AN ENERGY POLICY ESSAY

More Simplicity, Less Charisma

Improving the Effectiveness, Cost, and Fairness of California's Climate Agenda

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Executive Summary

Over the past several years, California's early-mover climate policy strategy has attracted considerable attention. This broad regulatory slate has included the nation's most ambitious Renewables Portfolio Standard (RPS) for electricity, vehicle, and building energy use rules that far exceed federal guidelines, and the much-discussed Global Warming Solutions Act of 2006, which takes a number of steps to lower California's carbon emissions.

Commonly known by its legislative moniker "AB 32," the Global Warming Solutions Act requires actions by state agencies to limit California's greenhouse gas (GHG) emissions to 1990 levels by the year 2020 through a platform of both regulatory and market-based measures. The rhetorical centerpiece of this program is a recently launched market-based cap-and-trade system for reducing carbon emissions. Yet, the majority of California's GHG emission reductions through 2020 are nevertheless expected to result from the implementation of existing regulatory policies, such as energy efficiency, renewables, and fuel standards.

California voters have sent a message of support for addressing climate change at the legislative level, when AB 32 was first passed, and then in direct democracy, when an initiative to suspend it was solidly defeated after a referendum that saw support from a broad swath of Californians: almost 40 percent support from the state's Republicans, over 60 percent support overall, and endorsements from both the Republican and Democratic candidates for governor.

In supporting AB 32, and then opposing its repeal, California's voters have clearly said they want California to take meaningful steps to address climate change. But

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implementing both AB 32 and other carbon-reduction regulations will incur real costs to Californians, and one state's actions alone will not have a meaningful change on global carbon emissions. And while California's use of the flexible cap-and-trade market mechanisms could improve upon existing conventional environmental regulatory measures in terms of effectiveness of emission reductions, cost, and fairness, the real costs of California's climate policy agenda as enacted today are still uncertain and remain little understood by California's voters.

California's regulatory agencies have spent considerable efforts to respond to stakeholder concerns and refine various program aspects over recent years. Moreover, in making our suggestions, we are not validating or criticizing the wisdom of California's voters in approving these programs—we are simply observing the reality of what these programs look like as the regulatory process has developed and suggesting the best way forward.

In this paper we argue that California's climate policy agenda needs to embrace the right regulatory tool for the right environmental problem if it is to accomplish its stated goals to both cost-effectively reduce California's own GHG emissions and act as a policy model for other jurisdictions. Namely, **to reduce the direct costs** of meeting AB 32's GHG emission-reduction targets, we suggest the following central reforms:

1. Increase compliance flexibility and lower costs by scaling back existing sector-specific regulatory mandates that have drifted far from their original environmental intent. One way to do this is to formally allow AB 32's more flexible cap-and-trade allowances to serve as alternative compliance mechanisms for them. This could be done without increasing the number of cap-and-trade allowances in circulation, thereby guaranteeing AB 32's desired GHG emission reductions. At minimum, any sector-specific regulation's "safety valve" compliance cost should be limited to a reasonable premium (perhaps double) from the current carbon price on AB 32's cap-and-trade market.

2. Substantially modify or repeal "technological unicorns" within AB 32 such as the Low Carbon Fuel Standard (LCFS), which are predicated on deploying technology that does not yet exist and, in the case of LCFS, does little for the environment and has very high associated costs.

In addition to LCFS, this paper offers assessments of the other specific California program areas that exist outside the formal cap-and-trade program: energy efficiency programs, the Renewables Portfolio Standard (RPS), and the zero-emission vehicle (ZEV) program. Generally speaking, we find the efficiency programs constitute the strongest sectoral measures within California's portfolio while the ZEV, and to a lesser extent RPS programs, are more problematic in several respects as currently structured. However, as these issues have been addressed in substantial degree elsewhere, we have concentrated our analysis particularly on the LCFS, which we think is problematic for complex reasons not well-understood by policymakers.

In addition to these steps that could reduce the costs of reducing California's GHG emissions, a companion paper to this piece addresses how AB 32's policy mechanisms could be modified to **reduce the fiscal drag on the California economy** of the costs that remain by making the AB 32 cap-and-trade market more revenue-neutral. (See "For California's AB 32: Cap-and-Trade-and–Cash Back, not Cap-and-Trade-and-Tax".)

Despite the substantial costs involved and its policy importance, we believe that public understanding of California's overall climate regulatory slate, and the steps being taken ostensibly to reduce GHG emissions, is very limited.[1] This paper attempts to provide a better understanding of how these rules are being implemented and how they should be reformed so that the intent of California's voters in promoting AB 32 can be carried out. Doing so will ultimately improve the likelihood of California's efforts being taken up elsewhere and effecting a measurable reduction in global GHG emissions.

A note on real vs. 'ideal' GHG policy in California

We continue to believe sustained support for energy R&D combined with a broad-based revenue-neutral carbon tax shift combined with the elimination of all subsidies for energy production and consumption would be a preferable means to obtain many of the same goals that AB 32 and California's related emission-reduction rules attempt to address. British Columbia, which has combined pricing carbon with a net tax cut, offers by far the best real-world model of this policy. Nonetheless, the fact remains that California's voters and legislators have chosen AB 32, not some hypothetical or academic ideal, as their preferred way of addressing the climate issue. With strong political support in both governorship and a supermajority of the legislature and with AB 32 having received a 61.5 percent endorsement from California voters, we believe that policy concerns are best directed at an effort to reform, rather than a futile attempt to start over from scratch, a prospect that offers neither obvious political or policy gains.

For example, though the AB 32 cap-and-trade framework is now well under way, there is still time to establish mechanisms to return the substantial revenues it will raise directly to California's taxpayers much like an ideal revenue-neutral carbon tax would. Similarly, the worst effects of regulatory mandates such as the Low Carbon Fuel Standard remain far enough in the future that substantial mitigating reform is worth undertaking today.

Despite significant regulatory and stakeholder efforts over the past few years, real hazards nonetheless remain within California's climate agenda. We believe that legislative and regulatory bodies can address the most severe of these hazards without harming AB 32's goals of carbon emissions reduction. But it is important that we act now.

Introduction: California's Climate Agenda Has Too Many "Charismatic Megafauna"

The term "charismatic megafauna" is well known within the environmental movement. It refers to large, photogenic animals with immediate popular appeal: pandas, whales, elephants, gorillas, etc. By catching popular imagination, they are often promoted in order to achieve broader environmental policy goals—some of which may be only dimly related to the species in question.

California's air and climate policies and programs suffer from an excess of charismatic policy megafauna, attractive and cuddly for their key constituencies, but often serving as poor methods to meet the state's environmental needs. In particular, those iconic "command-and-control"-style regulations, which the state has more or less effectively used over previous decades to address local air pollution, are now being called into action to fight the much more vexing problem of greenhouse gas (GHG) emissions. Success in applying old tools toward this new challenge has been mixed in terms of effectiveness, cost, and distributional equity.

Whether they are Low Carbon Fuel Standards (LCFS) or zero-emission vehicles (ZEVs), these charismatic climate policies garner publicity for those who push them and support from various industries that benefit from them, but they undermine the central goal of reducing emissions.[2] By aiming for charismatic environmental objectives other than true GHG emissions, and by siloing sectoral efforts, these needlessly drive up the costs of GHG emission reductions and concentrate them on particular industries or consumers. While there are reasonable arguments to be made for technology push policies rather than pure pricing strategies, to have their role in the policy landscape, such technology efforts are really best suited to the national level (where, in fact, many are already under way).

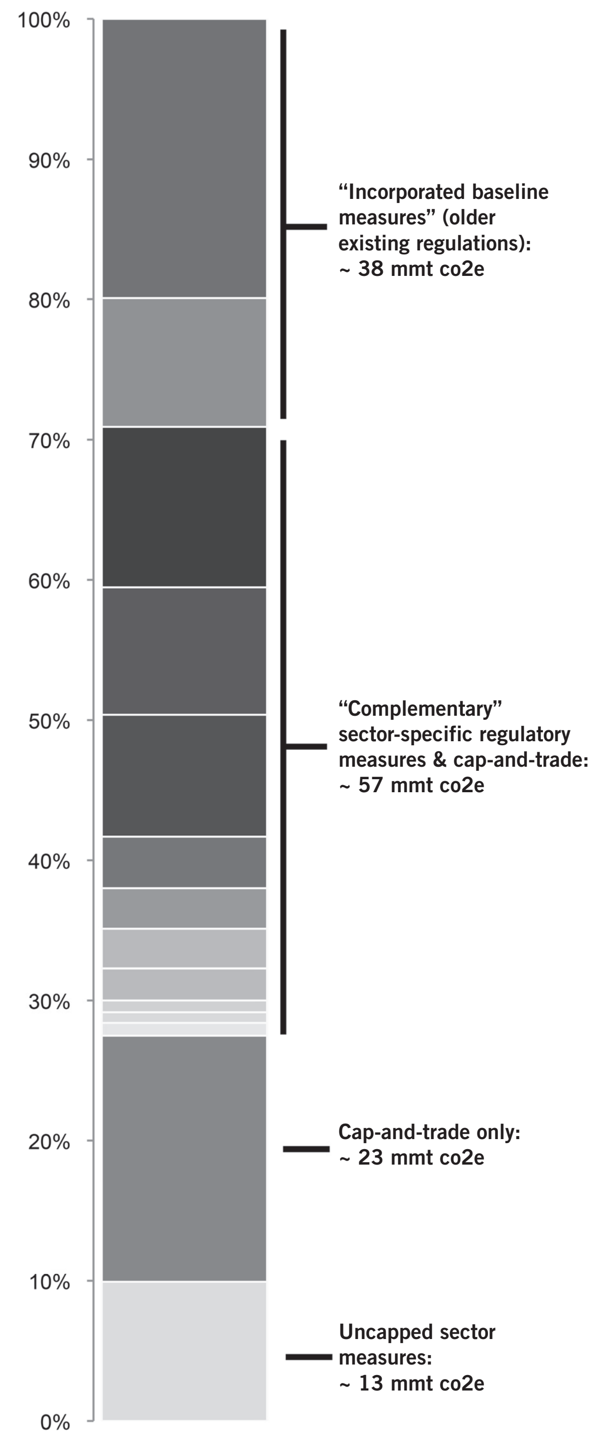
There is a better way to do this: a market-based approach such as cap-and-trade or a carbon tax shift can guarantee desired GHG emissions but do so relatively efficiently—at a lower cost.[3] However, in its current implementation, AB 32's "cap-and-trade" GHG reduction mechanism is relegated to a backseat position behind existing charismatic regulatory mandates. In fact, CARBs 2008 *Scoping Plan* expected existing regulatory mandates to deliver up to 76.4 percent of AB 32's legislated GHG emission reduction for 2020. It is important to make clear that these existing regulations—their GHG-reduction-related elements are referred to as "complementary measures" in regulatory lingo—are not actually "complements" to AB 32's market-based cap-and-trade centerpiece but rather substitutes. Any GHG emission reductions they achieve are functionally removed from cap-and-trade's more efficient (i.e., cheaper) system for emissions reductions.

California's cap-and-trade program has a number of vulnerabilities. It is administratively novel and technically complex, which makes it susceptible to

TABLE 1: Anticipated GHG emission reductions in 2020 from AB 32 and its "complementary measures", as reported in CARB's 2008 *Scoping Plan* and 2011 Status Update

	2008 Scoping Plan (mmtco2e)	2011 Status Update (mmtco2e)
2020 GHG EMISSION TARGET:	**427 mmt**	**427 mmt**
PROJECTED 2020 BAU EMISSION "BASELINE":	**596 mmt**	**545 mmt**
reductions in 2020 needed to meet target	*169 mmt*	*118 mmt*
2011 "Incorporated baseline measures"		
Pavely I vehicle efficiency standards	27.7	26.1
12–20% RPS	7.9	12
subtotal	*35.6 mmt*	*38.1 mmt*
"Capped" sector measures: **(i.e., covered by both cap-and-trade AND sector-specific regulations)**		
LCFS	15	15
Building energy efficiency & DSM	19.5	11.9
20–33% RPS (formerly RES)	13.4	11.4
Combined heat and power	0	4.8
Advanced Clean Cars	4	3.8
Other vehicle efficiency measures	4.5	3.7
SB 375 regional transport GHG targets	5	3
Million Solar Roofs	2.1	1.1
SF-LA high-speed rail	1	1
Medium/heavy-duty vehicle measures	1.4	0.9
Shore power for ocean vessels	0.2	0.2
Solar water heaters	0.1	0.1
Systemwide goods movement	3.5	0
Covered source industrial measures	0.3	0
subtotal	*70 mmt*	*56.9 mmt*
Remaining emissions reductions neeeded to reach target: (i.e., to be met by cap-and-trade alone)		
Baseline – (all measures + C&T) – 2020 target	***63.4 mmt***	***23.0 mmt***
"Uncapped" sources/sectors not subject to 2020 target (but addressed by other mitigation programs)		
High GWP stationary sources	10.9	5.9
Forestry	5	5
Landfill methane	1	1.5
Vehicle air-conditioning	0.3	0.2
Semiconductor	0.2	0.2
Consumer products	0.3	0.2
High GWP mitigation fee	5	0
SF6 (non-utility, non-semiconductor)		
High GWP mobile sources	3.3	
Oil/gas extraction and transmission	1.1	
subtotal	*27.1 mmt*	*13 mmt*

FIGURE 1: Anticipated year 2020 total GHG reduction shares, by measure, as reported in CARB's 2011 Status Update



gaming—similar to the experience of California's paralyzing electricity crisis of 2001. There are strong arguments that particular design elements could make the cap-and-trade program subject to extensive regional leakage, thereby negating in-state GHG emission reductions. One recent paper suggested that most of California's carbon emissions are subject to such reductions.[4] Major questions on how to handle the revenue generated by the auctioning of cap-and-trade permits, and the potential for fiscal drag as a result, remain unanswered.[5] These spending concerns are substantial and will be addressed in our companion paper. Furthermore, the program is still very early in its implementation. Nevertheless, given the already observed significant shortcomings of the alternative existing regulations, and subject to addressing the problems noted above, we believe that cap-and-trade should be treated as the core—rather than the backstop—of the state's current GHG-reduction policy agenda.

Existing command-and-control environmental regulations that serve as expensive platforms for the government favoring particular technologies should be reformed to allow alternative compliance through the cap-and-trade program directly, unless specific non-GHG emission-reduction-related regulatory environmental "co-benefits" can be articulated and justified against the added cost of achieving them.

In the following pages, we note some of California's existing "complementary" regulations that have been called into action against GHG emissions: what has worked, what is struggling, and how cap-and-trade or another carbon pricing scheme is likely to work better. In particular, we focus on the state's Low Carbon Fuel Standard (LCFS), as it is perhaps the most flawed attempt to use old regulatory tools to meet new technological challenges.

How Charismatic Policies Are Crowding Out the Climate Policy Ecosystem

Commonly known by its legislative moniker "AB 32," the Global Warming Solutions Act declared the state to be particularly vulnerable to the effects of a global warming and required the state's GHG emissions to be limited to 1990 levels by the year 2020.[6] AB 32 charged the California Air Resources Board (CARB) with developing a scoping plan to identify how this emission limit would be met. The most well-known outcome of this was the creation of a novel downstream cap-and-trade program that would require major GHG emitters to obtain and surrender allowances for each unit of GHG emissions through 2020. In addition, however, the *2008 Scoping Plan* (later updated in 2011) also identified how a slate of existing programs and regulations could be used to meet AB 32's required GHG reductions, assigning expected emission reductions to each (see Table 1, above).[7]

For example, the electric utility Renewables Portfolio Standard (RPS) requires that 33 percent of the state's electricity consumption comes from wind, solar, geothermal, and biomass resources by 2020.[8] In the buildings sector, stringent energy-efficiency standards apply to new commercial and residential construction or renovation. In the transport sector, the Pavley vehicle standards require that vehicle manufacture sales portfolios achieve increasingly ambitious fuel economy standards over time while the Advanced Clean Cars initiative explicitly requires increasing sales quotas of partial-electric, electric, or hydrogen drivetrain vehicles. SB 375's urban planning initiatives even seek to reduce Californians' vehicle miles traveled through transit-oriented development policies at the local government level. And for hydrocarbon fuels themselves, the Low Carbon Fuel Standard (LCFS) requires that fuel distributors reduce the life-cycle GHG emission intensity of gasoline and diesel per unit energy. Even elements of California's high-speed rail (HSR) make it into the AB 32 *Scoping Plan*.[9]

As many of the existing "complementary" measures are mandatory, they are expected to provide the bulk of AB 32's overall emission reductions—the *2008 Scoping Plan* estimated that they would provide 76.4 percent of AB 32's 2020 emission-reduction goals.[10] This means that if each such measure is fully implemented and results in the emissions reductions envisioned by CARB, AB 32's centerpiece cross-sectoral cap-and-trade program will be tasked only with delivering about one-quarter of all targeted statewide emission reductions. This is problematic for two reasons: one economic and the other a matter of technology. It is also indicative of the broader energy policy challenges in California:

a) Economic Efficiency

> *It is the intent of the Legislature that the State Air Resources Board design emissions reduction measures to meet the statewide emissions limits for greenhouse gases established pursuant to this division in a manner that minimizes costs and maximizes benefits for California's economy.*
> —AB 32, Chapter 2: Findings and Declarations

GHG pricing initiatives such as cap-and-trade or a revenue-neutral carbon tax inherently provide more flexibility than command-and-control regulations, thus explaining their greater popularity with economists.[11] Flexibility encourages innovation as firms find the most effective ways to abate without being constrained by specific (and potentially ineffective) regulatory-defined emission reduction pathways, driving down the marginal cost curve for the overall policy.

The AB 32 *Scoping Plan's* "hybrid" approach, however "backs" the cap-and-trade market instrument with conventional existing regulations. In fact, the act of "backing" sectoral abatement targets with proscriptive regulatory measures actually removes the single best attribute of a cap-and-trade system: its efficiency. To the extent that such measures fulfill the emission-reduction need within each sector, they remove flexibility in how to most cheaply achieve abatement targets; reducing this choice set drives up the marginal abatement curve and increases total compliance costs. Ultimately, this discourages the potential for market-driven innovations in finding novel ways to abate carbon.

Moreover, the existence of sector-specific conventional regulatory measures also reduces the potential to lower overall compliance costs by trading across sectors. For example, under a simple cap-and-trade mechanism, if it is very difficult or expensive to abate in one sector (e.g., transportation), that sector's own costs do not necessarily define the total system's marginal costs; emitters within the tech-constrained sector can instead pay those in another sector with better available technology (e.g., power generation) for additional abatement—the "trade" part of cap-and-trade. To the extent that required abatement is siloed within a particular sector by an overlapping sector-specific regulation, then such cost savings are not possible.[12]

This does not mean that California will not meet its emission-reduction goals using its current policies; it just means that it will do so with needless expense and with the substantial chance of picking politically favored winners.[13] As regulators and the media now begin to quote and analyze the significance of AB 32 "carbon prices" based on CARB's cap-and-trade allowance auctions alone, they are really missing 76.4 percent of the picture. Doing so potentially masks the much higher true marginal abatement costs of the entire California climate regulatory slate and may be deceptive with respect to how expensive it is to reduce carbon emissions in an environment where much of the low-hanging fruit has already been picked. Moreover, this approach will tend to make allowance prices more volatile and harder to make investment decisions around by the firms charged with actually delivering on AB 32's reduction targets.[14] In fact, the current low cap-and-trade allowance auction prices of about $12 per ton indicate less that reducing California's emissions are easier than expected and more that the bulk of emission reductions are in fact being siloed through mandatory compliance with "complementary" sector-specific command-and-control regulations (e.g., RPS) at costs exceeding the cap-and-trade market (see Figure 2, below).[15]

b) Unicorn Technologies

> *More importantly, investing in the development of innovative and pioneering technologies will assist California in achieving the 2020 statewide limit on emissions of greenhouse gases established by this division and will provide an opportunity for the state to take a global economic and technological leadership role in reducing emissions of greenhouse gases.*
> —AB 32, Chapter 2: Findings and Declarations

Since California is only a small slice of global GHG emissions, new mitigation efforts will also be needed globally to have an appreciable effect on the pace of anthropogenic global warming. Both such further steps are likely to require new clean technologies available at lower prices. This would seem to justify increasing investment in early-stage energy technologies over the long term, especially as California is a market ripe with the sort of skilled engineers and scientists to capture many of the gains made from new technologies.

A mistake made across California's existing GHG-reducing regulations, however, was in thinking that novel, low-price, low-carbon technologies could be legislated into existence on a predetermined time frame. Requiring new technology development and scaled delivery is ambitious but also risky: it goes beyond achievable in-state emission reductions and extends California's responsibility to innovating, or incenting innovation of, technologies that simply may not be available anywhere. It effectively requires that California shoulder the price of risky technology commercialization for the entire world.

Whether it is affordable grid-scale solar power and reliable management of its intermittency (RPS), large-scale availability of low-carbon cellulosic ethanol or synthetic drop-in biofuels (LCFS), or affordable and desirable electric or hydrogen vehicles (Advanced Clean Cars), California regulations functionally demand such "charismatic" technologies meet mandatory goals, even if there may be more effective ways to abate GHG emissions (e.g., through energy efficiency). While there is a certain logic to an explicit technology push instead of a solo price signal that may not spur specific innovations, the demanding of such a push on a static time line is extremely risky.

Effectiveness, Cost, and Distributional Equity of Existing Charismatic Regulations: EE, RPS, ZEVs, and the LCFS

As noted above, the success of existing "complementary" regulatory programs in terms of GHG-reduction effectiveness, cost, and distribution of those costs across society has been mixed. The major binding programs and regulations outlined below account for over half of the AB 32 *Scoping Plan's* anticipated emission reductions:

Energy Efficiency:
Good GHG effectiveness; low cost; reasonable cost distribution

California is internationally recognized for its successes in limiting the overall growth of energy use while population and economic activity has expanded. Statewide building and appliance standards generally exceeded national requirements, and a federal waiver has historically allowed the state to mandate aggressive vehicle manufacturer fuel economy requirements which the market has been able to bear. Through its partly deregulated electricity market, utilities are able to invest in customer-side energy-efficiency improvements and make an economic return on doing so instead of selling additional volumes.

These programs are not perfect, and their effectiveness in reducing statewide GHG emissions is partly mitigated by a rebound effect,[16] but they generally work. Because they often rely on improving deployment of existing technology or gradual technology improvement, total costs are relatively low. Moreover, the added upfront costs of improving energy efficiency are often repaid through fuel savings over time, significantly reducing or even eliminating net costs. To the extent that market failures exist in both agency of energy-efficiency decision making and the consumer evaluation of lifetime ownership costs, and the transaction costs to obtaining a private solution are high, then economic theory can be used to support many of California's energy efficiency programs. Finally, the costs and benefits that are incurred through energy efficiency programs are often widely distributed across society and so are reasonably equitable. **Energy efficiency programs generally represent the best of California's existing regulations that are now being tasked to address GHG emissions and, when properly implemented, save taxpayers money to boot.**

Renewables Portfolio Standard:
Medium GHG effectiveness; medium cost; poor cost distribution

California's Renewables Portfolio Standard (RPS) first required 20 percent, and eventually 33 percent, of electricity consumed in the state to come from renewable sources. Large hydropower and nuclear power do not, however, qualify, and proscribing a share of power from certain non-emitting sources is not a perfect proxy for actual overall GHG emission reductions.[17] This decision is an unfortunate example of when non-GHG concerns can affect GHG policy in a negative way. Large hydro and nuclear energy—including potential out-of-state imports—were excluded from (what could have been a more ambitious) RPS in favor of more charismatic technologies despite the fact that from a GHG perspective, they offer a stronger profile than wind or solar. They are baseload sources of power that have zero GHG emissions. One substantial project in these areas can provide the power of dozens of solar or wind projects. The exclusion of nuclear and large hydropower from RPS is, in fact, quite relevant to the California case: in 2012, while RPS-eligible technologies rose to 19.8 percent of total electricity supply, in-state power plant GHG emissions actually **grew** by 35 percent over 2011–2012 from increased use of natural gas after the closure of the San Onofre Nuclear Generating Station (SONGS) and diminished hydropower production.[18]

A combination of factors—some inside and some outside of California's control—has meant that the 33 percent RPS may be achievable without incurring electric grid or economic calamity (though many RPS costs have yet to show up on customer bills). Combined with gradual industry technology refinement, major enabling transmission infrastructure development, financial incentives, and other process improvements, grid-scale solar and wind power have become relatively more affordable in California and are being deployed in time to meet regulatory deadlines. At the same time, **generous US federal investment and production tax credits for**

the developers of large-scale solar and wind systems have socialized the cost of achieving California's RPS goals across all US taxpayers.

Had this timing been off by just a couple of years, California would have been looking at a much less rosy RPS situation, and the structural risk was very real. Moreover, the distribution of RPS costs across Californians remains extremely inequitable due to the state's continued use of outmoded inclining block, tiered electricity rates for customers served by investor-owned utilities.[19]

Zero-Emission Vehicles:
Medium effectiveness; high cost; poor cost distribution
The CARB Advanced Clean Cars program's zero-emission vehicle (ZEV) regulation (technically, these are really "elsewhere emission vehicles"[20] since unless they are totally fueled by renewable sources, emissions still take place—they are just associated with the power plant that charges their battery and not the vehicle) has shifted from a traditional focus on local criterion air pollutants to now explicitly targeting GHG emissions as well. And as its name suggests, the ZEV regulation does not simply require GHG emission reductions from the state's transport sector; rather, it specifically requires that an increasing share of California vehicle sales each year implement specific "charismatic" technologies, notwithstanding consumer demand, technology availability, environmental impact, or the cost to do so.

Specifically, according to the current legislation, 15.4 percent of California vehicle sales by 2025 are required to be either full ZEV or plug-in hybrid electric vehicles, with quotas assigned by manufacturer. As a result, despite cost and performance weaknesses currently associated with many immature electric drivetrain technologies, conventional vehicle manufacturers are nevertheless scrambling to put token retrofitted electric vehicles on the road—so-called "compliance cars" leased to California (and other ZEV state) consumers at significant unit losses—in order to meet regulatory quotas. Furthermore, it can often benefit one manufacturer dramatically at others' expense. Electric carmaker Tesla may have booked up to $30,000 per car in government subsidies during its first profitable quarter—a staggering case of corporate welfare.[21] This is not a recipe for good innovation: it is a clear case of a regulator trying to force a technology into existence.

California is trying to apply a regulatory toolset that has basically worked in the past to address one problem—vehicle fuel efficiency—to a whole new problem, but one with its own complications and its own technological options. It causes justified resentment of California in the business community and forces companies to pursue innovation strategies that may be more costly than equally effective alternative approaches. The cost distribution for this regulation is also poor as it potentially socializes the cost of deploying these cars to Californians over consumers of all vehicles produced by regulated manufacturers—ZEV or not—nationwide.[22]

Whether or not the GHG emission-mitigation aspect of the ZEV program will succeed is still up in the air. There seem to be some attractive technology options within this space, but requiring vehicle electrification along a forced time line is certain to incur significant consumer and business costs and market disruption. This is after the initial ZEV mandate in 1990 resulted in billions of dollars of expenditures with questionable tangible results.

The Low Carbon Fuel Standard:
Poor effectiveness; high cost; uncertain cost distribution

One existing command-and-control regulation that has been tapped to provide nearly two-thirds the GHG emission reductions expected of the cap-and-trade program alone is the Low Carbon Fuel Standard (LCFS). **LCFS is perhaps the most concerning case of a regulator requiring specific technology adoption according to a timescale and development path that may have looked reasonable six years ago but now appears quite risky—and expensive—given current technology realities.** The remainder of this paper therefore focuses on details of this program and how its flaws might be addressed. We believe that the best overall solution would be repeal, but given the reluctance of legislators and government officials to back down on such a public commitment, we offer other solutions as well.

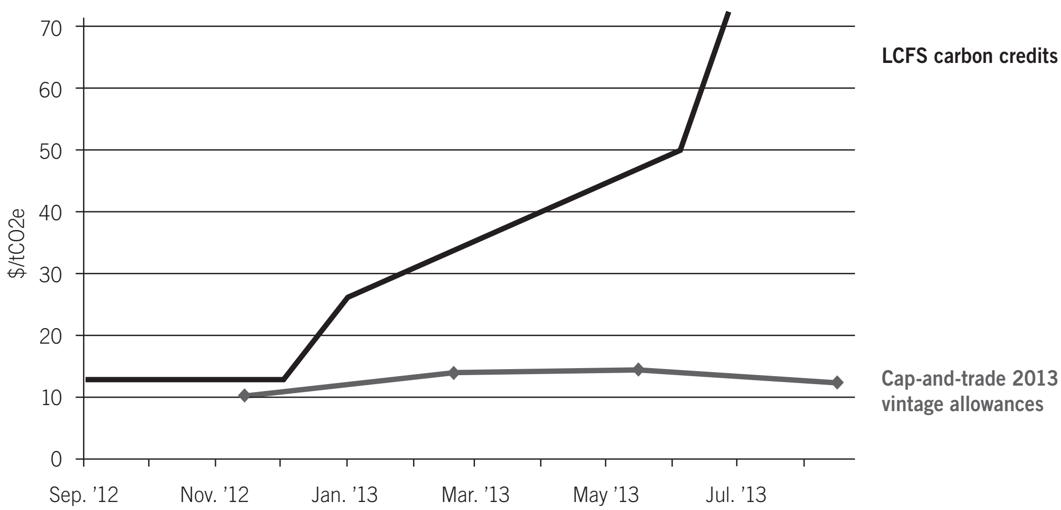
The LCFS requires that California fuel distributors reduce the life-cycle GHG *intensity* (per unit energy) of gasoline and diesel blends sold in the state by 10 percent by 2020. This mandate, not well-known among the general public, was explicitly crafted to bring about new technologies such as low life-cycle emission domestic cellulosic ethanol or synthetically produced drop-in biofuels. Cellulosic ethanol's switchgrass feedstock even famously made it into President Bush's 2006 "addicted to oil" State of the Union address. In fact, CARB's 2008 cost-benefit analysis of the LCFS 2020 goal assumed that LCFS biofuels would be equal to or lower cost than fossil fuels over the program implementation period.[23]

Though the GHG emissions from the combustion and refining of vehicle fuels are set to be included directly in California's AB 32 cap-and-trade program starting in 2015, thereby guaranteeing any desired statewide GHG emission reductions, this has not replaced the separately-legislated LCFS mandate. Similar to the state's other GHG-related technology push mandates, LCFS seeks to ensure that low carbon-intensity fuels are commercialized within the decade, even if the cost far exceeds the statewide marginal cost to reduce GHG emissions represented through the cap-and-trade market.

But where renewables prices and technology seem to have at least met the standard of being commercially deployable (albeit at a price premium to natural gas), and where the ZEV regulation's technologies may still have a shot, LCFS's zero-carbon fuel technologies have so far failed. Current technology commercialization time lines now easily exceed the expert consensus of the mid-2000s. From a research standpoint, such technology setbacks are not objectionable (learning still occurs, and efforts could simply shift to more attractive technology options), except that the regulation still stands. **Absent change in the regulation, California businesses, workers, and consumers are set to pay for a global failure to deliver this technological unicorn.** Moreover, the development of other potentially more effective clean energy technologies will suffer because of this artificial diversion of R&D funding, talent, and project capital to what is clearly an underperforming technology.[24]

We discuss the LCFS failure in some detail as it offers a compelling window on the dangers of these sorts of technology mandates.

FIGURE 2: California LCFS carbon credit price growth, September 2012–June 2013[28]



Targets: The LCFS requires an eventual 10 percent reduction in the life-cycle GHG emissions of gasoline and diesel sold in California by 2020. It has been in effect since 2011, but its "backloaded" compliance schedule means that the target reduction for 2013 is only 1 percent and increases rapidly in later years.[25] LCFS's 10 percent carbon-intensity reduction target, however, appears arbitrary: it lacks convincing technical, economic, or environmental justification.

Flexibility: LCFS is technically "technology-neutral" in that multiple low-carbon fuel pathways can potentially meet its requirements. In practice, however, this flexibility is relevant only when the intensity reduction targets are modest; the 2020 10 percent target is high enough to effectively require the use of cellulosic ethanol and synthetic drop-in biofuels (or, otherwise, biologically derived natural gas to fuel natural gas vehicles and low-carbon electricity to fuel electric vehicles) across the board.

LCFS does include some flexibility mechanisms, including compliance credit trading and inter-year banking. This mechanism will become particularly important in the next few years, as low-carbon biodiesel targets are thought to be relatively easier to meet than ethanol targets and compliance credits are freely tradable across fuel categories. But as intensity targets ratchet down, this tradable credit market has recently become volatile and expensive; after a year of stability, credit prices shot up from about $13 to $40 per ton of carbon in the first three months of 2013, $50 by June 3, and a reported $72 by the end of June.[26] Moreover, there is currently no "safety valve" mechanism to cap potentially very high traded credit costs as there is in the cap-and-trade market.[27]

In May 2013, CARB issued a list of compliance flexibility options for continued stakeholder discussion, but some regulated entities have been cool to the prospect of addressing deeper fundamental issues in the LCFS (i.e., the lack of suitable compliance technologies) through instituting a safety valve mechanism alone. This is because such an approach would effectively amount to a new tax (or fee) on conventional carbon-intensity fuel distributors (on top of AB 32 cap-and-trade compliance costs) with little useful emission-reduction effect. In this case, it would also be unclear how the revenues from such a *de facto* tax/fee (through the centralized sale of compliance credits at a fixed-ceiling price) could and should be handled by the agency receiving them.

GHG Reduction Effectiveness: Because the LCFS is focused on "life cycle" and not just fuel combustion emissions, CARB designates different carbon intensities for different fuel production pathways, effectively counting the emissions associated with a fuel's production outside California for imported products. For example, corn ethanol produced in the US Midwest from refineries using coal and a wet mill process may be assigned a carbon intensity of 120.99 gCO2e/MJ, while corn ethanol produced in California from biorefineries using natural gas through a dry mill process are assigned an intensity of 88.9 gCO2e/MJ.[29] In the absence of any cellulosic ethanol available on the California market, however, one of the most attractive "compliance pathway" fuels has become imported Brazilian sugarcane ethanol, with a rated intensity of just 73.4 gCO2e/MJ, 26 percent below that of gasoline.[30] The prospect of the US Midwest exporting its oversupply of high carbon-intensity corn ethanol to Brazil while California imports Brazilian sugarcane ethanol has become very real—though of course such "fuel shuffling," both domestic or international, raises costs while resulting in zero or even negative climate benefits.

Use of sugarcane-based ethanol in the California gasoline mix jumped from approximately zero to an annualized rate of 200 million gallons in the last six months of 2012, representing about 25 percent of all LCFS credits being generated from biofuels by the end of the year.[31] The problem with this is that Brazil already has significant domestic demand for ethanol but no policy analogue to the LCFS. This means that barring a massive scale-up of the Brazilian sugarcane ethanol industry, Brazil may simply choose to either import and consume the relatively high carbon-intensity US-produced corn ethanol that California does not want or opt to increasingly use conventional gasoline for its domestic market as the value (and price) of exporting its own ethanol rises. **The net result of this "carbon laundering" is that global GHG emissions do not change, consumers pay more, and distributors overinvest in unnecessary fuel transport infrastructure.**

Innovation-Inducement Effectiveness: LCFS's technology-inducement mechanism is quite limited in that is seeks only to provide a market signal. It ignores different market failures (and different mitigating policy options) that potentially exist across different stages of new technology development: from basic science, to demonstration, to scale-up, and market development. For example, LCFS's structure is poor at effectively encouraging precommercial R&D, providing demonstration capital, or reducing low carbon-intensity fuel infrastructure development risk in order to provide better access to commercial financial markets. Instead, it looks set to generate windfall profit to existing medium-range carbon-intensity fuel technologies already on the market. We believe that this focus on immediate-term deployment of not-good-enough technologies rather than the development of breakthrough technologies represents a principal weakness of LCFS.

Technical Barriers: Because LCFS expects a gasoline emission intensity reduction of 10 percent, but all current low carbon-intensity alternative fuels still have life-cycle GHG emissions that exceed zero, the blend of alternative fuels into the California gasoline supply will, on average, have to exceed 10 percent by volume statewide to meet LCFS targets.[32]

One way fuel distributers could handle this problem would be through the sale of higher-concentration E85 blends to the subset of California passenger vehicles able to support such fuels. A recent count, however, shows that E85 has not had broad uptake in California: only 65 locations in the state offer E85 fuel for sale,[33] and as of 2010 less than 2 percent of California passenger vehicles are E85 flex-fuel capable while less than 1 percent of the ethanol fuel consumed in California was actually in the form of E85.[34] Dramatically expanding the use of E85 in California to meet LCFS's *de facto* blending requirements would require significant new investment in flex-fuel vehicle stock, distribution infrastructure, or both—a misguided effort that would echo the state's well-documented failure to similarly encourage M85 methanol vehicle fuel use in the 1980s (see Annex I). Once available, consumers will also have to want to use this fuel; as they face no individual mandate to choose E85 over gasoline, this decision will have to be driven by incentives such as price or the policy-driven formation of novel preferences.

If E85 fuel is not extensively adopted to meet LCFS targets, and barring the rapid scale-up and deployment of other very low carbon-intensity liquid or gaseous vehicle fuels, LCFS might otherwise force California fuel distributors and consumers to adopt low-concentration ethanol blends that exceed the current E10 (~10 percent ethanol oxygenate) fuel blend, such as E15. But mirroring a similar controversy playing out at the national level, there are in fact significant technical, regulatory, and consumer hurdles to deploying ethanol blends above the 10 percent level that is already ubiquitous in California's gasoline supply.[35]

Scientific and Methodological Uncertainty: The emergence of the concept of global indirect land use change (ILUC—see note)[36] on the life-cycle GHG emissions for biofuels had a major effect on related scientific and policy discussions.[37] For the LCFS, implementation of the ILUC concept has a very clear implication: US corn ethanol, once regarded as a low carbon-intensity fuel, can actually play only a marginal role because of significant indirect "elsewhere" agricultural GHG emissions (note: not its own life-cycle emissions!) associated with its sale as a vehicle fuel. In its place, advanced and cellulosic biofuels are now needed. The incorporation of ILUC into LCFS also introduces a number of scientifically uncertain technical variables that significantly increase the overall GHG intensity "scores" of various alternative fuels. For example, CARB has assigned an ILUC penalty of 30 gCO2e/MJ to the typical US-produced corn ethanol, which increases its typical life-cycle emission score by about 50 percent. Small changes in this very broadly estimated ILUC penalty could make a big difference in the business case for various biofuel supply options.[38]

In any case, even if one accepts the ILUC causal hypothesis, it is not clear-cut that the best way to address the issue is to estimate and apply a single penalty "score" to certain biofuel production pathways. To do so assumes that all related economic process and human decisions within the ILUC causal chain are deterministic, homogenous, and static. If the intent of including ILUC concerns is to avoid induced GHG emissions in the international agricultural sector, then there are more direct ways to address the issue. For example, induced emissions could be explicitly avoided all along an ILUC decision chain through active interventions such as choosing to increase agricultural yield density rather than clearing new land, by proactively putting new lands into production that would be less carbon-intensive than an expected marginal unit of cleared land globally, by guiding the types of land cleared overall in developing countries, or by otherwise offsetting potential additional emissions. The farmer education and investment necessary to do this may in fact be significantly cheaper than developing novel biofuel technologies. Ignoring these opportunities in the LCFS by simply assigning a static ILUC score ignores the potential for the LCFS to actually help improve ILUC-related land use issues in the real world rather than regulating away legitimate economic activities both at home and in developing countries' rural economies. **In other words, planners are not omniscient and cannot always "know best" even when making sincere science-based efforts.**

Policy Interactions: Adding a layer of complication to this already ambitious fuel performance mandate, the LCFS overlaps with both the US Federal Renewable Fuel Standard (RFS2) program and its volatile RIN market (again exacerbated by a lack of the cellulosic ethanol technology that a decade ago was expected by many experts to be commercially available by now) and the in-state AB 32 cap-and-trade program that already applies to fuel refinery emissions and which will apply to vehicle fuel carbon content itself beginning in 2015. Though some analysis exists on this issue,[39] potential dynamic interactions among these three overlapping programs is uncertain and may not be well understood by regulators or businesses until we experience the effects firsthand.

Costs: Economic analyses of the LCFS published by CARB during the regulation's formation were overoptimistic. The AB 32 *2008 Scoping Plan's* cost estimates for LCFS that indicated a net-zero cost for the regulation by assuming that low carbon-intensity fuels would be available at scale cheaper than conventional gasoline were simplistic and unfortunately turned out to be wrong.[40] With the first cellulosic fuels now being commercially produced in the United States at an expected scale of just a few million gallons in 2013 and at an undisclosed price per gallon,[41] it is extremely worrisome that such analyses were forming the basis of CARB decision making as late at 2009. The broader point is that regulators are poor at predicting technology development and that robust regulations should ensure continued flexibility if anticipated technology does not materialize in the predicted time frame or cost parameters.

Requiring specific technologies for legal compliance is not a new phenomenon. It has always been part of the regulatory toolkit, especially in the environmental field. What is new and problematic with California's approach to GHGs, however, is a shift toward requiring specific compliance technologies that do not yet exist. Even the EPA Maximum Achievable Control Technology (MACT) restrictions on power plants, thought by many to be an example of excessive regulation, at least require that the "achievable" technologies actually exist in a commercial implementation. The LCFS does not even exceed that minimal bar. Instead, it attempts to use a regulatory technology-inducement mechanism designed for marginal improvements in vehicle fuel economy or criterion pollutant emissions and apply it to a much more vexing problem—a different industry, a different market, with harder technology, and implemented at a much larger scale. The expected costs of LCFS compliance are just that—unknowns, estimates (if available at all). **Future technology cost assumptions may inform a regulator's cost-benefit models, but it is business that ultimately has to make the investment case and consumers who ultimately shoulder the price risk. It boils down to the difference between asking for a horse and asking for a unicorn.**

Solutions: Reducing the Costs of LCFS and Other Existing Charismatic Regulations While Preserving AB 32's GHG Reduction Mandate

As an inherently flexible and purely GHG-focused cross-sector market mechanism, California's AB 32 cap-and-trade system seems to be more effective at reducing GHG emissions, is less costly, and is more equitable than the existing environmental regulatory measures that have now been called into action to deliver those same GHG emission reductions. Though cap-and-trade itself still faces significant implementation questions, the flaws in the existing "complementary" regulatory measures that in fact marginalize the cap-and-trade system are already evident today.

Because of this, we believe that a post-2020 California climate policy framework—beyond AB 32's currently legislated mandate—should embrace cap-and-trade or some other carbon pricing policy as the core of California's GHG-reduction policy. As cap-and-trade's overarching market mechanism proves in the real world that its GHG abatement is not illusory, the sometimes arbitrary and unnecessarily expensive regulatory measures that hide their true costs from the public should be phased out in favor of the flexibility and relative transparency of this cross-sectoral market mechanism. While we continue to believe that a revenue-neutral carbon tax is the best method for achieving such reductions, if we are going to use cap-and-trade, let the "complementary" measure training wheels come off.

Post-2020, there will still be a need for some existing regulatory mechanisms—for example, those which have generally been observed to function well historically, such as energy efficiency programs, or those which cost-effectively deliver non-GHG environmental objectives—but these should not be used to duplicate the GHG emission reductions that cap-and-trade can provide more effectively, cheaply, and fairly. Over time, any further voter-desired GHG reductions should be channeled through the cap-and-trade program (if not a revenue-neutral carbon tax) by ratcheting down its binding economy-wide cap, while other environmental regulatory measures should, as much as possible, trim their focus to non-GHG-related objectives. In doing so, some continued emission reductions may come from the "charismatic" sources that are already familiar—renewable power deployment on the electric grid, for example—whereas others will likely surprise both regulators and the rest of us with their ingenuity to more cheaply abate emissions in unforeseen ways. And this is precisely the point.

Specifically, for the LCFS, a fix for which cannot wait until 2020, there are a few potential changes that CARB or the legislature should immediately enact. Given the problematic nature of the LCFS as layered on AB 32, we believe a repeal would be the best option. Recognizing that AB 32's existing cap-and-trade mechanism will cover transportation fuels starting in 2015, removing the LCFS's specific fuel carbon-intensity mandates would not significantly affect statewide GHG emission reductions—there would just be more flexibility in how to achieve them. Failing this, quick revisions are needed. These should include the following:

- Creation of a safety valve for LCFS permit prices, where the government would agree to sell unlimited carbon intensity permits at a reasonable fixed price, not dramatically higher than the current cap-and-trade price. This would cap the downside potential of the LCFS spiraling out of control (with widespread noncompliance or effect on fuel price) while maintaining a price signal beneficial to the very nascent low-carbon biofuel industry.[42]

- LCFS induces an overweight push for the development of low-carbon biofuels and therefore creates an artificial failure in the "markets" to distribute capital and talent for clean energy technology R&D. To correct this, CARB should investigate how regulated parties could opt to trade their proximate LCFS-induced clean energy R&D responsibilities from low-carbon biofuels to other promising carbon-reduction research opportunities within the transport sector.

- More generally, for the LCFS and other relevant existing "complementary" regulations, regulated parties should be granted the ability to meet alternative compliance through direct participation in the cap-and-trade market in such a way that the GHG emission reductions targeted by the siloed subregulation are preserved, measurable, and not subject to leakage. Non-GHG emission-reduction co-benefits of such subregulations, to the extent applicable, should be made explicit—separate from GHG reductions—so that the additional costs or actions needed to achieve them can be submitted to standalone cost-benefit analysis.

- At worst, simply extending the LCFS compliance timetable to better match the schedule of biofuel technology availability would go a long way toward averting potential refinery closures, associated job losses, and fuel-pump rebellion.

For LCFS, it is clear that a game of regulatory chicken is under way; will the desired low-carbon technologies be delivered on time and at an acceptable cost? No one—not the regulator, not the regulated parties, and certainly not the consumers—is sure of the answer. The one thing that is clear is that no one wants a head-on collision. A failure here could sink the whole of California's climate efforts in the eyes of a watching world, just as Solyndra's bankruptcy inflicted broad collateral policy damage on government-supported energy R&D. Ideally, we would not be in such a difficult situation where the regulator has to make tough calls based on uncertain markets and technologies, which is a major advantage of broad-based market mechanisms such as cap-and-trade or a revenue-neutral carbon tax. But now that we are here, allowing flexibility without compromising GHG reductions—both for LCFS and the California climate regulatory slate more broadly—will help right the course.

ANNEX

The California Methanol Demonstration Program: A Failed Experience with State-Favored Technology Push

In a state where the automobile looms large, California regulators have long sought to secure a firm hand in directing evolution of vehicle drivetrains and fuel chains. The justifications for doing so have shifted over the years: energy security, urban air pollution, consumer protection, global warming, green jobs. Often, the state's interests are outside of what consumers and suppliers would otherwise pursue in the automotive market. Unsurprisingly, the process is not always smooth.

As just one example, the California Energy Commission's (CEC) attempt to popularize methanol fuel in the 1980s through the early 1990s shows the pitfalls of the state pushing a favored technology with some desirable attributes but which ultimately lacks clear short-term benefits to most consumers and existing producers.

The CEC's "Drive Clean California" Methanol Demonstration Program sought to significantly displace the use of gasoline in the state by deploying M85 (85 percent methanol, 15 percent gasoline blend) fueling stations and methanol-only or gasoline-methanol flex fuel vehicles across the state—a strategy that has been time and again recycled in California for natural gas, E85 ethanol, hydrogen, and electricity-powered automobile deployments as well. With an eye toward social utility, CEC saw a bundle of desirable attributes in methanol: when combusted, it tended to produce fewer smog precursors than the gasoline supply of the time; it could be produced domestically from natural gas from an initial supply infrastructure that was already in place; and its price moved differently than world oil markets. Getting it into automobiles, however, wo uld require a new retail distribution infrastructure, new vehicles with modest fuel system modifications, and a reason for people to care.

CEC approached the first two "logistical" challenges though a combination of public spending and negotiation. CEC established and operated its own 8-million-gallon California methanol reserve to supply retail pumps and set up cost-sharing joint ventures with incumbent fuel distributors including Amoco, Shell, Chevron, Exxon, and others. Methanol sales volumes were so low, however, that these joint ventures were far from economic: Chevron in 1992 reported that its average sales were only 18 gallons of M85 per station daily. At the same time, CEC negotiated with US automakers to develop and sell at retail small volumes of flex fuel vehicles in various models. CEC also provided cash rebates of a few hundred to a few thousand dollars to offset the potentially higher vehicle purchase price. State regulators' jobs were made easier on this end by federal CAFE standards from 1988 that gave generous vehicle fleet mileage bonus credits to manufacturers that sold such methanol flex fuel vehicles—whether or not they ever actually used methanol—and many manufacturers absorbed the increased unit production costs for their vehicles.

The last issue—getting people to care—was never sufficiently addressed. Though M85 fuel offered some desirable social benefits, achieving those would have ultimately required consumer acceptance, where direct benefits were thin. Methanol has half the energy density of gasoline, and so M85 cuts vehicle range by about 40 percent.[43] The number of M85 retail stations never exceeded more than about 60 in the state, giving way to range anxiety and inconvenience in trip planning. M85 fuel did have a few potential end-user selling points—marginally increased horsepower in some models and the personal satisfaction of using a domestic fuel—but these were weak draws across the broader automotive preference set. And as oil prices fell to historic lows, any price advantage for an end consumer to use M85 was wiped out: M85 prices in the early 1990s exceeded California retail gasoline prices by $0.30 to $0.50 per gasoline-equivalent gallon.[44]

Adoption rates fell consistently below CEC's (and other groups') optimistic forecasts. Chevron estimated that only 600 methanol flex fuel vehicles were on the road by 1992, compared to a CEC goal of 5,000 vehicles by 1993.[45] Earlier regulator aspirations, reported in 1987, were for 100,000 cars by 1992.[46] As the program tailed off, CEC in 1996 reported total California sales of methanol-capable vehicles of just 13,100 since the program's beginning in 1982.[47] Even then, many of these vehicles ultimately ended up in government or rental fleets, and actual methanol usage—which required the use of a separate methanol-only debit-type card in order to prevent accidental misfueling by conventional-gasoline vehicle drivers—was low. Monthly California retail sales of M85 peaked in August 1993, and the highest annual retail sales were 1,174,000 gallons of M85 in 1994; this compares to California gasoline sales of about 13 billion gallons in the same year.[48]

By 1990, however, the future of the methanol program had effectively been written, even though manufacturers would still deliver more than 12,000 flex fuel vehicles to the state and install 40 M85 retail locations in the years to follow. The invention and adoption of affordable "reformulated gasoline" in the California market showed that criteria air pollutants could be significantly reduced without the massive infrastructure, supply chain, and behavioral changes required for M85.[49] This neutralized one of the regulators' major justifications for methanol deployment. It also gave a clear lesson of the rule that technology moves faster than regulation, but rarely in the expected direction.

Ultimately, with the rapid and broad-scale deployment of cleaner-burning reformulated gasoline across the state, regulators got much of what they wanted from the methanol program—air quality improvement—but not at all in the form they had envisioned. Even without significant technology risk—methanol fuel was commercially available and its use was relatively well-understood—the awkwardness of a regulator trying to rapidly push market adoption at a massive scale was evident. Having a more flexible strategy from the beginning that focused on achievement of the desired social outcomes—rather than dwelling on the tactics assumed necessary to get there—might have gotten California there without wasting money, effort, and time that might be better spent on other pressing social or environmental issues.

Notes

1 For an example of California voters' lack of knowledge about the effects of current California Climate policy, see Hoover's recent Golden State Poll. http://www.advancingafreesociety.org/wp-content/uploads/2013/09/Hoover-Institution-Golden-State-Poll-2-Aug-27-Sept-5-20131.pdf.

2 See, generally, Stigler (1971), "The Theory of Economic Regulation"; Becker (1983), "A Theory of Competition Among Pressure Groups"; or Keohane et al. (1998), "The Use of Standards and Prices for Protection of the Environment."

3 The cap-and-trade program was created by the California Air Resources Board in response to AB 32's legislative mandate to reduce the state's GHG emissions to 1990 levels by 2020. It is important to note that a cap-and-trade system per se was not mandated under the terms of the legislation.

4 Cullenward and Weiskopf (2013), "Resource Shuffling and the California Carbon Market."

5 How to handle the revenues generated through the AB 32 cap-and-trade mechanism are the subject of a companion paper by the authors: Carl and Fedor (2013), "For California's AB 32: Cap-and-Trade-and-Cash-Back, Not Cap-and-Trade-and-Tax."

6 CA Assembly Bill No. 32, Chapter 488, approved by the governor September 27, 2006. According to CARB inventories, California's gross GHG emissions for 2006, when AB 32 was passed, were 484 million tons CO2-equivalent; this had fallen to 452 million tons CO2-equivalent by 2010. For comparison, California's emissions were about 6.8 percent of total US emissions in 2006 and 6.6 percent in 2010. The emission reductions from a business-as-usual baseline that AB 32 now targets for 2020 would represent about 1.7 percent of the US 2010 emission inventory.

7 AB 32 *Scoping Plan,* December 2008, "Recommended Actions," p. 15.

8 Notably, large hydro and nuclear are not included in this despite emitting zero carbon and serving as valuable baseload energy sources, as all of the aforementioned technologies, save geothermal, do not. Hydro and nuclear were excluded largely because they are far less popular with green groups despite addressing the underlying climate goals arguably far more effectively than alternative technologies.

9 See the CARB January 2011 AB 32 Updated *Scoping Plan,* "Functional Equivalent Document," for a description of these measures and their expected contributions toward AB 32's 2020 GHG emission target.

10 The 2011 AB 32 *Scoping Plan,* "Functional Equivalent Document," later updated AB 32's GHG reduction math to account for the effects of the recession and progress with implementation of "complementary policies"; our calculations show that this more recent document assigned about 71 percent of targeted GHG emission reduction to "complementary policies" and about 29 percent to cap-and-trade.

11 It is important to note that any such cap is not truly a hard cap, however, as if prices soared sufficiently, political exigency would demand that the cap be relaxed. It is probably more accurate to say that cap-and-trade offers relatively more certainty on emissions-reduction quantity, while a carbon tax offers more

certainty on price. See also, however, Wara et al (January 2014), "The Case for a Carbon Tax as US Climate Policy."

12 Even CARB's own AB 32 economic assumptions suggest that statewide compliance with GHG reduction targets could be cheaper without the use of any "complementary [regulatory] measures." A CRA-CARB collaborative modeling exercise using CRA's MRN-NEEM model and CARB's economic and technology assumptions found that the total social costs of AB 32 were reduced by over 50 percent—from about $60 billion to $30 billion over 10 years—when cap-and-trade was the sole mechanism used to meet AB 32 GHG reduction targets (as expected, cap-and-trade permit prices would trade around 60 percent higher, approximately $80 per ton, under this scenario). A major difference between CRA's findings and CARB's own (using its Energy2020 model), is that CRA's computable general equilibrium model does not treat energy-efficiency regulatory measures—the major source of CARB's expected AB 32 cost savings—as solving an existing market failure. [CRA (March 24, 2010), "Analysis of the California ARB's *Scoping Plan* and Related Policy Insights"]

13 An extensive economic literature addresses the issue of cost efficiency of market-based instruments such as tradable permits or taxes versus regulatory mandates and standards. See, for example, Spulber (1985), "Effluent regulation and long-run optimality"; Newell and Stavins (2003), "Cost Heterogeneity and Potential Savings from Market-based Policies"; or Goulder and Parry (2008), "Instrumental Choice In Environmental Policy."

14 See Diamant (2013), "Exploring the Interaction Between California's Greenhouse Gas Emissions Cap-and-Trade Program and Complementary Emissions Reduction Policies" EPRI.

15 For example, Schatzki and Stavins, August 2012, present a range of 23 cost estimates for the LCFS or similar federal biofuel mandate policies from the California Energy Commission, Air Resources Board, US EPA, National Research Council, and Boston Consulting Group that span from negative $315 to positive $945 per ton of carbon emission reduction. This wide range, with long tails at both ends, compares to actual AB 32 cap-and-trade allowance auction results to date that span from $10.09 to $14.00.

16 This effect notes that any money saved through efficiency will tend to be spent on other energy-consuming activities, thus reducing the overall GHG benefits of efficiency. While the size of the rebound effect is hotly debated and situational, a 10 percent to 20 percent reduction of overall savings is a general rule of thumb.

17 For example, the RPS policy artificially limits the ability of renewable or other zero-carbon power produced out of state to be credited even though such out-of-state production represents verifiable and potentially lower-cost GHG reductions. And RPS's design and mandate, though now often thought of in terms of GHG emission reductions, included other local pollution-related environmental aims.

18 RPS data from CPUC. CA In-state emission data from BNEF (November 19, 2013), "California emission scheme oversupplied by more than expected." Fifty percent of Southern California Edison's electricity in 2011 came from GHG-free sources; that dropped to 30 percent after the SONGS closure. California Energy Markets, November 8, 2013, p. 9.

19 A combination of complex tiered-rate designs intended to encourage consumer energy conservation and flawed legislation stemming from the California electricity crisis means that, currently, additional costs incurred by RPS are largely saddled upon a minority of electricity consumers. Current Public Utilities Commission rule-making is intended to address this problem, but new rate-making processes are slow and encumbered by legacy legislation. See Carl and Grueneich (2012), "Renewable and Distributed Power in California" for an extended exploration of this subject.

20 As coined by Lee Schipper.

21 Authors' estimate. ZEV credits are tradable, so the price that a conventional manufacturer is willing to pay for credits generated by an EV-capable manufacturer can be used as a proxy for the current approximate unit costs that would be required to develop a ZEV program-eligible full-electric vehicle. In its 2013 Q1 earnings letter to shareholders, electric car manufacturer Telsa Motors reported that it booked $68 million in ZEV credit revenues (from sales to other manufacturers) during the quarter in which it produced 4,900 vehicles. Since Tesla has stated that sales to ZEV program states (largely California, but other US states also operate ZEV programs) represent about half of sales, and assuming no time lag in booked vehicle sales and ZEV credit sales, this comes out to a current per unit ZEV credit of about $28,000 per vehicle, though Tesla anticipated that revenues from ZEV credits would decline quickly.

22 To the extent incurred costs are passed on to consumers from manufacturers with generally slim profit margins.

23 CARB (2008), "AB 32 *Scoping Plan* Document Appendices Volume II," Appendix I-8. "Staff estimates that there will be no net difference in the costs of producing fuels to meet the LCFS compared with the cost of producing traditional petroleum gasoline and diesel." In March 2009, CARB staff released the "Proposed Regulation to Implement the Low Carbon Fuel Standard, Volume I Staff Report: Initial Statement of Reasons" with a more extensive five-scenario cost-benefit analyses that indicated woodchip-based cellulosic ethanol costs of only $2.70 per gallon gasoline equivalent beginning in 2010 and declining through 2020; overall LCFS program savings to consumers were estimated at 2 to 8 cents per gallon for the entire California gasoline market (Section VIII-38). After AB 32 had been approved, CARB in the March 2010 "AB 32 *Scoping Plan* Updated Economic Analysis" later revised LCFS biofuel cost estimates up to be roughly 14 percent more expensive than fossil fuels over the implementation period (p. 26), noting, however, that this analysis "assumed that a sufficient amount of the type of biofuels needed to comply with the standard will be available." Similarly, the 2009 CARB staff report addressed advanced biofuel availability thusly: "The proposed LCFS allows several years—until 2014 or so—for the introduction of second- and third-generation lower-CI fuels into the market. ARB staff recognizes that RFS2 fuels will have to be available in significant quantities for the proposed LCFS to succeed." In fact, it is clear that CARB expected the federal RFS2 low-carbon biofuel production mandate to both shoulder the capital costs of new cellulosic biofuel production and to ensure availability (pVIII–38). With the failure of federal RFS2 mandates, the true marginal costs of LCFS must now be revisited.

24 The situation is similar to the US Federal Synthetic Fuels Corporation program developed in the late 1970s to deploy immature coal-to-liquids and coal-to-gas manufacturing technology commercially and at scale along a preset production time line in hope of displacing oil use. Billions of dollars were spent with little result, artificially diverting R&D resources nationwide and potentially setting back the development of more attractive energy technologies.

25 As recent carbon-intensity targets have been modest, many regulated parties have begun acquiring and banking carbon-intensity compliance permits for use in later years when they do not anticipate being able to meet mandated carbon-intensity reduction levels. Analyses that support feasibility of LCFS rely heavily on such banking to maintain compliance by 2020 (and in doing so assume no carbon-intensity liability beyond LCFS's current 2020 time horizon), [ICF international, July 2013, "California's low carbon fuel standard: compliance outlook for 2020"].

26 LCFS credit trading prices as reported in Yeh et al. 2013, Argus April 2013, OPIS June 2013, and Catherine Reheis-Boyd at the Silicon Valley Energy Summit June 28, 2013.

27 Note that the LCFS tradable carbon-intensity compliance credits are completely separate from the AB 32 cap-and-trade program's tradable emission allowances.

28 LCFS credit trading prices as reported in Yeh et al. 2013, Argus April 2013, OPIS June 2013, and Catherine Reheis-Boyd at SVES June 28, 2013; cap-and-trade 2013 vintage allowance auction results from the CARB website (September 2013).

29 This is compared to a standard California conventional gasoline intensity of 99.18 gCO2e/MJ. This has already led to the wholesale California commodity corn prices trading based upon the corn's carbon footprint [Yeh et al., 2012].

30 Carbon intensity as reported in fuel life-cycle carbon-intensity lookup tables published by CARB, 2012.

31 Yeh et al. 2013. This is clearly not CARB's intended result for LCFS: in the regulation's 2009 staff report, which identified four potential fuel compliance scenarios for 2020, cellulosic ethanol was expected to provide 47 percent to 49 percent of LCFS's carbon reductions from biofuel blending while sugarcane ethanol would provide only up to 5 percent. Though 2020 is still years away, current trends do not seem to support such a path, especially considering that the same 2009 CARB document expected scaled commercial production of cellulosic ethanol around 2015.

32 As described above, the actual amount exceeding 10 percent volumetrically in 2020 will be mitigated by how much regulated parties are able to bank credits in early years or substitute compliance in low carbon-intensity gasoline with low carbon-intensity diesel.

33 As of June 2013, ethanolretailer.com.

34 See 2011 LCFS advisory panel program review and 2011 CEC IEPR.

35 Exceeding the E10 "blend wall" with E15 or E20 blends does not significantly improve gasoline's combustion or criteria pollutant characteristics and may damage the pollution control and fuel systems of cars produced before 2007 (according to vehicle manufacturers). Deploying such blends throughout the state would therefore require the use of segregated fueling infrastructure and extensive consumer education while reducing vehicle range (ethanol is less energy dense than conventional gasoline), potentially harming consumer assets and offering little appreciable benefit apart from marginally reduced life-cycle GHG intensity of the fuel blend.

36 See Searchinger and Fargione articles, February 2008, *Science*.

37 The ILUC framework posits that as the supply of agricultural commodities (such as corn) is diverted from the global food chain to the global biofuel fuel chain, this drives up food prices and induces new food crop production around the world. While some of this new food crop production comes in the form of increased yields, crop switching, or efficiencies, some of it also comes from the conversion of otherwise unfarmed land to agriculture. And when undisturbed forest or grassland is converted to agriculture, there is often an associated GHG emission flux from the soil or burning of existing biomass. The ILUC paradigm shift argued that such emissions should be attributed to the marginal supply of biofuels instead of being seen as an agriculture sector phenomenon.

There remains, however, a broader conceptual question of how much ILUC emissions should even be ascribed to the biofuel sector. Even assuming that a clear causal mechanism can be established, it is not trivial that, for example, emissions generated by a farmer voluntarily choosing to improve his own livelihood in Brazil through new investments should be considered the responsibility of a California oil refiner or Midwestern corn commodity trader. The action of clearing new farmland that results in GHG emissions has benefits other than the production of US biofuels; one could argue therefore that a more accurate accounting system would at minimum distribute such emissions across the total value added through each related economic activity in this complex chain. The current ILUC framework treats rural economic development as essentially a negative phenomenon, because such development generates new GHG emissions.

38 To address this key issue, CARB convened a LCFS expert workgroup to submit recommendations for policy reform by January 2011. Nine subgroup final reports were submitted, but updates to technical aspects of ILUC results within the LCFS regulation in the years since have been minimal.

39 See, for example, ICF's 2012 "California Cap-and-Trade Outlook" or Diamant/EPRI's (2013) "Exploring the Interaction Between California's Greenhouse Gas Emissions Cap-and-Trade Program and Complementary Emissions Reduction Policies."

40 Later, the 2009 CARB LCFS *Staff Report* claimed that the regulation would actually generate net economic gains to Californians of $11 billion over the program's 2010–2020 implementation period, including potential reductions in the price per gallon of motor fuel. In that analysis, cellulosic ethanol, for example, was expected to be cheaper (on a unit energy basis) than corn ethanol or even conventional gasoline.

41 KiOR expects to produce around 3 million to 5 million gallons of cellulosic diesel; March 2013 Q4 2012 KiOR earning conference call. KiOR publicly projects 2013 "scaled" production costs of $5.95 per gallon, likely a best-case scenario.

42 Such a "standards and prices" approach could effectively mimic the technique recommended as least-cost by Baumol and Oates (1971), "The Use of Standards and Prices for Protection of the Environment," for situations where the regulator aims for an industry to achieve a target environmental performance standard but, lacking sufficient information on the costs to do so, can nonetheless apply a somewhat arbitrary tax that moves firms in the direction of the desired standard despite heterogeneity in compliance costs.

43 Ford's 1992 flex fuel Econoline van sported a 34-gallon tank to account for this reduced energy density.

44 CEC 1996, "Fifteen years of fuel methanol distribution," CEC-999-1996-017.

45 Los Angeles Times, February 2, 1990.

46 Lodi News-Sentinel, June 5, 1987.

47 CEC April 1996, "ABCs of AFVs."

48 Data from CEC-999-1996-017 and CA BOE "Gross Taxable Gasoline Gallons."

49 OGJ 1990, "Chevron starts reformulated fuels program."

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Shultz-Stephenson Task Force on Energy Policy

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