the program pursuant to

emission reductions mandated under Assembly Bill 32 (University of California Center for Law, Energy & the Environment, n.d.-a).

Emissions Cap

For 2022, the emissions cap is 307,500,000 CO_2 allowances, where each allowance is equal to one Mt CO_2-e (C2ES, n.d.-b). This applies to sources that emit at least 25,000 Mt CO_2-e per year, such as electricity generators, electricity importers, industrial facility operators, and fuel distributors (C2ES, n.d.-b). Figure 3 demonstrates how the emissions cap declines year on year in relation to BAU emission projections.

Figure 3. California Emissions Cap



Source: C2ES, n.d.

Distribution of Allowances

Allowances are distributed annually among four categories: cost-containment, utility allocation, industrial allocation, and auction (CARB, 2021). Cost-containment reserves are intended to reduce market volatility (CARB, 2021). Allocation to utilities is meant to benefit energy consumers, while industrial allocations are intended to prevent companies from relocating to regions without carbon pricing regulations (CARB, 2021). Remaining state-owned allowances are made available for purchase at quarterly actions, as are most allowances allocated to utilities (CARB, 2021).

Proceeds generated through auctioning allowances are used to prioritize ratepayer protections (as required by Assembly Bill 32) and to stock the Greenhouse Gas Reduction Fund (GGRF) (CARB, 2021). The GGRF is used to fund state agencies (e.g., CARB, California Department of Transportation) and to fund environmentally focused community projects that serve vulnerable populations (University of California Center for Law, Energy & the Environment, n.d.-b).

Banking and Borrowing

Regulated entities may bank allowances indefinitely. However, sources are bound by a holding limit which restricts the maximum amount of allowances an entity can hold at any given time (C2ES, n.d.-b). This limit incentivizes entities to pursue emission reductions early so that they can save allowances for future use when prices are higher, in theory leading to market stability (EDF, n.d.). However, to ensure emitters are able to meet their compliance obligations, the CARB grants limited exemption to holding limits (CARB, 2020). A recent examination of hold limit exemptions shows that they undermine banking constraints and

lead to an oversupply of allowances (Inman, 2018). Covered entities are not permitted to borrow allowances from future years, as is typical with most cap-and-trade programs (C2ES, n.d.-b.)

Offsets

Sources may use offsets to meet up to 4% of their total compliance obligation through 2025, and 6% between 2026 and 2030. Beginning in 2021, it is required that at least half the offsets used for compliance must come from projects that directly benefit California (e.g., in-state projects) (C2ES, n.d.-b). Offset projects can be located anywhere in the U.S., and must be listed with an CARB-approved Offset Project Registry (C2ES, n.d.-b). Allowable offset projects include forestry, livestock, ozone depleting substances (ODS) projects, mine methane capture (MMC), and rice cultivation (C2ES, n.d.-b). Approximately 85% of offset credits issued have been directed towards forestry projects (CARB, 2022). ODS, MMC, and livestock projects have been allocated 8.6%, 3.6%, and 3.1% respectively (CARB, 2022).

Eligible forestry projects include improved forest management, avoided conversion, and reforestation (CARB, 2019). CARB provides specific quantification methodologies that must be used to monitor carbon stocks and calculate the emission reductions. For example, under CARB, the baseline used for comparison and calculation of carbon benefit is designed to represent what could feasibly occur in a BAU scenario over 100 years using an approved growth and yield model (CARB, 2021).

Oregon Climate Protection Program

In 2020, Governor Kate Brown signed Executive Order (EO) 20-04 which directed multiple state agencies and departments to act against the worst effects of climate change by reducing emissions (DEQ, n.d.-a). Using existing regulatory authority, the Environmental Quality Commission and Department of Environmental Quality (DEQ) created a cap-and-trade program referred to as the Oregon Climate Protection Program (CPP). The program took effect on January 1, 2022.

According to DEQ, the purpose of the CPP is to reduce GHG emissions, achieve co-benefits from other air contaminant reductions, and enhance public welfare for Oregon communities in regards to environmental justice (DEQ, 2021).

Design Elements

Although there are similarities between the CPP and the other cap-and-trade programs discussed thus far, there are also clear differences. Notably, CPP allowances are not distributed through auctions and traditional offsets are not available.

Emissions Cap

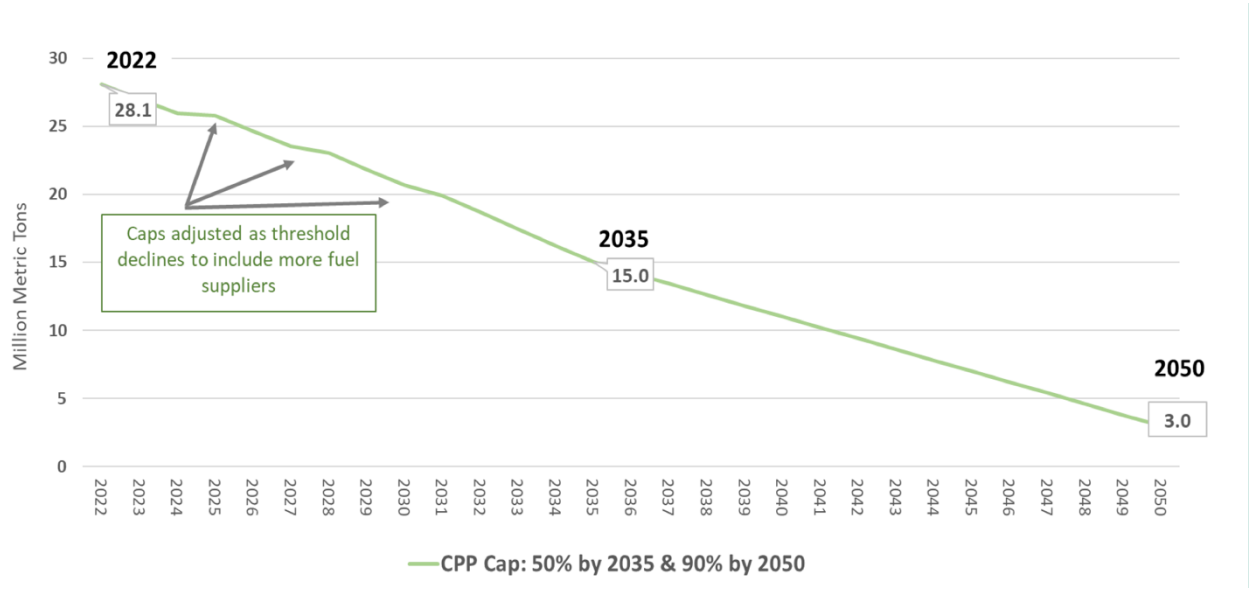
Based on average 2017–2019 emissions, the emissions cap for 2022 is 28.1 million Mt CO_2-e (DEQ, n.d.-b). This cap applies to liquid fuel and propane suppliers that have emitted 200,000 Mt CO2-e or more in any year since 2018 (DEQ, n.d.-b). As shown in Figure 4, the cap declines over time as more entities are covered under the program. Currently, the cap is set to decrease to 15 million Mt CO_2-e by 2035 and to 3 million Mt CO_2-e by 2050.

Distribution of Allowances

Under the CPP, each year, allowances (also known as compliance instruments) are distributed to covered entities free of charge (DEQ, n.d.-b). On March 31, 2022, DEQ issued compliance instruments for 2022 to covered fuel suppliers, distributed based on the following formula:

Number of Compliance Instruments = Total Compliance Instruments to Distribute * ([Covered Fuel Supplier Covered Emissions + Covered Fuel Supplier Biofuel Emissions]/Total Emissions)

Figure 4. CPP Emissions Cap



In total, 27,681,327 2022 compliance instruments were distributed to 18 covered fuel suppliers. Fossil fuel suppliers can trade unused compliance instruments or bank them for future use.

Banking and Borrowing

The program allows covered entities to bank compliance instruments for future use, with the explicit goal of incentivizing early emission reductions and providing regulatory flexibility (DEQ, n.d.-b). The CPP does not have provisions that allow sources to borrow allowances from future compliance periods.

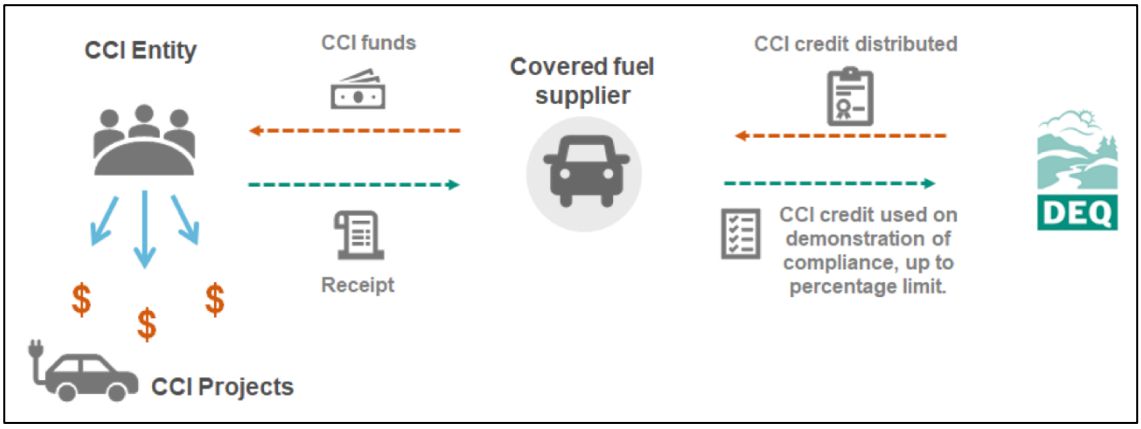
Offsets

Rather than rely upon traditional offset credits, the CPP allows covered fuel suppliers to earn community climate investment (CCI) credits. When fuel suppliers contribute funds to third-party non-profit entities, they earn CCI credits. These non-profits are then approved by DEQ to implement programs that reduce GHG emissions in Oregon. This alternative mechanism was selected primarily due to environmental justice concerns and criticism surrounding traditional offsets.

These credits allow an entity to demonstrate up to 10% of its compliance obligation for the first compliance period, increasing to 15% and 20% for the second and third periods. In 2022, one CCI credit is purchasable at $107 (in 2021 dollars), with that rate increasing a dollar per year and adjusted for inflation. Once purchased, CCI credits can be banked for

two compliance periods. In turn, CCI entities are given funds for CCI projects that seek to achieve the greatest benefit for environmental justice communities. This relationship is demonstrated in Figure .

Figure 5. CCI Credits



As November 2022, no CCI entities or projects have been implemented. Based on the current timeline, CCI entities will be selected and approved to receive funds in Spring 2023, with authorization to invest funds in Summer 2023 (DEQ, 2021).

Washington Cap-and-Invest

In 2021, the Climate Commitment Act (CCA) created a cap-and-invest program in Washington state. In a bid to enhance environmental justice, the Washington cap-and-invest program invests revenues created by selling allowances to fund climate initiatives. This includes projects that aim to tackle air quality and heath disparities, transportation, climate mitigation and adaptation, and relocation costs for tribal communities threatened by rising sea levels (Hemsworth, 2022).

Design Elements

The structure and scope of the Washington cap-and-invest program was modelled after the California cap-and-trade program. However, there is differentiation in how Washington treats offsets, how revenues are allocated, and the way in which environmental justice is centered (Hemsworth, 2022)

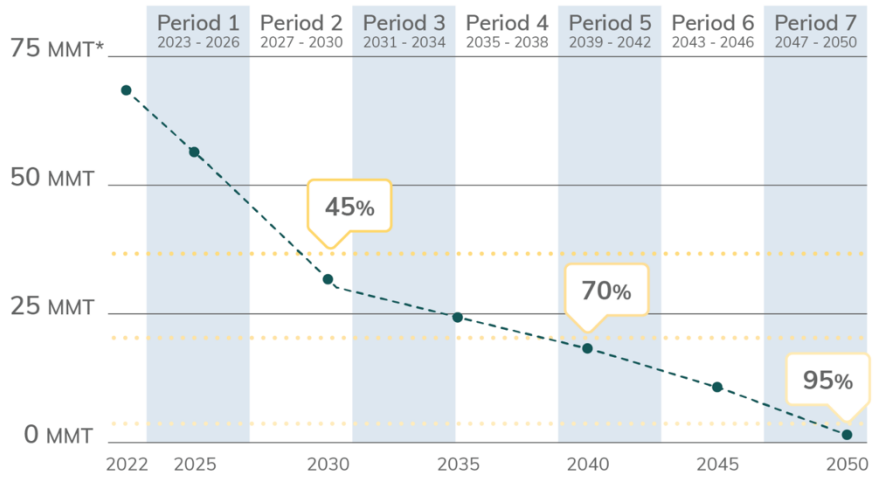
Emissions Cap

Approximately 75% of statewide emissions are covered under Washington cap-and-invest. Like in California, businesses that generate 25,000 Mt of CO_2-e or more per year are regulated under the program. This includes fuel suppliers, natural gas and electric utilities, waste-to-energy facilities (starting in 2027), and railroads (starting in 2031) (WDOE, n.d.).

The emissions cap is reduced each year to ensure Washington achieves its 2030, 2040, and 2050 emission targets of 45%, 70%, and 95% respectively. Figure shows the projected emissions cap over time.

The annual rate of cap decrease in Washington is 7% until 2030, then 2.5% until the program expiration in 2050 (Hemsworth, 2022). This rate is steeper than in California, which has a 5% decrease each year until the 2030 expiration of the program (Hemsworth, 2022).

Figure 6. Washington Emissions Cap



Distribution of Allowances

Allowances are distributed through quarterly, single-bid auctions (WDOE, n.d.). An auction floor and ceiling are announced 60 days before the auction date, with the 2023 floor price set at $19.70 increased by 5% plus the rate of inflation, and the ceiling price set at $72.29 increased by 5% plus the rate of inflation (WDOE, 2021).

Under the CCA, emissions-intensive, trade-exposed industries (EITEs), natural gas utilities, and electric utilities are issued allowances freely depending on the type of business and total baseline emissions (WDOE, n.d.). There are approximately 40 businesses qualify as EITEs.

Banking and Borrowing

Like in the California cap-and-trade program, allowances distributed under the Washington cap-and-invest program do not expire and may be held or banked in perpetuity (Hemsworth, 2022) without a holding limit. Borrowing from allowances for future years is not permitted.

Offsets

In the first compliance period (2023–2026), entities can use offset credits to demonstrate 5% of their compliance obligation with an additional 3% from credits generated by projects on Tribal lands (WDOE, n.d.). In the second period (2027–2030), this decreases to 4% with an additional 2% from projects on Tribal lands (WDOE, n.d.). As with California's requirements, at least 50% of offset credits must be purchased from in-state carbon projects or have direct in-state environmental benefits.

Under proposed language for the rules governing the cap-and-invest program, Washington is planning to adopt the four offset protocols adjacent to those defined for the cap-and-trade program in California. Washington's program allows forestry, urban forestry,

livestock, and ozone-depletion projects (WDOE, n.d.). Due to a lack of specific information on offsets, it can be assumed that forest projects in Washington will function similarly to those in California.

Forest and Climate Change Implications

Forests play a vital role in storing carbon, promoting biodiversity, purifying water, and filtering pollutants from the air. Between 2001 and 2019, global forests absorbed a net 7.6 billion Mt CO_2-e per year, more than 1.5 times the annual carbon footprint of the U.S (Harris et al., 2021).

By design, cap-and-trade programs have profound implications for forests and climate change, particularly in regard to carbon offset projects. Reforestation, afforestation, avoided conversion, and improved forest management projects can bolster ecosystem vitality, enhance resilience to climate change, and reduce emissions through improved carbon sequestration.

However, as it can be difficult to measure the emission reductions attributable to offset projects alone, there is a concern that the effect of offset projects in terms of net GHG reductions is overstated (UNEP, 2019). If this concern is proven legitimate, offsetting would no longer represent a valid substitute for real emission reductions, rather they would be seen as a mechanism allowing companies to "pay to pollute".

Additionally, critics point out that reducing emissions in one place, while continuing to pollute in another, results in further stratification and entrenchment of existing social and economic inequities. Some cap-and-trade systems (e.g., California and Washington) allow for purchasing offsets outside of the state, meaning state residents do not see the location-specific co-benefits of emission reductions (e.g., air quality). This relates to a concept known as leakage, which refers to a measurable increase in GHG emissions outside of a project's boundaries as a direct result of emissions reduction activities within the project boundary. An undesirable effect of some carbon projects, at times emissions are simply shifted to another location, meaning the project is not contributing to net emission reductions.

In a 2022 study, Coffield et al. attempt to quantify the additional carbon benefits of forest offset projects in California utilizing remote sensing-based geospatial data. They found that carbon is not increasing in offset project sites any more than in other areas of the state, and that logging activities have not decreased. In some cases, projects were established in areas where the risk of logging was low (e.g., areas with tree species of low monetary value), further complicating the need to prove additionality (Coffield et al., 2022). According to recent research, California underestimates the climate risks posed to forest offset projects in the state (Badgley, 2022). CARB requires only 2% or 4% of carbon credits be placed in an insurance pool against wildfires, which would act to supplement carbon lost due to natural disturbances. To remediate these issues, Coffield et al. recommend the following:

1. Use satellite data to monitor forests and carbon storage
2. Avoid putting offset projects on lands that are already being conserved

3. Prevent landowners from prematurely withdrawing from an offset program by increasing penalties
4. Increase the insurance pool to adequately cover the effects of worsening droughts, wildfires, diseases, and beetle infestations
5. Focus on other offset options (e.g., investing in solar and electrification projects in low-income urban areas)

Other innovative mechanisms, such as blockchain ledger technology, have been proposed as a way to improve the transparency, security, and integrity of trade in carbon markets by reducing double-counting and establishing unambiguous ownership (Pontecorvo, 2019).

In addition to specific concerns surrounding offsets, there are broader challenges facing cap-and-trade markets. Cap-and-trade systems rely on forecasts to inform adequate cap levels, which must be less than BAU emission levels to achieve net reductions. Issues arise when a cap is set too high, in which case more pollution is generated than would occur under a lower cap and net reductions are not achieved.

In any case, there is evidence that without alterations to the current system, net emissions may be undervalued and the effectiveness of cap-and-trade systems may be overvalued. As a result, there is a risk of contributing to the very issue cap-and-trade programs are designed to solve, while also distracting from the implementation of other policy alternatives if cap-and-trade programs are considered a sufficient solution.

Conclusion

Cap-and-trade programs attempt to incentivize emission reductions by creating a tradable permit market, which enables covered entities to buy and sell the allowances necessary to remain in compliance with an emissions cap. In the U.S., there are four main cap-and-trade markets focused on GHG emission reductions: the RGGI, California, Oregon, and Washington systems. Although many similarities of basic design are shared among these programs (e.g., banking and borrowing), key differences emerge in terms of coverage, emissions caps, distribution of allowances, and use of carbon offset credits.

References

Badgley, G., Chay, F., Chegwidden, O., Hamman, J., Freeman, J., & Cullenward, D. (2022). California's forest carbon offsets buffer pool is severely undercapitalized. *Frontiers in Forests and Global Change*, 5. https://doi.org/10.3389/ffgc.2022.930426

Burgert, P. (2008). RGGI Results Due Monday: Are Regional Initia2tives Ushering in the Forestry Age? Ecosystem Marketplace. https://www.ecosystemmarketplace.com/articles/rggi-results-due-monday-are-regional-initiatives-ushering-in-the-forestry-age/

California Air Resources Board [CARB]. (n.d.-a). Cap-and-Trade Program. https://ww2.arb.ca.gov/our-work/programs/cap-and-trade-program/about

California Air Resources Board [CARB]. (n.d.-b). Cap-and-Trade Program: Allowance Distribution Factsheet. https://ww2.arb.ca.gov/resources/documents/cap-and-trade-program-allowance-distribution-factsheet

California Air Resources Board [CARB]. (2015). ARB Emissions Trading Program. https://ww2.arb.ca.gov/sites/default/files/cap-and-trade/guidance/cap_trade_overview.pdf

California Air Resources Board [CARB]. (2019). U.S. Forest Offset Projects. https://ww2.arb.ca.gov/sites/default/files/cap-and-trade/offsets/overview.pdf

California Air Resources Board [CARB]. (2020). Guidance on Limited Exemption from the Holding Limit. https://ww2.arb.ca.gov/sites/default/files/cap-and-trade/limited_exemption.pdf

California Air Resources Board [CARB]. (2021). California's Compliance Offset Program. https://ww2.arb.ca.gov/sites/default/files/2021-10/nc-forest_offset_faq_20211027.pdf

California Air Resources Board [CARB]. (2022). CARB Offset Credits Issues. https://ww2.arb.ca.gov/sites/default/files/2022-07/nc-arboc_issuance.xlsx

Center for Climate and Energy Solutions [C2ES]. (n.d.-a). Cap-and-trade Basics. https://www.c2es.org/content/cap-and-trade-basics/

Center for Climate and Energy Solutions [C2ES]. (n.d.-b). California Cap-and-Trade. https://www.c2es.org/content/california-cap-and-trade/

Oregon Department of Environmental Quality [DEQ]. (n.d.-a). Background on Executive Order 20-04. https://www.oregon.gov/deq/ghgp/cpp/Pages/crprogramoverview.aspx

Oregon Department of Environmental Quality [DEQ]. (n.d.-b). CCP Overview. https://www.oregon.gov/deq/ghgp/Documents/CPP-Overview.pdf

Oregon Department of Environmental Quality [DEQ]. (2021). Climate Protection Program: Frequently Asked Questions https://www.oregon.gov/deq/ghgp/Documents/cciFAQ.pdf

Environmental Defense Fund [EDF]. (n.d.). California's cap-and-trade program step by step. https://www.edf.org/sites/default/files/californias-cap-and-trade-program-step-by-step.pdf

Environmental Defense Fund [EDF]. (2018). How economics solved acid rain. https://www.edf.org/approach/markets/acid-rain

Harris, N. L., Gibbs, D. A., Baccini, A., Birdsey, R. A., de Bruin, S., Farina, M., Fatoyinbo, L., Hansen, M. C., Herold, M., Houghton, R. A., Potapov, P. V., Suarez, D. R., Roman-Cuesta, R. M., Saatchi, S. S., Slay, C. M., Turubanova, S. A., & Tyukavina, A. (2021). Global maps of twenty-first century forest carbon fluxes. Nature Climate Change, 11(3), Article 3. https://doi.org/10.1038/s41558-020-00976-6

Hemsworth, P. (2022). Washington State's Cap-And-Invest Carbon Trading Program: Does It Correct California's Design Flaws? ISEP. https://sais-isep.org/washington-states-cap-and-invest-carbon-trading-program-does-it-correct-californias-design-flaws/

Inman, M. (2018). Holding limits don't constrain banking in California's cap-and-trade program. http://www.nearzero.org/wp/2018/12/13/holding-limits-dont-constrain-banking-in-californias-cap-and-trade-program/

Intergovernmental Panel on Climate Change [IPCC]. (2022). The evidence is clear: The time for action is now. We can halve emissions by 2030. https://www.ipcc.ch/2022/04/04/ipcc-ar6-wgiii-pressrelease/

Pontecorvo, E. (2019). Can this company build a better carbon offset? Grist. https://grist.org/article/can-this-company-build-a-better-carbon-offset/

Regional Greenhouse Gas Initiative [RGGI]. (n.d.-a). Program Design Archive. https://www.rggi.org/program-overview-and-design/design-archive

Regional Greenhouse Gas Initiative [RGGI]. (n.d.-b). Elements of RGGI. https://www.rggi.org/program-overview-and-design/elements

Regional Greenhouse Gas Initiative [RGGI]. (n.d.-c). Offsets. https://www.rggi.org/allowance-tracking/offsets

Regional Greenhouse Gas Initiative [RGGI]. (n.d.-d). Forestry and Afforestation. https://www.rggi.org/allowance-tracking/offsets/offset-categories/forestry-afforestation

Regional Greenhouse Gas Initiative [RGGI]. (n.d.-e). CO2 Allowance Tracking System. https://rggi-coats.org/eats/rggi/index.cfm?fuseaction=search.project_offset&clearfuseattribs=true

Regional Greenhouse Gas Initiative [RGGI]. (2018). Model Rule. https://www.rggi.org/sites/default/files/Uploads/Design-Archive/Model-Rule/2017-Program-Review-Update/2017_Model_Rule_revised.pdf

Regional Greenhouse Gas Initiative [RGGI]. (2021a). About the Regional Greenhouse Gas Initiative. https://www.rggi.org/sites/default/files/Uploads/Fact%20Sheets/RGGI_101_Factsheet.pdf

Regional Greenhouse Gas Initiative [RGGI]. (2021b). Summary of State Set-Aside Programs. https://www.rggi.org/sites/default/files/Uploads/Allowance-Tracking/States_Set-Aside_Accounts.pdf

Regional Greenhouse Gas Initiative [RGGI]. (2022). Auction 57. https://www.rggi.org/Auction/57

United Nations Environment Programme [UNEP]. (2019). Carbon offsets are not our get-out-of-jail free card. https://www.unep.org/news-and-stories/story/carbon-offsets-are-not-our-get-out-jail-free-card

University of California Center for Law, Energy & the Environment. (n.d.-a). California Climate Policy Fact Sheet: Cap-and-Trade. https://www.law.berkeley.edu/wp-content/uploads/2019/12/Fact-Sheet-Cap-and-Trade.pdf

University of California Center for Law, Energy & the Environment. (n.d.-b). California Climate Policy Fact Sheet: California Climate Investments. https://www.law.berkeley.edu/wp-content/uploads/2019/12/Fact-Sheet-Climate-Investments.pdf

Washington State Department of Ecology [WDOE]. (n.d.). Cap-and-invest. https://ecology.wa.gov/Air-Climate/Climate-Commitment-Act/Cap-and-invest

Washington State Department of Ecology [WDOE]. (2021). Climate Commitment Act Program Rule. https://ecology.wa.gov/DOE/files/4f/4ffb375b-2bec-4b66-afb3-9b613645896e.pdf