Policy Options for Reducing GHG Emissions from Transportation Fuels

Policy Brief **August 2009**

This policy brief outlines two mechanisms to reduce the carbon content of transportation fuels: an economy-wide cap-and-trade program, which would include transportation fuels under the cap, and a low-carbon fuel standard (LCFS), which would set a carbon intensity target for all transportation fuels.

TABLE OF CONTENTS

INTRODUCTION

The transportation sector includes a variety of different modes of transportation, ranging from passenger cars and light trucks to heavy-duty trucks and off-road vehicles to rail, marine, and air transport. All modes combined, transportation is the second largest contributor to total U.S. greenhouse gas (GHG) emissions and responsible for about one-third of U.S. carbon-dioxide (CO_2) emissions from the combustion of fossil fuels.[1] Transportation energy use and emissions are determined by four main elements: the fuels used, the efficiency of the equipment, the distance traveled, and the efficiency of the overall transportation system and infrastructure. This paper focuses on public policy options to address the first element, the fuels used. (For an overview of GHG emissions from the transportation sector, see *CLIMATE TECHBOOK: Transportation Sector*, at www.pewclimate.org/climate-techbook .)

The various transportation modes are almost entirely dependent on fossil fuels for energy; about 95 percent of transportation energy comes from oil-based fuels.[2] In the United States, the transportation sector accounts for more than two-thirds of the 19.4 million barrels of petroleum consumed daily; in 2008, 57 percent of the petroleum consumed in the United States was imported.[3] Over the next 25 years, transportation is expected to drive all the projected growth in petroleum consumption in the United States, an increase of 10 percent between 2005 and 2030.[4]

From a climate perspective, one of the main concerns with the transportation sector pertains to the growing reliance on fuels from unconventional fossil sources (e.g., tar sands, oil shale, or coal), which generally emit more GHG emissions over their life cycle[5] than conventional gasoline or diesel does.[6] Analysts predict that if present energy trends continue – increasing demand and depletion of major petroleum reserves – a transition from conventional to unconventional fossil fuels will be required

before 2030.[7] These unconventional fuels also benefit from compatibility with a convenient, well-developed gasoline infrastructure. While they may be strategically important for energy security concerns, fuels from these sources are more carbon-intensive and can have more harmful, long-term environmental consequences.[8] Policies to address energy security issues will not necessarily reduce GHG emissions unless they develop and increase low-carbon fuel choices that can be produced domestically.

There are a variety of policy strategies that can be used to address GHG emissions from the transportation sector. This paper focuses on two mechanisms to reduce the carbon content of transportation fuels (i.e., the carbon intensity[9] of transportation fuels). The first policy is an economy-wide cap-and-trade program, which would include transportation fuels under the cap and, thus, limit GHG emissions from fossil fuel combustion. The second is a low-carbon fuel standard (LCFS), which would set a carbon intensity target for the entire range of transportation fuels. Either one or both policies can be implemented as a means to reduce GHG emissions from transportation.

POLICY OPTIONS

A. Cap-and-Trade Program

The first policy option to reduce GHG emissions from the transportation sector is to include fuels in a cap-and-trade program.

In a cap-and-trade program, the government determines which GHG-emitting sources are covered by the program and sets an overall emissions target, or "cap," for these sources. Once the cap has been set and covered entities specified, tradable emissions allowances – equal to the level of the emissions cap – are distributed. Each allowance authorizes the release of one ton of GHG emissions. Covered entities must submit allowances equivalent to their level of emissions at the end of each compliance period. (For more information on how cap-and-trade programs work, see *Climate Change 101: Cap and Trade* and *Congressional Policy Brief Series: Cap-and-Trade Design Elements for a Greenhouse Gas Reduction Program*.)

Some of the basic criteria for considering whether to include transportation (or any source of GHG emissions) in an emissions cap are the following:

- **Point of regulation**: which entity has the compliance obligation, i.e., is required to hold allowances to match emissions?
- **Measurability**: is it easy to measure emissions from the sector or use a reliable proxy? Can the system use existing data collection mechanisms?
- **Administrative simplicity**: is it administratively feasible to track emissions, oversee allowance trading, and monitor compliance?

A discussion on how each of these would apply to the transportation sector follows.

If transportation is included in a multi-sector GHG cap-and-trade program, the requirement to hold allowances (i.e., the compliance obligation) can be placed at one of several points, known as the point of regulation. The measurability of emissions and administrative complexity of the program depends on this chosen point of regulation.

- **"Upstream" Point of Regulation:** If the point of regulation is set where fuels (that emit GHGs after combustion) enter the economy, this would be an "upstream" approach. For example, crude oil producers, refiners, suppliers, or distributors could be required to hold allowances based on the carbon content of the fuels they sell, as a reliable proxy to actual emissions.

- **"Downstream" Point of Regulation:** A "downstream" approach covers emissions where they are emitted into the atmosphere. Theoretically, for transportation sector emissions, the point of regulation could be individual consumers of transportation fuels. These individuals could be required to hold allowances for GHG emissions from fuel use. Although this approach is administratively difficult, some argue that the increase in price due to the cost of holding allowances (i.e., the price signal) would be more apparent at the consumer level, and thus, have a potentially larger behavioral impact as consumers shift to lower carbon options. However, this "downstream" approach to a cap on emissions from vehicles is not considered practical, with the large number of consumers and vehicles in the United States.

- **"Midstream" Point of Regulation:** GHGs can also be regulated at other points between the entry of fuels into the economy and the release of emissions into the atmosphere due to combustion. For example, within the transportation sector, vehicle manufacturers could hold allowances to cover the lifetime GHG emissions of new vehicles sold, determined by estimating vehicle use and efficiency. With this approach, manufacturers can adjust prices of the vehicle to reflect the number of allowances needed to cover emissions over the lifetime of the vehicle. This difference in price would then provide an incentive to consumers to choose vehicles with low lifetime GHG emissions. The challenge with this approach is the inability to accurately measure actual emissions. Manufacturers would have to rely on modeling or statistical estimates for the types of fuel used and their corresponding GHG emissions. If estimates of lifetime emissions were below true emissions, using this point of regulation would weaken the effectiveness of the cap. Furthermore, after sale, manufacturers have limited control over and information about the fuels used by vehicle owners and limited ability to decrease use.

Of the various options for incorporating the transportation sector in a cap, an upstream point of regulation offers the greatest administrative simplicity and a relatively accurate measure of actual emissions. To reduce emissions, covered entities in the transportation sector could shift the mix of fuels they provide by selling more lower carbon fuels. They could also pass along the cost of the allowances to consumers, who would then take the increased price of fuel into account in their transportation, work, and housing choices, at least over the long term, if not immediately.

The regulated entity for an upstream approach may vary depending on the level of government implementing the program; cap-and-trade programs are currently under consideration at the federal level and the state and regional level.

- **For a Federal Program**: There are a small number of refiners (about 150) and fuel importers in the United States, which can be required to hold allowances. Given the current federal fuel excise tax program, the fuel supplier or distributor also offer suitable points of regulation for this purpose, although that approach would entail regulating more entities.

- **For a State or Regional Program**: With upstream approach, the point of regulation can be set at any place at which liquid fuels are tracked. The covered entity would need to know the composition of the fuel (i.e., any blends or fuel additives that have been included in the fuel) to accurately calculate the carbon content of the fuel.

    - **Fuel Distributors:** In all states, fuel distributors are required to report the quantity of fuel delivered for the purpose of state excise taxes. If the taxation system is at a point where ethanol and other additives have already been blended in, relying on this system might not be feasible, and another point of regulation would be needed.

    - **Fuel Suppliers:** Refined petroleum products are transported via pipeline to "storage terminals," which are located near consuming areas. From these terminals, fuel suppliers then sell the fuel to distributors, local retailers, and end users.[10] The tracking system for the federal excise tax on motor fuels collects information at the terminal rack; the U.S. Energy Information Administration also collects data from Prime Suppliers[11] on the sales volumes for 15 different liquid fuels at this point. A state or regional cap-and-trade program could use these data collection processes to identify suppliers of transportation fuels and include them in the cap-and-trade program.

Benefits of including the transportation sector under the cap:
In the United States, two sectors – electric power and transportation – emit the majority of GHGs (about 60 percent). Other significant sources of emissions are the industrial sector (from on-site fossil fuel combustion and production processes) and the residential and commercial sectors (from the use of natural gas and oil for space and water heating). (For an overview of other GHG emitting sectors, see the Pew Center's *CLIMATE TECHBOOK*.) Integrating transportation into a broad, economy-wide cap-and-trade program allows for cost-effective reductions across sectors through allowance trading. Broader program coverage implies greater opportunities for emissions reduction. Entities with higher abatement costs can buy allowances from those with low-cost abatement options, reducing the overall cost of compliance with the program. Furthermore, omitting key sectors from the cap-and-trade program allows uncovered sectors to continue emitting GHGs and may induce leakage from covered to uncovered sectors.[12]

As oil prices rise and conventional oil supplies dwindle, producers are finding and extracting more carbon-intensive fuels, including heavy crude oil, oil sands, oil shale, and coal, to produce liquid transportation fuels. Covering fuels under a cap-and-trade program will promote innovation to lower the carbon content of all fuels. The development and use of low carbon fuels can help spur changes across all elements of the transportation sector to accommodate new energy sources (e.g., changes in vehicle technologies, transportation infrastructure, and land use patterns), over the long run. These changes can also address energy security and other related policy-objectives (e.g., the development of more livable and walkable communities).

Concerns with including the transportation sector under the cap:
The main concern with including the transportation sector in a cap-and-trade program is that, in the short term, reducing emissions from transportation is expected to be more costly than other sectors. This implies that reductions are more likely to come from other sectors and unlikely to reduce GHG emissions from transportation. Because most legislation starts with a modest initial GHG cap, the price signal on transportation fuel (i.e., the increase in price due to the cost of carbon allowances) is likely to be too small, at least in the short run, to drive a change in the types and amount of fuel used. The cost of carbon is unlikely to translate into a significant portion of the retail price of gasoline. For example, a $20 per ton of CO_2e[13] allowance price would translate into only about a 20 cent increase in the price of a gallon of gasoline, which represents a smaller change than the variability normally seen in gasoline prices. This same allowance price would have a much larger effect on natural gas and coal prices.[14]

In addition, consumers of transportation fuels are relatively insensitive to fluctuations in prices, particularly in the short term. In most parts of the United States, there are few viable alternatives to personal vehicle travel, thus the demand for gasoline does not change significantly with a change in price.[15] Over the long term or with a large, sustained price increase, consumer response may be more pronounced. For example, with the increase in gasoline prices over the summer of 2008, vehicle miles traveled decreased for the first time in decades[16] and the use of alternatives, such as mass transit, carpooling, etc., increased.[17] On the producer side of the market, there are presently few alternatives to gasoline and diesel, thus the response from suppliers may also be limited in the short term. Balancing this concern of limited responsiveness in the short term is the need for a long-term price signal that creates the necessary market forces to introduce low carbon fuels and technologies.

Another concern with including transportation fuels under the cap is whether the price signal on gasoline and diesel fuel will be politically sustainable. The price of fuel has a far-reaching effect in the economy. Faced with possibly severe consumer impacts, legislators may choose to remove transportation fuels from the cap to avoid higher fuel prices in the future.[18]

To guarantee significant emission reductions from the transportation sector, especially in the short term, sector-specific policies can be used to complement (or as a substitute for) the cap. The following section provides an overview of one possible policy measure, a low carbon fuel standard.

B. Low Carbon Fuel Standard

An alternative policy to a cap-and-trade program that covers the transportation sector is a fuel performance standard known as a low-carbon fuel standard (LFCS). An LCFS sets a target for life-cycle GHG or CO_2 emissions intensity from transportation fuels.[19]

The main components of an LCFS include the following:

- **Scope of the Standard**: Which transportation energy sources (or "fuels") are included? Which transportation modes does the standard cover? (i.e., fuel use in which types of vehicles)

- **Point of Regulation**: Where in the fuel supply chain is the regulatory burden placed?

- **Baseline Year and Reduction Schedule**: What are the reduction targets and relative to what baseline?

- **Greenhouse Gas Analysis**: How is the GHG intensity profile calculated? What are the key determinants of emissions in the fuel production process? How are the boundaries of the GHG life-cycle defined (e.g., are land use changes included, and if so, how)? How does it account for differences in emissions across fuel types and vehicles?

- **Compliance Options**: What actions count toward compliance (e.g., aside from providing a fuel or blend of fuels that meet the standard, entities can use previously banked credits or acquire credits from parties who exceed the standard)?

- **Credits**: How do regulated entities overcomply and generate credits?

An effective LCFS would cover all existing transportation fuels (e.g., gasoline, diesel, etc.) and would include future energy sources (e.g., electricity or advanced biofuels such as cellulosic ethanol), which can be phased in after reaching a specified threshold for use in the transportation sector. Like a cap-and-trade program, the point of regulation should rely on existing data collection points for ease of administration; although in the case of future energy sources, a new reporting structure may be needed. Fuel providers can generally be covered at the terminal rack, since all liquid fuels are distributed through this point. An LCFS policy could "piggyback" on the existing federal reporting structures at the terminal rack to collect data on the amount and types of fuels sold.

Key considerations for setting the life-cycle emissions intensity targets and timetable include: a scientific understanding of the necessary levels of overall GHG mitigation, the current and projected availability of low-carbon fuels, technological feasibility, and economic considerations. In each year, providers can either meet the standard for the fuel/fuel blend they supply or purchase credits to make up for the shortfall. Providers that go beyond the required reductions in carbon intensity (i.e., are below the standard) can generate emission credits equivalent to the difference in the GHG emissions of their fuels and the standard. These credits can then be traded and sold to providers of fuels with a carbon intensity higher than the standard, giving fuel providers more flexibility in meeting the standard and lowering the overall cost of compliance for the program.

One of the most challenging aspects of an LCFS is developing a methodology to calculate life-cycle emissions for each fuel. A complete and accurate life-cycle analysis includes emissions at each step of the production process: extraction of the fuel/production of the feedstock, processing (which is affected by the efficiency of the process and the type of energy used), distribution (via truck, tanker, or pipeline), and combustion in the vehicle, and avoids double counting. Defining the boundaries of each step can be challenging. For example, in the case of biofuels, should emissions resulting from indirect land-use change be counted as part of the production of the biomass feedstock? The regulating agency would need to work with researchers to develop estimation methods that are scientifically based, environmentally sound, transparent, and equitable.

Based on the life-cycle analysis methodology, the regulatory agency can set default carbon-intensity

values for fuels. To demonstrate compliance with the standard, regulated entities can rely on these default calculations of fuel carbon intensity for the specific fuel or blend of fuels they supply. Alternatively, regulated entities can submit actual data from their fuel production operations, to calculate their individual GHG profile. If coupled with a strong incentive to generate and sell credits, a calculation process based on actual data can create an incentive for companies to go beyond the default fuel values.

Benefits of a LCFS

An LCFS is intended to provide a level playing field for all current and potential transportation fuels that may be used in the future by focusing on life-cycle emissions. If all countries and all economic sectors were included in a cap-and-trade program, accounting for life-cycle emissions would be unnecessary because the entire lifecycle of emissions would be capped. However, if the cap is neither global nor economy-wide, an LCFS has the advantage of addressing the entire life cycle of emissions, from production to processing to combustion of the fuel, whereas the cap on fuels only covers emissions from combustion. A low carbon fuel standard also requires regulated entities to produce fuels with low life-cycle carbon intensity.

Compared to volumetric mandates based on fuel type and independent of environmental performance (e.g., the first federal Renewable Fuel Standard as mandated by the Energy Act of 2005), an LCFS is fuel-type neutral. An LFCS allows manufacturers to produce and retailers to purchase the mix of fuels that most cost-effectively meets the standard. Fuels and vehicles can be treated as a system, thereby accelerating the introduction of alternative vehicle types, the appropriate alternative energy sources to power these vehicles, and the necessary infrastructure to support new alternative energy sources (one example might be plug-in hybrid electric vehicles). If the program includes all major transportation modes, low carbon technology can be applied where it is the most efficiently used.

Drawbacks to an LCFS

When implementing an LCFS, one potential difficulty is dealing with the range of energy sources that may be introduced. New energy sources, such as electricity, may have distribution systems that may require different regulatory approaches from those that apply to more traditional liquid fuels. Not only would a new transportation energy source like electricity require new infrastructure for distribution, it would also need a system for measuring usage (e.g., meters on the home electric outlets used to charge electric vehicles) and collecting emissions data. One of the keys to properly designing an LCFS is dealing with these new “fuels” and having a process to determine which ones are covered, when are they covered, and how.

Another drawback to an LCFS is that it is an intensity standard, not an overall cap. An intensity standard regulates the amount of emissions per unit of fuel consumed; consequently, the total emissions depend on how much of a fuel is consumed. A cap puts a limit on the total quantity of emissions, regardless of how efficiently the energy is consumed. Thus, if fuel use increases significantly, emissions from transportation under an LCFS could increase, despite the decrease in fuel-carbon intensity.

Lastly, in terms of state-federal interaction, a future federal fuel policy under Section 211(c) of the Clean Air Act may preempt state efforts. The current Renewable Fuel Standard, enacted under the 2007 Energy Bill, amends Section 211(o) of the Clean Air Act and thus does *not* expressly preempt states from

taking further action at this time. Until the U.S. Environmental Protection Agency (EPA) sets a GHG fuel standard using its authority under Section 211(c) or finds that it is not necessary to have such a policy, states can adopt low carbon fuel standards. Federal programs have key advantages in comparison to state based ones: they are more environmentally effective and cost-effective, and they avoid "leakage" of emissions from covered to uncovered jurisdictions. However, in the absence of a federal LCFS, states can play an important role by developing and testing low carbon fuel policy and motivating action at the federal level. Harmonization of state standards can avoid some of the disadvantages of inconsistent state programs.

COMPARISON OF AND INTERACTION BETWEEN THE TWO POLICIES

To reduce GHG emissions from the transportation sector, a regulatory body can either include fuels in a cap-and-trade program or implement an LCFS or do both. This section compares the two policies and describes ways that they would interact, if implemented together.

Although both policies address GHGs from transportation fuels, they use different mechanisms to reduce GHG emissions. A cap limits the amount of CO_2 and other GHGs that can be emitted in total from all sectors covered in the program. Including transportation fuels in this cap would require fuel providers to either (1) lower their GHG emissions and contribute to GHG reductions or (2) buy excess allowances from other covered entities that have reduced their emissions. This results in lower fuel consumption; a switch to low-carbon alternatives that are lower in cost than the combined price of fossil fuels plus the added allowance price; or emission reductions from other sectors in the cap-and-trade program. If purchasing allowances, fuel providers would pass through the additional cost of allowances to consumers, who are expected to make changes in their purchasing behavior based on the increased price of fuel.

On the other hand, an LCFS targets a reduction in the overall carbon intensity of the fuel supply, but does not limit the total amount of GHG emissions from the sector. The LCFS creates an incentive to a shift to low carbon fuels and energy alternatives (such as electricity and hydrogen) that have lower life-cycle emission intensity than gasoline and diesel.

In the short term, emissions abatement in the transportation sector is expected to be more costly than in other sectors, such as the electric power sector. These other sectors have more low-cost reduction opportunities; thus, it is expected that transportation will be a net purchaser of allowances in the early years of a cap-and-trade program. In the short term, it may be difficult to achieve significant GHG reductions from the transportation sector through a price signal alone, and complementary measures, such as an LCFS, can be used to ensure reductions in fuel carbon intensity, albeit at an early higher cost.

When both policies are implemented concurrently, the LCFS is expected to stimulate technological innovation to reduce the carbon content of the fuel supply, while the cap would control overall GHG emissions to achieve necessary climate change mitigation. This extra push for technology through an LCFS may be especially important in the initial years of a cap-and-trade program, when the cap is expected to be modest and the resulting price signal on transportation fuels is likely to be small. An LCFS would be needed to address "carbon leakage" that may result as emissions move from capped sectors or countries to uncapped ones, by focusing on emissions over the full life-cycle of the fuel. Over the long

term, as more jurisdictions cap GHG emissions across multiple sectors, life-cycle emissions from transportation fuels would decrease because of the overall economy-wide cap.

Currently at the federal level, the only policy that covers GHG emissions from transportation fuels is the federal Renewable Fuel Standard (RFS). The RFS includes volumetric mandates for biofuels, including ethanol, biodiesel, and cellulosic biofuels. The regulation also includes GHG criteria to ensure that when used, the overall volume of these biofuels reduce GHG emissions compared to petroleum-based gasoline or diesel fuel. It would be important for any future LCFS at the federal level to include mechanisms for avoiding the regulatory burden of two fuel policies with two GHG accounting systems.

Recent discussions about fuel policy options have considered both policies. Legislation considered in the Senate in June 2008 (the Boxer-Lieberman-Warner Bill, S. 3036) included both a cap on fossil fuel emissions (including those from transportation) and a low carbon fuel standard. The cap-and-trade bill passed by the House of Representatives in June 2009 included transportation under the cap but did not include an LCFS.

At the state and regional levels, several efforts are underway to limit GHGs from the transportation sector. These efforts, in the absence of a federal cap-and-trade program or LCFS, serve an important role by developing and testing innovative policy solutions, as well as motivating broader action at the federal level. Both the Western Climate Initiative (WCI) and Midwest Greenhouse Gas Reduction Accord (MGGRA) have proposed to cover transportation fuels under the cap. These two regional initiatives as well as the northeast Regional Greenhouse Gas Initiative (RGGI) are also considering an LCFS as a complementary policy to cap and trade. At the state level, California has proposed regulations to implement an LCFS and is pursuing a cap-and-trade program, under AB32 and through its participation in the Western Climate Initiative. In Oregon, Governor Ted Kulongowski recently signed into law House Bill 2186, which would allow for the development of a state LCFS with a target reduction in fuel carbon intensity of 10 percent from 2010 levels by 2020. .[20] (See Table 1 for a full description of policies and proposals.)

The two policies can work in a complementary manner – lowering the carbon intensity of the fuel supply would make it easier to stay within the GHG cap – but implementing both would require the coordination of some program elements. In theory, it should be possible to implement both policies without creating an excessive regulatory burden. The two programs need not cover the same entities but they would work in sync with each other. At the federal level, the point of regulation for the cap-and-trade program is likely to be refineries and importers, while at the state level it is likely to be at motor fuel tax collection points. At both levels of government, emissions are calculated based on the amount of fossil fuel being sold. For the LCFS, the regulatory burden could be placed on any provider of transportation fuels (including biofuel and hydrogen suppliers) at the federal or state level. Both policies allow trading of credits or allowances to meet the targets, but allowances would not be fungible across systems, since they represent different units. Allowances for fuels included in the cap-and-trade program are based solely on their combustion emissions, while the LCFS considers the full life-cycle GHG profile of the fuel. Requiring covered entities to meet two separate standards could be administratively burdensome, if the point of regulation is not properly set. Implementing agencies would need to create data collection systems that allow covered entities to easily demonstrate compliance with the cap, the LCFS, or both.

CONCLUSION

Policies to reduce the GHG emissions from the transportation sector include coverage in an economy-wide cap-and-trade program or an LCFS. A regulatory body could implement either a cap-and-trade program, an LCFS, or do both. Although both policies address GHG emissions from transportation, they use different mechanisms to reduce GHG emissions. A cap limits the amount of CO_2 and other GHGs that can be emitted in total from all sectors covered in the program, while an LCFS provides a target reduction for the overall carbon intensity of the fuel supply, but does not limit the total amount of GHG emissions from the sector.

In the short term, since emissions abatement in the transportation sector is expected to be more costly than other sectors, it may be difficult to achieve significant GHG reductions through the price signal from a cap-and-trade program alone. Complementary measures can be used to ensure that the technological changes necessary for GHG mitigation are achieved, for example, through an LCFS reduces the carbon intensity of transportation fuels.

With either policy, the transition to low carbon fuels and alternative vehicles should create many synergies within and across the transportation and electric power sectors. The ability to serve the transportation sector can offer an added incentive for electricity generators to invest in renewables and carbon capture and storage. Both a cap-and-trade program and an LCFS can stimulate improvement and change in the current light duty vehicle fleet to consume less fuel and can also push other low carbon alternatives. Reducing fossil fuel consumption, especially from foreign sources, and creating diversity in domestic fuel supply will also have the co-benefit of increasing energy security.

ENDNOTES

[1] U.S. EPA, U.S. Greenhouse Gas Inventory Report, 2009. From http://epa.gov/climatechange/emissions/usinventoryreport.html
[2] U.S. EIA, Annual Energy Review 2007, Table 2.1e, Found at http://www.eia.doe.gov/emeu/aer/pdf/pages/sec2_8.pdf.
[3] From U.S. EIA, Petroleum Products Supplied, http://tonto.eia.doe.gov/dnav/pet/pet_cons_psup_dc_nus_mbblpd_a.htm. U.S. Net Imports by Country, http://tonto.eia.doe.gov/dnav/pet/pet_move_neti_a_ep00_IMN_mbblpd_a.htm.
[4] An overall growth of approximately 10 percent from 2005-2030. From U.S. EIA, Annual Energy Outlook 2008, http://www.eia.doe.gov/oiaf/aeo/.
[5] Life-cycle emission includes GHG emitted during production, distribution, and use of the fuel.
[6] According to Greene, et al. "Conventional oil includes liquid hydrocarbons of light and medium gravity and viscosity, occurring in porous and permeable reservoirs. …Unconventional oil comprises deposits of greater density than water (heavy oil), viscosities in excess of 10,000 cP (oil sands), and occurrences in tight formations (oil shale). Ultimately, the distinction between conventional and unconventional resources is based on technology and economics."
[7] Greene, D.L. et al. "Have we run out of oil yet? Oil peaking analysis from an optimist's perspective." Energy Policy, 2006, Vol. 34, pp. 515-531. http://www-cta.ornl.gov/cta/Publications/Reports/Have_We_Run_Out_of_Oil_Yet.pdf
[8] Farrell, A.E. and A.R. Brandt. "Risks of the Oil Transition." Environmental Research Letters, 2006, Vol. 1. http://www.iop.org/EJ/article/-search=57256011.10/1748-9326/1/1/014004/erl6_1_014004.html
[9] Carbon intensity is generally defined as the amount of carbon emitted per unit of energy consumed.
[10] For a brief overview of the gasoline distribution infrastructure, see U.S. DOE, Energy Information Administration, "Where Does My Gasoline Come From?," http://www.eia.doe.gov/bookshelf/brochures/gasoline/index.html
[11] These storage terminals are usually serviced by several Prime Suppliers, which the U.S. EIA defines as any "firm that produces, imports, or transports selected petroleum products across State boundaries and local marketing areas, and sells the product to local distributors, local retailers, or end users."
[12] Leakage occurs when emitters move – either physically or by switching to unregulated energy sources – to avoid regulation. In a cap-and-trade program, as prices rise in regulated sectors, due to the cost of allowances, regulated entities may switch to fuels and other energy sources not covered under the program. Broad coverage and inclusion all major sources of emissions helps avoids this tendency.
[13] Carbon dioxide equivalent (CO_2e) is the amount of CO_2 that would have the same global warming potential (GWP) as a given mixture of greenhouse gases.
[14] A \$20/tCO_2e allowance price would increase the price of coal by \$41/short ton and \$1.11/tCf of natural gas. The Energy Information Administration's projection for prices in 2010: \$2.55/gal of gasoline, \$6.33/tCf of natural gas (average wellhead price), and \$36.62/short ton of coal (delivered price for electric power sector). From US DoE, Energy Information Administration, Annual Energy Outlook 2008, http://www.eia.doe.gov/oiaf/aeo/.
[15] This means that the price elasticity for gasoline demand is relatively low. Elasticity is defined as the percent change in quantity demanded divided by the percent change in price. The demand for a good is relatively inelastic (i.e. the quantity demanded not very responsive to a change in price) when this value is less than one, and relatively elastic when greater than one. Studies that have attempted to estimate the elasticity of vehicle miles traveled with respect to gasoline price was -0.1 in the short run and increasing to -0.2 or more over the long run. This means that in the short run, with a 10 percent change in gas prices, consumers will drive 1 percent less. Studies also indicate that the responsiveness of consumers has decreased over time. For more information, see Parry, Ian W.H., et al, "Should CAFE Standards Be Tightened?," Resources for the Future, Discussion Paper 04-D63, Dec 2004; and Small, Kenneth and Kurt Van Dender, "Long Run Trends in Transport Demand, Fuel Price Elasticities and Implications of the Oil Outlook for Transport Policy," OECD/ITF, Discussion Paper No. 2007-16, Dec 2007.
[16] U.S. DoT, Federal Highway Administration, Traffic Volume Trends, May 2008, http://www.fhwa.dot.gov/ohim/tvtw/tvtpage.htm.
[17] For example, Voorhees, Josh. Transportation: High gasoline prices driving customers to Zipcar. Greenwire, July 10, 2008. http://www.eenews.net/Greenwire/2008/07/10/archive/8?terms=car+sharing
[18] For example, during the summer of 2008, several proposals to deal with the high gasoline prices advocated for a "gas tax holiday." This would lower the price of gasoline for a period of time, but dampen any responses to the price signal that lowered fuel use and GHG emissions (e.g., through increased use of mass transit), as well as decrease tax revenue used to fund transportation infrastructure projects.
[19] Life-cycle emission intensity, also called a fuel's GHG profile or footprint, is the sum of GHG emissions caused by the production, distribution, and use of the fuel, on a per unit basis.
[20] For more information, see Oregon Governor Signs Legislation for a Low Carbon Fuel Standard http://www.pewclimate.org/node/6868.

TABLE 1: POLICY IMPLEMENTATION

POLICY	DESCRIPTION	CAP AND TRADE FOR TRANSPORTATION	LOW CARBON FUEL STANDARD
Federal			
Renewable Fuel Standard (RFS)	• Established under the Energy Independence and Security Act of 2007 (EISA 2007). • Increases previous volumetric mandates for renewable fuels according to fuel type: corn-based ethanol, advanced biofuels, cellulosic biofuels, and biodiesel • Includes provisions to limit the life-cycle GHG emissions for the various fuel types		• While not a full LCFS, the GHG criteria in the RFS attempt to ensure that the policy achieves real reductions in the GHG intensity of biofuels. Because the mandates are based on fuel type, it does not create an incentive for the adoption of low carbon fuels other than those included in the legislation.
Climate Security Act of 2008 (S. 3036)[i]	• Introduced by Senators Barbara Boxer (D-CA), Joe Lieberman (I-CT), and John Warner (R-VA)[ii] • The bill was brought for debate on the Senate floor in June 2008. A motion to end debate on the bill (i.e., "invoke cloture") received 48 votes, falling short of the 60 votes required. If the motion had passed, the Senate would have moved to a post-cloture debate, followed by a vote on the bill itself.	• Cap-and-trade bill that would include about 87% of economy-wide, GHG emissions and reduce GHG emissions to 71% below 2005 levels by 2050 • Covers any facility that produces or entity that imports petroleum or coal-based fuels which will emit GHGs upon combustion • Petroleum-based fuels imported from a NAFTA country are exempted from coverage, as long as that country has enacted national GHG emission reduction requirements that are as stringent as those in the United States	• Establishes the LCFS under Section 211(o) of the Clean Air Act • Covers all fuel providers: any entity that produces, refines, blends, or imports fuel • Applies to fuels used in motor vehicles, non-road vehicles and engines, and aircraft. • EPA would establish the methodology for determining life-cycle GHG emissions • Reduction schedule: - Baseline: 2005 carbon intensity - 2011: 2005 intensity levels - 2012: reductions from 2005 baseline, equal to the GHG intensity reduction from the federal RFS 2 (i.e., expected reductions from the increased volume of low carbon biofuels) - 2023: 5% below 2005 levels - 2028: 10% below 2005 levels • Allows covered entities to generate and trade credits to comply with the standard

POLICY	DESCRIPTION	CAP AND TRADE FOR TRANSPORTATION	LOW CARBON FUEL STANDARD
Discussion Draft of the American Clean Energy and Security Act of 2009[iii]	• Released by Chairmen Henry Waxman (D-CA) and Edward Markey (D-MA) in March 2009. • The actual bill (H.R. 2454), which was introduced in the House Energy and Commerce committee in May did not include a LCFS.	• Cap-and-trade proposal that would include 85% of economy-wide, GHG emissions and reduce GHG emissions for covered entities to 83% below 2005 levels by 2050 • Covers any facility that produces or imports petroleum-based or coal-based liquid fuel	• Authorizes EPA to develop a LCFS under Section 211(c) of the Clean Air Act • Applies to all transportation fuels used in: motor vehicles, motor vehicle engines, non-road vehicles, non-road engines, and aircraft. EPA has discretion to include marine fuels • EPA would determine the lifecycle GHG emissions of all transportation fuels and the 2005 fuel emission baseline • Reduction schedule: - Baseline: 2005 carbon intensity - 2014 through 2022: fuels not covered by the RFS must have an average carbon intensity that does not exceed 2005 levels - 2023: 5% below 2005 baseline - 2030: 10% below 2005 baseline • Includes provisions to allow covered entities to generate and trade credits to comply with the standard
American Clean Energy and Security Act of 2009 (H.R. 2454)[iv]	• Introduced by Chairmen Henry Waxman and Edward Markey in the House Energy and Commerce Committee on May 15, 2009. • The U.S. House of Representatives passed the bill on June 26, 2009 by a vote of 219 to 212.	• Cap-and-trade proposal that would include 85% of economy-wide, GHG emissions and reduce GHG emissions for covered entities to 83% below 2005 levels by 2050 • Covers any facility that produces or imports petroleum-based or coal-based liquid fuel	

POLICY	DESCRIPTION	CAP AND TRADE FOR TRANSPORTATION	LOW CARBON FUEL STANDARD
State			
California	• Under California Executive Order S-1-07 issued in January 2008, the California Air Resources Board proposed regulations to implement a LCFS.[v] • The state is also pursuing a cap-and-trade program through its participation in the Western Climate Initiative.	• The Scoping Plan under AB 32 identifies a cap-and-trade program as one of the main strategies for the state to reduce the greenhouse gas (GHG) emissions.[vi] The state is working with other states through the Western Climate Initiative to design a regional cap-and-trade program.	• Includes gasoline, ultralow sulfur diesel fuel, compressed or liquefied natural gas, electricity, compressed or liquefied hydrogen, any fuel blend containing hydrogen, ethanol, biodiesel, and any other liquid or non-liquid fuel not otherwise exempted from the regulation • Reduction schedule: - Baseline: 2010 carbon intensity - 2020: 10% below 2010 baseline - Program compliance begins in 2011 and yearly standards are interpolated from the 2020 target • Default carbon-intensity values have been set using: - The California-modified, Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation model (CA-GREET) - The Global Trade Analysis Project (GTAP) model to assess emissions due to land use change • The regulations include provisions to allow covered entities to generate and trade credits to comply with the standard
Regional [vii]			
Regional Greenhouse Gas Initiative (RGGI)	• A regional initiative among 10 States: Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, and Vermont • Participating states released a final model rule for the program in August 2006; the first compliance period began on January 1, 2009	• A regional cap-and-trade program that covers only power plants with a GHG cap of 10% below 2005 levels by 2019 • The program does NOT include transportation fuels at this time	• RGGI member states plus the state of Pennsylvania signed a Letter of Intent on December 31, 2008 to develop a Low Carbon Fuel Standard

POLICY	DESCRIPTION	CAP AND TRADE FOR TRANSPORTATION	LOW CARBON FUEL STANDARD
Western Climate Initiative (WCI)	• A regional initiative that includes 7 western states (Arizona, California, Montana, New Mexico, Oregon, Utah, and Washington) and 4 Canadian provinces (British Columbia, Manitoba, Ontario, and Quebec) • Participating states and provinces released final program design recommendations in September 2008 • After a model rule is developed and adopted, the program would begin on January 1, 2012	• A regional multi-sector cap and trade program with a GHG target of 15% below 2005 levels by 2020 • The first phase of the program (beginning in 2012) will cover emissions from electricity generation and large industrial and commercial sources • The second phase (beginning in 2015) will include emissions from fuel use in the transportation sector	
Midwest Greenhouse Gas Reduction Accord (MGGRA)	• A regional initiative including Illinois, Iowa, Kansas, Michigan, Minnesota, and Wisconsin, as well as the Canadian Province of Manitoba • Participating states related draft recommendations on cap-and-trade program design in January 2009	• A regional multi-sector cap-and-trade program with a GHG target of 60-80% below 2005 by 2050 • The program would cover electricity generation, transportation fuels, industrial combustion sources and process emissions, and residential, commercial, and industrial building fuels	• A joint effort, between the MGGRA and the Midwest Energy Security and Climate Stewardship Platform (a related regional effort), released draft recommendations for a regional LCFS in January 2009

Table Notes

[i] For more information on S. 3036, see http://www.pewclimate.org/analysis/l-w.

[ii] Senators Lieberman and Warner introduced a previous version of the Climate Security Act (S. 2191) in the Senate Environment and Public Works Committee, which voted to approve the bill in December 2007. The LCFS was originally introduced by Senator Lamar Alexander (R-TN) and added as an amendment to S. 2191.

[iii] For more information on the discussion draft, see http://energycommerce.house.gov/index.php?option=com_content&view=article&id=1560:chairmen-waxman-markey-release-discussion-draft-of-new-clean-energy-legislation&catid=122:media-advisories&Itemid=55.

[iv] For more information on H.R. 2454, see http://www.pewclimate.org/acesa.

[v] See CARB, "Proposed Regulation to Implement the Low Carbon Fuel Standard: Volume I," http://www.arb.ca.gov/fuels/lcfs/030409lcfs_isor_vol1.pdf.

[vi] See AB 32 Scoping Plan http://www.arb.ca.gov/cc/scopingplan/scopingplan.htm.

[vii] For more information on the regional initiatives, visit http://www.pewclimate.org/what_s_being_done/in_the_states/regional_initiatives.cfm.