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California Compliance Offsets: Problematic Protocols and Buyer Behavior

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California Compliance Offsets: Problematic Protocols and Buyer Behavior

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Abstract

Carbon offsetting is a ubiquitous feature of emissions mitigation strategies that reduces the cost of compliance with mandatory greenhouse gas regulation and enables unregulated firms to meet voluntary emissions goals. Worldwide, compliance and voluntary offset markets have generated more than three billion offsets, which, in theory, each represent one metric ton of CO_2-equivalent emissions that have been prevented, sequestered, or otherwise mitigated outside of a regulatory regime. In practice, it is unclear whether carbon offset policy can guarantee the production of legitimate offsets—those that represent additional, permanent, enforceable, real, quantifiable, and verifiable greenhouse gas emissions reductions. California's compliance offset market, given its size, transparency, and recent establishment, presents a perfect opportunity to study the extent to which current carbon offset policy can produce legitimate offsets. This thesis analyzes four compliance offset protocols that have supplied more than 145 million offsets to the California Compliance Market and finds that all four have the potential to generate illegitimate offsets, compromising the integrity of California's cap on greenhouse gas emissions. The current US Forest Projects Protocol is both the most productive and most problematic; so far, it has produced more than 115.6 million illegitimate offsets, 79% of California's total compliance offset supply. To reduce the risk of protocols generating illegitimate offsets in California and other markets, this thesis will suggest improvements to additionality tests and emissions quantification that can be added to current and future offset protocols. It will also suggest alternatives to offset policy that can deliver emissions reductions with less risk to the integrity of emissions reduction goals. Last, this thesis will argue that even if offset protocols guarantee legitimate offset production, achieving carbon neutrality via voluntary carbon offsetting hinders progress toward a zero-emissions future.

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List of Acronyms

ACR	American Carbon Registry
BAU	Business as Usual
BC	British Columbia
CAISO	California Independent System Operator
CAP	Climate Action Plan
CAR	Climate Action Reserve
CARB	California Air Resources Board
CAT	Cap-And-Trade
CCM	California Compliance Market
CDM	Clean Development Mechanism
CER	Certified Emissions Reduction
CEU	City of Colton Electric Utility
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
CPEM	CP Energy Marketing (US), Inc.
CP1	Compliance Period One (2013-2014)
CP2	Compliance Period Two (2015-2017)
DNDC	Denitrification Decomposition
ERU	Emissions Reduction Unit
GHG	Greenhouse Gas
GWP	Global Warming Potential
ICAO	International Civil Aviation Organization
IPCC	Intergovernmental Panel on Climate Change
JI	Joint Implementation
LADWP	Los Angeles Department of Water and Power
MMC	Mine Methane Capture
ODS	Ozone Depleting Substance
PCAST	Presidential Council of Advisors on Science and Technology
RAU	Recovery and Use

REDD	Reduced Emissions from Deforestation and Degradation
RGGI	Regional Greenhouse Gas Initiative
RPS	Renewable Power Standard
SLCP	Short Lived Climate Pollutant
tCO_2e	Metric Ton of Carbon Dioxide Equivalent
UC	University of California
UNFCCC	United Nations Framework Convention on Climate Change

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Introduction

As policymakers strive to set and meet greenhouse gas emissions reduction goals, they also design policies aimed at reducing the cost of greenhouse gas (GHG) mitigation. Carbon offsetting has emerged across all major emissions mitigation policies as a method for reducing the cost of compliance with mandatory GHG regulation while also enabling unregulated firms to voluntarily reduce their carbon footprints. Those voluntary reductions are often touted as a means for achieving net-zero carbon emissions or "carbon neutrality," a status that has gained popularity in the public and private sectors despite uncertain environmental benefits.

Carbon offsetting is based upon the idea that firms do not need to reduce their GHG emissions themselves to reduce the total stock of GHGs in the atmosphere. Instead, they can neutralize or "offset" their emissions by paying firms outside the scope of emissions regulation to reduce *their* emissions. This concept has given rise to numerous government policies and private companies that allow firms to buy and sell emissions reductions in standard units called "carbon offsets." Each offset represents one metric ton of CO_2-equivalent (tCO_2e) emissions that has been voluntarily averted, sequestered, or otherwise mitigated through a variety of eligible emissions-reducing activities.

Emissions reductions that produce offsets must, of course, be carefully accounted for and credited. If illegitimate offsets are bought and sold alongside legitimate offsets, total atmospheric emissions can become much higher than intended, compromising the integrity of mandatory emissions limits and voluntary emissions reduction goals. Unseen emissions increases like this not only intensify climate change, but also represent wasted investment in nonexistent climate benefits.

This thesis will argue that four offset policies currently operating in California do not guarantee the production of legitimate offsets that deliver their intended emissions reductions. Consequently, these policies compromise the integrity of California's mandatory cap on emissions while wasting time, effort, and resources. Three of California's policies, which focus on mine methane destruction, livestock manure methane destruction, and ozone depleting substance destruction, can produce both legitimate and illegitimate offsets and can be improved to increase the number of legitimate offsets generated. The fourth, however, which sequesters carbon in forests, overvalues temporary emissions reductions by assuming they are able to compensate for atmospheric emissions, rendering all 115.6 million offsets it has produced illegitimate.[1] Since forests are widely considered the largest potential source of carbon offsets on the planet, this fundamental flaw must not be replicated in future offset protocols.

This thesis will begin by describing the fundamentals of carbon offsetting—the types of markets in which they are bought and sold, the magnitude of carbon emissions involved, and the need for policy investigation in California. It will then continue in Chapter One with a discussion of the intended benefits and potential drawbacks of offsetting that underlie any analysis of specific offset policies. Chapter Two will focus on California's offset market and the four protocols currently producing offsets, arguing how they fail to ensure the production of legitimate offsets. Once Chapter Two identifies problems in California's protocols, Chapter Three will put California offset production in context by examining general offset utilization trends and the behavior of four specific

[1] CARB, "Compliance Offset Program"

firms participating in the market. Finally, the Conclusion will offer recommendations for policymakers and firms engaged in carbon offsetting and close with a wider argument about the relationship between offset use and climate leadership.

Offset Fundamentals

Carbon offsets are purchased in two types of markets: voluntary markets and compliance markets. Within these two types of markets, different offset suppliers provide many different types of offsets of varying levels of quality. Overall, voluntary and compliance markets that publish their offset production have produced more than three billion known carbon offsets, a lower bound on the total number of offsets produced globally.[2] California's compliance offset market, given its transparency, recent establishment, and offset production, provides an ideal opportunity to study offset policy today.

The Voluntary Market

Voluntary markets are created by individuals and firms whose emissions are not regulated, but who want to voluntarily neutralize their emissions to meet personal or organizational emissions reduction goals. Often, voluntary carbon offsetting is a central component of achieving net-zero carbon emissions, also known as "carbon neutrality."

[2] Joint Implementation has produced 871 million (JI, "JI ERU Issuance."), the Clean Development Mechanism 1.96 billion ("CDM: CDM-Home."), the California Compliance Market 145 million (CARB, "Compliance Offset Program"), and the Chicago Climate Exchange 84 million ("CORE: Chicago Climate Exchange.").

In 2016, the total estimated volume of voluntary offset transactions topped one billion tCO_2e, but it is nearly impossible to determine the exact quantity produced since the voluntary market operates worldwide and is highly decentralized.[3] Numerous organizations called "standard bodies" generate voluntary offsets according to their own rules and promise to provide offsets that represent legitimate, real emissions reductions.

Over time, voluntary buyers have consolidated their trust in a handful of well-regarded standard bodies that now dominate voluntary market transactions. In 2016, the leading standards included the Verified Carbon Standard (58% of total transactions), the Gold Standard (17%), Climate Action Reserve (8%), ISO-14064 (4%), and American Carbon Registry (3%). Among these leaders, average offset prices vary from $0.4 per tCO_2e (ISO-14064) to $4.6 per tCO_2e (Gold Standard).[4] In the market at large, prices range even further, from one cent per tCO_2e, up to $70 or more.[5] This range reflects the subjectivity of the voluntary market. Buyers do not treat every ton of CO_2e as equal—they care about how offsets are generated, where they are generated, who generates them, and what co-benefits are attached. One buyer for example, might consider reforestation more important because they went camping as a child, increasing their willingness-to-pay relative to another buyer who grew up in a city.

Buyer preferences have not only produced a wide range of prices, but have also spawned offset protocols in nearly every possible emissions-reduction category: renewable energy, forestry, land-use, methane, efficiency, household devices,

[3] Hamrick and Gallant, "Unlocking Potential: State of the Voluntary Carbon Markets 2017."
[4] Hamrick and Gallant, "Unlocking Potential: State of the Voluntary Carbon Markets 2017."
[5] Hamrick and Gallant, "Voluntary Carbon Markets Insights: 2018 Outlook and First-Quarter Trends."

transportation, gas destruction, and countless other niche categories.[6] Like markets for soft drinks, offset protocols have been developed to suit every taste to attract more buyers to the market.

The Compliance Market

Compliance markets are created by cap-and-trade (CAT) systems, a type of government regulation that puts a limit or "cap" on the total quantity of CO_2e that all covered firms can emit. A government will then issue or auction emissions permits called "allowances" that add to that limit and require that firms periodically surrender allowances equal to their individual emissions. Over time, the cap on emissions decreases, and firms that can most easily reduce their emissions have an opportunity to mitigate more than is necessary, creating surplus allowances that they can sell to firms that have a harder time reducing their emissions. In theory, CAT systems thereby incentivize the easiest, cheapest emissions reductions first, minimizing the overall cost of regulatory compliance.

Offset policy prescribes specific methods for firms outside the regulatory regime of the CAT system to voluntarily reduce their emissions, generating offsets that may be bought, sold, or turned in within the CAT system equivalently to allowances. Since compliance firms consider all offsets equally capable of fulfilling their compliance

[6] Hamrick and Gallant, "Unlocking Potential: State of the Voluntary Carbon Markets 2017." Lovell and Liverman, "Understanding Carbon Offset Technologies."

obligations, offset prices are therefore uniform within each compliance market regardless of how offsets are generated.[7]

Today, 10 CAT systems operate throughout the world, covering the European Union, Switzerland, Kazakhstan, South Korea, New Zealand, Quebec, parts of China, nine northeastern states in the United States, California, and Tokyo.[8] Each CAT system includes its own specific rules for compliance offsetting domestically and in many cases internationally, creating enormous demand for compliance offsets.

Most demand for offsets worldwide has been met by two international mechanisms implemented in 2005 via the Kyoto Protocol: Joint Implementation (JI) and the Clean Development Mechanism (CDM). Both use terms other than “offsets,” but the concept is the same—JI establishes rules for developed countries to fund emissions reductions in other developed countries, earning emission reduction units (ERUs) that may be used to meet Kyoto emissions targets. Similarly, the CDM establishes rules for developed countries to fund emissions reductions in developing countries, earning saleable certified emission reduction (CER) credits. So far, JI and the CDM have produced more than 871 million[9] and 1.96 billion offsets, respectively.[10]

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[7] The CA compliance market does separate offsets into three price categories based upon the risk associated with the offset’s generation, but this multi-price system remains uniform compared to the voluntary market.

[8] “International Carbon Action Partnership (ICAP).”

[9] JI. “JI ERU Issuance.”

[10] “CDM: CDM-Home.”

The Need for Offset Policy Investigation

Multiple international, national, and sub-national offset protocols are in development and will look to existing offset policy for design inspiration and guidance. At the international level, the United Nations Framework Convention on Climate Change (UNFCCC) and United Nations' International Civil Aviation Organization (ICAO) are currently designing two offset programs that will have wide ramifications for global greenhouse gas mitigation. The UNFCCC's offset mechanism, initiated by Article 6.4 of the Paris Agreement, will replace the CDM and promote greenhouse gas mitigation and sustainable development between Parties to the Paris Agreement.[11] Standardized rules, modalities, and procedures that will allow Parties to generate carbon reduction credits for sale will be adopted at the 25th Conference of the Parties in 2019.[12] ICAO is currently setting up a voluntary Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), which is expected to enter a Pilot Phase from 2021 to 2023.[13]

At the national level, United States Congresswoman Alexandria Ocasio-Cortez's "Green New Deal" has proposed that the United States commit to "net-zero carbon emissions" by 2030.[14] While the Green New Deal is only a proposal, the inclusion of

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[11] United Nations Framework Convention on Climate Change, "Paris Agreement."
[12] "COP24: Key Outcomes Agreed at the UN Climate Talks in Katowice."
[13] United Nations International Civil Aviation Organization, "Resolution A39-3: Consolidated Statement of Continuing ICAO Policies and Practices Related to Environmental Protection – Global Market-Based Measure (MBM) Scheme."
[14] Ocasio-Cortez, "Text - H.Res.109 - 116th Congress (2019-2020)."

such an expansive, near-term carbon neutrality goal indicates the potential for carbon offsetting in future U.S. climate change mitigation strategies.[15]

At the sub-national level, California's passage of AB 398 in 2017 committed it to adopting new offset protocols for its CAT system,[16] while Quebec continues to design additional protocols in the agriculture and land-use sector.[17] As these programs take shape, it is essential to learn from existing markets, particularly the extent to which current offset protocols ensure climate benefits. It is also necessary to study what drives regulated firms to purchase specific types of offsets to understand how the co-benefits created by different emissions mitigating activities contribute to environmental health.

The voluntary market is ill-suited to studying these questions; private transactions render it extremely non-transparent, and as an unregulated market, incentives to develop stringent offset protocols are less strong than in compliance markets. To protect buyers, 99% of voluntary offsets today are third-party verified, but the stringency of the protocols against which offsets are verified varies. The defining principle of the voluntary market is *caveat emptor*—with so many standard bodies each developing their own rules for offset generation, fully understanding the quality of a standards' offsets is difficult and assessing the overall quality of offsets in the market is impossible. Even assessing the

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[15] While the Green New Deal specifies a 100% renewable energy goal or the United States, continued emissions unrelated to energy production will require one or both of two methods for achieving net-zero carbon emissions: offsetting and carbon capture and storage. Of these two, carbon offsetting is likely to be the primary component of current carbon neutrality goals. Carbon capture and storage may be technologically feasible, but it remains many times more expensive than offsetting and has never been deployed on a large scale, while several billion tCO_2e have been mitigated via carbon offsets worldwide.

[16] Garcia, Assembly Bill 398.

[17] Quebec Environment et Lutte contre les changements climatiques, "Offset Credits."

overall quantity of offsets sold in the voluntary market is difficult since many transactions are private.[18]

The CDM and JI, which to date have supplied more offsets for sale than any other program, are also ill suited for study in this thesis. A wide body of research addresses the strengths and weaknesses of both offset programs, and their enormous scope and many protocols complicate comprehensive study.

This thesis will focus on the California Compliance Market (CCM), a relatively new and understudied compliance offset market. California's CAT system, what The New York times called a "Grand Experiment to Rein in Climate Change," took effect in 2013 and was designed to learn from and improve upon offsetting in the voluntary market and CDM.[19] After the CDM and JI, the CCM is the largest compliance offset market in the world, and includes six offset protocols that each focus on a major category of unregulated emissions: Ozone Depleting Substances (adopted 2011), Livestock (2011), US Forest (2011), Urban Forest (2011), Mine Methane (2014), and Rice Cultivation (2015). Of these six protocols, only four have produced offsets (Figure 1), but those four have produced more than 145 million.[20] All of California's protocols are publicly viewable online alongside market data that describes how many of each type of offset has been produced, which firms have surrendered offset to the Californian government, and

[18] The leading voluntary market resource, "The State of the Voluntary Offset Market" released annually by Ecosystems Marketplace, relies upon voluntary information disclosure gathered from offset sellers via survey.

[19] Barringer, "In California, a Grand Experiment to Rein in Climate Change - The New York Times."

[20] The exact value is 145,994,499 offsets. This total includes early action offsets and was taken from CARB's offset registry March 8, 2019. See CARB "Compliance Offset Program."

how many of each type of offset firms have surrendered. As the most recent effort to establish a compliance offset market, California's offset protocols represent the cutting edge of offset policy, and the UNFCCC and ICAO will look to California as an example for how to design international offset policies. The combination of the CCM's size, transparency, and importance as a model for future markets make it an ideal, essential study of whether offset protocols can deliver their intended benefits.

Protocol	Ozone Depleting Substances	Livestock Manure Management	U.S. Forest	Urban Forest	Mine Methane Capture	Rice Cultivation	**Total**
Compliance Offsets Issued	18,913,976	5,6078,361	115,610,154	0	5,863,008	0	145,994,499

Figure 1

Chapter 1: Benefits and Criticisms of Offsetting

Across voluntary and compliance markets, offset protocols must produce offsets that truly compensate for emissions or else they compromise the integrity of their associated CAT systems or voluntary emissions reduction goals. Over time, the fundamental criteria for high-quality offsets have settled into six terms recognized across most markets: real, permanent, quantifiable, verifiable, enforceable, and additional.[21] When offset protocols uphold these criteria, offsets can provide a wide variety of benefits. In practice, however, it is difficult for offset policy to guarantee these six criteria, so offsets in the real world do not always yield their intended benefits. This chapter will describe the intended benefits of offsets and criticisms of offset policy's ability to uphold the six offset criteria. It will also describe unintended negative consequences that can occur as a result of offsetting even if protocols uphold the six criteria.

[21] Many markets use this exact language, e.g. RGGI ("Offset Requirements | RGGI, Inc.") and the California Compliance Market (Health and Safety Code §38562(d)(1) and (2)). There is some slight variation, for example the CDM, which only uses the terms "real, measurable, verifiable and additional," but all approach the same meaning (United Nation Framework Convention on Climate Change, "The Kyoto Protocol Mechanisms.").

Benefits of Carbon Offsetting

Lower the Cost of Compliance Inside CAT Systems

CAT systems include offset policy as a cost-containment mechanism. Since potential emissions reductions outside the coverage of a CAT system are typically cheaper than those within it, offset policy creates access to cheaper, lower-hanging sources of reductions for regulated firms, reducing their compliance costs. Lower compliance costs increase the economic efficiency of emissions regulation and can create an opportunity to increase emissions mitigation ambition within the CAT system, accelerating the transition to a low-emissions economy.

Accelerate Sustainable Development Among Unregulated Firms

Many offset protocols are designed to generate emissions reductions while also establishing new best-practices that create financial and environmental co-benefits outside the CAT system among unregulated firms. In the agricultural sector, this can include more efficient use of manure and nitrogen fertilizer, reducing methane and nitrous oxide emissions while improving air and water quality and decreasing agricultural input costs. Offset protocols can also incentivize landowners to improve their management of forestland or reduce the conversion of grassland, forestland, and wetland to farmland, fortifying local ecosystems while providing ecosystem services. In the industrial sector, multiple offset protocols incentivize the destruction of gasses that, in addition to contributing to climate change, damage the ozone layer and enable harmful UV rays to reach the earth’s surface.

Offset protocols can also steer streams of capital into sustainable infrastructure development, including renewable energy generation, improved water pumping efficiency, and increased rapid transit efficiency.[22] The ability of offset policy to "contribute to the mitigation of greenhouse gas emissions and support sustainable development" was a primary motivator for the international offset mechanism established by Article 6.4 of the Paris Agreement.[23]

Positive Public Relations

The opportunity to buy offsets can enable firms to demonstrate corporate social responsibility and environmental values. By funding offset projects that support community health and sustainability, firms can improve their relationships with local community stakeholders and cast themselves in a positive light for the public. Carbon "neutrality"—that is, offsetting all of a company's emissions—is a growing trend among businesses worldwide. Many dominant businesses have already claimed carbon neutrality, including Google since 2007,[24] Microsoft since 2012,[25] Marks & Spencer since 2012,[26] and many others. Still more business leaders (e.g. Siemens and REI) have committed to carbon neutrality in the future in an effort to communicate their sustainable values.[27]

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[22] UNFCCC, "CDM: Approved Baseline and Monitoring Methodologies for Large Scale CDM Project Activities."
[23]UNFCCC, "Paris Agreement"
[24] Dreyfuss, "How Google Keeps Its Power-Hungry Operations Carbon Neutral."
[25] Microsoft, "Commitment to Carbon Neutral – Microsoft Environment."
[26] Marks and Spencer, "On the Road to Carbon Reduction."
[27] Siemens, "Siemens Is Going Carbon Neutral by 2030." and https://www.rei.com/stewardship/core-practices

Criticisms of Carbon Offsetting

Despite the potential benefits of offsetting, the six fundamental criteria for high quality offsets—additional, permanent, enforceable, real, quantifiable, and verifiable—can be impossible to guarantee. Even if offsets do meet all six criteria, they can cause unintended negative consequences for the climate and human populations. The following sections will describe the six offset criteria, criticisms of offset policy's ability to guarantee them, and potential unintended consequences of offsetting.

Additionality

Description

For offsets to compensate for atmospheric emissions, they must be additional—that is, they must represent action above and beyond what would have happened in the absence of an offset program. Determining what would have happened without an offset program in a business-as-usual (BAU) scenario is the central question of additionality.[28]

Offset protocols include various "tests" for additionality that attempt to model the BAU scenario. Standard bodies including the Clean Development Mechanism (CDM),[29] American Carbon Registry (ACR), [30] Climate Action Reserve (CAR),[31] and California Air Resources Board (CARB)[32] each utilize the same basic combination of tests (Figure

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[28] Bennett, "Additionality."
[29] United Nation Framework Convention on Climate Change, "Tool for the demonstration and assessment of additionality Version 07.0.0"
[30] American Carbon Registry, "Hybrid Additionality Approach."
[31] Climate Action Reserve, "Criteria for Protocol Development : Climate Action Reserve."
[32] CARB, "California Air Resources Board's Process for the Review and Approval of Compliance Offset Protocols in Support of the Cap-and-Trade Regulation"

1), although which tests are used and the scale at which they are applied differs. The CDM assesses projects individually, while CAR reduces transaction costs by using the same standard additionality criteria for all projects. CARB and ACR both utilize hybrid approaches based upon a desire to reduce transaction costs while accounting for project site-specific characteristics and anomalies. Thoroughly running these tests is time consuming and expensive, creating a trade-off between regulatory stringency and project financial feasibility.[33]

Test	Description	If Yes	If No
Financial Feasibility	Does the project need offset revenue to be financially viable?	Pass	Fail
Regulatory Compliance	Does the project go above and beyond practices that are legally required?	Pass	Fail
Common Practice	Is the project the first-of-its-kind or a significant departure from common practice?	Pass	Fail
Other Barriers	Are there other social, environmental, or political barriers that prevent the project from occurring?	Pass	Fail

Figure 1.1

Criticism

Many argue that regardless of additionality tests, a business-as-usual scenario is impossible to know or prove.[34] Professor Robert Stavins, Director of Environmental Economics at Harvard University, commented to the Washington Post, “That’s

[33] Meyers, “Additionality of Emissions Reductions from Clean Development Mechanism Projects.”
[34] Murray, Sohngen, and Ross, “Economic Consequences of Consideration of Permanence, Leakage and Additionality for Soil Carbon Sequestration Projects.”

essentially unobserved, and fundamentally unobservable, I mean, who knows what you would have done?"[35]

Additionality scandals that have taken place in spite of additionality tests have also shown that tests are not always foolproof. One such scandal took place from 2009 to 2013 and involved offsets generated through the CDM for destroying the gas HFC-23. HFC-23 is produced as a byproduct of manufacturing the refrigerant HFC-22, which takes place primarily in India and China. Although HFC-23 is only produced in small quantities, it is an extremely potent GHG—11,700 times more potent than CO_2—so destroying even small quantities can yield tremendous value in CO_2e offsets.[36]

From 2009 to 2011, the average price of CDM offsets was near $20, about 70 times the true cost of destroying HFC-23. Chinese and Indian chemical manufacturers, recognizing a new opportunity for revenue generation, increased HFC-22 production specifically to produce and destroy HFC-23 and cash-in on offsets. In all, nearly 500 million HFC-23 credits were issued, inundating the CDM market with non-additional offsets that permitted increased emissions without compensating for them. By 2013, 362 million offsets had been issued to Chinese HFC-23 projects alone. Much of that revenue drained into government coffers; a 65% tax on CDM revenue enabled the Chinese government collected an estimated 1.98 billion USD by 2013.[37]

A temporary HFC-23 offset ban took effect in 2010 following initial indicators that the CDM's HFC-23 protocol was creating perverse incentives to expand gas

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[35] Quoted from Fahrenthold, "Caps, Trades and Offsets."
[36] IPCC, 2013
[37] Wara and Victor, "A realistic policy on international carbon offsets"

production. It took until 2013, however, to formally ban all offsets generated by HFC-23 destruction, enabling more non-additional offsets to infiltrate the CDM's market. In total, more than $5 billion went to refrigerant manufacturers, the Chinese government, and offset brokers for HFC-23 projects, while the actual cost of HFC-23 abatement has been estimated at less than $114 million.[38]

The 2013 ban not only validated doubts in the ability of offset policy to guarantee additionality, but it also set off a secondary scandal. In the month following the HFC-23 offset ban, some Chinese and Indian chemical manufacturers demanded that HFC-23 payments continue, or else they would release all HFC-23 into the atmosphere. In the words of Mark Roberts, International Policy Advisor for the Environmental Investigation Agency, "Chinese and Indian companies are holding the world hostage by threatening to set off a climate bomb if they don't receive millions of dollars for the destruction of the HFC-23 that they are producing."[39]

Western offset buyers, primarily in Europe, were already deeply upset that they had been paying for non-additional emissions and putting their dollars into the Chinese government's pocket. This reaction from gas manufacturers was salt in an open wound, and today, the HFC-23 scandal is remembered as a prime example of what can go wrong when offsets are non-additional.

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[38] Wara and Victor, "A realistic policy on international carbon offsets"
[39] "Explosion of HFC-23 Super Greenhouse Gases Is Expected."

Permanence

Description

For carbon offsets to compensate for regulated firms' emissions, they must also be permanent—that is, they must represent emissions reductions that can never be released back into the atmosphere. If offsets are generated by impermanent emissions reductions, they permit regulated firms to release GHGs without counterbalancing them, undermining the central mission of a CAT system and of voluntary emissions reduction goals.

Certain types of offset protocols incentivize emissions reductions that are inherently permanent. Avoided consumption of a product that will create GHGs, for example, will permanently reduce emissions since it is impossible to travel back in time and opt to consume more of the product. Avoided fuel consumption and avoided fertilizer application, which create offsets in the voluntary market, fit into this category since both products produce GHGs when consumed.

Protocols that alter the irrigation regimes of rice cultivation represent a second category of permanent offset, since they involve changing the natural product of decomposing organic matter from methane to carbon dioxide. Protocols that involve destroying GHGs comprise a third category of permanent offset. Livestock manure and coal mine protocols focus on destroying methane by burning it, which releases CO_2, a less potent GHG. Similar protocols incinerate or otherwise transform potent ozone depleting substances (ODS) into less potent forms. Offset protocols like these cannot reduce emissions to zero, since combustion releases some CO_2, but they reduce the overall global warming potential of emissions, and their combusted products can never spontaneously revert to their pre-combusted forms, rendering their emissions reductions permanent.[40]

Protocols that rely upon carbon sequestration, however, include an inherent risk of impermanence. Protocols that involve planting or managing forestland fall into this category, since projects earn offsets up-front for storing carbon in biomass that may not exist forever. Other sequestration-reliant protocols focus on maintaining or creating carbon stocks in agricultural soils and grassland soils through improved tillage practices or preventing the conversion of grassland to cropland.[41]

Sequestration protocols are vulnerable to two types of carbon releases, or "reversals." The first is natural, relatively unpredictable, and uncontrollable: if a forest burns, experiences a pest outbreak, severe weather event, or is struck by blight, the carbon contained in the forest's biomass can be released back into the atmosphere. Grassland offsets are considered less vulnerable to fire, since soil carbon remains if grass burns away,[42] but disease and a wide variety of climate-related factors can affect soil decomposition, threatening permanence.[43] The second type of reversal is intentional and includes cutting down forestland, ceasing forest management, returning from no-till to conventional tillage, and converting grassland to cropland.

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[40] CARB, "Compliance Offset Program"
[41] Murray, Sohngen, and Ross, "Economic Consequences of Consideration of Permanence, Leakage and Additionality for Soil Carbon Sequestration Projects."
[42] Climate Action Reserve, "Grassland Project Protocol."
[43] Davidson and Janssens, "Temperature Sensitivity of Soil Carbon Decomposition and Feedbacks to Climate Change."

All standard bodies include features in their sequestration protocols that are designed to minimize reversal risk. Many standard bodies withhold a certain percentage of each project's offsets in a buffer pool, which acts as an insurance mechanism. Should a reversal ever cause a project's offsets to be invalidated, an equivalent quantity of offsets within the buffer pool are nullified to compensate for the illegitimate offsets at large in the market. By reducing the number of offsets in circulation, buffer pools build an implicit safety premium into offset price.

In addition to buffer pools, standard bodies also set contractually-required minimum project lengths to ensure that sequestration continues over time. CAR and CARB have set the longest mandatory project lengths, requiring that sequestration continues for 100 years beyond the date of the last offset awarded to a project. If an offset is awarded 99 years after the project start date, for example, that means that the project's carbon must remain stored until 199 years after the project's start date.[44] Other standard bodies offer a range of contract periods: Verra stipulates 20-100 years, while ACR requires a minimum of 40 years with an opt-out option if project owners replace their offsets.[45]

To boost the economic appeal of forest protocols, some standards include provisions for timber harvest from sequestration projects, which affects permanence calculations. Verra, for example, allows a project's trees to be cut down, but weights the project's offsets by the expected life of the wood products crafted from the timber. The

[44] American Carbon Registry, "Methodology for the Quantification"
CARB, "US Forest Project Compliance Offset Protocol"
[45] Verra, "VCS Standard v3.7."

carbon storage of short-lived products (decaying within three years) are totally subtracted from a project's offsets, medium-lived products (3-100 years) register a 1/20th decrease in carbon storage for 20 years, and long-lived products (greater than 100 years) face no discount or decrease in their carbon storing value.[46] ACR utilizes a similar approach in its Afforestation and Reforestation of Degraded Lands protocol, which "calculates the proportion of wood products that have not been emitted to the atmosphere 100 years after harvest and assumes that this proportion is permanently sequestered."[47]

Criticism

Buffer pools and minimum project lengths have both been subject to severe criticism. The central challenge of buffer pools is that they must be large enough to cover potential reversals without withholding so many offsets from each project that projects become financially infeasible or unattractive.[48] The standard bodies Verra, the Climate Action Reserve (CAR), and American Carbon Registry (ACR) manage this tradeoff by mandating project-specific risk assessments that determine what percentage of a project's offsets must be withheld.[49] As some have pointed out, however, the "potential for large-scale reversals to undermine such a risk-management system is troubling."[50]

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[46] Verra, "Approved VCS Methodology VM0003 v1.2: Methodology for Improved Forest Management Through Extension of Rotation Age."

[47] American Carbon Registry, "Methodology for the Quantification, Monitoring, Reporting and Verification of Greenhouse Gas Emissions Reductions and Removals From Afforestation and Reforestation of Degraded Land Version 1.2."

[48] Galik et al., "Alternative Approaches for Addressing Non-Permanence in Carbon Projects."

[49] Verra, "Approved VCS Methodology VM0003"
American Carbon Registry, "Methodology for the Quantification"
Climate Action Reserve, "Rice Cultivation Project Protocol"

[50] Murray and Kasibhatla, "Equating Permanence of Emission Reductions and Carbon Sequestration."
Galik and Jackson, "Risks to Forest Carbon Offset Projects in a Changing Climate."

Minimum project lengths are problematic because they equate a finite period of sequestration, often 100 years, with permanent sequestration. This convention is usually explained by referencing the Intergovernmental Panel on Climate Change's use of a 100-year horizon to calculate the Global Warming Potential (GWP) of different GHGs.[51] Such references implicitly accept that a 100-year span was chosen arbitrarily because it is a round number at the far limits of a feasible and realistic policy horizon, not because it reflects the residence time of CO_2 in the atmosphere. Emissions of CO_2 into the atmosphere do not disappear after 100 years; 25-40% of a pulse of CO_2 will remain in the atmosphere for thousands of years, and 10-20% will persist for tens of thousands of years.[52] It follows that in order for a carbon sink to completely offset a pulse of CO_2, it must continue to sequester CO_2 for tens of thousands of years, orders of magnitude longer than the minimum project lengths mandated by offset protocols today.[53]

When a carbon sink releases sequestered carbon, it will ultimately yield the same increase in global temperature as if it had not been sequestered—the only effect it may yield is a delay in warming. Some members of the scientific community argue that the delay in warming created by temporary storage still warrants carbon crediting. They cite reasons like "buying time" for technological advancement, learning, and capital turnover,[54] smoothing out emissions peaks to limit maximum impacts,[55] and the hope that

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[51] A convention that has, itself, been challenged repeatedly. Keith P. Shine, one of the lead authors of the IPCC's first assessment report, called the use of the GWP_{100} an "inadvertent consensus" in his 2009 article "The Global Warming Potential—the Need for an Interdisciplinary Retrial."

[52] Archer and Brovkin, "The Millennial Atmospheric Lifetime of Anthropogenic CO2." found through Shoemaker and Schrag, "The Danger of Overvaluing Methane's Influence on Future Climate Change."

[53] Murray and Kasibhatla, "Equating Permanence of Emission Reductions and Carbon Sequestration."

[54] Marland, Fruit, and Sedjo, "Accounting for Sequestered Carbon."

[55] Dornburg and Marland, "Temporary Storage of Carbon in the Biosphere Does Have Value for Climate Change Mitigation: A Response to the Paper by Miko Kirschbaum."

"some temporary sequestration may turn out to be permanent."[56] These arguments may well be true, but none of them go as far as to say that temporary sequestration is *equally* valuable as permanent emissions reduction. Dornburg and Marland (2007), who vehemently argue that "even sinks that are known to be temporary have value," accept that "permanent sinks are obviously preferable to temporary sinks."[57] Consequently, offsets generated by carbon sequestration should not be viewed as equivalent to permanent offsets in the policy community or the marketplace—their price and importance in emissions mitigation strategies should reflect their actual value, which is less than a legitimate, permanent offset.

Just how valuable is the delay created by temporary sequestration? That ultimately depends on unknowable factors including the future rate of technological innovation and level of ambition to cut business-as-usual emissions during the time "purchased" with temporary sequestration. One way to begin assessing the value of delay, however, is to ask how much delay can be achieved with an ambitious rate of sequestration. High estimates of the global capacity of forests to sequester carbon are about 4 billion tCO_2e per year,[58] while global CO_2 emissions are about 32.5 billion tCO_2 per year.[59] If sequestration were to continue at that same rate for 100 years, 400 billion tCO_2 would be sequestered. Even assuming that the rate of global CO_2 emissions stays

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[56] Chomitz, "Evaluating Carbon Offsets from Forestry and Energy Projects."
[57] Dornburg and Marland, "Temporary Storage of Carbon in the Biosphere Does Have Value for Climate Change Mitigation: A Response to the Paper by Miko Kirschbaum."

[58] Coren, Streck, and Madeira, "Estimated Supply of RED Credits 2011–2035."
Cannell, "Carbon Sequestration and Biomass Energy Offset."
[59] "Global Energy & CO2 Status Report."

the same and that 50% of those emissions are instantaneously absorbed by the ocean and biosphere,[60] atmospheric CO_2 concentrations would only be delayed by 25 years.[61]

Even if these emissions assumptions hold true in the next 100 years, 4 billion tons of sequestered carbon per year dwarfs the rate forest offset issuance in the real world, suggesting that temporary carbon sequestration already achieved via offsetting has created very little delay in rising CO_2 concentrations and, therefore, on global average temperature rise. Ecosystems Marketplace estimates that between 2005-2018, global forest and land-use offsets issued in the voluntary market (including the CDM) totaled 95.3 million tCO_2e.[62] The California Compliance market adds about another 115 million more offsets to total global sequestration-based offset generation.[63] Even if every single one of those offsets remains sequestered for 100 years, 210.3 million tons across 20 years is infinitesimal compared to 4 billion tons per year for 100 years. The total value of delay that sequestration-based offsets have therefore produced in global temperature rise is minute, reinforcing the conclusion that short-term carbon sequestration in temporary sinks ‘‘achieves effectively no climate-change mitigation.’’[64]

Arguments for valuing delay and for enforcing sequestration for 100 years or longer also introduce the extraordinary administrative challenge of holding firms liable

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[60] This value comes from an approximation in the National Oceanic and Atmospheric Administration’s article, “Ocean-Atmosphere CO2 Exchange.”

[61] These assumptions deliberately underestimate global emissions in the next 100 years to show that even at an emissions rate that is lower-than-expected, the delay that forest sequestration can create in rising CO_2 concentrations is small. The delay in global average temperature rise is therefore also expected to be small. Determining the precise delay in global average temperature rise if all 400 billion tCO_2 were released after 100 years is outside the scope of this thesis but warrants further research.

[62] Hamrick and Gallant, “Voluntary Carbon Markets Insights: 2018 Outlook and First-Quarter Trends.”

[63] CARB, “Compliance Offset Program.”

[64] Kirschbaum, “Temporary Carbon Sequestration Cannot Prevent Climate Change.”

for carbon reversals decades or centuries after they generated or purchased offsets—a problem of enforceability.[65]

Enforceability

Description

An offset is enforceable if the emissions reductions that created it are "supported by legal instruments that define their creation, provide for transparency, and ensure exclusive ownership."[66] In practice, this means that offsets are backed up by a legally enforceable contract between seller and buyer to ensure that offsets meet agreed-upon criteria. One of the most challenging criteria, as described earlier, is permanence. Since permanent sequestration requires many decades of continuous activity under current protocols, offset contracts include legal penalties for carbon release that must remain enforceable for the duration of a project. In California's US Forest Protocol for example, project owners who discontinue sequestration activities less than 100 years after their last offset is issued are contractually obligated to either replace the offsets that their project generated or face legal consequences.[67]

As Palmer et al. (2009) point out, current compliance offset markets (e.g. California) also create a private sector incentive to purchase enforceable emissions reductions by assigning liability to replace invalidated offsets to the offset buyer. Since

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[65] Sedjo and Marland, "Inter-Trading Permanent Emissions Credits and Rented Temporary Carbon Emissions Offsets: Some Issues and Alternatives:"
[66] Gero, "The Role of Carbon Offsets in Cap-and-Trade."
[67] CARB, "Compliance Offset Protocol U.S. Forest Projects."

the "buyer risks the loss of his investment if the seller decides to switch land use," it is in buyers' best interest to seek out offsets that will be enforced. Of course, Palmer et al. (2009) fail to mention that once a buyer does purchase offsets, the effect reverses—both buyer and seller will be incentivized to ignore enforcement issues to avoid losing their investment.

Criticism

Enforceability relies upon government and judicial institutions' capability to enforce contracts. Today, that capability varies between countries, complicating international offsetting. Weak contract enforcement in many developing countries is an accepted reality in international offsetting; the potential for opportunistic offset producers to breach contracts whenever an "attractive outside option arises" is a constant risk that disincentivizes investments in carbon offset projects.[68]

Within countries where government and judicial institutions enforce contracts today, the long timescales demanded by permanent sequestration still make enforceability uncertain. Since true permanence requires virtually eternal sequestration, enforceability requires that contracts remain binding far beyond the horizon of political certainty. To argue that enforcement is possible hundreds of years from today, one must assume that government and judicial institutions honor and enforce contracts signed today and that third-party verifiers are still paid to periodically inspect projects to determine whether project activities continue. There is no way to be sure that a government will enforce

[68] MacKenzie, Ohndorf, and Palmer, "Enforcement-Proof Contracts with Moral Hazard in Precaution."

sequestration contracts long enough to render sequestration offsets permanent, and at the multi-century scale, third-party verification may become financially impossible; the capability of any terrain to sequester carbon is limited, so the offset-related value of sequestration is also limited. As third-party verification continues over centuries, the cost will eventually overcome offset revenue and make verification financially impossible. Once there is no way to pay verifiers, there is no way to check in on projects to ensure that sequestration activities continue.

As protocols currently stand, the political decision to equate 100-year sequestration with permanent sequestration implicitly concedes that 100 years is the furthest realistic horizon of reliable enforcement. This does help to create certainty in enforcement. Given a finite time horizon, contract structures like those suggested by MacKenzie et al. (2012) in which sellers receive a payment upon delivery of a permanent offset also become possible. Enforcing a non-permanent offset, however, is no better than failing to enforce a permanent offset, since neither yield the climate benefits they were intended to create. This illuminates the tradeoff between permanence and enforcement inherent to sequestration projects. As a project's permanence increases, its enforceability decreases.

Reality, Quantifiability, and Verifiability

Description

The criteria "real," "quantifiable," and "verifiable" are closely tied together. A project is real if it took place and was carried out according to the standards and activities of an offset protocol, it is quantifiable if its emissions reductions can be precisely calculated, and it is verifiable if a third party (a "verifier") can check to make sure that activities occurred and were properly quantified. Verifiability is the keystone criterion of these three; a project's claims of reality and quantifiability are meaningless unless an unbiased third-party verifier can validate them.

Quantifiability can consist of direct measurements of project emissions, which is possible for projects that destroy methane produced by anaerobic manure digestion, for example, or it can consist of modeling project emissions based upon project-specific data inputs. For most types of offsets (e.g. forest, rice paddy emissions, fertilizer efficiency, soil carbon sequestration), direct measurement is infeasible, so process-based biogeochemical models are utilized to predict baseline emissions and avoided emissions.[69]

Third party verifiers are independent organizations who are responsible for establishing "reasonable assurance" that a project meets offset protocol criteria.[70] They are trained according to the methodology of an offset protocol and conduct required investigations of each offset project. Verification typically has two parts: a desk review of submitted project materials and a project site-visit. The frequency of both types of review varies between protocols and between standard bodies. Verifiers are also required to sign a form stating that they have no conflicts of interest for each project they verify.

In compliance markets like the CDM and CCM, where a centralized body has jurisdiction over the market, various policy tools hold verifiers accountable and

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[69] CARB, "Compliance Offset Protocol Rice Cultivation Projects."
[70] CARB, "Technical Guidance for Offset Verifiers Verification of Offset Project Data Reports."

standardize verification. These include a centralized board performing its own final review of project documentation after verification but before offset issuance and in-depth audits by a centralized body of projects and project verification. As CARB states, "Audits associated with the offset verification program should not be viewed as adversarial; the purpose of auditing is for CARB to monitor and oversee functioning of the offset program and offset verification program, and to ensure quality, rigor, and consistency across verification bodies."[71]

Criticism

Quantifiability

Process-based, biogeochemical models can calculate emissions with great accuracy once calibrated and validated for a specific project, but the ways they account for uncertainty and the potential for omitted variables pose a risk to accurate offset crediting. The De-Nitrification De-Composition (DNDC) model, utilized in California's compliance Rice Protocol, exemplifies these risks. Two types of uncertainty determine the accuracy of DNDC-calculated emissions reductions. The first is "input uncertainty," which is determined by the accuracy of the data that offset project owners can collect and feed into the DNDC model. This type of uncertainty is very difficult to quantify since different projects utilize different data collection techniques and the quality standards for data collection may vary between projects. The second type of uncertainty is "structural uncertainty," an inherent component of "process-based models that remains even if all

[71] CARB, "Technical Guidance for Offset Verifiers Verification of Offset Project Data Reports."

input data were error-free."[72] Across all agricultural protocols that utilize process-based, biogeochemical models like the DNDC, the level of uncertainty can at times exceed modeled emissions reductions, preventing offset crediting.

Protocols attempt to minimize over-crediting due to modeling uncertainties by deducting a quantity from each project's emissions reductions. Those deductions, however, vary by protocol and by offset registry. In California's compliance Rice Protocol, for example, standard input uncertainty and structural uncertainty deductions are applied to all rice projects, while in the voluntary market, rice protocols calculate custom deductions for each project.[73] These differences highlight that each California rice offset likely represents a different precise quantity of climate benefits than each voluntary rice offset, even when both are generated by identical activities and purport to represent one avoided tCO_2e.

The DNDC-rice model used in the California Rice Protocol also exemplifies the potential for process-based, biogeochemical models to omit important variables that affect emissions reductions calculations. While the DNDC model is very effective for calculating CH_4 emissions,[74] it can significantly underestimate the emissions of N_2O, a GHG 265 times more potent than CO_2 on a 100-year timescale.[75] As a result, the increase in N_2O emissions can overcome the decrease in CH_4 emissions caused by project

[72] CARB, "Compliance Offset Protocol Rice Cultivation Projects."
[73] American Carbon Registry, "Rice Management Systems."
Climate Action Reserve, "Rice Cultivation Project Protocol."
[74] Jagadeesh et al., "Field Validation of DNDC Model"
Katayanagi et al., "Validation of the DNDC-Rice Model"
[75] IPCC, 2013

activities, increasing net GHG emissions even as projects are credited with offsets.[76] Capturing GHG trade-offs like this is essential to accurate GHG accounting when offset protocols rely on emissions modeling.

Verification

Offset project verifiers are often subject to perverse incentives and conflicts of interest. Since an offset's buyer and seller both want projects to produce the largest number of offsets possible at the lowest cost possible, they are both incentivized to overestimate baseline emissions or otherwise inflate their offset calculations while demanding the cheapest verification possible. Offset verifiers, regardless of whether they are paid by an offset buyer or seller, face incentives to meet the desires of their employer and to approve projects and the offsets they create at low cost.[77] Even if verifiers are paid regardless of whether they approve a project and its offsets, the desire to sustain advantageous business relationships in a competitive market of verifiers puts pressure on verifiers to approve projects and cut costs.

Since the term "verifier" refers to many non-standardized, third-party groups, the standards and stringency of verification may also vary according to each verifier's concept of "reasonable assurance" of legitimate offset production. In CARB's words, verifiers must use their "professional judgment," a concept that may vary between verifiers within compliance and voluntary markets. In the voluntary market, few if any standard bodies have "specific procedures in place to review the approved auditors nor to

[76] Majumdar, "Methane and Nitrous Oxide Emission"
[77] Wara and Victor, "A realistic policy on international carbon offsets"

allow for sanctions against or the discrediting of an underperforming auditor."[78] Although verifiers in some compliance markets may be subject to auditing, the effectiveness of audits is determined by their frequency, for which there is no mandated minimum in the CDM or CCM.

Unintended Consequences

Even if offsets are additional, permanent, enforceable, real, quantifiable, and verifiable, offsetting can cause unintended negative consequences that raise serious questions about the value of offsetting. These include higher long-term global average temperatures from trading short-lived emissions for long-lived emissions, rebound effects, and displaced impacts caused by altering where emissions reductions occur.

Trading Short-Lived Emissions for Long-Lived Emissions

The emissions reductions that generate carbon offsets are converted to "CO_2-equivalent" so that multiple different greenhouse gasses can be traded equivalently. While this conversion allows carbon credit markets to operate smoothly, it does not acknowledge that trading GHGs with different residence times in the atmosphere can have profound environmental impacts.

Figure 1.2 shows the radiative forcing of a pulse of CO_2 compared to a pulse of CH_4 (methane) as natural processes remove both from the atmosphere. As the graphs indicate, methane's short-term effect on radiative forcing is much higher than CO_2's (note the different y-axis scales), but methane is removed from the atmosphere much

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[78] Kollmuss, Zink, and Polycarp, "A Comparison of Carbon Offset Standards."

more quickly, so its ability to warm the atmosphere declines to zero after a few decades.[79] Many other short-lived climate pollutants (SLCPs) including black carbon, tropospheric ozone, and hydrofluorocarbons exhibit similar behavior. CO_2's peak radiative forcing may be lower, but CO_2 remains in the atmosphere for an extremely long time; as mentioned earlier, 25-40% of a pulse of CO_2 will remain in the atmosphere for thousands of years, and 10-20% will persist for tens of thousands of years.[80]

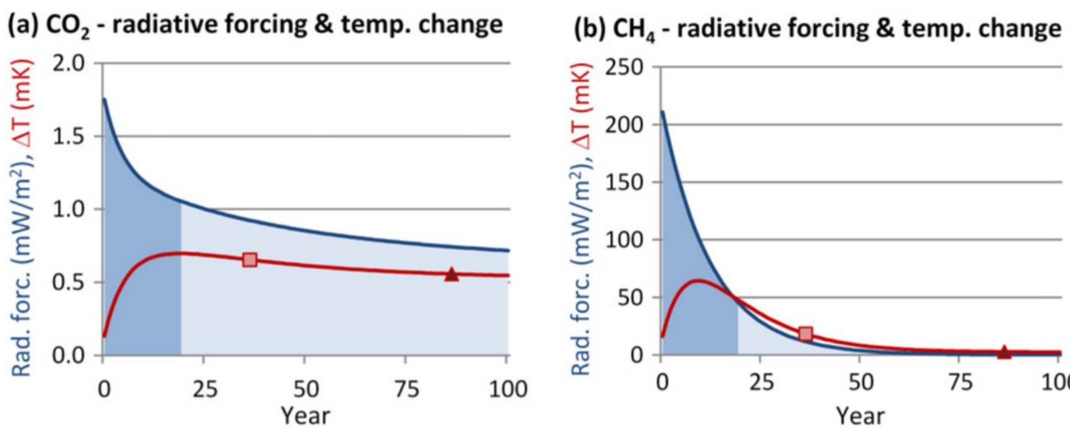

Figure 1.2

Emissions mitigation strategies that increase ambition to destroy SLCPs at the expense of ambition to decrease CO_2 therefore affect long term global warming trajectories. In the short term, peak temperatures can be avoided, but in the long term, temperatures are guaranteed to be higher (Figure 1.3).[81]

[79] Figure 1.2 from Persson et al., "Climate Metrics and the Carbon Footprint of Livestock Products."
[80] Archer and Brovkin, "The Millennial Atmospheric Lifetime of Anthropogenic CO2." found through Shoemaker and Schrag, "The Danger of Overvaluing Methane's Influence on Future Climate Change."
[81] Shoemaker et al., "What Role for Short-Lived Climate Pollutants in Mitigation Policy?"

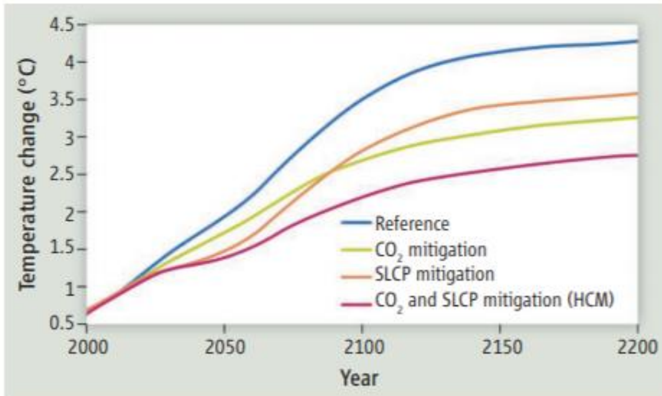

Figure 1.3

The red trajectory in Figure 1.3 indicates that SCLP mitigation is still an essential component of achieving the lowest possible warming trajectory, but as the yellow and orange trajectories show, reducing CO_2 emissions is ultimately necessary to minimize long-term temperature rise.

Carbon offsets protocols that compensate for regulated firms' CO_2 emissions by destroying methane (e.g. livestock manure management protocols and mine methane capture protocols) explicitly trade methane emissions for CO_2 emissions, creating short-term benefits at the expense of future generations, who will bear the cost of higher temperatures in perpetuity.

Offsets' ability to facilitate the trade of SLCPs like methane for CO_2 is, in some sense, evidence of offset policy's most celebrated benefit—lower compliance costs. Mitigating methane is cheaper than mitigating CO_2, so methane-generated offsets are cheap, available, and help firms lower their compliance costs, increasing overall economic efficiency. In this case, however, offsets' ability to seize low-hanging fruit also presents a case against offset generation. CO_2 mitigation—the only way to minimize long-term warming trajectories—requires technological innovation and invention, processes that only occur with the proper market incentives. Utilizing methane-derived offsets to decrease CAT compliance costs decreases financial incentives to develop technology that can cheaply reduce CO_2 emissions, ultimately delaying CO_2 emissions mitigation and locking in a higher long-term warming trajectory. As Shoemaker and Schrag (2013) show, for every 15 years of delayed action to decrease rising CO_2 concentrations, long term temperatures will rise by ¾ degrees Celsius.[82]

Rebound Effects

Rebound effects occur when a product or service designed to make an undesirable behavior less dangerous causes people to exhibit more of the behavior. Examples include drivers who become more reckless as car safety standards increase and individuals who consume more energy as appliances become more efficient. In the context of offsets, there is concern in the voluntary market that offsetting will decrease “green guilt” and provide buyers with the moral license to pollute more.[83]

It is unclear whether offsetting rebound effects exist on a large scale. Some studies have found evidence of modest rebound effects from offsetting, while others have not.[84] Nevertheless, concern that offsets will increase polluting behavior and reduce public will to make meaningful emissions reductions has affected the landscape of

[82] Shoemaker and Schrag, “The Danger of Overvaluing Methane’s Influence on Future Climate Change.”
[83] Kotchen et al., “Do Voluntary Carbon Offsets Help Counteract Greenhouse Gases, or Are They Just a Way for Guilt-Ridden Consumers to Buy Their Way out of Bad Feelings?”
[84] Ibid.
Harding and Rapson, “Do Voluntary Carbon Offsets Induce Energy Rebound? A Conservationist’s Dilemma.”

voluntary offsetting. Responsible Travel, one of the first travel companies to provide customers with an opportunity to offset their emissions in 2002, cancelled their program after Managing Director Justin Francis noticed helicopter tours and other decadent emitters offering compensatory offsets. "The carbon offset has become this magic pill, a kind of get-out-of-jail-free card," Francis stated to the New York Times in 2009, "It's seductive to the consumer who says, 'It's $4 and I'm carbon-neutral, so I can fly all I want.'"[85]

Displaced impacts

Since CO_2 is a uniformly mixed pollutant in the atmosphere, CO_2 emissions reductions create the same global climate benefits wherever they occur. CO_2 (and CO_2-equivalent) emissions reductions, however, are tied to a wide variety of co-benefits and co-costs that impact their local environment. Since carbon offsetting facilitates the trade of carbon emissions reductions across space, it also shifts co-benefits and co-costs between areas, creating unanticipated negative consequences for populations that lose co-benefits and experience new co-costs.

The first type of population that can experience negative impacts from offsetting is the population immediately around offset buyers. These impacts arise because in many cases, emissions reductions from reduced fossil fuel use yield local co-benefits. Burning less coal, for example, will not only decrease CO_2 emissions, but will also decrease the quantity of harmful particulate matter in local air and reduce acid rain in the surrounding

[85] Rosenthal, "Paying More for Flights Eases Guilt, Not Emissions - The New York Times."

area. When fossil fuel users buy offsets, they don't have to mitigate as much of their operational emissions, and co-benefits that would have otherwise been enjoyed locally disappear, exchanged for co-benefits at the location where offsets are produced. Concerns that offsetting can therefore lead to emissions hot-spots around buyers and negatively impact communities covered by a CAT system have historically caused policymakers to limit the quantity of offsets that each firm can use, ensuring that most emissions reductions and co-benefits are achieved locally. In California, for example, regulated firms may only use offsets to meet 8% of their compliance obligations through 2020.[86]

A second type of co-cost created by offsetting occurs at the site of offset production when emissions reduction activities negatively impact local populations. The most striking examples of these impacts have occurred because of Reduced Emissions from Deforestation and Degradation (REDD) projects, which aim to financially compensate developing nations for the preservation or expansion of their forestland. REDD projects are primarily intended to prevent the release of forest carbon to generate offsets, but they are also purported to yield a host of co-benefits including reduced flooding, runoff, erosion, and river siltation, and preserved fisheries, investments in hydropower, biodiversity, cultures, and traditions.[87] The United Nations Food and Agriculture Organization has assisted over 80 countries across Africa, Asia Pacific and Latin America and the Caribbean in preparing and implementing REDD projects.[88]

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[86] CARB, "Climate Change Scoping Plan a Framework for Change."
[87] Stickler et al., "The Potential Ecological Costs and Cobenefits of REDD."
"What Is REDD+?"
[88] Food and Agriculture Organization of the United Nations, "REDD+ Reducing Emissions from Deforestation and Forest Degradation."

Forestlands throughout the world, however, are occupied by between 350 million and 1.2 billion people, whose ways of life and relationships with forestland are not always taken into account when REDD projects are established. Many indigenous global forest dwellers are economically poor, “live outside the reach of global financial and market structures,” or lack recognition as citizens or lack a legal right to their lands.[89] These disadvantages reduce or preclude the ability of indigenous populations to participate in the development of REDD projects.[90] Pilot projects, notably the Noel Kempff National Park project launched in 1997 in Bolivia, have demonstrated that the top-down design and implementation of REDD projects can exclude indigenous populations while strengthening state and private sector control over forests. This power dynamic prevents indigenous populations from capturing the financial benefits of REDD projects even as they face restrictions on hunting, fishing, and cultivation practices or, at worst, as they are expelled from their traditional lands.[91] Numerous case studies and publications illuminate current and potential threats to indigenous peoples’ rights, autonomy, and way of life caused by REDD projects.[92] Whether REDD will ultimately benefit or marginalize local communities will depend on the extent to which local populations can participate in the systems of rights, rules, and institutions that shape REDD projects throughout the world.

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[89] Colchester, “Beyond Tenure: Rights-Based Approaches to Peoples and Forests Some Lessons from the Forest Peoples Programme.”
[90] Schroeder, “Agency in International Climate Negotiations.”
[91] Griffiths, “Seeing ‘RED’? ‘Avoided Deforestation’ and the Rights of Indigenous Peoples and Local Communities.”
[92] Lemaitre, “Indigenous Peoples’ Land Rights and REDD.”
Cotula and Mayers, *Tenure in REDD*.

Chapter 2: California Compliance Market Policy Analysis

California Compliance Market (CCM) Background

The CCM, established in 2013 by Assembly Bill 32 (AB 32), capped the emissions of all Californian firms that emit more than 25,000 tCO_2e per year—a list that includes more than 450 power plants, energy utilities, mining companies, product manufacturers, and universities. Together, these firms contribute approximately 85% of California's GHG emissions. In 2015, California's emissions cap expanded to also include emissions from fuel distribution.[93]

Offset protocols in the CCM must be adopted by the California Air Resources Board (CARB), the regulatory body that oversees the implementation of AB-32. To aid in the management of offsets and development of new offset protocols, CARB has approved three voluntary market standard bodies to act as Offset Project Registries (OPRs): the American Carbon Registry (ACR), Climate Action Reserve (CAR), and Verra (formerly the Verified Carbon Standard). Together, OPRs provide an initial bulwark of review and stringency to ensure that projects follow the protocols adopted by CARB and to ensure that only real, additional, quantifiable, permanent, verifiable, and enforceable emissions reductions are rewarded with offsets. Once OPRs generate offsets according to CARB's protocols, all offsets must pass a final review of documentation by CARB to become California Compliance Offsets. This symbiotic relationship is designed

[93] CARB, "Cap-and-Trade Regulation Instructional Guidance, CHAPTER 1: HOW DOES THE CAP-AND-TRADE PROGRAM WORK?"

to increase regulatory stringency and to create a testing ground in the voluntary market for new offset policy. So far, the six compliance protocols that CARB has adopted have produced varying numbers of offsets (Figure 2.1).[94]

Protocol	Ozone Depleting Substances	Livestock Manure Management	U.S. Forest	Urban Forest	Mine Methane Capture	Rice Cultivation
Compliance Offsets Issued	18,913,976	5,6078,361	115,610,154	0	5,863,008	0

Figure 2.1

Compliance Obligations and Offset Limits

Just as in other CAT systems, firms in the CCM must turn in allowances and offsets according to a government-set timetable. Through 2020, AB 32 divides that timetable into three multi-year Compliance Periods (Figure 2.2).[95]

Annual and Triennial Compliance Obligations			
First Compliance Period			
Covered Emissions Year	**Compliance Obligation Due Date**	**Percent of Compliance Obligation Due**	**Eligible Vintages of Allowances**
2013	November 1, 2014	30% of 2013 covered emissions	Vintage 2013 only
2014	November 1, 2015	70% of 2013 and 100% of 2014 covered emissions	Vintages 2013 and 2014, any combination
Second Compliance Period			
2015	November 1, 2016	30% of 2015 covered emissions	Vintages 2013-2015, any combination
2016	November 1, 2017	30% of 2016 covered emissions	Vintages 2013-2016, any combination
2017	November 1, 2018	70% of 2015 and 2016, and 100% of 2017 covered emissions	Vintages 2013-2017, any combination
Third Compliance Period			
2018	November 1, 2019	30% of 2018 covered emissions	Vintages 2013-2018, any combination
2019	November 1, 2020	30% of 2019 covered emissions	Vintages 2013- 2019, any combination
2020	November 1, 2021	70% of 2018 and 2019, and 100% of 2020 covered emissions	Vintages 2013-2020, any combination

For more details, see section 95856 of the Cap-and-Trade Regulation.

Figure 2.2

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[94] Values include early action offsets and were taken from CARB's online offset registry March 8, 2019. See Carb, "Compliance Offset Program."

[95] CARB, "20130419 Guidance Document Chapter 3: What Does My Company Need to Do to Comply with the Cap-And-Trade Regulation?"

Firms can use offsets to meet up to 8% of their compliance obligations in each compliance period until 2020. This 8% limit has been contentious; While regulated firms would have preferred unlimited access to offsets—thereby seizing the maximum cost savings possible—CARB regulators determined in AB 32's 2008 Scoping Plan that "While some offsets provide benefits, allowing unlimited offsets would reduce the amount of reductions of greenhouse gas emissions occurring within the sectors covered by the cap-and-trade program. [The 8%] limit will help provide balance between the need to achieve meaningful emissions reductions from capped sources with the need to provide sources within capped sectors the opportunity for low-cost reduction opportunities that offsets can provide."[96] Limiting offset use to 8% per compliance period still allows a significant quantity of emissions to be offset—so far over 145 million have been generated and sold into the market.[97]

AB 398, which passed in 2017, extended California's CAT system to 2030 and established new limits on carbon offsetting post 2020. From 2021 to 2025, firms can utilize offset to meet 4% of their compliance obligations, and from 2025 to 2030, offset use can increase to 6%. In both periods, at least 50% of the offsets any firm turns in must come from projects with "direct environmental benefits" for the State of California, a nebulous term that has recently been accepted by CARB to mean that they were generated by offset projects located within California.[98] AB 398 also mandates that CARB develop new protocols for carbon offsetting in addition to those already adopted.

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[96] CARB, "Climate Change Scoping Plan a Framework for Change."
[97] CARB, "Compliance Offset Program"
[98] Garcia, Assembly Bill 398.

The quantity of emissions that may be offset in the CCM and the push to develop new protocols are both motivators to closely review California's current protocols to maintain the integrity of California's cap on emissions. Ensuring that lessons from the CCM's offset protocols are illuminated and that offset policy continually improves is also essential to the integrity of future international emissions mitigation.

Additionality in California

Methods for ensuring additionality in California have generated controversy since their inception. CARB defines additional practices as those that are "beyond any reduction required through regulation or action that would have otherwise occurred in a conservative business-as-usual scenario."[99] Californian regulation defines the business-as-usual scenario as the "set of conditions reasonably expected to occur within the offset project boundary in the absence of the financial incentives provided by offset credits, taking into account all current laws and regulations, as well as current economic and technological trends."[100]

This definition includes three types of additionality tests that appear in California's offset protocols.

1. A project is considered additional if it is only financially viable due to offset revenue

[99] CARB, "California Air Resources Board's Process for the Review and Approval of Compliance Offset Protocols in Support of the Cap-and-Trade Regulation."
[100] Title 17, California Code of Regulations, section 95802(a).

2. A project is considered additional if it goes above and beyond all current laws and regulation
3. A project is considered additional if it goes above and beyond economic and technological trends

A third-party verifier can observe the first two criteria since they are based in observable fact. As long as both are included in specific offset protocols, they can help ensure that a project is additional. The third test, however, includes a subjective assessment of whether current economic and technological trends render a practice commonplace and therefore non-additional, or better enough than average to qualify as additional. To prevent inconsistencies between projects, that judgement is built into protocols in the form of performance standards intended to "establish a threshold that is significantly better than average […] for a specified activity, which, if met or exceeded by a project developer, satisfies the criterion of 'additionality.'"[101]

On March 28, 2012, the Citizens Climate Lobby and Our Children's Earth Foundation filed a lawsuit against CARB over the subjectivity of its performance standards, provoking a case that has illuminated how difficult it is for Californian offset protocols to definitively prove additionality.

[101] CARB, "Proposed Regulation to Implement the California Cap-and-Trade Program PART IV STAFF REPORT AND COMPLIANCE OFFSET PROTOCOL LIVESTOCK MANURE (DIGESTER) PROJECTS."

Our Children's Earth Foundation v. California Air Resources Board

Our Children's Earth Foundation based the suit on a claim that the performance-standard-based approach to additionality used in all four then-approved protocols (Livestock Projects, Ozone Depleting Substances, Urban Forest Projects, and US. Forest Projects) was "flawed because offset activities which are merely 'significantly better than average' or beyond 'common practice' include, by definition, activities which already exist, are ongoing, and, therefore, do not produce greenhouse gas reductions or removals which [in accordance with California law,] are in addition to any greenhouse gas emission reduction that otherwise would occur."[102] The plaintiffs further argued that CARB's performance standards were so vulnerable to subjectivity that all four offset protocols were "arbitrary and capricious."[103]

CARB maintained that "[e]ach protocol provides clear criteria to support the generation of offsets that meet the AB 32 offset criteria," and that "There is no subjectivity left to verifiers to assess whether or not the project meets the AB 32 criteria."

The judge ruled in CARB's favor, upholding its carbon offset program on January 25, 2013, but Our Children's Earth Foundation appealed, continuing to "demand a perfect additionality determination that precisely delineates between additional and non-additional reductions […] for 'each, every, and all'" offset. Two years later in 2015, the

[102] Hays and Costa, "First Amended Petition for Writ of Mandate and Complaint for Declaratory and Injunctive Relief; Verifications"
[103] Our Children's Earth Foundation v. California Air Resources Board, February 23 2015, case A138830

Court of Appeals also ruled in CARB's favor. Three aspects of the second ruling continue to frame CARB's approach to additionality:

(1) The court affirmed for posterity (regarding additionality), "the fact that it is virtually impossible to know what otherwise would have occurred in most cases. Whether a project would have been implemented without the offset incentive 'is hypothetical and counter-factual—it can never be proven with absolute certainty.'"[104]

(2) "Legislature delegated rule-making authority to the [Air Resources] Board to establish a **workable method** of ensuring additionality with respect to offset credits" (emphasis added).[105]

(3) The court affirmed that it "will not, 'in the guise of a challenge' to an agency's statutory authority, […] substitute [its] judgment for that of the agency with respect to such things as the existence and weight to be accorded the facts and policy considerations that support the regulation."[106]

Impact on Additionality

By formally acknowledging the impossibility of proving additionality while giving CARB the discretion to define a "workable method" for assessing additionality, this court decision perpetuated the possibility for non-additional offsets to enter the

[104] Ibid.
[105] Ibid.
[106] Ibid.

CCM. CARB cannot guarantee additionality, yet the court will not challenge CARB's judgement of how stringent additionality tests must be. This means that if current protocols allow non-additional offsets to enter the CCM, CARB could assert that protocols nevertheless meet its definition of a "workable method" and are effective enough. At the same time, this court case renewed CARB's independent authority to continually fine-tune offset protocols, innovating to bring the probability of producing additional offsets ever-higher. Today's offset protocols represent the latest iteration of CARB's attempt to maximize the number of additional offsets in the CCM. As this chapter will argue, however, California's protocols can still improve.

California Compliance Offset Protocol Analysis

The remainder of this chapter will analyze the four California compliance offset protocols that have produced offsets to date: the US Forest Protocol, Livestock Protocol, Ozone Depleting Substances Protocol, and Mine Methane Capture Protocol.[107] It will focus specifically on permanence in the US Forest Protocol, California's only productive sequestration-based protocol, quantification in the ODS Protocol, and additionality in the Livestock and MMC Protocols. This chapter's purpose is to describe the risk of each protocol producing illegitimate offsets and to suggest policy changes that can mitigate that risk.

[107] CARB, "Compliance Offset Protocol Ozone Depleting Substances Projects."
CARB, "Compliance Offset Protocol Mine Methane Capture Projects."
CARB, "Compliance Offset Protocol U.S. Forest Projects."
CARB, "Compliance Offset Protocol Livestock Projects."

U.S. Forest Protocol

Background

The US Forest Protocol provides requirements and methods for quantifying and reporting the "net climate benefits of activities that sequester carbon on forestland." Those activities can take three forms: (1) reforestation involving restoring tree cover on land that has minimal short-term commercial opportunities, (2) improved forest management involving implementing management techniques that increase carbon stocks relative to a baseline, and (3) avoided conversion, which prevents the conversion of forestland to a non-forest land-use by dedicating the land to continuous forest cover through a Qualified Conservation Easement. Projects may be credited with offsets for 25-year crediting periods that may be renewed indefinitely. All forest projects must continue to monitor, verify, and report offset project data for 100 years following the date that the last offset was issued to the project, after which forest land use may change and release carbon back to the atmosphere without penalty. The US Forest Protocol is by far the most productive offset protocol—it has produced more than 115 million California Compliance Offsets to date.[108]

California's US forest protocol, like many forest-related protocols, contains multiple features designed to ensure permanence: a buffer pool, which guards against unintentional reversals, a requirement to replace offsets if an intentional reversal occurs, and a minimum project length of 100 years beyond the issuance of a project's final offset.

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[108] CARB, "Compliance Offset Program."

Forest Buffer Pool

According to the latest version of the protocol adopted in June 2015, forest project owners must each submit between 9 and 18% of their projects' offsets to CARB's buffer pool, depending on a project-specific "reversal risk rating."[109] Project owners calculate that risk rating by adding together the reversal risk in each of four categories defined by CARB (Figure 2.3, Appendix I). Each category's contribution to reversal risk is chosen from a multiple-choice box (e.g. Financial Risk, seen in Figure 2.4, Appendix I) containing between one and three risk values also calculated and provided by CARB.

Replacement Requirement

The replacement requirement describes the penalty for intentionally ending sequestration activities before the end of a project. If a project owner intentionally releases the carbon from their project, that project owner must send CARB a quantity of compliance instruments (either allowances or offsets) equal to the quantity of released carbon. If the project owner cannot afford to do so or chooses not to, the necessary number of offsets is retired from the forest buffer account and the project owner is considered in violation of the law.

Minimum Project Length

The US Forest Protocol states that, "For purposes of this protocol, 100 years is considered permanent." After a project's final offset is issued, project owners must

[109] Values calculated according to Appendix D of the Compliance Offset Protocol U.S. Forest Projects adopted by CARB June 25, 2015. (See CARB, "Compliance Offset Protocol U.S. Forest Projects.")

continue to keep carbon sequestered and must continue to undergo site visits by third-party verifiers every six years for a minimum of 100 years.

Permanence Analysis

Buffer Pool

The most immediate concern about any buffer pool is whether it is large enough to protect against all potential unintentional reversals. Although assessing the accuracy of the specific values CARB has calculated for different categories of risk rating is outside the scope of this thesis, the potential for low-probability, high-magnitude reversal events (e.g. catastrophic wildfires) poses a risk to any sequestration-based scheme.[110] It is also disconcerting to note that if a forest project is highly vulnerable to every risk type defined by CARB—that is, if its owner is on the brink of bankruptcy and if the project is highly susceptible to illegal logging, wildfire, disease, insect attack, flooding and severe winds all at once—the maximum quantity of offsets it must contribute to the buffer pool is only about 18%. For a hypothetical project that is almost sure to experience a significant reversal, that seems remarkably low; a hypothetically sure-to-reverse project ought to contribute 50% of its offsets to the buffer pool, ensuring that when a reversal occurs, the high-risk project does not reduce the buffer pool's ability to protect against other projects' potential reversals.

[110] Although recent catastrophic fires naturally prompt questions about how that contribution to risk, for example, ought to change address future changes in wildfire scale and frequency.

Defenders of the current Reversal Risk Rating system might rightly argue that it is unlikely for a single project to be vulnerable in every defined risk category. They might also point out that Contributions to Reversal Risk Rating are calculated according to average risk; they don't need to precisely describe the risk of any individual project; a risky project should be compensated for by a low-risk project. Pooled risk is, after all, the foundational concept behind a buffer pool.

This kind of assumption brings buffer pools into dangerous terrain. Calculating risk ratings based upon historical data describing reversals does not account for changing conditions over the course of the next century, which demand constantly reviewed and updated calculations of risk. In addition, only assigning a single Contribution to Reversal Risk Rating for each Project Specific Circumstance (as seen in Figure 2.4) offers no incentive to develop low-risk projects. Since projects that are high-risk in a given risk category and project specific circumstance contribute the same (or nearly the same) buffer contribution as low-risk projects, forest offsets at high-risk of unintentional reversal can enter the CCM as easily as those at low-risk, and it becomes impossible to track how many high-risk versus low-risk projects are generating offsets. This allows the ratio of high-risk offsets to low-risk offsets to change, unseen, over time, threatening the assumption that project risk will balance out. It also perpetuates the asymmetry of information between project developers and project buyers, who have no way of knowing how reversal-prone a specific offset may be.

Replacement Requirement

The risk that the Protocol's replacement requirement poses to the forest buffer pool is likely very small. Few rational forest project owners will voluntarily place themselves in violation of the law or in bankruptcy by intentionally ending a sequestration project. Most will only end a project if they can meet the replacement requirement. The primary challenge to the replacement requirement is whether it can be enforced on long timescales—issues discussed above in Chapter One, under Enforcement.

Minimum Project Length

The 100-year minimum project length mandated by the protocol is its Achilles heel. As discussed in Chapter One, no scientific research supports the declaration that "for the purposes of this protocol, 100 years is considered permanent." This assumption prevents the protocol from generating permanent offsets and renders all 115.6 million offsets generated by the protocol to date illegitimate.[111] Although the protocol allows projects to be renewed indefinitely, limits on a forest's ability to sequester carbon limit the capital available to pay third-party verifiers to continue verifying project activities. This naturally imposed limit prevents projects from extending eternally and from achieving permanence.

Since the current protocol ensures that sequestration will occur for at least a century, California's emissions cap is not in immediate danger. The problem of global average temperature rise, however, is not confined to a single century, and the current Forest Protocol threatens the integrity of California's emissions cap on a longer, climate-relevant timescale. Ignoring the current protocol's inability to guarantee permanence "can

[111] This offset total includes early action offsets and was taken from CARB's offset registry March 8, 2019 (CARB, "Compliance Offset Program.").

cause long-term global warming impacts to be hidden by short-term storage solutions that may not offer real long-term climate change mitigation."[112] Increasing the mandatory project length to span multiple centuries cannot solve the Forest Protocol's permanence problem; as discussed in Chapter One, as the timescale of a project (i.e. its nearness to permanence) increases, the certainty of enforcement decreases.

One Option for Improvement: Ton-Year Accounting

Even though the benefits of temporarily stored tons of CO_2e cannot equal those of permanently stored tons of CO_2e in a 1:1 ratio, multiple peer reviewed authors have asserted that there may be a higher ratio that captures the benefits of temporary sequestration on global average temperature rise. Attempts to define that ratio have led to the "ton-year accounting" method, which calculates the total number of permanent offsets that each impermanent sequestration project ought to be worth based upon how long it lasts.[113] Although ton-year accounting has not been incorporated into any offset protocols to date, it is a potential alternative method for crediting carbon sequestration with offsets.

Under a ton-year accounting approach, each year that a ton of CO_2e is sequestered within a project contributes one "ton-year" to the overall project—a unit of measure that standardizes the valuation of different-lengthed projects over time. As a project progresses, it accumulates more ton-years, gradually increasing its value. The central question of ton-year accounting is how many ton-years are equivalent to one permanently sequestered ton. That number has changed over time. In 2000, a study performed by

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[112] Jørgensen and Hauschild, "Need for Relevant Timescales When Crediting Temporary Carbon Storage."
[113] Moura Costa and Wilson, "An Equivalence Factor between CO2 Avoided Emissions and Sequestration – Description And Applications in Forestry."

EcoSecurities Ltd. found that approximately 55 ton-years yielded the same climate benefits as one ton of permanently sequestered carbon.[114] In a more recent 2013 study, Duke University's environmental economist Murray and atmospheric chemist Kasibhatla argue that it takes 120 ton-years to equal one ton of permanently stored CO_2.[115] This lack of consensus makes it difficult to justify shifting to a ton-year approach and indicates that more research is needed before offset protocols put it into practice.

Ton-year accounting also significantly reduces the financial attraction and feasibility of sequestration projects, reducing the political economy of shifting to a ton-year approach. Under current protocols, forest project owners receive an up-front tranche of offset credits worth between 57-100 tons per acre. This payment may dwarf future earnings—which in the long-term settles between 0-3 tons per acre—but provides a very strong incentive for market entry. In the words of one consultant forester, some forest owners "do the math ... and say, 'You could have 2.5 million credits coming in the market at $11.50 and wow, that's payday.'"[116]

Ton-year accounting, in contrast, provides gradual payments over the lifetime of a project, eliminating up-front rewards for enrollment. In addition, the nature of converting ton-years to permanent tons means that value accumulates exponentially, rewarding later years much more than early years. That means that the net present value for foresters today is comparatively low. Over decades-long, multi-generational projects, most of the benefits of enrollment will not be enjoyed by the individual who enrolls. Further, ton-

[114] Ibid.
[115] Murray and Kasibhatla, "Equating Permanence of Emission Reductions and Carbon Sequestration."
[116] Kelly and Schmitz, "Forest Offsets and the California Compliance Market."

year accounting significantly decreases the total offsetting value of forestland compared to current protocols—by 55 to 120 times, due to the conversion of impermanent to permanent tons. A tract of forest currently worth $15,000 per year, for example, would plummet to $125 per year under a ton-year accounting approach.[117] The more land a forest owner owns, the more he or she stands to lose from a shift to ton-year accounting.

This value reduction would decrease forest owner profits and make it financially impossible for many to participate in offset protocols. The costs associated with monitoring, verifying, and reporting forest project data are enormous—between $250,000 and $500,000 net present value over the life of a 100-year project—requiring significant gross offset value to make projects economical.[118] A shift to ton-year accounting would make only the largest projects possible.

Reducing the productivity and financial attractiveness of the Forest Protocol is no reason to avoid improving it. If it is too expensive or politically difficult to ensure that forest projects generate legitimate offsets, forest projects should be barred from generating offsets to preserve the integrity of caps on emissions. From the perspective of forest landowners involved in the current protocol, however, changing to ton-year accounting looks less sensible. Shifting away from the current approach to permanence, while necessary, may therefore prompt stiff opposition. Nevertheless, the potential for ton-year accounting to more accurately assess the benefits of temporary carbon sequestration seems to address both permanence and enforcement concerns with

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[117] 1000 tons per year multiplied by $15 per ton yields $15,000. 1000 ton-years and converted to permanent tons in a 1:125 ratio yields $125.

[118] Kelly and Schmitz, "Forest Offsets and the California Compliance Market."

California's current U.S. Forest Protocol and may enable sequestration activities to generate legitimate offsets in the future.

Ozone Depleting Substances (ODS) Protocol

Background

Ozone depleting substances (ODS), which include chlorofluorocarbons (CFCs), hydrofluorocarbons (HFCs), and hydrochlorofluorocarbons (HCFCs), are utilized in air conditioning and refrigeration equipment. In the U.S., ODS are tightly controlled by federal regulation. Section 608 of the 1990 Clean Air Act prohibits the knowing release of any ODS during the maintenance, service, repair, and disposal of air-conditioning and refrigeration equipment, and the EPA requires proper refrigerant management practices by appliance disposal facilities, owners and operators of refrigeration and air-conditioning systems, technicians, reclaimers, and others to prevent ODS release.[119] According to EPA mandate, "For equipment that is typically disassembled on-site before disposal (such as retail food refrigeration, central air conditioners, and chillers), the refrigerant must be recovered in accordance with EPA's requirements for servicing. For equipment that typically enters the waste stream with the charge intact (such as household refrigerators and freezers and room air conditioners), the final person in the disposal chain (such as a scrap metal recycler or landfill owner) must ensure that the refrigerant is recovered from the equipment before its disposal."[120] After ODS have been

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[119] Clean Air Act § 601-618; United States Code § 7671-7671q
[120] US EPA, "Technicians and Contractors."

recovered, they are either “reclaimed”—purified and used again in new equipment—or incinerated.

The only legal type of ODS release is leakage from operating refrigeration equipment (as opposed to during maintenance, servicing, repair, or disposal of equipment). The rate and quantity of this leakage is unregulated for all equipment containing less than 50 pounds of refrigerant, which includes essentially all residential air conditioning and refrigerator units in the United States.[121] For equipment that contains over 50 pounds of refrigerant, the EPA mandates that leaks must be repaired once their rate of flow hits specific “trigger rates,” which were updated from their original values for the first time January 1, 2019 (Figure 2.5).[122] Since the updated regulation still allows for a quantity of legal, business-as-usual leakage across all equipment that uses ODS, it creates an opportunity for generating ODS offsets by preventing that leakage from taking place.

Appliance Type	Current Leak Rate	Leak Rate Effective 1/1/2019
Industrial process refrigeration[a]	35%	30%
Commercial refrigeration	35%	20%
Comfort cooling	15%	10%
All other appliances	15%	10%

Figure 2.5

[121] AC units require more refrigerant than refrigerators, and range in the US from 1.5-5 “tons,” a measure of cooling capacity. In general, an industry rule of thumb is 2-4 lbs. of refrigerant per ton of capacity, meaning that even a 5-ton AC unit will likely require around 20 lbs. of refrigerant—far less than the 50 lb. cut off for mandatory leak monitoring and repair (“What Size Central Air Conditioner Do I Need?” ; “How Many Pounds of Freon or Refrigerant, Does an AC or Heat Pump Need?”).

[122] US EPA, “Stationary Refrigeration - Prohibition on Venting Refrigerants.”

California's ODS offset protocol prevents ODS leakage by destroying ODS gasses recovered from retired equipment, preventing it from being recycled into new equipment and leaked over time.[123] Once the ODS have been destroyed, projects are credited with offsets based upon ten future years of assumed BAU leakage. Since ODS are more potent GHGs than CO_2 (Figure 2.6, Appendix I), offsetting potential can be very high. The additionality of ODS offsets therefore depends on whether ODS recovered from old equipment would have been reclaimed and recycled (thereby gradually leaked) or destroyed anyway.

Additionality

The decision to reclaim and recycle or to destroy recovered ODS in the absence of an offset incentive depends on the cost of reclamation, recycling, and destruction and the potential market value of reclaimed and recycled ODS. The market value of reclaimed ODS is driven by the quality of the material, whether a convenient market exists for the material, whether shipping to another location makes economic sense, and how high the demand is for the specific ODS. As regulations such as the Montreal Protocol progressively phase out various ODS, making their manufacture and import into the US illegal, their resale value after reclamation generally increases while the ODS are still required for servicing existing equipment.[124] Among reclaimed ODS that have market value, however, contamination, lack of adequate reclamation training, and lack of access

[123] Here retired means no longer in service, disposed of, mothballed, etc.
[124] Stratus Consulting Inc., "Analysis of Equipment and Practices in the Reclamation Industry."

to reclamation facilities still necessitate that some ODS are destroyed rather than recycled.

Each year, more ODS are reclaimed than destroyed. In 2016 for example, 10,804,918 lbs. of ODS refrigerant were reclaimed in the US, while 3,174,657 lbs. of ODS refrigerant were destroyed, including those ODS destroyed to generate offsets.[125] Since 2010, reclamation trends have remained relatively stable, while destruction of ODS in the US has decreased by 50%—more than 4.5 million pounds.[126] Although reclamation is the leading use of recovered ODS, it is in the hands of third-party verifiers to determine with reasonable assurance that ODS offsets are generated only by destroying ODS that would have been reclaimed and recycled, not those that would have already been destroyed.

Discussion

Updating mandatory leakage repair trigger rates in 2019 to become more stringent was a step in the right direction, but it also perpetuated two fundamental issues with current federal ODS regulation. First, basing the trigger point for mandatory leakage repair upon a leakage rate ignores the difference in residence times between CFCs, HCFCs, and HFCs. For HCFCs and HFCs, which have relatively short atmospheric residence times, a trigger rate makes sense since the damage they do depends on their flow rate into the atmosphere. Damage to the environment from CFCs, however, which

[125] US EPA, "ODS Refrigerant Reclamation Totals by Year."

[126] A small portion of this decrease is due to a decrease in ODS imported specifically for destruction, which decreased 2010 to 2016 by over 90 percent, from approximately 550 metric tons to less than 50 metric tons (ICF International, Inc., "ODS Destruction in the United States and Abroad.").

have long atmospheric residence times (Figure 2.6, Appendix I), is a function of their total stock in the air, not a function of their flow rate.

It follows that repairs for equipment utilizing CFCs ought to be triggered once a certain quantity of emissions has been released, not once a certain rate of leakage has been reached. Under current rules, refrigeration equipment can leak substantial quantities of ODS pollution over time and may never need to be repaired as long as leaks do not exceed trigger rates.

Second, exempting ODS equipment that uses less than 50 lbs. of ODS from mandatory leakage repair allows for many refrigeration systems and air conditioners to leak unchecked, and creates no financial incentive for manufacturers of refrigeration and air conditioning units of in this size category to innovate and design equipment that further minimizes ODS leakage.

If ODS leakage regulation accounted for ODS residence times and were more stringent, ODS offsetting would be unnecessary to reduce ODS emissions. Indeed, past updates to section 608 of the Clean Air Act have demonstrated the effects of updating federally-mandated best practices on ODS emissions. By requiring improved handling of refrigerants in 2016, the EPA calculated an annual emissions reduction of 7.3 million metric tons of CO_2e, equivalent to the annual emissions of 1.5 million cars, and greater than the average annual emissions reductions credited with ODS offsets.[127]

[127] US EPA, "Updates to the Section 608 Refrigerant Management Program."

As the protocol currently stands, it is in the hands of third-party verifiers to assess and guarantee additionality. Even if they do, however, ODS offsets do not necessarily provide net climate benefits. The impact of ODS offset generation on net emissions depends on the difference in global warming potential between the specific gas that is destroyed and the gas that replaces it in new equipment—a calculation that is unaccounted for in the current protocol's quantification methodology. When a unit of ODS is destroyed rather than reclaimed, a new unit of refrigerant gas must be produced to take its place in new equipment. As CFCs have been phased out under the Montreal Protocol, HCFCs have largely taken their place. By 2020, HCFCs, will, like CFCs, also be illegal to produce or import, so HFCs will replace destroyed HCFCs in new equipment. The faster CFCs and HCFCs are destroyed, the faster HFCs will be produced and installed in their place. From the perspective of preserving the ozone layer, this transition is an improvement—HFCs are not ozone depleting substances. From the perspective of GHG emissions, accelerating the transition to HFCs while leakage rates remain constant can increase net emissions, causing the ODS Offset protocol to backfire and undermine California's emissions cap.

Currently, HCFC-22 (GWP100 1,810) is the most widely used ODS refrigerants in the US. As HCFC is replaced by alternatives, the global warming potential of leakage may increase, depending on the specific replacement that is used (Figure 2.7, Appendix I). According to the EPA, "If HFC growth continues on the current trajectory," particularly due to increased demand for refrigeration and air conditioning in developing countries, "the increase in HFC emissions is projected to offset much of the climate benefit achieved by phasing out ODS."[128]

Under October 2016's Kigali Amendment to the Montreal protocol, developed nations will begin to reduce HFC consumption in 2019 and freeze consumption by 2024, hopefully driving innovation to develop new, lower GWP refrigerants. Numerous private sector companies have also made pledges to phase out HFC use.[129] Until HFCs are completely replaced by a climate-friendly alternative in the US, however, producing ODS offsets under California's ODS protocol can continue to enhance greenhouse gas emissions from leaking refrigeration and AC equipment. These differences in emissions are not captured by the current ODS protocol because it does not account for the leakage of the refrigerants that replace destroyed ODS in new equipment.[130] Given the different global warming potentials of the many CFCs, HCFCs, and HFCs, it is therefore impossible to know how accurately offsets have been awarded to ODS offset projects, calling into question the validity of the 18.9 million offsets generated by the ODS protocol.[131] Future iterations of the ODS protocol must account for the emissions from the leaking refrigerants that will replace destroyed ODS to ensure conservative and accurate offset crediting.

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[128] US EPA, "Recent International Developments under the Montreal Protocol."
[129] "Timeline of Actions on HFCs."
[130] CARB, "Compliance Offset Protocol Ozone Depleting Substances Projects."
[131] This offset total includes early action offsets and was taken from CARB's offset registry March 8, 2019 (CARB, "Compliance Offset Program.").

Livestock Protocol

Background

The livestock protocol, adopted in 2011, defines methods for capturing and destroying methane from manure lagoons. Lagoons one or more meters deep release methane into the atmosphere, a GHG 28 times more potent than CO_2,[132] and are associated with numerous other public health and environmental concerns including foul odors, airborne particulate matter, and bacteria.[133]

Livestock offset projects involve installing anaerobic manure digesters in place of manure lagoons. Digesters come in multiple sizes and designs, but all are essentially tanks that collect manure and create the controlled, anaerobic conditions for bacteria to decompose manure into methane and solids. Methane is then captured and can be flared, burned to generate on-site electricity, or sold to local natural gas distributors. While each molecule of combusted methane releases CO_2 to the atmosphere, preventing livestock offset projects from completely eliminating emissions, livestock offset projecta earn offsets based upon the calculated reduction in net global warming potential created by converting methane to CO_2. Project owners can also earn supplemental revenue from project co-benefits including electricity savings, natural gas sales, and other digester byproducts, which can be used as fertilizer or animal bedding. So far, the Livestock Protocol has produced more than 5.6 million California Compliance Offsets.[134]

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[132] IPCC, 2013
[133] Zhang, “Air Quality and Community Health Impact of Animal Manure Management.”
[134] This offset total includes early action offsets and was taken from CARB’s offset registry March 8, 2019 (CARB, “Compliance Offset Program.”).

Additionality

The Livestock Protocol utilizes two additionality tests: a legal-requirements test and a performance standard. Projects must pass both tests to generate additional offsets. The livestock protocol's legal requirements test mandates that "Emission reductions achieved by a Livestock Project must exceed those required by any law, regulation, or legally binding mandate," and that "If no law, regulation, or legally binding mandate requiring the destruction of methane at which the project is located exists, all emission reductions resulting from the capture and destruction of methane are considered to not be legally required, and therefore eligible for crediting under this protocol." This test is intuitive and sensible—obeying the law should not require additional incentives such as offsets. Since no laws mandate that livestock owners anaerobically digest manure, all projects satisfy this test. The Livestock protocol's performance standard has two parts:

(a) Emission reductions achieved by a livestock project must exceed those likely to occur in a conservative business-as-usual scenario.

(b) The depth of the anaerobic lagoons or ponds prior to the offset project's commencement must be sufficient to prevent algal oxygen production and create an oxygen-free bottom layer which means at least one meter in depth at the shallowest area.

Part (b) is specific, directly measurable, and easily verified via a site visit. Part (a), however, is dangerously subjective.[135] It is this first criterion that remains vulnerable, since the Livestock Protocol does not account for the financial opportunities that manure

[135] This subjectivity is what sparked the 2012 additionality court case against CARB discussed in earlier.

digesters create aside from offset revenue and other non-offset incentives to install digesters. Together, the scale of the non-offset revenue and the current lack of any method for disentangling multiple incentives to install anaerobic digesters can erode livestock project additionality.

The Economics of a Livestock Project

Livestock offset projects have very high up-front costs, but may also have high potential to generate non-offset revenue once they are up and running. This is unlike California's other protocols, which require offset revenue on an ongoing basis to be financially feasible. From one perspective, this is extremely beneficial. If California's offset policy were to disappear, livestock owners would be more likely to continue to utilize installed manure digesters regardless of lost offset revenue, staying on track to a low-carbon future, while many other types of offset projects revert to a cheaper, higher-emissions business-as-usual. California's Livestock Protocol counts on this technological lock-in. Projects only earn offsets for 10 years, incentivizing adoption, then allowing other benefits of digesters to take over.

This approach to additionality prompts an important question not asked by the current protocol: if non-offset revenue is assumed to be sufficient for maintaining a digester's feasibility after 10 years, is offset revenue necessary for the adoption of an anaerobic digester in the first place? This is the precise question asked by additionality tests that focus on financial feasibility. If the answer is "no, offset revenue is not necessary for revenue to exceed costs," then projects fail the financial feasibility test and should not be considered additional. Since the current Livestock Protocol does not include a built-in financial feasibility test of additionality, livestock projects so far have not been examined to see if there were existing financial incentives for digester installation. Given data provided by the United States Environmental Protection Agency (EPA) and CARB, it seems possible that a quantity of emissions reductions achieved by the Livestock Protocol would have occurred without it, necessitating further investigation of how offset revenue compares to non-offset incentives for digester installation.

According to the EPA, installing an anaerobic digester today costs between $400,000 and $5,000,000, with an average cost of $1,200,000—a significant financial barrier to adoption. Once digesters are in place, however, they can provide substantial financial benefits. Besides producing offsets, the methane that digesters generate can be sold as natural gas or burned to generate on-site electrify, digester effluent can be sold or utilized as a variety of products including fertilizer and animal bedding, and project owners may earn tipping fees from accepting non-farm waste streams. While the EPA has not conducted site-specific digester analyses and acknowledges that site conditions including energy contracts and permitting requirements affect the financial feasibility of specific projects, it stated in 2018 that a positive financial return appears most likely on all dairy operations with more than 500 cows and swine operations with more than 2,000 swine.[136]

To understand site-specific dairy manure digestion in California, CARB conducted an in-depth analysis of dairy farm methane capture in 2017.[137] CARB's analysis examined the specific economics of a stylized 2,000-cow dairy farm

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[136] AgSTAR, "Market Opportunities for Biogas Recovery Systems at U.S. Livestock Facilities."
[137] CARB, "Short-Lived Climate Pollutant Reduction Strategy." found through Lee and Sumner, "Dependence on Policy Revenue Poses Risks for Investments in Dairy Digesters."

participating in a cluster of farms operating a local, centralized digester system. Today, CARB estimates that the San Joaquin Valley could contain 55 such clusters, collecting manure from 1.05 million cows responsible for nearly 60% of milk cows in California.

CARB's economic analysis did not include subsidies and financing options that decrease the financial barriers to adoption, and it did not include potential revenue from offset generation, products derived from digester effluent, or tipping fees—all of which make anaerobic digester projects more financially feasible. Even so, CARB's estimate for a digester project's net present value over a 10-year lifespan was $6,203,000—not only positive and large, but $5 million more than the EPA's calculation of the average cost of a digester.[138] To further contextualize this value, $6 million is more than $2 million more than the value of a dairy farmers entire 2,000-cow herd.[139] This result highlights the significant financial incentives for participation in anaerobic digestion regardless of offset policy.

CARB's cost-revenue analysis (Figure 2.8, Appendix I) reveals that national and Californian biofuel credit programs comprise most of the revenue for the modeled dairy digesters. "RIN credits" (or "RINs", in Figure 2.8, Appendix I) are federal credits generated through the Renewable Fuel Standard, a national policy that requires refiners to replace a portion of their petroleum-based fuels with renewable fuels. Methane generated by manure digestion qualifies as a renewable fuel, and therefore for RIN crediting. "LCFS credits" are generated through the California-specific "Low Carbon Fuel

[138] AgSTAR, "Market Opportunities for Biogas Recovery Systems at U.S. Livestock Facilities."
[139] Lee and Sumner, "Dependence on Policy Revenue Poses Risks for Investments in Dairy Digesters."

Standard," a similar program to the RFS that assigns eligible transportation fuels lifecycle carbon intensities and mandates that the fuel mix provided by oil refineries and distributors meet declining targets for carbon intensities. Under current LCFS rules, manure-based biofuels are assigned the lowest carbon intensity of any fuel, −276 gCO_2e per megajoule, which creates large potential for LCFS credit generation and financial incentives for digester installation.[140] While the market price of LCFS credits has fluctuated between $20 and $125 per metric ton of CO_2e since 2013, prices today exceed $100 per metric ton—nearly 10 times the value of a California compliance offset.[141]

As RIN and LCFS credits improve the financial benefits of anaerobic digesters, grants and subsidies provided by state agencies the cost of installation, amplifying incentives to install digesters. In 2017, the Dairy Digester Research and Development Program (DDRDP) of the California Department of Food and Agriculture (CDFA) provided $35 million to 18 digester projects. Also in 2017, $99 million of California's Greenhouse Gas Reduction Fund were made available for constructing digesters on dairy farms, of which more than $60 million will be distributed by the DDRDP to construct anaerobic digesters on Californian dairy farms.[142]

Between revenues from co-benefits, biofuel credits, and installation subsidies, dairy farmers face multiple incentives for installing anaerobic digesters aside from offset revenue. Disentangling the relative effects of these incentives to determine whether offset revenue was indeed the last straw necessary to convince a livestock owner to install a

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[140] CARB, "Short-Lived Climate Pollutant Reduction Strategy."
[141] CARB, "LCFS Credit Trading Activity Reports."
[142] Lee and Sumner, "Dependence on Policy Revenue Poses Risks for Investments in Dairy Digesters."

digester would only be possible with an in-depth review of each project's finances. Since the Livestock Protocol does not include a financial feasibility test of additionality, we cannot know how many projects would have been feasible without offset revenue and are therefore non-additional. This reality calls into question all 5.6 million livestock offsets generated so far and necessitates future investigation into livestock project finances.

Mine Methane Capture (MMC) Protocol

Background

Both coal and trona, a source of sodium bicarbonate, co-occur with strata that leak methane, the primary constituent of natural gas. This creates a suffocation and explosion hazard within mines and a significant source of unregulated greenhouse gas emissions—US mine methane emissions in 2015 totaled approximately 70 million tCO_2e.[143]

Since the 1990s, however, long before California's MMC Protocol was adopted, the U.S. has been the global leader in capturing methane released by coal and trona extraction and using it to generate economic and safety benefits. Mine methane recovery and use (RAU) projects today utilize mine methane for power generation, natural gas pipeline injection, vehicle fuel, industrial process feed stocks, onsite mine boilers, mine heating, and home heating distribution systems. All these uses involve burning or otherwise destroying mine methane, maintaining safe concentrations of the explosive gas within mines while creating financial returns and climate benefits. In 2015 alone, RAU

[143] US EPA, "Coal Mine Methane Country Profiles."

projects reduced methane emissions by nearly 1.1 billion cubic meters.[144] While this is a substantial emissions reduction, 2015 also saw more than 2.5 billion cubic meters of mine methane released to the atmosphere. Financial barriers to mine methane RAU projects are responsible for a large portion of this release; the proximity of a mine to pipeline infrastructure, state-specific alternative or renewable energy incentives, and location-specific disputes over ownership of methane produced from coal seams all affect the financial feasibility of mine methane RAU projects.[145] California's MMC Protocol is intended to incentivize the destruction of mine methane at mines where RAU projects are infeasible without additional financial incentives.

Additionality

The same two additionality tests built into the Livestock Protocol are also built into the MMC Protocol to ensure that mine methane destroyed by offset projects would not have been destroyed anyway by RAU projects: a legal requirement test and a performance standard.

The MMC Protocol's legal requirement test mandates that a project's emissions reductions must exceed those required by any law, regulation, or legally binding mandate to be credited with offsets. Since destroying or utilizing captured mine methane is not legally required in the US, all treatments of captured mine methane are considered additional according to this test.

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[144] US EPA, "Coal Mine Methane Developments in the United States."

[145] Colorado, Indiana, Ohio, Pennsylvania, and Utah currently consider coal mine methane an "alternative" or "Renewable" energy resource (US EPA, "Coal Mine Methane Developments in the United States.")

The performance standard states for both active and abandoned mines that pipeline injection of mine methane is “common practice and considered business-as-usual, and therefore ineligible for crediting under this protocol,” while “destruction of extracted mine methane via any end-use management option except [pipeline injection] automatically satisfies the performance standard evaluation because it is not common practice nor considered business-as usual, and is therefore eligible for crediting under this protocol.”[146]

Discussion

The two additionality tests embedded in the MMC protocol tests are inadequate; projects can produce non-additional offsets while in compliance with both existing tests in two scenarios. First, by singling out pipeline injection as the only non-additional end-use of mine methane, the MMC performance standard contradicts the EPA’s assertion that US mines engage in other types of profitable, business-as-usual mine methane use. Utilizing mine methane onsite for mine heating, for example, may already generate financial returns, but is nevertheless eligible for offset crediting, creating an opportunity for non-additional offsets to infiltrate the CCM.

A second non-additionality scenario can arise if an RAU project and an offset project are both financially feasible, but an offset project is more financially attractive at a mine location. If potential offset revenue exceeds potential RAU revenue, then a mine that would have destroyed methane via pipeline injection, for example, will develop an

[146] CARB, “Compliance Offset Protocol Mine Methane Capture Projects.”

offset project instead and generate offsets. These offsets are non-additional, but will still satisfy current MMC additionality tests, allowing them to enter the CCM and undermine California's emissions cap. Comparing the offset revenue from destroying 1000 ft^3 of methane to the average wellhead price of 1000 ft^3 of methane shows that this scenario has been possible in the past and may be possible today.

Potential Revenue from Selling Natural Gas per 1000 ft^3

The average net revenue of destroying 1000 ft^3 of methane to generate offsets is $4.18 (see Appendix II for calculations). In order to compare net revenue of offset and RAU projects, it would be necessary to know the average profit margin of producing 1000 ft^3 of natural gas for pipeline injection. This could be found by subtracting the average breakeven price of natural gas production from the average wellhead price of natural gas. Since both are variable across time and space, and to emphasize the scale of the additionality risk illustrated here, the wellhead price is assumed equal to net revenue. In other words, for the purposes of these calculations the breakeven price for pipeline injection is assumed to be $0. Although this assumption reflects reality at select locations where methane is produced as a byproduct of oil production, it does not reflect the reality of producing methane from coal and trona mines. Rather, assuming that the breakeven price is $0 significantly undervalues the costs of methane production from mines.

Since the US Energy Information Administration has only released average wellhead price data through 2012, the Henry Hub Price is used here as a proxy for the wellhead price.[147] Since the Henry Hub Price is generally higher than the average

[147] US EIA, "U.S. Natural Gas Wellhead Price (Dollars per Thousand Cubic Feet)."

national wellhead price, using it as a proxy further overvalues the potential revenue of selling methane as natural gas.

If the average revenue from offset generation exceeds this highly inflated estimate of revenue from pipeline injection, therefore, the average revenue from offset generation will exceed the actual revenue from pipeline injection by an even larger margin.

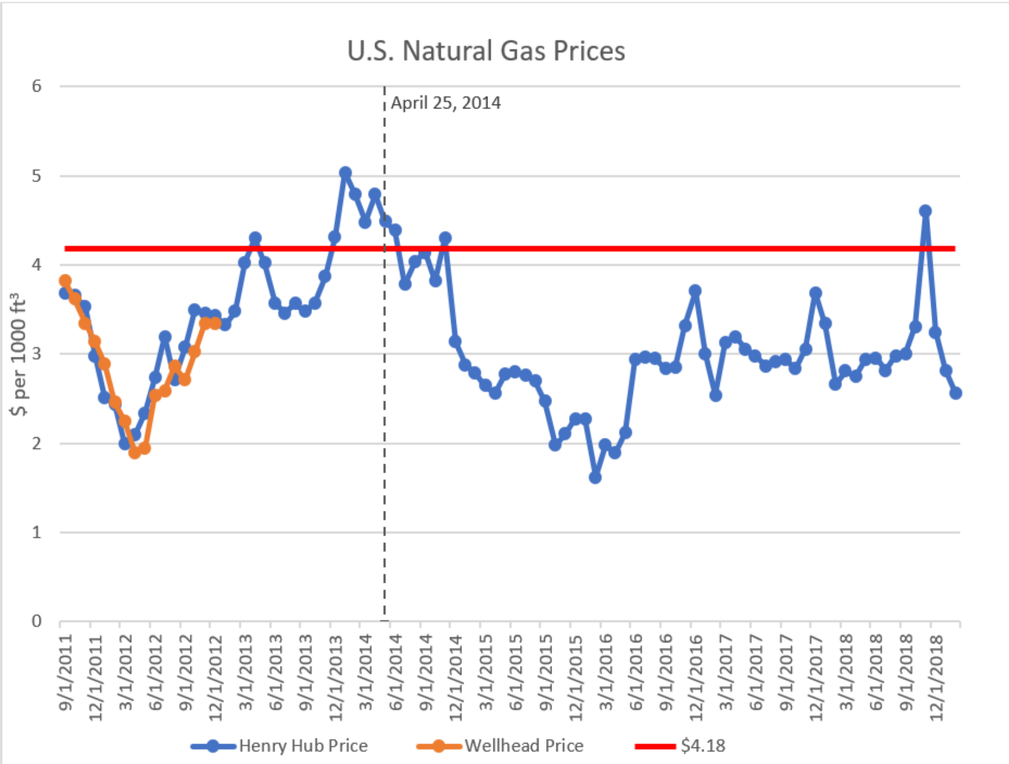

Figure 2.9

As seen in Figure 2.9, since April 25, 2014, the day the MMC Protocol was adopted, the average revenue from destroying 1000 ft^3 to generate offsets has exceeded the Henry Hub Price of methane nearly every month.[148] This means that offset generation

148 "Natural Gas Prices - Historical Chart."

could have been more financially attractive than RAU project development when an RAU project would also have been feasible.

Many site-specific factors contribute to whether an offset project is more financially attractive than an RAU project at a specific mine. These include, for example, capital costs, the quantity and market value of other gasses captured in addition to methane, transaction costs involved in verifying and selling offsets, the market price of offsets and of methane. The variance of these factors means that not every mine location producing offsets has produced non-additional offsets. It does, however, necessitate an in-depth, project specific review of past and prospective offset project finances to determine the magnitude of this additionality concern. There is currently no test built into the MMC that requires such a review, so more research is needed assess how many MMC offsets generated are non-additional. Given the risk of non-additional offsets infiltrating the CCM, all 5.8 million MMC offsets generated to date must be called into question.[149] Future iterations of the MMC protocol must include an additionality test that compares the financial feasibility of offset projects to RAU projects to remedy this current lack of transparency. Figure 2.10 summarizes the components of such a test performed on a prospective MMC offset project.[150]

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[149] This offset total includes early action offsets and was taken from CARB's offset registry March 8, 2019 (CARB, "Compliance Offset Program.").

[150] This test assumes that other additionality tests in the protocol have determined that the project is additional.

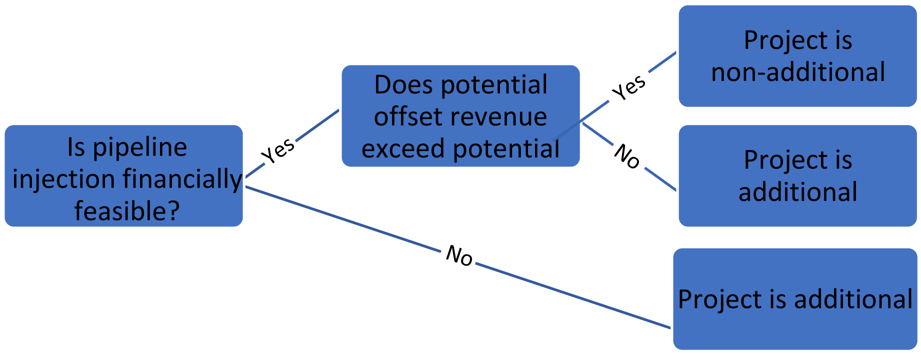

Figure 2.10

Chapter Conclusions and Summary

This chapter argues that all four offset protocols currently producing offsets for sale in the CCM have the potential to produce illegitimate offsets, compromising the integrity of California's emissions cap. In the case of the Forest Protocol, the assumption that 100-year sequestration provides equivalent climate benefits to permanent sequestration prevents any of the 115.6 million offsets generated from delivering their intended benefits. The other three protocols each also include a risk of generating non-additional or otherwise illegitimate offsets, but the scope of that risk remain unknown. Assessing the financial feasibility and opportunity of livestock and mine methane projects and integrating the effects of the leakage of replacement refrigerants into ODS offset accounting are necessary to determine the scope of that risk to California's emissions cap. This chapter's conclusions and recommendations are summarized in Figure 2.11.

Protocol	Criterion Analyzed	Conclusion	Result	Recommendation
Forest	Permanence	Since 100-year sequestration is inequivalent to permanent sequestration, the Forest Protocol cannot produce permanent offsets	All 115.6 million offsets issued are impermanent and therefore illegitimate	Invalidate all forest offsets or change from a 100-year permanence assumption, reassigning the value of issued offsets via a ton-year accounting or a carbon rental system
ODS	Quantification	The net climate benefits of the protocol depend on which gas replaces those that are destroyed, a factor that is not accounted for in the protocol's quantification methodology	All 18.9 million are called into question	1. Include the effects of future leakage of replacement gas in quantification of emissions reductions 2. Tighten mandatory leakage repair requirements, and change mandatory repair trigger rates to trigger quantities depending on which type of ODS is installed
Livestock	Additionality	Cannot disentangle the offset incentive from non-offset incentives to install anaerobic digesters	All 5.6 million offsets are called into question	Include a financial feasibility additionality test to determine whether a digester would have been installed in the absence of offset revenue
MMC	Additionality	Cannot tell if mines would have already developed a recovery and use project, destroying mine methane in the absence of an offset protocol	All 5.8 million offsets are called into question	Include a financial feasibility additionality test to determine whether a recovery and use project is also feasible at a project site and whether expected offset revenue exceeds expected recovery-and-use revenue for each project

Figure 2.11

Chapter 3: Market Trends and Case Studies in the California Compliance Market 2013-2016

Against a backdrop of questions about California Compliance Offset validity, this chapter will further investigate the scope of the threat that California's compliance offset protocols pose to the integrity of California's CAT system. This chapter will show that the most problematic type of offsets, those generated by the Forest Protocol, are also the most utilized, compromising the integrity of California's cap on GHG emissions. It will also investigate the offset submission behavior of different types of firms through four case studies (Figure 3.1). All market data in this chapter comes from CARB's publicly available Compliance Reports.[151]

Firm	Category the Firm Represents
Regents of the University of California	Firms with a deep, value-driven commitment to sustainability
City of Colton	Low emitters that submit few offsets
LA Department of Water and Power	High emitters that submit few offsets
CP Energy	Low Emitters that submit many offsets

Figure 3.1

[151] CARB, "2013-2014 Compliance Report"
CARB, "2015-2017 Compliance Report"

Market Trends in the CCM

Most firms regulated under AB 32 do not participate in compliance offsetting. In Compliance Period One (CP1), which went from 2013-2014, and Compliance Period Two (CP2), which went from 2015-2017, only 39% and 32% of firms, respectively, turned in offsets. Among those firms, more than half submitted less than 7.5%, opting not to maximize offset use.

There is no clear relationship between the quantity of a firm's emissions and the quantity of offsets that the firm submits. Figures 3.2 and 3.3 (Appendix I) show that many large emitters with significant potential for offset-derived cost savings turned in no offsets at all or opted to submit less than 8%. In CP1, twelve firms emitting more than 2.5 million tCO_2e submitted no offsets at all, seeming to pass up $200,000 or more in gross cost savings.[152] Conversely, some very small emitters maximized offset submissions, seizing sometimes negligible cost savings.

The difference in potential cost savings between the smallest emitters and the largest emitters in the CCM is enormous. Firms' emissions obligations spans nine orders of magnitude (note the logarithmic scale of the x-axis in Figures 3.2 and 3.3, Appendix I), ranging from 3 tons CO_2e (Noble Americas Energy Solutions, LLC in CP1) to nearly 162 million tons CO_2e (Tesoro Refining & Marketing Company LLC's emissions in CP2).

[152] 8% of 2.5 million is 200,000, and offset prices lag behind allowance price by approximately 20%, delivering approximate gross cost savings of $1 each (The Climate Trust, "The Gap between the Price for Allowances and Offsets Appears to Be Closing. Is This a Long Term Trend or a Short Term Phase?")

An increase in total CCM market size expanded the total potential number of offsets utilized from CP1 to CP2. New firms entering the market and the 2015 inclusion of emissions from fossil fuel distribution under the cap more than tripled total covered emissions from one compliance period to the next—291,211,108 tCO_2e in CP1 versus 986,400,626 tCO_2e in CP2. For many of the largest emitters, three of which are shown in Figure 3.4 below, this expansion dramatically increased covered emissions in the second compliance period.

Firm	Average Annual Emissions Obligations CP1 (tCO_2e)	Average Annual Emissions Obligations CP2 (tCO_2e)
Tesoro Refining & Marketing Company LLC	8,709,951.5	53,988,150.3
Chevron U.S.A. Inc.	10,385,769.5	43,217,457.3
Phillips 66 Company	4,674,418.5	23,326,708

Figure 3.4

As a result of this expansion in CP2, offset submissions nearly quintupled, rising from 12,773,097 in CP1 to 62,717,868 in CP2.[153] Despite the expansion of the CCM in 2015 and subsequent increase in total offset submissions, the proportion of firms that utilized offsets, and the proportion of offset users that submitted the maximum number of offsets possible, changed very little. As seen in Figure 3.5 (Appendix I), most firms in

[153] It is essential to note that the total number of offsets submitted is far smaller than the number produced. This does not mean that market is flooded with unsold offsets. Rather, CARB's quarterly Compliance Instrument Report indicates that unsubmitted offsets reside in CARB's forest buffer pool and compliance entities' general accounts, waiting and ready for submission (CARB, "Compliance Instrument Report.").

both compliance periods submitted no offsets at all, and among those who did submit offsets, less than half submitted the maximum number of offsets.

Types of Offsets Submitted

The types of offsets that compliance entities have submitted vary by offset protocol, compliance period, and by the type of firm. Figure 3.6 (Appendix I) shows that offset submissions increased in every category of offset from CP1 to CP2, but that CP2 forest offsets dominated offset submissions, composing 61% of all offsets submitted in both compliance periods.

The mix of offsets submitted reflects the stream of offsets supplied to the Californian offset market. In Figure 3.7 (Appendix I), which compares total offset submissions to total offset production, the mix of offsets submitted closely resembles the mix of offsets produced, with forest offsets constituting most of supply and submissions. Offset submissions and supply are not identical, but a chi-squared test for independence shows that the differences are statistically insignificant, with three degrees of freedom and a p-value of 0.05.

Within subsets of the population of firms covered by AB 32, however, the types of offsets submitted do not always closely match supply (Figure 3.8, Appendix I). For this analysis, four groups of 10 firms were selected from all firms covered within both compliance periods. Each group contains the 10 firms that were furthest from the origin in each quadrant in Figures 3.2 and 3.3, yielding four groups of the most "extreme" firms: 10 highest emitters and highest offsetters (HEHO), 10 lowest emitters and highest offsetters (LEHO), 10 lowest emitters and lowest offsetters (LELO), and 10 highest emitters and lowest offsetters (HELO).

The offset submissions of the 10 LEHO and 10 HELO firms were found to be statistically significantly different from the mix of offsets supplied (x^2=1.75 and 0.58 respectively), while the difference between the submissions of the 10 HEHO firms and total supply were insignificant (x^2=0.017). It is essential to note that these 10 HEHO firms represent a much larger quantity of offsets submitted to the market—8,178,567—while the 20 LEHO and HELO firms sampled here only represent only 145,848 offsets submitted. These sampled firms indicate an overarching reality of the CCM: while emitters of all sizes do turn in offsets, the largest quantity of offsets submissions come from the largest emitters in the market. In addition, the offsets submitted by the largest emitters closely resembles the mix of offsets supplied to the market.

Case Studies

Figures 3.2 and 3.3 (Appendix I) indicate that many firms in the CCM do not exhibit offsetting behavior that appears, at first glance, rational. Many submit fewer offsets than the 8% maximum limit, foregoing substantial cost savings, while others maximize offset submissions even when their cost savings are minute. The remainder of this chapter will elaborate upon some of these behaviors and explain their rationale through case studies of four firms in the CCM. These case studies will show that despite apparent departures from behavioral expectations, a desire to minimize compliance costs is still the primary motivator of offsetting behavior. Nevertheless, other factors including imperfect information, social pressure, and relationships with larger companies also contribute, complicating firms' offsetting behavior.

Firm	Type of Behavior
City of Colton	Low emitters that consistently submit small numbers of offsets
CP Energy	Low Emitters that submit many offsets
Regents of the University of California	Firms buying voluntary market offsets in addition to compliance offsets
LA Department of Water and Power	High emitters that submit few offsets

Figure 3.9

Case Study: City of Colton

The City of Colton is located 57 miles east of Los Angeles and contains 53,000 citizens, about 2.5% of the population of San Bernardino County. Colton's emissions reductions fall into two categories: voluntary reductions made by Colton's local government and utilities, and compliance reductions made by the city's only stationary source covered by AB 32: The City of Colton Electric Utility (CEU). Amid significant efforts to cut its emissions, the CEU has consistently submitted offsets during both compliance periods, but in extremely small numbers, only saving approximately $200.[154]

The CEU's offsetting behavior demonstrates that pure cost savings are not the only reason why firms submit or refuse to submit offsets. Misinformation and

[154] The CEU, as will be discussed, has submitted 173 offsets according to CARB's online registry. Offset prices have lagged behind allowance prices approximately 20%, so estimated gross cost savings are about $207 (The Climate Trust, "The Gap between the Price for Allowances and Offsets Appears to Be Closing. Is This a Long Term Trend or a Short Term Phase?"). When transaction costs are taken into account, net savings are likely even smaller.

interactions with local community sustainability goals can affect how firms utilize offsets and which offsets they submit. Colton's example highlights the interplay between compliance entities' emissions goals and the goals of the communities they are nested in while also suggesting why local utilities may submit ODS offsets.

Voluntary GHG Mitigation in Colton

While AB 32 targeted a large portion of California's emissions with mandatory GHG reduction measures (e.g. cap-and-trade), it also tasked CARB with developing a Scoping Plan that defines methods for reducing non-compliance emissions. In response, CARB articulated a unique role for regional and local governments, which can influence community emissions through "planning and permitting processes, local ordinances, outreach and education efforts, and municipal operations." While the Scoping Plan does not mandate specific community emissions goals, its call for "local governments to adopt a reduction goal for municipal operations emissions and move toward establishing similar goals for community emissions that parallel the State commitment to reduce greenhouse gas emissions by approximately 15 percent from current [2008] levels by 2020."[155] By 2015, more than 50 southern California jurisdictions including the City of Colton had responded by completing a GHG Inventory and Reduction Plan, also known as a Climate Action Plan (CAP).[156]

As Colton's CAP points out, state and county-level emissions reduction measures including changes to the Renewable Portfolio Standard, Low Carbon Fuel Standard, and

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[155] CARB, "Local Government Actions for Climate Change."
[156] "City of Colton Climate Action Plan."

lighting best-practices are more than sufficient for reducing Colton's GHG emissions 15% below a 2008 baseline. Even so, Colton's CAP describes additional ambition to reduce local emissions through a combination of local utility measures and city government programs, summarized below. Many of the utilities' programs were preexisting and were rolled into Colton's wider strategy when the CAP was adopted. The City of Colton Water Department, Southern California Gas Company, City of Colton Electric Utility, and Southern California Edison each offers a litany of rebates and incentive programs designed to increase efficiency and promote renewable energy use.

1. City of Colton Electricity Department (CEU)

The CEU offers 18 rebate and incentive programs, including A/C tune-up and replacement rebates, residential energy efficiency rebates, weatherization rebates, small business and commercial energy efficiency rebates, refrigeration replacement rebates, and a "treebate" for planting building-shading trees. It also provided energy efficiency audits and energy efficiency kits for a LivingWise® School Program, which empowers 6th graders to apply what they learn about energy efficiency in the classroom at home.

2. City of Colton Water and Wastewater Department (CWD)

The CWD offers rebates for installing EnergyStar-approved clothes washers, dishwashers, and for installing efficient commercial appliances.

3. Southern California Edison (SCE)

SCE provides 16 GHG-reducing rebates, incentives, and subsidy programs that promote energy efficiency, electric vehicle deployment, and solar power installation. These include a program that pays all purchase and installation costs for energy efficient appliances (for eligible customers), a refrigerator recycling program, rebates for efficient light bulbs and A/C units, and multiple programs that provide financial support or cash incentives for installing solar panels.

4. Southern California Gas Company (SCGC)

SCGC offers 29 separate company programs that promote residential and commercial gas use efficiency, which include installation rebates and financing, zero-charge efficiency tracking, project design assistance, a school program, and interactive online self-assessments.

In addition to utility-provided programs, the City of Colton has also instituted measures that promote emissions reductions, including:

- Electric vehicle and alternative fuel purchasing for the city car fleet
- City facility electric vehicle infrastructure investments
- A city facility energy efficiency retrofit initiative
- Modified work week schedule for city staff
- An administrative procurement policy to purchase recycled products
- CALGreen Building Code
- Water Efficient Landscape Ordinance

Colton's CAP estimates that, stationary sources of emissions aside, the combination of state, regional, and voluntary local measures can reduce emissions Colton's emissions from 682,418 tCO_2e (2008) to 478,344 tCO_2e by 2020, a 34.7% reduction.[157]

[157] "City of Colton Climate Action Plan."

Compliance GHG Mitigation in Colton: The Colton Electric Utility

As the City of Colton strives for voluntary emissions reductions, Colton's only compliance entity faces intense regulatory, financial, and legislative pressure to reduce GHG emissions while minimizing costs for consumers. Historically, the City of Colton Electric Utility (CEU), which owns and operates a power plant, five substations, and Colton's electrical infrastructure, "has sought to acquire new resources at the lowest possible cost (consistent with safety and reliability requirements) without considering environmental constraints." Environmental litigation and Federal and state GHG-focused legislation since 2011, however, "are reshaping" the CEU's power mix and have complicated the CEU's cost considerations.[158]

Environmental Litigation

In 2013, the San Juan Generating Station (SJGS), which supplied roughly two-thirds of the CEU's total retail power load, was involved in environmental litigation proposing nearly $1 billion in new pollution control equipment. After extensive discussion and negotiations with the US Environmental Protection Agency and between utilities in California, New Mexico, Arizona, and Colorado, two of the four generating units at the SJGS were slated for decommission by December 31, 2017. As a result, the CEU began replacing over 225,000 MWh of energy and 30 MW of capacity formerly supplied by the SJGS. At the time, it also seemed possible that the plant would be shut down earlier than anticipated, requiring the CEU to replace capacity and energy earlier at

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[158] "City of Colton Electric Department 2017 Integrated Resource Plan."

additional cost. Uncertainty surrounding the SJGS plant also coincided with a host of regulatory changes with the potential to increase operating costs.

Legislative and Regulatory Pressure

According to the CEU, four environmental regulations that have the "greatest initial impact on costs" include regionalization by the California Independent System Operator (CAISO), California's AB 32, SB 350, and California's proposed movement to a centralized capacity market. Cost concerns driven by these regulations ought to increase the CEU's demand for cost-cutting policies like offsets.

CAISO regionalization would mean establishing a "west-wide grid" containing multiple western states and led by the CAISO. Although the intention behind regionalization proposals is to make it easier for Californian utilities to import renewable energy from other states, particularly wind from Montana and Wyoming, the CEU and other Californian participants are concerned about the allocation of transmission costs to western utilities, forcing utilities outside of California to comply with CAISO regulation, and about who would bear the cost of carbon emissions from out-of-state renewable resources.[159] According to the CEU, municipalities within California generally oppose CAISO expansion, while renewable energy producers outside California and California's Governor Brown continue to push for CAISO expansion.[160] As of September 1, 2018, the latest legislative attempt to expand the CAISO failed to pass in California for the third time in three years.[161] Nevertheless, the looming potential for expansion since 2012 has

[159] Roberts, "California's Huge Energy Decision."
[160] "City of Colton Electric Department 2017 Integrated Resource Plan."
[161] Sangree, "CAISO Western RTO Expansion Bill Dies in Committee."

affected the CEU's expectations of future costs and created uncertainty over the availability of additional renewable energy.

AB 32 (2006) and more recently SB 350 (2015) "potentially have the greatest impact" on the CEU. AB 32, as previously discussed, regulates emissions from electricity generation and established California's CAT system. In 2009, three years before the CAT system took effect, CARB allocated free emissions allowances to the CEU equal to its then-estimated emissions through 2020.[162] Although the exact quantity of free allowances is not publicly available, the CEU's reported emissions in CP1 and CP2 were 396,490 tCO_2e and 599,211 tCO_2e, respectively, giving a general idea of the magnitude of the CEU's free allowance allocation.[163] While the SJGS plant continued to operate, however, the freely allocated allowances proved insufficient, and freely allocated allowances may not be used to compensate for emissions from electricity purchased from CAISO. These deficiencies mean that the CEU has had to participate in quarterly allowance auctions, imposing compliance costs.[164] It has also created an opportunity for compliance offset utilization.

SB 350, also known as the Clean Energy and Pollution Reduction Act of 2015, increased existing mandatory Renewable Portfolio Standard for electric Load Serving Entities (LSEs) from 25% by 2016 and 33% by 2020, to 50% by 2030 and mandated that LSEs increase their renewable portfolio by 2% per year starting in 2021. From 2011 to

[162] "City of Colton Electric Department 2017 Integrated Resource Plan."
[163] CARB, "2013-2014 Compliance Report"
CARB "2015-2017 Compliance Report"
[164] "City of Colton Electric Department 2017 Integrated Resource Plan."

2013, the cost for the CEU of meeting its RPS was so high that it was unable to comply, and instead claimed a cost-limitation delay allowable under SB 32.

As California has increased its Renewable Portfolio Standard and higher levels of wind and solar enter the grid, many electricity generators have claimed that they are being run out of business, creating support for a centralized capacity market. This type of market secures power delivery contracts years in the future, which advocates argue creates grid reliability and financial certainty. Detractors argue that capacity markets slow technological advancement and can result in excess generation capacity.[165] Uncertainty over the future of a Californian capacity market has created uncertainty about long-term energy procurement and costs for the CEU.[166]

CEU Response to Cost Concerns

Given the 20 to 50-year lifespan of transmission resources and the potential for long term contracts arising within a capacity market, the CEU faces conflicting desires to reduce costs today in response to current legislation and to avoid changes that may lock it into suboptimal, higher-cost circumstances in the future. So far, this tension has prompted a conservative attitude toward supply-side action. Although some changes, like procuring adequate renewable energy under RPS requirements, are necessary by law, the CEU "believes that it is better for the community and the CEU to reduce customer demand through conservation programs and rebates, rather than purchasing additional generation resources from power marketers."[167] Consequently, all the CEU's formerly voluntary

[165] McCabe and Moore, "PJM's Capacity Market Proposal."
[166] "City of Colton Electric Department 2017 Integrated Resource Plan."
[167] Ibid.

rebate and efficiency programs have become part of its compliance strategy to increase efficiency and reduce energy use and compliance costs.

Offsetting, however, has not been a significant part of the CEU's cost-saving strategy. If the CEU had submitted 8% of its compliance obligations as offsets, it could have legally submitted 79,655 offsets across both compliance periods 2013-2017, realizing gross cost savings of nearly $80,000. This value does not account for the transaction costs associated with offset procurement, but it still represents a sum of money that could have alleviated a portion of the CEU's cost concerns. Even if the CEU's freely allocated allowances covered all the CEU's emissions, maximizing offset submission early while offsets are cheaper can allow firms to save more valuable excess allowances for later use, saving additional costs in the long term. Nevertheless, while the CEU has consistently submitted offsets, it has submitted extremely few each compliance period—88 ODS offsets in CP1, representing .022% of Colton's emissions, and 85 ODS offsets in CP2, representing .014% of Colton's emissions. The CEU's apparently foregone cost savings and simultaneous commitment to such a small number of ODS offsets suggests that values other than cost savings are driving the CEU's offsetting behavior and that ODS offsetting may reflect preferences of the CEU. To gain some insight into the CEU's offset-related values, I interviewed Dr. David Kolk, the Director of Utilities of Colton, and Jessica Sutorus, Colton's Environmental Conservation Supervisor, over the phone October 29, 2018.

Interview with Dr. Kolk and Ms. Sutorus

Speaking with Dr. Kolk and Ms. Sutorus revealed that transaction costs and concerns over offset risk have prevented the CEU from buying offsets, but that offsets awarded for pre-existing program have nevertheless contributed to the CEU's compliance obligations.

Moments into our conference call, Dr. Kolk expressed his confusion at my interest in Colton's offsetting behavior, since, he said, "I didn't claim any offsets as part of our compliance." If Ms. Sutorus received any, he went on, they would have taken them and hopefully sold them. Any offsetting in Colton, Kolk assured, "is news to me."

When I explained that CARB's publicly available compliance records indicate that Colton has engaged in offsetting, Ms. Sutorus suggested, "don't we get those from the refrigerator program?" and an explanation for Colton's offsetting behavior began to take shape. Sutorus continued that she didn't think that the program was generating offsets, but that the CEU recycles 50 to 80 refrigerators per year through its refrigerator replacement program—a potential source of ODS. Kolk and Sutorus surmised that when the CEU became a compliance entity, its preexisting refrigerator recycling program must have become part of an offset generating project that had credited the CEU with ODS offsets. It was a discovery for all of us. "Neither of us knew about it," Dr. Kolk said, "we didn't do anything with them."

Neither Kolk nor Sutorus expressed concerns over being given offsets, but Kolk made clear that purchasing offsets is not an important part of Colton's strategy. "It's not worth our time to buy an offset versus a renewable energy source," he said, adding that offsets often include too much risk. In the "early years" of offsets, he said, people were buying them from the "Amazon basin," and there was no way to know if the emissions reductions generating them were real or if they had been already sold to someone else. Verification concerns, according to Kolk, continue to negatively impact the California

Energy Commission's view of offsets, causing it to discourage their use. In addition, offsets are difficult to get—just not a "typical tool" used by the CEU.

The day after our interview, Dr. Kolk emailed me to say, "We just verified that the offsets are transferred to us through the California Tracking System Service (CTSS) from the Clime-Co. We get them for recycling the refrigeration through our refrigeration program." This confirmation officially put to rest any mystery surrounding Colton's ODS offsets, and in conjunction with Kolk's reasoning against Colton's offset use, provide insight into the offsetting behavior of local utilities like the CEU.

Discussion

Some of the CEU's reasons against offset use are unsurprising and rational, while others indicate a level of misinformation and overvaluation of the risks involved with offsetting. The claim that offsets are not worth the CEU's time, for example, is predictable. Transaction costs involved in working with an offset broker or establishing a project would have reduced the $80,000 of potential gross savings, and across 2013-2017, $80,000 is a small sum of money compared to other business-as-usual costs borne by the CEU. Even aside from operating costs, incidental costs dwarf $80,000; from just 2012 to 2013, for example, the utility lost more than $360,000 due to thieves stealing the metal plates off of damaged patches of road throughout the town, and ultimately had to pay $110,000 to settle a lawsuit with a disabled man who fell into an improperly covered electricity maintenance trench.[168] While these expenses are unrelated to the CEU's

[168] Parrilla, "Colton Pays $110,000 in Settlement with Disabled Man."

emissions, they illustrate the magnitude of business-as-usual costs that the CEU incurs. When the CEU's staff availability is also taken into account, offsetting looks even less attractive. When offset savings will yield less than $20,000 per year, an individual cannot be hired exclusively to navigate offset procurement and compliance, and offsetting would add to the workload of already busy CEU or city employees.

The CEU's concerns over offset risk are less supported. While verification is indeed difficult to guarantee as discussed in Chapter One of this thesis, the number of offsets that have been invalidated is minute. Only 88,955 offsets have been invalidated out of more than 145,000,000 produced (about .06%), and incidentally, all of the invalidated offsets were from an ODS project, the same type of offset that the CEU has exclusively submitted. The CEU would not be the first firm to interpret CARB's invalidation of these ODS offsets as an indication of wider market vulnerability—as Ecosystem Marketplace reported in 2015, the invalidation inquiry into the ultimately invalidated ODS offsets created uncertainty among market participants and "shadowed" the market long after, reducing buyer and project developer participation.[169] As time has passed however, no other invalidation events have occurred, and the scope of invalidation risk continues to be small.

Concerns that low-quality Amazonian offsets are infiltrating the CCM are also unfounded. All compliance offsets in California are generated by CARB's protocols, which only operate within the boundaries of the United States. The CEU's concerns indicate either a false understanding of Californian compliance offset production or a

[169] Gonzalez, "Invalidation Risk Still Shadows California Offsets Market."

perception of risk developed in the voluntary market (where some protocols do generate offsets in the Amazon) that is erroneously applied to the CCM. Claims that the California Energy Commission shares the CEU's disapproval of offsetting could not be verified.

Conclusions

At 599,291 tCO_2e covered in CP2, the CEU is a relatively small emitter in the CCM, so its individual offsetting behavior has little effect on the offset market at large or the environment.[170] Even so, the CEU shows that even as electricity generators face the pressures of a transition to renewable energy, offsetting does not always create cost savings that are large enough to warrant staff members' time and energy, especially when staff are limited. Having fewer staff members also means that an individual's opinion or understanding of policy can drive the offsetting behavior of an entire firm, leading it to behave according to the beliefs of an individual. This allows the behavioral idiosyncrasies inherent to individuals, such as misperceptions of risk, to influence market behavior.

Case Study: CP Energy Marketing (US), Inc.

CP Energy Marketing (US), Inc. (CPEM) is an extremely small emitter—only responsible for 1,502 tCO_2e in CP1—but it submitted 120 ODS offsets to fulfill 7.989% of its compliance obligations, the maximum quantity allowable by law. The cost savings

[170] To put the CEU's emissions in perspective, firms that emitted more than the CEU were collectively responsible for 96.76% of California's covered emissions in CP1 (CARB, "2013-2014 Compliance Report").

created by purchasing and turning in 120 offsets are miniscule, prompting the question: why utilize offsets at all?

This case study will show that in CPEM's case, compliance offsetting does not express environmental values beyond cost savings, however negligible. Although CPEM is responsible for very few emissions in the California Compliance Market, it is a subsidiary of the Capital Power Corporation, a much larger Canadian company with the staff, inclination, and experience to procure even a small number of offsets for CPEM. The phenomenon of a larger parent company assisting a subsidiary compliance entity in compliance offsetting may help explain why many small emitters maximize offset usage. It also illustrates that market experience and designated staff members can overcome transaction costs to make submitting even a small number of offsets practical.

CP Energy and Albertan Capital Power Corporation

The Capital Power Corporation is a "growth-oriented North American power producer headquartered in Edmonton, Alberta." The Corporation has indeed been growing steadily, acquiring more energy producing capacity each year since its $500 million initial public offering in 2009, when it had interests in 31 facilities in Canada and the U.S. totaling approximately 3,300 megawatts of generation capacity." By the time California's CP1 began in 2013, Capital Power owned more than 3,600 megawatts of generation capacity across 16 facilities in North America and was developing an additional 595 megawatts of owned generation capacity in Alberta and Ontario. By 2018, Capital Power owned approximately 5,100 megawatts of power generation capacity at 25 facilities, was pursuing contracted generation capacity throughout North America, and was developing an additional 1,000 MW of owned generation capacity in Alberta, North Dakota, and Illinois.[171] The Capital Power Corporation's growth trajectory and interests in multiple states and provinces in the United States and Canada have led to the development of subsidiaries, including CPEM, and has necessitated regulatory compliance across many jurisdictions.

Capital Power Corporation Greenhouse Gas Regulatory Compliance

The Capital Power Corporation has extensive experience complying with environmental regulations at the federal, state, and provincial level that address "air emissions; wastewater discharges; wildlife and habitat protection; hazardous material handling, storage, treatment, and disposal of waste and other materials; and remediation of sites and land-use responsibility."[172] It must also comply with regulations that set GHG reduction goals, which have imposed significant expenses upon Capital Power and compelled it to participate in multiple GHG markets. Alberta's GHG regulation has had the largest effect on Capital Power's operations, but British Columbia and the United States, particularly California, have also regulated Capital Power's emissions and provided opportunities to utilize compliance offsets. By 2013, when CPEM became a compliance entity in California, Capital Power was already an experienced GHG market participant and large-scale offset buyer in other markets.

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[171] "News Releases Pre-IPO to 2019."
[172] "Annual Information Form Capital Power Corporation 2014."

Alberta GHG Regulation Experience

Capital Power's native province provided years of experience in compliance offsetting prior to CPEM's involvement in the CCM. Alberta's Specified Gas Emitters Regulation (SGER), which came into force in 2007, established the first compliance offset market in North America and applied to all facilities in Alberta that produced over 100,000 tCO_2e per year. SGER mandated a 12% reduction in CO_2e intensity from the average CO_2e intensity of each facility from a 2003 to 2005 baseline period and was neither a cap-and-trade system nor a carbon tax per se, but defined three methods for achieving compliance:

1. Reduce operational emissions below 100,000 tCO_2e
2. Pay the Government of Alberta Climate Change Emission Management Fund $15 per t$CO_2$e for each t$CO_2$e emitted in excess of the emission intensity target
3. Purchase GHG emissions offsets created from Alberta-based projects

The desire to minimize high compliance costs borne under SGER made offsetting a pillar of Capital Power's compliance strategy. Capital Power's 2014 compliance costs for its 1106 MW of owned generation capacity and 860 MW of contracted for generation capacity in Alberta totaled $11 million, not all of which could be recovered from consumers, and as a contractually obligated power buyer, Capital Power was also on the receiving end of $3.3 million of passed-down compliance costs. Capital Power's 2014 Annual Information Form states that by 2014, the company had been "acquiring offsets for almost a decade," and that in 2014 alone, it had "entered into more than 42 offset purchase agreements across North America," totaling approximately $15 million of offset investment (up from $9 million in 2013). Compared to the cost of paying Alberta's Climate Change and Emission Management Fund, Capital Power estimated that its investments in offsets resulted in savings of approximately $1.2 million in 2014."[173]

British Columbia GHG Regulation Experience

British Columbia (BC) enacted North America's first carbon tax in 2008, which began at $10 per tCO_2e and increased each year until it reached $30 in 2012.[174] While the tax increased the operating costs of Capital Power's single fossil-fuel-fired power plant in BC, contractual arrangements have allowed environmental costs to be passed down to BC Hydro through 2022. In 2012, Capital Power expected the BC Government to operationalize a cap-and-trade system and to harmonize it with the Western Climate Initiative, a combined market also including Ontario, Quebec and Manitoba at the time. Although Capital Power did not have enough information to determine the costs of a such a cap-and-trade program, the prospect of one replacing BC's carbon tax made emissions trading experience essential to Capital Power's compliance strategy.[175]

United States GHG Regulation Experience

In 2012 and 2013, the United States EPA, ten states involved in the Regional Greenhouse Gas Initiative (RGGI), and California each imposed separate GHG emissions

[173] "Annual Information Form Capital Power Corporation 2014."
[174] Murray and Rivers, "British Columbia's Revenue-Neutral Carbon Tax."
[175] Ibid.

mitigation regulation and emissions trading procedures on Capital Power, increasing its GHG market and offset procurement experience. Overall, Capital Power's compliance in California has proven to be one of the most low-cost, insignificant uses of offsets in the history of Capital Power's GHG market participation.

The EPA regulates GHGs under the Clean Air Act, which at the time required "best available control technology" for new large, stationary GHG sources and for major modifications to existing sources. Since 2005, it has also required reductions in NO_x and SO_2 emissions via the Clean Air Interstate Rule, for which Capital Power's power plants in the US must buy and retire NO_x and SO_2 credits. In addition, as of March 2012 the EPA implemented a Carbon Pollution Standard, which set a national carbon emissions intensity target of 1,000 lbs. CO_2 per MWh of electricity for each new fossil-fuel-fired power plant. While the target did not affect Capital Power's existing US plants, the impact on future plants and of future regulation applying to existing sources necessitated close attention to EPA GHG mitigation plans.

When RGGI launched in 2008, it became the first market-based GHG mitigation program in the US and its earliest compliance offset market. RGGI established a regional cap on CO_2 emissions from power plants located in ten states and enabled compliance entities to utilize offsets for 3.3% of their compliance obligations. In 2012, RGGI covered three New England facilities owned by Capital Power, requiring them to possess tradeable permits or offsets for each short ton of CO_2 they emitted. Including offset-derived savings, Capital Power's compliance costs under RGGI totaled $4.2 million in 2012, demonstrating its experience complying with costly GHG regulation.

Capital Power's participation in California's compliance GHG market via CPEM was short, low-cost, and administratively non-complex compared to its other GHG market experiences. Capital Power does not own any power plants in California, but sales of electricity into California during a single year, 2013, necessitated reporting and compliance with AB 32. With years of practice participating in other GHG markets and experience handling millions of dollars of compliance costs, procuring 1,328 emissions allowances and 120 offsets for CPEM was a negligible burden—a small, yet representative example of Capital Power's general cost-saving compliance strategy.[176]

Discussion and Conclusions

Capital Power's expansion into multiple states, provinces, and countries in North America has necessitated compliance with a wide variety of regulatory regimes and developed deep offsetting experience within the Capital Power commodity portfolio management group (CPM). By 2012, the CPM lists as one of its primary function, "compliance with existing and emerging market-based environmental regulations" using "GHG offset investments" to "proactively manage potential compliance risks and costs." When Capital Power sold electricity into California via CPEM, Capital Power already had many years and tens of millions of dollars of experience in GHG markets and offset investments. It also had a sizeable staff working in the United States—by 2013, 178 out of Capital Power's total 939 employees worked in its US operations.[177] The small magnitude of Capital Power's compliance obligation in California coupled with the

[176]Ibid.
[177] "Annual Information Form Capital Power Corporation 2012."

company's experience and staff members made maximizing offsetting a simple, business-as-usual task.

Case Study: The University of California

The University of California (UC) is an organization of 10 public university campuses and five medical centers located throughout California. that employs more than 190,000 faculty and staff, making it one of the largest employers in the CCM.[178] The UC stands out in the CCM because it participates in compliance and voluntary offsetting simultaneously, demonstrating a desire to minimize compliance costs while also voluntarily spending to showcase environmental values.

The UC's commitment to sustainability predates AB 32 regulation and has motivated ambitious, self-imposed emissions reduction goals in addition to those mandated under AB 32. The UC has used carbon offsets to progress toward both goals, but the purpose and type of offsets differ between them. Compliance offsets are used exclusively to meet regulatory requirements, while voluntary offsets allow the UC to go above-an-beyond to meet carbon neutrality goals.

The UC's Sustainable History and Identity

The UC system's ties to the health of the environment date to its origins in the mid-19th century when the College of California offered its buildings and resources to the State-founded Agricultural, Mining and Mechanical Arts College. The so-called

[178] "The UC System."

"complete university" that resulted was fundamentally rooted in California's agricultural tradition and tied to the State government.[179] In 1878 as the UC continued to expand, it established the Agricultural Experiment Station, which has continued to develop knowledge that "will ensure a continuing supply of nutritious foods, useful fibers, and natural resources products in adequate amounts at low cost without adverse effects on the physical environment or consumer."[180]

Over time, the desire to ensure a high-quality physical environment for future generations has evolved into an investment strategy committed to the modern concept of sustainability, defined by the Brundtland Commission and referenced on the UC's website as "activity that meets the needs of the present without compromising future generations' ability to meet their own needs."[181]

The UC formalized that commitment in 2003 through a student initiative that led to the UC Regents adopting the Presidential Policy on Green Building Design and Clean Energy Standards. In 2004, the UC established a comprehensive Sustainable Practices Policy, which establishes goals in nine areas: green building, clean energy, transportation, climate protection, sustainable operations, waste reduction and recycling, environmentally preferable purchasing, sustainable foodservice, and sustainable water systems. Progress toward each of the nine goals is published in a comprehensive Annual Report on Sustainable Practices, which is publicly available online in a transparent expression of sustainable values.[182]

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[179] University of California, "A Brief History of the University of California"
[180] University of California, "Agricultural Experiment Station"
[181] University of California, University of California, "Sustainable Investment."
[182] University of California, "Sustainability."

Emissions reductions became a central focus of UC sustainability in November of 2013, when UC President Janet Napolitano announced the Carbon Neutrality Initiative—a commitment to emit net-zero greenhouse gasses from all UC buildings and vehicles by 2025.[183] The title "Carbon Neutrality Initiative" implies carbon offsetting—it does not promise to reduce emissions to absolute zero, but to net zero, by compensating for emissions with offsets. The Initiative was the first of its kind in the nation and has demonstrated the importance of sustainability to the UC's prestige and institutional identity. In President Napolitano's words, "if we invest in our own research and change the game on energy consumption, then UC will demonstrate to the nation, and beyond, the fundamental and unique value of a world-class public research university."[184]

In 2015, two years into the Initiative, the Office of the Chief Investment Officer of the Regents (OCIO) also committed to using its $100 billion endowment to advance sustainability by approving the Framework for Sustainable Investing. The Framework moves beyond value statements, asserting that "Sustainability is not a "checked box," but a critical component of risk management and maintaining dependable returns across multiple generations. "We do not seek merely to establish a "sustainability policy" for our holdings," wrote the OCIO, "but rather to embed sustainability analysis into our investment culture."[185] Following the Framework's approval, "the OCIO's global ranking on sustainability rose by eight spots to be ranked 17th among all worldwide investment funds and ranked first among university investment funds addressing climate change."[186]

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[183] University of California, "Carbon Neutrality Initiative."
[184] UC Office of the President, "President Napolitano Proposes Tuition Freeze, New Systemwide Initiatives."
[185] Office of the Chief Investment Officer of the Regents of the UC, "Sustainable Investment Framework."
[186] University of California, "Sustainability."

The Framework for Sustainability is another concrete example of the UC's willingness to invest in environmental goods and services not only to advance sustainability, but also to showcase its values.

Offsets, AB-32, and the UC

AB 32 has covered the UC's emissions since CP1 in 2013. In the first several allowance auctions, the UC purchased allowances. In subsequent years, CARB granted free allowances to UC to alleviate financial burdens and recognize that they "were already devoting considerable effort to directly reduce their emissions."[187] The UC's response to AB 32 has been coordinated by a cap-and-trade steering committee containing representatives from nine campuses and one medical center. While campuses individually verify and report emissions directly to CARB, the Office of the President "maintains account holdings and documentations and ensures regulatory compliance." According to the UC, "This structure allows campuses to make cap-and-trade purchase decisions independently with advice from the Office of the President and consultants. Thanks to the sequestration of funds earmarked for compliance and returns on those early investments, UC's current cap-and-trade program is now fully funded through about 2025. Thus, the program has been an effective strategy to cost-effectively administer UC's regulatory compliance obligations regarding greenhouse gas emissions." Today, nine out of 15 UC facilities are mandatorily regulated under AB 32, and one facility has opted into regulation.[188]

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[187] UC Office of the President, "Carbon Neutrality at the University of California."
[188] UC Office of the President, "Carbon Neutrality at the University of California."

When interviewed over the phone, Nick Balistreri—a Renewable Energy Manager of the Regents of the UC who works with offset brokers to buy the UC's offsets—described a clear dichotomy between the UC's value-motivated offset purchases and its compliance-motivated offsetting.[189] In the compliance market, the UC has always utilized its full 8% of offsets to seize the maximum available cost savings. As Balistreri pointed out, offset prices have consistently lagged about 10% behind allowance prices, creating a constant opportunity to exploit offset-derived savings. Even in the future when offset use must drop to 4%, then 6%, Balistreri emphasized that the UC will take what cost savings it can get. Even if the savings aren't huge, the risk of offset invalidation is so small that engaging with offsets still makes sense. At the end of the day, Balistreri emphasized, procuring compliance offsets "kills two birds with one stone," since offsets trade at lower prices than allowances and help reduce the UC's carbon footprint.

Balistreri also asserted that the UC is different than most other firms, which in his view buy compliance instruments year by year to satisfy their obligations, rather than planning long in advance. Instead, the UC has always planned for the future and anticipated rising offset prices, so their strategy has been to buy early, spending and taking on risk today so that the future is less costly and risky. Part of what has enabled the UC to think long-term is that offsetting has not been "administratively complex." Balistreri works as a dedicated internal resource with the UC's offset broker, and the UC has economies of scale. Balistreri chuckled and said that offsets really only make sense

[189] Interview conducted via phone October 24, 2018

when you're buying "at least 1,000" at a time and when you have a staff member dedicated to the job.

When it comes to offset project location, the UC does value in-state projects more than out of state projects, but it has been difficult for the UC to target offsets in-state due to supply constraints.

When the opportunity arose in 2016 to buy offsets from within California, Balistreri "jumped on it." Given the new requirement mandated by AB 398 that after 2020 at least 50% of offsets must come from projects within California, the UC would love to "sit on" the offsets it already has from within California, doling them out over time to enable continued maximization of offset use. In Balistreri's view, the UC, like many other firms, would like to "load up" on California-produced offsets now. Complying with regulation today, though, is the highest priority, so the UC may use up its in-state offsets prior to 2020. "At the end of the day," Balistreri said, "the goal is to meet the regulatory objective." In general, that has made the UC "not too discerning" between offset types—its apparent preference for ODS offsets does not reflect true values or preferences.

In the voluntary market, meanwhile, the Regents of the UC plan to "ramp up" offset purchases to meet their 2025 Carbon Neutrality goal. Currently, the Regents are asking questions like "what is the UC?" and "do we want [our offsets] to reach a higher bar?" In the voluntary market, the UC's preferences for higher quality and local offsets are strong—the UC recognizes its ability to promote sustainable social norms and demonstrate leadership. The "subjectivity" of the voluntary market enables the UC to express its values with purpose and intentionality.

UC Discussion and Conclusions

The UC exemplifies the classic offsetting approach of both compliance and voluntary buyers. In the compliance market, cost containment is the UC's focus. Economies of scale are essential to offset use, both in the ability to pay a dedicated staff member to handle offsetting and in buying large quantities of offsets at once. Various types of offsets are all viewed as equally valuable—the UC will buy whatever is available in the market, and the co-benefits attached to various offsets do not factor into procurement. This behavior coincides with that of many large emitters in the CCM who utilize large quantities of offsets and whose mix of submitted offsets match the mix supplied to the market. If the mix of supplied offsets were to change, the mix of compliance offsets that the UC submits would likely change proportionately.

At the same time, the UC utilizes voluntary offsetting as a platform to demonstrate sustainable values and exercise its preferences for specific offset-generating activities and locations. Voluntary offsetting allows the UC to compensate for emissions that are not covered by California's emissions cap, allowing it to pursue "carbon neutrality," a status associated with greater commercial success. Carbon neutrality may boost employee morale, allow greater brand differentiation, and create good will and a better reputation among stakeholders. While these are attractive benefits to any business, from the perspective of long-term emissions mitigation, the benefits of carbon neutrality are unclear. Firms that achieve carbon neutrality via offsetting may hope that they inspire others to sustainable action, but voluntary offsetting may also weaken firms' ambition to lower their own operational emissions and be too expensive or complicated for inspired firms to participate in.

Case Study: The Los Angeles Department of Water and Power

The offset submission behavior of the Los Angeles Department of Water and Power (LADWP), given its potential for offset-derived cost-savings, is singular in the CCM. Although LADWP is one of the largest regulated emitters participating in the cap-and-trade system, its compliance strategy does not include the purchase and submission of compliance offsets. The LADWP is not against offsetting, but demonstrates an alternative approach to cost-effective compliance that prioritizes operational emissions reductions achieved via power providers' unique ability to change their fuel mix over time.

Background Information

LADWP was founded in 1902 to deliver water to the City of Los Angeles. When it also began supplying electricity in 1916, LADWP began a long history of growth accompanied by GHG emissions from fossil fuel combustion.[190] Today, the LADWP is the largest municipal utility in the nation and employs 9,400 people, supplying 26 million megawatt hours of electricity per year through an infrastructural footprint that stretches across 23 generation plants, 308,523 utility poles, and 15,000 miles of transmission lines.[191]

The historical fuel mix of LADWP, like most electricity generators and providers in the United States, has been dominated by coal. In recent decades, however,

[190] LADWP, "LADWP Facts and Figures."
[191] LADWP, "Facts & Figures."

California's Renewable Power Standard has driven significant changes in LADWP's provision of renewable power. On May 23, 2005, prior to the passage of AB 32, the Board of Water and Power Commissioners of the City of Los Angeles (the Board) adopted RPS Policy that "established the goal of increasing the amount of energy LADWP generates from renewable power sources to 20 percent of its energy sales to retail customers by 2017, with an interim goal of 13 percent by 2010."[192] In 2007, the Board increased the ambition of LADWP's Renewable Power Standard, raising the 2010 goal to 20% renewable energy. LADWP met this goal through an aggressive combination of new renewable power acquisition and the phase-out of older coal facilities (Figure 3.10, Appendix I).

June 2010 marked the release of the Los Angeles City council's new sustainability plan, "Water & Power Long Term Strategy – Building a New Los Angeles," and of LADWP's completion of its Pine Tree Wind Farm, a wind power facility that now generates up to 135 MW of power, enough to serve over 63,6000 households "while reducing 215,000 tons of greenhouses gases per year—about the same as removing 41,330 cars from the road."[193] Renewable power acquisitions and expansions like this exemplify LADWP's approach to emissions mitigation: long-term, large scale changes to its power mix. Since 2010, LADWP has continued to expand its renewable generation capacity in preparation for future RPS targets (Figure 3.11,

[192] LADWP, "Renewables Portfolio Standard Policy and Enforcement Program."
[193] LADWP, "Greening the Grid."

Appendix I)[194]. By 2016, LADWP had exceeded the mandatory 25% target by 4%, and has since stayed on track for the 2020 goal of 33%.[195]

AB 32 Compliance

In CP1, LADWP was the single largest emitter in the CCM, responsible for 29,483,232 tCO_2e. The next largest emitter, Chevron USA, only reached 20,771,539 tCO_2e. In CP2, however, LADWP dropped to eighth place behind Tesoro Refining and Marketing, Chevron USA, Phillips 66, Southern California Gas Company, Pacific Gas and Electric Company, Shell, and Valero. This was due to a scheduled expansion of the cap-and-trade system in 2015 to include fossil fuel distribution and due to LADWP's efforts to change its power mix and reduce it emissions. While Chevron's average yearly covered emissions covered emissions increased from 10,385,769 tCO_2e to 43,217,457 tCO_2, LADWP's efforts decreased its average yearly emissions from 14,741,616 tCO_2e to 11,061,772 tCO_2e per year.

In both compliance periods, despite the appearance of potential cost savings, LADWP's compliance offset submissions were minute. In CP1, LADWP submitted 14,813 offsets, .05% of its emissions obligations, and in CP2, just 3,597, .01% of its emissions obligations, far fewer than the 8% maximum limit. All of LADWP's submitted offsets were generated via the ODS protocol. This submission behavior differs from essentially all compliance firms responsible for similar quantities of emissions. In Figures

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[194] LADWP, "LADWP 2017 Power Content Label."
LADWP, "LADWP 2016 Power Content Label."
"LADWP Power Supply Since 2003 | Los Angeles - Open Data Portal."

[195] LADWP, "Briefing Book 2017-2018."

3.2 and 3.3, LADWP is represented by the bottom-right-most dot—a clear outlier given its potential for turning in offsets and seizing cost savings. Between both compliance periods, LADWP could have turned in 5,013,473 offsets, seizing more than $5 million in estimated gross compliance costs.[196] The reason why LADWP did not purchase offsets is that there is the risk that CARB could deem the offsets invalid at a later date, which could lead to future noncompliance with CARB's rules (i.e. having insufficient emissions allowances for compliance).[197]

Interview with LADWP

Speaking with members of LADWP's Environmental Affairs team revealed that LADWP has no aversion to offsetting, but that it has prioritized operational emission reductions through the transition to renewables rather than offsetting. Indeed, LADWP's lack of offset submissions does not reflect foregone cost savings, but a desire to maximize other sources of long-term cost savings.[198]

When I reached out to Maria Sison-Roces, Manager of Corporate Sustainability Programs, she set up a call that also included Mark Sedlacek, Director of Environmental affairs and Carol Tucker, Senior Public Relations Specialist. I had already sent in questions to LADWP's HR department, which asked what the LADWP's focus is in terms of sustainability, how offsets fit into LADWP's vision of sustainability, why

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[196] Transaction costs associated with offset procurement would reduce net revenue, but this upper bound on cost-savings indicates the approximate order of magnitude of LADWP's potential offset-derived cost savings.

[197] This clarification comes from an email correspondence March 11, 2018 with Carol Tucker, Senior Public Relations Specialist of LADWP.

[198] Interview conducted via phone with Maria Sison-Roces, Mark Sedlacek, and Carol Tucker (Senior Public Relations Specialist) December 13, 2018.

LADWP has not utilized the full 8% of offsets, and why the offsets it has submitted have all been generated via the ODS Protocol.

Sedlacek was extremely forthcoming—while offsets are certainly something LADWP looks at, its focus is on allowances issued by CARB and on funding projects that improve its renewable resource mix and dispatch capabilities. This approach delivers the same results—decreased emissions and compliance costs—within LADWP's system, decreasing risk while enabling greater control and long-term benefits. While offsetting may suit other business models, "We can change out our fuel resources," said Sedlacek.

Sedlacek also emphasized that RPS requirements are just a "starting point" for LADWP's focus on the shift to renewables. SB 1368, passed in 2006, also contributes by preventing long-term investment in coal-fired power plants, and other long-term infrastructural updates have decreased operational emissions. In 2016, LADWP proactively instituted a "carbon adder," which internalized the cost of GHG emissions and significantly decreased the coal power dispatched to the grid. As a municipal power provider, the desire to minimize financial risk and focus on what is within LADWP's wheelhouse has led to a strategy that does not include offset procurement. The only offsets that LADWP has submitted have been ODS offsets produced through a refrigerator recycling program that predates AB 32.

Conclusions

RPS regulation contributed to LADWP's transition to renewable prior to AB 32 and has enabled LADWP to cut operational emissions cost-effectively, making offsetting unnecessary. When cap-and-trade regulation imposed further costs on LADWP, changing its power mix remained the priority of its compliance strategy and has continued to deliver emissions reductions and cost reductions over time. Just as in Colton, discussed earlier, a pre-existing refrigerator recycling program is responsible for LADWP's offset submissions rather than a concerted effort to procure compliance offsets. Unlike in Colton, LADWP's staff emphasized that LADWP is not against offsetting. Devoting time and energy to changing its fuel mix has simply fit LADWP's long-term goals better. The offsetting behavior of LADWP ultimately demonstrates that when a firm has an opportunity to cost-effectively reduce operational emissions, a desire to minimize costs can actually incentivize low, rather than high, levels of offset utilization.

Chapter 3 Discussion and Conclusions

Departures from Expectation

The offset-related behavior of firms in the CCM defies expectations in many ways. The transaction costs, administration costs, and procurement constraints associated with offsetting ought to discourage small emitters from offsetting, while large emitters whose potential cost savings are much larger ought to maximize offset usage. Many firms behave according to these expectations, while others defy them; a number of small firms maximize offset use, while many large firms opt to submit few or no offsets and appear to miss out on cost savings. Some firms of all sizes, meanwhile, consistently submit very a small number of offsets. This behavior suggests that factors other than cost savings drive some firms' offsetting behavior.

The City of Colton Electric Utility (CEU), CP Energy and Market (CPEM), and Los Angeles Department of Water and Power (LADWP) each highlight a different explanation for unexpected behaviors. The CEU does not purchase offsets because it overestimates the risk associated with offsetting, but submits the few offsets given to it through a pre-existing recycling program. CPEM, which appears as a small emitter, is actually the subsidiary of a massive company with deep experience with offsetting, explaining its maximization of so few offsets. The LADWP, while supportive of the idea of offsetting, prioritizes changes to its fuel mix over offset procurement.

At the same time, several general rules of offsetting hold: the type of offsets that case-studied firms submitted did not indicate preferences for co-benefits, but were a product of what was most convenient for them to procure or submit. In addition, case-studied firms confirmed that larger firms are more likely to utilize offsets since they can pay a dedicated individual or team to handle offset procurement and since they can purchase many offsets at once. The exception to this rule is LADWP, which, despite its administrative capacity to offset and apparent potential for savings, devoted its personnel to other aspects of its compliance strategy.

Overall, offsets appear to be underutilized in the CCM, which means that the threats that impermanent and non-additional offsets pose to the integrity of California's emissions cap are not as large as they could be in a maximum-utilization scenario. Nevertheless, more than 75.5 million offsets that have been submitted for compliance, representing a substantial quantity of carbon and financial investment. Further, as the emissions cap declines and compliance becomes more expensive, the proportion of firms submitting offsets may increase, exacerbating issues identified in current protocols.

Implications of Offset Type

Although sub-groups of firms and some individual firms in the CCM (e.g. the CEU, CPEM, and LADWP) submit a high percentage of non-forest offsets, forest offsets—the most problematic variety of California Compliance Offset—are by far the most produced and utilized type of offset, representing 79% of offsets produced to date and 69% of all offsets submitted in CP1 and CP2. Since forest offsets are generated by impermanent emissions reductions, the majority of offsets utilized for compliance in the CCM do not compensate for firms' emissions, compromising the integrity of California's emissions cap. Preliminary analysis by CaliforniaCarbon.Info indicates that the passage of AB 398, which mandated that at least 50% of firms' compliance offsets come from California after 2025, will increase forest offset demand further, since forest offsets are the primary variety produced in California.[199]

Concerns over offset policy's ability to facilitate the trade of methane emissions for CO_2 emissions (discussed in Chapter One) are much smaller in magnitude than the threat posed by forest offsets. Although the submissions of MMC offsets increased by a greater percentage than all other protocols from CP1 to CP2, MMC and livestock offsets still represent a small proportion of the total offsets submitted for compliance. If methane-focused protocols become more productive in the future, concerns over the long-term effects of mitigating methane in lieu of CO_2 will increase.

[199] Hamshaw, "California Carbon Info."

Implications of Types of Offsets that Different Sized Emitters Submit

Since the offset submissions of the largest emitters in the CCM match the mix of offsets supplied to the market, the largest emitters are responsible for the lion's share of forest offsets submitted for compliance. These firms, which include international oil and gas companies and other energy-intensive, trade-exposed firms, are the primary targets of emissions mitigation policy and are responsible for the largest proportion of current and historical emissions. They also possess some of the greatest capacity to innovate to develop low-carbon technologies. Inexpensive, impermanent forest offsets reduce the pressure on these firms to innovate and allow the largest, most emissive firms to emit GHGs that are not compensated for, compromising the integrity of California's emissions cap.

Smaller emitters in the CCM and large emitters that submit few offsets do not have an outsized impact on the integrity of the CCM, but the differences between the mix of offsets that are produced and the offsets they submit suggest that more study is needed to determine all the factors including cost savings that influence their utilization of offsets. The case studies presented in this chapter suggest only a few factors that motivate firms' offsetting behavior.

Conclusion: Recommendations for Policymakers and Firms Engaged in Offsetting

This thesis has argued that California's four productive carbon offset protocols each present a threat to the integrity of California's cap on greenhouse gas emissions. Although the scope of that threat varies enormously between protocols, California's US Forest Protocol alone has produced over 115.6 million illegitimate offsets—an estimated $1.38 billion worth of temporarily sequestered carbon that cannot compensate for atmospheric emissions.[200]

Faced with the flaws of California's current offset policy, policymakers in California and other carbon markets have two options: improve carbon offset policy for the future, or implement alternative policies that deliver equivalent benefits and avoid the risks of offsetting. Both of these options, as applied in California, can inform the action of policymakers engaged in current and emerging carbon markets worldwide. California's offset protocols also offer lessons for firms engaged in carbon offsetting, whether they participate in compliance markets or are also active in voluntary markets.

Flaws Identified in California's Offset Protocols

Both the Livestock and MMC Protocols present additionality questions that require further examination of projects' financial context. In livestock projects' case, non-offset incentives to install anaerobic manure digesters must be disentangled from the

[200] At $12 per tCO_2e

incentive created by offset generation to determine whether digesters would have been installed regardless of the offset protocol. In mine methane projects' case, the feasibility and potential value of a methane RAU project must be compared to the potential value of a methane-destroying offset project to determine if an RAU project could have occurred in the absence of the offset protocol. So far, 3.9 million livestock offsets have been submitted for compliance out of 5.6 million generated, while 3.8 million MMC offsets have been submitted for compliance out of 5.8 million generated. Estimating the number of these offsets that are illegitimate according to the concerns above requires further study.

The ODS Protocol is less vulnerable to additionality concerns, but does not account for the greenhouse gas emissions of refrigerants that take the place of ODS destroyed by the protocol. This means that destroying ODS may increase net emissions by accelerating the transition to ODS that are more potent GHGs, which will leak over the operational lifespan of equipment. So far, 15.7 million ODS offsets have been submitted for compliance out of 18.9 million generated. Just as with livestock and MMC offsets, determining the scope of this potential offset over crediting requires further research.

The Forest Protocol arbitrarily equates 100-year sequestration with permanent sequestration, a convention that is not supported by science. As a result, all offsets generated by the protocol are unable to compensate for real CO_2 emissions into the atmosphere by compliance entities on a climate-relevant timescale. Even if CARB were to mandate that forest project extend ad infinitem, it would be administratively and financially impossible to enforce sequestration activities long enough to fully offset today's emissions into the atmosphere. It follows that all 52,068,592 offsets submitted for compliance so far (68.9% of total submitted) and all 115,610,154 generated so far (79% of total produced) are illegitimate and undermine California's emissions reduction goals.

Implications for Global Offset Policy

The flaws in California's protocols have implications for the CCM and for current and future offsetting and carbon neutrality schemes worldwide. The United Nations Framework Convention on Climate Change (UNFCCC) has not yet adopted the rules and modalities for the international market mechanism described in Article 2.6 of the Paris Agreement, and the International Civil Aviation Organization (ICAO) has not yet confirmed which offsetting activities will be eligible in its Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). California's four productive offset protocols target activities that release substantial GHG emissions worldwide, making all four protocols, particularly the US Forest Protocol, valuable models for international offset programs. Learning from California's protocols and correcting flaws where possible will be essential to establishing international offset policies that offer meaningful climate benefits.

Of the four California compliance offset protocols examined in this thesis, the US Forest Protocol and its inherent impermanence issue has the most significant ramifications for global emissions mitigation efforts. Forest sequestration is one of the top offset-producing activity worldwide, and future estimations of forest offset supply range from 1.3 to 4.3 billion tCO_2e per year at less than $20 per tCO_2e.[201]

This potential makes forest offsetting an attractive opportunity for the UNFCCC's international mechanism and CORSIA. Including forest offsets in both mechanisms, however, has already proven contentious. At the 24th Conference of the Parties to the Paris Agreement (COP) in 2018, Brazil's desire to maximize its forests' offsetting potential and to sell its stock of CDM offsets into the new mechanism impeded negotiations for days, preventing the Parties from reaching an agreement about the rules and modalities for a new international offset program. Ultimately, the issue was pushed to COP25, which will be held in 2019.[202] Disagreements over the potential role of forest offsets in CORSIA are well represented by the conflicting opinions of influential non-governmental organizations, including Environmental Defense Fund (supportive), Greenpeace (opposed), Our Children's Earth Foundation (opposed), and many others.[203]

If future national and international offset programs utilize forest carbon sequestration, they must not make the same mistake as California's US Forest Protocol and arbitrarily equate temporary sequestration with permanent sequestration. If they do, the production of illegitimate offsets will dramatically increase, and global emissions will not be compensated for on a climate-relevant timescale. They must also acknowledge that even if project lengths are dramatically extended, it is not possible to be sure that

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[201] Coren, Streck, and Madeira, "Estimated Supply of RED Credits 2011–2035."
[202] "COP24: Key outcomes"
[203] Cooper, "ICAO and Forest Offsets."
Timperley, "Corsia."

sequestration projects will continue long enough to compensate for atmospheric emissions. Until policymakers solve this permanence-enforcement tradeoff, forest offset production must stop.

Recommendations for Policymakers

Millions of tons of GHG emissions and millions of dollars are at stake. In California alone, forest offsets represent more than 115.6 million tons of carbon dioxide that have only temporarily been sequestered and which will allow firms to release permanent emissions into the atmosphere unless policy changes. Policymakers must take action to change offset policy to increase market efficiency, preserve the pressure to develop low-carbon technology, avoid the trade-off between co-benefits and emissions mitigation, and contribute to the political economy of emissions regulation without undermining its integrity.

Improve Market Efficiency

As long as legitimate offsets outnumber illegitimate offsets, offset policy creates net benefits for the climate. However, even while the number of legitimate offsets outnumbers illegitimate offsets, the sale of illegitimate offsets compromises the efficiency of emissions regulation, representing both wasted investment and rent-seeking on behalf of buyers and producers, respectively. Policymaker action today can reduce the number of illegitimate offsets in the market, increasing market efficiency.

In the CCM, illegitimate offsets already outnumber legitimate offsets. Forest offsets comprise a majority of offsets produced and submitted, and still represent only a lower bound on the number of illegitimate offsets in the CCM given concerns raised about the other protocols. Changing Californian offset policy is therefore essential for offset policy to deliver positive net climate benefits.

Preserve Incentives to Develop Low-Carbon Technology

Some may argue that since offset use is typically limited in a compliance market, most of the market will remain intact and will continue to incentivize emissions reductions and technological advancement even if illegitimate offsets enter the market.

The first premise of this argument—namely that offset use is always limited—does not always hold true. It is currently unknown whether there will be a cap on offset use in the UNFCCC's international offset market, and in the case of CORSIA, there is no cap at all. Offsets will be utilized to compensate for 100% of emissions growth in the aviation sector, so ensuring that all offsets are all legitimate is essential.

Even when offset use is capped within a compliance market, the threat that illegitimate offsets pose to the ultimate goal of emissions regulation—the development of new, low-carbon technologies—is too large to allow flawed offset policy to persist. In California, for example, where offset use is capped at 8% through 2020, the Union of Concerned Scientists have argued that utilizing 8% offsets will enable up to 85% of the emissions reductions from 2013 to 2020 to be achieved via offsets.[204] If many offsets are

[204] Mulkern, "Offsets Could Make Up 85% of Calif.'s Cap-And-Trade Program."

illegitimate, most of the apparent emissions 'reductions' achieved by the market do not exist.

Offset use in California has so far constituted only 5.9% of California's total compliance obligations. If this trend continues through 2020 and the Union of Concerned Scientists' calculations are correct, up to 62% of the emissions reductions mandated by California's cap through 2020 will be fulfilled with offsets. When more than 60% of those offsets come from forestry and are known to be illegitimate, a significant portion of the emissions reductions mandated in California appear to have been accomplished with offsets that do not compensate for emissions into the atmosphere. This means that net emissions have increased as a result of offsetting and that the financial pressure to develop low-carbon technology has been delayed.

Avoid the Trade-off Between Co-benefits and Emissions Mitigation

Carbon offset policy is often seen as a policy tool that harnesses the financial resources of firms responsible for pollution to create societal co-benefits such as sustainable development. While this is certainly one of the most attractive and meaningful benefits of offsetting, offset policy that does not also ensure, as a first priority, legitimate emissions reductions, also creates costs by enabling regulated firms to pollute above the designated cap on emissions.

While populations near offset project sites may experience co-benefits from emissions-reducing activities, populations near offset buyers may experience co-costs including compromised air and water quality from increased emissions. Offset policy is not designed to evaluate whether the combination of these collateral impacts yields net-benefits for society. Offset policy quantifies benefits purely based upon CO_2e-emissions; if policymakers accept that emissions need not be legitimate but use emissions as a method for creating co-benefits outside the emissions cap, they have no way of knowing that the benefits they create will outweigh the costs that other populations incur.

If offset policy is co-opted to achieve non-emissions related goals regardless of the effect on net emissions, is also creates a tradeoff between the effectiveness of emissions mitigation policy and social goals (i.e. sustainable development). This tradeoff has not been made explicit or been agreed upon by voters or regulated firms, thereby constituting an abuse of policy. While offset projects can promote sustainable innovation and development in unregulated sectors, that should not come at the expense of sustainable innovation and development among regulated sectors, which are responsible for the majority of current emissions and have an outsized effect on future emissions trajectories.

Contribute to the Political Economy of Emissions Regulation Without Undermining its Integrity

Offsetting has historically been included in major emissions mitigation policy to increase compliance flexibility and enable decreased compliance costs, improving the political economy of emissions regulation. Offset policy is not the only flexibility mechanism embedded in emissions mitigation policy, however; the level of the emissions cap, the presence and level of price floors and ceilings for emissions allowances, the quantity and allocation of free allowances, and the scope of a cap-and-trade system's coverage, for example, can all be manipulated to change the financial pressure that firms feel in response to emissions regulation. Since offset policy is not essential, policymakers can solve the problems created by offset policy by replacing offset policy with alternatives that achieve similar benefits.

Two Ways Forward: Better Offset Policy or Alternative Policy

With three changes, California's offset protocols can provide a valuable framework for policymakers interested in designing global offset policy for the future. California's offset protocols also demonstrate, however, that upstream regulatory solutions and preexisting incentive programs can often accomplish the same emissions mitigation goals as offset protocols and decrease the need for offset incentives. Given the difficulty in ensuring reality, additionality, permanence, enforceability, and verifiability and the unintended consequences that offsets can create, alternative methods for reducing emissions outside of a CAT system may offer a lower-risk method for delivering offsets' intended emissions reductions.

Options for Offset Policy Improvement

1. Three Additionality Tests

California's Livestock and MMC Protocols already include two additionality tests: a legal requirement test and performance standard. This thesis has shown that it is also essential to investigate the financial context of projects to determine whether activities would have occurred in the absence of offset incentives. An additionality test that examines the financial feasibility of projects without offset revenue must be included in all future protocols to help ensure offset additionality.

2. Account for Impacts of Substituted Goods

As discussed in Chapter Two, the destruction of ODS for offset generation will accelerate the transition to substitute gasses, which may affect projects' net emissions. Whenever offset protocols incentivize the destruction of materials with substitutes, the emissions impact transitioning to those substitutes must be accounted for in protocols' quantification methodologies.

3. Reevaluate Quantification of Temporary Sequestration

As discussed in Chapter Two, sequestration activities must persist for an extraordinary amount of time to compensate for emissions into the atmosphere—longer than any policy today can guarantee. To overcome the tradeoff between permanence and enforceability of carbon sequestration, ton-year accounting offers one method for quantifying the climate change mitigation benefits of temporary carbon sequestration. Ton-year accounting has not been applied in policy due to uncertainty surrounding the number of ton-years that are equivalent to one permanently sequestered ton, necessitating further research. The political economy of shifting to a ton-year approach may also prove challenging since it dramatically decreases the value of sequestered carbon. Still, an alternative to the current status quo, which severely over values temporarily sequestered carbon, must be found. Until an alternative to current protocols' assumption of permanence has been researched and implemented, forest offset production must cease.

Policy Alternatives

As mentioned above, numerous policy features other than offsets can increase the flexibility of regulatory compliance, rendering offset policy non-essential to cap-and-trade systems. In the context of California's offset protocols, upstream regulatory interventions and preexisting incentive programs can, in many cases, also deliver the emissions reductions and co-benefits of offsets without their inherent risks. This section will suggest potential alternatives to the four types of offset currently generated for sale into the CCM.

Livestock Manure Emissions Management

The current inability to disentangle the incentives for anaerobic manure digestion provided by Low Carbon Fuel Standard credits, Renewable Identification Number credits, installation subsidies, and carbon offsets indicates the extent to which existing policies unrelated to offsets can successfully incentivize improved livestock manure emissions management. Indeed, SB 1383 in California indicates that anaerobic manure methane management will be mandatory within the state as early as 2024, exemplifying the momentum behind anaerobic digester installation and political economy of command-and-control manure management regulation.[205] Expanding non-offset incentive programs and financial support for installation can further increase the adoption rate of anaerobic manure digesters.

[205] SB 1383 mandates a reduction in the statewide emissions of methane by 40% below 2013 levels by 2030 utilizing regulation adopted no sooner than January 1, 2024 (Lara, Senate Bill 1383.). Since livestock manure is a significant methane source in California and anaerobic digestion is a feasible, cost-effective method for reducing livestock manure emissions, livestock owners take SB 1383's methane target as a strong hint to install anaerobic digesters by 2024 ("Implementing CA SB 1383: Dairy Methane Reduction.").

ODS

As discussed in Chapter Two, if the mandatory leakage repair rates mandated by the US EPA were more stringent, there would be no need to incentivize ODS destruction with offsets to avert leakage. Federal leakage requirements were updated in 2019 despite industry disapproval, demonstrating the potential feasibility of increased upstream regulation. Defining a timeline for future decreases in leakage requirements today can create certainty and market incentives for manufacturers of air conditioning and refrigeration equipment to develop equipment that can meet higher leakage standards in the future and reduce or eliminate the need for ODS-targeted offset policy.

Mine methane

Mine methane recovery-and-use (RAU) projects are currently researched and implemented under the US government's Coalbed Methane Outreach Program (CMOP).[206] Although the CMOP has worked voluntarily with the coal mining industry and other key stakeholders since 1994, many sites remain uninvestigated, so it is not possible to know whether more RAU project are feasible. More research is needed to address the feasibility of implementing RAU projects throughout the US without offset revenue. Once it is known how many mining operations are unable to implement an RAU project, it will also be possible to know which sites can only reduce their methane emissions with the revenue provided by offsetting.

Colorado, Indiana, Ohio, Pennsylvania, and Utah also incentivize coal mine methane RAU projects by listing coal mine methane as a renewable or alternative energy

[206] US EPA, "Frequent Questions About Coal Mine Methane."

source. As a result, power providers can implement RAU projects to satisfy in-state Renewable Portfolio Standards.[207] This policy technique that can be expanded and adopted by other states to increase the number of RAU projects that are implemented without offset revenue.

Forest

Forest conservation and management engage more stakeholders outside of offset production than any of the three activities discussed above. At the national level, the US Forest Service manages the National Forest System, while state governments, local governments, forest industries, and private landowners govern and manage forest land in non-Federal ownership.[208]

Government owned and managed forestland provides one potential pool for improved management through the top-down establishment and enforcement of official best-practices that increase carbon storage. On private lands, numerous Federal financial incentive program promote various management practices, including but not limited to the Forest Stewardship Program, Conservation Reserve Program, Environmental Quality Incentives Program, Forest Land Enhancement Program, and many others. States offer property tax programs and incentive programs, while industry and non-governmental organizations also offer a litany of programs that affect forest land management.[209]

To list and describe every forest and forest-management program offered in the US would be outside the scope and intent of this thesis. As Jacobson et al. (2009)

[207] US EPA, "Webinar Market Incentives for U.S. Coal Mine Methane Projects."
[208] US Forest Service, "Agency Organization."
[209] Jacobson et al., "Financial Incentive Programs' Influence in Promoting Sustainable Forestry in the Northern Region."

suggest, increased visibility, availability, funding, and streamlining can improve many of these programs.[210] Further research is needed, however, to determine the specific effects of these programs on carbon cycling, which will illuminate which programs to expand to specifically promote increased carbon storage on public and private lands.

Conclusion

These alternatives to offsetting are not an exhaustive list, but are meant to emphasize that there are alternatives to offset policy at the national and state level that can incentivize emissions reductions. Before policymakers consider revising existing offset protocols or adopting new ones, analysis of potential alternatives may reveal more instances where upstream regulation or expanding existing programs can accomplish the emissions reducing goals of offset policy while reducing administrative burdens and avoiding the uncertainties surrounding additionality, quantification, enforcement and verification that are essential to offsetting.

Recommendations for Firms that Utilize Offsets

California's compliance offset protocols also offer lessons for firms participating in compliance and voluntary offset markets. In the compliance market, this thesis recommends features that firms should look for to ensure that they purchase low-risk offsets that represent legitimate emissions reductions. In the voluntary market, the University of California's voluntary offsetting motivates a reexamination of whether achieving carbon neutrality via carbon offsetting shows climate leadership. I will argue

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[210] Ibid.

that it does not, and that firms trying to show climate leadership should reconsider buying offsets.

Seeking Quality in Compliance Markets

Firms participating in compliance markets utilize offsets that are lowest-cost and most available. At the same time, however, it is in buyers' best interest to purchase legitimate emissions reductions. Not only because submitting illegitimate offsets for compliance, if discovered, can compromise a firm's public image, but also because in some markets (e.g. California) buyers are liable for replacing any offsets that are found to be illegitimate and invalidated. Many compliance firms may take the claims of compliance offset registries at face value, assuming that their protocols deliver legitimate offsets. This thesis has argued, however, that four of today's most recent and productive compliance offset protocols have produced offsets that are illegitimate and should be invalidated. To minimize the risk of having to replace invalidated offsets and to ensure legitimate offset purchases, compliance firms seeking offsets should demand offsets produced by protocols that include the three options for policy improvement described under "Options for Policy Improvement" above.

Demonstrating Climate Leadership in the Voluntary Market

The University of California (UC), discussed in Chapter Three of this thesis, purchases voluntary offsets outside of the California Compliance Market to compensate for its unregulated emissions and achieve carbon neutrality. The overarching question that this kind of voluntary carbon offsetting prompts is whether it is better for societal emissions mitigation trajectories to offset unregulated emissions and celebrate carbon neutrality or to strive toward operational emissions reductions that lead to infrastructural change.

The UC is one of many high-profile firms that have demonstrated a belief in the value of carbon neutrality. Google has been carbon neutral since 2007, Microsoft since 2012, Salesforce since 2017, and Mckinsey and Company since 2018.[211] Carbon neutrality today is a global phenomenon—in 2015, with the support of IKEA, Marks & Spencer's, Microsoft, and numerous others, the United Nations launched "Climate Neutral Now," a scheme that encourages governments, companies, and individuals worldwide to measure their impact on the environment, reduce GHG emissions, and offset the remainder of their emissions.[212] Bank of America, Morgan Stanley, Siemens, and many others have committed to achieving carbon neutrality in the coming decades.[213]

Natural Capital Partners, a green consulting firms that has helped over 350 businesses in over 35 countries achieve carbon neutrality, asserts that carbon neutrality enables firms to:

- "Meet [their] stakeholders' demands and build [their] reputation by demonstrating climate and renewable energy leadership and standing out from [their] competitors

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[211] Dreyfuss, "How Google Keeps Its Power-Hungry Operations Carbon Neutral."
"Salesforce Achieves Net-Zero Greenhouse Gas Emissions The Company Now Provides a Carbon Neutral Cloud for All Customers."
McKinsey & Company, "Environmental Sustainability | McKinsey & Company."
[212] UNFCCC, "Go Climate Neutral Now."
[213] Bank of America, "Impact of Environmental Sustainability from Bank of America."
Morgan Stanley, "Morgan Stanley Announces New Goal of Carbon Neutrality for Global Operations by 2022."
Siemens, "Siemens Is Going Carbon Neutral by 2030."

- Anticipate and reduce climate risks and costs to the business associated with policy and energy price alterations
- Generate revenue and increase market share by differentiating products and services with a powerful statement of environmental credentials
- Drive demand for renewable energy around the world and direct carbon finance to parts of the globe where it is most needed and most effective
- Engage staff and attract new talent with an authentic and compelling climate action programme
- Encourage suppliers and customers to take responsibility for their carbon emissions by demonstrating [their] own commitment."[214]

These benefits boil down to demonstrating climate leadership—going above-and-beyond compliance obligations to showcase sustainable values, inspire others to act, and limit the impacts of climate change. While this altruistic ambition should be celebrated, many firms worldwide have made a pivotal mistake by embracing carbon offsetting as a means for achieving carbon neutrality. Achieving carbon neutrality *via carbon offsetting* does not demonstrate climate leadership. It may be voluntary, but voluntary action only matters if it inspires others to follow suit and increases the probability of political or social changes that will bring society closer to a low-carbon future. Offsetting does not pave a path for others to follow; it depends on the limited coverage of carbon regulation, channels resources away from innovation, and perpetuates a false notion that individual

[214] Natural Capital Partners, "Why Become Carbon Neutral?"

action will solve climate change—that neutralizing one's individual carbon footprint fulfills one's responsibility to the environment and society. If firms want to demonstrate climate leadership, a first step would be to stop offsetting.

Offsetting Depends on the Limited Coverage of Carbon Regulation

Offsets, by definition, must be generated by emissions reductions that occur outside the coverage of a GHG regulatory regime. For firms to achieve carbon neutrality via offsetting, therefore, GHG regulation must be limited in scope, leaving an unregulated pool of emissions that can be mitigated. Not only does this mean that the commercial benefits of achieving carbon neutrality via offseting come at the expense of greater overall emissions,[215] but it also prevents a segment of the population (offset producers) from following in the footsteps of firms that achieve carbon neutrality via offsetting.

If GHG regulation were to expand to cover currently unregulated sectors, higher offset prices would exclude more firms from achieving carbon neutrality via offsetting. Today, GHG regulation covers a very small proportion of all firms, so most potential emissions reductions are outside GHG regulatory regimes and can count as offsets. Since offsets are plentiful, they remain cheap. As GHG regulation expands, however, the pool

[215] If the emissions of a sector currently generating offsets were regulated, that sector's overall emissions would decrease because all firms would seize available emissions reductions, not just those participating in offsetting. Once offsetting begins, however, the political economy of expanding the scope of GHG regulation may decrease; Once offset buyers have picked unregulated firms' low-hanging fruit, the cost of compliance, if GHG regulation were to expand to include unregulated firms, increases for them. It is therefore only natural for unregulated firms to fight expansions to GHG regulation, preferring to sell easy, voluntary reductions as offsets rather than face the difficulty of achieving deeper, mandatory reductions.

of potential offsets will shrink, driving up their prices.[216] As more offset-producing activities become mandatory, offset production will have to shift to more difficult, expensive emissions-reducing activities, further increasing offset prices. When offsetting becomes more expensive, the cost of staying carbon neutral will also rise. Neutrality might be an attractive option at $2.90 per ton CO_2,[217] but at $30? or $50? Carbon neutrality via offsetting will become unattainable for the average person or business. The status will reflect wealth, not sustainable values, and many will abandon it.

Wealthy institutions may argue that expensive expressions of sustainable values for their own sake are valuable because they raise awareness and draw attention to the issue of climate change, inspiring onlookers to behave more sustainably in their own lives. They may be right, but negative impacts are just as likely. Onlookers may feel disempowered—not only can they not afford to follow suit, but they also gain no actionable knowledge they can apply in their own lives and operations. Alternatively, onlookers may be so impressed that they think that the solutions to climate change are already in hand, or at least that climate change is in more capable hands than theirs. At best, they may take the mental license to free-ride and do nothing. At worst, they may rebound and behave less sustainably. Expensive projects are indeed necessary to reduce the impacts of climate change, but the expense is only justified if it points the way to

[216] Every newly-regulated firm will count available emissions reductions toward their personal compliance goals, and any excess reductions will sell as allowances, not offsets. For firms whose emissions are completely covered by market-based mechanisms like cap-and-trade, carbon neutrality becomes completely meaningless—they have already internalized the cost of their emissions.

[217] The average price of voluntary offsets in North America in 2016 (Hamrick and Gallant, “Unlocking Potential.”).

collective action or innovation, not if its best intention is to inspire admiration and vague awareness of climate change.

Channeling Resources Away from Innovation

The cost of offsetting, however large or small, channels resources away from investment in technological innovation necessary to reach a zero-carbon future. Achieving carbon neutrality via offsetting is often assumed to buy time for technological advancement that will bring down the cost of real operational changes. Yet offsetting consumes time and financial resources, distracting from efforts to cut operational emissions from within.

Some of the most widely produced types of offsets, utilized by Google, Harvard, and numerous firms in the CCM, come from methane destruction for which the essential technology and expertise already exist. Deep, meaningful cuts to business-as-usual CO_2 emissions will require new technological solutions that are only deferred by offsetting. For institutions like universities that feel an ethical imperative and see a competitive advantage in showing climate leadership, achieving carbon neutrality via offsetting rather than striving to mitigate their own business-as-usual emissions is an easier, cheaper path to social appeal that slows progress toward an emissions-free future.

Deep changes to business-as-usual emissions can be difficult and expensive, and they may not shine as bright as fulfilled neutrality goals, but being a climate leader means acknowledging difficulty and publicly owning the rate of progress at the frontier of innovation. Carbon neutrality via offsetting may seem like an active contribution to climate change mitigation, but beneath the veneer of voluntary action, carbon neutrality achieved via offsetting expresses a deeper bias toward passivity, whereby firms take action to meet personal goals, then wait for others to develop low-cost solutions for society.

Individual Action and Collective Action

Instead of facilitating collective action, achieving carbon neutrality via offsetting perpetuates the false notion that neutralizing individual emissions satisfies one's responsibility to society and the environment. Climate change demands broad, continuous participation. When firms announce that they have achieved carbon neutrality via offsetting, they send a message that they have done their part for the environment, indeed, that they have gone above-and-beyond, but they have not. When individuals utilize the United State Postal Service's carbon-neutral shipping or offset the emissions from their transatlantic flight, they may feel that they have absolved themselves of their responsibility to the environment and one another, but they have not. As Gernot Wagner and Martin Weitzman once wrote, "Reducing your own carbon footprint to zero is a noble gesture, but it's less than a drop in the bucket. Quite literally: the standard U.S. bucket holds about 300,000 drops; but you are one in over 300,000,000 as an American, and you are one in seven billion as a human being."[218]

Neutralizing the emissions of an individual is not enough to change the emissions-intense infrastructure of society. Neither is neutralizing the emissions of an entire business, or a country. Does all of this mean that companies, universities, and individuals

[218] Wagner and Weitzman, "The Planet Won't Notice You Recycle, and Your Vote Doesn't Count."

should stop reducing their carbon footprints? Absolutely not. But climate leaders must look beyond self-important goals, judging the value of individual actions by their ability to inspire others to follow and promote changes throughout society. When carbon neutrality changes from an individual pursuit to a cascade of collective action, climate leaders will contribute more than drops in a bucket.

Appendix I

Risk Category	Risk Type	Description
Financial	Financial Failure Leading to Bankruptcy	Financial failure can lead to bankruptcy and/or alternative management decisions to generate income that result in reversals through over-harvesting or conversion
Management	Illegal Harvesting	Loss of project stocks due to timber theft
	Conversion to Non-Forest Uses	Alternative land uses are exercised at project carbon expense
	Over-Harvesting	Exercising timber value at expense of project carbon
Social	Social Risks	Changing government policies, regulations, and general economic conditions
Natural Disturbance	Wildfire	Loss of project carbon through wildfire
	Disease/Insects	Loss of project carbon through disease and/or insects
	Other Episodic Catastrophic Events	Loss of project carbon from wind, snow and ice, or flooding events

Figure 2.3

Table D.2. Financial Risk

Project Specific Circumstances	Contribution to Reversal Risk Rating
Forest project with a qualified conservation easement	1%
Forest project on public or tribal lands	1%
Forest project without a qualified conservation easement and not on public or tribal lands	5%

Figure 2.4

ODS Name	Atmospheric Residence Time (Years)	100 Year Global Warming Potential (IPCC AR4)
CFC-11	45	4,750
CFC-12	100	10,900
CFC- 13	640	16,400
CFC-113	85	6,130
CFC-114	300	8,730
HFC-23	270	14,800
HFC-32	4.9	675
HFC-125	29	3,500
HFC-134a	14	1,430
HFC-143a	52	4,470
HFC-152a	1.4	124
HFC-227ea	34.2	3,220
HFC-236fa	240	9,810
HFC-245fa	7.6	314
HFC-365mfc	8.6	241
HFC-43-10mee	15.9	1,640
HCFC-22	12	1,810
HCFC-123	1.3	77
HCFC-124	5.8	609
HCFC-141b	9.3	220
HCFC-142b	17.9	2,310
HCFC-225ca	1.9	37
HCFC-225cb	5.8	181

Figure 2.6[219]

[219] IPCC, 2013

HFCs that may replace HCFC-22	IPCC AR4 2007 GWP100
HFC-32	675
HFC-134a	1430
R-407C	1744
R-507	3985
R-404A	3922
R-410A	2088
R-422D	2729
R-407F	1824

Figure 2.7[220]

TABLE 2. Costs, revenues and net present value of a digester project producing pipeline-injectable natural gas, per participating farm

Costs	Capital cost	Annual O&M cost
Scrape conversion	$696,000	$21,000
Digester	$2,905,000	$174,000
Pipeline (low pressure)	$75,000	$4,000
Pipeline (transmission)	$104,000	$5,000
Low NOx truck purchase	$140,000	—
Manure hauling	—	$95,000
Interconnection	$849,000	$30,000
Upgrading the biogas*	—	$258,000
CNG station (small fleet)	$23,000	$2,000
Total cost	**$4,792,000**	**$588,000** ‡
Revenue		**Annual revenue**
Fuel sales ($3.46/1,000 ft^3)	—	$149,000
RINs ($1.85/credit)	—	$1,060,000
LCFS credits ($100/credit)	—	$865,000
Total revenue	—	$2,074,000
Net present value†	—	**$6,203,000**

* Capital cost for upgrading biogas is embedded in the O&M cost.
† Present value calculations assume a 10-year life for the project, a 7% interest rate for amortizing capital cost and a 5% discount rate for future revenues.
‡ Total differs from sum of values above due to rounding.
Source: CARB (2017), Table 14 of Appendix F.

Figure 2.8

[220] IPCC, 2007 cited by Honeywell, "Guide to Alternative Refrigerants." Devotta et al., "Alternatives to HCFC-22 for Air Conditioners."

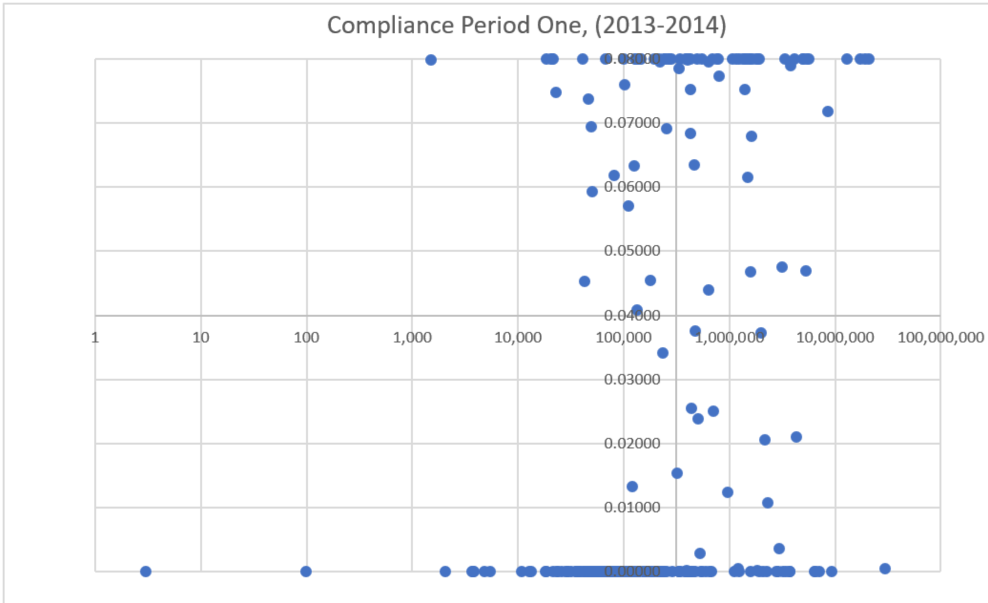

Figure 3.2

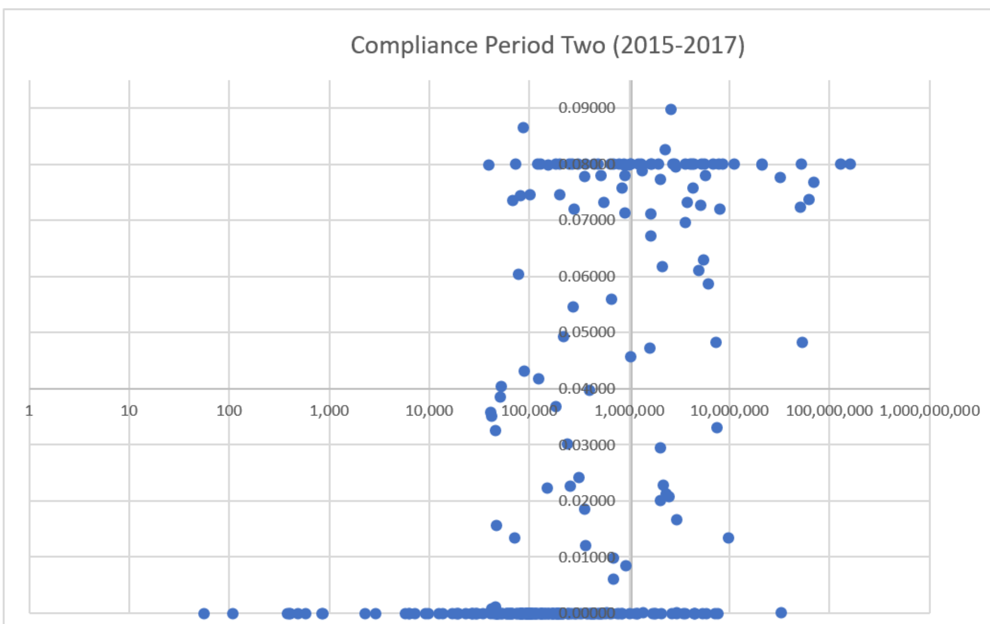

Figure 3.3

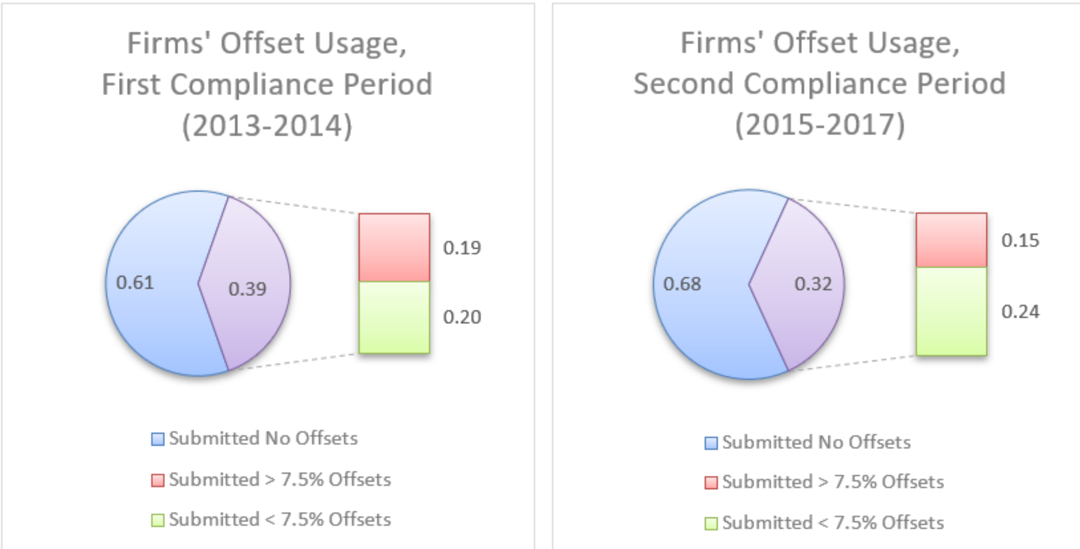

Figure 3.5

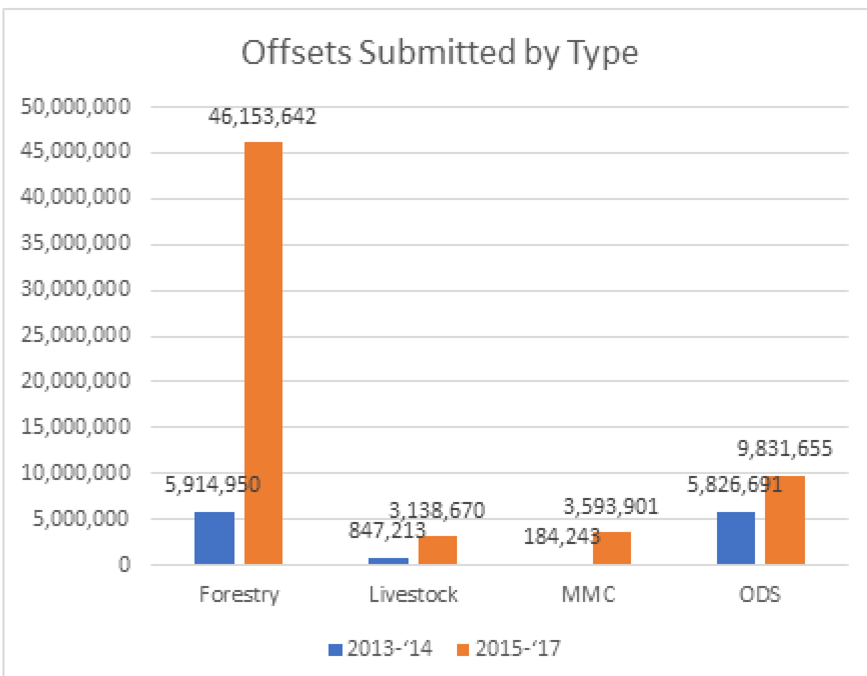

Figure 3.6

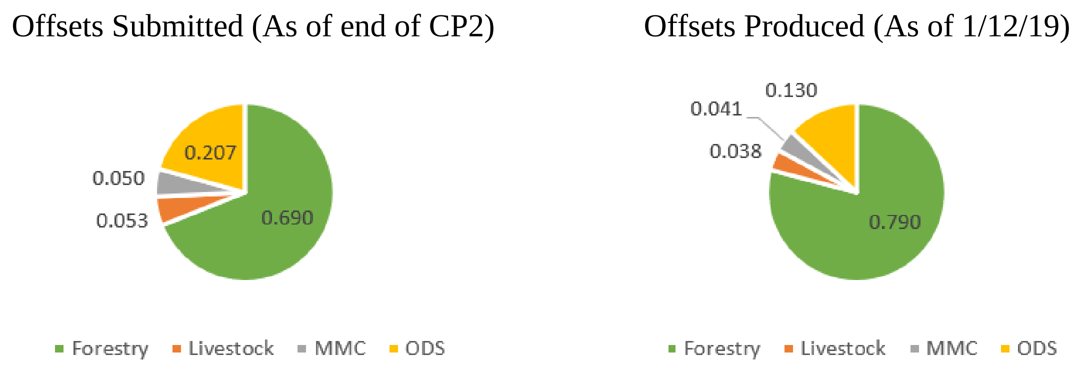

Figure 3.7

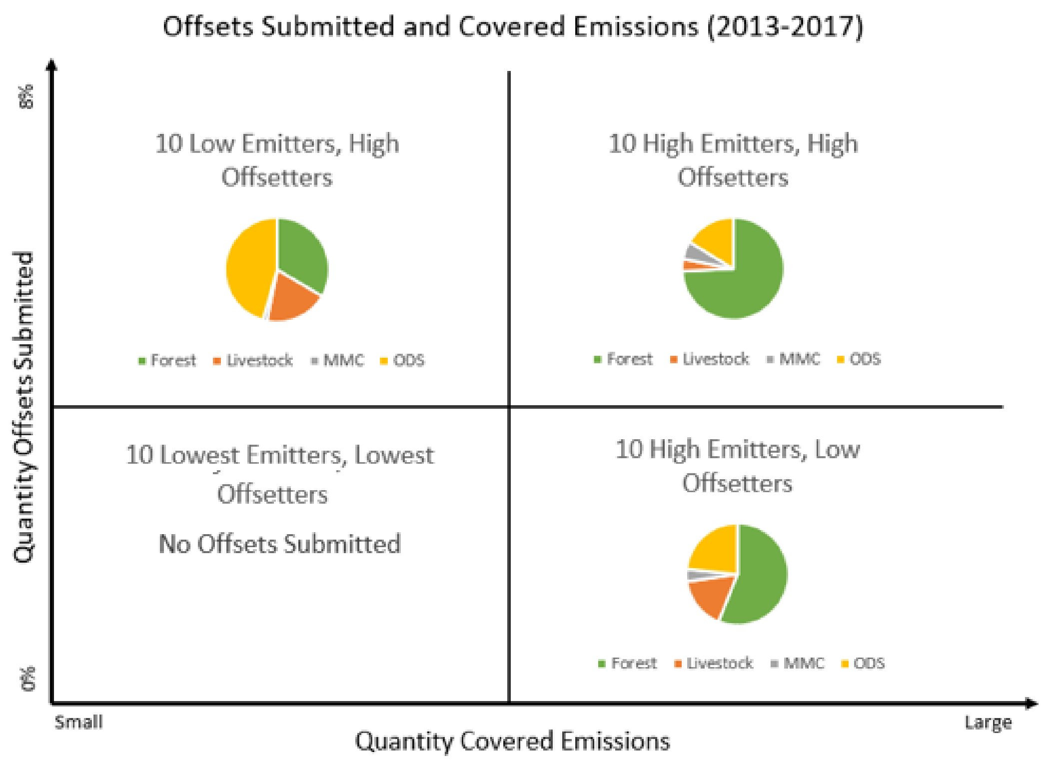

Figure 3.8[221]

[221] HOHO Firms: Tesoro, Chevron, Phillips 66, Southern California Gas, Shell, Pacific Gas and Electric, Valero, Calpine, PBF Energy Western, British Petroleum

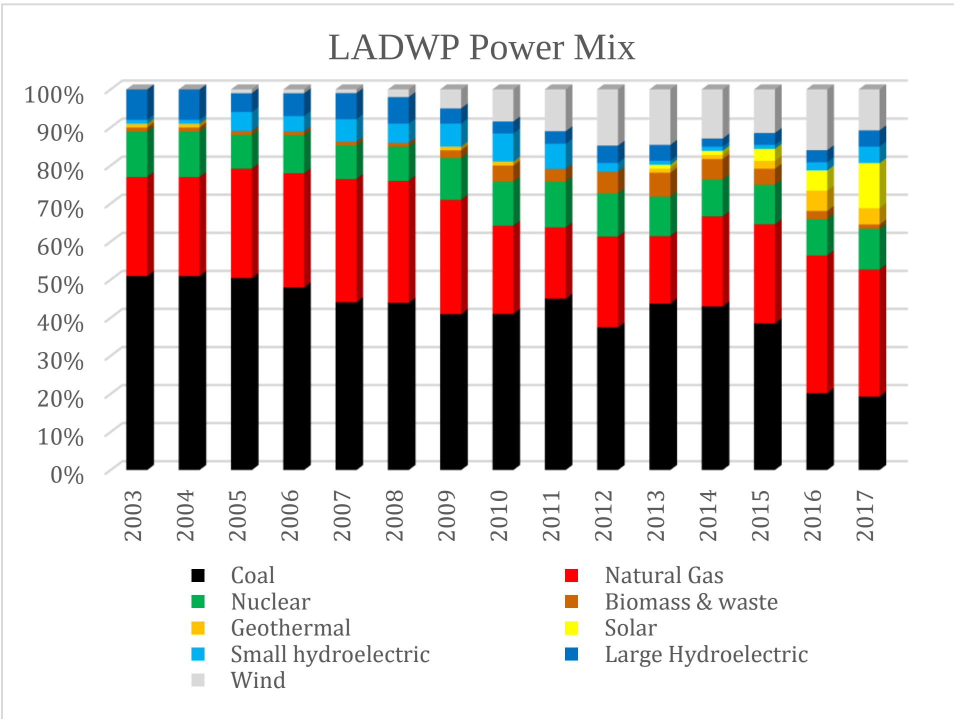

Figure 3.10

LEHO firms: CP Energy Marketing, Valley Electric, Mizkan America, Bridge Energy, Crimson Resource Management, Orange Groves, McKittrick Ltd., Chalk Cliff Limited, Ferrellgas L.P., Portland General Electric

LELO firms: precise firm choice does not matter since numerous small emitters submit zero offsets

HELO firms: LADWP, Aera Energy, Sacramento Municipal Utility District, San Diego Gas an Electric, Lehigh Southwest Cement, City of Anaheim, Kern Oil and Refining, Imperial Irrigation District, Searles Valley Minerals, Exxon Mobile

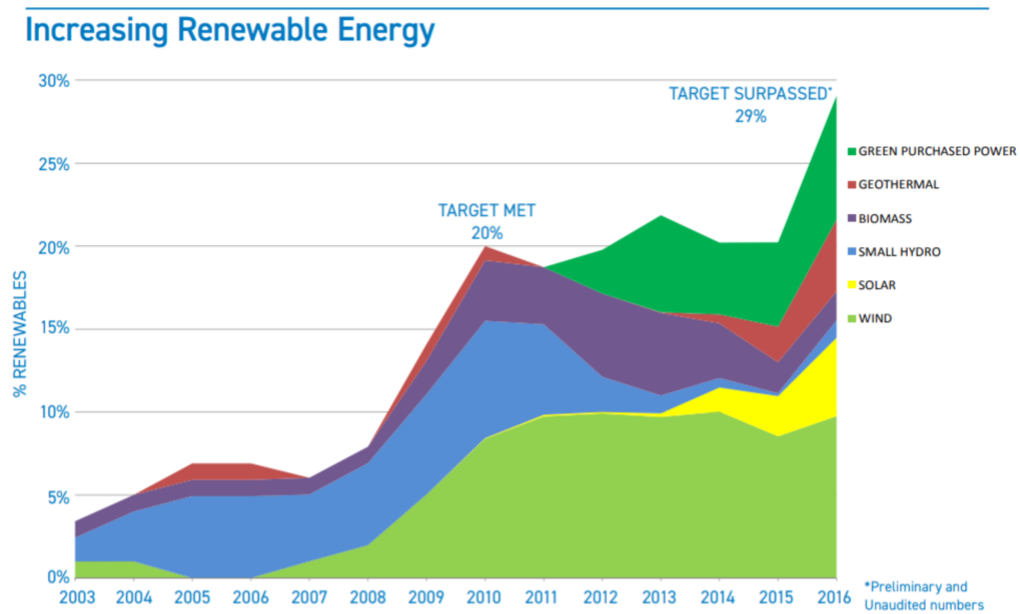
Increasing Renewable Energy
30%
25%
20%
15%
10%
5%
0%
% RENEWABLES
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
TARGET MET
20%
TARGET SURPASSED*
29%
GREEN PURCHASED POWER
GEOTHERMAL
BIOMASS
SMALL HYDRO
SOLAR
WIND
*Preliminary and
Unaudited numbers

Figure 3.11

Appendix II

Potential Offset Revenue per 1000 ft^3 Methane Destroyed to Produce Offsets:

By dividing the total number offsets issued since the protocol was adopted (5,863,008) by the total number of years the 13 projects listed by CARB have been operating (47 years), the average number of offsets per year per project as found to be 124,775 offsets.[222]

Offset prices began at approximately $11 in 2013 and have risen to approximately $14, so $12 was chosen as a conservative estimate of the average offset price, while $30,000 was used as a high estimate for the verification and other transaction costs associated with developing an offset project (excluding capital costs).

This yields the expected revenue of an offset project:

(124,775 * $12) - $30,000 = $1,467,300

By dividing the expected revenue by the number of offsets, the average revenue per offset can then be found:

$1,467,300 / 124,775 = $11.76 per offset

This value can then be used to find the average value of destroying 1000 cubic feet of methane and selling the resulting emissions reductions as MMC offsets.

$$1000\ ft^3 CH4 * \frac{1085\ kJ}{1\ ft^3\ CH4} * \frac{1\ MJ}{1000\ kJ} * \frac{1\ kg\ CH4}{55\ MJ} * \frac{1000g}{1kg} * \frac{21\ g\ CO2}{1g\ CH4} * \frac{1\ tonne\ CO2}{1{,}000{,}000g\ CO2} * \frac{\$11.76}{1\ tonne\ CO2}$$
= $4.87

CO_2 created via combustion:

$$1000\ ft^3 CH4 * \frac{1085\ kJ}{1\ ft^3\ CH4} * \frac{1\ mole\ CH4}{810\ kJ} * \frac{1\ mole\ CO2}{1\ mole\ CH4} * \frac{1\ tonne\ CO2}{22{,}730\ moles\ CO2} * \frac{\$11.76}{1\ tonne\ CO2}$$

= $0.69

Estimated Average Offset Revenue per 1000 ft^3 Destroyed Methane: $4.87 – 0.69 =

$4.18

[222] CARB, "Compliance Offset Program."

Bibliography

AgSTAR. "Market Opportunities for Biogas Recovery Systems at U.S. Livestock Facilities." US EPA, June 2018. https://www.epa.gov/sites/production/files/2018-06/documents/epa430r18006agstarmarketreport2018.pdf.

American Carbon Registry. "Hybrid Additionality Approach." Accessed March 11, 2019. https://americancarbonregistry.org/carbon-accounting/old/carbon-accounting/documents/Additionality%20Criteria.pdf/.

American Carbon Registry. "Methodology for the Quantification, Monitoring, Reporting and Verification of Greenhouse Gas Emissions Reductions and Removals From Afforestation and Reforestation of Degraded Land Version 1.2," 2017. https://americancarbonregistry.org/carbon-accounting/standards-methodologies/afforestation-and-reforestation-of-degraded-lands/acr-ar-of-degraded-land-v1-2-2017.pdf

American Carbon Registry. "Rice Management Systems," 2013. https://americancarbonregistry.org/carbon-accounting/standards-methodologies/emission-reductions-in-rice-management-systems.

"Annual Information Form Capital Power Corporation 2012." Capital Power, March 14, 2013. https://www.capitalpower.com/InvestorRelations/FinancialReporting/Other_Documents/2012%20Annual%20Information%20Form.pdf.

"Annual Information Form Capital Power Corporation 2014." Capital Power, March 4, 2015. https://www.capitalpower.com/InvestorRelations/FinancialReporting/Other_Documents/2014%20Annual%20Information%20Form.PDF.

Archer, David, and Victor Brovkin. "The Millennial Atmospheric Lifetime of Anthropogenic CO2." *Climatic Change* 90, no. 3 (October 2008): 283–97. https://doi.org/10.1007/s10584-008-9413-1.

Bank of America. "Impact of Environmental Sustainability from Bank of America." About Bank of America. Accessed March 12, 2019. https://about.bankofamerica.com/en-us/what-guides-us/environmental-sustainability-operations-and-employees.html.

Barringer, Felicity. "In California, a Grand Experiment to Rein in Climate Change - The New York Times." *The New York Times*. Accessed March 11, 2019. https://www.nytimes.com/2012/10/14/science/earth/in-california-a-grand-experiment-to-rein-in-climate-change.html.

Bennett, Karen. “Additionality: The Next Step for Ecosystem Service Markets.” *Duke Environmental Law & Policy Forum* 20 (2010): 417.

California Air Resources Board [CARB]. “Compliance Offset Program.” Accessed March 11, 2019. https://www.arb.ca.gov/cc/capandtrade/offsets/offsets.htm.

Cannell, Melvin G. R. “Carbon Sequestration and Biomass Energy Offset: Theoretical, Potential and Achievable Capacities Globally, in Europe and the UK.” *Biomass and Bioenergy* 24, no. 2 (February 1, 2003): 97–116. https://doi.org/10.1016/S0961-9534(02)00103-4.

CARB, “Compliance Offset Program,” accessed March 11, 2019, https://www.arb.ca.gov/cc/capandtrade/offsets/offsets.htm.

CARB. “20130419 Guidance Document Chapter 3: What Does My Company Need to Do to Comply with the Cap-And-Trade Regulation?,” April 2013. https://www.arb.ca.gov/cc/capandtrade/guidance/20130419%20Guidance%20Document%20Ch%203%20posting.pdf.

CARB. “2013-2014 Compliance Report,” March 21, 2016. https://www.arb.ca.gov/cc/capandtrade/2013-2014compliancereport.xlsx.

CARB. “2014-2017 Compliance Report,” December 18, 2018. https://www.arb.ca.gov/cc/capandtrade/2015-2017compliancereport.xlsx.

CARB. “California Air Resources Board’s Process for the Review and Approval of Compliance Offset Protocols in Support of the Cap-and-Trade Regulation.” Accessed March 11, 2019. https://www.arb.ca.gov/cc/capandtrade/compliance-offset-protocol-process.pdf.

CARB. “Cap-and-Trade Regulation Instructional Guidance, CHAPTER 1: HOW DOES THE CAP-AND-TRADE PROGRAM WORK?,” September 2012. https://www.arb.ca.gov/cc/capandtrade/guidance/chapter1.pdf#page=2.

CARB. “Climate Change Scoping Plan a Framework for Change,” December 2008. https://www.arb.ca.gov/cc/scopingplan/document/adopted_scoping_plan.pdf.

CARB. “Compliance Instrument Report.” Accessed March 12, 2019. http://www.arb.ca.gov/cc/capandtrade/complianceinstrumentreport.xlsx.

CARB. “Compliance Offset Protocol Livestock Projects.” Accessed March 12, 2019. https://www.arb.ca.gov/regact/2014/capandtrade14/ctlivestockprotocol.pdf.

CARB. “Compliance Offset Protocol Mine Methane Capture Projects.” Accessed March 12, 2019. https://www.arb.ca.gov/regact/2013/capandtrade13/ctmmcprotocol.pdf.

CARB. "Compliance Offset Protocol Ozone Depleting Substances Projects." Accessed March 11, 2019. https://www.arb.ca.gov/regact/2014/capandtrade14/ctodsprotocol.pdf.

CARB. "Compliance Offset Protocol Rice Cultivation Projects," June 25, 2015. https://www.arb.ca.gov/cc/capandtrade/protocols/rice/riceprotocol2015.pdf.

CARB. "Compliance Offset Protocol U.S. Forest Projects," June 25, 2015. https://www.arb.ca.gov/cc/capandtrade/protocols/usforest/forestprotocol2015.pdf.

CARB. "LCFS Credit Trading Activity Reports." Accessed March 12, 2019. https://www.arb.ca.gov/fuels/lcfs/credit/lrtcreditreports.htm.

CARB. "Local Government Actions for Climate Change," December 2018. https://www.arb.ca.gov/cc/localgovernment/localgovernment.htm.

CARB. "Proposed Regulation to Implement the California Cap-and-Trade Program PART IV STAFF REPORT AND COMPLIANCE OFFSET PROTOCOL LIVESTOCK MANURE (DIGESTER) PROJECTS." California Environmental Protection Agency, October 28, 2010. https://www.arb.ca.gov/regact/2010/capandtrade10/cappt4.pdf.

CARB. "Short-Lived Climate Pollutant Reduction Strategy," March 14, 2017. https://www.arb.ca.gov/cc/shortlived/meetings/03142017/final_slcp_report.pdf.

CARB. "Technical Guidance for Offset Verifiers Verification of Offset Project Data Reports," October 2013. https://www.arb.ca.gov/cc/capandtrade/offsets/offset-verification-guidance.pdf.

"CDM: CDM-Home." Accessed March 11, 2019. https://cdm.unfccc.int/.

Chomitz, Kenneth. "Evaluating Carbon Offsets from Forestry and Energy Projects: How Do They Compare?" The World Bank, November 30, 1999. https://doi.org/10.1596/1813-9450-2357.

"City of Colton Climate Action Plan." City of Colton, November 3, 2015. http://ca-colton.civicplus.com/DocumentCenter/View/2774.

"City of Colton Electric Department 2017 Integrated Resource Plan." City of Colton Electric Department. Accessed March 12, 2019. http://www.coltononline.com/DocumentCenter/View/3495.

Climate Action Reserve. "Criteria for Protocol Development : Climate Action Reserve." Accessed March 11, 2019. http://www.climateactionreserve.org/how/future-protocol-development/criteria/.

Climate Action Reserve. "Grassland Project Protocol." Accessed March 11, 2019. http://www.climateactionreserve.org/how/protocols/grassland/.

Climate Action Reserve. "Rice Cultivation Project Protocol," 2013. http://www.climateactionreserve.org/how/protocols/rice-cultivation/.

Colchester, Marcus. "Beyond Tenure: Rights-Based Approaches to Peoples and Forests Some Lessons from the Forest Peoples Programme," 2008. http://www.forestpeoples.org/sites/default/files/publication/2011/01/beyondtenure2008marcusfpprrieng.pdf.

Cooper, Lauren. "ICAO and Forest Offsets: Substantial Opportunities and Exceptional Benefits (Commentary)." Mongabay Environmental News, March 2, 2018. https://news.mongabay.com/2018/03/icao-and-forest-offsets-substantial-opportunities-and-exceptional-benefits-commentary/.

"COP24: Key Outcomes Agreed at the UN Climate Talks in Katowice." CarbonBrief, December 16, 2018. https://www.carbonbrief.org/cop24-key-outcomes-agreed-at-the-un-climate-talks-in-katowice.

"CORE: Chicago Climate Exchange." Accessed March 11, 2019. http://www.co2offsetresearch.org/policy/CCX.html.

Coren, Michael J., Charlotte Streck, and Erin Myers Madeira. "Estimated Supply of RED Credits 2011–2035." *Climate Policy* 11, no. 6 (November 1, 2011): 1272–88. https://doi.org/10.1080/14693062.2011.579318.

Cotula, Lorenzo, and James Mayers. *Tenure in REDD: Start-Point Or Afterthought?* IIED, 2009.

Davidson, Eric A., and Ivan A. Janssens. "Temperature Sensitivity of Soil Carbon Decomposition and Feedbacks to Climate Change." *Nature*, March 9, 2006, 165–73.

Devotta, S., A. V. Waghmare, N. N. Sawant, and B. M. Domkundwar. "Alternatives to HCFC-22 for Air Conditioners." *Applied Thermal Engineering* 21, no. 6 (April 1, 2001): 703–15. https://doi.org/10.1016/S1359-4311(00)00079-X.

Dornburg, Veronika, and Gregg Marland. "Temporary Storage of Carbon in the Biosphere Does Have Value for Climate Change Mitigation: A Response to the Paper by Miko Kirschbaum," January 2008. https://link.springer.com/article/10.1007/s11027-007-9113-6.

Dreyfuss, Emily. "How Google Keeps Its Power-Hungry Operations Carbon Neutral." *Wired*, December 1, 2018. https://www.wired.com/story/how-google-keeps-power-hungry-operations-carbon-neutral/.

"Explosion of HFC-23 Super Greenhouse Gases Is Expected." EIA International, June 24, 2013. https://eia-international.org/explosion-of-super-greenhouse-gases-expected-over-next-decade/.

Fahrenthold, David. “Caps, Trades and Offsets: Can Climate Plan Work?” *Washington Post*, May 26, 2009. http://www.washingtonpost.com/wp-dyn/content/article/2009/05/25/AR2009052502264.html.

Food and Agriculture Organization of the United Nations. “REDD+ Reducing Emissions from Deforestation and Forest Degradation.” FAO.org. Accessed March 12, 2019. http://www.fao.org/redd/countries/en/.

Galik, Christopher S., and Robert B. Jackson. “Risks to Forest Carbon Offset Projects in a Changing Climate.” *Forest Ecology and Management* 257, no. 11 (May 2009): 2209–16. https://doi.org/10.1016/j.foreco.2009.03.017.

Galik, Christopher S., Brian C. Murray, Stephen Mitchell, and Phil Cottle. “Alternative Approaches for Addressing Non-Permanence in Carbon Projects: An Application to Afforestation and Reforestation under the Clean Development Mechanism.” *Mitigation and Adaptation Strategies for Global Change* 21, no. 1 (January 1, 2016): 101–18. https://doi.org/10.1007/s11027-014-9573-4.

George E. Hays, Michael A. Costa. “First Amended Petition for Writ of Mandate and Complaint for Declaratory and Injunctive Relief; Verifications”. Superior Court of California Country of San Francisco. April 27, 2012. http://citizensclimatelobby.org/files/images/AB32AmendedComplaint42712.pdf

Gero, Gary. “The Role of Carbon Offsets in Cap-and-Trade.” presented at the U.S. EPA SF6 Emission Reduction Partnership Meeting, Chicago, June 2, 2009. https://www.epa.gov/sites/production/files/2016-02/documents/gero_carr_at_epa.pdf.

“Global Energy & CO2 Status Report.” Accessed March 12, 2019. https://www.iea.org/geco/emissions/.

Gonzalez, Gloria. “Invalidation Risk Still Shadows California Offsets Market.” Ecosystem Marketplace. Accessed March 12, 2019. http://www.ecosystemmarketplace.com/articles/invalidation-risk-still-shadows-california-offsets-market/.

Griffiths, Tom. “Seeing ‘RED’? ‘Avoided Deforestation’ and the Rights of Indigenous Peoples and Local Communities.” Forest Peoples Programme, June 2007. https://www.forestpeoples.org/sites/default/files/publication/2010/01/avoideddeforestationredjun07eng_0.pdf.

Hamrick, Kelley, and Melissa Gallant. “Unlocking Potential: State of the Voluntary Carbon Markets 2017,” 2017. https://www.forest-trends.org/wp-content/uploads/2017/07/doc_5591.pdf.

Hamrick, Kelley, and Melissa Gallant. “Voluntary Carbon Markets Insights: 2018 Outlook and First-Quarter Trends,” 2018. https://www.forest-trends.org/wp-content/uploads/2018/09/VCM-Q1-Report_Full-Version-2.pdf.

Hamshaw, Billy. “California Carbon Info: Analyzing California’s Offset Demand.” *Stillwater Associates* (blog), September 14, 2017. https://stillwaterassociates.com/california-carbon-info-analyzing-californias-offset-demand/.

Harding, Matthew, and David Rapson. “Do Voluntary Carbon Offsets Induce Energy Rebound? A Conservationist’s Dilemma,” 2013, 47. https://pdfs.semanticscholar.org/a7cc/024b4fda64f374b2db6a454c0373f542f852.pdf

“How Many Pounds of Freon or Refrigerant, Does an AC or Heat Pump Need?” Charlotte HVAC Guide, June 5, 2011. http://www.charlottehvacguide.com/guides/how-many-pounds-of-freon-or-refrigerant-does-an-ac-or-heat-pump-need/.

ICF International, Inc. “ODS Destruction in the United States and Abroad.” US EPA. Accessed March 12, 2019. https://www.epa.gov/sites/production/files/2018-03/documents/ods-destruction-in-the-us-and-abroad_feb2018.pdf.

“Implementing CA SB 1383: Dairy Methane Reduction.” Dairy Cares, April 2017. https://www.dairycares.com/dairymethanereduction.

“International Carbon Action Partnership (ICAP).” International Carbon Action Partnership. Accessed March 12, 2019. https://icapcarbonaction.com.

IPCC, 2007: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 996 pp. https://www.ipcc.ch/site/assets/uploads/2018/05/ar4_wg1_full_report-1.pdf

IPCC, 2013: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1535 pp, doi:10.1017/CBO9781107415324.https://www.ipcc.ch/site/assets/uploads/2018/02/WG1AR5_Chapter08_FINAL.pdf

Jacobson, Michael G, Thomas J Straka, John L Greene, Michael A Kilgore, and Steven E Daniels. “Financial Incentive Programs’ Influence in Promoting Sustainable Forestry in the Northern Region.” *NORTH. J. APPL. FOR.*, 2009, 7. https://srs.fs.fed.us/econ/data/forestincentives/jacobson-etal-njaf0609.pdf

Jagadeesh Babu, Y., C. Li, S. Frolking, D. R. Nayak, and T. K. Adhya. “Field Validation of DNDC Model for Methane and Nitrous Oxide Emissions from Rice-Based

Production Systems of India,” 2006. Nutrient Cycling in Agroecosystems 74 (2): 157–74. https://doi.org/10.1007/s10705-005-6111-5.

JI. “JI ERU Issuance.” Accessed March 11, 2019. http://ji.unfccc.int/statistics/2015/ERU_Issuance_2015_10_15_1200.pdf.

Jørgensen, Susanne V., and Michael Z. Hauschild. “Need for Relevant Timescales When Crediting Temporary Carbon Storage.” *The International Journal of Life Cycle Assessment* 18, no. 4 (May 1, 2013): 747–54. https://doi.org/10.1007/s11367-012-0527-3.

Katayanagi, Nobuko, Yuichiro Furukawa, Tamon Fumoto, and Yasukazu Hosen. “Validation of the DNDC-Rice Model by Using CH4 and N2O Flux Data from Rice Cultivated in Pots under Alternate Wetting and Drying Irrigation Management: Soil Science and Plant Nutrition: Vol 58, No 3.” Soil Science and Plant Nutrition 58, no. 3 (June 11, 2012): 360–72.

Kelly, Erin Clover, and Marissa Bongiovanni Schmitz. “Forest Offsets and the California Compliance Market: Bringing an Abstract Ecosystem Good to Market.” *Geoforum* 75 (October 2016): 99–109. https://doi.org/10.1016/j.geoforum.2016.06.021.

Kirschbaum, Miko. “Temporary Carbon Sequestration Cannot Prevent Climate Change.” *Mitigation and Adaptation Strategies for Global Change; Dordrecht* 11, no. 5–6 (September 2006): 1151–64. http://dx.doi.org.ezp-prod1.hul.harvard.edu/10.1007/s11027-006-9027-8.

Kollmuss, Anja, Helge Zink, and Clifford Polycarp. “A Comparison of Carbon Offset Standards,” 2008, 119. http://climatesolver.org/sites/default/files/pdf/making.pdf

Kotchen, Matthew J, William Landes, Peter Kim, Barbara Christiansen, Andrew J Hoffman, and Philip Auerswald. “Do Voluntary Carbon Offsets Help Counteract Greenhouse Gases, or Are They Just a Way for Guilt-Ridden Consumers to Buy Their Way out of Bad Feelings?,” n.d., 7.

“LADWP Power Supply Since 2003 | Los Angeles - Open Data Portal.” City of Los Angeles. Accessed March 12, 2019. https://data.lacity.org/A-Livable-and-Sustainable-City/LADWP-Power-Supply-Since-2003/hmiy-sxh5/data.

LADWP. “Briefing Book 2017-2018.” Accessed March 12, 2019. https://s3-us-west-2.amazonaws.com/ladwp-jtti/wp-content/uploads/sites/3/2017/09/08143247/Briefing-Book-Rolling-PDF.pdf.

LADWP. “Facts & Figures.” Accessed March 12, 2019. https://www.ladwp.com/ladwp/faces/ladwp/aboutus/a-power/a-p-factandfigures?_adf.ctrl-state=s3s89fyml_4&_afrLoop=3286345243477.

LADWP. “Greening the Grid.” Accessed March 12, 2019. https://ladwp.com/ladwp/faces/ladwp/aboutus/a-inourcommunity/a-ioc-goinggreen/a-ioc-gg-greeningthegrid?_adf.ctrl-state=o5vnthhd4_4&_afrLoop=60625903259239&_afrWindowMode=0&_afrWindowId=ut30tqisb_1#%40%3F_afrWindowId%3Dut30tqisb_1%26_afrLoop%3D60625903259239%26_afrWindowMode%3D0%26_adf.ctrl-state%3D1cpg97824u_46.

LADWP. “LADWP 2016 Power Content Label.” Accessed March 12, 2019. https://www.energy.ca.gov/pcl/labels/2016_labels/Los_Angeles_Department_of_Water_and_Power.pdf.

LADWP. “LADWP 2017 Power Content Label,” July 2018. https://www.energy.ca.gov/pcl/labels/2017_labels/LADWP_2017_PCL.pdf.

LADWP. “LADWP Facts and Figures.” Accessed March 12, 2019. https://planning.lacity.org/eir/CrossroadsHwd/deir/files/references/M420.pdf.

LADWP. “Renewables Portfolio Standard Policy and Enforcement Program,” December 2013. https://www.energy.ca.gov/portfolio/pous/ladwp/2013-12-03_LADWP_RPS_Policy_Enforcement_Program.pdf.

Lee, H., and D. Sumner. “Dependence on Policy Revenue Poses Risks for Investments in Dairy Digesters.” *California Agriculture* 72, no. 4 (December 17, 2018): 226–35.

Lemaitre, Sophie. “Indigenous Peoples’ Land Rights and REDD: A Case Study.” *Review of European Community & International Environmental Law* 20, no. 2 (2011): 150–62. https://doi.org/10.1111/j.1467-9388.2011.00716.x.

Levasseur, Annie, Pascal Lesage, Manuele Margni, Miguel Brandão, and Réjean Samson. “Assessing Temporary Carbon Sequestration and Storage Projects through Land Use, Land-Use Change and Forestry: Comparison of Dynamic Life Cycle Assessment with Ton-Year Approaches.” *Climatic Change* 115, no. 3 (December 1, 2012): 759–76. https://doi.org/10.1007/s10584-012-0473-x.

Lovell, Heather, and Diana Liverman. “Understanding Carbon Offset Technologies.” *New Political Economy* 15, no. 2 (June 1, 2010): 255–73. https://doi.org/10.1080/13563460903548699.

MacKenzie, Ian A., Markus Ohndorf, and Charles Palmer. “Enforcement-Proof Contracts with Moral Hazard in Precaution: Ensuring ‘permanence’ in Carbon Sequestration.” *Oxford Economic Papers* 64, no. 2 (2012): 350–74.

Majumdar, Deepanjan. “Methane and Nitrous Oxide Emission from Irrigated Rice Fields: Proposed Mitigation Strategies,” 2003. Current Science 84 (10): 1317–26. https://www.jstor.org/stable/24108463?seq=1#page_scan_tab_contents

Marks and Spencer. “On the Road to Carbon Reduction.” On the road to carbon reduction. Accessed March 11, 2019. http://corporate.marksandspencer.com/stories/blog/on-the-road-to-carbon-reduction.

Marland, Gregg, Kristy Fruit, and Roger Sedjo. “Accounting for Sequestered Carbon: The Question of Permanence.” *Environmental Science & Policy* 4, no. 6 (December 1, 2001): 259–68. https://doi.org/10.1016/S1462-9011(01)00038-7.

McCabe, Ann, and John Moore. “PJM’s Capacity Market Proposal: Bad for Customers, States, and the Fight against Climate Change.” Utility Dive. Accessed March 13, 2019. https://www.utilitydive.com/news/pjms-capacity-market-proposal-bad-for-customers-states-and-the-fight-ag/540723/.

McKinsey & Company. “Environmental Sustainability.” Accessed March 12, 2019. https://www.mckinsey.com/about-us/environmental-sustainability.

Meyers, Stephen. “Additionality of Emissions Reductions from Clean Development Mechanism Projects: Issues and Options for Project-Level Assessments,” July 1, 1999. https://doi.org/10.2172/760331.

Microsoft, “Commitment to Carbon Neutral – Microsoft Environment.” Accessed March 11, 2019. https://www.microsoft.com/en-us/environment/carbon.

Morgan Stanley. “Morgan Stanley Announces New Goal of Carbon Neutrality for Global Operations by 2022.” Accessed March 12, 2019. https://www.morganstanley.com/press-releases/morgan-stanley-announces-new-goal-of-carbon-neutrality-for-globa.

Moura Costa, Pedro, and Charlie Wilson. “An Equivalence Factor between CO2 Avoided Emissions and Sequestration – Description And Applications in Forestry.” *Mitigation and Adaptation Strategies for Global Change* 5, no. 1 (March 1, 2000): 51–60. https://doi.org/10.1023/A:1009697625521.

Mulkern, Anne. “Offsets Could Make Up 85% of Calif.’s Cap-And-Trade Program.” *New York Times*, August 8, 2011. https://archive.nytimes.com/www.nytimes.com/gwire/2011/08/08/08greenwire-offsets-could-make-up-85-of-califs-cap-and-tra-29081.html?pagewanted=2.

Murray, Brian C., and Prasad Kasibhatla. “Equating Permanence of Emission Reductions and Carbon Sequestration: Scientific and Economic Foundations for Policy Options.” SSRN Scholarly Paper. Rochester, NY: Social Science Research Network, December 1, 2013. https://papers.ssrn.com/abstract=2467567.

Murray, Brian C., Brent Sohngen, and Martin T. Ross. “Economic Consequences of Consideration of Permanence, Leakage and Additionality for Soil Carbon Sequestration Projects.” *Climatic Change* 80, no. 1–2 (2007): 127–43. http://dx.doi.org.ezp-prod1.hul.harvard.edu/10.1007/s10584-006-9169-4.

Murray, Brian, and Nicholas Rivers. "British Columbia's Revenue-Neutral Carbon Tax: A Review of the Latest 'Grand Experiment' in Environmental Policy." *Energy Policy* 86 (November 2015): 674–83. https://doi.org/10.1016/j.enpol.2015.08.011.

National Oceanic and Atmospheric Administration. "Ocean-Atmosphere CO2 Exchange." Accessed March 12, 2019. https://sos.noaa.gov/datasets/ocean-atmosphere-co2-exchange/.

Natural Capital Partners. "Why Become Carbon Neutral?" Carbon Neutral. Accessed March 12, 2019. https://www.carbonneutral.com/why.

"Natural Gas Prices - Historical Chart." Accessed March 12, 2019. https://www.macrotrends.net/2478/natural-gas-prices-historical-chart.

"News Releases Pre-IPO to 2019." Capital Power. Accessed March 12, 2019. https://www.capitalpower.com/MediaRoom/newsreleases/Pages/default.aspx.

Ocasio-Cortez, Alexandria. "Text - H.Res.109 - 116th Congress (2019-2020): Recognizing the Duty of the Federal Government to Create a Green New Deal." Webpage, February 12, 2019. https://www.congress.gov/bill/116th-congress/house-resolution/109/text.

Office of the Chief Investment Officer of the Regents of the UC. "Sustainable Investment Framework." Accessed March 12, 2019. https://www.ucop.edu/investment-office/_files/sustainable-investment-framework.pdf.

"Offsets Requirements | RGGI, Inc." Accessed March 11, 2019. https://www.rggi.org/allowance-tracking/offsets/requirements.

Palmer, Charles, Markus Ohndorf, and Ian A. MacKenzie. "Life's a Breach! Ensuring 'Permanence' in Forest Carbon Sinks under Incomplete Contract Enforcement." SSRN Scholarly Paper. Rochester, NY: Social Science Research Network, July 1, 2009. https://papers.ssrn.com/abstract=1434373.

Parrilla, Leslie. "Colton Pays $110,000 in Settlement with Disabled Man." San Bernardino Sun, January 16, 2015. http://www.sbsun.com/general-news/20150116/colton-pays-110000-in-settlement-with-disabled-man.

Persson, U Martin, Daniel J A Johansson, Christel Cederberg, Fredrik Hedenus, and David Bryngelsson. "Climate Metrics and the Carbon Footprint of Livestock Products: Where's the Beef?" *Environmental Research Letters* 10, no. 3 (March 1, 2015): 034005. https://doi.org/10.1088/1748-9326/10/3/034005.

Quebec Environment et Lutte contre les changements climatiques. "Offset Credits." Accessed March 11, 2019. http://www.environnement.gouv.qc.ca/changements/carbone/credits-compensatoires/index-en.htm.

Roberts, David. “California’s Huge Energy Decision: Link Its Grid to Its Neighbors, or Stay Autonomous?” Vox, July 31, 2018. https://www.vox.com/energy-and-environment/2018/7/31/17611288/california-energy-grid-regionalization-caiso-wecc-iso.

Rosenthal, Elisabeth. “Paying More for Flights Eases Guilt, Not Emissions - The New York Times,” November 17, 2009. https://www.nytimes.com/2009/11/18/science/earth/18offset.html.

“Salesforce Achieves Net-Zero Greenhouse Gas Emissions The Company Now Provides a Carbon Neutral Cloud for All Customers.” Salesforce.com. Accessed March 12, 2019. https://www.salesforce.com/company/news-press/press-releases/2017/04/170413/.

Sangree, Hudson. “CAISO Western RTO Expansion Bill Dies in Committee.” *RTO Insider*, September 1, 2018. https://www.rtoinsider.com/caiso-western-rto-99047/.

Schroeder, Heike. “Agency in International Climate Negotiations: The Case of Indigenous Peoples and Avoided Deforestation.” *International Environmental Agreements: Politics, Law and Economics* 10, no. 4 (December 1, 2010): 317–32. https://doi.org/10.1007/s10784-010-9138-2.

Sedjo, Roger, and Gregg Marland. “Inter-Trading Permanent Emissions Credits and Rented Temporary Carbon Emissions Offsets: Some Issues and Alternatives:” *Climate Policy* 3, no. 4 (2003): 435–44.

Shoemaker, J. K., D. P. Schrag, M. J. Molina, and V. Ramanathan. “What Role for Short-Lived Climate Pollutants in Mitigation Policy?” *Science* 342, no. 6164 (December 13, 2013): 1323–24. https://doi.org/10.1126/science.1240162.

Shoemaker, Julie K., and Daniel P. Schrag. “The Danger of Overvaluing Methane’s Influence on Future Climate Change.” *Climatic Change* 120, no. 4 (2013): 903–14. http://dx.doi.org.ezp-prod1.hul.harvard.edu/10.1007/s10584-013-0861-x.

Siemens. “Siemens Is Going Carbon Neutral by 2030.” Ctc_event. Accessed March 11, 2019. https://www.siemens.com/press/en/feature/2015/corporate/2015-09-co2-neutral.php.

Stickler, Claudia M., Daniel C. Nepstad, Michael T. Coe, David G. McGRATH, Hermann O. Rodrigues, Wayne S. Walker, Britaldo S. Soares-Filho, and Eric A. Davidson. “The Potential Ecological Costs and Cobenefits of REDD: A Critical Review and Case Study from the Amazon Region.” *Global Change Biology* 15, no. 12 (2009): 2803–24. https://doi.org/10.1111/j.1365-2486.2009.02109.x.

Stratus Consulting Inc. “Analysis of Equipment and Practices in the Reclamation Industry,” October 29, 2010. https://www.epa.gov/sites/production/files/2015-

08/documents/analysis_of_equipment_and_practices_in_the_reclamation_industry.pdf.

The Climate Trust. "The Gap between the Price for Allowances and Offsets Appears to Be Closing. Is This a Long Term Trend or a Short Term Phase?" Accessed March 12, 2019. https://climatetrust.org/the-gap-between-the-price-for-allowances-and-offsets-appears-to-be-closing-is-this-a-long-term-trend-or-a-short-term-phase/.

"Timeline of Actions on HFCs." US EPA, 2016. https://www.epa.gov/sites/production/files/2016-12/documents/timeline_of_actions_on_hfcs.pdf.

Timperley, Jocelyn. "Corsia: The UN's Plan to 'Offset' Growth in Aviation Emissions after 2020." Carbon Brief, February 4, 2019. https://www.carbonbrief.org/corsia-un-plan-to-offset-growth-in-aviation-emissions-after-2020.

UC Office of the President. "Carbon Neutrality at the University of California." Accessed March 12, 2019. https://regents.universityofcalifornia.edu/regmeet/sept17/b2.pdf.

UC Office of the President. "President Napolitano Proposes Tuition Freeze, New Systemwide Initiatives." University of California, December 3, 2013. https://www.universityofcalifornia.edu/press-room/president-napolitano-proposes-tuition-freeze-new-systemwide-initiatives.

UNFCCC. "Go Climate Neutral Now," September 22, 2015. https://unfccc.int/news/go-climate-neutral-now.

United Nation Framework Convention on Climate Change. "CDM: Approved Baseline and Monitoring Methodologies for Large Scale CDM Project Activities." Accessed March 11, 2019. https://cdm.unfccc.int/methodologies/PAmethodologies/approved.

United Nation Framework Convention on Climate Change. "The Kyoto Protocol Mechanisms," 2010. https://unfccc.int/sites/default/files/cdm_kpm2010.pdf.

United Nation Framework Convention on Climate Change. "Tool for the demonstration and assessment of additionality Version 07.0.0" https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-01-v5.2.pdf/history_view

United Nations Framework Convention on Climate Change. "Paris Agreement," 2015. https://unfccc.int/sites/default/files/english_paris_agreement.pdf.

United Nations International Civil Aviation Organization. "Resolution A39-3: Consolidated Statement of Continuing ICAO Policies and Practices Related to Environmental Protection – Global Market-Based Measure (MBM) Scheme." Accessed March 11, 2019. https://www.icao.int/environmental-protection/CORSIA/Documents/Resolution_A39_3.pdf.

"United States Code, 2013 Edition Title 42 - THE PUBLIC HEALTH AND WELFARE CHAPTER 85 - AIR POLLUTION PREVENTION AND CONTROL SUBCHAPTER VI - STRATOSPHERIC OZONE PROTECTION Sec. 7671g - National Recycling and Emission Reduction Program." U.S. Government Publishing Office, 2013. https://www.govinfo.gov/content/pkg/USCODE-2013-title42/html/USCODE-2013-title42-chap85-subchapVI-sec7671g.htm.

University of California. "A Brief History of the University of California." Accessed March 12, 2019. https://www.ucop.edu/academic-personnel-programs/programs-and-initiatives/faculty-resources-advancement/faculty-handbook-sections/brief-history.html.

University of California. "Agricultural Experiment Station." Accessed March 12, 2019. https://www.ucop.edu/academic-personnel-programs/programs-and-initiatives/faculty-resources-advancement/faculty-handbook-sections/agricultural-experiment-station.html.

University of California. "Carbon Neutrality Initiative." Accessed March 12, 2019. https://ucop.edu/carbon-neutrality-initiative/index.html.

University of California. "Sustainability." Accessed March 12, 2019. https://ucop.edu/carbon-neutrality-initiative/index.html.

University of California. "Sustainable Investment." Accessed March 12, 2019. https://www.ucop.edu/investment-office/sustainable-investment/index.html.

University of California. "The UC System." March 18, 2015. https://www.universityofcalifornia.edu/uc-system.

US EIA. "U.S. Natural Gas Wellhead Price (Dollars per Thousand Cubic Feet)," February 28, 2019. https://www.eia.gov/dnav/ng/hist/n9190us3m.htm.

US EPA, OAR. "Frequent Questions About Coal Mine Methane." Overviews and Factsheets. US EPA, December 8, 2015. https://www.epa.gov/cmop/frequent-questions.

US EPA, OAR. "Recent International Developments under the Montreal Protocol." Policies and Guidance. US EPA, July 15, 2015. https://www.epa.gov/ozone-layer-protection/recent-international-developments-under-montreal-protocol.

US EPA, OAR. "Stationary Refrigeration - Prohibition on Venting Refrigerants." Policies and Guidance. US EPA, October 8, 2015. https://www.epa.gov/section608/stationary-refrigeration-prohibition-venting-refrigerants.

US EPA, OAR. "Technicians and Contractors: Frequent Questions." Overviews and Factsheets. US EPA, August 5, 2015. https://www.epa.gov/ods-phaseout/technicians-and-contractors-frequent-questions.

US EPA. “Coal Mine Methane Country Profiles.” June 2015. https://www.globalmethane.org/documents/Toolsres_coal_overview_fullreport.pdf.

US EPA. “Coal Mine Methane Developments in the United States,” February 2018. https://www.epa.gov/sites/production/files/2018-03/documents/cmm_developments_in_the_us.pdf.

US EPA. “ODS Refrigerant Reclamation Totals by Year.” Accessed March 12, 2019. https://www.epa.gov/sites/production/files/2018-04/documents/ods_and_hfc_reclamation_tables.pdf.

US EPA. “Updates to the Section 608 Refrigerant Management Program.” November 2, 2016. https://www.epa.gov/sites/production/files/2016-11/documents/608_rule_webinar.pdf.

US EPA. “Webinar Market Incentives for U.S. Coal Mine Methane Projects.” September 2018. https://www.epa.gov/sites/production/files/2018-09/documents/cmop_webinar091218.pdf.

US Forest Service. “Agency Organization.” Accessed March 12, 2019. https://www.fs.fed.us/about-agency/organization.

Verra. “Approved VCS Methodology VM0003 v1.2: Methodology for Improved Forest Management Through Extension of Rotation Age,” August 29, 2013. https://verra.org/wp-content/uploads/2017/10/VM0003v1.2.pdf.

Verra. “VCS Standard v3.7,” June 21, 2017. https://verra.org/wp-content/uploads/2018/03/VCS_Standard_v3.7.pdf.

Wagner, Gernot, and Martin L. Weitzman. “The Planet Won’t Notice You Recycle, and Your Vote Doesn’t Count.” Salon. Accessed March 12, 2019. https://www.salon.com/2015/03/29/the_planet_wont_notice_you_recycle_and_your_vote_doesnt_count/.

Wara, M. W. and Victor, D. G. (2008). A realistic policy on international carbon offsets. Stanford University, Program on Energy and Sustainable Development, Working Paper 74, Stanford, USA https://fsi-live.s3.us-west-1.amazonaws.com/s3fs-public/WP74_final_final.pdf

“What Is REDD+?” The Forest Carbon Partnership Facility. Accessed March 12, 2019. https://www.forestcarbonpartnership.org/what-redd.

“What Size Central Air Conditioner Do I Need? A Short AC Guide.” ASM Heating and Air Conditioning Consultation Company, October 25, 2014. https://asm-air.com/asm-air-conditioning-blog/what-size-central-air-conditioner-for-my-house/.

Zhang, Siduo. "Air Quality and Community Health Impact of Animal Manure Management," 2011. http://www.ncceh.ca/sites/default/files/Air_Quality_and_Animal_Manure_Sept_2011.pdf.