Vehicle Standards in a Climate Policy Framework

WORKING PAPER

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Abstract

Policy makers have long turned to vehicle regulation for addressing public concerns about transportation's energy and environmental impacts. This paradigm is ratified in recent action to raise Corporate Average Fuel Economy (CAFE) standards and issue vehicle greenhouse gas (GHG) emissions standards both in California and federally. At the same time, U.S. policy makers are moving toward a national program to limit GHG emissions economy wide. The most robust strategy entails capping emissions from all major sectors including transportation. Such a policy would place an overall constraint on the dominant, carbon dioxide (CO_2) portion of vehicle GHG emissions, which are also regulated by vehicle standards. This overlap raises questions of how vehicle-specific regulations should relate to the broader policy and what metric vehicle standards should use in such a context.

Answers can be found by reviewing the strengths and weaknesses of past policies and drawing on recent discussions regarding the design of national climate policy. One conclusion is that climate policy should require agencies to administer vehicle standards as part of an overall transportation sector GHG management plan that explicitly considers the costs and benefits of the standards relative to other measures that affect emissions. Another is that vehicle standards should be based on an energy metric rather than on GHG emissions rates, which depend on the fuel supply system and not just the vehicle itself. In general, vehicle standards should be promulgated as part of a policy structure that provides appropriate incentives for all actors in the sector: fuel suppliers, transportation infrastructure and land-use planners, consumers and vehicle manufacturers. Such an approach will ensure balanced and ongoing progress in limiting transportation emissions in a manner reasonably commensurate with national climate protection goals, such as those defined by a declining cap on GHG emissions economy wide.

INTRODUCTION

Regulations have been a mainstay of public policy for addressing societal impacts affected by vehicle design since the first automotive air pollution standards were authorized by California's Motor Vehicle Pollution Control Act in 1960. Safety standards were instituted with the passage of major road safety legislation in 1966. The Clean Air Act required nationwide limits on tailpipe pollution starting in 1975 (CAA 1970). Following the 1973 oil embargo, the Energy Policy and Conservation Act established Corporate Average Fuel Economy (CAFE) standards as a way to control oil demand (EPCA 1975). Taking effect for cars in 1978 and light trucks in 1979, CAFE standards required a roughly 63 percent improvement by 1985 for the overall light duty fleet relative to its 1975 level of 15.3 mpg, or an average improvement rate of 5 percent per year (EPA 2008).

Many policy makers see vehicle fuel economy and greenhouse gas (GHG) emissions standards as crucial for addressing the transportation portion of the global warming problem. For the auto industry and many economists, however, vehicle regulation is not an obvious tool for controlling GHG emissions. Their preferred solutions are taxing carbon or using a cap-and-trade system to put a price on carbon throughout the economy. From an environmental perspective, a cap-and-trade approach has the advantage of constraining emissions while maximizing flexibility and cost-effectiveness (Stavins 2008). If vehicle standards remain in place, economic efficiency gains can be realized if the regulations are integrated into the cap-and-trade regime (Ellerman *et al.* 2006).

Transportation Emissions and Regulation

Transportation accounts for 28 percent of the total GHG inventory in the United States and is, after industrial energy use, the second-largest end-use source (EPA 2007). Therefore, it is essential to include transportation in any comprehensive national climate program. A cap-based design confronts the dispersed nature of transportation emissions, which come from millions of individual vehicle tailpipes. Directly regulating GHG emissions from consumers' vehicles is not workable (House E&C 2007).

Some analysts suggest using a "sectoral hybrid" strategy (Nordhaus & Danish 2003). In this case, cap-and-trade covers major stationary sources and transportation is handled with vehicle efficiency standards. Similarly, the European Union's Emissions Trading System (EU-ETS) addresses power generation and industrial sources. The EU addresses transportation through a combination of voluntary vehicle CO_2 standards and pricing policies, including high fuel and vehicle taxes. Without transportation under the cap, however, this strategy does not assure the integrity of economy-wide emissions limits.

Most U.S. cap-and-trade proposals require that transportation fuel suppliers submit allowances to cover the CO_2 emitted from the use of fossil-derived fuels that they sell. Transportation emissions are therefore covered indirectly based on fuel chemical characteristics, which are readily measured. This approach is seen in bills dating from the McCain-Lieberman proposal of 2003 through the Waxman-Markey bill that passed the House in June 2009 (ACESA 2009) and Senate bills under discussion as of this writing. California authorized a cap-and-trade system in its Global Warming Solutions Act (AB 32, 2006). The state's draft regulation proposes to place transportation fuels under the cap starting in 2015 (CARB 2009). All of these policies assume that vehicle standards are already in place.

The tailpipe CO_2 emissions covered by cap-and-trade are the same as those addressed by vehicle regulations, including both CAFE standards and GHG emissions standards such as California's Pavley rules (AB 1493, 2002) and newly proposed federal rules (EPA & DOT 2009). Environmental advocates believe that vehicle standards leverage the technology change needed for reducing emissions (ASE *et al.* 2002; Sierra Club 1991, 2005). Others believe that if the objective is to reduce total fuel use and emissions, fuel and carbon taxes or a carbon cap are more cost effective (Portney *et al.* 2003).

At this point vehicle standards are a *fait accompli*. For light duty vehicles, the single national program announced by the Obama Administration on May 19, 2009, is in place for model years 2012 to 2016 (White House 2009a). This program entails a ramp-up of stringency similar to that called for by California's Pavley standards. For fuel economy, it amounts to a four-year advance approaching the 35 miles per gallon (mpg) combined fleet target that EISA (2007) had required by 2020. Moreover, authority for direct regulation of motor vehicles is unlikely to be superseded by climate policy. Pending climate legislation is either silent on the matter or extends authority to vehicle classes not regulated historically. California policymakers are starting to plan for post-2016 Pavley standards, identifying hypothetical levels for analytic purposes (CARB 2008a).

Regulatory Coordination Questions

To date, vehicle standards have been developed independently of GHG targets, being set instead through engineering and economic studies of how much fuel economy gain can be accomplished over a given time frame (Greene & DeCicco 2000; NRC 1992, 2002). Such studies use a technology assessment rather than an economic efficiency framework, and are not quantitatively tied to the emissions limitations needed to meet climate targets. Neither have fuel economy rules been formally driven by quantitative energy conservation or petroleum reduction goals, even for the original CAFE standards that required a near doubling of automobile fuel economy over ten years (DOT & EPA 1974). Interestingly, however, an aspirational goal of saving two million barrels per day figured prominently in the Congressional deliberations that led to the original CAFE standards (Nivola 1986, Chapter 5).

Going forward, the issue is whether future motor vehicle standards, promulgated after a national climate policy is in place, should be coordinated relative to economy-wide GHG targets. Questions include how the effort required by vehicle regulation relates to that for other parts of the transportation system, such as fuels, travel demand and other modes; how it relates to the level of effort in other sectors of the economy; and what metric is best for administering vehicle standards within a broader climate policy.

A CLIMATE POLICY FRAMEWORK

To successfully confront a problem as vast as global warming, it is necessary to evaluate numerous GHG reduction measures in terms of how well they collectively limit emissions to climate protective targets. As stated by the U.S. House of Representatives Energy and Commerce Committee:

> The climate change program must be an economy-wide program that accounts for all greenhouse gas emissions in the United States because (1) dramatic emissions reductions are required; (2) many economic sectors contribute to greenhouse gas emissions; and (3) everyone must fairly share responsibility for reductions. An

> economy-wide climate change program does not mean, however, that all sectors contribute their fair share in the same way. (House E&C 2007, 3)

As climate strategy advances, policy makers increasingly see merit in setting GHG emissions caps at national or regional levels and using emissions trading as a way to balance environmental effectiveness with economic efficiency.

Cap-and-trade enables the creation of an international system for tracking GHG emissions allowances. It minimizes costs through trading within and among capped nations and the use of emissions credits earned by uncapped countries or sectors (Jorgenson *et al.* 2008). Incentives to reduce emissions are thereby extended to sources that otherwise would be unregulated. Only cap-and-trade moves economies toward a uniform, cross-jurisdictional price on carbon, because markets linked through emissions trade will gravitate toward a common price if the trading rules are transparent (Rühl 2009).

For domestic policy, a cap-and-trade system ties together the elements of what is otherwise a piecemeal strategy. The cap establishes a well-defined limit on the GHG emissions inventory, providing an anchor for other parts of the policy and linking economic sectors together in a legally enforceable manner. Through such a framework, policy makers can have reasonable confidence that the GHG inventory will stay within the bounds necessary for climate protection (EDF 2007).

Pros and Cons of Cap-and-Trade for Transportation

As a leading transportation energy analyst notes, creating an economy-wide price signal is considered "the essential cornerstone of a meaningful climate change strategy" (Greene 2007). However, a cap alone is not sufficient for transportation. Greene (2007) also states, "other policies will be needed in addition to a cap-and-trade system in order to make the reductions in GHG emissions that are likely to be necessary" for addressing the sector. This view builds on the rationale for vehicle efficiency regulation that exists apart from climate concerns. Technologies that increase fuel economy face market barriers that a carbon price signal is unlikely to overcome because consumers do not fully value fuel savings over a vehicle's lifetime (Greene & Shafer 2003; Greene *et al.* 2009). One reason is that fuel represents a relatively small share of total vehicle ownership costs (von Hippel and Levi 1983).

Some analysts conclude that cap-and-trade is not useful for the sector (German 2007; Sperling & Yeh 2009). Indeed, it has been called a "nonsolution" for transportation, the argument being that

> … until biofuels and electric and hydrogen vehicles become commercially viable … it is better to focus on more direct forcing mechanisms, such as a low-carbon fuel standard for refiners, coupled with fuel and greenhouse gas standards for vehicle makers and incentives and rules to reduce driving. (Sperling & Gordon 2009, 149)

Nordhaus and Danish (2003) conclude that cap-and-trade is the best design overall, but because it poorly handles transportation, they propose a sectoral hybrid approach that omits transportation fuels from the cap and relies instead on vehicle efficiency standards as the primary means of controlling GHG emissions from the sector.

Other analysts view vehicle standards as a complement to, rather than replacement for, including transportation within a cap-and-trade system. The Energy and Commerce Committee wrote:

> If refiners and importers are designated as the "point of regulation" for the transportation sector in the cap-and-trade program, a comprehensive climate change program will also regulate motor vehicle manufacturers through efficiency or other performance standards for vehicles. (House E&C 2007, 13)

In addition, that paper said that climate policy should involve all parties that contribute to emissions from the sector, with a design that treats vehicles and fuels as a system and addresses consumer demand.

Structure of Transportation Markets

The insufficiency of simply putting fuels under the cap can be understood by a close look at the markets comprising the sector. It is not just the fuels market that underpins transportation GHG emissions. The "three-legged stool" analogy reflects how emissions are a product of factors, rather than a sum of terms. These three factors are vehicle usage, vehicle fuel consumption rate and fuel carbon intensity. The result is a "factorization dilemma," meaning that the GHG inventory for each major mode of transportation cannot be subdivided in a manner that assigns unique shares of emissions to the sector's key actors.

Figure 1 shows the market structure for the automotive subsector. The emissions come from vehicles operated by consumers, shown in the middle of the triangle. The points of the triangle correspond to the sector's other major actors, whose financial transactions with consumers define the distinct but interlinked markets that influence emissions:

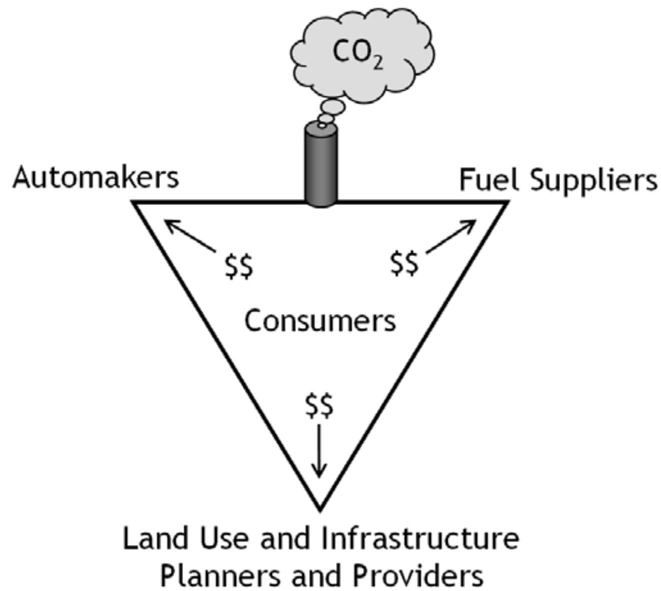
- Consumers purchase vehicles from automakers.
- Consumers buy motor fuel from fuel suppliers, now mainly the petroleum industry.
- Consumers purchase roads, parking, land and its associated uses and land-use patterns through taxes, user fees and in the price of many bundled services of the built environment from the array of public and private entities that provide transportation infrastructures, plus urban and regional plans that underpin travel demand.

The distinct markets that influence transportation emissions can be seen as cash flows from consumers or other system users who are the source of demand to the suppliers of transportation-related products and services. Analogous structures exist for other transportation subsectors.

No one price-quantity relationship captures the decision making that determines transportation emissions. Neither can a simple, single market model adequately inform policy design for integrating the sector into a carbon market. A complex set of different but interlinked markets defines the way actual decisions are made. It is not reducible to the market for motor fuel, although fuel suppliers are the actors best suited to serve as the point of regulation for cap-and-trade.

A complete market-based policy needs to reckon with all of these relationships. Focusing on only one, such as the fuel market price-quantity response or the auto market fuel economy response, risks an imbalanced and ineffective policy. Because the vehicle, fuel and travel demand markets are so different, one cannot expect to easily levelize costs of carbon reduction among them, let alone among transportation markets and other sectors.

Figure 1. Actors in the interlinked markets that determine automotive sector CO_2 emissions



USCAP Recommendations

The above concepts buttress recommendations made by the U.S. Climate Action Partnership (USCAP), a coalition of corporations that includes diversified industrial firms, automakers, oil companies, utilities and other businesses as well as several environmental groups. USCAP's (2009) *Blueprint for Legislative Action* outlines a framework that includes a cap-and-trade program plus cost-containment measures and complementary policies. For transportation, it recommends a systematic approach in which responsibility for limiting emissions is shared among fuel suppliers, vehicle manufacturers, consumers and public officials who plan and manage infrastructure and land use (see Table 1).

Although fuel suppliers are the point of regulation, the principle of shared responsibility implies that they serve in an accounting capacity on behalf of all actors in the sector. Vehicle standards are a mechanism by which automakers do their share, but as for other measures in a capped sector, efficiency standards are not expected to significantly decrease CO_2 emissions below the level set by the cap. As Table 1 indicates, other measures needed to control transportation energy use and thereby limit demand for allowances include policies to reduce GHG-intensive travel and improve system efficiency.

USCAP also recommends fuel-related performance standards in addition to including fuels in the cap. A low-carbon fuel standard (LCFS) has been proposed for this purpose (Hwang 2009; Sperling & Yeh 2009). Such an approach is used in California, with the state's LCFS designed to mesh with its vehicle GHG emissions standards. A purely market-based approach for addressing uncapped emissions and motivating fuel technology change has also been proposed (DeCicco 2009).

Table 1. Elements of the USCAP Approach for Transportation Climate Policy

Transportation Fuels in the Cap	Complementary Measures
• Fuel suppliers submit allowances to cover fossil-based CO_2 emitted from transportation fuel use by consumers and other end users • Point of regulation at the refinery gate and importers of refined products • Transparency of the carbon price signal to end users • Fair and equitable allocation of allowance value for addressing carbon price impacts on transportation fuel consumers	• Fuel-related GHG performance standards • Vehicle-related GHG performance standards • Policies to reduce carbon-intensive travel, educate consumers and improve system efficiency • Overall transportation sector GHG management policy • Technology transformation programs for the sector, including RD&D for advanced low-carbon vehicles and fuels
A crosscutting recommendation is that local, state, regional and federal programs should be complementary, aiming to achieve compatibility and avoiding conflicts that might drive up compliance costs and make it more difficult to achieve environmental goals.	

Source: USCAP (2009), pp. 6-7, 12-13, 16, 21-23.

The item most pertinent to the question of how to coordinate vehicle standards with the broader climate program is USCAP's recommendation for an overall transportation sector GHG management policy. Such a provision would require the Environmental Protection Agency (EPA), Department of Transportation (DOT) and other federal agencies to assess progress in controlling GHG emissions from the sector, examining contributions from vehicle efficiency, fuels, consumer demand, infrastructure and other transportation systems, and update their policies as needed to keep the sector on track.

TYING TARGETS TO SOCIETAL NEEDS

This last recommendation suggests a formal public process for tying vehicle standards to national GHG mitigation goals specified by cap-and-trade legislation. Even without a legislated cap, standard setting could be guided by administrative goals, such as the Obama Administration's targets of 17 percent below 2005 levels by 2020 ramping down to 83 percent below by 2050 (White House 2009b). Note that this linkage does not imply that vehicle standards have the same targets as an economy-wide program; it only means that the national targets should be formally factored into the standard setting process.

Exactly how such a linkage can be made has not been determined to date. California's Pavley standards were set before the statewide climate policy was enacted. Those targets, plus the EISA-dictated CAFE levels, defined the negotiating space in which the White House compromise was struck in May 2009, without any formal tie to national GHG targets.

"The need of the nation to conserve energy"

EPCA requires CAFE standards to be set at the maximum feasible level based on four considerations: technological feasibility, economic practicability, the effect of other standards of the government on fuel economy, and the need of the nation to conserve energy (EPA & DOT 2009). Program administration has, however, varied greatly, from the Carter Administration’s rapid increase in light truck standards to the Reagan Administration's rollbacks of car standards. It is difficult to see how purely objective assessments of the first three statutory considerations could result in such widely different outcomes unless their application was itself guided by differing subjective views of the need to conserve energy.

Aside from the initial near doubling of passenger car fuel economy mandated by EPCA, Congress has not made a firm commitment on limiting U.S. transportation energy use. The many failed attempts to move stronger standards through Congress and the appropriations riders that prevented the National Highway Traffic Safety Administration (NHTSA) from raising CAFE standards demonstrate this reluctance. Legally, the recent CAFE increases can be seen as just another transient response to political pressures of the time, in contrast to a well-defined, long-term commitment such as a carbon cap might provide.

EPCA and EISA do not provide rigorous guidance for determining societal need, even though EISA strengthened some economic analysis requirements. The CAFE program lacks "any statutorily prescribed formula for balancing the factors" that go into standard setting (EPA & DOT 2009: 49463). NHTSA has broad discretion in how to interpret the law when determining the "maximum feasible" fuel economy levels required for a future model year. Challenges to CAFE rules were rarely upheld by the courts until the notable Ninth Circuit Court decision in 2007, which remanded the model year 2008-11 light truck rule to NHTSA for reconsideration. Among the reasons cited was the agency's failure to monetize CO_2 emissions when setting the standards (Ninth Circuit 2007).

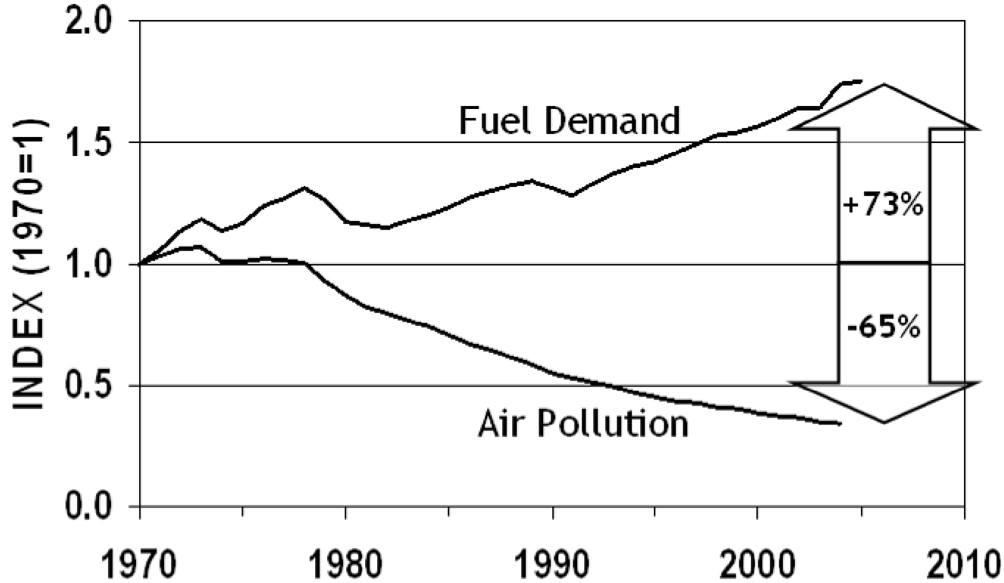
Clean Air Act Lessons

EPCA's lack of specificity for evaluating "the need of the nation to conserve energy" when setting CAFE standards contrasts with the administrative approach in the Clean Air Act (CAA). The act requires attainment of National Ambient Air Quality Standards (NAAQS), which are in turn scientifically determined based on the impacts of air pollution on public health and welfare. This formal linkage is essential because the long, ongoing quest for clean air has driven successive rounds of emissions standards for all major sources of air pollution, including motor vehicles. The results can be seen in Figure 2, which compares the reduction of total conventional pollutants from U.S. light duty vehicles with the lack of progress in reducing fuel use over the past 35 years.

Bottom-up, engineering assessments are a major part of the regulatory process for developing vehicle emissions standards. Questions of technological feasibility and cost loom large, involving lively debates regarding what is possible over a given time frame and at what cost. Regulated industrial firms, such as automakers, are understandably cautious about environmental investments because they are rewarded poorly in the private market. Conversely, environmental advocates and officials representing regions with strong support for clean air, such as California, are optimistic about the ability to improve technology at an acceptable cost. Ongoing "clean air wars" have reflected this dynamic (Doyle 2000).

The CAA legal foundation has been critical for achieving the absolute reductions in environmental impact seen in Figure 2. As long as areas were not in attainment, public officials were obligated to cut emissions further, leading to tighter inventory targets for criteria pollutants and their precursors. Specific regulatory requirements for meeting these targets were then apportioned among major sources based on technical and economic considerations.

Figure 2. Trends in Total Fuel Consumption and Conventional Air Pollution for U.S. Cars and Light Trucks, 1970-2005



Source: Derived by author using total nationwide fuel use and emissions levels (not per-mile rates) from U.S. DOT and EPA data; the air pollution index is based on a health damage cost weighting of tailpipe nitrogen oxides (NOx), volatile organic compounds (VOC), particulate matter (PM_{10}), carbon monoxide (CO) and sulfur dioxide (SO_2).

This process balances the concerns and capabilities of different industrial and regional stakeholders. An instructive example is the EPA-led effort to help the Northeast with ozone attainment in the face of interstate nitrogen oxide (NOx) transport. The resulting recommendations by the Ozone Transport Assessment Group led to stricter standards for vehicles and fuels, power plants, industrial boilers and other sources (OTAG 1997). This process of basing source-specific standards on scientifically determined inventory targets is seen in the EPA-mandated revisions to State Implementation Plans (the "NOx SIP call"), the Tier 2 and heavy-duty diesel programs and related regulations, the health benefits of which are still accruing today.

Seen in this light, it is not the simple analogy of vehicle GHG emissions standards to emissions standards for controlling criteria pollutants that is most relevant for climate policy, even though that analogy may have had tactical value for leveraging climate action broadly and vehicle regulation in particular. Rather, it is the core CAA paradigm of attainment and the administrative process it entails. Such a requirement is a missing link in the energy policy embodied in EPCA's guidelines for the CAFE program and the way those guidelines are mimicked in California's AB 1493 law. Technology and economic assessments can be argued to greater or lesser levels of stringency, but by themselves lack a legal link to quantitative environmental requirements.

As administered to date, vehicle efficiency and GHG emissions standards answer only the question of "how much *can* we do," rather than the more critical question of "how much *must* we do" to meet a societal goal. The Clean Air Act works because it compels an ongoing effort to do what must be done to protect public health and welfare. Recognizing the importance of this foundation, most climate legislation is crafted to build on the Clean Air Act, preserving its core enforceability provisions, while specifying a sequence of GHG emission limits though the cap, which plays the role for climate protection that the NAAQS do for air quality.

Toward Carbon Management for Transportation

The national climate policy proposals of 2009 do not ensure that the authorities affecting transportation limit GHG emissions to levels low enough to meet the cap. ACESA does not address light duty CAFE and GHG emissions standards, providing for no coordination with the bill's cap-and-trade program. Most new measures authorized, such as GHG standards for heavy vehicles and alternative fuel promotions, are given in Titles I and II of the bill without a link to Title III, which sets the cap. The energy efficiency and clean energy provisions for other sectors are similarly disconnected from the cap. In California, although the first round of AB 1493 standards was promulgated before the statewide climate policy established by AB 32, the goals of latter legislation are being applied as the state develops additional policies and updated measures under its scoping plan (CARB 2008b). Thus, the state is moving toward a cross-sectoral GHG management framework that will presumably include future rounds of motor vehicle GHG standards.

The closest connection federally is ACESA's transportation system efficiency provision. This section of the bill requires DOT to "establish national transportation-related greenhouse gas emissions reduction goals" plus procedures for evaluating targets for achieving those goals. The sector goals are to be set at levels "commensurate with the emissions reductions goals" given by the legislation's economy-wide global warming provisions (ACESA 2009). The bill also requires DOT to assess progress in reducing transportation GHG emissions at least every six years. It does not, however, require an administrative process to modify the programs if the sector fails to make adequate progress. Thus, this proposed GHG policy differs from the CAA transportation conformity provisions, which require state and local transportation plans to demonstrate consistency with air quality goals before federal project funding is approved (FHWA 2005).

Some might argue that weak administration of complementary measures does not matter if a cap is in place because the carbon price will rise enough to bring emissions into line. However, real-world complexities -- including the actual structure of transportation markets as illustrated in Figure 1 -- dictate that climate policy include carefully crafted sets of measures addressing sector-specific concerns and many other issues. If lack of progress in a major sector such as transportation causes very high carbon prices, the overall program could be jeopardized. It might trigger provisions that allow emissions to exceed the cap or provoke a political backlash that eviscerates the policy. Therefore, measures to limit transportation energy demand must be administered to ensure adequate progress relative to other measures both within and across sectors.

The transportation sector GHG management policy suggested by the USCAP *Blueprint* provides such a coordination mechanism:

> Congress should require EPA, in collaboration with the Department of Transportation and other federal and state and local agencies, to carry out a periodic in-depth assessment of current and projected progress in transportation sector GHG emissions reductions…This assessment should examine the contributions … attributable to improvements in vehicle efficiency and GHG performance of transportation fuels, increased efficiency in utilizing the transportation infrastructure,

> as well as changes in consumer demand and use of transportation systems, and any other GHG-related transportation policies enacted by Congress. (USCAP 2009, 23)

The results of this assessment should be applied to modify policies as needed to ensure sufficient progress, without a need to go back to Congress:

> On the basis of such assessments EPA, DOT and other agencies with authorities and responsibilities for elements of the transportation sector should be required to promulgate updated programs and rules—including revisions to any authorized market incentives, performance standards, and other policies and measures—as needed to ensure that the transportation sector is making a reasonably commensurate contribution to the achievement of national GHG emissions targets. (USCAP 2009, 23)

The resulting linkage between complementary measures such as vehicle standards and economy-wide goals provides a coordination mechanism now absent from climate policy as proposed to date.

This approach offers protections for regulated parties such as automakers. It does not create a new expectation for increasingly more stringent vehicle standards; the authority to raise standards already exists under EISA and the Clean Air Act. What it means instead is that standards would no longer be developed in isolation from other measures. Agencies could use an OTAG-like process, with stakeholders able to air their concerns and guide the analysis used to update not only vehicle standards, but all sector policies affecting GHG emissions. If the cap itself—perhaps amplified by incentives that reward measured as opposed to projected realization of low net carbon vehicle-fuel systems—begins to accelerate progress in limiting transportation emissions, then further increases in vehicle standards may become unnecessary.

WHAT METRIC FOR VEHICLE STANDARDS?

Two metrics are now in use: 1) fuel economy measured in miles per gallon as used for CAFE standards; and 2) GHG emissions rate measured in grams of CO_2-equivalent emissions per mile as used by CARB and proposed by EPA. The EPA & DOT (2009) proposed rule notes that the vast majority of CO_2 emissions from vehicles are related to fuel economy because they are proportional to fuel consumption. Most reductions under vehicle GHG standards come from fuel-related CO_2, the exceptions being halocarbons from air-conditioning systems and small amounts of methane and nitrous oxide. These trace gases, which comprise about five percent of total vehicle GHG emissions, would need to be specially handled in any case, as discussed by CARB and EPA.

In considering the metric for vehicle regulation, the actors diagram of Figure 1 is a useful point of reference. A policy should motivate parties according to aspects they most directly control. Vehicle standards target automakers, but automakers do not control the processes associated with producing fuel. Automakers can develop vehicles that use any given fuel more efficiently. Therefore, a metric for energy rather than emissions, such as fuel efficiency or consumption rate, makes the most sense. This view is corroborated in the USCAP *Blueprint,* which, in reference to CAFE, states:

> These vehicle fuel economy programs have a scope and structure that are consistent with the need for complementary measures for on-road vehicles, as stated in the Call for Action, and can serve as the basis for such measures going forward. (USCAP 2009, 22)

Thus, fuel economy standards are now supported by a wide range of stakeholders.

Problems with GHG Emissions Rates for Vehicle Standards

Vehicle GHG emissions rates can be evaluated on an end-use ("tailpipe") basis or on a lifecycle ("well-to-wheels") basis. An end-use basis misses the emissions associated with supplying fuel. For a zero emissions vehicle (ZEV) such as a battery electric or hydrogen fuel cell car, essentially all impacts occur upstream during fuel production and distribution. Rating such vehicles as having zero GHG emissions is misleading and provides no incentive for efficiency. A direct basis is also problematic for biofuels if the "renewability shortcut," which excludes CO_2 emissions from biogenic carbon, is used (DeCicco 2009).

For these reasons, GHG standards are commonly defined on a lifecycle, or "carbon footprint," basis. Compliance relies on CO_2-equivalent gram-per-mile (gCO_2e/mi) results from lifecycle analysis (LCA) models that account for vehicle use-phase emissions (and therefore fuel economy) plus fuel supply-phase emissions. Notably, vehicle supply-phase (manufacturing) emissions are not included in vehicle GHG standards as proposed to date, even though the regulated parties (automakers) arguably have more control over emissions from the production of their product than they do over the emissions associated with the production of fuel.

A vehicle's GHG emissions rate is not a well-defined attribute of the vehicle itself. Although it has taken on great familiarity from the voluminous well-to-wheels analyses over the years, the gCO_2e/mi metric is an abstraction based on the joint characteristics of an assumed vehicle-fuel system. Unlike fuel economy or vehicle emissions as traditionally regulated, it cannot be measured using repeatable, objective tests of a given vehicle. Fuel lifecycle assumptions must be introduced and these assumptions have a very large impact on the results.

Another rationale for vehicle GHG emissions standards is that they provide a technology-forcing mechanism for alternative vehicle-fuel systems. The belief that alternatives will solve transportation energy problems has long motivated policies to promote alternative fuel vehicles (AFVs), which fuel lifecycle analyses suggest are capable of deep reductions in emissions. Although numerous federal and state AFV and ZEV mandates and programs have been pursued over the years, none have had a measurably transformative impact (McNutt & Rodgers 2004). Nevertheless, hope springs eternal for policies that seek to change the car in order to change the fuel, as seen in the current enthusiasm for plug-in hybrids like the Chevy Volt. Vehicle GHG standards expand this paradigm, embedding assumptions about the promise of alternative fuels (whether liquid, gaseous or electricity) in standards that regulate vehicles.

Vehicle focused-policies cannot affect fuel availability or infrastructure (Viera 2009). Neither do they affect fuel supply and the upstream processes that dominate the impacts of many alternative fuels. Moreover, it is not clear that reducing fuel GHG intensity requires changing fuel chemistry. Attempting to use vehicle policies to force changes in transportation energy supply may turn out to be as ill-advised over the decades ahead as it has been ineffectual over the decades past.

Energy-Based Metrics

A vehicle regulatory metric based on energy entails the fewest assumptions and avoids confounding attributes of the vehicle with those of the fuel supply system. Energy-related impacts, such as demand for GHG emissions allowances, scale with fuel consumption, and so vehicle energy use rate (e.g., Btu per mile) is an ideal metric. It can be directly measured for any vehicle, including dual-fuel vehicles or plug-in hybrids, based on repeatable tests.

While fuel consumption rate might be ideal, a fuel economy metric could be reformed to avoid its existing distortions based on assumptions about particular fuels. CAFE has used regulatory parameters related to petroleum use and other special assumptions such as those for dual-fuel vehicle credits. The planned phase-out of those credits is helpful in moving to a well-specified metric that will stand the test of time. An energy-based metric maintains a clean division of labor between the regulated parties on the demand side of the market, such as automakers, and transportation fuel providers on the supply side.

Much recent effort by CARB and EPA has gone into defining GHG emissions standards for vehicles. The Supreme Court (2007) found no conflict in having both GHG and CAFE standards in place. Although complicated, the overlapping regulation is administratively workable, as discussed by EPA & DOT (2009). This does not mean, however, that dual regulation of vehicles for both fuel economy and GHG emissions is the best long-term approach for policy.

Compared with an energy-based metric, a GHG metric introduces numerous problems and no clear benefits. GHG emissions standards were advanced for tactical reasons to overcome automakers' strong objections to raising CAFE standards. It may well be that it is politically important to preserve such leverage. However, if a mechanism -- such as the overall sector GHG management policy described above -- is put in place to ensure coordination of standards with national GHG reduction goals, then these tactical considerations may become less important.

Handling Fuel Cycle Emissions

What an energy-based vehicle metric leaves unaddressed is the upstream portion of fuel cycle GHG emissions, which are incorporated into a vehicle GHG emissions standard using fuel LCA modeling. These upstream emissions are under the control of actors in the fuel supply chain, who should be directly targeted in order to carbon-constrain or otherwise provide an incentive to reduce their emissions. Such fuels-industry oriented mechanisms would be among the set of measures assessed under the overall transportation sector GHG management policy suggested here. This paper's focus on vehicle-oriented policy should not be interpreted to mean that an equal focus is not needed on climate policy targeting transportation fuels; it is worth highlighting this issue as one in need of much more careful attention than it has received to date.

Some concerns raised above in arguing against lifecycle GHG emissions standards for vehicles also apply to lifecycle standards for fuels (such as an LCFS). The idea of fuel lifecycle regulation was perhaps first published by DeCicco & Lynd (1997), who suggested extending conventional fuel composition standards to "standards specifying a maximum full-fuel-cycle GHG factor (for example, in grams of carbon-equivalent per joule of energy content)." As the notion of carbon footprint became commonplace, an LCFS found support by some policymakers, as in California, and related academic circles (Sperling & Yeh 2009). The problem is that the abstract concept of carbon footprint -- in this case fuel lifecycle GHG intensity -- corresponds poorly to the concrete realities of fuel supply systems. An LCFS is product-specific rather than source-specific, but chemically identical products can have GHG intensities that vary greatly based on the actual (as opposed to modeled) emissions in their supply chain. A source-specific approach anchored in cap-and-trade would be more effective as long as all fuel-related emissions are either under the cap or accounted for by mechanisms tied to the cap (DeCicco 2009). The "actor"-based analysis paradigm presented here might be useful for examining how best to handle transportation fuels in a climate policy framework, which is left as a topic for future work.

CONCLUSIONS

Vehicle standards are an essential part of climate policy because they target decisions in the auto market, an important determinant of transportation GHG emissions. Although standards have been based on fuel economy (CAFE) or GHG emissions rates (CARB and EPA rules), neither approach now includes a mechanism that ties the regulations into a broader climate policy framework such as cap-and-trade.

A lesson from the success of the Clean Air Act is that a formal linkage to a well-defined national goal is crucial for ongoing progress. This legal framework is more important than the resemblance of GHG emissions standards to conventional emissions standards. Linkage can be achieved through an overall transportation GHG management policy that binds the administration of vehicle standards and other sector programs to national climate protection goals. It would entail requiring agencies that oversee aspects of the transportation system to assess progress in reducing emissions and to update their policies as needed to ensure that the sector progresses along a path that is reasonably consistent with the economy-wide GHG targets and timetable.

For specifying vehicle standards as part of a broader climate policy, an energy-based metric makes the most sense. This conclusion is reached for several reasons: vehicle efficiency is a factor that automakers can influence, while they have little influence on fuel supply or the fuel production processes that determine fuel GHG intensity; unlike fuel GHG intensity, vehicle energy consumption and fuel economy can be measured unambiguously; and because efficiency-based reductions of fuel demand are important for limiting GHG emissions under a cap.

A focus on energy end-use for vehicle standards leaves fuel-cycle GHG emissions to be addressed by other means. It will be necessary to have a strong policy for fuels, ideally anchored by having transportation fuels under the cap but with additional mechanisms as needed to ensure the integrity of GHG accounting. How best to specify fuels-oriented mechanisms within a climate policy framework remains a topic for future work; the actors-based analytic paradigm described above is likely to be useful in that regard. Assessing progress in reducing fuel-cycle emissions and updating the fuels-oriented mechanisms accordingly will be one of the tasks involved in implementing the overall transportation sector GHG management policy suggested here.

Further analysis and discussion are needed regarding how to implement such a policy, which needs to consider the structure of the multiple markets that affect transportation emissions. Nevertheless, the challenges involved are similar to those of conventional air quality management, if not indeed technically more straightforward. The successful approach that federal and state agencies have taken in balancing the costs and benefits of various air pollution control strategies serves as a model for an effective transportation sector GHG management policy. Such a policy would enable more stable and evenhanded administration of vehicle standards than seen historically as stringency varied with the politics of the day. It would harmonize the level of effort on vehicle regulation with the levels of effort on fuels and travel demand as well as on other sectors of the economy. The resulting framework will create a stronger and more equitable climate policy for both transportation and the economy overall.

REFERENCES

AB 32. 2006. The California Global Warming Solutions Act of 2006. California Assembly Bill No. 32, signed into law on September 27, 2006.

AB 1493. 2002. California Assembly Bill No. 1493 (lead sponsor, Rep. Fran Pavley), signed into law on July 22, 2002.

ACESA. 2009. The American Clean Energy and Security Act of 2009. H.R. 2454, passed by the U.S. House of Representatives on June 26, 2009. http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=111_cong_bills&docid=f:h2454pcs.txt.pdf

ASE *et al.* 2002. Increasing America's Fuel Economy. Briefing Book. Washington, DC: Alliance to Save Energy, February.

CARB. 2008a. Comparison of Greenhouse Gas Reductions for the United States and Canada Under U.S. CAFE Standards and California Air Resources Board Greenhouse Gas Regulations. Enhanced Technical Assessment. Sacramento: California Air Resources Board, February 25. www.arb.ca.gov/cc/ccms/reports/pavleycafe_reportfeb25_08.pdf

CARB. 2008b. Climate Change Scoping Plan. A Framework for Change, Pursuant to AB 32, the Global Warming Solutions Act of 2006. Sacramento, CA: California Air Resource Board, December. www.arb.ca.gov/cc/scopingplan/document/scopingplandocument.htm

CARB. 2009. Climate Change Program, Cap-and-Trade Background. Webpage accessed 25 November. www.arb.ca.gov/cc/capandtrade/capandtrade.htm

CAA. 1970. The Clean Air Act. www.epa.gov/oar/caa/

DeCicco, J.M. 2009. Addressing Biofuel GHG Emissions in the Context of a Fossil-Based Carbon Cap. Discussion Paper. Ann Arbor: University of Michigan, School of Natural Resources and Environment, October.

DeCicco, J., and L. Lynd. 1997. Combining Vehicle Efficiency and Renewable Biofuels to Reduce Light Vehicle Oil Use and CO_2 Emissions. Chapter 4 in J. DeCicco and M. Delucchi (eds.), *Transportation, Energy, and the Environment: How Far Can Technology Take Us?* Washington, DC: American Council for an Energy-Efficient Economy.

DOT & EPA. 1974. Potential for Motor Vehicle Fuel Economy Improvement (the "120 Day Study"). Report to Congress. Washington, DC: Department of Transportation and Environmental Protection Agency, October.

Doyle, J. 2000. *Taken for a Ride: Detroit's Big Three and the Politics of Pollution.* New York: Four Walls Eight Windows Press.

Ellerman, A.D., *et al.* 2006. Bringing Transportation into a Cap-and-Trade Regime. Report No. 136, MIT Joint Program on the Science and Policy of Global Change. Cambridge, MA: Massachusetts Institute of Technology, June.

EISA. 2007. Energy Independence and Security Act. Public Law 110-140, signed into law December 19, 2007. Washington, DC: U.S. Congress.

EPCA. 1975. Energy Policy and Conservation Act. Public Law 94-163 signed into law on December 22, 1975. Washington, DC: U.S. Congress.

EDF. 2007. Toward a Fair and Effective Climate Policy for the United States. White paper submitted to the U.S. House of Representatives, Committee on Energy and Commerce and Subcommittee on Energy and Air Quality. Washington, DC: Environmental Defense Fund, March.

EPA. 2007. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2005. Washington, DC: U.S. Environmental Protection Agency. www.epa.gov/climatechange/emissions/usinventoryreport.html

EPA. 2008. Light-Duty Automotive Technology and Fuel Economy Trends: 1975 through 2008. Report EPA420-R-08-015. Washington, DC: U.S. Environmental Protection Agency, Office of Transportation and Air Quality, September.

EPA & DOT. 2009. Proposed Rulemaking To Establish Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards; Proposed Rule. *Federal Register* 74 (186): 49453-789. Washington, DC: U.S. Environmental Protection Agency and U.S. Department of Transportation, National Highway Traffic Safety Administration.

FHWA. 2005. Transportation Conformity: A Basic Guide for State & Local Officials. Washington, DC: Federal Highway Administration, April. www.fhwa.dot.gov/environment/conformity/bguide05.pdf

German, J. 2007. Reducing Vehicle Emissions Through Cap-and-Trade Schemes. Chapter 6 in Sperling, D., and J. Cannon (eds.), *Driving Climate Change: Cutting Carbon from Transportation*. Burlington, MA: Academic Press.

Greene, D.L. 1998. Why CAFE worked. *Energy Policy* 26(8): 595-613.

Greene, D.L. 2007. Is Cap-and-Trade a Sufficient Carbon Policy for Transportation? Testimony to U.S. Senate Committee on Environment and Public Works. November 13.

Greene, D.L., and J.M. DeCicco. 2000. Engineering-Economic Analyses of Automotive Fuel Economy Potential in the United States. *Annual Review of Energy and Environment* 25:477-535.

Greene, D.L., and A. Schafer. 2003. Reducing Greenhouse Gas Emissions from U.S. Transportation. Washington, DC: Pew Center on Global Climate Change, May.

Greene, D.L., *et al.* 2009. Fuel economy: The Case for Market Failure. Chapter 11 in D. Sperling & J.S. Cannon (eds.), *Reducing Climate Impacts in the Transportation Sector*. Springer.com.

House E&C. 2007. Climate Change Legislation Design White Paper: Scope of a Cap-and-Trade Program. Washington, DC: U.S. House of Representatives, Committee on Energy and Commerce, October.

Hwang, R.J. 2009. The Case for a National Low Carbon Fuel Standard. Presentation at the Asilomar Conference on Transportation and Climate Policy, Pacific Grove, California, July 2009. www.its.ucdavis.edu/events/outreachevents/asilomar2009/presentations/Session%203/Hwang_Asilomar_2009.pdf

Jorgenson, D.W. *et al.* 2008. The Economic Costs of a Market-based Climate Policy. White Paper. Washington, DC: Pew Center on Global Climate Change, June. www.pewclimate.org/white-paper/economic-costs-of-market-based-climate-policy

McNutt, B., and D. Rodgers. 2004. Lessons Learned from 15 Years of Alternative Fuels Experience: 1988-2003. Chapter 12 in Sperling, D., and Cannon, J.S. (eds.), *The Hydrogen Transition: Moving Toward the Post-Petroleum Age in Transportation*. Burlington, MA: Academic Press.

Ninth Circuit. 2007. Center for Biological Diversity v. National Highway Traffic Safety Administration. Case No. 06-71891. United States Court of Appeals for the Ninth Circuit, November 15. www.ca9.uscourts.gov/datastore/opinions/2007/11/14/0671891.pdf

Nivola, P.S. 1986. *The Politics of Energy Conservation*. Washington, DC: Brookings Institution.

Nordhaus, R.R., and K.W. Danish. 2003. Designing a Mandatory Greenhouse Gas Reduction Program for the U.S. Washington, DC: Pew Center on Global Climate Change. May 2003.

National Research Council (NRC). 1992. Automotive Fuel Economy: How Far Should We Go? Report of the National Research Council, Committee on Fuel Economy of Automobiles and Light Trucks. Washington, DC: National Academy Press.

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

OTAG. 1997. Ozone Transport Assessment Group Recommendations to the U.S. Environmental Protection Agency. Conveyed in letter from Mary A. Gade, Chair, Ozone Transport Assessment Group (OTAG) Policy Group, to Mary Nichols, Assistant Administrator for Air and Radiation, EPA, July 8.

Portney, P.R., *et al.* 2003. The Economics of Fuel Economy Standards. *Journal of Economic Perspectives* 17(4): 203-217.

Rühl, C. 2009. Remarks during presentation on the release of the BP Statistical Review of World Energy 2009. Washington, DC: Council on Foreign Relations, June 11.

Sierra Club. 1991. The Biggest Single Step to Curbing Global Warming and Saving Oil. Fact Sheet. Washington, DC: Sierra Club.

Sierra Club. 2005. The Biggest Single Step. Fact Sheet. Washington, DC: Sierra Club.

Sperling, D., and D. Gordon. 2009. *Two Billion Cars: Driving Toward Sustainability*. New York: Oxford University Press.

Sperling, D., and S. Yeh. 2009. Transforming the Oil Industry into the Energy Industry. *Access* 34: 21-28, Spring. www.uctc.net/access/

Stavins, R.N. 2008. Addressing Climate Change with a Comprehensive US Cap-and-Trade System. *Oxford Review of Economic Policy* 24(2): 298-321 http://oxrep.oxfordjournals.org/cgi/content/full/24/2/298

Supreme Court. 2007. Massachusetts *et al. v.* Environmental Protection Agency *et al.* Washington, DC: U.S. Supreme Court, April 2. www.supremecourtus.gov/opinions/06pdf/05-1120.pdf

USCAP. 2009. A Blueprint for Legislative Action. Consensus Recommendations for U.S. Climate Protection Legislation. Washington, DC: U.S. Climate Action Partnership, January. www.us-cap.org/blueprint/index.asp

Viera, J. 2009. Opening presentation on Future of Vehicle Fuel Economy and Greenhouse Gas Standards, Asilomar Conference on Transportation and Climate Policy. Pacific Grove, California, July 30.

von Hippel, F., and B. Levi. 1983. Automobile Fuel Efficiency: The Opportunity and the Weakness of Existing Market Incentives. *Resources and Conservation* 10: 103-124.

White House. 2009a. President Obama Announces National Fuel Efficiency Policy. Press release. Washington, DC: The White House, May 19. www.whitehouse.gov/the_press_office/President-Obama-Announces-National-Fuel-Efficiency-Policy/

White House. 2009b. President to Attend Copenhagen Climate Talks; Administration Announces U.S. Emission Target for Copenhagen. Press release. Washington, DC: The White House, November 25. www.whitehouse.gov/the-press-office/president-attend-copenhagen-climate-talks