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Clearing the Zero-Emission Path

A Review of Financial Transfers to Polluting Fuels via California Carbon Trading Programs

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Executive Summary

California gave oil companies and biofuel suppliers nearly $28 billion from state-controlled climate funding streams for carbon-emitting transportation from 2013 to 2024. This is the combined value in 2023 dollars of free Cap and Trade allowances given to oil refiners and drillers and Low Carbon Fuel Standard (LCFS) credits awarded to oil companies and other suppliers of transportation biofuels during those 12 years. The money came mainly from Californians at the gas pump. It was intended to incentivize the lowest-carbon transport measures feasible, including electric vehicles and public transit. Instead, it funded carbon-emitting transportation, further locking it into place.

Purpose and scope

Understanding subsidies to the carbon-emitting transport system is important because they slow the switch to zero-emission electric vehicles and public transit and because transportation remains the dominant carbon-emitting sector in California. The subsidies fuel carbon lock-in: the resistance of a carbon-emitting system to change caused by mutually reinforcing technological, capital, institutional, and social commitments to the

system that have become entrenched as it was developed and used. Chapter 1 reviews the need to expose state support for transport system carbon lock-in.

This report describes and quantifies funding streams within state government control that subsidize fossil and other polluting fuels and that could have been directed to support equitable climate stabilization priorities. It focuses on ground transportation in California and on transfers of tradeable emission allowances and credits pursuant to the state's Cap and Trade and LCFS programs during the period 2013 through 2024.

Transfer mechanisms

Chapter 2 describes Cap and Trade allowances, LCFS credits, and the mechanisms by which these allowances and credits flow to oil companies and other suppliers of transportation biofuels. Oil refiners and drillers got free allowances to minimize emission "leakage" despite lack of evidence for any such climate policy-driven shift in emissions out of state. Refiners and drillers also got credits for projects to extend oil infrastructure that marginally reduced emissions. Biofuel credits, inflated by significant estimation and attribution problems, flowed to oil companies and other suppliers of biofuels. This further enabled oil companies to generate and buy cheap credits, which financed even more carbon emissions.

Value of allowance and credit transfers

Chapter 3 presents quantitative estimates for the dollar value of free allowances given to oil companies by Cap and Trade and LCFS credits they acquired by producing or funding biofuels. Figure 1 illustrates the cumulative value of these transfers from 2013 through 2024 and breaks them down by policy and type of transfer.

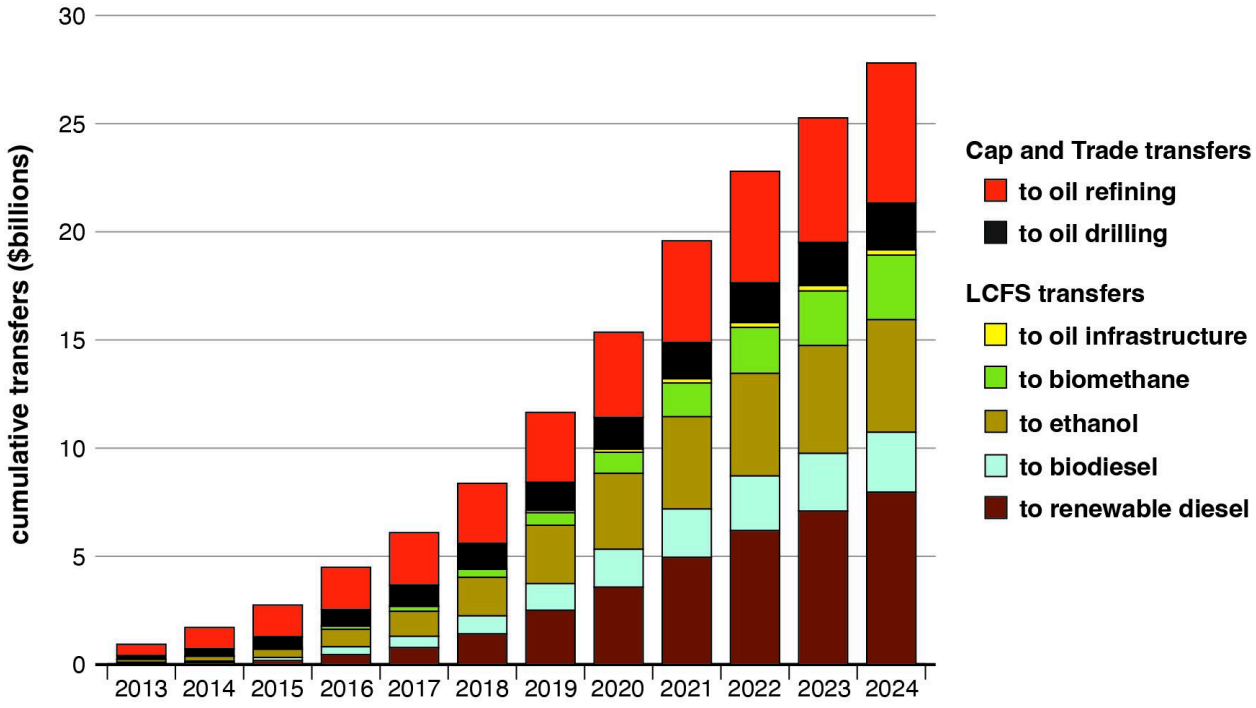

Figure 1. Nearly $28 billion was transferred to the producers and sellers of carbon-based transportation fuels under California's Cap and Trade and LCFS, 2013 to 2024. Results in 2023 USD from Community Energy reSource analysis of Air Resources Board and Public Utilities Commission data (see tables 1-5). Transfers were via tradeable Cap and Trade allowances and LCFS credits.

Over these 12 years, the estimated total cumulative value of these transfers reached nearly $28 billion. Cap and Trade transfers to oil refiners and drillers account for about $8.64 billion, and LCFS transfers to oil companies and other suppliers of biofuels that support combustion fuel infrastructure account for some $19.2 billion of this total.

Opportunity costs

Chapter 4 discusses preliminary scenario analyses intended to explore alternative and better uses of these funds for transitioning our transportation energy system to clean, non-combustion energy in order to stabilize our climate. The $28 billion in question could have paid for the installation of 2.8 million level-two EV chargers to serve roughly 11 million Californians. It could have made public transit free statewide, paid for a just transition for statewide oil workers, or covered local taxes paid by refiners — and more. The scenario analyses are illustrations and not necessarily recommendations. Development of plans for better use of these funds should be carried out in a fully transparent and democratic process with meaningful multi-stakeholder engagement.

Recommendations

The Climate Center recommends a foundational reorientation of California climate policy to prioritize the state's decarbonization goals. This will involve a reevaluation and recalibration of both the Cap and Trade and LCFS programs.

Three core principles should guide this foundational reorientation, reevaluation and recalibration of state climate policy incentives for the transportation sector:

1. Carbon markets need stronger guardrails. Refinery-level emissions standards ("caps") and the state's recently challenged zero-emission vehicle (ZEV) standards are key examples of guardrails that appear essential to a properly functioning carbon market.
2. Climate policies must not fund combustion fuels that compete with much cleaner ZEVs.
3. Sustainable policy decisions to set up these guardrails and end these perverse subsidies must be based upon a fully transparent and democratic process with meaningful multi-stakeholder engagement.

Specific recommendations for next steps along the state's zero-emission path in accordance with these principles are set forth in Chapter 5.

Documentation

At the end of this report, quantitative data and methods are detailed in the Data Tables and Notes chapter, followed by source data for all references cited in the text.

1. On the Need to Expose State Support for Carbon Lock-in

State financial support for the combustion-based transport system slows down the urgently needed transition to clean transportation.

1.1 Need for change

Meeting California's goal to cut greenhouse gas emissions 85 percent below 1990 levels by mid-century will require decarbonizing electricity, electrifying transportation, and reducing vehicle miles traveled (VMT) by expanding public transit, among other measures.[1-4]

Progress has been limited, with efforts to decarbonize electricity much further along than those to electrify transportation. Solar, wind, and other non-combustion generation supplied 60 percent of California's electricity demand in 2024.[5] But electricity use in transportation still accounts for less than two percent of statewide ground transportation energy.[6] Meanwhile, the efficiency of the transport system, as measured by VMT, improved only slowly if at all.[4] The resultant carbon dioxide equivalent (CO_2e) emissions from producing and burning transportation fuels continue to dominate the statewide emissions profile and rival those from all other activities combined.[7]

1.2 Resistance to change

Delaying the move to electrify transportation runs counter to California's ZEV goals and makes little economic sense. Electric cars, trucks, buses, and trains are more efficient and lower-maintenance than combustion-fueled vehicles.[8] Electrified public transit further amplifies that efficiency advantage, serving more people per VMT. And with the addition of bidirectional charging, electric vehicle batteries can supply grid management and reliability services to support variable solar and wind resources, helping to decarbonize electricity and build better grid resilience.[9] Better still, savings from avoided air pollution costs to public health are huge and could offset the costs of transition to decarbonized electricity and electrified transportation in California.[10]

Resistance comes from oil companies. Instead of cooperating in the transition to superior transportation energy (electricity), to protect their already-built, highly profitable infrastructure and operations, oil companies choose to compete with it for market share and resources. But other institutional and social factors are in the mix as well.

The resistance to changing carbon-emitting systems — caused by mutually reinforcing technological, capital, institutional, and social commitments to the emitting system which have become entrenched as it was developed and used — is known as "carbon lock-in."

Seto et al. review types, causes, and policy implications of carbon lock-in.[11] Unruh describes how interactions among technologies and institutions create carbon lock-in.[12] Commitments to future emissions locked in by past, present, and new investments in carbon-emitting infrastructure were assessed by important national and global-scale analyses.[13-15] More recent work highlights subsidies to biofuels and carbon capture that enable oil projects and thereby reinforce carbon lock-in,[16-18] and warns

against “choices that result in dead ends, like replacement investments in capital infrastructure almost certain to be stranded” by future climate protection constraints.[18]

1.3 California evidence

State law prohibits air quality officials from imposing direct carbon dioxide (CO_2) emission control standards on any oil refining or drilling facility covered by Cap and Trade.[19] But Cap and Trade gives these facilities free emission allowances to minimize “leakage” (a reduction in CO_2e emissions within the state that results in an increase in CO_2e emissions outside the state) by a formula with a leakage minimization factor of 100 percent.[20] That gave refiners and drillers free allowances for more than three-quarters of their emissions covered by Cap and Trade from 2013 to 2023.[21] There was no empirical evidence for the 100 percent leakage factor, which did not phase out after 2017 as originally intended.[24, 25] In effect, these free emission allowances are subsidies to oil refining and drilling in California.[25]

The LCFS also allows oil companies to earn credits for investments in their refining and drilling facilities that reduce CO_2e emissions.[26] Companies can use the credits to cover LCFS compliance costs or sell them to pay off project investments or for other purposes. These subsidies create commitments to future emissions. As Hache describes[27]:

> *“What matters is not only how much emissions are reduced but also how this is done. Emission cuts resulting from a switch to renewable technologies and away from fossil fuel dependency is entirely different from emission cuts resulting from routine, low-cost efficiency improvements. The former is a structural change contributing to the overall objective and potentially leading to major future cuts, whereas the latter entrenches existing practices by delaying long-term, non-fossil investments. Yet both are treated as equivalent in carbon markets, undermining the environmental objective.”*

Another set of state policy choices led the LCFS to prioritize subsidies to combustion fuels over those to electric vehicles and public transit. As Cullenward reported based on data from 2013 to 2023[28]: *“Although the state’s primary objective is to replace combustion vehicles with zero-emitting alternatives, about 80 percent of the LCFS credits issued to date — worth more than $17.7 billion in 2023 USD — have instead gone to combustion-based biofuels.”*

The state chose to include liquid biofuels as alternatives to petrofuels in the LCFS. This allowed gasoline and diesel refiners to comply with the LCFS by producing biofuels or buying biofuel credits. Since liquid biofuels use the same refining, distribution, or vehicle infrastructure as gasoline and diesel, they "will tend to have a strong advantage" over zero-emission transport alternatives under the LCFS.[29] And as petrofuel demand declines in-state, liquid biofuels keep oil infrastructure running closer to full, thereby reinforcing it, while biofuel subsidies lock in a commitment to future carbon emissions.

The state also chose to include biomethane captured from dairy manure, which does not replace gasoline or diesel and may not even be delivered in California, in the LCFS.[28, 30] Further, it made credits for biomethane cheaper to generate by assigning an extreme-low negative (below zero-emission) carbon intensity score.[28, 30] That contributed to declining LCFS credit prices since 2020.[28] To comply with the LCFS without switching from petrofuels, oil companies reap an indirect subsidy buying abundant, relatively cheap biomethane credits.

Accounting problems inflate LCFS biofuel subsidies and undercut "clean biofuel" claims. Evidence suggests the LCFS underestimates the carbon intensities of biofuels it supports, which approach or exceed those of gasoline and diesel in some credible estimates.[31-39] Worse, the LCFS pays biofuel suppliers for emission cuts that another law already mandated. The LCFS gave them credits for cutting an estimated 145 million metric tons of CO_2e emissions from 2013 to 2024,[6] but the vast majority of those emission cuts estimated from biofuels were already required and supported by the U.S. Renewable Fuels Standard.[36, 40]

1.4 Steps to avoid funding carbon lock-in

The evidence reviewed above suggests that state financial support for the combustion-based transportation system has delayed an urgently needed transition to zero-emission electrified transportation. Remarkably, the primary state policies to incentivize replacing that polluting transportation system are implicated. Better understanding the mechanisms and price tag of these transfers to oil companies and carbon-emitting fuels could help us break free from this carbon lock-in.

2. Mechanisms: How Did State Carbon Markets Give Oil Companies Money?

This chapter describes Cap and Trade allowances, LCFS credits, and the mechanisms by which these tradeable allowances and credits were transferred to oil companies and combustion biofuel suppliers. Cap and Trade and the LCFS are the main policies designed to help achieve the state's maximum feasible CO_2e emission reduction and decarbonization goals through financial incentives. We look at each in turn.

2.1 Relevant Cap and Trade design features

Basic functional structure

Under Cap and Trade, an "allowance" is a permit to emit one metric ton of carbon dioxide equivalents (CO_2e). This carbon trading scheme generally requires covered entities to acquire emission allowances from the state or buy them from other entities under a declining statewide carbon emissions cap. The Air Resources Board (ARB) actively runs this allowance trading market via quarterly auctions.[58, i] Allowance prices have ranged from approximately $15 in 2014 to more than $33 in 2024.[ii] Oil companies generally pass their costs through to the gas pump. The state estimated that, on average, Cap and Trade added approximately $0.25 per gallon to the price of gasoline in 2025.[41]

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[i] California's Cap and Trade program also features a secondary market, in which entities trade allowances and offsets outside official state auctions. These secondary markets operate over-the-counter (OTC), via brokers, and through electronic platforms such as the InterContinental Exchange (ICE), creating price discovery, liquidity, and risk management opportunities for compliance entities and investors.

[ii] See Table 1 in the Data Tables and Notes section for annual price data. Figures are in 2023 USD unless noted.

Free allowances for polluting industries

Entities in emission-intensive, trade-exposed (EITE) industrial sectors are given free allowances, which reduce the cost of their compliance obligations under Cap and Trade. Oil refineries, hydrogen production plants associated with refineries, and oil and gas extraction facilities are among the EITE sectors that are given free allowances.[42, 43]

The ARB also allocates free allowances to electrical distribution utilities, which are then sold at auction, with some proceeds given to firms in EITE sectors under California Public Utilities Commission (CPUC) direction, including the oil refining and oil drilling sector.[43, 46, 57] Allocations of free allowances under Cap and Trade are reported to the public annually at the sectoral level. Allocations to individual firms are kept confidential. Cap and Trade does not restrict the firms from deciding how to use this financial support.

Free allowances are allocated to firms in the refining and drilling sectors for "transition assistance and leakage minimization."[44] The ARB distributes these free allowances based on the product of industry transition assistance ("leakage") factors, product-based efficiency benchmarks, cap adjustment factors, and production rates.[45] Thus the "leakage" assistance factor drives the allocation of free allowances. As discussed in Section 1.3 above, this factor was set and maintained at a level of 100 percent despite a lack of empirical evidence and despite the original intent to gradually phase it out.[24, 25]

2.2 Relevant LCFS design features

Basic functional structure

The LCFS is a state-regulated standard for the average carbon intensity (CI)[iii] of transportation fuels that declines over time. It assigns a CI score to each fuel. Fuels with CI scores below the benchmark CI of gasoline or diesel earn credits; fuels with CI scores above the standard incur deficits.

[iii] CI scores are expressed as grams of CO_2e per unit of fuel energy, adjusted for the efficiency of vehicle drivetrains.

Fuel suppliers must acquire credits to offset their deficits. Credits and deficits are denominated in metric tons of CO_2e. A credit is thus a permit to emit one metric ton of CO_2e under the LCFS. The ARB facilitates and oversees the credit trading market, in which companies buy and sell credits daily. LCFS credit prices have ranged from less than $41 in 2014 to more than $234 in 2020.[iv] Oil companies — the credit buyers, since the standard is set below gasoline and diesel CI scores — generally pass their LCFS program costs through to the gas pump. The state estimated that the LCFS added an average of $0.13 per gallon of gasoline in 2025.[41]

[iv] See Table 1 in the Data Tables and Notes Section below for annual LCFS price data. Figures are in 2023 USD.

Biofuel credits

Biofuels received the vast majority of LCFS credits from 2013 to 2024.[6] Oil companies and other suppliers of gasoline and diesel use these biofuel credits to meet their compliance obligations under the LCFS by producing biofuels in their refineries or purchasing them.

Credit award criteria are set by regulation.[48] Biofuels deemed to be alternatives to gasoline or diesel include ethanol, biodiesel, renewable diesel, and biomethane.[6, 48] The gap between a biofuel's CI score and the CI benchmark for gasoline or diesel determines how many credits — or deficits — the biofuel earns per unit of fuel energy. In this way, lower-CI biofuels can earn more credits, increasing generation of credits, thereby decreasing prices for credit buyers and driving LCFS subsidies to oil companies higher.

The resultant financial support for carbon-emitting transportation flows to oil companies indirectly via a structural credit price discount, in addition to direct support to oil companies with biofuel refineries and direct support to other biofuel suppliers.

Thus, CI scores and biofuel volumes claimed by the LCFS drive LCFS biofuel credits. But significant estimation and attribution problems artificially inflate credit generation. Some credible biofuel CI estimates approach or exceed those of gasoline and diesel.[31-39] And most of the emission cuts claimed by suppliers of biofuels under the LCFS appear to already be required by, supported by, and claimed under the U.S. Renewable Fuels Standard.[36, 40] Underestimating biofuel CI while double-counting biofuel emission cuts dramatically inflates biofuel credits.

Oil infrastructure project credits

LCFS credits are awarded to oil companies for infrastructure project investments in their oil refining and oil drilling facilities.[49] Credits were awarded for one or more "innovative crude" projects that produce and supply crude oil to California refineries using solar or wind for heat and power or carbon capture utilization and storage (CCUS); for a low-complexity and low-energy-use refinery; and for one or more "Refinery Investment Credit" projects that claimed a reduction of CO_2e emissions in a refinery using CCUS, renewable electricity, lower-CI process energy, or process improvements.[6, 51]

As stated in Chapter 1, LCFS implementation ignores the difference between investing in an emission reduction from a technology that commits us to future emissions and investing in one that does not.[13-15, 27]

These oil infrastructure projects got fewer credits than biofuels from 2013 through 2024.[6] However, the LCFS continues to promote these types of projects,[50] and refinery CCUS projects have been proposed in the state. Credits for all of these types of oil infrastructure projects are awarded directly to oil companies, which can use them to cover LCFS compliance costs or sell them and use the money to pay off project investments or for other purposes.

3. Value of Allowances and Credits: How Big Are the State-controlled Dollar Streams So Far?

This chapter presents quantitative estimates for the dollar value of free allowances given to producers and sellers of carbon-based transportation fuels from the Cap and Trade program and the dollar value of credits given to them by the LCFS.

3.1 Estimation data

The monetary value of an allowance or credit transfer is a function of the number of allowances or credits transferred, which are denominated in metric tons of CO_2e emission permitted, and the price per ton of those allowances or credits. Estimates in this report are the product of these prices per ton and tons of allowances or credits, calculated annually. Our estimates compare well to those in prior independent reviews of the Cap and Trade[25] and LCFS[28] programs. Details of estimation data and methods are given in the Data Tables and Notes section below. Transfer values are adjusted for inflation and reported in constant 2023 US dollars unless otherwise noted.

3.2 Cumulative value of allowance and credit transfers

We estimate the total cumulative value of free Cap and Trade allowances and LCFS credits transferred to producers and sellers of carbon-based transportation fuels from 2013 through 2024 at approximately $27.8 billion. See the right hand column in Figure 1, reproduced below. Cap and Trade transfers to oil refineries via free allowances (red shading, Figure 1) accounted for approximately $6.48 billion, or 23 percent, of this $27.8 billion total. Cap and Invest transfers to oil drilling (black shading) were about $2.16 billion, or 8 percent of this total.

Transfers to refiners and sellers of renewable diesel under the LCFS (dark brown at the bottom of the figure) accounted for approximately $7.96 billion, or nearly 29 percent, of this cumulative total from 2013 to 2024. Ethanol (light brown) accounted for about $5.2 billion, or 19 percent, of this total. Biomethane and biodiesel (green and blue shading) were about $2.99 billion (11 percent) and $2.78 billion (10 percent) of the total, respectively.

3.3 Trends

Transfers to oil refineries under Cap and Trade remained larger than those to oil drilling facilities and grew slightly from 2013 to 2024 (red versus black shading in Figure 1). This reflects rising allowance prices (Table 1) and the fact that by importing crude, refiners processed a greater volume of crude than was extracted in-state.[52]

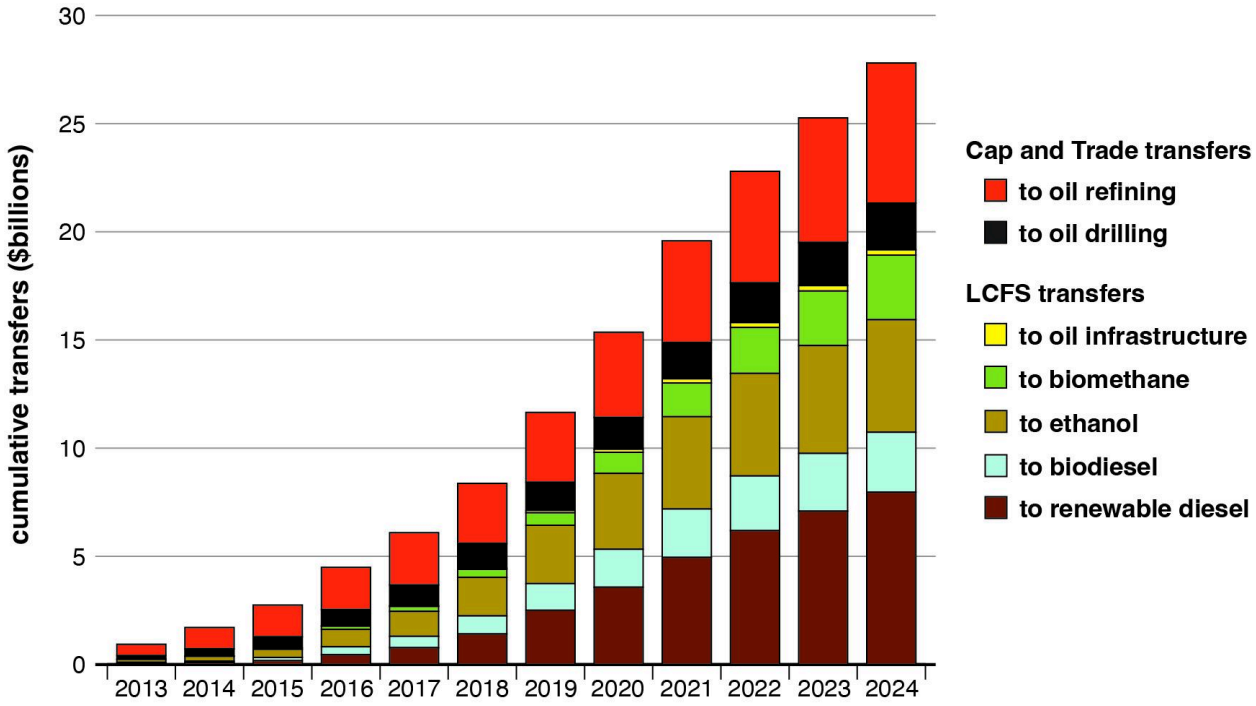

Figure 1. Nearly $28 billion was transferred to the producers and sellers of carbon-based transportation fuels under California's Cap and Trade and LCFS, 2013 to 2024. Results in 2023 USD from Community Energy reSource analysis of Air Resources Board and California Public Utilities Commission data (see tables 1-5). Transfers were via tradeable Cap and Trade allowances and LCFS credits.

Despite rising allowance prices, the total value of LCFS transfers to producers and sellers of biofuels grew larger than that of refiners' and drillers' free allowances. This is mostly due to explosive growth in renewable diesel and biomethane (dark brown and green shading in Figure 1) and partly due to relatively higher credit prices (Table 1).

Combined LCFS credit awards to renewable diesel and biomethane grew from less than 1 million tons in 2013 to more than 22 million tons in 2024 (Table 4). That growth was spurred by rich LCFS subsidies piled on top of federal subsidies, the ability to "drop in" renewable diesel into existing petro-diesel infrastructure at any blend ratio, and LCFS credit issuance for biomethane that need not be delivered to California.[28]

The nature of those subsidy growth drivers — a market distortion created by rich state and federal subsidies coupled with the lack of any effective "cap" on biofuel credits — suggest a precautionary note in light of potentially huge federal CCUS subsidies. LCFS transfers to oil infrastructure (yellow shading in Figure 1) were relatively small from 2013 to 2024. However, federal subsidies for CCUS have expanded, the LCFS promotes CCUS projects,[50] and refinery CCUS projects have been proposed in California.

4. Preliminary Scenario Analyses

Our analysis shows that the Cap and Trade and LCFS programs transferred nearly $28 billion to the carbon-based transportation system from 2013 to 2024. Here, before we discuss recommendations in the next chapter, we present a few scenarios to help convey the magnitude of the funds in question and to demonstrate the opportunity cost of using state-controlled funds to subsidize the oil industry rather than more effective and efficient programs to reach California's climate goals. Our goal in this chapter is to shed more light on the importance and value of that money for the feasibility of transforming our transportation energy system in time to stabilize the climate below 2 degrees Celsius.

4.1 Redirecting $28 billion toward the cleanest transportation

The state could prioritize, fund, and require electrified ZEVs along with more attractive public transit to reduce VMT, as is necessary to achieve California's transportation and climate stabilization goals.

The money that Cap and Trade and the LCFS give to drilling, refining, and burning carbon-based fuels can be used to build out renewables-powered electric vehicle infrastructure and make riding on public transit more attractive.

- In one example scenario, $28 billion could have paid for the installation of 2.8 million level-two EV chargers,[v] prioritizing charging at or near multi-unit dwellings, which could serve more than 11 million Californians.[vi]
- In another example scenario, $28 billion could have made public transit free by paying for 100 percent of the fares collected statewide from 2013 to 2024, with more than $11 billion left over to support transit service improvements and the transition to electrification.[vii]

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[v] Based on a cost of $10,000 per charger installation, the high end of the range cited by the U.S. Department of Energy.[53]

[vi] Assuming that charger/EV sharing extends on average across four-person families or households.

[vii] Statewide public transit passenger fares totaled approximately $16.7 billion from 2013 to 2024.[54]

4.2 Redirecting $28 billion toward a fair deal for oil workers

Labor standards could be strengthened to raise wages, benefits, and pensions in the new sectors where oil workers can get new jobs, and, at a minimum, to ensure effective wage, benefits, retraining, and pension support for existing workers who will lose oil industry jobs.

For example, oil worker union locals of United Steelworkers in both Los Angeles and Contra Costa counties supported a "Program for Economic Recovery and Clean Energy Transition in California."[55] This 2021 proposal is the only transition plan for fossil fuel workers in California to quantify a statewide cost estimate including income, retraining, relocation, and glide-path support, to our knowledge. Even assuming the high end of the estimate range to fully support this program over 12 years ($13 billion),[viii] $28 billion could fund it, with $15 billion left for other needs.

4.3 Redirecting $28 billion toward economic transitions for oil-dependent communities

Oil infrastructure can account for as much as 20 percent of the local tax base in some California cities. Communities should not be forced to choose between ongoing pollution and loss of the services and jobs that are funded by these taxes when oil refineries close. That type of enviro-economic injustice slows the transition from oil, thereby worsening cumulative emission impacts on our climate and health.

The state could fund or require oil companies to fund the gap during the period from plant closure until site cleanup and rebuilding of the local tax base.

For example, the $28 billion that Cap and Trade and the LCFS gave to oil refiners, drillers, and liquid biofuels from 2013 to 2024 could replace the local taxes paid by each oil refinery and major biofuel refinery in California for more than ten years after it closes permanently. This rough estimate is based on tax payments by the relatively large Chevron Richmond refinery to that city, which will total $90 million in 2025 according to a 2024 tax agreement,[ix] and the capacities of 15 "open" (petroleum) and four "idle" (biofuel)[x] refineries in California.

[viii] The $13 billion estimate is in 2023 dollars over 12 years of transitional support, conservatively assuming that the reported high-end value of $833 million per year for 'episodic' transition was reported in 2018 dollars.

[ix] See total of Agreement tax and other taxes in Attachment A, 2024 Tax Payment Agreement.[56]

[x] See CEC (2024).[57] As of this writing the "idle" listings include at least two operating refineries that have been converted to refining diesel biofuel, the Marathon plant in Martinez and Phillips 66 plant in Rodeo.

5. Recommendations

The Climate Center recommends a foundational reorientation of California climate policy to prioritize the state's decarbonization goals. This will involve a reevaluation and recalibration of both Cap and Trade (now renamed Cap and Invest) Program and the LCFS.

Three core principles should guide this foundational reorientation, reevaluation, and recalibration of state climate policy incentives for the transportation sector:

1. Carbon markets need stronger guardrails to limit unintended consequences and ensure effective policy outcomes. Strong external guardrails appear essential to a properly functioning carbon market. Specific next steps could:
    a. Repeal the prohibition on refinery-level carbon dioxide (CO_2) emission standards enacted by AB 398 (2017). This Cap and Invest legislation prohibits regional air districts from imposing direct regulations on point source CO_2 emissions;
    b. Re-adopt California's ZEV standards based explicitly upon state needs and authorities. Our climate, health, energy system, and economy need these guardrails.
2. Climate policies must not fund combustion fuels that compete with much cleaner ZEVs. Specific next steps could:
    a. Rapidly phase out issuing free Cap and Invest allowances to oil refiners and drillers;
    b. Rapidly phase out issuing LCFS credits to producers and suppliers of combustion fuels that compete with the electrification of transportation. End petroleum-related project crediting now and phase out credits for biofuels in order to prioritize LCFS support for transportation electrification and public transit pathways.
3. Sustainable policy decisions to set up these guardrails and end these perverse subsidies must be based upon a fully transparent and democratic process with meaningful multi-stakeholder engagement. A specific next step could:
    a. Address the regressive nature of Cap and Invest and LCFS funding streams by redirecting the revenue streams in the existing programs, or by replacing one or both programs with a progressive revenue generation program feeding a publicly held trust fund, designed via a democratic process with multiple stakeholders.

The Climate Center recommends these actions to help clear the path to zero-emission transportation.

Data Tables and Notes

Monetary value estimates in this report are the product of Cap and Trade allowance or LCFS credit prices per ton and tons of allowances or credits. Data, detailed results of analyses and methodological details are given in annotated tables 1 through 5 below.

Allowance and credit prices

Annual allowance and credit price estimates are given in Table 1.

Table 1. Weighted mean prices of Cap and Trade allowances and LCFS credits, 2013–2024

	Cap and Trade Allowance Price [a]		LCFS Credit Price [b]	
Period	Nominal $/ton	2023 $/ton [c]	Nominal $/ton	2023 $/ton [c]
2013	12.14	16.39	55.13	74.43
2014	11.63	15.00	31.32	40.40
2015	12.42	16.02	60.77	78.39
2016	12.73	16.17	100.42	127.53
2017	14.49	17.97	89.34	110.78
2018	14.88	18.00	159.89	193.47
2019	16.78	19.97	191.88	228.34
2020	17.14	20.23	198.76	234.54
2021	22.40	25.09	187.58	210.09
2022	28.19	29.32	124.28	129.25
2023	32.95	32.95	75.35	75.35
2024	35.17	33.41	63.79	60.60

Allowance: a permit to emit 1 metric ton CO_2e under Cap and Trade. **Credit:** a permit to emit 1 metric ton CO_2e under the Low Carbon Fuel Standard (LCFS). **a.** Nominal allowance prices are the trading volume-weighted mean prices based on data from the 'Summary of Auction Prices and Results' accessed from https://ww2.arb.ca.gov/our-work/programs/cap-and-trade-program/program-data/cap-and-trade-program-data-dashboard#Figure7. **b.** Nominal LCFS credit prices are trading volume-weighted mean prices based on data from the 'LCFS Weekly Activity Log spreadsheet, accessed from https://ww2.arb.ca.gov/resources/documents/weekly-lcfs-credit-transfer-activity-reports (see 'LCFS Credit Transactions Log' tab). **c.** Conversions to 2023 dollars used the Federal Reserve Bank of Minneapolis calculator; https://www.minneapolisfed.org/about-us/monetary-policy/inflation-calculator.

These annual price estimates are trading volume-weighted means, which account for the trading volume (metric tons of allowances or credits transferred) as well as the price point (dollars per ton) of each transaction during a calendar year. Allowance price data

were taken from Cap and Trade auction results.[58] Credit price data were taken from the LCFS Credit Transactions Log.[59]

Free allowance allocations

Oil refiners and drillers got an estimated 421 million metric tons of free allowances under Cap and Trade from 2013 to 2024, as detailed in Table 2.

Table 2. Cap and Trade allowances given to oil companies free of charge, 2013–2024

	Free emission allowances given to oil refining and drilling facilities (millions)				
Period	Petroleum refining [a]		Oil & gas extraction		Refining & extraction (Direct and EDU)
	Direct [b]	via EDU [c]	Direct [b]	via EDU [c]	
2013	31.8	—	10.10	—	41.9
2014	31.3	0.53	10.13	0.38	42.3
2015	28.3	0.58	11.66	0.41	41.0
2016	27.9	2.65	12.25	1.87	44.7
2017	25.0	0.71	11.36	0.56	37.7
2018	19.2	0.74	9.36	0.52	29.8
2019	22.0	0.64	7.76	0.45	30.8
2020	34.3	0.93	7.62	0.66	43.5
2021	29.8	0.64	7.33	0.45	38.2
2022	14.7	0.55	5.69	0.39	21.3
2023	17.6	0.76	4.37	0.41	23.1
2024	21.0	0.65	4.21	0.45	26.3
2013–2024	303	9.47	102	6.55	421

a. Petroleum refining sector including co-located production of hydrogen, which is integral to refinery processing. **b.** Free allowances given directly to oil refiners and drillers; see vintage allowance allocation for various years at https://ww2.arb.ca.gov/our-work/programs/cap-and-trade-program/cap-and-trade-program-data. **c.** A separate allocation of free allowances to electrical distribution utilities (EDUs), which were sold with the proceeds then transferred to refiners and drillers by the CPUC and EDU. The number of these 'via EDU' allowances was not reported publicly but is estimated here based on reported monetary transfer and price data (see tables 1, 3). **Allowance:** a tradeable permit to emit one metric ton CO_2e. Figures in this table may not add due to rounding.

Values in the table for “direct” allocations of free allowances are based on data from the petroleum refining and oil and gas extraction sectors in vintage allowance allocation reports for 2013 through 2024.[22] All no-cost allocations to facilities in these industrial categories were tallied, with one adjustment (allowances equal to covered emissions from hydrogen plants that were not co-located with refineries were subtracted). Comparison of the more detailed data in the Air Resources Board vintage allowance reports[22] to the Board’s summary of the same data[58] confirms the multi-year direct allocation totals for 2013 to 2024 but indicates shifts in allowance totals among some years, reportedly due to true-up steps.

Values in the columns of Table 2 labeled “via EDU” reflect free allowances given to electrical distribution utilities (EDUs) and sold at auction with the auction proceeds then given to refiners and drillers, as described in Chapter 2.[43, 47] The number of these “via EDU” allowances was not reported publicly, but is estimated based on monetary transfer and price data (see tables 1, 3).

Value of allowance transfers

The estimated value of Cap and Trade allowances given to oil companies at no cost from 2013 through 2024 amounts to $8.64 billion (2023 USD) as detailed in Table 3.

Table 3. Value of allowances given to oil companies free of charge, 2013–2024

Value of transfers to oil refining and drilling facilities ($millions)

Period	Petroleum refining [a]		Oil & gas extraction		Refining & extraction
	Direct [b]	via EDU [c]	Direct [b]	via EDU [c]	(Direct and EDU)
2013	521	—	165	—	$687 million
2014	469	8.0	152	5.6	$635 million
2015	454	9.2	187	6.5	$656 million
2016	451	42.8	198	30.2	$723 million
2017	449	14.4	204	10.1	$678 million
2018	345	13.4	168	9.4	$536 million
2019	439	12.7	155	9.0	$616 million
2020	694	18.9	154	13.3	$880 million
2021	748	16.0	184	11.3	$959 million
2022	431	16.2	167	11.4	$625 million
2023	579	25.1	144	13.6	$762 million
2024	700	21.8	141	15.0	$878 million
2013–2024	6,280	199.0	2,020	136.0	$8,640 million

Data in 2023 US dollars. **a.** Petroleum refining sector including co-located production of hydrogen for refining. **b.** Transfers via direct allocation of allowances to refiners and drillers based on free allowances given (Table 2) and allowance prices (Table 1). **c.** Transfers via EDU are reported by sector since 2023; prior transfers via EDU are estimated based on aggregate industry totals from 2014–2022 and weighted mean sector portions of reported 2023–2025 totals (https://www.cpuc.ca.gov/industries-and-topics/natural-gas/greenhouse-gas-cap-and-trade-program; https://www.cpuc.ca.gov/industries-and-topics/natural-gas/greenhouse-gas-cap-and-trade-program/california-industry-assistance). **Allowance:** a tradeable permit to emit one metric ton of CO_2e under Cap and Trade. Figures may not add due to rounding.

Direct allocation values in Table 3 are estimated from allowance prices shown in Table 1 and free allowances shown in Table 2. Transfers via EDU in Table 3 are reported values for 2023 and 2024.[43] Estimates for prior years are based on aggregate totals for all industrial sectors from 2014 to 2022[47] and weighted mean sector portions of those totals during 2023 to 2025.[43, 57] This estimation method was judged reasonably

representative for transfers via EDUs during the pre-2023 period in the absence of sector level data for transfers via EDU.[60]

This estimate compares well to prior work: the estimate for direct transfers to petroleum refining and oil and gas extraction in Table 3 ($8.3 billion) is within one percent of CARB's Independent Emissions Market Advisory Committee estimate ($8.26 billion).[25]

LCFS credits

Suppliers of liquid biofuels and oil infrastructure projects got approximately 146.5 million metric tons of credits under the LCFS from 2013 to 2024, as detailed in Table 4.

Table 4. Low Carbon Fuel Standard credits given for combustion fuels, 2013–2024

	Credits for biofuels and petroleum infrastructure (millions) [a]					
Period	Ethanol [b]	Biodiesel	Ren. diesel	Biomethane	Infrastructure [c]	Total
2013	1.88	0.54	0.78	0.10	—	3.3
2014	1.94	0.66	0.84	0.24	—	3.7
2015	2.00	1.13	1.03	0.58	—	4.7
2016	3.32	1.71	2.16	0.68	0.16	8.0
2017	3.20	1.37	2.96	0.68	0.15	8.4
2018	3.26	1.57	3.29	0.75	0.14	9.0
2019	3.97	1.80	4.77	0.94	0.18	11.6
2020	3.48	2.19	4.57	1.66	0.17	12.1
2021	3.62	2.31	6.56	2.79	0.23	15.5
2022	3.67	2.20	9.58	4.34	0.26	20.0
2023	3.29	1.96	11.89	5.32	0.26	22.7
2024	3.46	1.74	14.45	7.67	0.03	27.3
2013–2024	37.08	19.18	62.88	25.76	1.57	146.5

Credit: a permit to emit one metric ton of CO_2e that is tradeable under the Low Carbon Fuel Standard (LCFS).
a. Net credits (less any LCFS deficits) are taken from the fuels tab of the LCFS Quarterly Data Spreadsheet at https://ww2.arb.ca.gov/resources/documents/low-carbon-fuel-standard-reporting-tool-quarterly-summaries.
b. Ethanol figures include a small number of Renewable Gasoline Blend stock credits. **c.** Infrastructure projects awarded credits during 2013–2024 included 'Innovative Crude', 'Low-complexity/low energy use Refinery', and 'Refinery Investment Credit' projects. Figures shown may not add due to rounding.

Values in Table 4 are based on data in the "fuels" tab of the LCFS Quarterly Data Spreadsheet.[6] Estimates for the biofuels are net credits: total credits reported minus deficits reported for a fuel. This was done to ensure against overstating the LCFS biofuels subsidy. The "infrastructure" column in Table 4 shows annual credits given to oil drilling facilities for "innovative crude" production projects and given to oil refineries

for “low complexity” and “low energy use” operations or “refinery investment credit” projects. These projects received credits starting in 2016.[6]

Value of credit transfers

Approximately $19.17 billion was transferred to oil companies under the LCFS from 2013 to 2024 based on the estimated value of credits given to refiners, drillers, and suppliers of liquid combustion fuels, as detailed in Table 5.

Table 5. Value of LCFS credits that supported combustion fuels, 2013–2024

	Transfers to biofuel sellers and petroleum infrastructure ($billions) [a]					
Period	Ethanol [b]	Biodiesel	Ren. diesel	Biomethane	Infrastructure [c]	Total
2013	0.140	0.041	0.058	0.007	––	$0.25 billion
2014	0.078	0.027	0.034	0.010	––	$0.15 billion
2015	0.156	0.089	0.081	0.045	––	$0.37 billion
2016	0.423	0.218	0.276	0.087	0.020	$1.02 billion
2017	0.355	0.152	0.328	0.075	0.016	$0.93 billion
2018	0.631	0.304	0.637	0.145	0.027	$1.74 billion
2019	0.906	0.410	1.089	0.214	0.041	$2.66 billion
2020	0.816	0.514	1.072	0.390	0.041	$2.83 billion
2021	0.760	0.485	1.377	0.586	0.049	$3.26 billion
2022	0.474	0.284	1.238	0.562	0.033	$2.59 billion
2023	0.248	0.148	0.896	0.401	0.020	$1.71 billion
2024	0.210	0.105	0.876	0.465	0.002	$1.66 billion
2013–2024	5.197	2.776	7.961	2.987	0.248	$19.17 billion

Data in 2023 US dollars. **a.** Transfers are based on credits awarded (Table 4) and mean credit prices (Table 1). **b.** Transfers to sellers of ethanol include small amounts of transfers to sellers of renewable gasoline blend stock. **c.** Transfers to in-state refiners and drillers for Innovative Crude drilling projects, a Low-complexity/low energy use Refinery, and 'Refinery Investment Credit' projects. **Credit:** a tradeable permit to emit one metric ton of CO_2e under the Low Carbon Fuel Standard (LCFS). Figures shown may not add due to rounding.

Values in Table 5 are estimated based on credit prices reported by CARB summarized in Table 1 and credit awards reported by CARB as summarized in Table 4.

This estimate also compares well to prior work. Cullenward estimated the combined value of LCFS credits to ethanol, biodiesel, renewable diesel, and biomethane from 2013 to 2023 at approximately $17.72 billion.[28] Done earlier for somewhat different purposes, that estimate did not subtract biofuel deficits from biofuel credits, include oil infrastructure project credits, or include data for 2024.[28] Adjusting our estimate to account for those factors for purposes of comparison would yield an estimated value of approximately $17.68 billion over the 2013 to 2023 period. This value ($17.68 billion) is within 0.3 percent of Cullenward’s estimate ($17.72 billion).

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(49) For LCFS oil infrastructure project mechanism details see CCR § 95489.

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Glossary

ARB: Air Resources Board. Also frequently referred to as CARB. The California air quality and climate protection agency.

Allowance: A permit to emit one metric ton of carbon dioxide equivalent (CO_2e) that is generally bought and sold among companies subject to requirements of the Cap and Trade program.

Cap and Invest or Cap and Trade: These terms both refer to the state's market-based carbon emissions program. While the California legislature officially renamed "Cap and Trade" to "Cap and Invest" in September 2025 to reflect a focus on investing auction proceeds in climate initiatives, this report uses "Cap and Trade" for consistency with the program's name during the period of study.

Carbon intensity (CI): The amount of climate emission caused by a given amount of activity at a particular emission source or in a particular fuel chain.

Carbon lock-in: Resistance to change of CO_2e-emitting systems, which is caused by mutually reinforcing technological, capital, institutional, and social commitments to the emitting system that have become entrenched as it was developed and used.

Carbon sink: A system that absorbs more carbon dioxide from the atmosphere than it releases.

Carbon trading market: A market in which entities can buy and sell permits to emit CO_2e. In California, carbon trading markets were set up under the Cap and Trade program and Low Carbon Fuel Standard (LCFS).

CCUS: Carbon Capture Utilization and Storage (or sequestration).

CO_2: Carbon dioxide.

CO_2e: Carbon dioxide equivalents. In this report, CO_2e is based on the 100-year horizon.

Credit: (1) A permit to emit one metric ton of CO_2e that generally is bought and sold among companies subject to requirements of the LCFS. (2) A unit of measure, equal to one metric ton of CO_2e, used for determining compliance with the carbon intensity standard of the LCFS by offsetting a deficit. See also “deficit.”

Deficit: A unit of measure, equal to one metric ton of CO_2e, which is incurred by supplying a fuel that exceeds the carbon intensity standard of the LCFS and can be offset by obtaining a credit to determine compliance with the LCFS. See also “credit.”

Drop-in fuel: A liquid hydrocarbon fuel that is chemically equivalent to conventional petroleum fuels like gasoline, diesel, or jet fuel, allowing it to be used as a direct replacement without requiring major modifications to engines or infrastructure.

Efficiency (energy): The consumption of less energy to do the same amount of useful work.

EITE: Emissions-intensive, trade exposed. A designation for industrial sectors that are both large emitters of greenhouse gases and are subject to international competition.

EV: Electric vehicle. In this report EV refers to any vehicle that is fully battery-electric, including cars, trucks, buses, trains, etc.

Fuel chain: The sequence of interdependent steps in the acquisition, conversion, distribution, and end use of a particular type of fuel energy.

GGRF: Greenhouse Gas Reduction Fund.

GHG: Greenhouse Gas.

LCFS: Low Carbon Fuel Standard.

Leakage: A situation in which a reduction in emissions within a regulated jurisdiction results in an increase in emissions in an unregulated jurisdiction.

Lifecycle analysis (LCA): An accounting for the carbon intensity of a fuel that accounts for emissions associated with all steps in its particular fuel chain. See also “fuel chain.”

Mid-transition: A term used to describe the period during an energy transition when zero-carbon systems and emitting fossil fuel systems co-exist at scales where each imposes operationally relevant constraints on the other. During mid-transition, neither zero-carbon nor carbon-emitting infrastructure can fully support all energy services on their own, and the overall system is not optimized for either infrastructure’s sociotechnical particularities.

Renewable diesel: A formal fuel specification for a type of biomass-based diesel with chemical composition nearly identical to petroleum diesel, which is distinct from biodiesel mainly due to the removal of oxygen from the mixture of hydrocarbons in it. The term renewable diesel is a euphemism and a misnomer that can be viewed as greenwashing, since production and use of this fuel is credibly linked to food price inflation, deforestation, carbon-intensive and hazardous refining, unhealthy tailpipe emissions, and fuel chain carbon emissions that rival those of petroleum diesel. In this report, “renewable diesel” references the fuel specification.

ZEV: Zero-Emission Vehicle