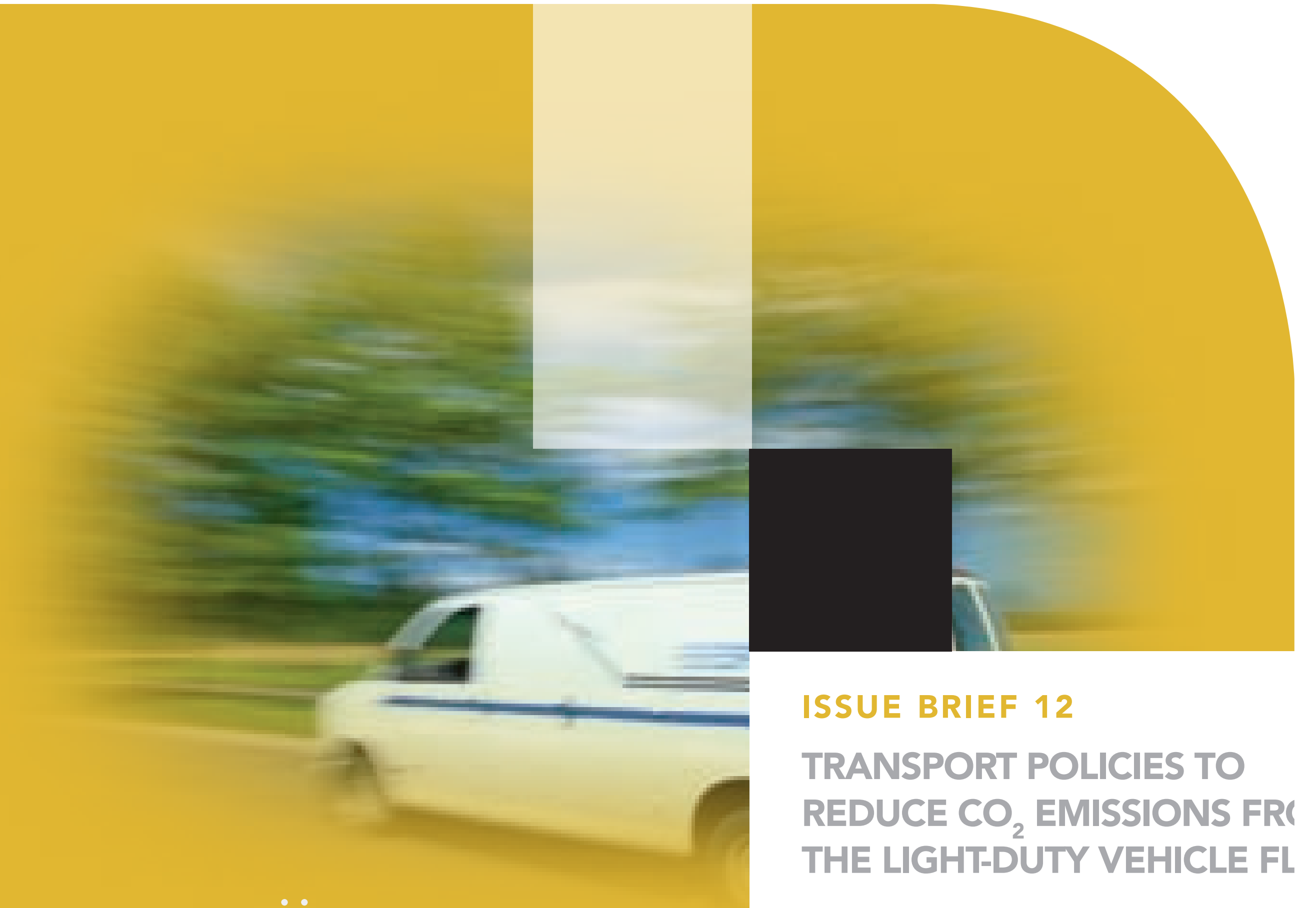

ISSUE BRIEF 12

TRANSPORT POLICIES TO REDUCE CO_2 EMISSIONS FR[O]
THE LIGHT-DUTY VEHICLE FL[EET]

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POLICIES TO REDUCE CO_2 EMISSIONS FROM THE LIGHT-DUTY VEHICLE FLEET

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SUMMARY

- Transport is the second-largest source of carbon dioxide (CO_2) emissions and household vehicle use alone accounts for roughly 16 percent of total U.S. emissions. These emissions have been growing roughly 1.5 percent per year.

- Three factors affect CO_2 emissions from light-duty vehicles: vehicle use (typically expressed as vehicle miles traveled or VMT), fuel economy (typically expressed in miles per gallon or mpg), and net greenhouse gas (GHG) emissions associated with the production and consumption of the transportation fuel(s) used. Fuel economy in turn is affected by vehicle characteristics as well as by operating conditions and practices. Growth in VMT has been the principal driver of rising emissions from the light-duty vehicle fleet, since fleet fuel economy and fuel carbon content have remained relatively unchanged over the past decade.

- An emissions tax or cap-and-trade system (or other carbon pricing mechanism) is the only incentive policy that simultaneously address all three of these factors, efficiently allowing trade-offs among them. Policies that target vehicle fuel economy or fuel carbon content, by contrast, do not provide incentives for reducing VMT.

- Concern about whether consumers properly value fuel economy when purchasing vehicles has led to an emphasis on policies that directly address fuel economy rather than increase the price of fuel. Historically, the primary policy tool for influencing transport-sector energy use has been the Corporate Average Fuel Economy (CAFE) program. Although recent reforms to CAFE as it applies to light trucks have likely improved the program's economic efficiency, further changes could potentially yield additional improvements in cost effectiveness. Such changes could include allowing trading across fleets and manufacturers, incorporating a "safety valve" or other cost-containment mechanism, and shifting to a "feebate" system.

- A cap-and-trade mechanism for CO_2 emissions could be designed to focus on vehicle manufacturers. Based on expected lifetime emissions, it would look very similar to a tradable CAFE or feebate program, except that it would tend to raise the price of *all* vehicles to reflect their projected future emissions, not just those with low fuel economy. Such a program could be modified to encourage manufacturers to produce vehicles that utilize lower-carbon transportation fuels, such as biofuels, electricity, or eventually hydrogen.

- Fuel standards have also been proposed to address apparent obstacles to the deployment of low-carbon fuels, such as the interconnectedness of infrastructure, vehicle fuel flexibility, and fuel production and distribution. In their most flexible and hence most cost-effective form, these proposals specify an average life-cycle emissions rate per gallon that must be met

in aggregate (where the life-cycle emissions rate includes emissions from all stages in the production and use of different fuels).

- When assessing the merits of policies designed to alter the carbon intensity of transport fuels and energy sources, one must consider carbon impacts from the entire fuel cycle, taking into account the technologies and energy sources used to produce and distribute new fuels as well as emissions at the point of use. This is especially true for vehicles powered by biofuels, electricity, or hydrogen where upstream factors have a large impact on full fuel-cycle GHG characteristics.

- Although both a carbon tax and an emissions cap-and-trade mechanism address all three drivers of transport-sector GHG emissions, concern about other market failures—along with the view, held by some, that typical CO_2 market prices will not produce the level of emissions reductions needed from this sector—makes it likely that complementary policies to address vehicle fuel economy and fuel carbon content will be adopted, either in addition to or instead of a CO_2 pricing policy for transport-sector GHG emissions. The rationale for such policies does not rest on economic cost or efficiency arguments, but rather brings in a number of other policy judgments and objectives that are often deemed important.

- There is no doubt that an economy-wide carbon price would align all incentives in the right direction and is needed. Additional policies may be useful, however, for the reasons noted above. To the extent that such policies are adopted, economic-efficiency considerations argue for maximizing cost flexibility to the extent possible (for example, by applying either trading or price-based mechanisms). Ideally, policymakers should seek to provide simultaneous incentives for vehicle manufacturers to continually improve fuel economy, for fuel providers to produce fuels with lower life-cycle carbon emissions, and for households to reduce VMT.

- If it proves necessary over time to undertake very deep reductions in transport-sector emissions, fundamentally new technologies, infrastructure, and related institutions could be needed. Policies that may work well in the near term to elicit early emissions reductions at a reasonable cost may not be as effective in a context where much deeper reductions and significant technology breakthroughs are required.

Transport-Sector Emissions

Electricity generation accounts for one-third of total U.S. GHG emissions, but transportation follows close behind, at 28 percent. The light-duty vehicle fleet (cars and light-duty trucks) accounts for almost two-thirds (62 percent) of CO_2 emissions from transportation. Of these emissions, the vast majority—around 90 percent—comes from household vehicle use; commercial use represents the remainder. Since 1990, CO_2 emissions from the transport sector have increased about 1.5 percent per year, compared to an annual average increase of 1.8 percent for electric power-sector emissions.

The Federal Highway Administration (FHA) reports that the average fuel economy of new passenger cars rose from 17.4 mpg in 1985 to 22.9 mpg by 2005, while the fuel economy of light trucks actually fell from 17.3 to 16.2 mpg.[1] Over the same period, FHA reports that VMT increased by more than 60 percent nationwide, from 1.6 trillion miles per year to almost 2.7 trillion miles. It is precisely this combination of relatively flat fuel economy and sharply higher VMT that has driven recent growth in transport-sector CO_2 emissions.

GHG reductions can be achieved by changing any of the three factors that drive overall emissions from the light-duty vehicle fleet: (1) net emissions associated with the production and use of vehicle fuels, (2) vehicle fuel economy, and (3) total miles driven (VMT).

For example, the carbon content of fuel could be reduced by mixing low-carbon biofuels with petroleum or by running vehicles on electricity or fuel cells that make use of low-carbon energy sources instead of using petroleum-derived fuels.[2] Improving vehicle fuel economy is an obvious way to reduce CO_2 emissions, but this option may indirectly increase VMT if it lowers vehicle operating costs.[3] Finally, any actions that reduce VMT will lower CO_2 emissions as long as fossil fuels continue to supply a significant share of transportation energy needs.

Relevant Economic Actors

Decisions that affect transport-sector emissions are controlled by three groups of economic actors: households (including vehicle operators or drivers), vehicle manufacturers, and

1 U.S. Department of Transportation (2006). Highway Statistics 2005. Washington, DC, Federal Highway Administration. The Federal Highway Administration lists all 2-axle, 4-wheel vehicles as light trucks. This doesn't match the CAFE new vehicle calculations, which only includes trucks up to 8500 GVWR (gross vehicle weight rating). There is a substantial number of pickups sold above 8500 GVWR so the numbers are not directly comparable.

2 CO_2 emissions are associated with the production of biofuels and may be released during electricity and hydrogen production as well; these must be taken into account when the benefits of these options are calculated.

3 This is know as the "rebound effect": increased fuel economy lowers the per mile cost of driving and therefore could lead to more miles driven.

fuel providers. Drivers and households have different preferences and their vehicle purchase decisions will reflect their willingness to pay for characteristics like power, comfort, appearance, utility, and fuel economy. All else equal, these preferences significantly affect the characteristics of the vehicles that manufacturers offer for sale. Equally important, households and drivers have significant control over VMT and over vehicle operating characteristics.[4]

For their part, vehicle manufacturers respond to consumer preferences, the competitive marketplace, and government requirements in determining the characteristics of the vehicles they produce. Manufacturers can alter the overall fuel economy of their fleets with existing technology, alter the fuel economy of specific models by changing technology, and alter their vehicles' ability to use different fuels. Government mandates aside, manufacturers have sole control over the technology that will be offered for sale in new vehicles.

Fuel producers have the most direct control over the carbon content of the fuel delivered. Their decisions are affected by a number of factors, including fuel prices, vehicle fuel flexibility, fuel quality requirements, and fuel delivery infrastructure.

Regulatory Options for Reducing Light-Duty Vehicle CO_2 Emissions

This issue brief discusses three categories of policies for reducing CO_2 emissions from the light-duty vehicle fleet. Broad-based policies act to place a price on emissions from vehicles or, equivalently, to price the carbon content of the fuels they use; polices targeted at vehicles seek to reduce CO_2 emissions per vehicle mile traveled; and fuel polices seek to lower the carbon content of fuel directly. While each approach has strengths and weaknesses, the merits of one approach relative to another may change depending on the magnitude of emissions reductions targeted and the timeframe involved. If it proves necessary over time to undertake very deep reductions in transport-sector emissions—reductions that would require fundamentally new technologies, infrastructure, and related institutions[5] —policies that may work well to elicit relatively low-cost reductions in the near term may become less effective.

Many of the policies reviewed here seek to incentivize or mandate new technologies for improving the fuel economy of vehicles and the carbon content of vehicle fuels. When

It is an open question whether carbon prices at the levels currently under discussion will be sufficient, by themselves, to bring "new" fuel efficiency technology into the marketplace.

assessing the merits of these policies one must consider the carbon impacts of the entire fuel cycle of the new technologies and fuels. For example, full electric vehicles produce no direct CO_2 emissions, but CO_2 would likely be produced in generating the electricity needed to charge their batteries.[6] Similarly, biofuels can have lower carbon content than hydrocarbon fuels, but accurately assessing their carbon content requires accounting for the entire fuel life-cycle, from the technologies and energy sources used to process biomass feedstocks into transportation fuel back to the energy inputs and emissions outputs associated with cultivating, harvesting, and transporting energy crops in the first place.

Broad-Based Pricing Policies

Current federal-level discussions of broad-based, economy-wide programs to reduce domestic GHG emissions have focused on a cap-and-trade system using emissions permits or allowances and, to a lesser extent, on carbon taxes. Both policies put a price on emissions and thereby create economic incentives for emissions reductions. As noted in Issue Briefs #4 and #5, either an upstream carbon tax, an economywide upstream CO_2 cap-and-trade system, or a stand-alone fuels tax would have the effect of pricing carbon emissions from transportation fuels.[7]

Because an emissions charge levied on the carbon content of fuel would increase the cost of driving, while imposing

4 Even holding VMT constant, the manner in which vehicles are driven and maintained, as well as the character of the transportation infrastructure, can affect CO_2 emissions per mile traveled.
5 An example of a "related insitution" would be an agency responsible for transportation planning.

6 The same is true for hydrogen powered vehicles.
7 In an upstream system the regulated entity would likely be the petroleum refiner.

proportionally higher costs on less fuel-efficient vehicles,[8] it could alter the vehicle purchasing and operating behavior of households. A higher per mile operating cost would provide incentives for households to reduce VMT, both by traveling less and by using other modes of transport (public transit, bicycling, etc.).[9] It would also create incentives for households to purchase vehicles with better fuel economy and/or the ability to run on less carbon-intensive fuels.[10] Changing consumer demand might in turn alter the mix of vehicles offered by manufacturers; it might or might not alter the fuel-efficiency technologies incorporated in new vehicles, at least in the near-term. Whether a carbon charge would be sufficient to encourage a significant increase in the actual production, distribution, and use of low-carbon fuels depends on the magnitude of the charge.

The effectiveness of a carbon price depends in large part on how responsive consumer behavior is to higher driving costs. Current estimates suggest that a 10 percent increase in fuel prices will cause fuel consumption to fall by 3 to 7 percent over the long run. The decline in fuel consumption would be expected to come from a combination of reduced VMT and long-run changes in average fleet fuel economy.[11] Current analyses indicate that less than half the response would be expected to come from reduced VMT, while just over half would be attributable to improvements in fleet fuel economy.[12]

Although most empirical studies support the notion that household consumption of gasoline is responsive to gasoline prices (which in turn would suggest that a carbon charge would elicit changes in overall VMT and average-fleet fuel economy), it is an open question whether carbon prices at the levels currently under discussion will be sufficient, by themselves, to bring "new" fuel efficiency technology into the marketplace. As one recent study points out, "there is a wide range of existing and emerging technologies for increasing new-vehicle fuel economy for which the discounted, lifetime fuel savings appear to exceed the upfront installation costs."[13] One explanation is that households undervalue fuel economy and therefore are not willing to pay the marginally higher purchase cost of more efficient vehicles, leaving manufacturers with no incentive to develop or offer new fuel-saving technologies.[14]

If it turns out that households do value fuel economy, then new technologies will come into the marketplace when the cost of fuel becomes expensive enough. On the other hand, if the undervaluation issue is real, modest carbon charges alone may not create sufficient incentives to drive new technology into the market. Importantly, fuel economy standards, to the extent they correct a market failure separate from climate change—namely, the failure of fuel prices to capture the full energy-security costs of oil consumption—could be a relatively low-cost way to reduce emissions.

Vehicle-Oriented Policies

This section discusses a variety of policy options that aim to directly alter the GHG-emissions characteristics of vehicles. These options include fuel economy standards, emissions performance standards, tradable performance standards, feebates, vehicle-based CO_2 cap-and-trade systems, and technology mandates.

Fuel-Economy Standards

Although U.S. gasoline taxes (which currently average 40 cents per gallon) raise the cost of driving and therefore provide some incentive to reduce VMT and improve fleet fuel efficiency, the magnitude of this incentive has actually declined in real terms over the past several decades.[15] Therefore, the primary sector-specific policy that currently exists to promote reduced transportation-related energy consumption is the Corporate Average Fuel Economy (CAFE) program.

The CAFE program was enacted in 1975 to reduce U.S. dependence on foreign oil. It requires each vehicle manufacturer to meet an average fuel-economy standard across new vehicles sold in the United States. Standards are applied separately to each manufacturer's domestically manufactured cars, its foreign manufactured cars, and its light trucks. From 1975 to 1985, CAFE was responsible for a significant rise in the fuel efficiency of new cars (from less than 15 mpg when the program was launched to approximately 25

8 Conceptually, similar incentives could be achieved via a different mechanism—for example, by applying taxes through vehicle registrations on the basis of carbon emissions per mile (a straightforward function of the vehicle's average fuel economy) multiplied by miles driven. This would require the vehicle's computer to be "read" once a year for the mileage data. This approach would not yield precise results because of the difficulty of tracking other factors—such as the type of fuel consumed or driver behavior—that would affect actual emissions.

9 Alternative policies have been proposed for incentivizing VMT reductions by increasing the cost per mile traveled—examples include pay-by-the-mile auto insurance, road taxes, tolls, and congestion fees. Other policies attempt to alter VMT through land-use planning and enhanced (and/or subsidized) public transport.

10 Consumer demand for lower-emissions vehicles would give manufacturers a near-term incentive to offer flexible- and alternative-fuel vehicles capable of using lower-carbon biofuels. Manufacturers would also have greater incentives to make long-term investments in the development of "zero-carbon" all-electric and hydrogen-based vehicles. Since many forms of electricity generation and hydrogen production produce CO_2 emissions, however, regulations on these upstream emissions sources would need to be in place to ensure that the policy produces desired results.

11 Changes in average fleet fuel economy could result from consumers purchasing more fuel-efficient vehicles or from manufacturers incorporating more efficient technologies in the models they offer for sale, or a combination of both.

12 See Parry, I., M. Walls, et al. (2007). "Automobile Externalities and Policies." *Journal of Economic Literature* **45**(3): 373-399.

13 Ibid.

14 The word "undervalue" is meant to describe the possibility that households appreciate the dollar value of the fuel savings that new technologies would provide, but for one reason or another do not properly consider these savings when evaluating the purchase price of a new or used vehicle.

15 See Parry, I., M. Walls, et al. (2007). "Automobile Externalities and Policies." *Journal of Economic Literature* **45**(3): 373-399.

mpg in the mid-1980s).[16] Since 1985, however, the overall fuel economy of the entire light-duty fleet (including light trucks) has been relatively flat or slightly declining. This is largely because the standards remained unchanged (until recently) even as consumer demand shifted toward larger vehicles which tend to have lower fuel economy (e.g., light trucks and sport utility vehicles).

The cost-effectiveness of CAFE as a public policy tool has been much debated,[17] most recently in the context of modifications to the light-duty truck provisions of the program. Beginning in 2011, CAFE standards for light truck will vary according to the "footprint" of the vehicle.[18] This change is intended to discourage manufacturers from relying on the production of smaller vehicles (which tend to have higher fuel economy) as a compliance strategy while creating differentiated standards that will more effectively encourage fuel economy improvements in light-duty trucks. Generally speaking, CAFE or any variant on a fuel-economy standard will serve to force efficiency improvements into the vehicle fleet. Moreover, if properly structured, fuel-economy standards can also provide incentives for manufacturers to produce flexible and alternative-fuel vehicles. However, CAFE by itself does not create direct incentives for consumers to purchase fuel-efficient or alternative-fuel vehicles, nor does it ensure either that low-carbon fuels will be available and used by consumers.

Fuel economy standards like CAFE have been criticized more generally for a lack of cost flexibility. That is, all manufacturers must meet the same standard regardless of the cost of meeting that standard. Proposals for "tradable" CAFE credits would, in theory, add cost flexibility to these policy instruments. However, the benefits of this flexibility would be realized only if a viable trading market for fuel-economy credits developed, and such a market is not guaranteed.[19] A second alternative, recommended in a 2002 study by the National Research Council, would be to include a "safety valve" mechanism in the CAFE program to limit costs. Much like the safety-valve provisions that have been proposed in connection with an economywide GHG cap-and-trade program, the idea would be to make additional compliance credits available at a predetermined price. This would effectively cap the costs manufacturers could incur in complying with program requirements.

The existing CAFE program has other downsides in addition to the lack of cost flexibility. Standards must be updated over time if efficiency is to be continually improved—something that has proved to be politically difficult, at least in the U.S. context. Moreover, policies of this type provide no incentives to exceed the standard, in contrast to market-based policies like cap-and-trade and CO_2 taxes, which create financial incentives for continual improvement. Finally, and importantly, fuel economy requirements provide no incentive to reduce VMT.[20]

In addition, fuel-economy standards have been criticized for forcing manufacturers to adopt vehicle technologies that consumers do not value and, in doing so, perhaps degrading characteristics that consumers do value. This is worrisome from the manufacturers' perspective, since it serves to dilute consumers' enthusiasm for the vehicles offered and could reduce sales.

Emissions Performance Standards

A vehicle performance standard based on expected CO_2 emissions per mile traveled would directly target vehicle GHG emissions. Like a fuel economy standard, a per-mile performance standard would require manufacturers to produce vehicles with improved fuel economy, but it would also encourage manufacturers to introduce vehicles that run on less carbon intensive fuels (such as biofuels, electricity, or hydrogen).

To be effective, it is critical that performance standards account for GHG emissions from the entire fuel cycle—that is, emissions generated during the production as well as from the use of fuels. This is especially important where vehicles utilize biomass, hydrogen, or electricity "fuels." In contrast to conventional hydrocarbon fuels, where the great majority of emissions occur at the point of use rather than during upstream production, refining, and distribution processes, full fuel-cycle emissions for many alternative transportation fuels are dominated by upstream emissions. Thus, for example, GHG emissions from an all-electric vehicle are entirely dependent on how the electricity used to charge the vehicle was generated; similarly, different biofuels can have very different full fuel-cycle GHG characteristics depending on the specific biomass feedstocks, conversion technologies, and energy sources used to produce the fuel.

From a GHG-mitigation perspective, a per-mile CO_2 performance standard is more straightforward and perhaps effective than a fuel economy standard, since it goes directly

16 See NRC (2002). Effectiveness and Impact of Corporate Average Fuel Economy (CAFE) Standards. Washington, DC: National Research Council, National Academy Press.

17 Ibid.

18 See Pizer, W. and M. Baker (2005). Understanding Proposed CAFÉ Reforms for Light Trucks. Backgrounder. Washington, DC, Resources for the Future.

19 Numerous auto manufacturer representatives have stated that such trading is indeed unlikely.

20 The "rebound effect" may increase VMT. See Small, K. and K. V. Dender (2005). The Effect of Improved Fuel Economy on Vehicle Miles Traveled: Estimating the Rebound Effect Using U.S. State Data, 1966-2001. University of California Energy Institute.

to the policy objective of interest (reducing emissions) and gives manufacturers incentives to produce not only more efficient vehicles, but vehicles capable of running on lower-carbon fuels. A CO_2 performance standard, however, suffers from many of the same problems as fuel economy standards: it is inflexible with respect to cost, requires continual updating, does not provide incentives to exceed the standard, does not provide incentives to reduce VMT, and risks forcing consumers to pay for technologies they are not interested in purchasing. Flexible-fuel vehicles present an additional difficulty because there is no way to be certain about the extent to which they will actually be operated on the lower-carbon fuel, especially if there is some question about how widely available that fuel alternative will be.

Tradable Performance Standards

Fuel economy or emissions standards for new vehicles that do not allow trading among vehicle manufacturers are economically less efficient than policies that allow this kind of flexibility. Conceptually, cost-flexible standards encourage manufacturers with cheaper compliance opportunities to exceed the standard and generate credits, and then sell those credits to manufacturers who face higher compliance costs. Without trading, manufacturers who already meet the standard or who can reach it relatively cheaply have no incentive to do anything more, while other manufacturers must expend considerable resources to achieve the same ends.

Adding tradability to performance standards is straightforward. Say new vehicles are subject to a fleet-average emissions performance standard of 0.37 kilograms CO_2 per mile (the equivalent of 27 mpg for a vehicle operating on gasoline). A manufacturer that beats (falls below) the standard by an average of 0.005 kilograms per mile on a million cars collects 5,000 1-kilogram-per-mile credits (0.005 kg per mile per vehicle x 1 million vehicles). These credits can be sold to another manufacturer whose own fleet misses the standard. The same type of trading could be accomplished within CAFE by allowing manufacturers to buy and sell fuel-economy credits for compliance purposes.

It should be noted that simply introducing trading is not guaranteed to improve the economic efficiency of a performance standard. Trading must actually occur when cost differences exist. Given the small number of major vehicle manufacturers, tradable fuel economy or emissions performance credits may or may not lead to a viable trading market.

Feebates

The term "feebate" usually refers to a symmetric system of fees and rebates (taxes and subsides) designed to provide consumer incentives for improved technologies. For purposes of this discussion we assume that feebates would apply to the purchase price of new vehicles based on their CO_2 emissions or fuel economy characteristics.[21] This type of policy would have two parts: the "feebate rate" that specifies the level of the fee or rebate at different levels of performance, and the "pivot point" that defines which vehicles will be subject to a fee and which will receive a rebate.[22] The pivot point could be a specific CO_2 per mile performance benchmark (or equivalently, a mile per gallon fuel economy benchmark for gasoline-powered vehicles). Purchasers of vehicles with emissions above this pivot point or benchmark would pay a fee. Logically, vehicles with emissions significantly above the benchmark would be assessed a larger fee than vehicles with emissions only slightly above the benchmark. Similarly, vehicles with emissions below the benchmark would receive a rebate in proportion to their emissions performance relative to the benchmark. Most often, feebate programs are modeled to be revenue neutral—that is, the amount of money collected in fees is enough to pay for the rebates, with the pivot point adjusting over time to maintain revenue neutrality.[23]

A system of feebates would provide incentives for both vehicle purchasers and manufacturers and could induce a fleet-wide shift to lower-emitting vehicles over time. In the near-term consumers would have an incentive to choose relatively more efficient models among existing product offerings. In the longer run, manufacturers would have an incentive to install new efficiency-enhancing technologies so their vehicles could qualify for more favorable treatment under the feebate system. Provided that competitive pressures allow the price of technology improvement to be passed on to the customer, manufacturers would have an incentive to include all forms of low-carbon technology that produce a reduction in fees or an increase in rebates that is larger than their cost. From an emissions-mitigation perspective, this is the most important effect of a feebate policy. In fact, studies by the Department of Energy have concluded that about 90 percent of the impact from feebates would be expected to result from manufacturers electing to incorporate new technology, while only about 10 percent of the impact would be attributable to changes in customer purchase decisions.[24] It is worth

21 While feebates have desirable properties they have not been adopted on a wide scale.
22 See Greene, D., P. Patterson, et al. (2005). "Feebates, Rebates and gas guzzler taxes: a Study of Incentives for Increased Fuel Economy." *Energy Policy* **33**: 757-775.
23 Current "gas guzzler" taxes are a variant on the policy where only a tax is appied and the tax is levied on the basis of fuel economy.
24 See Davis, W., M. Levine, et al. (1995). Effects of Feebates on Vehicle Fuel Economy, Carbon Dioxide Emissions, and Consumer Surplus. *Technical Report Two of Energy Efficiency in the U.S. Economy*. Washington,

noting, however, that this finding assumes manufacturers will not be forced to sacrifice vehicle characteristics that are more highly valued by the customer to make fuel economy improvements. If this is not the case, then the fact that trade-offs exist with other equally or more highly valued vehicle characteristics will tend to diminish the effectiveness of feebates.[25] Finally, unlike a fixed, per-mile CO_2 performance standard, the feebate mechanism creates dynamic incentives for continual improvement. Under this system, it is worthwhile for manufacturers to continue incorporating improvements so long as those improvements are paid for by reduced fees or higher rebates. This would be true even if the vehicle's performance at the outset is already fairly good.

Feebates could be implemented in a variety of ways. Different fee and rebate schedules could apply to different types of vehicles or even to individual manufacturers. This might ameliorate large differences among manufacturers due to differences in their product mix—full-line manufacturers, for example, could have a very different emissions profile than smaller manufacturers that specialize in particular types of vehicles. The disadvantage of this approach, however, is that vehicles with the same fuel economy could face different feebates.

Cap-and-Trade Program for Vehicle Emissions

Transportation emissions could be included in an economy-wide cap-and-trade permit system; alternatively, a tradable permit system could be constructed for the transport sector alone. [26] Either way, a good many implementation issues would need to be overcome.[27]

One of the most important questions in designing a cap-and-trade system is where to regulate. If the compliance obligation were imposed fully downstream, at the level of the vehicle operator, the logistics of dealing with 200 million regulated entities would be prohibitive. Alternatively, a fully upstream approach could be used to cover the transport sector as part of an economy-wide tradable permit program. In the latter case, the obligation to surrender GHG allowances or permits would be imposed on fuel producers or refiners, and importers based on the carbon content and volume of fuel they handle. Yet another alternative might be to impose the compliance obligation on vehicle manufacturers based on expected emissions from the vehicles they sell.

Given that a fully downstream system is impractical for regulating transportation emissions, the most often discussed approach for this sector is fully upstream. This means the compliance obligation for most transportation emissions would fall on petroleum refiners. Such a policy would have the same incentives, strengths, and weaknesses as a price or charge on carbon (discussed above).[28] Because reducing CO_2 emissions from the transport sector is likely—at least in the short run—to be more costly than reducing emissions in other sectors of the economy (notably the electricity generation sector), only relatively small reductions, if any, would be expected from the light-duty vehicle fleet—at least at the level of price signal contemplated in most current cap-and-trade proposals. These proposals would produce only a relatively small increase in the price of gasoline—not enough to overcome current price differentials with most lower-carbon alternative fuels or to motivate consumers to significantly alter their driving habits or vehicle purchasing decisions, at least in the short term.[29]

A cap-and-trade or CO_2 tax system that regulated vehicle emissions at the manufacturer level would be similar to a tradable CAFE program or a feebate (discussed above), except that it would effectively tax *all* vehicles (rather than effectively taxing vehicles that emit above the standard or threshold, while subsidizing vehicles that have lower emissions—as both fuel economy standards and a feebate system do). Manufacturers would need to acquire allowances (or pay emissions taxes) equal to some effective lifetime measure of expected emissions from the vehicles they sell—perhaps 100 tons of CO_2 per car at current fleet-average levels of fuel economy. Even with free allowance allocations to manufacturers, much of this allowance cost would be priced into the car and passed along to car buyers.[30] Because the level of the price increase would depend on the vehicle's emissions characteristics, purchasers would have an incentive to choose relatively more efficient models (or models that run on lower-carbon alternative fuels).

DC: US DOE Office of Policy. Greene, D., P. Patterson, et al. (2005). "Feebates, Rebates and gas guzzler taxes: a Study of Incentives for Increased Fuel Economy." Energy Policy **33**: 757-775.

25 See Davis, W., M. Levine, et al. (1995). Effects of Feebates on Vehicle Fuel Economy, Carbon Dioxide Emissions, and Consumer Surplus, U.S. Department of Energy, OPA.

26 See Nordhaus, W. and K. Danish (2003). Designing a Mandatory Greenhouse Gas Reduction Program for the U.S., Prepared for the Pew Center on Global Climate Change, Ellerman, D., H. Jacoby, et al. (2006). Bringing Transportation into a Cap-and-Trade Regime. *MIT Joint Program.* Cambridge, MA. Gallagher, K. S., G. Collantes, et al. (2007). Policy Options for Reducing Oil Consumption and Greenhouse-gas Emissions from the U.S. Transportation Sector. Cambridge, MA, Harvard Kennedy School of Government.

27 See German, J. (2007). Reducing Vehicle Emissions Through Cap and Trade Schemes". *Driving Climate Change: Cutting Carbon from Transportation.* D. Sperling and J. Cannon, Academic Press.

28 If refiners were responsible for the carbon content of the fuel they sold, they could have an incentive to purchase and blend more biofuels than is currently the case. The strength of this incentive of course depends on the cost of the biofuels vis-à-vis the permit price, the number of vehicles in use that are capable of using biofuels, and the availability of a suitable distribution infrastructure.

29 For example, a $10/ton CO_2 permit price would have a large impact on coal prices, creating a relatively strong incentive for coal-dependent electric ulitities to consider shifts in their generation portfolio. In the transport sector, by contrast, the same carbon price would translate into a 10-cent per gallon increase in gasoline prices—a relatively small change especially when compared to the price fluctuations that have affected oil markets in recent years. Given the short-run inelasticity of demand for gasoline, one would not expect a strong response: very likely, refiners would simply pass along the $10 price of permits and consumers would absorb that cost without significantly changing their behavior.

30 Because allowances would have a significant opportunity cost in the CO_2 market—especially in the context of an economy-wide program—manufacturers would be expected to pass along the cost of using allowances, *even if* they originally receive the allowances for free. For further discussion of cost pass-through issues and of the incentive properties of allocation decisions, see Issue Brief #6.

A manufacturer-based cap-and-trade system for vehicle GHG emissions that was not integrated into an economy-wide carbon market might be less liquid and hence less likely to transmit a clear price signal to vehicle purchasers; in that case, it could be very expensive and inefficient. On the other hand, if a viable permit market did develop—that is, if vehicle manufacturers could freely buy and sell permits—manufacturers would face incentives to continually lower vehicle carbon intensity by either (or both) improving fuel economy and producing more flexible-fuel vehicles. Even then, however, a manufacturer-based approach, especially if it were not part of a broader carbon pricing policy, would likely have the drawback that it fails to create incentives for vehicle operators to actually use lower-carbon fuels or reduce VMT (on the contrary, people might actually drive somewhat more because more efficient vehicles would have lower operating costs[31]).

Technology Mandates

Technology mandates require manufacturers to produce and sell specific types of vehicles. One of the best-known examples is the California Zero Emissions Vehicle (ZEV) mandate. Other mandates could be fashioned around the production and sale of flexible- and alternative-fuel vehicles.

The purpose of mandates is to force specific technologies, technology characteristics, or performance improvements into the marketplace. This approach has risks and drawbacks, however. It is fair to say, for example, that the California ZEV mandate has not been successful in bringing large numbers of zero-emissions vehicles into the California market. Mandates create no incentives for consumers to purchase new technologies, and therefore consumer acceptance of vehicles produced in response to a mandate is an open issue. A policy that relies on vehicle mandates also risks being ineffective and expensive if the chosen technology and its effect on emissions turn out to fall short of what could be achieved using other technologies that have not been mandated.

Fuel-Oriented Policies

Fuel-oriented policies constitute another frequently-discussed option for reducing CO_2 emissions from the light-duty vehicle fleet. Regulations that bring about a shift from traditional hydrocarbon-based fuels to new, less carbon-intensive transportation energy sources can lead to lower CO_2 emissions. As has already been noted, however, it will be extremely important for such policies to account for GHG emissions throughout the full fuel cycle, since CO_2 emissions for many of the likeliest petroleum alternatives are more likely to occur during fuel production rather than at the point of use. In addition, it will be important to consider non-climate environmental and other impacts associated with a shift to lower-carbon fuels—an example would be land-use impacts from a major expansion of the biofuels industry. Such impacts could become important, especially if the expectation is that these new fuels will be deployed in large quantities.

Fuel standards

Fuel standards would require fuel manufacturers or distributors to produce and sell fuels with lower carbon content. This can be done in different ways and with more or less flexibility. A proposal for a California Low Carbon Fuel Standard (LCFS)[32] is an example—it provides a high degree of flexibility because the standard must be met in aggregate for all transport fuels sold, based on life-cycle emissions.[33] Fuels that beat the standard generate excess permits that can be used to offset emissions from fuels that do not meet the standard.

In a recent analysis of a proposed LCFS for California, Farrell and Sperling argue that permits should be made tradable—that is, it should be possible to buy and sell permits in the market, thereby creating a price differential between fuels with different carbon emissions. In other words, if the standard were tradable in the aggregate, high-carbon fuel could coexist in the market with low-carbon fuel, and relative prices for different fuels would adjust in the market—along with the permit price—to meet the standard.[34] Low-carbon fuels like E85 (a gasoline-ethanol blend with 85 percent ethanol content) would become cheaper—effectively it would be subsidized by conventional gasoline with higher carbon content. The change in relative fuel prices might also encourage consumers to purchase vehicles capable of utilizing low-carbon fuel. While trading would significantly increase flexibility and reduce costs associated with a fuel standard, it is worth noting that there is some risk—simply because the number of fuel providers is small—that a viable market would not develop, even if trading among regulated fuel providers were allowed as it is in the California program.

Fuel Feebates

Some of the same benefits of a tradable fuel standard could

31 As noted previously, this concern applies more generally to any policy (including CAFE) that only targets vehicle fuel economy without delivering concurrent incentives to reduce VMT.

32 Farrell, A. and D. Sperling (2007). A Low-Carbon Fuel Standard for California: Part 2: Policy Analysi, University of California.

33 In contrast, some fuel standards would require regulated entities to sell specific volumes of particular fuels—for example, the Energy Policy Act of 2005 mandates a specific proportion of biofuel sales.

34 Several alternative policies could alter the relative prices of low- and high-carbon fuels, thereby encouraging the use of low-carbon fuels and the development and deployment of vehicles that can run on them. These policies include explicit government subsidies for the production of low-carbon fuels (e.g., current subsidies for ethanol production), revenue-neutral feebates that would tax high-carbon fuels and subsidize low-carbon fuels, policies to improve the infrastructure for delivering low-carbon fuels, and government-funded R&D to bring down the cost of production.

be achieved by transforming the standard into a feebate, where the pivot point might be grams of carbon emissions per gallon of fuel. The mechanics of such a system would be analogous to those discussed previously for vehicle feebates. Fuels with emissions above some threshold or pivot point would be taxed; those with lower emissions would be subsidized. By changing the relative price of fuels in proportion to their emissions impacts, feebates would generate incentives for fuel providers to introduce lower-carbon fuels and for consumers to purchase those fuels.

Fuel-Specific Mandates

This type of mandate requires fuel providers to produce and sell a minimum quantity of specific fuel alternatives. It can be used to force unconventional fuels such as E-85 into the marketplace. Fuel mandates can be expressed in terms of a required minimum volume of alternative fuels or as a share or percent of overall fuel or energy consumption. The federal Renewable Fuel Standard (RFS) introduced as part of the Energy Policy Act of 2005 is an example: it is expected to require 7.5 billion gallons of renewable fuels in 2012.

Conclusion

As noted at the outset of this issue brief, CO_2 emissions from the transport sector are largely driven by light-duty vehicles. Light-duty vehicle emissions, in turn, are driven by three factors: vehicle fuel economy, the carbon intensity of vehicle fuels, and VMT. To the extent that market failures exist in this sector that cannot be addressed by a single, economywide price on CO_2 emissions, it is unlikely any single policy can effectively target all three of these drivers at once. Thus, some combination of policies to address vehicle characteristics, fuel characteristics, and VMT may be desirable. Moreover, climate policies for the transport sector cannot be considered in a vacuum; in many cases they may not produce desired results without complementary policies to reduce CO_2 emissions from other sectors and to address other energy and social concerns. (For example, efforts to promote all-electric and hybrid-electric vehicles might not produce desired GHG reductions unless policies were also in place to limit emissions from stationary sources such as power plants.)

Only the first regulatory option discussed in this issue brief—a broad-based emissions pricing policy—would simultaneously provide incentives for lower-carbon vehicles, lower-carbon fuels, and reduced VMT. Given that pricing policies like a carbon tax or cap-and-trade program can be implemented on an economywide basis—that is, so that they provide seamless coverage of the transport sector along with other sectors—the question arises: is there a need for separate transport policies? Many would say yes, based simply on the observation that any politically feasible economywide carbon charge would initially increase gasoline prices by only pennies per gallon and therefore have little or no impact on transport emissions, at least in the short term. Others disagree, arguing that if it is more costly to reduce emissions from light-duty vehicles than from, for example, electric power generators, then it is economically efficient for most emissions reductions to come initially from other sectors while deferring significant transport-sector reductions until some time in the future.

There are, however, additional factors to be considered. The first is the possible existence of a market failure. If consumers undervalue fuel efficiency for some reason, a carbon price signal by itself will not elicit all cost-effective emissions reductions. A second issue concerns the adequacy of incentives for bringing about fundamental technological change. Will a carbon charge alone provide adequate incentives for vehicle manufacturers to begin investing now in the breakthrough technologies that will be needed to achieve significantly deeper emissions reductions later? Finally, a similar threshold issue may exist with respect to the large-scale deployment of lower carbon fuels, especially where those fuels would require substantial investments in a new or enhanced delivery infrastructure. Again, the incentives provided by a carbon pricing policy might not be adequate, by themselves, to overcome the considerable financial and other barriers that might hinder progress in this area.