Low-Carbon Transportation Policies

A Comparison of California's Low-Carbon Fuel Standard and Other Transportation Policies

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Abstract

Low Carbon Fuel Standards (LCFSs), hybrids of market and regulatory approaches, have been proposed as one way to address issues of energy security, climate change and life cycle emissions, without stifling economic growth. We explored the range of low-carbon transportation policies available to regulators, describe the role of California's low-carbon fuel standard within the context of these other policies, suggest evaluation criteria that regulators can use to evaluate low-carbon transportation policy options and alternatives to the low-carbon fuel standard.

We found that low-carbon transportation policies should be evaluated on five implementation criteria and five outcome criteria. Using these evaluation criteria we evaluated California's suite of transportation policies with a low-carbon fuel standard against three alternative scenarios: 1. Cap and trade with transportation emissions replaces the low-carbon fuel standard, 2. carbon tax on fuels replaces the low-carbon fuel and standard and 3. Removing the low-carbon fuel standard completely. Cap and trade with transportation emissions included resulted in the most improved outcomes with the least implementation difficulties in the California context. However, all policies had different negative and positive aspects.

This report was commissioned by Suncor Energy Inc (Suncor) and conducted by The Pembina Institute (Pembina) in order to provide both Suncor and Pembina with a better understanding of a broad suite of evolving policy options that might achieve the objectives of a Low Carbon Transportation framework. Pembina was requested to survey current research and seek a diverse set of expert opinions to learn more about the state of the debate on the merits and challenges of different policy alternatives and to encourage further discussion. This report follows an earlier report by Pembina, also commissioned by Suncor, entitled "Low Carbon Fuels Standard: Technical, Stakeholder and Policy Analysis of the Low Carbon Fuel Movement".

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1. Introduction

With the United States facing an unprecedented dependency on oil, a fuel source with declining national reserves, the limited fuel alternatives available to vehicle owners is worrying. So too are the GHG emissions that arise from transport fuel use. In the United States, transportation is one of the most strategic sectors to reduce greenhouse gas emissions (GHG). Transportation represents 27 percent of national GHG emissions and accounts for 47 percent of all the increases in GHG emissions between 1990 and 2006, making transportation the fastest growing source of GHG emissions in the country.[1]

The high and ever-increasing GHG emissions in the transport sector can be explained by a number of factors: increasing car ownership rates, the rise in auto-centric cities, suburbs and ex-urbs, lack of viable alternative forms of cleaner transport, car culture, the economic and political influence of the petroleum and auto industries and inexpensive carbon-intensive fuel. Transport sector GHG emissions are not just dependent on fuel type but also from transportation fuel production, vehicle technology, and vehicle miles travelled (VMT). For GHG emission reduction policies to be most effective, they should consider all sources or risk having benefits gained in one area lost in another.

Low Carbon Fuel Standards (LCFSs), hybrids of market and regulatory approaches, have been proposed as one way to address issues of energy security, climate change and life cycle emissions, without stifling economic growth. Still, opinion regarding the efficacy of the standard among obligated parties, politicians, bureaucrats and environmental non-governmental organizations is mixed.

The primary goal of this white paper is to generate discussion on low-carbon transportation policies, specifically the low-carbon fuel standard relative to other policy options. It aims to identify the range of low-carbon transportation policies available to regulators, describe the role of California's low-carbon fuel standard within the context of these other policies, suggest evaluation criteria that regulators can use to evaluate low-carbon transportation policy options and alternatives. The white paper concludes with considerations and suggestions for further research.

To produce the paper, the authors combined a literature review with expert interviews. The policy options and information on California's low-carbon fuel standard are primarily drawn from literature sources. The evaluation criteria, alternatives to the low-carbon fuel standard and the analysis itself are based primarily on the opinions of the interviewees and prior research undertaken by the authors. Further, the scope of the research for the white paper was limited to the United States and Canada, and did not consider policy options prevalent on other continents.

Note that the paper should not be viewed as a rigorous analysis but rather as a starting point for dialogue leading to a second draft. Accordingly, the authors encourage feedback and commentary from readers. The authors would like to thank the interviewees for their time and perspectives on this topic. Note that the interviewees were only asked for their opinions and in no way endorse this report or its conclusions.

Table 1 List of interviewees

Name	Organization	Name	Organization
Simon Mui	NRDC	**Dr. Sonia Yeh**	University of California - Davis
Dr. Heather MacLean	University of Toronto	**Catherine Reheis-Boyd**	Western States Petroleum Association
Jim Cormack	TransCanada	**Jackson Schreiber**	Pechan and Associates
Don O'Connor	$(S\&T)^2$ Consultants Inc.	**Brian Foody**	Iogen Corporation
Chris Hessler	AJW Group	**Todd Litman**	Victoria Transport Policy Institute
Dr. Joule Bergerson	University of Calgary	**Dr. Hadi Dowlatabadi**	University of British Columbia
Sanjana Ahmad	Pew Center on Global Climate Change	**Lois Corbett**	

2. Transportation Policies

There are many transportation policies available to regulators to achieve a variety of policy objectives, including but not limited to reducing transportation-related GHGs. The following section describes those that the authors considered as most applicable for the purposes of this paper. To facilitate grouping and later comparison, each policy is categorized in one of three ways: transportation fuel production, vehicle technologies and vehicle miles travelled (VMT).

2.1 Transportation Fuel Production

Transportation fuel production policies are defined as those policies directly affecting the inputs of the transportation sector. In particular this includes the exploration, recovery and production of transportation fuels but may also include other inputs, such as steel, asphalt and concrete. Currently, there are four major transportation fuel policies: low-carbon fuel standard, renewable fuel standards, carbon tax and cap and trade. Low carbon fuel standards are described in more detail in Section of this report.

2.1.1 Renewable Fuel Standards

The U.S. Renewable Fuel Standard (RFS), adopted in 2005, promotes the use of biofuels as a tool to reduce our dependence on petroleum-based fuel.[2] Originally the RFS called for 7.5 billion gallons to be produced by 2012; however, the 2007 Energy Independence and Security Act created an additional target of 36 billion gallons of biofuels by 2022. The California Bioenergy Action Plan is the California analogue to the RFS. The Californian policy requires 75 percent of biofuel production to be in-state by 2050.

Biofuels are currently a popular consideration as a transportation fuel policy across transportation subsectors (light and heavy duty vehicles, aviation, marine, *etc*).[3] Moreover, some consider biofuels to be the most viable near term fuel alternative in the transportation sector.[4] These proponents argue that biofuels, excluding land use changes, are a viable alternative to gasoline and diesel, representing significant GHG and petroleum savings. They claim that land use changes can be minimized by planting biofuel on marginal agricultural land that does not produce any food or by creating biofuels from biomass waste or algae.

Still, biofuels are not without their detractors. Many recent reports indicate that the scientific and policy-making community is far from consensus on the policy outcomes of biofuels.[5] Many of the existing RFS policies, including California's do not account for GHG emissions from indirect land-use changes. (i.e. significant GHG emissions can occur when land is converted to agricultural production to make up for crops that are now diverted from traditional agriculture markets). [6] The food produced on that land may be sourced from more distant locations, ironically resulting in more transportation related GHG emissions.[7] Even when excluding land use changes, the EPA has found that some corn and soy derived biofuels actually increase GHG emissions.[8] Moreover, there currently is a significant deficit in biofuel feedstocks. In 2006, corn and soybean production would only meet twelve percent of the nation's gasoline needs and only six percent of the diesel needs.[9] Second generation biofuels, such as cellulosic ethanol which uses switchgrass or *Mecanthus*, which replace first generation fuels like corn ethanol, are not yet commercially available.[10] Lastly, biofuels, depending on the price of oil, are currently more expensive than fossil fuels.[11,12]

2.1.2 Carbon Tax

A carbon tax is a transportation fuel policy that in theory applies to fuel producers, both refineries and oil producers. This policy taxes high carbon fuel sources, causing their price to rise. Consumers then modify their behaviour towards less carbon intensive goods and services based upon the price signal received by the carbon tax.[13] For example, a carbon tax would result in a similar response witnessed during the fuel price increase in the spring and summer of 2008 and the resultant shift to more efficient vehicles in the United States.[14]

A clear benefit of a carbon tax is that the administrative costs of an economy-wide tax would be minimized if it were imposed on transportation fuel producers.[15] The other main economy-wide policy, cap and trade, is often faulted for high administrative costs. A recent study found that a carbon tax would cause greater carbon emission reductions sooner than a cap and trade program, and only reduce GDP by one percent, costing households 1.6% of their annual income if carbon tax revenue was returned as income tax relief.[16]

Carbon tax does have its drawbacks. In particular, there is no guarantee of an achievement of certain emission levels.[17] It is also difficult to harmonize regionally and internationally, as tax regimes vary widely across jurisdictions. While overall a carbon tax is less complex than cap and trade, determining compensation and redistribution under a carbon tax scheme will be difficult. From a transportation perspective some policy analysts feel the price signal given by a carbon tax would be too weak to incent change.[18] Similar to the renewable fuel standards, there exists no method to account for land use change in current carbon tax policies. Taxes are also less politically palatable among some regions of the United States, resulting in poor political support for a carbon tax.

2.1.3 Cap and Trade

Cap and trade carbon policies place a cap on industrial emitters (refiners, oil producers, electricity generating facilities, etc) below current GHG emissions. Underneath this cap industry can trade a set amount of emissions. Emission permits may be given out or auctioned at the time of permitting, depending on the particular cap and trade system. In theory, emission reductions occur in areas where the marginal cost for emissions reductions is the lowest. Cap and trade is being considered by several jurisdictions including federal application in U.S. under the Waxman-Markey cap and trade bill and in California as an essential policy tool under AB 32.[19] The American Clean Energy and Security Act of 2009 includes cap and trade with transportation emissions for 2012.[20]

There are a number of benefits of cap and trade over other policy options mentioned. Cap and trade lends itself well to regional and international harmonization when compared to other policy options.[21] Unlike a carbon tax, a cap and trade mechanism sets measurable emission reductions, increasing the certainty and tracking of emission levels for industry and government. The U.S. Congressional Budget Office estimates the cost of a cap and trade program is only 0.2% of household income, arguably less costly than a carbon tax.[22] That being said there is wide variety of cost estimates of cap and trade on consumers, making it difficult to accurately judge costs.[23] Lastly, there are a number of successful precedents of cap and trade systems in the U.S., increasing the political palatability of a cap and trade carbon policy.

Cap and trade is not without drawbacks. There is concern that cap and trade will have minimal effects on the transportation sector.[24] Costs to offset carbon will likely be cheaper to fuel producers and vehicle manufacturers than the cost to innovate and actually reduce transportation-based emissions. Like a renewable fuel standard and a carbon tax, it is difficult to incorporate the added GHG emissions from land use change because of data availability. There is also concern that cap and trade alone could lead to leakage: carbon intensive activities in jurisdictions with cap and trade policies simply move to jurisdictions without such regulations. While this is a valid concern, it can be addressed in cap and trade policy design.[25]

2.2 Vehicle Transportation Policies

Vehicle focused transportation policies target vehicle technologies themselves. Current vehicles are incredibly inefficient, with two thirds of fuel energy lost to heat in the vehicle (not including transportation fuel production losses).[26] Improvement of current vehicle technology, and new technology has a potential for considerable impact. These new technologies have emerged as a result of policy and economics driven research and development. Currently, three general policy tools influence vehicle technology improvements aimed at the manufacturer – fuel economy standards, vehicle efficiency policies, and vehicle lifetime optimization. In addition, many consumer-based policies encourage the uptake of these vehicles, such as feebates and fuel demand policies. Another interesting element of vehicle transportation policies is the recent government ownership of vehicle manufacturers in the United States. It is unclear what influence the Obama administration will exert on the manufacturers.

2.2.1 Fuel Economy Standards

The U.S. fuel economy standards are one method to reduce GHG emissions. While fuel mileage can be a surrogate for GHG emissions they are not positively correlated; a carbon intensive fuel can be fuel-efficient and a carbon reduced fuel can be fuel-inefficient.[27]

Enacted by U.S. Congress in 1975, the Corporate Average Fuel Economy (CAFE) standard is the most well known fuel economy standard in the U.S. CAFE standards are a sales-weighted standard that must be achieved for a particular model year, by nearly every manufacturer of new vehicles. Manufacturers pay penalties for failing to meet CAFE standards and earn credits which may be passed forward or backwards three years when standards are exceeded.

Other standards include California Assembly Bill 1493 (Pavley Bill),[28] which mandates auto manufacturers to produce vehicles under specific GHG intensity levels.[29] The low-carbon fuel standard is like the Pavley bill in that it targets GHG emissions but is unique insofar that it targets transportation fuel producers. Low carbon fuel standards are addressed in-depth in Section .

Standards certainly can create desirable outcomes that would not otherwise occur. Market failures such as consumers lacking information about life cycle costs of fuel can create distortions that standards can address. Standards can be used as a substitute or supplement to a cap and trade system.[30]

Not without criticism, standards have been cited as an ineffective way to incent change. Specifically, there is no incentive for car manufacturers or fuel producers to achieve better results than the standard. Furthermore, current standards only apply to future stocks of vehicles and not the current fleet that can take years to be retired.[31] Standards can also increase the cost of capital replacements, perversely incenting the use of current vehicles.[32] There are equity concerns with standards as well; they impose uniform requirements on all entities using a given type of equipment or operating a given facility, even though these facilities or socio-economic groups may bear very different emission reductions costs.[33] Lastly, there is also concern of the "rebound effect" whereby consumers could use their fuel savings to drive additional miles or larger vehicles.[34] For example, one study found that fuel savings increase from only two to three percent in the short term, rising to a more substantive ten to fifteen percent in the longer term.[35] The rebound effect can be mitigated through other policies that increase the cost of fuel so consumers see no net change in cost per mile, but use less fuel per mile.

2.2.2 Vehicle efficiency technologies

Current inefficiencies in non-engine components (tires, air conditioning, vehicle mass), vehicle speed and driving style, and engine and driveline technologies create a host of opportunities for improvements in the automobile industry. Non-engine losses in heavy-duty vehicles account for a forty five percent decrease in efficiency.[36] Meanwhile, hybrid electric cars have been found to be 34-60 percent more efficient over their conventional counterparts.[37] Of course the production and distribution of electricity must be taken into consideration with electric vehicles.

2.2.2.1 Vehicle Technology Shift

While internal combustion engines can be made more efficient through the aforementioned technologies, switching power sources completely to fully electric motors can yield substantially more reductions in GHG emissions. Fully electric motors convert energy at ninety percent efficiency compared to ten to twenty percent for internal combustion engines.[38] GHG emissions can be further reduced by using renewable power sources.

2.2.3 Vehicle Lifetime Optimization

The manufacture of vehicles necessarily requires a trade-off between short-term manufacturing and environmental costs and longer-term profits and environmental liabilities. Using a life cycle assessment to account for the lifetime energy use of a vehicle, vehicle lifetime optimization encourages the production of more fuel-efficient and cost-effective vehicles. Volvo, Toyota and the BMW Group are manufacturers that employ life cycle assessment in their manufacturing.[39]

2.2.4 Policies to encourage uptake of vehicle technology

2.2.4.1 Feebates

Feebates are a semi-market based policy where vehicles are assessed a fee or awarded a rebate, reflected in the price of a vehicle, based on failing to meet or exceeding a “pivot” fuel consumption rate. They are intended to provide a continuing incentive to manufacturers to improve fuel economy while ensuring sufficiently strong consumer price signals to lure those not motivated by long-term fuel savings.[40]

Model results suggest that manufacturers respond to feebates by incorporating fuel-saving technology in order to maintain the retail price of their vehicles while nearly meeting pivot targets.[41] Feebates also successfully avoid the critique of not encouraging beyond compliance behaviour.

Like fuel economy standards, feebates are criticized for creating a “rebound effect” that cause some consumers to drive their fuel efficient vehicles more often than a less efficient vehicles.

2.3 Vehicle Miles Travelled

Transportation planners use vehicle miles travelled (VMT) as an indicator of travel demand for a given area. Reducing VMT can arguably have many more co-benefits than vehicle focused transportation policies and have much more tangible benefits to local communities than fuel production transportation policies.[42] Besides reducing GHG emissions, lowering VMT can reduce traffic congestion, decrease vehicle collisions, reduce air, noise and water pollution, protect green space, biodiversity and agricultural land, extend the life and decrease the maintenance costs of existing road infrastructure, improve public health through more active lifestyles, improve the livability of communities, reduce sprawl and encourage the development of other modes of transport that are more accessible and affordable than privately owned cars.

2.3.1 Urban Form / Smart Growth Policies

Policies that focus on reducing VMT are only now beginning to examine the role of land use as a catalyst for reducing GHG emissions. A review of more than 40 cities around the world shows that the strongest driver of vehicle dependence and use is urban form, not consumer wealth or the cost of purchasing and operating a vehicle.[43]

California's Senate Bill 375 is a unique law in that it explicitly links GHG emissions to urban form.[44] The bill requires the state Air Resources Board (ARB) to develop regional GHG emission reduction targets to be achieved from automobile and light truck sectors for 2020 and 2035. The 18 metropolitan planning organizations in California will prepare a "sustainable communities strategy" to reduce the amount of VMT in their respective regions and demonstrate the ability for the region to attain ARB's targets. Land developers would get relief from certain environmental reviews under the stringent California Environmental Quality Act if they build projects consistent with the new sustainable community, "Smart Growth," strategies. In addition to their state cap and trade, fuel efficiency standards, and low-carbon fuel standards, California has linked GHG emissions with land use. They incentivize additional GHG reductions through the avoidance of travel all together, through smart growth communities and the development of less polluting modes of transport.

Numerous other urban form-based policy options that reduce VMT have been adopted and proven effective by local and state governments in the last decade. These policies include transit oriented development, infill/brownfield development, pedestrian oriented design, smart school siting, permitting and zoning reform, , green mortgages, comprehensive smart growth programs, open space programs, and safe routes to school programs.[45]

2.3.2 Alternative Transportation Policies and Technologies

Alternative transportation is another avenue to reduce VMT and GHG emissions. Transit service improvement policies target existing transit infrastructure and services. Light rail transit, among other things, reduces the need for new roads and parking infrastructure investments and attracts more riders who have the option to drive, while improving property values. Bus rapid transit is a permanent system of facilities that collectively improve the speed, reliability and identity of bus transit without having the higher costs associated light rail. Many bicycle initiatives now exist to increase cycling demand through creating a safe environment and bike-friendly facilities.[46]

2.3.3 Fiscal Tools and Incentives

Besides using urban form or alternative transportation to reduce vehicle miles travelled, a suite of policies exist which use fiscal policy to influence consumer behaviour.

- **Targeting infrastructure funding –** Through strategic disbursement of traditional transportation funding, resources that previously built infrastructure that resulted in increased GHG emissions can then be used to fund projects that reduce VMT.[47]
- **Road Price –** Through a market-based mechanism that applies a user fee to existing transportation infrastructure, road pricing helps to balance the supply and demand of road transportation by causing road users to pay for their road use. It also has been demonstrated to reduce GHG emissions and improve air quality through lower regional fuel consumption.[48]
- **Commuter Incentives –** Commuter incentives are workplace-based programs to encourage the number of car commuters in an organization. Benefits include: lower

commute costs for employees, reduced congestion, reduced infrastructure costs, improved employee retention and employer tax savings.[49]

- **Pay-as-you-Drive Auto Insurance** – Traditionally auto insurance charges the same rate to high mileage customers and low mileage customers. This goes against the notion that higher risk groups should have higher premiums; high mileage customers are statistically a higher risk group than low mileage customers. Pay-as-you-drive auto insurance incorporates this into their fee structure, in-directly incenting customers to reduce their VMT.[50]
- **Fuel Demand Policies** – Several policies have emerged that target fuel demand directly, not indirectly through feebates or fuel standards. Gas taxes provide not only a way to raise revenue but also help drivers internalize the costs of their energy consumption and GHG emissions, while reducing VMT. Other countries have used gas taxes as a way to increase efficiency in their transportation sector. In 2007, gas prices in France, Germany, Japan, and the U.K. were respectively 2.5, 2.6, 1.8, and 2.7 times higher than in the U.S., largely due to higher motor fuel taxes.[51] Recent studies, however, have shown that the price elasticity of demand for gasoline is relatively low,[52] as consumers often have few alternatives forms of transport other than cars. Gas taxes are also less obvious to consumers than vehicle sticker prices.[53] As a result, acting alone they may not be sufficient to encourage the purchase of fuel-efficient cars.[54]

3. Low-Carbon Fuel Standard Features and Objectives

The low-carbon fuel standard is a fuel production transportation policy that targets the fuels portion of the transportation system. It regulates producers and providers of transportation fuels, such as gasoline, diesel, biofuels, electricity, natural gas and hydrogen, on their life cycle emissions. The life cycle typically includes the production, refining, transportation and use of the fuels (combustion in vehicles) as well as direct and indirect land use change. The regulated parties are required to reduce the carbon intensity of their fuels by a specified schedule.

This section outlines the objectives, design features and outstanding design issues of one low-carbon fuel standard, the Californian approach. California's low-carbon fuel standard forms the bases of this analysis because it is the furthest developed of all the low-carbon fuel standards following the April 2009 California Air Resources Board's decision to pursue the standard in regulation. In this way the California example can be considered as a pioneer model. As with many pioneer models it can likely be improved upon and customized to specific jurisdictions. For more information on California's low-carbon fuel standard please consult CARB's summary.[55]

3.1 Primary objectives of the California LCFS

Many people consider the low-carbon fuel standard as primarily a GHG transportation policy. In actuality, its objectives are far broader. While the low-carbon fuel standard aims to "reduce GHG emissions from the transportation sector in California by 16 million metric tons [almost 10%] in 2020"[56], the policy is also designed to achieve three further objectives:

1. Reduce California's dependence on petroleum.

2. Create a lasting market for clean transportation technology.
3. Stimulate the production and use of alternative low-carbon fuels in California.[57]

The four objectives above lead to some unique design features in the Californian low-carbon fuel standard that make it an energy security, technology and GHG policy. These features are discussed in more detail below.

3.2 Design Features

In order to attain both the GHG objective and the three other objectives discussed above the Californian low-carbon fuel standard contains several distinguishing design features. These features are discussed in more detail below including what impact these features have and the pros and cons of each. While a low-carbon fuel standard need not have these design features, Ontario and British Columbia are considering modified version of California's policy, these features do provide a starting point for analysis.

Credit system: The Californian low-carbon fuel standard only allows regulated parties to purchase credits that are generated from other regulated entities with fuels of lower carbon intensity than required by the standard. Regulated parties cannot purchase credits from outside the bounds of the low-carbon fuel standard, unlike economy-wide cap and trade policies. This credit system creates a cap and trade system for just the transportation system. This design feature requires emission reductions to occur in the transportation system. GHG reductions in the transportation sector are more difficult and more expensive than reductions in other sectors such as power generation and industrial production.[58] As a result, low-carbon fuel standard proponents advocate this additional expense is precisely why resources must be invested in the transportation sector otherwise it will lag behind other sectors in emissions reductions.

Diesel and gasoline baselines: The Californian low-carbon fuel standard provides separate baselines and reduction targets for both gasoline and diesel. The justification for these separate baselines is to encourage the development of non-fossil fuels and to prevent funding of vehicle technologies that will likely not meet future GHG regulations. For example, some of the interviewees consider diesel vehicles as a necessary transition technology because diesel vehicles are relatively less GHG intensive than gasoline vehicles. [59] California has decided to discourage a switch to diesel vehicles because the diesel is derived from fossil fuels and they are concerned that diesel vehicles will not be able to meet future GHG reductions targets and may lead to an increase in other air emissions.

Interaction with other policies: The low-carbon fuel standard does not guarantee absolute reduction targets because it is an intensity-based policy. To use a purchasing analogy if the price of gasoline dropped by 15% but people drove an additional 30% there would be no net savings to the individual. The same applies to GHG policies, if the GHG intensity per km travelled decreases but overall travel increases than there is no savings. The low-carbon fuel standard interacts with several other policies, including cap and trade, vehicle and infrastructure technology investments and VMT policies to address this and other limitations. Regulated parties can find this combination of policies confusing and, if not designed properly, can lead to double or triple regulation of the same entity.

Land use change: CARB's low-carbon fuel standard includes indirect land use change (ILUC) as a significant additional source of additional GHG emissions for crop-based bio-fuels.[60] Not including ILUC could lead to investment and use of bio-fuels with life-cycle GHG emissions that are higher than gasoline emissions. However, the science on land use change is ongoing and some feel that CARB applied ILUC values inequitably among biofuel sources.

3.3 Outstanding Issues

For the purposes of the discussion below this white paper assumes the above design features are part of the low-carbon fuel standard and that potential replacement options for the low-carbon fuel standard must achieve the same objectives as a low-carbon fuel standard.

California's low-carbon fuel standard has its detractors. Some of the more common issues include administrative ease in the form of data availability and uncertainty, the level of achievability of the standard and energy security concerns associated with the lack of contingency scenarios being developed in the case that new technologies and fuel sources are unable to meet demand for low-carbon fuels. The comments discussed below are primarily pulled from several interviews performed for this report and a previous report Pembina completed entitled "Low Carbon Fuel Standard: Technical, Stakeholder and Policy Analysis of the Low Carbon Fuel Movement". None of the comments discussed below are attributed.

Achievability: Several of those we interviewed are concerned with the achievability of the standard. They agree with the need for a performance based standard that incents technology development. However, the low-carbon fuel standard, in their opinion, creates unrealistic targets and expectations for technology development. They fear that a failure to achieve the short-term targets will ultimately undermine the long-term goals of the policy to create transform California's transportation system.

Because achievability of the low-carbon fuel standard is questioned the need for contingency scenarios becomes more important. For instance, one could envision scenarios where the supply of low-carbon fuels lags behind the need for transportation fuels. How are transportation fuels provided in this scenario? What if California lost its refinery capacity so that it was unable to provide fossil fuels to fill a temporary need? Several interviewees feel that these questions need to be considered in more detail and contingency plans incorporated into the standard.

Data Availability: To further complicate matters life-cycle data is limited and uncertain for some sectors and activities. For example, greenhouse emissions for crude sources from regions such as Mexico and Venezuela have to be estimated based on specific reservoir characteristics and production technologies.[61] These data gaps can be filled over time; however some are concerned that the level of current data availability may incent the wrong fuels in the short-term.

Uncertainty: While the interviewees' comments were directed at the low-carbon fuel standard they acknowledged that these issues would likely apply to any policy requiring similar changes to the transportation network. The emission reductions required from the transportation sector are significant and will require significant restructuring the transportation system. This restructuring is inherently risky and expensive, and the optimal design is ultimately uncertain.

4. Alternative Policies for Achieving California Low-Carbon Fuel Standard Goals

California's suite of environmental and transportation legislation is arguably the most comprehensive in the United States, with some suggesting that the state "has been a leader in the development of policy and regulation that relate to reductions in GHG emissions from the transportation sector."[62] The state government has a number of policies and regulations that specifically relate to GHG emissions reductions and transportation sector efficiency. Since the low-carbon fuel standard was designed to integrate with this system the authors felt it to be useful to evaluate it against other policies within the context of California's current policy approach.

The following section outlines four policy plan considerations for attempting to achieve the four-fold primary objectives of the California LCFS: California's current approach (i.e. the baseline for the paper's comparison), the California approach minus the LCFS (to test for redundancy and possible policy overlap), the California approach minus the LCFS but with transportation emissions covered by a cap and trade system (i.e. by regulating fuel wholesalers, who would pass on the carbon price to consumers through the price of fuel – as proposed by Waxman-Markey), and the California approach minus the LCFS but with a carbon tax applied at the pump (as in British Columbia, Canada as of 2008). In Section 5 the plans are compared against each other using ease or difficulty of implementation and their likely effectiveness in delivering on outcomes as yardsticks.

4.1 Current California Policy Approach

The *California Global Warming Solutions Act* of 2006 (AB 32) is described as the "first-in-the-world comprehensive program of regulatory and market mechanisms to achieve real, quantifiable, cost-effective reductions of GHGs."[63] The act calls for total state GHG emissions reductions to 1990 levels by 2020 and grandfathers a previous act that requires 80 percent reductions in GHG emissions below 1990 levels by 2050. AB 32 creates a regulatory authority (CARB) that is responsible for monitoring and reducing GHG emissions, and contains a 'safety valve' whereby the Governor can make the legislation notwithstanding for up to twelve months at a time in the case of extraordinary circumstances, catastrophic events, or the threat of significant economic harm. There are several distinct policies that address the transportation sector. These policies are summarized in the Figure 1, below.

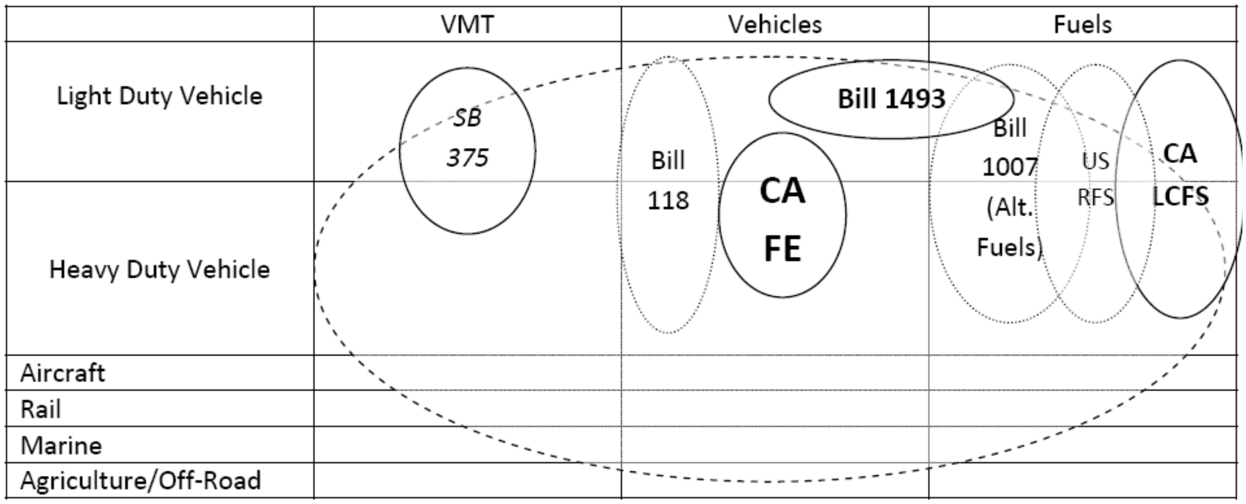

Figure 1: Summary of existing and proposed transportation policies in California.[1]

Figure 1 presents the diversity of policies that exist or are planned in California. Four important points are highlighted in this figure: i) the low-carbon fuel standard is only one among several policies that target the transportation sector; ii) the aircraft, rail, marine sectors are largely untouched by current policies; iii) the lack of clarity over how this suite of policies will address emissions from freight sources; iv) there is a lack of coordinated policy in reducing VMT.

4.2 California without the low-carbon fuel standard, cap and trade or carbon tax

The first alternative scenario includes every policy in the mix above but excludes the low-carbon fuel standard. Any perceived benefits associated with the low-carbon fuel standard such as the 16 million metric ton reduction in GHG emission, life cycle accounting of GHG emissions, and the additional incentive for technology development disappear in the absence of replacement policies. However, on the plus side the administrative burden associated with the low-carbon fuel standard makes this policy suite easier to implement and more achievable, by virtue of its decreased stringency.

4.3 Cap and Trade with Transportation Emissions

In this scenario downstream transportation emissions are included in California's proposed cap and trade system. The cap and trade system is incremental to all other policy options included in the California policy mix. This plan assumes the following for cap and trade system design:

- **Regulated Party:** The regulated parties include refiners and importers.

[1] California policy mix: SB 375 – Land use planning, Bill 118 funding for vehicle technologies, Bill 1493 (Paveley) regulate GHG emissions from vehicle emissions, CAFE – Corporate Average Fuel Economy, Bill 1007 (Paveley) California State Alternatives Fuel Plan, US RFS – Renewable Fuels Standard, CA low-carbon fuel standard – California low-carbon fuel standard.

- **Life-cycle:** This plan assumes that regulated parties will be responsible for the downstream combustion of the fuel, and portions of the life-cycle not covered by the cap and trade program. For example, indirect land use change for biofuels. Many other activities like electricity production or refining should already be covered by the cap and trade policy. The plan also assumes that importers are held responsible for the transportation fuel production carbon emissions associated with their fuel importing.
- **Credits:** Credits would be auctioned off and funding used to protect industries that could suffer from leakage, protect low-income Californians, ensure a regional balance, invest in communities, infrastructure and technology development and provide support to developing countries. Unlike the low-carbon fuel standard emission reductions would not have to occur in the transportation system.

In this system fuel producers are charged the full cost of carbon emissions associated with fuel, who then pass this cost on to the consumer. Reductions can occur anywhere in the system, so would tend to occur where least expensive. While the system may be simpler to administer than a policy mix that includes LCFS, given that it extends the reach of an existing cap and trade system, data availability and uncertainty remain as issues given the requirement of life-cycle carbon accounting. The American Clean Energy and Security Act of 2009 includes cap and trade with transportation emissions for 2012.[64]

4.4 Carbon Tax on Transportation Fuels

In this scenario downstream transportation fuels are taxed. The tax system is incremental to all other policy options included in the California policy mix but replaces the low-carbon fuel standard. This plan assumes the following for cap and trade system design:

- **Regulated Party:** The carbon tax is applied at the pump.
- **Life-cycle:** The tax rate would be based on the amount of carbon emitted from the fuel once it is combusted. For biofuels this number would be based on life cycle values.
- **Income:** Similar to the cap and trade system income from the tax would be used to protect industries that could suffer from leakage, protect low-income Californians, ensure a regional balance, invest in communities, infrastructure and technology development and provide support to developing countries. In addition, a large portion of the tax revenue would be returned to tax payers in the form of income tax rebates.

A carbon tax on fuel purchases provides a clear price signal to the consumer and theoretically incents low-carbon transportation activities over high-carbon transportation activities. While this approach would be in effect an additional policy that carries with it its own administrative burden, the burden is by many accounts slight relative to cap and trade and a LCFS. Data uncertainty and availability for biofuels and oil sources from outside the state remain as issues.

5. Design Criteria

In order to evaluate the above policy plans, and to aid interested parties in similar exercises, the authors of this white paper canvassed interviewees on the criteria they thought most useful for determining overall policy effectiveness. This section presents the results of this canvass. The resulting criteria list can be broadly divided into two categories: those related to implementation and those related to the economic, environmental and social outcomes they produce. This distinction recognizes that a policy plan must not only achieve worthy outcomes, it must also be implementable.[65]

The below list of design criteria is only one of many attempts to develop comprehensive design criteria that regulators can use to evaluate different transportation policy options. However, its breadth of scope would encourage decision makers to consider broader societal contexts in addition to GHG reduction goals.

5.1 Implementation

- **Complementary:** Policies should complement each other and work in coordination to achieve a goal.
- **Acceptability:** Policies should be both politically and socially acceptable. A policy combination acceptable in one jurisdiction may not be acceptable in another. (Note that acceptability is not considered as a component in the implementation portion of the following analysis, given the high degree of variance and subjectivity depending on the jurisdiction.)
- **Administrative Ease:** Both the regulator and the regulated benefit from policies that are administratively simple.
- **Flexibility:** The regulated prefer to have multiple options to achieve a given target. Performance based, technology neutral policies that can incorporate new data or technologies as they evolve are preferred.
- **Achievability:** Targets should only be based on what is reasonably achievable following detailed study of technology and financial considerations. Short-term, unachievable targets may jeopardize long-term goals. However, it must be recognized that what is considered achievable is often based on opinion and there will be risk associated with any policies that attempts to incent change.

5.2 Outcomes

- **GHG reductions:** Greenhouse gas transportation policies should lead to real reductions in GHG emissions. In order to be certain full carbon accounting that incorporates life cycle thinking must be included.[66]
- **Energy Security:** Transportation policy should consider energy security, as current fuel sources are finite and future fuel sources are largely undeveloped. Policy options should therefore consider short term and long term energy supply concerns.
- **Economic/Social/Environmental Cost:** Any policy combination will have intended and unintended consequences. Environmental, social and cost impacts in areas like air emissions, congestion reduction, access to energy, economic cost, health, safety and water quality should be considered. (Note that this criterion is not measured in the

analysis below because there is very limited information on this criterion for transportation policies.

- **Economic/Social/Environmental Benefit:** Any policy combination will have intended and unintended co-benefits. Environmental, social and cost impacts in areas like air emissions, congestion reduction, access to energy, economic cost, health, safety and water quality should be considered. (Note that this criterion is not considered as a component in the outcomes portion of the following analysis, given the paucity of information here specific to transportation policies.)

- **Long-term goals:** Short-term goals should be considered in the context of long-term goals. In the case of transportation technology, development in the short-term will be necessary to achieve long-term climate goals.

6. Preliminary Evaluation

Figure 2 rates each policy option based on the implementation and outcome criteria above. When considering the figure please note that the policies were considered relative to each other. For example, the California without the low-carbon fuel standard scenario has relatively lower GHG benefits than the other three policies so rates low on the outcomes scale. This is not to say the current suite of policies in California will not result in the significant reduction of GHG emission, rather that the emissions reductions will be relatively less than the three other scenarios. The rankings are based on interviewee responses and positions available in public literature sources. Explanations for the policy ranking as shown in Figure 2 are described in more detail below it.

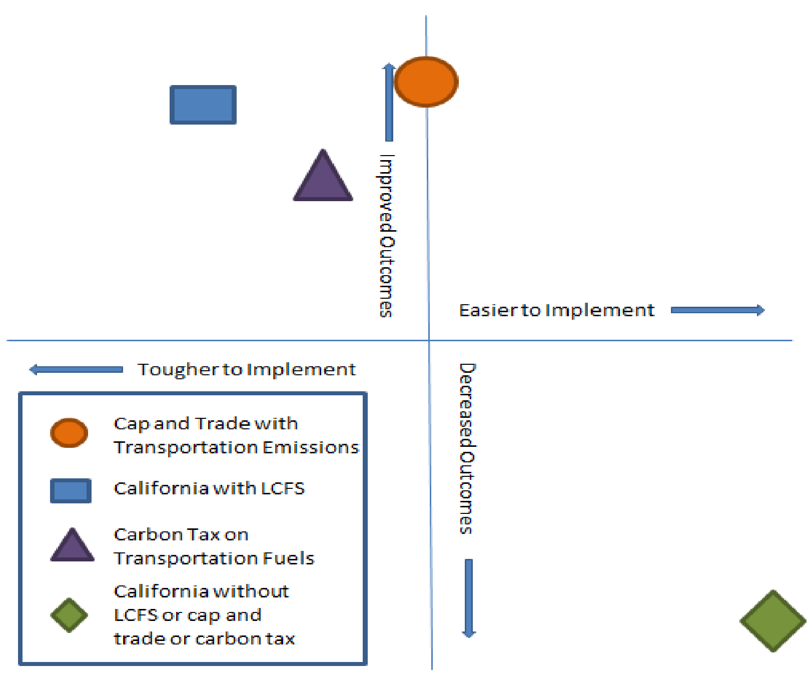

Figure 2: Summary of relative implementation and outcomes of the low-carbon fuel standard and alternative policies.

6.1 Cap and Trade with Transportation Emissions

The cap and trade including transportation emissions scenario is seen as marginally easier to implement than the low-carbon fuel standard or carbon tax systems because a cap and trade system is already being proposed in California. In addition, it is seen as more flexible and achievable because the emission reductions can occur where they are cheapest in the broader economy. Regulated parties would be able to purchase carbon reduction credits from the electricity or manufacturing industries. However, to incorporate biofuels and to address fuels entering from out of state the policy would need to consider life-cycle emissions in a similar manner to a low-carbon fuel standard.

The outcomes from this cap and trade program would likely be more certain because it creates an absolute cap on emissions. The short-term cap on emissions would also be set in the context of long-term emission reductions targets. However, several respondents worry that including transportation in a cap and trade system will elevate the carbon price in the trading system to the detriment of other industries. It is also uncertain whether even this elevated carbon price will lead to technology and infrastructure development in the transportation network.

6.2 Carbon Tax on Transportation Fuels

The carbon tax is considered marginally more difficult to implement than the cap and trade system because it adds another layer to regulations in California. The tax also shares the same administration difficulties as the cap and trade and low carbon fuel standard policies in that life cycle emissions for bio-fuels and other transportation fuels entering the state must still be considered to set an appropriate tax on these fuel sources. A carbon tax is also considered more flexible than the low-carbon fuel standard because it doesn’t require reductions to occur in the transportation system itself.

The outcomes of a carbon tax are relatively less certain than a cap and trade system or a low-carbon fuel standard because there is no absolute cap on emissions. In addition, many feel the energy security benefits of a carbon tax are unclear. On the one hand the carbon tax does not set a performance target that may be unachievable; on the other, a carbon tax may not lead to short-term investment in fuel and vehicle technologies required for future deep reductions in carbon emissions.

6.3 Low-Carbon Fuel Standard

The low-carbon fuel standard is seen as tougher to implement than the cap and trade system because it adds another reporting layer for regulators and the regulated parties. Regulated parties also have less flexibility to meet the target making it more difficult to achieve. It is less flexible because it requires that emission reductions occur in the transportation sector itself. The other systems, cap and trade and carbon tax, allow for emission reductions to occur where least expensive in the economy. Several of the interviewees consider the low-carbon fuel standard more difficult to achieve for this same reason. Achieving emission reductions in the transportation sector is expensive and difficult relative to other sectors because of infrastructure barriers and the lack of fuel and vehicle alternatives.

Alternatively, the low-carbon fuel standard would likely be the best policy for short-term technology change and fuel diversification. The interviewees disagree on whether changes in the transportation over the short-term increase or decrease energy security for California. This analysis assumes short-term changes are required for long-term energy security and the low-carbon fuel standard is therefore more likely to lead the drive for increased energy security than a cap and trade or carbon tax.

6.4 California without the Low-Carbon Fuel Standard, Cap and Trade or Carbon Tax

The California policy mix without a low-carbon fuel standard scenario is relatively much easier to implement than the other scenarios because none of the implementation issues discussed for the other three scenarios apply. It is administratively easier, more flexible and more achievable because the emission reductions required under the other policies are not required. The ease of implementation does have a trade off of uncertain outcomes. The greenhouse gas emission reductions, energy security benefits, technology development and consideration of long-term goals are relatively less certain without the low-carbon fuel standard or a replacement policy.

7. Conclusions and Further Research

7.1 Conclusions

The deep emission reductions required from the transportation sector will have intended and unintended consequences on all aspects of society. Achieving these deep reductions will require coordinated policies that tackle all three drivers of greenhouse gas emissions associated with the transportation sector: vehicle fuels, vehicle technologies and vehicle miles travelled. Jurisdictions considering low-carbon transportation policies must consider all three drivers when developing policy options. When considering low-carbon transportation policy regulators are also encouraged to consider the broader social/environmental and economic context by using an evaluation criteria list. Jurisdiction should consider transportation policies in the context of the following criteria:

- How complementary the policies are
- Acceptability
- Flexibility
- Achievability
- GHG reduction potential
- Energy Security
- Economic/Social/Environmental costs and benefits
- Ability to achieve long-term goals

Low-carbon fuel standards are one type of low-carbon transportation policy among many options available to regulators. California's low-carbon fuel standard, and low-carbon fuel standards in general suffer from inherent implementation challenges because they regulate GHG emissions based on life-cycle data. There are data uncertainty, data availability and complexity issues that many fear will make in the policy un-implementable. Others fear the GHG reduction outcomes of policy are uncertain because of the reliance on emerging technologies to reduce emissions. However, most agree with the objectives of California's low-carbon fuel standard, to reduce transportation greenhouse gas emissions while supporting technology change.

We compared California's low-carbon fuel standard with a cap and trade system including transportation emissions and a carbon tax on transportation fuels to determine whether these policy options would be more effective at achieving the objectives of a low-carbon fuel standard. Our analysis found that although there are differences in the relative ease of implementing the three different policies they all must incorporate life-cycle carbon accounting to be effective. Including life-cycle carbon accounting as part of a cap and trade or carbon tax would lead to many of the same implementation challenges as a low-carbon fuel standard. Each policy option has its positive and negative aspects but further research is required to determine the optimum policy.

Jurisdictions considering low-carbon transportation policies should consider what is achievable in their jurisdiction and fully appreciate the risks and benefits of the policies they are considering. To achieve the emission reductions required in the transportation sector requires a coordinated suite of low-carbon transportation policies that target fuels, vehicles and vehicle miles traveled; no one policy will lead to the long-term emission reductions required. The low-carbon fuel standard is one of many policy options and has some critical implementation challenges. However, its attempt to incorporate life-cycle carbon accounting into a transportation policy is essential to achieving real carbon emission reductions and any policy that incorporates life-cycle carbon accounting will encounter similar implementation challenges to the low-carbon fuel standard.

7.2 Further Research

This white paper is focused on the low-carbon fuel standard, alternative policy options and how to evaluate policy options. However, a number of questions were generated during the course of this research that we were unable to answer. A sampling of these questions is provided below.

- What combination of VMT, fuel and vehicle policies can best reduce GHG emissions and rank well over a breadth of criteria?
- In what order should policies be implemented in jurisdictions that are just starting to implement low-carbon transportation policies?
- What's the best way to integrate disparate policies? For example, California has a range of low-carbon policies; however, many are unclear as to how they integrate with each other.
- How effective will California's low-carbon fuel standard, as currently designed, be at achieving its objectives?
- What other policy combinations could achieve the same objectives as the low-carbon fuel standard?

- Why target transportation GHG emissions given the relatively high costs of reducing emissions in this sector?

8. Endnotes

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