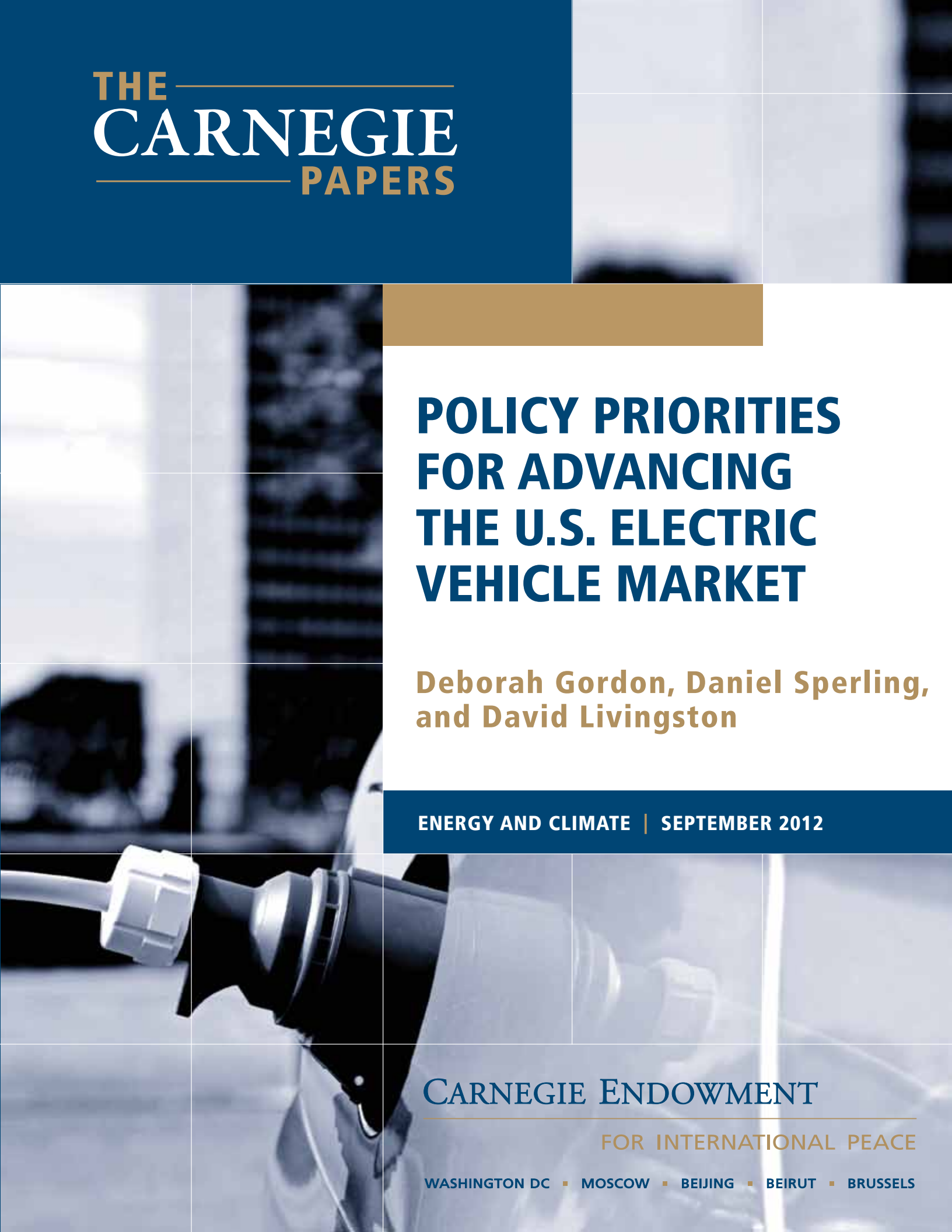
THE CARNEGIE PAPERS



POLICY PRIORITIES FOR ADVANCING THE U.S. ELECTRIC VEHICLE MARKET

Deborah Gordon, Daniel Sperling, and David Livingston

ENERGY AND CLIMATE | SEPTEMBER 2012

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The Carnegie Endowment is grateful to the Energy Foundation for its generous support of this publication.

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Washington, D.C. 20036
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www.CarnegieEndowment.org

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CP 157

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Summary

The U.S. electric-vehicle industry has posted impressive growth over the last decade, with hundreds of companies now advancing the plug-in electric vehicle (PEV) market. But there is still much to do to further the transition to electric-drive vehicles. It will take a sophisticated set of policy tools and local action to spur manufacturers, utilities, localities, and states to fully commercialize PEVs.

Key Themes

- With the price, complexity, and carbon footprint of oil increasing and new climate regulations facilitating the shift to cleaner power, there has arguably never been a more pressing time for advancing vehicle electrification.
- Light-duty PEVs used for passenger travel, including plug-in hybrid and full battery electric vehicles, have the potential to make the greatest impact on the market and to reduce greenhouse gas emissions and local air pollution.
- Federal and state regulators are adopting emissions and fuel economy standards, but, while necessary, those may not be enough to transform the vehicle market.
- States and localities, which have generally advanced PEV commercialization more directly and effectively than has Washington, will likely be the source of the most durable solutions.

Recommendations for U.S. Policymakers

Motivate PEV manufacturers: Policies that help boost PEV sales will foster the large-scale commercialization of electric vehicles. In particular, policies should more broadly distribute tax incentives for purchasing these vehicles, and federal electric-vehicle programs should be extended and expanded to provide direct financial incentives to PEV manufacturers. Auto dealers leading the way in PEV sales should also be rewarded.

Shine the spotlight on states: Those states making the most headway in advancing low-carbon electric vehicles should be held up as examples to help assure uncommitted states of the opportunities offered by PEV

commercialization. They should also be benchmarked to maintain their leading edge, and states should move away from fuel taxes and toward carbon pricing to compensate governments for their lost revenue.

Cultivate local PEV clusters: The federal government should target PEV policies at those regions where cleaner, renewable electricity is already generated because expanded PEV use in those regions will reduce carbon emissions. Similarly, programs should be targeted at cities already facilitating PEV use.

Promote PEV interactions with utilities: The transition to PEVs will be discouraged if electric-vehicle drivers who need to charge their cars face excessive electricity prices. Utility providers must be encouraged to revisit their electricity rate designs, invest strategically in recharging infrastructure, and investigate the effectiveness of decoupling regulations.

The Low-Carbon Path

Plug-in electric vehicle (PEV) sales and use could soar—or stagnate—from today's levels. A number of manufacturers are making major investments in PEVs and thousands of consumers, in some key markets, are purchasing them. But much could go awry. The challenge is to craft and strengthen policies that support PEV commercialization in a way that benefits the public interest. Policies are needed that bolster nascent markets, facilitate PEV ownership and use, and boost public confidence in electrified transportation options.

The transition to electric-drive vehicles offers the potential for long-term structural reductions in local air pollution, greenhouse gas emissions, and petroleum consumption. Moreover, electric vehicles' power needs can be met with domestic renewable and natural gas resources, and PEVs' batteries can serve as distributed storage devices for twenty-first-century electrical grids.

The transition to electric-drive vehicles offers the potential for long-term structural reductions in local air pollution, greenhouse gas emissions, and petroleum consumption.

Yet, despite their promise of tangible benefits, significant barriers remain to the wholesale adoption of PEVs. Vehicle affordability, battery longevity, public charging availability, vehicle-grid compatibility, system reliability, and consumer acceptability are continuing concerns.

Those barriers are unlikely to be surmounted without policy action. States and regions may have the greatest opportunity to implement effective EV policies, and to send the needed market signals to automakers, utilities, and consumers. A mix of approaches will be needed to make progress. Some issues can be addressed through public education and outreach while others will take concerted regulatory and fiscal measures. Still other roadblocks will require altogether new strategies.

Light-duty, on-road autos represent the lion's share of vehicles in circulation. As such, light-duty PEVs used for passenger travel, including plug-in hybrid and full battery electric vehicles, have the greatest potential of all vehicle applications to replace petroleum and reduce greenhouse gas emissions and local air pollution. They are thus a good place to start when developing electrification policies. There are, however, other important electric vehicle applications that merit attention that are not addressed here.[1] These include light- and medium-duty commercial trucks, especially those in fleets used for urban deliveries and service, as well as off-road vehicles, such as forklifts, where battery limitations are minimal and air pollution benefits might be considerable.

Tackling the growing global concern over transportation carbon will require an Electric Vehicle roadmap that extends to both motorized and motorizing nations.

Many of the issues involved in the U.S. vehicle electrification process have international applications. They will be germane in global urban geographies of China, India, Japan and the European Union, and international stakeholders could benefit greatly from adapting the findings of this analysis to their particular PEV conditions. Tackling the growing global concern over transportation carbon will require an EV roadmap that extends to both motorized and motorizing nations.

The first step forward is to remove barriers that are nearly as old as motorization itself. The second step is to take advantage of existing opportunities and key points of leverage to transform transportation. The overall goal is for federal, state, and local governments to concentrate their efforts on the main levers for change. This includes advancing strategic policies aimed at motivating manufacturers that are poised to make major investments in PEVs. U.S. states that are leading on low-carbon PEV implementation should be showcased nationally and provided additional federal support. PEV regional clusters should be cultivated to accelerate the commercialization of these vehicles in strategic locations. And PEV–utility company interactions should be promoted through redesigned and reformed utility policy.

There has arguably never been a more pressing time for advancing vehicle electrification. Forces promoting and suppressing PEVs are building. Low natural gas prices are creating alternatives to coal electricity generation, new climate regulations are facilitating the shift to cleaner power, and uncertain gasoline prices are building consumer interest in alternatives. But new petroleum resources are also emerging worldwide, locking in renewed investments in oil-fueled transportation infrastructure.

One transport-energy path leads to the continued use of risky, carbon-intense liquid fuels. The other offers the potential for distributed, low-carbon electricity. Still, moving to clean electricity and PEVs is politically charged because these vehicles are highly disruptive to the current market, with powerful private interests vested in maintaining the status quo. The United States must revisit its PEV roadmap to chart new vehicle electrification opportunities and policies.

On the Road to Vehicle Electrification

Essentially all of today's light-duty motor vehicles run on oil blended with a small amount of corn ethanol. But the supply of that oil will not remain consistent over coming years. As conventional oil supplies plateau, the 8.5 million barrels of oil a day that fuel U.S. cars and light-duty trucks will likely emit more carbon dioxide and require more energy to produce,[2] with many new oil resources tending to be heavier (with higher imbedded carbon) and harder to extract.[3]

Still, even with higher gasoline prices, market forces alone will not elicit a major shift to low-carbon transportation fuels. Absent enhanced policy intervention, petroleum lock-in will continue into the future.

Policymakers keen on vehicle-market transformation realize this and have set goals for vehicle electrification. Momentum for a shift to PEVs has been growing rapidly over the past few years, and the Obama administration has developed federal policies to support its goal of 1 million electric vehicles by 2015. These policies include vehicle fuel economy (greenhouse gas emission) standards with provisions for PEVs, and billions in PEV grants for industry, consumer tax credits, recharging facilities, and research and development, as shown in table 1.

Table 1: **Federal PEV Policies Supporting PEV Development and Commercialization**

2012 Through 2016 Greenhouse Gas Emission Regulations	Zero gram/mile credit in US EPA regulations for 2012–2016 vehicle GHG emissions, for the manufacturer's first 200,000 PEV sales.
Beyong 2017 Greenhouse Gas Emission Regulations	Proposed doubling of zero g/mi credit for PEVs under GHG emission regulations in 2017 (gradually diminishing over time) applying to all PEVs through 2012 and up to the manufacturers' first 600,000 PEV sales between 2022 and 2025.
Advanced Technology Vehicle Manufacturing (ATVM) loan program	Loan support for PEVs and PEV components, as well as associated engineering integration costs. Three loans of more than $2.4 billion have been distributed to three firms (Nissan, Tesla, and Fisker) for PEV manufacturing. The ATVM program retains approximately $4 billion in appropriated subsidies to help leverage further loan guarantees, but unfavorable media coverage of other federal clean technology loans has resulted in the government increasingly applying more stringent loan terms and larger amounts of required collateral, bringing recent disbursements to a halt.
Stimulus-funded grants for advanced battery manufacturers	Direct loans to manufacturers of up to 30% of the cost to re-equip, expand, or establish manufacturing facilities; $2.4 billion grant program reached its volumetric cap on funding by the end of 2009.

EV charging station tax credit	The tax credit was not renewed and expired in 2012. Hydrogen refueling property remains eligible to 2014, but the expected use of the credit for hydrogen stations is expected to be negligible.
PEV community readiness projects	$8.5 million in 16 cities throughout 2011 and 2012. Plus in 2009, the ARRA-funded Transportation Electrification Initiative (TEI) provided $400 million to select communities for the deployment and analysis of EV charging infrastructure.
PEV-related research and development (R&D)	Direct grants for high-risk/reward research on next-generation battery systems. DOE expended approximately $146 million in FY 2011 and $165 million in FY 2012 (batteries and electric drive technology, vehicle and systems simulation and testing).
Federal PEV tax credits	$2500 per vehicle with a 4 kWh battery, up to $7,500 per vehicle for 16 kWh batteries. A phase-out period for a manufacturer's vehicles kicks in after the given manufacturer has sold 200,000 qualified PEVs. The credits are not expected to expire until 2015 or later, but volumetric cap may be reached earlier in particular circumstances.

Sources: Nick Nigro, "Plug-in Electric Vehicle Market: State of Play," Pew, July 2011, www.C2ES.org

Recently, however, there has been pushback against federal PEV support. It is unclear whether this is political rhetoric in an election year or burgeoning public concern about balancing support for vehicle electrification with fiscal austerity.[4] Moreover, the impact of the controversy over the failed U.S. investment in the solar company Solyndra—which had to declare bankruptcy despite receiving hundreds of millions of dollars in federal loans—cannot be discounted. U.S. Department of Energy loans have been virtually halted given greater congressional scrutiny on government as a venture capital investor.[5] All told, it is likely that the road ahead for PEVs will be bumpy.

The new vehicle fuel economy and greenhouse gas performance standards being adopted by federal and state regulators provide a starting point but may not be enough to transform the vehicle market. Even with special incentives for PEVs, studies suggest that these new performance standards—which require a doubling of efficiency by 2025—may be met largely by improvements to current combustion engine vehicles operating on petroleum.[6] In one scenario that assumes companies utilize the most cost-effective technological improvements, an estimated 1 percent of vehicle sales would be battery electric vehicles in 2025. Policy intervention will be needed if government desires to accelerate the transition to highly efficient, low-carbon, oil-free vehicles.[7]

Generally, states and localities have been able to advance PEVs more effectively than Washington. California has been leading the way, and the state's Air Resources Board (CARB) has played a central policymaking role. Because vehicle electrification is "disruptive"—that is, it is a new technology that unexpectedly displaces an existing technology—PEV adoption is an

inherently slow process. For that reason, CARB maintains a strong commitment to technology-forcing in the early years of the transition.

CARB first adopted aggressive zero-emission-vehicle sales requirements in 1990 but was forced to ease up on the requirements due to the slow pace of technological development. Its adoption of new, stronger zero-emission-vehicle requirements in January 2012 was the first time since 1990 that it strengthened, rather than weakened, those requirements for automakers.

Gathering Momentum and Navigating Bumps

The significant benefits derived from PEVs—namely, reducing U.S. oil use at a time when the price, complexity, and carbon footprint of oil is increasing—are cause for action. Still, the successful development and adoption of an action agenda depends on the perceived urgency of addressing such energy and environmental challenges. If the urgency is great, then the impetus for action is large and the process is accelerated.

Uncertainty and gaps in knowledge are perhaps the most significant challenges for PEV commercialization. One uncertainty is the future cost and performance of PEV technology. Battery and associated drivetrain technology remains more expensive than comparable gasoline and diesel drivetrain technology.[8] The U.S. Advanced Battery Consortium has said battery costs will have to fall to about $150 per kilowatt-hour (kWh) for EVs to be price-competitive with conventional vehicles, but it is estimated that the cost for EV battery systems is now (in 2012) under $700 per kWh of capacity (see figure 1). These cost challenges are illustrated by the first two mass produced electric vehicles commercialized in the twenty-first century—General Motor's Chevrolet Volt and Nissan's Leaf. The Leaf has a 24 kWh battery and the Volt has 16 kWh. These numbers imply a cost premium of up to $18,000 for these vehicles. Many battery experts insist the costs will continue to drop due to economies of scale, learning by doing, and expanded research and development.[9] But even if they do decline, the cost premium will still be significant. Consumer incentives will be needed for some time. The size and nature of the incentives and the preferred type of policy instrument depend in large part on how quickly costs decline and why they do so.

Another uncertainty is consumer demand. How will consumers respond to different types of monetary and non-monetary incentives, and how will that vary for different types of PEVs and for people of different income groups and demographics? It is not clear how important tax incentives or access to carpool lanes are for the general population.

PEVs also have a more limited range than conventional vehicles, and the market is uncertain about how quickly consumers can overcome their "range

anxiety." Range is not an issue with plug-in hybrid vehicles, so they could prove to be preferred over battery electric vehicles. Also unclear is what role the availability of public and workplace charging, including fast charging, will play. Will owners of plug-in hybrid electric vehicles diligently recharge when the battery discharges or "lazily" run on gasoline for extended periods?

These and many other uncertainties and knowledge gaps have an effect on the desirability and effectiveness of different policy initiatives. There is no shortage of bumps on the road to vehicle electrification. But this is true of all disruptive technologies that challenge the status quo.

The issue is how best to manage the transformation of transportation. Most likely, a two-pronged strategy is needed: one that utilizes policies to overcome the vehicle and infrastructure barriers for PEVs and another that promotes the low-carbon use of PEVs. The use of prescriptive regulations and mandates can unlock market transformations to spur PEV development. So too can incentives play a role as long as they reward low-carbon performance instead of PEV technologies.

If reducing greenhouse gas emissions is a key rationale for vehicle electrification, policymakers should seek out the greatest "return on investment" possible in terms of those reductions. To ensure that greenhouse gas emissions are reduced quickly and cost effectively, PEV policies will need to be complementary and coordinated. Perhaps most important in this regard is targeting states and regions that already generate low-carbon electricity, encouraging lower-carbon recharging practices, and integrating carbon reduction as a measurable goal associated with PEV adoption. This would concentrate PEV use in regions where low-carbon electricity dominates and PEV lifecycle greenhouse gas emissions savings are the greatest. The first step is building momentum for PEVs by motivating manufacturers, showcasing states, cultivating PEV clusters, and restructuring recharging.

To ensure that greenhouse gas emissions are reduced quickly and cost effectively, PEV policies will need to be complementary and coordinated.

Motivate PEV Manufacturers

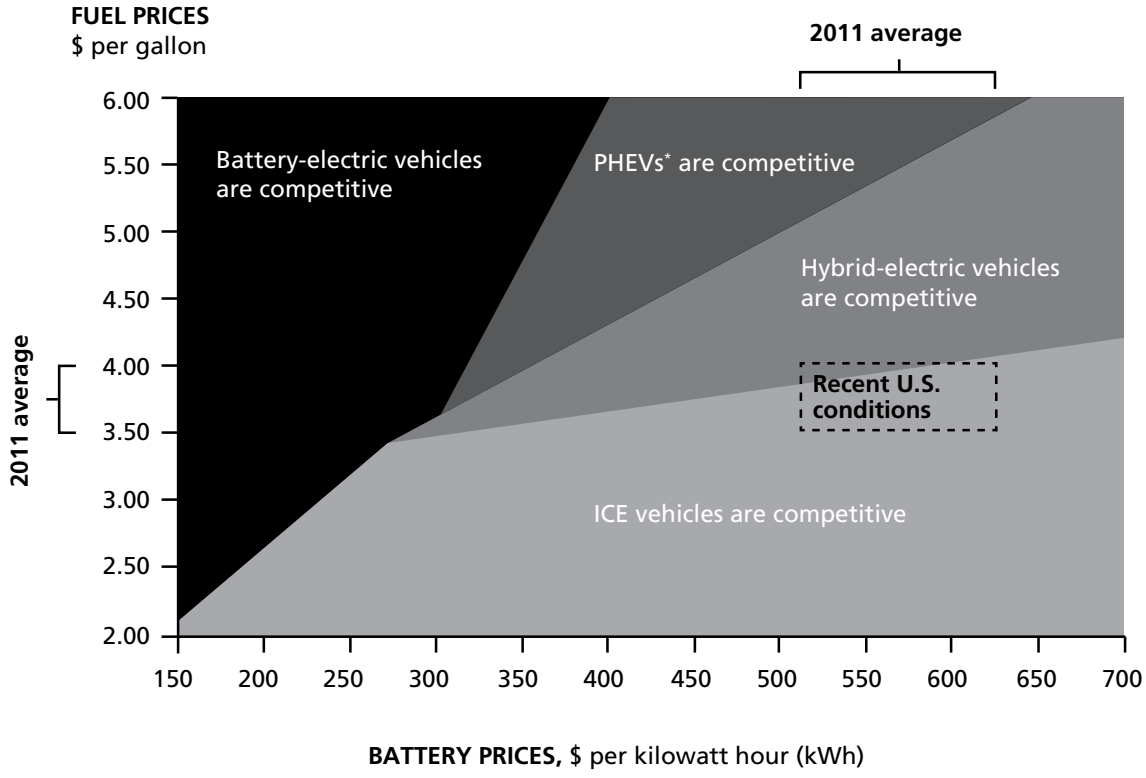
It takes a major effort to break into the established conventional vehicle market. In 2011, there were 18,000 PEVs sold in the United States out of 12.8 million new light-duty vehicles.[10] Of that, General Motors sold 7,671 Volts, slightly below its goal of 10,000, compared to Nissan's 9,674 Leaf sales.[11] It is worth noting that these PEV sales are nearly double the total number of hybrid vehicles sold in their full first year on the market—9,350 in 2000.[12]

Positive signs for electric carmakers were seen in spring 2012. The Toyota Prius Plug-in, Ford Focus Electric, Honda Fit EV, and Mitsubishi-I (MiEV) joined the Leaf and Volt, soon followed by the Tesla Model S and Ford C-Max Energi. In 2013, the Chevy Spark EV, and BMW 1-Series ActiveE are expected.

All in all, hundreds of companies are competing in PEV markets—from automakers to battery manufacturers to charging infrastructure specialists.[13]

The prevalence of new PEV models and the growth of the industry in such a short time is impressive. Still, much more needs to be done to realize the transformation to vehicle electrification. At present, PEVs remain a small niche market that needs policy support to survive and thrive. Figure 1 depicts the current position of the PEV market relative to fuel prices and battery costs. Though prices for energy storage are expected to fall in the years ahead, experts disagree over how far and how fast. Cheaper batteries could enable the broader adoption of electrified vehicles, potentially disrupting the transportation, power, and petroleum sectors and provoking backlash.[14] Given these conditions, moving automakers into major PEV production will take a concerted effort.

Figure 1. **U.S. Electric Vehicle Projected Competitiveness With Conventional Vehicles**



* Plug-in hybrid-electric vehicles

Source: McKinsey and U.S. Energy Information Administration, www.mckinseyquarterly.com/Energy_Resources_Materials/Electric_Power/Battery_technology_charges_ahead_2997

Studies vary widely about PEVs' future share of new vehicles, citing anywhere from 1 percent to 33 percent in the 2020–2030 timeframe.[15] A recently released 2012 automotive executive survey by Booz & Co. underscores increasingly

divergent outlooks for PEVs and other alternative drive trains,[16] with 71 percent of respondents expressing less confidence in battery electric vehicles than in the previous year. Plug-in hybrids elicited a mixed response, with 55 percent of executives reporting increased optimism in 2012. Interestingly, 14 percent of executives of supplier firms expected the leading alternative powertrain in 2020 to be PEV, compared with 37 percent of manufacturers. An overwhelming share of suppliers—82 percent of respondents—is betting on full or mild hybrids as the dominant alternative technology by 2020.

There is widespread concern about the near-term viability of any alternative to the internal combustion engine without high levels of maintained government support. Although auto executives expect alternative powertrains to gradually gain market share, over half of those surveyed by Booz & Co. expect alternatives to represent less than 5 percent of the market in 2020, absent government incentives. In contrast, with continued government support, nearly 60 percent of those surveyed see a 10 percent or greater market share for PEVs and other alternatives in 2020.

While most do not expect government support to disappear over night, they are increasingly reluctant to make large investment decisions based on current policy. An indeterminate oil price outlook and looming budget decisions at both the federal and local level are often cited by industry as casting uncertainty on the future market penetration of electric vehicles.

Motivating PEV manufacturing and sales amid fluctuating oil markets will provide consumers long-sought-after new fuel options for personal mobility, and highly efficient electric-drive vehicles can reduce greenhouse gas emissions. But without continuing policy support, vehicle and fuel markets will likely embrace unconventional oils and advanced gasoline and diesel vehicle technologies. Should low oil prices emerge, they would likely deliver a crushing blow to PEVs and all other alternative fuels. Policy intervention is essential.

Reform the Electric Vehicle Consumer Tax Credit

PEVs cost more than a comparable conventional vehicle. The policy currently in place—the Qualified Plug-In Electric Drive Motor Vehicle Tax Credit—provides a $2,500 tax credit for vehicles with batteries of at least four kWh. As the battery gets bigger the credit steps up to a maximum of $7,500. While the Nissan Leaf and Chevy Volt qualify for the full $7,500 tax credit, the Toyota Prius Plug-in Hybrid only qualifies for $2,500 given its smaller battery. This incentive applies only to the first 200,000 cars sold for any given company.

Tax credits are limited to the tax owed in any given year. Whether a consumer gets the full EV tax credit comes down to household tax liability. For example, a consumer with a tax bill of $2,000 would forfeit the remaining $500 EV tax credit when purchasing a Prius Plug-in hybrid. It has been reported by tax experts that a married couple would have to make at least $74,300, after a standard deduction and have no other tax credits or dependents, to earn the

full $7,500 tax credit on a PEV purchase. A single filer would have to earn at least $54,600. The median income for a single filer in 2011 was less than one-half that amount.[17]

Moreover, the tax credit is complicated and many people believe their new EV pricetag is lower than it actually is because they do not fully understand the details of the PEV tax credit calculation. Over time, complexity and inequity can reduce the effectiveness of PEV incentives.

As it is currently designed, a tax credit may not be the most equitable way to offer this benefit to the middle-income shoppers because only those in higher income brackets can benefit fully. This is the case because tax credits only offset tax liabilities. The lower the income, the less tax owed and the smaller the current benefit from the PEV tax credit. Tax rebates are paid to a taxpayer regardless of tax status, and a PEV tax rebate could better motivate those less-affluent individuals who would otherwise not purchase these vehicles.[18]

Incentives, if designed correctly, can influence consumer and manufacturer behavior. Issues of vehicle price appear to be salient concerns for mass-market adoption of PEVs. Other considerations entail giving the rebate directly to PEV manufacturers, as this might motivate automakers to invest greater amounts of capital sooner in PEVs than a consumer incentive that introduces uncertainty and a time lag in receiving the tax break.

Extend Federal PEV Policies to Encourage Industry Support

Automakers require market signals to spur transition in the motor vehicle market. Certain conditions are aligning that could prop up PEVs—higher gasoline prices and mounting public acknowledgment of climate change. At the same time, new oils are being discovered worldwide and Saudi Arabia is increasing its oil production to keep the price of oil at manageable levels, which means the uncertainty for market-driven PEV commercialization looms large.

Maintaining and growing federal support for industry and academia will be necessary to push manufacturers beyond niche vehicles and to bolster large-scale PEV commercialization. This includes grants and loans to industry, basic research and development support to academia and national labs, vehicle demonstration funds, support for charging infrastructure, market and other applied research, and grants for training and education, including emergency response, technician training, and other supporting roles.[19]

Engage Auto Dealers

Auto dealers play a central role in the commercialization of PEVs. They also tend to be politically powerful, because there are many of them and they are typically influential small business owners in their communities. Engaging auto dealers as PEV marketers and supporters of local PEV initiatives can be very helpful if those local actors endorse policies with their legislatures,

disseminate information about new PEV options through advertising, and develop relationships with local utilities.

Carmakers' marketing techniques can help transition consumers from one purchase behavior to the next through education, public relations, advertising, word of mouth, and social media. Automakers will need to work closely with dealers so that sales behavior meets customers' expectations from first purchase to ongoing maintenance and repair.

In Arizona, for example, the state requires car dealers to make information about alternative fuel vehicles and Arizona-based incentives for purchasing or leasing alternative fuel vehicles available to the public. The state also created an Electric Vehicles Arizona stakeholder group to bring together auto dealers and other interested parties so that they better understand the opportunities and barriers that electric vehicles face in the state.

The abundance of potential product offerings still needs to be sorted out as consumers enter vehicle showrooms. Different EV technologies—battery electric vehicles, plug-in hybrids, battery EVs with small range-extender engines, fuel cell electric vehicles—should expand purchase options. Greater interaction between dealers and consumers, as well as their increased exposure to each other and to information, would do much to help break through the confusion, helping to increase sales and encourage manufacturers to press onward with commercialization.

Shine a PEV Spotlight on States

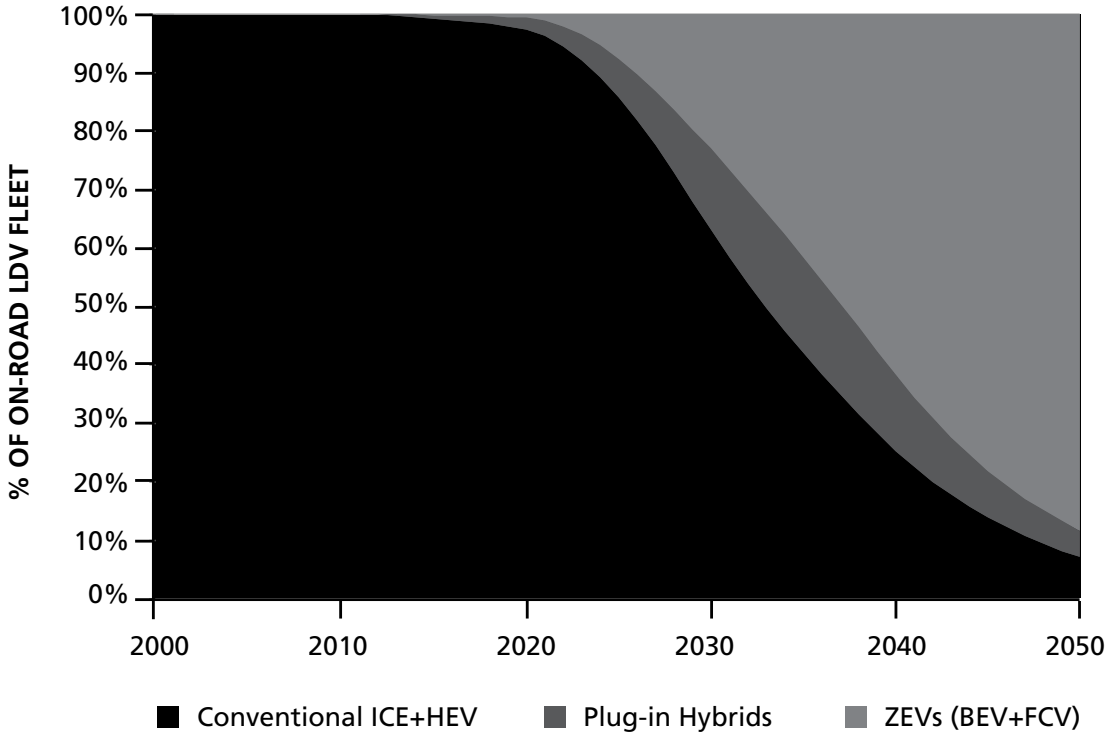
Many states have introduced their own incentive programs to encourage the production, purchase, and use of electric vehicles. The most popular policy instrument used by states is a tax incentive aimed at reducing the incremental cost of purchasing an electric vehicle. In addition, many states provide grants and loans to local governments to promote use of PEVs, and provide funds to electrify school buses, purchase PEVs for municipal fleets, and install recharging infrastructure. As such, states play a major part in PEV commercialization. Showcasing this role and its benefits could help disseminate PEV policies nationwide.

Showcase States Leading on Low-Carbon PEVs

Meeting the greenhouse gas reduction target for vehicles of 80 percent by 2050 depends on expediting the adoption of zero-emission vehicles, taking into account vehicle turnover and historical experiences in commercializing new technologies (such as gasoline hybrid cars). According to a scenario adapted from the California Air Resources Board, nearly all light-duty vehicles—87 percent in the scenario in figure 2—must shift to PEVs by 2050 to reduce greenhouse gas emissions by 80 percent. Although uncertainty remains about the exact future mix of PEVs in the marketplace, this particular scenario is based on a tipping point between 2025 and 2030 at which more than one-half

of light-duty vehicles are PEVs or fuel-cell electric vehicles. The actual mix will depend on manufacturer and consumer choices, guided in part by energy economics and relative technological progress on PEVs. It is important to acknowledge that the categories below camouflage a rich mix of technologies that underpin vehicle electrification.[20]

Figure 2. **CARB Sample 2050 Vehicle Mix for Low-Carbon On-Road Light-Duty Vehicles**



Source: Adapted from California Air Resources Board (CARB), "2012 Proposed Amendments to the California Zero Emission Vehicle Program Regulations," Staff Report: Initial Statement of Reasons (ISOR)–Advanced Clean Cars, December 7, 2011, www.arb.ca.gov/regact/2012/zev2012/zevisor.pdf

Note: Target is an 80 percent reduction by 2050.

Though California has taken the lead in this area, other states have followed thanks to a special provision in federal law. Ten states have adopted California's zero-emission vehicle program under the Clean Air Act (Section 177), which allows other states to adopt California's vehicle regulations. These Section 177 states are Vermont, Oregon, Connecticut, Maine, New Jersey, New York, Rhode Island, Massachusetts, Maryland, and New Mexico.

These states do not have uniformly low-carbon electricity footprints despite the fact that they are all advancing PEVs. The carbon footprint of PEVs is largely determined by the source of power they use for recharging. In terms of the carbon intensity of electricity generation (in kilograms of carbon dioxide

per megawatt hour), Vermont has by far the lowest carbon intensity—by an order of magnitude less than other states.[21] Washington and Oregon come close but have more than double Vermont's low levels. Connecticut, Maine, New Jersey, New York, and Rhode Island all rank better than average in terms of electricity-generation carbon intensity. Several non–Section 177 states—including New Hampshire, Arizona, South Carolina, Idaho, and Alaska—also have low-carbon emissions compared to the national average (see table 2 for state rankings). Policy efforts in support of PEVs could focus on those states with the greatest potential to deliver carbon reductions.

Benchmarking and geographically targeting states with the lowest carbon emissions from electricity generation could help focus PEV-adoption policy efforts. Policy (and advocacy) priorities can be based on how each state currently measures up and on which policies it has in place to further reduce carbon emissions from its electricity grid. Electricity supply policies on the demand side include electricity efficiency programs, and on the supply side, clean energy standards, renewable portfolio standards, and energy efficiency resource standards.

Table 2. **Benchmarking Low-Carbon PEV States**

State	Section 177 under Clean Air Act	Low-CO2 Power Generation	Electricity Efficiency	Renewable Portfolio Standards	Energy Efficiency Resource Standards	Preferred Roadway/ Parking Access
California	✓	✓	✓	✓	✓	✓
New York	✓	✓	✓	✓	✓	
Massachusetts	✓	✓	✓		✓	
Rhode Island	✓	✓	✓		✓	
Oregon	✓	✓	✓	✓		
Vermont	✓	✓	✓		✓	
New Jersey	✓	✓		✓		✓
Connecticut	✓	✓		✓		
Maine	✓	✓		✓		
Minnesota			✓	✓	✓	
Arizona		✓			✓	✓
Washington		✓	✓			
New Hampshire		✓		✓		
Maryland	✓					✓
Utah		✓				✓
Illinois		✓		✓		

Sources: http://apps1.eere.energy.gov/states/maps/renewable_portfolio_states.cfm#chart (RPS); Nick Nigro, "Plug-in Electric Vehicles Market: State of Play," C2ES, July 2011 (Incentives); and UCS, "State of Charge," April 2012, www.ucsusa.org/assets/documents/clean_vehicles/electric-car-global-warming-emissions-report.pdf; Boyce and Riddle, November 2010, www.peri.umass.edu/fileadmin/pdf/other_publication_types/green_economics/Cap_Dividend_States_nov2010.pdf (Low-carbon power generation)

An extensive array of state PEV policies in place, including HOV lane and emission test exemptions, monetary and parking incentives, and the availability of EV charging stations, is reviewed in the Appendix.[22]

Advance PEVs in Uncommitted States

PEVs are generally associated with environmental benefits and are thus not at the top of the agenda for every decisionmaker in every state. But a small investment in broadening PEV advocacy programs could go a long way. PEVs present a job-boosting, revenue-generating, and technology-enhancing economic opportunity that could situate states for long-term gain. For example, electric vehicle charging hardware and software revenues are forecasted to amount to some $6 billion by 2017.[23] Such a large dollar amount indicates that PEVs are big business from which states can derive future economic benefits.

Moreover, the potential to reduce fuel costs could appeal to uncommitted regions that tend not to put the environment at the top of the agenda. Consumers in some states pay a larger share of their income for gasoline than others.[24] And gas prices vary widely from state to state—for example, gasoline prices in California and Wyoming are over $1 per gallon apart.

Political swing states—Florida, Pennsylvania, Ohio, Michigan, North Carolina, Virginia, Wisconsin, Colorado, Iowa, Nevada, New Mexico, and New Hampshire—may be particularly good candidates for PEV policies.[25] Some states are leading the charge. Arizona, for example, requires state boards and commissions to purchase PEVs and other low greenhouse gas fleet vehicles, offers PEV access to high-occupancy vehicle lanes and carpool parking spaces, and provides tax credits for vehicle purchase and recharger installation. Likewise, Indiana, New Mexico, Virginia, and Wisconsin have PEV fleet vehicle requirements and provide financial incentives for PEV purchase. Colorado offers PEV financial incentives while Pennsylvania has fleet requirements for PEVs.

Such PEV policies could be expanded and extended to a wide array of states. If gasoline prices increase, all states could find new benefits from the fuel diversification that vehicle electrification delivers.

Transition to Transportation Carbon Pricing

Gasoline and diesel taxes were the predominant generator of transportation infrastructure revenues throughout the twentieth century. But as the country moves to reduce fossil fuel consumption as oil prices rise and fluctuate, it may make sense to reconsider these oil-only targeted taxes.[26]

In the United States, for half a century, the federal gas tax generated enough revenue to finance the Highway Trust Fund, which comprises two separate accounts, one for highways and one for mass transit. A large share of public transportation expenditures—for roads, transit, and supporting mobility services—has historically been funded by gasoline and diesel fuel taxes.

However, a combination of rising gasoline prices, increased vehicle efficiency, and demographic changes have led to a flattening of fuel use since 2008. Combined with inflation, these trends have resulted in a fund deficit that has required Congress to transfer general revenues into the highway account to keep the fund solvent.[27] But these funds are no longer adequate to maintain the nation's transportation infrastructure and services—partly because fuel tax rates have remained flat for decades, while costs have grown.

The transition to PEVs further cuts into fuel revenue streams. Today, motorists face an average gas tax of 49 cents per gallon of gasoline (18 cents in federal taxes) and 54 cents per gallon of diesel (24 cents in federal taxes).[28] Electric vehicle drivers, however, are spared these fees. Many state officials are wary of seeing the tax revenue stream dry up in the face of escalating infrastructure and maintenance needs, and some states are beginning to brainstorm potential remedies. The issue is at the forefront of transportation

officials' minds and, in the case of PEVs (and other alternative fuels), threatens to drive a wedge between long-term transportation, economic, energy, and environmental goals.

Lost revenues could provide barriers to PEV commercialization and must be addressed. Ultimately, the solution would be to establish a carbon fee on vehicles or fuels. In the meantime, in some locales, pressure has already arisen to resolve the issue, with Washington and Oregon considering programs to tax PEV use to replace lost revenues. Likewise, New Hampshire has established an Alternative Fuel Vehicle Study Commission to evaluate the impact advanced vehicles, such as PEVs, have on existing state taxation rules. Simply charging PEVs a shadow fuel tax does not reflect the differential climate benefits of PEVs compared to other vehicles.

Washington will become the first state to charge a fee for electric vehicles. The governor signed a bill in March 2012 that levies $100 annually on EV drivers in order to sustain a "user fee" model in electric transportation. The fee will not apply to hybrids, with the $100 assessed on pure electric vehicles and deposited in the state highway fund. In Oregon, lawmakers are considering a bill that would charge drivers of electric and plug-in hybrid vehicles 1.43 cents for each mile they drive, compared to an average of 2 cents per mile in gas taxes currently paid by American drivers. It would enter into effect starting in 2014. In Arizona, a bill has been introduced that would also assess a 1.43 cent per mile fee. Both bills are being closely watched by other state officials as a potential model to be replicated, although similar plans faced stiff opposition in both Mississippi and Texas and were ultimately defeated.

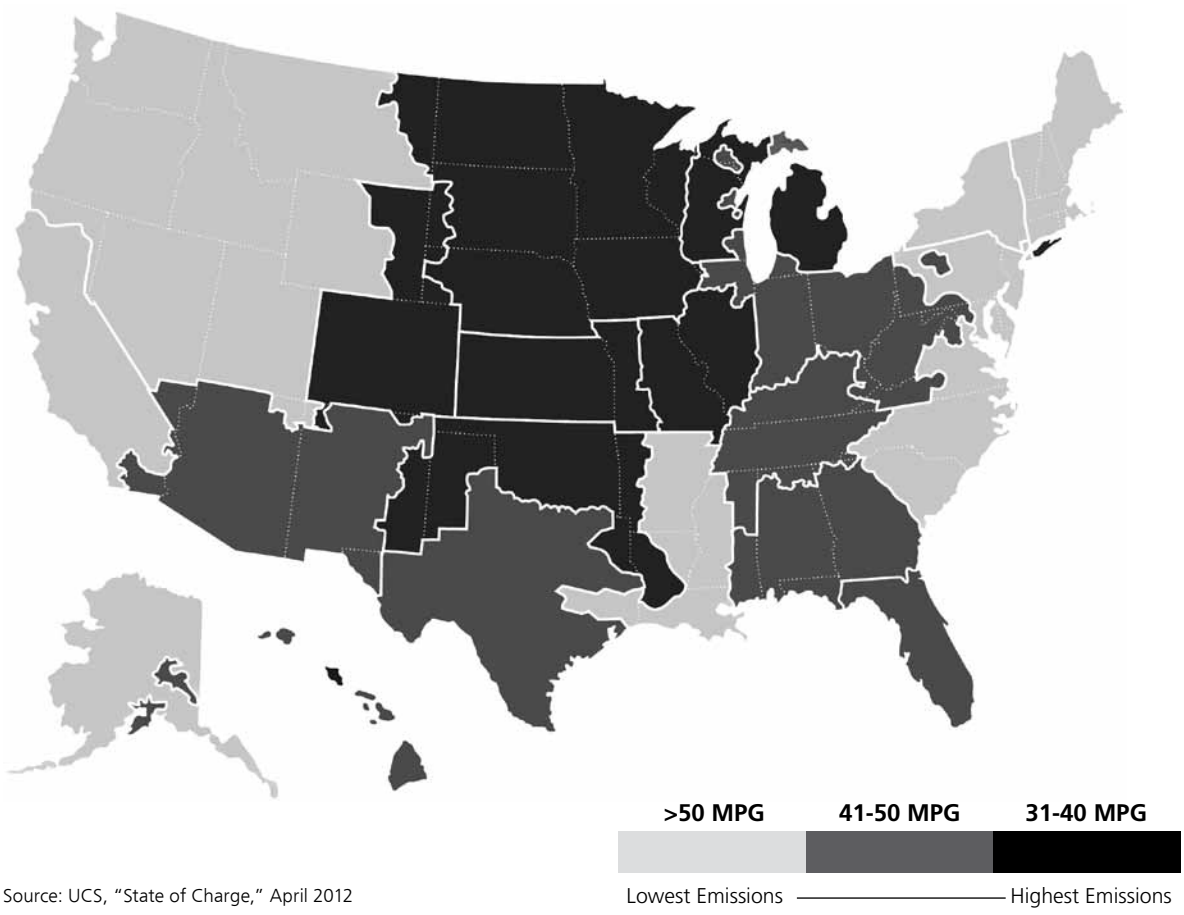
Cultivate Local PEV Clusters

Certain regions are pushing ahead in PEV development and others are good candidates for doing so. Identifying and promoting these emerging local PEV clusters is an important strategy for accelerating the transition to electric-drive vehicles. Several initiatives can be considered in advancing vehicles at this level.

Advance PEVs in Regional Clusters with Low-Carbon Electricity

Researchers have found that there are several U.S. regions in which electric vehicles have far lower global warming emissions than the average new gasoline vehicle, as shown in figure 3.[29] While coal once dominated American power generation, today many regions have much cleaner sources of electricity as part of their grid mix, which keeps the global warming emissions of today's EVs lower than that of the average gasoline vehicle. In fact, states that depend largely on coal to generate electricity, PEVs are no more carbon intensive than conventional vehicles.[30] And with the shrinking use of coal, PEVs will be even more attractive. PEVs in low-carbon electricity states rate upward of an equivalent 74–112 miles per gallon.

Figure 3. **PEV Regional Global Warming Pollution Ratings (in gasoline-eq. mpg)**



Source: UCS, "State of Charge," April 2012

There is a great deal of variation when it comes to greenhouse gas emissions from utility power generation. The highest emission rate is more than 2.5 times that of the lowest.[31] But these emissions are dynamic—changing daily, seasonally, and annually. By targeting PEV policies at select regions, especially those with cleaner power production, the U.S. federal government can open the way to long-term benefits from PEV use. Upstate New York, the Northwest, California, Virginia, the Mississippi River Valley, and New England are a few of the lower-carbon-utility regions.

Research into individual localities is needed to analyze how PEV recharging induces marginal power demands and consequently emissions. If vehicles can be charged at night, if they do not exceed available low-carbon electricity supply, or if they help integrate more low-carbon fuel supplies by providing battery storage space, PEVs will deliver a lower-carbon outcome.

Numerous cities are at the vanguard, working to foster PEV use. A major effort, the U.S. Department of Energy's Clean Cities program, is supporting this goal. This program dates back to the Alternative Motor Fuels Act of 1988

and the Clean Air Act Amendments of 1990, which encouraged the production and use of alternative fuel vehicles and the reduction of vehicle emissions. PEVs advance these energy and environmental goals.

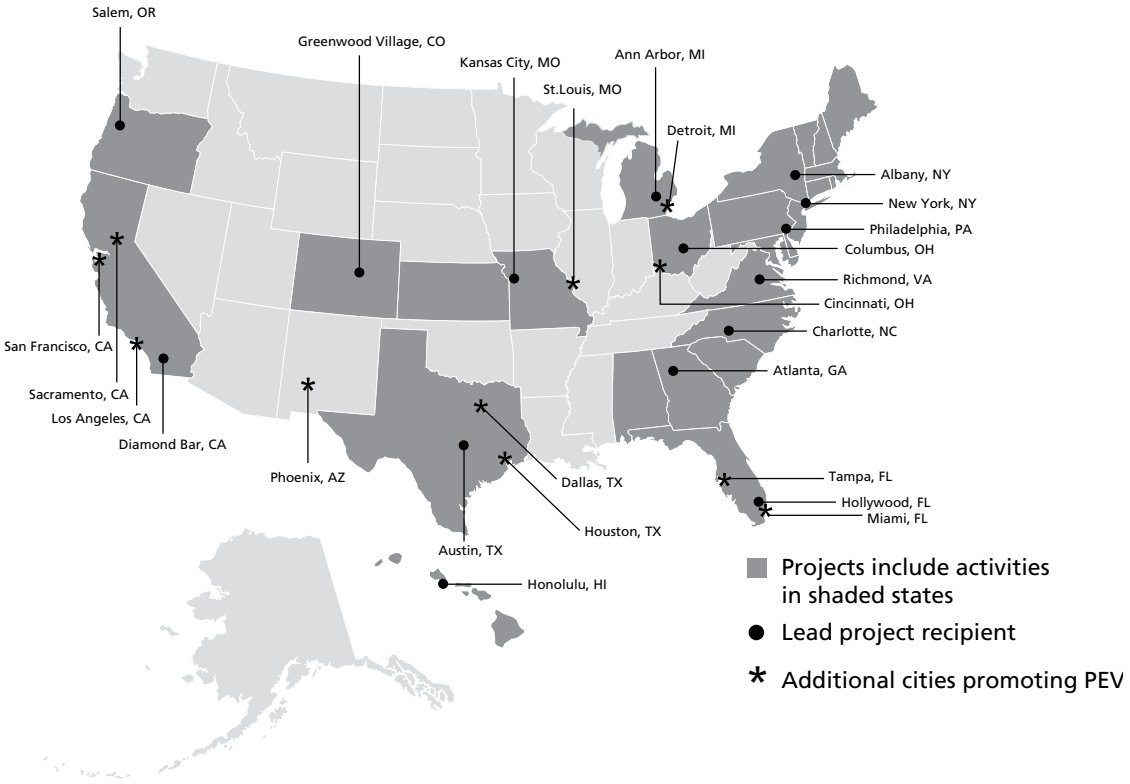
The Department of Energy announced in late 2011 that it would allocate $8.5 million to sixteen "EV community readiness" grants covering 24 states through the Clean Cities program. These projects are aimed at streamlining permitting protocols, building codes, and municipal personnel training and/or developing incentive structures to better accommodate electric vehicles and electric vehicle infrastructure.[32] Each grant is scheduled to last one year, and all project plans are mandated to be publicly available so that other communities can participate in the learning process. These grants support local projects for PEV use and help to lay the foundation for the eventual emergence of comprehensive "EV ecosystems" in selected metropolitan regions.

Although the initial funding source is relatively small, the grants are sufficient to identify promising EV commercialization pathways that are sensitive to local contexts. Once identified, these pathways should attract further federal, state, and nonprofit funds.

The Clean Cities program is also in the process of compiling a series of four "PEV Handbooks," each tailored to a specific subset of stakeholders—consumers, fleet managers, public charging station hosts, and electrical contractors. The most recent release, geared toward fleet managers, contains a number of resources aimed at helping integrate PEVs into fleet operations by addressing maintenance, safety, emissions, charging equipment, and other important considerations.[33]

Other U.S. cities promoting PEVs include Dallas, Houston, Detroit, St. Louis, Miami, Tampa, Phoenix, Cincinnati, and Sacramento. Each of these cities boasts millions of commuters who live within 50 miles of the city center.[34] And over 90 percent of these commuters already drive to work—a commute distance well within the range of PEVs. The initial Clean Cities PEV locations and other PEV-promoting cities are mapped in figure 4.

Figure 4. **PEV Vanguard Cities**



Source: U.S. Department of Energy, September 8, 2011, http://energy.gov/articles/awards-advanced-vehicle-development and authors' modifications

Houston, home to the world's largest oil and gas companies, covers 624 square miles, much of which is urban sprawl. Overcoming the "Houstonian" mindset—where fossil fuels predominate—has been a passion of Mayor Annise Parker. The city is partnering with eVgo, GRIDbot, and ECOtality on a variety of PEV pilot projects. Houston adopted a comprehensive citywide EV program in 2011, including vehicle purchases, extensive recharging infrastructure installation, policy research, mapping, and public education.[35]

Atlanta has a strategic public/private partnership creating Georgia's PEV roadmap.[36] Plug-in Georgia has set its sights on deploying 50,000 PEVs in the Atlanta metro region by 2015, advancing the state as a premier PEV-ready state and building a perception of metro Atlanta as a top PEV-ready region.[37] Georgia is working on identifying and removing barriers for PEV owners, customizing education for hundreds of thousands of business and fleet managers and consumers, working with smart grid companies to locate in Atlanta, and building a pro-EV business lobby.

The Southeast Regional EV Readiness Planning Program is a coalition of Clean Cities in Alabama, Georgia, and South Carolina.[38] This select region is working on the placement of charging stations to connect Birmingham to Chattanooga to Atlanta. The goal is 100,000 PEVs in the three states by 2015.

Low electricity rates and strong tax incentives to support PEVs in this area of the United States are expected to help.

Louisville's Clean Fuels Coalition (established in 1993) is a PEV and alternative fuel resource for educators, consumers, and providers in Kentucky. This self-supporting organization advances PEV infrastructure with regional industry, transit, and fleet operators.[39] In addition, Kentucky utility companies provide funding for PEV fleets and recharging facilities, and the University of Louisville is partnering with General Electric to install charging stations, offer outreach, and provide public information.

Richmond offers important economic opportunities in Virginia through PEVs.[40] The Richmond Electric Vehicle Initiative is working to advance this region as an attractive market for PEV technology. Numerous organizations are involved in laying the groundwork for infrastructure installation and PEV use, and the mayor has lent his support to the initiative.

Tampa Bay, Florida, is home to a regional collaboration between the Tampa Bay Regional Planning Council, local governments, electric utility companies, and other business partners. The goal of this project is to prepare Tampa Bay for the rollout of electric vehicles in the near future.[41] The program launched its first PEVs in 2011.

Promote and Streamline PEV Interactions With Utilities

State public utility commissions must be encouraged to reassess their regulatory frameworks to harmonize technical standards, streamline the installation of household and commercial charging stations, and use electricity rate structures to promote charging at off-peak hours. Scheduling EV loads at night, for example, can actually improve the economics of power providers by making better use of existing assets. If utilities do so, increased numbers of PEVs could improve the efficiency of electricity systems and reduce rates.

Reform Power Regulations

The regulation of U.S. electricity generation, transmission, and sales, while highly complex, is organized according to jurisdictional boundaries, and based on determinations of fair prices and the allocation of roles and responsibilities to ensure that the electricity sector functions smoothly and efficiently. Because utility structure and operations are diverse, an allocation of regulatory authority among the federal government and the regulatory bodies of states has developed over time. However, many in the sector still believe the regulatory environment to be opaque, ossified, and essentially closed in practice.

Reform options include opening up the recharging infrastructure market to utility participation, strategic partnerships, and the inclusion of third-party

vendors. Oregon's and California's recent developments merit particular attention. These two states are leaders in PEV policy innovation, so their respective choices may be instructive for policymakers in other states and at the national level who are seeking out new models.

Oregon's Public Utility Commission recently took a step toward opening the recharging equipment market to broader participation by utilities when it ruled in early 2012 that they will be permitted to build and maintain PEV charging infrastructure and recoup capital costs through the utility rate base, albeit after crossing a high bar set by the commission. At the core of the Public Utility Commission's decision was a finding that rate recovery can only occur once the utility has made a "compelling case" that its ownership and operation of recharging equipment is particularly beneficial to PEV drivers, not just the general public.

Another reform model mimics the one applied to the telecommunications industry. A state public utility commission could allow utilities to have a hand in the recharging market but require them to accommodate third-party providers, much as regulators forced telecommunications companies to open their infrastructure to competition in the late 1990s. This would lead to greater competition in providing power and utility service for PEVs. It is a promising approach that is ripe for future policy and market impact analysis, and further studies are needed.

The Oregon decision comes on the heels of a slightly different ruling in California, in which the California Public Utility Commission opted to exclude California utilities from the recharging infrastructure market. Objections to the California decision by various utility players are likely to continue, particularly in light of the $100 million settlement of a long-running dispute between the California Public Utility Commission and Texas-based utility NRG Energy dating back to the 2001 California electricity crisis. As part of the settlement terms, NRG will use its EV infrastructure subsidiary—EVgo—to build at least 200 fast-charge stations along major state highway corridors, as well as 10,000 individual charging stations at apartment complexes, office parks, schools, and hospitals in California. NRG will reportedly have exclusive access to the customers at these locations for eighteen months.

Regulation in this area is a work in progress. Finding the most effective way to reform utility regulations to accommodate PEV use requires extensive study and testing.

Revisit Electricity Rate Design

There is no standard rate design that can be applied to recharging PEVs throughout the United States. Each type of utility sets its rates differently. Private investor–owned utilities typically constrain electricity rates by a prescriptive formula. Public utility rates, on the other hand, are generally set by a

local electricity board with far less oversight by utility regulators. A summary of different U.S. utility types is provided in table 3.

Table 3. **U.S. Retail Sales of Electricity, by Utility Category (2010)**

Utility Type	Number of Utilities	Consumers	Sales (MWh)	2010 Revenue (Thousands $)	Average ($/kWh)
Cooperative	924	18,489,821	411,867,929	$39,751,784	$0.0965
Federal Power Agencies	23	40,827	43,710,083	$1,798,144	$0.0411
Investor-owned	216	93,187,386	2,134,857,298	$210,338,646	$0.0985
Power Marketer	70	6,282,395	217,031,113	$21,426,731	$0.0987
Public	1947	20,940,561	557,451,711	$52,254,160	$0.0937

Source: U.S. EIA, 2010 data

How those utilities design their rates is a crucial tool for encouraging PEV use and managing PEV load demand growth. If drivers are burdened with excessive electricity rates for electric transport fuel, the transition to PEVs will be discouraged. State public utility commissions in particular have a major part to play. They license competitive electricity suppliers, set retail electricity rates for vertically integrated or distribution-only utilities on a cost-of-service basis, and can alter the "rate of return" afforded to regulated utilities based on a utility's efforts in obtaining reliable electricity at the lowest possible cost.

At night, there is generally significant excess power plant capacity that is not earning the utility money. Nighttime recharging helps utilities and, when the electricity is priced lower, offset PEVs' higher initial purchase price. During the daytime, however, increased electricity use generally requires more generation capacity and utility investment. Marginal rates, which raise prices for additional usage, are a blunt tool to try to deal with variable conditions. Time-of-use rates are a more effective approach and can offer much less expensive electricity. As such, time-of-use, rather than marginal consumption, is a key criteria for electricity sold for transportation use. State public utility commissions should consider making this approach a core element of state strategy.

This point has been made to the California Public Utility Commission in PEV proceedings. In a recent ruling, the commission stated, "rate structures can convey the costs and environmental impacts of the supply and demand of electricity to consumers, providing incentives for individuals to make choices consistent with the collective good." Because electricity for electric vehicles can displace fossil fuel consumption, it is appropriate for utilities to structure rates so that off-peak charging is encouraged.

Once time-of-use rates are instituted, these new rates must be made easily accessible to consumers. This requires separate meters for PEVs so that these differential rates are not applied to the entire household. Getting consumers to voluntarily sign up for time-of-use rates will require facilitation.

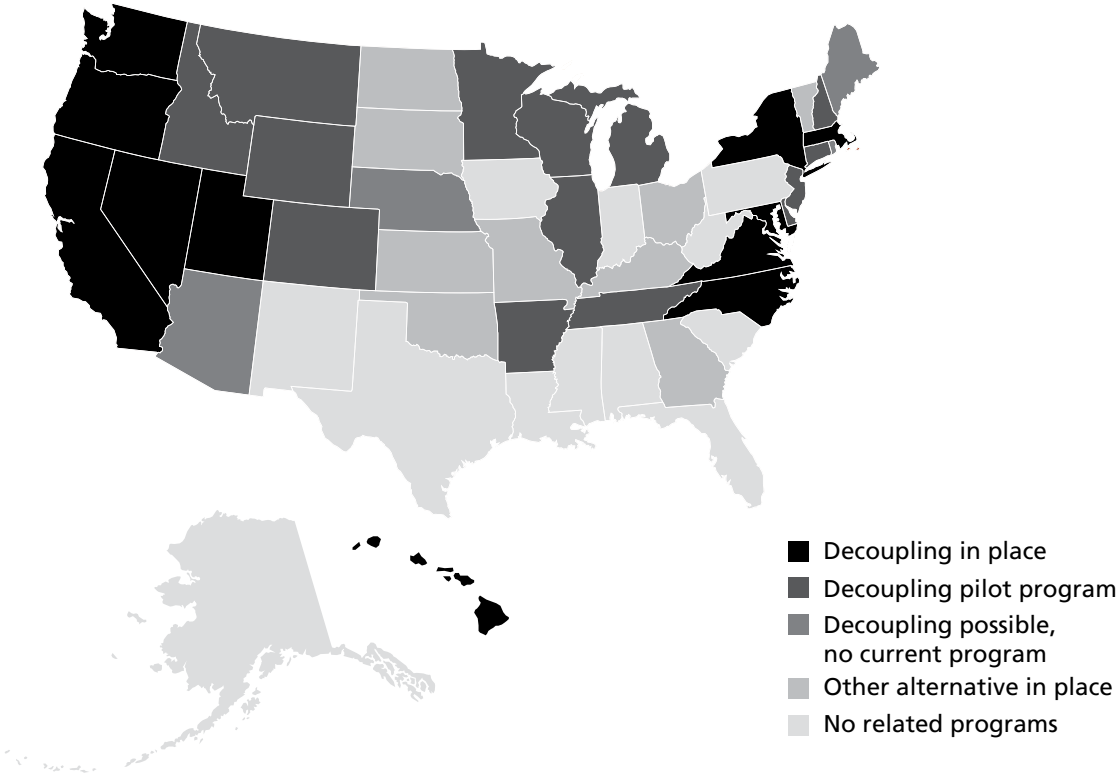
While a massive overhaul of utility rate design may not be pressing at this time, it would be wise for regulators to schedule biennial reviews. The transition of billing software in particular will be a huge undertaking that merits forethought.[42] Furthermore, the efficacy of existing policy will have to be reappraised and supplementary features, such as demand charges, reconsidered over time.

Investigate Utility "Decoupling" Regulation

Under traditional regulatory models in the United States, the public utility commissions regulate their utility's economic and safety operations as a natural monopoly. Electricity prices are regulated so that utilities can recover fixed and variable costs along with a fair rate of return, which means the utility's profits are tied directly to electricity sale volumes, with more kilowatt-hours sold generating more profit. Programs that target energy efficiency or conservation—such as rebates for more efficient appliances and demand-response programs—can reduce utility profits under this model.

In response, many U.S. states have adopted electric utility regulatory regimes that decouple revenues and profits (figure 5 shows the distribution of these decoupling policies).[43] The intent of decoupling is to encourage investments in energy efficiency. But it has the side effect of discouraging electricity sales for PEVs because utilities do not necessarily recoup revenue for the sale of increased electricity going to vehicles.

Figure 5. **Energy Utility Decoupling, by State**



Source: Energy Information Administration (EIA), "State programs encourage energy efficiency programs by adjusting utilities' cost recovery," May 4, 2011

If a utility has no profit incentive to expand electricity sales to recharge PEVs it can stifle the commercialization of PEVs. Moreover, if the utility does not benefit directly from the new PEV demand, it is forced to spread the fixed cost of the new electricity-generation and infrastructure assets over a shrinking rate base. This can cause utility rates to increase across the board, which would be problematic for PEV owners and other utility customers.

The potential benefits of decoupling home electricity use from PEV recharging require utilities' consideration. Such practices could provide utilities flexibility in structuring home electricity rates to encourage conservation while structuring EV rates to encourage beneficial charging behavior. Decoupling rates also provides PEV owners knowledge about how much they are saving on motor fuel. The key to enabling this is developing a low-cost way to separately meter EV consumption.

It is premature for public utility commissions to simply recouple all or a portion of the utility sector or to make wholesale changes to cost-recovery methods. Further study into how best to manage future PEV recharging demands is needed.

Invest Strategically in Recharging Infrastructure

Time will tell which recharging infrastructure business model is best positioned to maximize value for consumers and a return on investment for the infrastructure provider. But currently, there is a good amount of uncertainty about how to plan for and how much to spend on installing recharging infrastructure—in homes, public spaces, workplaces, and retail establishments, and for vehicle fleets. Some of the answers lie in which vehicle configurations (battery electric vehicles or plug-in hybrid electric vehicles) and battery technologies will predominate. And some assumptions may need revisiting. Consumers may not require widespread recharging infrastructure in order to buy PEVs, especially plug-in hybrids. Public charging stations may appear to reduce drivers' range anxiety for pure EVs but the realized utility of such infrastructure may not measure up. It also remains unclear what motorists want and are willing to pay for.

From a business perspective, given the wide variety of vehicle and recharging configurations but no clear-cut choice, new models for non-home charging are needed. Moreover, market projections for recharging infrastructure vary widely and are highly sensitive to technological specifications, as shown in table 4. It is generally accepted that charging at 3.3 kW or less can be managed sufficiently by the power distribution system and will not require massive upgrades to existing networks.

Table 4. **Charging Infrastructure Choice and Representative Charge Times**

Charger Type	Capacity (kW)	Time to Charge	
		Chevy Volt	Nissan Leaf
AC Level 1	1.3	~6 hours	~16-18 hours
AC Level 2	3.3	~3 hours	~6-8 hours
	6.6	~1.5 hours	~3 hours
DC Fast Charger	~60	<10 minutes	~30 minutes

Source: Silver Spring Networks using data from GM-Volt.com; NissanUSA.com; US DOE PHEV Charging Infrastructure Review

While the ultimate configuration of the recharging infrastructure market will be largely driven by consumer preferences, motorists are not yet familiar enough with these emerging PEV technologies to strongly voice their needs. As such, near-term recharging decisions will be left up to the private sector, with the potential for government guidance.

Many automakers believe that a relatively small number of direct-current (DC) "fast-charger" stations could go a long way toward alleviating range anxiety, especially if placed in highly visible, heavily trafficked locations. Public fast-charging stations mirror the gas station experience by allowing drivers to pull up to a "pump" for a charge in a matter of minutes. Investing in a limited number of public DC fast chargers is not expected to be cost prohibitive and would complement the majority of slower commercial alternating current (AC) charging stations installed in houses and workplaces.[44] This option of combining DC and AC recharging implies a role for government in deciding where and how DC fast chargers are utilized.

A second recharging vision holds that fast-charge stations best serve major intercity corridors, thus allowing PEVs to cover distances on par with that of conventional autos. Fast chargers (or battery swap stations) may be the only feasible option for this model.[45] Nevertheless, even as fast-charging advances, new issues crop up elsewhere. The repeated high-voltage cycling of a battery has spurred many unanswered questions regarding battery longevity and performance degradation over time. In addition, power grid stability is of concern due to marginal demands along the intercity corridors where fast-charge infrastructure would be installed. Such fast charging will not necessarily be responsive to time-of-use rates as a result. The electricity demands, storage capacity, and particular generation assets of these grids would have to be thoroughly analyzed before introducing highly variable new sources of demand.

A third perspective is that public recharging stations will be needed to serve beyond single-family garages for those customers who have no access to off-street parking.[46] One option is to install outdoor chargers. But this will require coordination with local authorities, given that many of the spaces where these charges would be installed is often considered a city's right-of-way. Another

option is to establish neighborhood electric car-sharing networks, which would reduce individual recharging capacity through centralized charging infrastructure, offer electric mobility to a broad segment of the community, and offer a more favorable total cost of ownership for the vehicle purchasers. Clearly, additional study is required to determine how best to strategically invest in public recharging infrastructure, especially if low-carbon PEV use is a priority.

Revisit the U.S. EV Roadmap

Significant progress has been made over the past decade on vehicle electrification. Goals were set and studies were done. Battery costs are dropping steadily—about 8 percent per year—and PEV technology is advancing quickly, with a vast range of new technology types being introduced. These range from PHEVs with small batteries to those with large batteries, and a variety of battery EVs. While this mix of models are challenging for policy, they represent important advances in choice and quality for consumers.

The EV roadmap now needs to be updated in order to navigate the transformation of the vehicle market. Even with a clear sense of purpose and direction, it will take a sophisticated set of policy tools—new rules, financial tools, management practices—that spur manufacturers, states, localities, and utilities to advance these vehicles.

PEVs challenge old habits and vested interests, so a concerted effort is needed to move them from emerging status to self-sustaining major market. Federal policies will be necessary, but they will not be sufficient. State and local policies are already more advanced and are likely to be more durable, as they engage motorists, local decisionmakers, and auto dealers. Moreover, a series of nongovernmental initiatives may hold the key to continued movement toward PEV adoption. All of these policies form the basis of the U.S. roadmap, which involves:

Motivating PEV Manufacturers

- Reform the electric vehicle consumer tax credit
- Extend federal PEV policies to encourage industry support
- Engage auto dealers

Shining the Spotlight on States

- Showcase states leading on low-carbon PEVs
- Advance PEVs in uncommitted states
- Transition to transportation carbon pricing

Cultivating Local PEV Clusters

- Advance PEVs in regions with low-carbon electricity
- Target programs in PEV vanguard cities

Promoting PEV Interactions With Electricity Providers

- Reform power regulations
- Revisit electricity rate design
- Investigate utility "decoupling" regulations
- Invest strategically in recharging infrastructure

The design and adoption of these PEV-related policies must confront large technological, economic, political, and behavioral uncertainties that create opportunities as well as challenges. Changing market dynamics, new energy circumstances, and increasing climate risks suggest that greater PEV traction in the market is necessary. Pragmatic PEV policies will be needed to usher in a more diverse transportation future in the United States and worldwide.

There are benefits to sharing the U.S. EV roadmap with other nations. Many of the issues identified are relevant to countries with burgeoning auto fleets, including China, India, as well as the European Union, Japan, and others. Tackling the major and growing global concern over transportation carbon will require an EV roadmap that stretches across the globe.

Appendix

State	HOV Lane Ex.	Monetary Incentives	Emission Test Exemption	Parking Incentives	Charging Station
Arizona	Y	Electric Vehicle Equipment Tax Credit: Maximum of $75 available to individuals for installation of EV charging outlets. Reduced Alternative Fuel Vehicle License Tax Alternative Fuel Vehicle Tax Exemption		Alternative Fuel Vehicle Parking Incentive: An individual may park an AFV in areas designated for carpool operators.	
California	Y	Vehicle Purchase Incentives: City of Riverside residents are eligible for a rebate (worth up to $2,000 for a new vehicle, $1,000 for a used vehicle) toward the purchase of a qualified hybrid electric vehicle purchased in the City of Riverside.		**CA A 475** Allows only a vehicle that is connected for electric charging purposes to park in off-street parking stalls or spaces designated for fueling.	A $1 million grant to South Coast Air Quality Management District from DOE Clean Cities Program to create a unified statewide approach to planning and implementation of critical plug-in electric vehicle charging infrastructure activities in order to support and expand the market for plug-in electric vehicles in California.
Colorado		Alternative Fuel Equipment Tax Credit: An income tax credit is available for a motor vehicle that uses or is converted to a hybrid electric vehicle.			Develop a comprehensive electric vehicle and electric vehicle supply equipment (EVSE) readiness and implementation plan for Colorado targeting regulatory, permitting, planning, policy and marketing, education, and outreach initiatives to prepare for electric vehicles and charging infrastructure deployment.
Connecticut				Alternative Fuel Vehicle and Hybrid Electric Vehicle Parking—New Haven, CT: New Haven provides free parking on all city streets for qualified AFVs and HEVs registered in New Haven, CT.	

	Other EV Legislation	2012 Pending Incentives
	CA A 1314 Alternative and Renewable Fuel and Vehicle Program **CA A 631** Defines the difference between a public utility and people and corporations with ownership, control, operation, or management of a facility that supplies electricity to the public. **CA S 880** Authorizes the board of directors of a common interest development to install and use an electric vehicle charging station in an owner's garage or designated parking space, under specified circumstances.	**CA S 730** Establishes the Plug-In Electric Vehicle Readiness Pilot Program strategies that address several objectives relating to the permitting and planning of plug-in electric vehicle residential charging. **CA S 1257** Local jurisdiction may not impose a utility user tax upon the consumption of electricity used to charge electric bus propulsion batteries. **CA A 1608** Requires the State Air Resources Board in implementing the Clean Vehicle Rebate Project to provide rebates for the purchase of eligible vehicles under the Hybrid Truck and Bus Voucher Incentive Project. **CA A 2631** Authorizing a local authority or owner of a parking facility to designate space for parking a vehicle that is connected for electric charging purposes. **CA A 2644** Building Standards Commission must adopt building standards for the construction, installation, and alteration of electric vehicle charging stations in single-family residential real property.
	CO H 1258 Regulation of public utilities in terms of alternative fuel vehicles, sellers of electricity as fuel for alternative fuel vehicles are not regulated as public utilities. Public utilities must try to provide connection of electric service to alternative fuel vehicle charging facilities.	

State	HOV Lane Ex.	Monetary Incentives	Emissions Test Exemption	Parking Incentives	Charging Station
District of Columbia		Alternative Fuel and Fuel-Efficient Vehicle Title Tax Exemption: Qualified vehicles are exempt from the excise tax imposed on an original certificate of title.			
Florida	Y				**FL H 7117** Funding for electric vehicle charging stations.
Georgia	Y	Alternative Fuel Vehicle Tax Credit: An income tax credit is available for 10% of the cost (up to $2,500 per vehicle) to purchase, lease or convert a qualified AFV. Zero Emission Vehicle Tax Credit: An income tax credit is available for 20% (up to $5,000 per vehicle) of the cost to purchase or lease a new Zero Emission Vehicle. **GA H 868** Exemptions from state income tax for alternate energy products and electric vehicles.			
Hawaii		Electric Vehicle and Electric Vehicle Supply Equipment Rebate: Qualified residents may apply for rebates (20% of the vehicle purchase price, up to $4,500 per vehicle) for the price of Electric Vehicles and Supply Equipment through the Hawaii EV Ready Rebate Program.		**HI HR 155** Requests the Department of Business, Economic Development, and Tourism to determine financing mechanisms to assist private parking lot owners with the costs associated with providing parking stalls and charging units for electric vehicles.	
Illinois	Y	Alternative Fuel Vehicle and Alternative Fuel Rebates: The Illinois Alternate Fuels Rebate Program provides a rebate (80%, up to $4,000) of the cost of purchasing an alternative fuel vehicle. **IL H 3073** 15% deduction on the tax to sell a vehicle—but only if AF or EV.			

	Other EV Legislation	2012 Pending Incentives
		Prepare South Florida for successful and accelerated deployment of plug-in electric vehicles and infrastructure. This project will develop a plan to address technical, commercial, market and regulatory barriers to support EV infrastructure and vehicle adoption.
	IL S 2902 Appointment of an Electric Vehicle Coordinator to promote the use of electric vehicles, including potential infrastructure improvements, regulatory streamlining, and changes to electric utility rates and tariffs. **IL H 2903** Rebate programs under the Alternate Fuels Act in support of the adoption of electric vehicles, authorizes the Environmental Protection Agency to make grants for the purchase of electric vehicles.	**IL S 1532** Provides that certain electric vehicles are exempt from taxation under the IL Acts. **IL H 2867** Provides for tax exemptions for electric vehicles. **IL H 3754** All regional and local transportation planning organizations in the state shall be invited to collaborate with electric utilities generating electricity within the state. **IL H 3083** After January 1, 2015, 25% of all vehicles purchased with state funds shall be alternative fuel (including EV).

State	HOV Lane Ex.	Monetary Incentives	Emission Test Exemption	Parking Incentives	Charging Station
Illinois (cont.)		Electric Vehicle Registration Fee Reduction: Electric vehicles can be registered at a discounted fee of no more than $18 per year.			
Louisiana		Alternative Fuel Vehicle and Fueling Infrastructure Tax Credit: An income tax credit worth 50% of converting or purchasing an alternative fuel vehicle or constructing an alternative fueling station is available.			
Massachusetts					
Maryland	Y	Electric Vehicle (EV) Tax Credit: A tax credit of up to $2,000 is available against the excise tax imposed for the purchase of qualified plug-in electric vehicles.	Hybrid Electric Vehicle Exemption from Vehicle Testing Requirements		**MD H 163** Allows a state income tax credit for tax years 2011, 2012, and 2013 only, for 20% of the cost of qualified electric vehicle recharging equipment placed in service by a taxpayer during a taxable year.
Michigan			Alternative Fuel Vehicle Emissions Inspection Exemption		Support the development of a plug-in electric vehicle charging infrastructure community preparedness plan for Michigan. The project will incorporate state and local level policy implementation, education, and outreach. The plan will be a Michigan-specific guide enabling local communities to support a comprehensive plan for the widespread adoption of plug-in electric vehicles.

	Other EV Legislation	2012 Pending Incentives
		MA SD 487 Allows hybrid and alternate fuel vehicles in HOV-designated (high-occupancy vehicle) highway lanes. **MA S 1490** Provides that an electric car and battery recharging station shall be exempt from sales tax. **MA SD 1641** Promotes the use of electric vehicles. **MA H 1798** Relates to electric vehicles. **MA HD 2296** Promotes the establishment and use of electric vehicle charging stations.
	MD S 997 Alters the definitions of electricity supplier and public service company. **MD S 998** Disclosure specified personal information related to plug-in vehicles for use in planning for the availability and reliability of the electric power supply by an electric company.	

State	HOV Lane Ex.	Monetary Incentives	Emission Test Exemption	Parking Incentives	Charging Station
Missouri			**MO H 354** Alternative Fuel Vehicle Emission Inspection Exemption		
Montana		Alternative Fuel Vehicle Conversion Tax Credit: An income tax credit for up to 50% of the equipment and labor costs for converting vehicles to operate using alternative fuels is available.			
Nevada	Y		Alternative Fuel Vehicle and Hybrid Electric Vehicle Emissions Inspection Exemption	**NV A 511** provides that the owner of a EV may apply for a decal and park the vehicle without the payment of a parking fee.	
New Jersey	Y		Zero Emissions Vehicle Tax Exemption		
New York	Y			Develop infrastructure deployment plans for light duty vehicles in New York City, focusing primarily on parking lots located in both the central business district and key residential neighborhoods.	A $1 million DOE grant to NYSERDA to develop a plan and accompanying guidance documents to accelerate the introduction of a network of electric vehicle charging stations.

	Other EV Legislation	2012 Pending Incentives
		Develop phased EV infrastructure installation plans for the Kansas City metropolitan area and for smaller communities, including the travel corridors between them. It will develop and implement replicable actions for adoption by individual municipalities in the areas of planning, zoning, construction, permitting, and fleet policies.
	NV A 511 Provides certain privileges to the owner or long-term lessee of a qualified plug-in electric drive vehicle.	
		NJ S 340 corporation business tax credit and allows gross income tax deduction for purchase of electric or plug-in hybrid electric vehicles **NJ S 341** and charging stations corporation **NJ A 566** business tax credit and gross income tax credits for purchase and installation of certain electric vehicle charging stations **NJ A 821** Requires owners of certain newly developed shopping centers to provide electric vehicle charging stations **NJ A 822** and on state toll roads. **NJ S 955** Exempts electric vehicle charging systems from real property taxation. **NJ S 980** Encourages development of electric vehicle charging stations in transportation projects. **NJ A 1583** corporation business tax credits and gross income tax credits for purchase of certain electric or plug-in hybrid electric vehicles. **NJ A 1996** Establishes public-private pilot program for level 3 electric vehicle charging stations. **NJ A 2169** Electric public utilities to develop plans to upgrade their distribution equipment in order to accommodate any increased use to charge motor vehicles propelled by electricity. **NJ A 2416** Encourages development of electric vehicle charging stations in transportation projects.
		NY A 4390 Exempts new electric vehicles, clean fuel vehicles, and vehicles that meet the clean vehicle standards from the first year of registration fees. **NY A 5611** Makes the retail sale of new and used hybrid and certain high-efficiency vehicles exempt from state sales and compensating use taxes. **NY A 6592** Exempts electric vehicles from state sales and compensating use taxes.

State	HOV Lane Ex.	Monetary Incentives	Emission Test Exemption	Parking Incentives	Charging Station
New York (cont.)				It will also address solutions for regional travel to and from regional destination hubs.	Throughout the Northeast and Mid-Atlantic regions of the United States.
Oregon		Alternative Fuel Vehicle and Fueling Infrastructure Tax Credit for Residents: Tax credits for 25% of the cost or $750 (whichever is less) are available for the purchase or conversion of an alternative fuel vehicle and the purchase of alternative fuel infrastructure.	Pollution Control Equipment Exemption: Dedicated original equipment manufacturer natural gas and electric vehicles are not required to be equipped with a certified pollution control system.		
Pennsylvania					Deliver a regionally-coordinated plan to address the introduction of plug-in electric drive vehicle charging infrastructure into the five counties of southeastern Pennsylvania. The project will provide strategic direction to the implementation of policies, procedures, and incentives to accelerate the deployment of EVs and EV infrastructure.
Rhode Island		Alternative Fuel Vehicle Tax Exemption: The town of Warren, RI allows excise tax exemptions of up to $100 for qualified AFVs registered in Warren.			
South Carolina		Alternative Fuel and Advanced Vehicle Tax Credit: 1) Residents who claim the federal vehicle tax credit are eligible for a state income tax credit equal to 20% of the federal credit. **SC H 3059** Plug In Vehicle Tax Credit revision.			

	Other EV Legislation	2012 Pending Incentives
		NY A 7984 Authorizes the county of Suffolk to elect to be exempt from certain taxes related to hybrid, fuel efficient, alternative fuel, "clean fuel" or electric motor vehicles. **NY A 8624** Establishes a tax credit for the installation of electrical outlets for charging electric cars in certain parking garages. **NY A 10356** provides an exemption to the retail sale of plug-in hybrid electric vehicles from state sales and compensating use taxes.
		Development of a comprehensive strategic plug-in electric vehicle market and community plan to address next-generation deployment strategies. The plan will serve as a roadmap to achieve Oregon's goal of 30,000 PEVs by 2015.
		PA H 702 Exempts hybrid electric vehicles from the requirement for periodic inspection of vehicles. **PA H 101** Excludes the purchase price of electric vehicles, hybrid electric vehicles and zero emission vehicles from the sales and use tax. **PA H 1675** Provides for an electric vehicle charging corridor tax credit. **PA H 1745** Provides for plug-in vehicle charging station tax credits. **PA H 1746** Provides for plug-in vehicle charging station grants.
		RI S 590 Exempts qualified electric plug-in drive vehicles from excise taxes.
		SC S 1455 Provides a $1,000 tax credit for the in-state purchase or lease of a new qualified hybrid electric vehicle. **SC H 4053** State sales tax exemption for any device, equipment, or machinery actually used in the production of electric or hybrid motor vehicles.

State	HOV Lane Ex.	Monetary Incentives	Emission Test Exemption	Parking Incentives	Charging Station
Texas					Develop a plan for plug-in electric vehicle charging infrastructure between the "Texas Triangle" cities of Dallas/Fort Worth, Houston/Galveston, and Austin/San Antonio along with topical areas of statewide application.
Utah	Y	Reduced Alternative Fuels Tax: The tax imposed on propane and electricity used to operate motor vehicles is 3/19 of the traditional motor fuels tax rate of $0.245.			
Virginia	Y				**VA H 2105** Excludes any person who is not a public service corporation and who provides electric vehicle charging service at retail from the meaning of the terms public utility (and no state regulation rates for private EV charging services).
Washington		Alternative Fuel Vehicle Tax Exemption: New passenger cars, light-duty trucks, and medium-duty passenger vehicles that are dedicated alternative fuel vehicles are exempt from the state motor vehicle sales and use taxes.	Alternative Fuel Vehicle and Hybrid Electric Vehicle Emissions Inspection Exemption		
West Virginia		Alternative Fuel Vehicle Tax Credit: An income tax credit for 35% of the purchase price or 50% of the vehicle conversion cost is available to convert or purchase an alternative fuel vehicle.			
Wisconsin		Alternative Fuel Tax Exemption: No tax is allowed on alternative fuels, or on the purchase, sale, handling, or consumption of alternative fuels.			

	Other EV Legislation	2012 Pending Incentives
		Develop a plan and template that will support regional stakeholders in the development and implementation of local codes, expedited permitting and inspections, and processes and procedures to enable efficient and cost-effective placement of charging infrastructure in the area between San Antonio and Georgetown, Texas.
	VA H 780 Converted electric vehicles do not have to be examined by the Department of Motor Vehicles if accompanied by certain documents.	Lay the educational and policy groundwork for electric vehicle adoption and charging infrastructure installation in the Richmond, VA region. A strategic plan will be developed and will identify and foster policies to expedite infrastructure implementation specific to the area and prepare the Commonwealth for successful deployment of plug-in electric drive vehicles.
	WA H 1571 Utilities and Transportation Commission may not regulate the rates, services, facilities, and practices of an entity that offers charging facilities to the public if that entity is not otherwise subject to commission jurisdiction as an electrical company.	

Notes

1 Other vehicle applications may have different barriers that require different policy approaches than those focused on here for passenger PEVs.
2 Oak Ridge National Laboratory, "Transportation Energy Databook: Edition 30," June 25, 2011, Table 1.15, http://cta.ornl.gov/data/chapter1.shtml.
3 Deborah Gordon, "Understanding Unconventional Oil," Carnegie Paper, May 2012, http://carnegieendowment.org/files/unconventional_oil.pdf.
4 Darren Samuelsohn, "Chevy Volt a Charged Issue," *Politico*, April 23, 2012, www.politico.com/news/stories/0412/75449.html.
5 Bill Vlasic and Matthew Wald, "Solyndra Is Blamed as Clean Energy-Loan Program Stalls," March 12, 2012, www.nytimes.com/2012/03/13/business/energy-environment/stalled-clean-energy-loan-program-feels-solyndras-chill.html?pagewanted=all.
6 Nicholas Lutsey and Daniel Sperling, "Regulatory Adaptation: Accommodating Electric Vehicles in a Petroleum World, *Energy Policy*, 45: 308–16, 2012.
7 Incremental fuel economy improvements to internal combustion engine vehicles, to the extent that gains from non-engine improvements (for example, weight reduction, aerodynamics, and tires) can actually complement PEV deployment in the long term by increasing vehicle range (and consumer acceptance) when electric motors replace internal combustion engines.
8 Andrew Burke and Hengbing Zhao, "Energy Saving and Cost Projections for Advanced Hybrid, Battery Electric, and Fuel Cell Vehicles in 2015-2030," May 2012, UC Davis, Institute of Transportation Studies, UCD-ITS-RR-12-05, http://pubs.its.ucdavis.edu/publication_detail.php?id=1636.
9 The electric cars we now are seeing are the first generation. As with personal computers, electric car prices are expected to be driven down even without the technological "breakthroughs" (such as dramatically improved batteries) that are already in development. See www.realclimate.org/index.php/archives/2011/11/keystone-xl-game-over/comment-page-2/#comments.
10 David Hurst, "Gartner's PEV Forecast: Rosy or Realistic?" February 23, 2012, www.pikeresearch.com/blog/gartner%E2%80%99s-pev-forecast-rosy-or-realistic.
11 Eric Loveday, "January 24, 2012, www.plugincars.com/nissan-leaf-sales-trump-chevy-volt-2011-111308.html.
12 Hybrid Electric Vehicles Have Cumulative Sales Over 2 million as of December 2011. See: Wikipedia, "Hybrid Electric Vehicles in the United States," http://en.wikipedia.org/wiki/Hybrid_electric_vehicles_in_the_United_States.
13 For a schematic of electric-vehicle-related manufacturers, see Bradford, Travis and Dominic Hofstetter, "Electric Vehicles 2011: Technology, Economics, and Market," Greentech Media and The Prometheus Institute, November 22, 2011.
14 Russell Hensley, John Newman, and Matt Rogers, "Battery Technology Charges Ahead," McKinsey, July 2012, www.mckinseyquarterly.com/Battery_technology_charges_ahead_2997.
15 Lutsey and Sperling.
16 Booz & Co., "2012 U.S. Automotive Industry Survey and Confidence Index: A Return to Optimism," www.booz.com/media/file/BoozCo_2012-US-Automotive-Industry-Survey-and-Confidence-Index.pdf.

17 See cars.com, 2010, http://blogs.cars.com/kickingtires/2010/12/considering-nissan-leaf-or-chevy-volt-leasing-may-make-more-sense.html and Jim Wang, "2011 Income Percentiles," www.bargaineering.com/articles/2011-income-percentiles.html.
18 There is an exception to this rule: the earned income tax credit, which operates like a rebate.
19 For more detail see: Nick Nigro, Pew, "Plug-in Electric Vehicle Market: State of Play," July 2011.
20 Different PEV technologies are embedded in CARB's roadmap, including: plug-in hybrid electric vehicles with small batteries (the Prius plug-in), plug-in hybrid electric vehicles with large batteries (Chevy–Volt), battery electric vehicles with hybrid range extenders (BMW vehicles with a two- to three-gallon gas tank), and battery electric vehicles without petroleum capacity (Nissan Leaf). Other electric vehicles configurations not explored in this report include: microhybrids with start-stop capacity, full hybrids (Toyota Prius), and fuel-cell vehicles.
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22 Lutsey and Sperling.
23 Caelus Green Room, December 16, 2012, www.caelusgreenroom.com/2011/12/16/electric-vehicle-charging-equipment-sales-to-reach-4-3-billion-worldwide-by-2017 and December 20, 2011, www.caelusgreenroom.com/2011/12/20/the-market-for-electric-vehicle-telematics-will-reach-1-4-billion-by-2017.
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25 Brad Plumer, "Gas Prices Hurt Red States More Than Blue States," March 7, 2012, www.washingtonpost.com/blogs/ezra-klein/post/gas-prices-hurt-red-states-more-than-blue-states/2012/03/07/gIQAp8jNxR_blog.html. Gasoline expenditures as a share of personal income in the following states are: MI (5.2%), IA (5), NC (4.9), NH/NM (4.6), OH (4.5), WI (4.4), FL (4.2), NV/VA (4.1), PA (3.7), CO (3.2).
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27 Bill Bradley, Tom Ridge, and David Walker, *Road to Recovery: Transforming America's Transportation*, Carnegie Endowment for International Peace, July 2011.
28 American Petroleum Institute, Fuel Taxes, January 2012, www.api.org/statistics/fueltaxes/upload/gasoline-diesel-summary.pdf.
29 Union of Concerned Scientists, "State of Charge," April 2012, www.ucsusa.org/assets/documents/clean_vehicles/electric-car-global-warming-emissions-report.pdf.
30 Ibid.
31 Ibid.
32 See, for example, Theodore Bohn, Clean Cities and PEVs, February 27, 2012, www1.eere.energy.gov/cleancities/toolbox/pdfs/plug-in_electric_vehicle_standards.pdf.
33 U.S. Department of Energy (DOE), "Plug-In Electric Vehicle Handbook for Fleet Managers," DOE Clean Cities Program, Energy Efficiency and Renewable Energy Division, April 18, 2012.
34 Using data from the American Community Survey, a U.S. Census Bureau database, General Electric looked at commuting habits for the 25 largest U.S. metro areas for the population within 50 miles of the city center, based on data collected in 2009. It ranked cities in equal parts by how many commuters lived within a 50-mile radius of the city center and the percentage of commuters who drive to work already—as those are the cities with infrastructure currently set up to handle car commuters.
35 For background information see www.greenhoustontx.gov/ev/findachargingstation.pdf; http://www.theevproject.com.
36 For additional goals and strategies, see http://plugingeorgia.com.
37 "Plug-In Georgia Charter: Subcommittee Leader Management System," October 17, 2011, www.plugingeorgia.com/pdf/plug-in_georgia_charter.pdf.

38 Plug-In Georgia Committee Meeting Notes, December 9, 2011, www.plugingeorgia.com/pdf/committee_meeting_notes/12_8_11_slides.pdf.

39 See Kentucky Clean Fuels Coalition website, http://kentuckycleanfuels.org/aboutkcfc/aboutkcfc.htm.

40 "Virginia Clean Cities Get Ready Roundtable," May 18, 2010, www.vacleancities.org/news/virginia-get-ready.

41 See Get Ready Tampa Bay for Electric Transportation website, www.tbrpc.org/getready.

42 The challenges of software transition are enormous, though it has received little notice publicly. The Sacramento Municipal Utility District underwent a five-year process consisting of three separate consulting contracts in order to translate their hundreds of thousands of customers and hundreds of different grandfathered rates into a new software system that could support smart grid capabilities and the integration of EVs.

43 In order to motivate utilities to consider all the options when planning and making resource decisions on how to meet their customers' needs, the sales-revenue link in current rate design must be broken. This entails setting an adjustable price mechanism that disassociates the amount of energy sold and the actual (allowed) revenue collected by the utility. See Regulatory Assistance Project, "Revenue Regulation and Decoupling," 2011, www.raponline.org/document/download/id/861.

44 For descriptions of AC versus DC rechargers see http://evsolutions.avinc.com/products/public_charging/commercial_ac_charging_station.

45 Battery swapping, the other option for intercity corridor travel, does save time compared to the fifteen- to thirty-minute intervals required for partial recharge using fast-charge stations, but the business model has been called into question by many. One industry player estimated in a conversation with the authors that battery swapping is competitive only when used on a monthly or more frequent basis, and also requires that most major vehicle manufacturers adopt common battery standards.

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