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Steps into Postfossil Mobility
A Vision and Policy Plan for Sustainable Transportation

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A Vision of the Future

Imagining a transportation world of 2050 can give us an inkling of what is required to dramatically reduce oil use and greenhouse gas emissions. What might this future look like? With sustainability as the goal, it most certainly will not continue to embrace the US car-centric model—near universal ownership of big, powerful, gas-guzzling cars in mega-garages and suburban enclaves. We can and must begin to create something much more efficient, affordable, and civilized.

This future world would not depend on internal combustion engine cars and oil and would be populated by a wide range of mobility services. In this world, suburbs have come to resemble villages or urban neighborhoods, with commercial and recreational centers aesthetically integrated so that residents can walk, bike, or take a neighborhood electric vehicle to jobs, schools, doctors, playfields, and local merchants of food, clothing, home wares, and entertainment. For urban and suburban dwellers alike, a powerful, pocket-sized computer serves as an electronic travel agent arranging for mobility beyond the immediate neighborhood. The list of menu items includes carsharing, ridesharing, and jitney service, all of which can be lined up automatically and instantaneously—thanks to advanced technology.

Imagine garages that once housed gas-guzzling SUVs now sheltering zero-emission neighborhood electric vehicles, plug-in hybrids, and e-bikes. Imagine being able to recharge these with the neighborhood's intelligent renewable-energy grid, which automatically switches from recharging to feeding electricity from the battery back to the system. Imagine easy access to bus rapid transit (BRT) with your neighborhood electric car or a smart jitney that picks you up within five minutes of your electronic call. A typical traveler might use one form of transportation or mobility service one day and another the next, depending on the nature of the errand, time available, distance, weather and traffic conditions, and personal considerations. And imagine banking credits for all of the carbon you save to use later for a special travel vacation.

In this future world, electric-drive vehicles have supplanted most of those old-fashioned gasoline cars with internal combustion engines. These electric-drive vehicles are powered in part by electricity generated by power plants with near-zero emissions, along with hydrogen made from a mix of renewables and natural gas. The remaining electric-drive vehicles are very efficient hybrids getting well over 100 mpg and powered by biofuels—not the old kind made from corn, but from grasses, wood, algae, and various waste materials. Choices have expanded. Convenience and sustainability have become primary considerations. Transportation with near-zero carbon emissions has replaced the carbon-laden transportation monoculture.

Essential underpinnings

For this future world to take root, an entirely new set of incentives must be put in place. These incentives will motivate consumers, governments at all levels, and business to respond rationally to the carbon and energy constraints that increasingly bind us.

These incentives will work alongside an expanded set of technological gadgetry to realize a new array of mobility options. Computers that understand the human brain, recognize individual and collective behavior patterns, and enhance intelligence will be part of this tool set. Real-time information and global communications will facilitate the transfer of ideas, enabling policymakers to replicate each others' best practices without waiting. Intelligent technology embedded in cars and other vehicles will promote eco-driving, helping travelers reduce their carbon footprints.

The new incentives will motivate socially rational behavior by giving tomorrow's consumers much clearer signals about the impacts of their choices. Personal carbon budgets will be set up for individuals and families. Carbon accounts will be credited and debited based on travelers' decisions. A portion of the balances that accrue from low-carbon lifestyles can be spent by individuals or sold to others. Taxes and fees will be indexed to carbon, so that those making greener choices will pay less for goods and services. Heavier polluters will help finance the low-carbon purchases of others by paying a surcharge that goes to provide rebates for less-polluting cars and fuels.

Local officials and developers will follow consumers' lead. As demand for low-carbon products and lifestyles increases, sprawl will cease and smarter development will ensue. Cities, businesses, and even developers will also have carbon budgets to adhere to. The decisions will be theirs to make, but with changes in tax laws and federal financing to reward compact development, local governments will be motivated to reduce sprawl and offer creative ways to reduce vehicle travel. In the United States, decades of zoning and permitting rules that had codified sprawl into law will be reversed.

Cities and individuals will be motivated and empowered to find ways to reduce energy use and carbon emissions. Not only will they be rewarded with lower energy bills—and in the case of cities, more funding for low-carbon transportation (spent on a wide selection of new mobility options)—but they'll also be able to sell their excess credits to other governments, businesses, or individuals.

As for state and national governments, not only will they alter transportation funding formulas to favor low-carbon mobility services and low-impact infrastructure, but they'll also alter the tax code and the vast array of rules and standards they administer to reward energy efficiency and low-carbon investments and behavior. Mortgage deductions, sales taxes, and much more will be tied to environmental impact. Comprehensive regulations will replace piecemeal policies to guide the development of low-carbon vehicles and fuels. These regulations will be fuel and technology neutral, taking governments out of the business of picking winners and instead setting clear targets so that the most promising technologies will advance.

Investments in clean tech R&D will ramp up to buoy companies in their competition for global markets. Entrepreneurs will become even more engaged in the green energy and vehicle race. Their efforts will be rewarded by global communications that halo them, new collaborations that inspire them, and new markets for novel products that enrich them. With higher oil prices and vibrant carbon markets, paybacks will be high on their low-carbon technology investments. In good times and bad, the most innovative entrepreneurs will advance a diverse portfolio of smart bets and pie-in-the-sky dreams.

Needed changes

Three sets of changes are needed to realize this vision of the future: vehicles must become far more energy efficient, the carbon content of fuels must be greatly reduced, and consumers and travelers must behave in a more eco-friendly manner. By mid-century, we envision a massive shift under way in all three realms. Electric-drive vehicles will have largely supplanted internal combustion engine vehicles, low-carbon fuels will have nearly vanquished petroleum, and the transportation monoculture will be fragmenting, even in car-centric America.

The automotive transformation is already beginning. Automakers are shifting toward electric-drive vehicles that use electric motors for propulsion and to control steering, braking, and acceleration. They are moving from a mechanical engineering to an electrical engineering culture. The first generation of electric-drive vehicles, gasoline hybrids, are still fueled by petroleum fuels, with the fuel converted into electricity onboard the vehicle. But several major automakers are about to unveil battery electric and plug-in hybrid vehicles that will operate mostly or totally on electricity—motivated in part by California's zero-emission vehicle program. And automakers continue to invest in hydrogen-powered fuel cell vehicles that

could reach mass commercialization in the next decade and beyond. There's little uncertainty about this evolution toward efficient, electric-drive vehicles—it's more a question of how fast it will occur.

With transportation fuels, the path to the future is less certain and probably slower. While biofuels are already well established in two regions, America's farm belt and Brazil, these biofuels of today are not likely to play important future roles. In this vision, biomass will contribute a modest chunk of future transport fuels, some of it from Brazil's sugar cane but none from corn or other food crops. Biofuels of the future will come mostly from waste materials—crop residues, forestry wastes, and urban trash—plus grasses and trees in areas where food crops don't grow well. The more important fuels will be electricity and hydrogen, used in battery, plug-in hybrid, and fuel cell vehicles. But the transition to these latter fuels will require major transformations of the very large companies that dominate the automotive and oil industries, and thus will proceed slowly.

In this time frame, the two other big energy stories are unconventional oil and coal. A big challenge of policy is to head off oil companies' embrace of tar sands, very heavy oil, and oil shale as conventional oil supplies become less available. The other big challenge, the one that requires more nuanced treatment, is coal. Because it's so abundant and so cheap to extract, coal will be an important energy source for a long time. It will continue to be a principal source of electricity and will be a tempting source of future transportation fuels. Its CO_2 emissions are so inordinately high, though, far more than petroleum, that dramatic changes are needed in how coal is processed and used. Coal conversion must become much more efficient and, most critically, the embedded carbon must be prevented from entering the atmosphere. For transportation fuels, that means converting the coal into carbon-free fuels such as hydrogen and electricity, capturing CO_2 emitted at the production facility, and then sequestering that CO_2 underground—with the understanding that "cleaner" coal is a half-century stopgap measure awaiting low-cost renewable hydrogen and electricity.

The third arena, eco-friendly travel behavior, is the most problematic. Cars are firmly entrenched in our culture and modern way of life. Reducing inefficient car dependent vehicle travel requires reforming monopolistic transit agencies, anachronistic land use controls, distorted taxing policies, and the mindsets of millions of drivers who've been conditioned to reflexively get into the car every morning. It's much more challenging than transforming a small number of energy and car companies. But even in California, the birthplace of car-centric living, the realization is starting to settle in that mobility must be more sustainable. Spurred by escalating gas prices and accelerating evidence of climate change, consumers are already beginning to recognize that the transformation of the car-centric monoculture is long overdue.

The really big changes in travel will come slowly. By mid-century, it's possible that the transportation monoculture will be fragmenting. A myriad of electronic, communications, and mobility innovations—including carsharing, dynamic ridesharing, smart paratransit, bus rapid transit, and advanced telecommunications services, all coupled with small neighborhood cars, revitalized transit providers, enhanced pedestrian and bicycling facilities, and smarter land use—will enable a new transportation system that better serves the diverse needs of all people, including those less fortunate, aging, and disabled. This transport system will be less expensive, more efficient, and more sustainable than today's.

This vision of the future might have seemed far-fetched even a few years ago, but much has already changed. If we had to pick one year when the world seemed to turn a corner, when it began to be motivated to make large changes, it would be 2006. It will be a decade or more before history will be able to confirm this observation. But it was in 2006 that the United States, the laggard among rich nations, finally accepted that climate change is a threat to humanity. Oil and car companies, politicians of all stripes, and voters finally accepted mounting scientific evidence that climate change is real.[1] Led by California, the national debate shifted from "if" to "what."

But realization and understanding are just a first step. The world is still in denial about the staggering challenge it faces and the radical transformation it must undertake. Achieving a 50 to 80 percent net reduction in greenhouse gas emissions isn't something that businesses, consumers, and politicians can fully imagine. Life after cheap oil evokes images of crises to come. There's no escaping that there will be winners and losers, but strong leadership and good policy can ease the transition.

Because CO_2 resides in the atmosphere for a hundred years and because investments in energy and infrastructure endure for decades, it's important to get started immediately.

Strategy for Getting There

To realize this future vision of a lower-carbon, less oil-driven future, we need a strategy for getting there—a pragmatic, action-oriented approach inspired by innovation, fueled by entrepreneurialism, and sensitive to political and economic realities. This approach must be rooted in and responsive to the realities of today, but with an eye to the future.

The recommendations that follow constitute a strategy for achieving this vision of the future. The recommendations are guided by two overarching principles. First, enact policies to align consumer and industry private interests with the public good. And second, develop and advance a broad portfolio of efficient, low-carbon technologies to transform transportation.

Policymakers must overcome the temptation to prescribe and mandate any one particular solution. While there's a role for prescriptions and mandates in addressing societal problems, there's an even more compelling need for durable policy frameworks that permanently shift consumer and industry behavior (and also the behavior of governments themselves).

Similarly, they must resist the temptation to pick winners. We deliberately emphasize the word *broad* in connection with pursuing a portfolio of technologies. There's an unfortunate tendency for technological experts and politicians alike to embrace "silver bullets" and pick winners. Innovation and technological changes are too dynamic and too difficult to predict. Not even highly savvy experts, much less seasoned politicians, have technological crystal balls. It's self-defeating to pick winners, in part because technologies once selected and blessed often take on a life of their own, with entrenched interests championing them. The result is a technological determinism that loses sight of its original goal. The prime example is America's hugely subsidized corn ethanol industry. It provides few societal benefits—and has many drawbacks—yet its now-powerful political and economic constituency resists all efforts to phase it out.

The simplest way to avoid the temptation to pick winners and prescribe specific changes is to impose performance standards. This advice is simple—yet routinely ignored. The use of performance standards, codified into durable policy frameworks, will invigorate competition among different fuels, vehicles, and mobility services, promote technological breakthroughs, and spur marketing of new technologies. It will empower manufacturers and consumers to take more responsibility for reducing energy use and carbon emissions.

In summary, a new approach is advanced here, one that engenders individual and corporate accountability, promotes innovation, balances private and public interests, and endures over the long run. This plan addresses the transformation of vehicles, fuels, and behavior. The tools of this transformation are incentives and regulations, and research, development, and demonstration (RD&D).

Table 1

Srategy for transforming vehicles, fuels, and behavior

TOOLS	TRANSFORMATIONS		
	Energy-efficient vehicles	***Low-carbon fuels***	***Green consumer and government behavior***
Incentives and regulations	Ratchet up fuel economy and GHG standards for cars and light trucks over time Develop dynamic fuel economy and GHG standards for large trucks Increase California's zero-emission vehicle requirements	Impose low-carbon fuel standards for fuel providers Create incentives to develop a low-carbon fuel infrastructure	Reward low-carbon consumerism (fuels, vehicles, and travel) Restructure taxes, fees, and other incentives to reduce vehicle usage Establish carbon budgets and banks for individuals, households, local governments to reward low-carbon behavior and discourage sprawl Create incentives to advance new mobility options and enhanced regulation of public transit
Research, development, and demonstration	Expand basic research and demonstration of advanced vehicle technologies	Expand R&D for low-carbon fuels Facilitate global development of low-carbon technologies, standards, and treaties	Research, develop, and test new mobility services Develop and test strategies to motivate low-carbon behavior

Transforming Vehicles

The most effective and least costly way to reduce transportation oil use and greenhouse gas emissions is to improve the energy efficiency of vehicles. And yet, it's surprising, even appalling, how little the United States and many other areas have done. For twenty-five years, from the early 1980s to 2008, the fuel economy of new cars and light trucks remained stagnant. Vehicle technology improved dramatically, but the energy-efficiency improvements have been diverted to serving private desires for bigger and more powerful cars—especially in the United States. The challenge is to capture more of the benefit of technology improvements to serve the public interest, even if that means scaling back vehicle size, weight, and especially power and performance. Sizable fuel economy gains are possible through incremental improvements to today's technology; even more gains are possible with an accelerated transition to electric-drive vehicles. Following are recommendations to move vehicle fuel efficiency in the right direction.

Ratchet up fuel economy and greenhouse gas standards over time

The most powerful and effective action available to government is to impose and then ratchet up vehicle performance standards. Some action is finally afoot in the United States. The Energy Independence and Security Act of 2007 boosted fuel economy standards by 40 percent, requiring cars and light trucks to achieve 35 mpg by 2020. In April 2009, President Obama accelerated this schedule, declaring that the 40 percent improvement must be by 2016. Obama's announcement was precipitated by California and fifteen other states that had already adopted laws and rules requiring the roughly 40% improvement by 2016. Now California and the national government are proposing improvements of 3-6% per year from 2017 to 2025.

Elsewhere, the European Union, Japan, and China are embarking on even more aggressive standards.

Vehicle performance standards are clearly the most effective policy instrument for reducing oil use and greenhouse gas emissions when markets fail to spur desired results. American automakers have complained that these standards force them to sell cars that consumers don't want. They've argued (but never lobbied) for high fuel taxes as a better way to improve fuel economy. But even Europe and Japan, with much higher fuel taxes than the United States, find that stringent vehicle standards are needed to improve fuel economy and reduce greenhouse gases. The stark reality is that market forces (short of draconian taxes) have proven inadequate by themselves to motivate such improvements. The relative wealth of new-car buyers and consumer undervaluation of fuel economy and climate change in the vehicle purchase decision create a market failure.[2]

Develop dynamic fuel economy and greenhouse gas standards for heavy trucks

The greater energy and climate change challenge is with heavy trucks. Their fuel economy has never been regulated, for two reasons. First, truck makers argue that fuel costs are such a big part of doing business that the normal workings of the market are sufficient motivation to improve fuel efficiency. And second, truck designs vary so much and trucks are used in so many different ways that regulation has been impossibly difficult. But truck and engine builders now confirm that greatly improved truck efficiency is possible.[3] And in 2006, Japan's regulators made a breakthrough. They began the process of regulating trucks using mathematical models to simulate fuel use for different applications and mixes of engines and vehicle types.[4] The Japanese example blazes a new trail that makes possible heavy-duty truck regulation.

Substantial reductions are also possible from shifting the movement of goods to more efficient means such as rail. In some cases reductions could be large. But because the complexities of freight systems aren't well understood and unforeseen consequences for the economy can be large, policymakers are reluctant to intervene—probably with good reason. The challenge of transforming freight systems is even more daunting than transforming passenger travel and urban land use.

Increase California's zero-emission vehicle requirements

In general, performance standards are preferable to prescriptions and mandates. But something more than performance standards is needed to kick-start plug-in hybrid, battery electric, and fuel cell vehicles—especially because the nature of big organizations is to resist disruptive innovations. California's zero-emission vehicle program has provided the needed push since its passage in 1990. The mandate has led a tortured life, but has been effective at focusing automaker attention and resources on advanced technology. It's the best tool for accelerating the early commercialization of electric-drive vehicles.

The current requirement in California, adopted in early 2008, is modest: 7,500 fuel cell vehicles or 12,500 battery electric vehicles between 2012 and 2014 (or some combination), plus 58,000 plug-in hybrids. That requirement gives companies time to lock in final designs and test the market. Beginning in 2015, the mandated battery and fuel cell vehicles should be increased roughly by a factor of ten. This California program, already adopted by a dozen other states, is a model for the United States and other nations as well.

Expand research and development of advanced vehicle technologies

A massive investment in research is needed to support and accelerate the development of energy-efficient, low-carbon fuels and vehicles. The majority of this funding must come from industry. Both the automotive and energy industries are populated by huge companies with strong research capabilities and financial resources that dwarf those of governments. Automotive companies are already devoting huge resources to vehicle propulsion, a core technology for vehicles. Government R&D funding is also needed, but it should be a small part of the total.

The primary role of government is to support very basic research at universities and national laboratories. Industry is neither well qualified nor inclined to conduct such research. This basic scientific research is the underpinning of technology advances by industry—for all new technologies but especially those with large environmental and public benefits. The U.S. government has devoted about $200 million per year to automotive research for many years (through President Clinton's Partnership for a New Generation of Vehicles and President Bush's follow-on FutureCAR). Unfortunately, relatively little has gone to basic science and not enough has gone to universities. The one area where more funding is needed is in building a stronger science foundation for batteries, fuel cells, and hydrogen storage. Much of this is basic material science research.

A second government function relating to automotive technology is to support the demonstration of advanced vehicles. This need not be costly—and it doesn't mean government has to support the vehicles themselves. Most of the vehicle funding can come from industry. But companies will invest only if they're assured that government leaders will work with them to facilitate the acceptance of the technology. Industry needs local governments to modify codes and standards to support (not restrict) the new technologies. And it needs local and regional governments to support and fund training programs for technicians at junior colleges, and to work with energy companies to provide energy stations to fuel vehicles powered by hydrogen and electricity.

Transforming Fuels

Dramatic changes are needed in the energy sector. Given the flawed marketplace and absence of guiding policy, today's oil industry is maximizing private gains. But that behavior isn't in the public interest. Oil markets are unresponsive to prices, largely ignore greenhouse gases, and invite geopolitical conflict. Massive investments are being directed toward high-carbon unconventional petroleum.

New policies are needed that spur energy companies to invest in low-carbon fuels and necessary infrastructure. Large oil companies need to be encouraged to transition into broader energy companies that are less dependent on fossil energy. Many politicians and companies across the United States and other affluent nations are embracing the need for a more coherent approach to energy. But, alas, the public debate is focusing on corn ethanol and policies unlikely to have much effect on transport fuels, including carbon taxes and cap-and-trade programs. And where policies have been adopted—the biofuels directive in Europe and the renewable fuel standard in the United States—they're deeply flawed. Following are suggestions to transform fuels, acknowledging political and economic realities but with an eye toward energy and climate sustainability.

Impose low-carbon fuel standards

A low-carbon fuel standard would require oil companies and other fuel providers to reduce carbon and other greenhouse gas emissions associated with transportation fuels.[5] We recommend a reduction of at least 10 percent between 2010 and 2020, with the percentage ratcheting up over time, reaching at least 40 percent by 2050. Oil suppliers would decide how to meet the standard, whether by blending low-carbon biofuels into conventional gasoline, selling low-carbon fuels such as hydrogen, or buying credits from low-carbon energy electricity generators.

The idea of imposing a low-carbon fuel standard is highly attractive because this approach provides a durable framework, doesn't pick winners, encourages innovation, and sends a direct, unambiguous, fuels-neutral signal to fuel providers that alternatives are welcome. It's a hybrid of regulatory and market approaches, which makes it more politically palatable (and economically efficient) than a purely regulatory approach. Behind vehicle standards, it's arguably the second most compelling

policy instrument for reducing greenhouse gas emissions from the transport sector. Implementation of such a standard is central to solving the greenhouse gas problems attributed to transport fuels.

California adopted a low-carbon fuel standard in April 2009 that took effect in 2010. Serious proposals for such a standard are under discussion in two Canadian provinces and many U. S. states. The EU is also moving in this direction, after earlier adopting a biofuels directive that called for 5.75 percent replacement of gasoline and diesel fuel by biofuels by 2010. A report from the Joint Transport Research Centre of the Organization for Economic Cooperation and Development (OECD) states that, "volumetric production targets for biofuels fail to provide incentives to contain costs, to avoid environmental damage or even to ensure greenhouse gas emission reductions are delivered. Carbon content targets for fuels, accompanied by certification, are a better alternative."[6]

Create incentives to develop low-carbon fuel infrastructure

America's renewable fuel standard and Europe's biofuels directive target liquid fuels. Oil companies will undoubtedly take principal responsibility for distributing and marketing those fuels (though they might not produce them) and thus will assume responsibility for building an appropriate fuel distribution infrastructure. But what about the more promising low-carbon fuels: electricity and hydrogen? Because the barriers to these nonliquid fuels are far greater than the barriers to biofuels, greater attention needs to be given to supporting the early fueling infrastructure for electricity and hydrogen. Incentives are needed to overcome uncertainty about oil prices, as well as oil industry ambivalence and even hostility.

Funding could come from carbon-indexed fuel taxes, where a higher tax would be imposed on fuels higher in carbon (on a life-cycle basis). Carbon-indexed fuel taxes would have a relatively modest effect at first in transforming fuels or reducing fuel use, but they could be a source of revenue initially to support new fuel infrastructure. With future vehicles likely outfitted with transponder devices that could be coded with the vehicles' certified greenhouse gas attributes, it would be possible for vehicles to communicate with the fuel pump (or electricity charger) to determine the correct tax.

Incentives to develop low-carbon fuel infrastructure could also come from the auctioning of emission credits under a carbon cap-and-trade program.[7] While cap-and-trade programs are likely to have only a modest effect on fuel suppliers, they could be effective at generating substantial funds for use in subsidizing the timely deployment of electricity and hydrogen fueling stations. Another approach to ensure development of early nonliquid-fuel stations is to require that petroleum fuel suppliers make electricity and hydrogen available at a certain percentage of their gasoline stations in coordination with expanding sales of electric, plug-in hybrid, and hydrogen fuel cell vehicles.

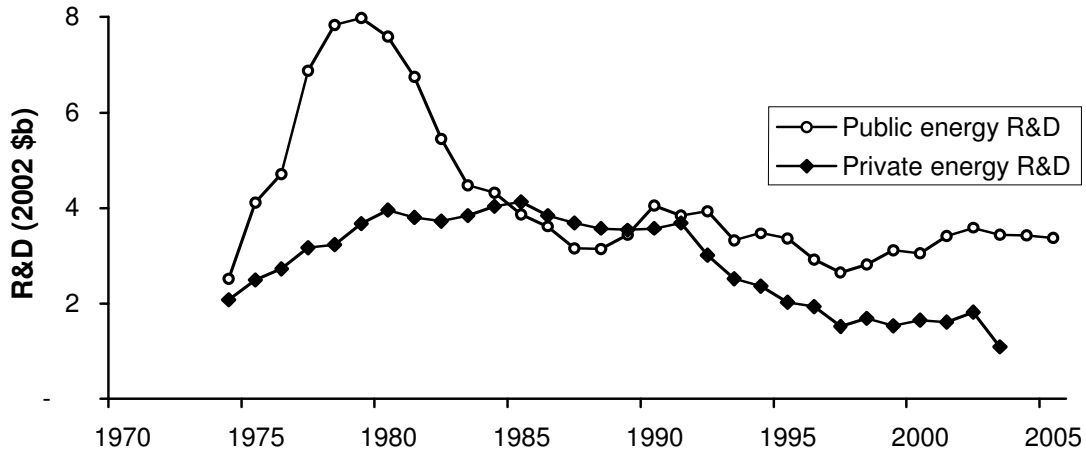
Expand research and development for low-carbon fuels

A clean energy revolution is about to get under way, linked with the transformation of vehicles. And yet energy R&D funded by both government and industry fell off precipitously after the early 1980s and is still far below what it was. The energy revolution will proceed much faster if clean energy R&D is dramatically increased. A massive commitment to clean energy is desperately needed. Government can do its share, but the needs are far greater than can be met by governments.

The R&D challenge is steeper with energy than with cars. Whereas automotive companies are highly motivated to invest in next-generation low-carbon vehicles, oil companies are not. Vehicle makers see electric-drive technology as central to their business and their future—and see value in being early to market with these products.

Figure 1

The sharp decline of energy R&D spending in the United States since 1980



Source: Kammen and Nemet, "Real Numbers," *Issues in Science and Technology* (Fall 2005): 84–88.

Oil companies don't see renewable fuels, electricity, and hydrogen in the same way. They're investing small amounts in all these fuels but more as a defense, just in case something happens that dramatically hastens the need for low-carbon alternatives. Electric utilities are making minimal investments in electric transportation, mostly a function of being regulated entities; and agricultural companies don't see energy as a core business and are too small and too diffuse to be pioneering investors in the development of advanced biofuels. The net result is lagging industry investment in low-carbon transport fuels. Thus, government R&D policy is more pivotal for low-carbon fuels than it is for low-carbon vehicles.

The greatest research need is the development of effective new ways of producing fuel from renewable sources and capturing and sequestering carbon from fossil sources such as coal and tar sands (as well as storing electricity and hydrogen). Carbon capture and sequestration will be a necessary interim step until renewable fuels are more broadly competitive and available.

The U.S. government in particular should vastly increase energy R&D investments, leveraging private ventures in strategic areas. Just like with battery and fuel cell science, it should also fund basic energy research at universities and national labs to provide a foundation for more applied technology development by others. Funding could come from the same restructured tax and cap-and-trade sources mentioned earlier.

Government also needs to take the lead in supporting demonstrations of cutting-edge energy technologies, just like with vehicle demonstrations.[8] Such demonstrations are necessary partly to create public acceptance but also to work through the many issues with codes and standards and with training of safety, maintenance, and other personnel that are part of an energy transition. While the scale of resources for this more applied research is less, its impact is large.

Perhaps most important, government should encourage industry to direct its massive resources to the task of developing clean energy. It can do this in many ways already discussed, generally by adopting performance standards and policies that reduce uncertainty and reassure industry that the country and world really are committed to a low-carbon future. It can also reduce conventional energy subsidies, adopt tax breaks for clean energy R&D, and reduce barriers at national labs to engage with industry.

Facilitate global development of low-carbon technologies, standards, and treaties

Transfer of innovative, low-carbon technologies, standards, and treaties between the developed and developing nations must be facilitated and encouraged. Such transfers will be of the utmost importance in inducing innovation and change. Studies show that programs and agreements aimed at knowledge sharing, research, development, and demonstration, when combined with aggressive domestic and international policies, could accelerate the global response to climate change.[9] Establishing consistent cross-national policy requirements, adopting coordinated agreements, and harmonizing energy and carbon markets are also useful strategies.

Most critical is the relationship with China and India, with their huge populations, growing economies, and huge reserves of coal. It's in the interest of the coal-rich United States to collaborate with these two countries to learn how to exploit coal more sustainably, share that technological know-how, give incentives for the adoption of best practices, and reward those who arrive at innovative solutions first.

There are many ways to increase the efficiency of coal conversion processes and to capture and sequester carbon emissions. Eventually, renewable sources will dominate, but that future is as much as a century away. Meanwhile, it's urgent that more sustainable ways of using fossil energy, especially coal, be developed. But research on coal conversion processes has languished, and research on capture and sequestration is in its infancy. It's in the world's interests for the United States, China, India, and others, to tackle this challenge together. Cooperation can take many forms, including university and national lab collaboration, academies of science and technology and other honest information brokers, preferential licensing of low-carbon technologies, purchase of carbon emissions from low-carbon coal projects, and government-supported joint ventures. Many such interactions are already beginning to happen. What's needed is more active government support and engagement.

Transforming Consumer and Local Government Behavior

Automakers can ultimately build efficient vehicles, and energy companies can supply low-carbon fuels. But unless consumers are willing to buy more-efficient vehicles that use low-carbon fuels and to reduce vehicle travel, there's no hope of reducing oil use and greenhouse gases. Thus, the focus here is on consumer behavior, plus one other player, local governments, since they operate and manage—and indirectly influence—much of the transportation system, particularly transit services. They also regulate land use, which has a large effect on vehicle usage. Only with enhanced transport choices and smarter land use can individuals and cities reduce their carbon footprints.

Reward low-carbon consumerism

Let us begin with individuals and their purchase of vehicles. Without an incentive to alter their habits, consumers tend to maintain the status quo, even when aware of adverse impacts. High oil prices (assuming they continue) provide some incentive for low-carbon vehicle purchases, but even so consumers are likely to overlook or undervalue the environmental impacts and energy savings of new vehicles, fuels, or other products. Their behavior may be the result of market failures, ignorance, or just lack of engagement. Whatever the reason, financial incentives and disincentives rivet consumer attention on the impacts of their choices and influence their buying behavior.

Financial incentives and disincentives include rebates and surcharges.[10] These are important strategies to align consumer behavior with shifts in automaker offerings in response to stringent fuel economy and greenhouse gas standards, especially if fuel prices prove as volatile as they have in the past. The success of these financial policies is tied to three key factors. First, they must be sensitive to equity implications—they can't be seen as hurting disadvantaged people. Second, dollar amounts must be set high enough to have a meaningful effect on consumer, manufacturer, fuel supplier, and car dealer behavior, but not so high that they provoke strong political opposition. And third, they're most effective when linked with a specific regulatory goal such as fuel economy and greenhouse gas standards imposed on automakers and fuel suppliers.

A remarkably large number of incentives aimed at focusing consumer attention on new vehicle fuel economy and carbon emissions are now being enacted around the world—much more so than in the United States.[11] Such incentives range widely by country and often vary by a vehicle's carbon emissions,

weight, engine size, or other related factor. In Denmark, for example, consumers who buy cars using less than 3.6 liters of gas per 100 kilometers (58.8 mpg) get a rebate on the country's high car tax (which can amount to up to 105 percent of the vehicle's value).[12] Ireland, on the other hand, imposes a variable tax, from 22.5 to 30 percent, based on a new vehicle's engine size. And the Netherlands adopted a so-called "gulp tax" in early 2008 that imposes a large tax on sales of gas guzzlers. Other countries, such as France, have recently adopted policies that bundle incentives and disincentives together. Cars emitting less than 130 grams of carbon dioxide per kilometer (g CO_2/km) receive a 5000 Euro (€) rebate, while those emitting more than 250 g CO_2/km pay a 2600 € fee, and those between 131 and 160 neither pay a fee nor receive a rebate.[13]

The idea behind such "feebate" policies[14] is simple: impose fees on consumers who purchase vehicles that guzzle gas and pollute, and award rebates to those who buy fuel-efficient, low-emitting vehicles. The impact of a feebate program depends on its structure. One study in California projected that combining the state's (pending) greenhouse gas vehicle standards with the feebate program almost adopted by the legislature in 2007 would have reduced greenhouse gases up to 25 percent beyond what the standards themselves would achieve.[15]

Consumer incentives are attractive not only because they shift consumer purchase decisions but also because they motivate manufacturers to accelerate the development and adoption of lower-carbon, fuel-efficient technologies.[16] Feebates give automakers and their technology suppliers the certainty of knowing that fuel economy will be highly valued into the future even as gasoline prices ebb and flow. This inspires more innovation and more commitment to getting energy-efficient technology into vehicles.

Local governments can also influence buying behavior by offering a variety of nonmonetary incentives to those driving low-carbon vehicles, such as free parking and use of high-occupancy vehicle lanes. In the 1990s, many cities in California installed charging stations for electric vehicles in parking areas and offered free parking to the vehicles. Los Angeles International Airport offers free parking for electric vehicles in two of its parking structures. A few states, including Virginia and California, allow electric and natural gas vehicles as well as a certain number of the most efficient hybrids to use carpool lanes with just a single occupant.

Restructure taxes, fees, and other incentives to reduce vehicle usage

Once people buy a car, they rarely consider using other modes of transport. One reason is that they perceive the marginal cost of driving to be very low, usually just the cost of gasoline, tolls, and parking in downtown areas. They ignore not only a raft of burdens they impose on others—air pollution, noise, climate change, energy insecurity, and increased traffic congestion—but also costs to themselves from the vehicle's wear and tear, insurance, depreciating value, and other ancillary expenses.

Part of the problem can be solved by restructuring the way fees and taxes are charged. Examples include fuel taxes indexed to carbon content, congestion fees, and more favorable tax treatment of new mobility options—such as reducing or waiving sales and registration taxes for vehicles used in carsharing, formalized carpool arrangements, and commercial paratransit service, and even waiving bridge and road tolls for these same vehicles. These incentives work together to promote less dependency on high-carbon cars with a single occupant and more on innovative mobility services.

The more fundamental problem of assuring that drivers make decisions based on the real cost of driving can be addressed by converting fixed (or intermittent) costs into variable costs. One such expense that could be converted is insurance. This policy, known as pay-as-you-drive (PAYD) insurance, ties insurance payments to how much a driver travels. The insurance cost could be paid at the pump, along with the fuel cost, or charged monthly based on odometer readings. Many insurance companies support this concept, in part because it also solves the problem of uninsured drivers.[17]

Another innovative way to restructure vehicle expenses, championed by Professor Donald Shoup of UCLA, is to give commuters cash in lieu of free parking.[18] Many employers offer free parking to workers as a fringe benefit, but this is a subsidy for driving. Why not make the value of this benefit directly available to all employees? Some employees will choose to park for free but others will choose to accept a certificate that can be used for transit or cashed (if they bike, walk, or telecommute). The net effect is to reduce vehicle use. California mandated parking cash out, but many exemptions and too little publicity have prevented enforcement statewide, except in Santa Monica. According to the California Air

Resources Board (the program's administrator), many California employers don't realize that they should be cashing out free parking for their workers. A study of eight firms that complied with California's cash-out requirement found that the number of people driving solo to work fell by 17 percent, carpooling increased by 64 percent, transit ridership increased by 50 percent, the number of people who walked or biked to work increased by 39 percent, and vehicle commute travel at the eight firms fell by 12 percent.[19]

In addition to giving travelers incentives to leave their cars at home, there are other ways to use information to reduce energy use and greenhouse gas emissions of vehicles—what is now referred to as eco-driving. The theory is that more information will lead to better driving and car maintenance habits that reduce carbon emissions. Inflating tires to proper pressure, tuning engines more frequently, keeping air filters clean, aligning wheels, driving less aggressively, speeding less, minimizing air conditioning, and removing roof racks all help. Gentler driving, for instance, can reduce fuel consumption by up to 25 percent or more, according to studies in Europe, where eco-driving is more actively promoted.[20] A Belgian study compared aggressive and relaxed driving of four different cars and found that aggressive driving consumed as much as 60 percent more energy over an urban and rural driving cycle than a relaxed eco-driving style (though the savings are considerably less in most cases).[21] Drivers of some new high-end cars, as well as hybrids, have dashboard instruments that show them how much fuel they use on a second-by-second basis.

Establish carbon budgets and banks for individuals, households, and local governments

Consider that individuals and cities readily accept that they must live within a financial budget. Why not also within a carbon budget?[22] The appeal of carbon budgets is that they push responsibility for reducing greenhouse gases down to the decision makers—cities in the case of land use, and individuals in the case of travel and purchases.

Carbon budgets could be an effective way to focus the attention of local governments on greenhouse gases. Historically, localities haven't routinely considered the climate change implications of their decisions (although many voluntary initiatives have sprouted in recent times).[23] Those decisions have often encouraged sprawled development and car dependence.

In the United States, local governments control land use and jealously guard that right, without full regard for greenhouse gas emissions. Local decisions to build a new road, approve a new development, or change zoning rules are mostly related to tax considerations and the financial influence of developers. If carbon budgets were established, local governments might gravitate to infill development, greater density around transit stations, and land development patterns that support the use of neighborhood vehicles and walking.

Local carbon budgets are one approach that could help balance energy and environmental goals.[24] City and county governments would be required to reduce their per capita emissions by a fixed percentage, forming the basis of their carbon budget. Each land use decision would be analyzed to determine the greenhouse gas impact. Initially, the focus should be on carrots, not sticks, since most cities are strapped for funds. If they stay under budget, they could either bank their savings toward future use or receive bonus funds to subsidize low-carbon transport modes. Special provisions could also be available for lower-income communities that have less ability to meet carbon budget constraints.

A more radical approach is to impose carbon budgets on individuals or households. The idea is for consumers to create budgetary rules to guide their everyday behavior using dual currencies—dollars and carbon units. Tracking their energy use and carbon emissions on a routine basis makes consumers conscious of the impacts of their decisions. Once they know when and where they expend carbon, consumers are better equipped to fashion solutions tailored to their individual lifestyles.

The first foray into this arena is in the United Kingdom. Here, Environment Minister David Miliband unveiled a plan to introduce individual carbon budgets. All citizens would be allocated an identical annual carbon allowance, which would be stored on an electronic card. Consumers would decide how to meet their budgets. Those exceeding the annual allowance would have to buy credits to balance their budget from those who managed to live under budget. Such plans could be an important aspect of valuing carbon and building consumer action and markets around future climate change policies.

It will take some time for consumers to become comfortable with the idea of carbon budgets, but some fringe groups are already adopting such a plan voluntarily.[25] Robust systems that include banking and trading carbon credits may become popular and find their way into online markets, providing value to their owners.

Create incentives to advance new mobility options and enhanced regulation of transit

In the United States, departments of transportation from the local to the national level focus primarily on cars and highways, secondarily on conventional bus and rail, and very little on innovative alternatives (other than bike paths, for which there's now a small pot of federal funding in the United States). Government agencies have implemented funding systems and tend to have mindsets that ignore and are even hostile to alternative mobility services. Cities, which might be more inclined to experiment with innovative services, usually have tight budgets and little expertise. Furthermore, conventional transit services, most of them plucked out of bankruptcy by local governments in the 1960s or earlier, generally operate as monopolies. It's now clear that such an anticompetitive approach isn't always in the public interest. Transit operators have become ossified and even more resistant to disruptive innovations than large corporations.

Regulations and incentives must be used to restructure transit operations and to encourage competition and invite a broader array of mobility services. Anachronistic rules must be eliminated. Further, those privatized services that meet low-carbon standards and other overall societal goals should be eligible for public transit subsidies.

Research, develop, and test new mobility services

Perhaps the greatest transportation research need is in the area of new mobility services. Ironically, the core technologies are those favored by venture capitalists—technologies linked to the processing of information. These innovative mobility services have been largely ignored so far because investors are scared off by the conservative transit monopolies that resist innovation and competition, and the huge government subsidies for incumbent transit services.

Developing software and hardware technologies is the easy part of launching new mobility services. Innovative communications needed to support new mobility services dovetails well with current research on the interface between computers, the human brain, and decisionmaking. But because there's so little experience with these types of mobility services, the challenge is less technological and more related to designing, marketing, and financing. More research is needed to answer the following questions:[26] Who are the early markets for new mobility services—commuters, college students, city dwellers, disabled persons, retirees? How should smart paratransit and dynamic ridesharing services be designed? Is faster service more important than price, how many transfers might travelers accept, and how should personal security be protected? How might these services differ at different times and places—in cities versus suburbia, winter versus summer, poor versus rich communities? And what business models will be most effective? Will subsidies be needed? Who will provide them? How will these services interface with conventional transit services?

The challenge is to create a compelling vision of innovative mobility services and to highlight successful innovations so that state and national governments and transportation agencies, as well as private foundations and ventures, will provide funds to study, design, and advance mobility options.

Develop and test strategies and policies to motivate low-carbon behavior

In the end, scientists, engineers, and companies can produce very efficient, low-carbon, and even inexpensive new mobility options, but if no one buys or uses them, then all is for naught.

The research world has little understanding of low-carbon travel behavior. What's the demand for new forms of mobility such as smart paratransit or dynamic ridesharing? Who might purchase an alternative-fuel vehicle? What would be the effect of different incentives on vehicle purchase and usage? And how might these behaviors vary across age and social class, and across countries and specific land use patterns? Behavioral science research could play a central role in guiding the transformation of transportation.

There's growing awareness that cars and fuels are much more than technological puzzles, and that they elicit highly emotional reactions that must be better understood if transport habits are going to be altered. Behavioral research can be conducted to test strategies that motivate low-carbon habits, with the understanding that behavior is cultural. Americans differ in their lifestyles, beliefs, preferences, and attitudes from those in the EU, China, Brazil, or Russia. Developing a better understanding of evolving behavior patterns worldwide can help inform low-carbon policy design and implementation.

Realizing the Vision

As we head toward a future world of increasing vehicle ownership, innovative strategies are needed to transform behavior, vehicles, and fuels. We can look to innovative policymaking in California for new ideas on how to proceed. We can learn from innovative cities in Europe, such as Freiburg, Paris, London, and Stockholm. We can invoke novel ways to stimulate China and other awakening giants to be part of the solution and not part of the problem. We can align incentives to motivate consumers to act for the greater public good. We can rewrite the rules so local governments make decisions that further low-carbon transportation options. And we can invite entrepreneurs to develop the needed transformations in transportation.

Indeed, the first transformation, that of vehicles and fuels, is already under way, albeit tentatively. It will take many years for this transformation to play out. It will undoubtedly happen in surprising ways, calling for open-ended policy approaches that don't pick winning technologies but instead establish fair but tough, escalating goals. The second stage of the transportation revolution, a complete rethinking of how we move about, will evolve more slowly. Both transformations will require incentives, mandates, research, and demonstrations.

Change will happen. It must happen. The days of conventional cars dominating personal mobility are numbered. There aren't sufficient financial and natural resources, or climatic capacity, to follow the patterns of the past. Consumers, governments, and companies all have essential roles to play in making the needed changes. The sooner we get on with addressing the issues, the better. And a durable framework is a better approach than the haphazard and ad hoc road we've been on. Adopting a strategic, long-range view is the key.

The road to surviving and thriving is paved with low-carbon fuels and electric-drive vehicles, new mobility options, and smarter governance. Enlightened consumers, innovative policymakers, and entrepreneurial businesses worldwide can drive us to a sustainable future.

Endnotes

[1] At the national level, the Bush Administration finally acknowledged the reality of climate change and the need for humans to do something about it. But President Bush was the laggard. For documentation of the vast number of climate initiatives sweeping across the nation at that time, see Nic Lutsey and Daniel Sperling, "America's Bottom-Up Climate Change Mitigation Policy," *Energy Policy* 36 (2008): 673–85.

[2] David Greene, John German, and Mark Delucchi, "Fuel Economy: The Case for Market Failure," in Dan Sperling and James Cannon, eds., *Reducing Climate Impacts in the Transportation Sector* (Dordrecht, NL: Springer, 2008).

[3] See Anthony Grezler, "Heavy Duty Vehicle Fleet Technologies for Reducing Carbon Dioxide: An Industry Perspective," in Dan Sperling and James Cannon, *Climate Policy for Transportation* (Dordrecht, NL: Springer, 2008); J. Leonardi and M. Baumgartner, "CO_2 Efficiency in Road Freight Transportation: Status Quo, 45 Measures and Potential," *Transportation Research*, Part D, 9 (2004): 451–64; A. Vyas, C. Saricks, and F. Stodolsky, *The Potential Effect of Future Energy-Efficiency and Emissions-Improving Technologies on Fuel Consumption of Heavy Trucks,* Argonne National Laboratory ANL/ESD/02-4 (2002).

[4] International Energy Agency and International Transportation Forum, *Fuel Efficiency for HDVs, Standards and Other Policy Instruments: Towards a Plan of Action*, Paris, France (2007). For an expanded description of the Japanese program, see the untitled final report (translated from Japanese) prepared by the Heavy Vehicle Fuel Efficiency Standard Evaluation Group, Heavy Vehicle Standards Evaluation Subcommittee, Energy Efficiency Standards Subcommittee of the Advisory Committee for Natural Resources and Energy. http://www.eccj.or.jp/top_runner/pdf/heavy_vehicles_nov2005.pdf.

[5] This carbon performance standard would actually be a life-cycle greenhouse gas standard. See Alexander Farrell and Daniel Sperling, *A Low-Carbon Fuel Standard for California, Part 1: Technical Analysis*, Institute of Transportation Studies, University of California, Davis, Research Report UCD-ITS-RR-07-07 (2007); and Alexander Farrell and Daniel Sperling, *A Low-Carbon Fuel Standard for California, Part 2: Policy Analysis*, Institute of Transportation Studies, University of California, Davis, Research Report UCD-ITS-RR-07-08 (2007).

[6] See OECD, Joint Transport Research Centre, *Biofuels: Linking Support to Performance*, *Summary and Conclusions* (Paris, 2007), 3.

[7] As discussed in Chapter 5, we're lukewarm on cap-and-trade policies. But since this approach is gaining momentum, and because it's important to send a consistent signal to the entire economy, we think economywide cap-and-trade programs are worth pursuing. The principal reason to support cap-and-trade programs for the transport sector would be to generate a huge revenue stream from the sale of the carbon allowances to oil refineries—in the billions of dollars per year in the United States and Europe.

[8] The war in Iraq is estimated to cost $3 trillion. See Joseph Stiglitz, www2.gsb.columbia.edu/faculty/jstiglitz. A portion of these funds used for geopolitical purposes related in part to oil dependence could go a long way toward funding the needed public R&D on fuels and vehicles that sidestep the use of oil.

[9] Heleen de Coninck, Carolyn Fischer, Richard G. Newell, and Takahiro Ueno, "International Technology-Oriented Agreements to Address Climate Change," *Energy Policy* 36 (2007): 335–56.

[10] For a more extensive discussion of each of these fiscal and other policies see Deborah Gordon, *Steering a New Course: Transportation Energy and the Environment* (Washington, DC: Island Press, 1991); OECD, *Policy Instruments for Achieving Environmentally Sustainable Transport*, Organization for Economic Co-Operation and Development, Paris (2002); Y. Hayashi, H. Kato, R. Val R. Teodoro, "A Model System for the Assessment of the Effects of Car and Fuel Green Taxes on CO2 Emissions," *Transportation Research* Part D, 6 (2001): 123–39; and D. L. Greene, P. D. Patterson, M. Sing, and J. Li., "Feebates, Rebates and Gas-Guzzler Taxes: A Study of Incentives for Increased Fuel Economy," *Energy Policy* 33 (2004): 721–827.

[11] U.S. initiatives include a limited gas-guzzler tax on cars (not light trucks) and some incentives for hybrid vehicles. For elsewhere, see Japan Automobile Manufacturers Association (JAMA), *The Motor*

Industry of Japan 2007, May 2007; Transport Canada, Budget 2007, *Eco Transport Vehicle Eligibility*, 2007; Government of Ontario, Ministry of Finance, 2007, *Tax for Fuel Conservation (TFFC)*; ACEA 2007.

[12] Association of European Automobile Manufacturers (ACEA), *2007 Tax Guide*, January 2007.

[13] 5000 € was equivalent to $US 7800 in spring 2008. See "France to Institute Vehicle Feebate Based on CO_2 Emissions," www.greencarcongress.com, December 7, 2007, based on an announcement by the Ministry of Ecology (Ministère de l'Ecologie, de l'Energie, du Développement durable et de l'Aménagement du territoire).

[14] The feebate concept was first developed in D. Gordon and L. Levenson, "DRIVE+: Promoting Cleaner and More Fuel-Efficient Motor Vehicles Through a Self-Financing System of State Tax Incentives," *Journal of Policy Analysis and Management* 9 (1990): 409–15.

[15] The analysis assumed that fees and rebates would be no larger than $2500 per vehicle, the zero band (those vehicles neither charged nor rebated) would include 20 to 25 percent of vehicles, and the tariff schedule would be structured to be revenue neutral. See Walter McManus, "Economic Analysis of Feebates to Reduce Greenhouse Gas Emissions from Light Vehicles for California," University of Michigan Transportation Research Institute, UMTRI-2007-19-1 (2007).

[16] W. B. Davis, M. D. Levine, K. Train, and K. G. Duleep, *Effects of Feebates on Vehicle Fuel Economy, Carbon Dioxide Emissions, and Consumer Surplus*, DOE/PO-0031 (Washington, DC: Office of Policy, U.S. Department of Energy, 1995).

[17] Progressive Insurance Company piloted PAYD insurance in Texas, using global positioning satellite (GPS) technology. Another pilot project is being launched in Georgia, with funding from the Federal Highway Administration's Value Pricing Program. Oregon, Washington, Massachusetts, and other states are also working toward PAYD. In the United Kingdom, Norwich Union has become the first insurer to offer PAYD.

[18] Donald Shoup, *Parking Cash Out* (Chicago: Planning Advisory Service, 2005).

[19] Donald C. Shoup, "Evaluating the Effects of Cashing Out Employer-Paid Parking: Eight Case Studies," *Transport Policy* 4 (1997): 201–16.

[20] The U.S. Environmental Protection Agency is also attuned to the fuel savings associated with smoother driving, which it estimates can improve fuel economy by as much as one third.

[21] Reported by G. Lenaers (Vehicle Technologies, VITO-Belgium) at the 17th CRC On-road Vehicle Emissions Workshop, San Diego, California, March 26–28, 2007. The study defined eco-driving as shifting gears to lower engine speeds, reducing acceleration speeds, using cruise control, and anticipating slowdowns. The similar "relaxed" style involved accelerations of 0.45 to 0.65 m/s2 on urban and rural roads, while aggressive driving involved accelerations of 0.85 to 1.1 m/s2. At a 2006 OECD workshop on eco-driving, Martin Kroons, a former eco-driving instructor for the Dutch government, reported that advanced eco-driving can reduce fuel consumption for an individual by up to 25 percent.

[22] According to the United Nations Development Programme, which is calling on the U.S. to adopt carbon budgets, the 19 million residents of New York State have a bigger carbon footprint than the 766 million people living in the world's fifty least developed countries. And the average American car emits nearly ten times more carbon dioxide in a year than a person in Afghanistan or Cambodia during his or her lifetime. United Nations, Human Development Report, "Fighting Climate Change: Human Solidarity in a Divided World," 2007.

[23] Lutsey and Sperling, "America's Bottom-Up Climate Change Mitigation Policy."

[24] For fuller development of the concept of city carbon budgets, see Deborah Salon, Daniel Sperling, Alan Meier, Roger Gorham, Sinnott Murphy, and James Barrett, "City Carbon Budgets: Aligning Incentives for Climate-Friendly Communities," Institute of Transportation Studies, University of California, Davis, Research Report UCD-ITS-RR-08-17 (2008).

[25] James Kanter, "Groups' Aim: The Greening of Britain," *New York Times*, October 21, 2007.

[26] For an early review of the challenges and opportunities, see the following report on a 1999 conference held on this topic: D. Salon, D. Sperling, S. A. Shaheen, and D. Sturges, *New Mobility: Using Technology and Partnerships to Create More Sustainable Transportation*, Institute of Transportation Studies, University of California, Davis, Research Report UCD-ITS-RR-99-01 (1999).

Since then, Dr. Susan Shaheen developed and directed a program on “innovative mobility services” for the California Partners for Advanced Transit and Highways (PATH), a research center of the University of California largely supported by the California Department of Transportation. Various research initiatives have emerged elsewhere, but none have gained widespread attention or resources.