PLUG-IN ELECTRIC VEHICLES

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WHAT ROLE FOR WASHINGTON?

David B. Sandalow
editor

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CHAPTER TEN

Federal Policy Options to Support Early Electric Vehicle Deployment by Reducing Financial and Technological Risks

BRACKEN HENDRICKS and BENJAMIN GOLDSTEIN

Plug-in electric vehicles (PEVs) represent one of the most promising near-term technologies to reduce U.S. dependence on oil and cut the carbon footprint of our transportation sector. Yet despite their enormous potential, progress toward mass commercialization has been slowed by a variety of roadblocks, primarily related to technology, risk, and cost.

This chapter identifies a number of obstacles to commercialization of PEVs, with a specific focus on how automakers' concerns over battery safety, durability, longevity, and cost have slowed adoption of this technology and delayed deployment across the U.S. fleet. The chapter then discusses in detail three complementary federal policy options to reduce financial and technology risk for early adopters; diminish automakers' concerns over moving toward mass production; alleviate consumer anxiety about battery safety, durability, and longevity over the life of the vehicle warranty; and provide a controlled testing environment in which to monitor battery performance. These options are as follows:

—adopt a federal fleet purchasing agreement to ensure a stable market and controlled testing environment for the first massive deployment of PEVs

—create the "Federal Battery Guarantee Corporation," which would underwrite insurance on battery life for the duration of the vehicle warranty

—guarantee a secondary market for used battery assemblies, which have reduced efficacy in vehicles but generally retain 80 percent of their energy storage capacity.

In the near term, these policies are intended to reduce risk and address industry and consumer fears about battery obsolescence enough to get the first wave of PEVs on the road. Ultimately, the goal is to help the PEV industry mature to the point that government support is no longer necessary, achieve economies of scale required to make PEVs affordable for the average consumer, and move rapidly to mass commercialization of this promising technology.

Why PEVs Now?

The U.S. auto industry is in a tumultuous period and faces an uncertain future. News of plant closings, layoffs, and persistent unprofitability appears almost daily, as the Big Three automakers recoil from a business model that invested heavily in larger vehicles (SUVs, crossovers, and pickups) with low fuel economy. With oil exceeding $140 a barrel in 2008, gasoline surpassing $4 a gallon, and the reality of global warming driving new policies to limit greenhouse gas emissions, the U.S. auto industry faces a completely new landscape that demands fresh thinking about its product lines.

The vehicle market is responding to those price signals. U.S. new-vehicle sales dropped sharply in 2008, with declines in almost all major models except for fuel-efficient compact vehicles.[1] On the other hand, sales of hybrid vehicles in April 2008 had climbed nearly 50 percent since April 2007, pushing the new-vehicle market share for hybrids past the 3 percent mark for the first time.[2] Because consumers have experienced record-high gasoline prices, consumer confidence in fuel-efficient hybrids is a trend that is here to stay: in a recent poll, nearly 50 percent of Americans estimated that in ten years, roughly half of all new cars sold would be hybrid vehicles.[3]

PEVs, with the benefit of their extended electric range, enjoy enormous popular support. According to an August 2007 survey for the Automotive X Prize Team, Americans see PEVs that get 100 miles per gallon (mpg) as the single most powerful way, of six ways tested, to combat global warming. Nearly two-thirds of respondents were "extremely" or "very" interested in

buying a 100-mpg car. And Americans see the development of such cars as an important national objective—an important detail for the politics of promoting PEVs. Seventy-seven percent say that it would be "extremely" or "very" important to have a project that would lead to such cars being manufactured and sold in the United States in the next five years.[4] Moreover, consumers are showing sincere interest: as of June 2008, there were 11,512 "soft" orders on the Plug-In-Partners website, which tallies pledges to purchase PEVs once they are commercially available.

PEVs are unmistakably a game-changing technology in the auto sector. Their potential to reduce oil consumption, curb greenhouse gas emissions, and save consumers money makes them an urgent national security, public health, environmental, and economic priority. Moreover, if the U.S. auto industry is to reverse its downturn and succeed in the twenty-first-century vehicle market, it needs to move fast. Asian companies like Toyota and Hyundai are rapidly developing their own PEV lines, and U.S. automakers do not want to be caught in another game of catch-up, as they were with hybrids. Moreover, the auto industry is capital intensive, and the plant conversions and retooling necessary to support electric drivetrains will take time. The moment to act is now.

Obstacles to Commercialization

What, then, is inhibiting quicker adoption of PEVs by the auto industry? Other chapters in this volume discuss some of the challenges with respect to battery chemistry and concerns about the readiness of grid infrastructure. Yet neither issue is serious enough to prohibit getting the first generation of vehicles on the road.[5]

PEV technology has been approached cautiously by automakers primarily because of concerns over battery durability, longevity, and cost. Large-format battery assemblies—currently estimated to cost at least $10,000 for a forty-mile range—will constitute a hefty portion of a vehicle's value, and the relatively new technology is viewed as a liability by an industry accustomed to ten-year, 100,000-mile power train warranties. Thus, finding policy mechanisms to help reduce the cost and technology risk thresholds for early adopters is crucial to getting the first generation of the vehicles to market—thus priming consumers, spurring investment and innovation in the private sector, and scaling up to reduce costs.

However, generous policy support from Washington cannot go unmatched by the auto industry, which historically has been resistant to higher fuel efficiency standards and sluggish in exploring alternative drivetrains. Automakers have been especially cautious about vehicle electrification, in part because it represents such a large departure from the internal combustion engine. Accustomed to controlling the entire production process and selling the auto body, drivetrain, and accessories as a complete package, automakers are concerned that problems with battery assemblies will affect the integrity of their brands.

Yet now is the time for some constructive new thinking. If concerns over battery cost, risk, and performance underlie the auto industry's reluctance to act, then let the industry take a page from its own history and approach batteries as a serviceable, replaceable, and separately warranted component of the vehicle, just like tires. Cars must be designed so that the battery assemblies can be easily serviced or replaced as they age. And automakers must be receptive to innovative business models, like that promoted by Better Place, as new synergies are created among battery manufacturers, utility companies, automakers, and consumers.

This is a period of "creative destruction" for the auto industry, especially for the U.S. Big Three. They can seize the opportunity to develop and commercialize a new generation of low- and zero-emissions vehicles, or they can continue to hemorrhage jobs, close plants, and cede their market share to more nimble, innovative companies. Washington will have an important role in facilitating the transition to low-emissions vehicles, but it is up to the auto industry to do its part as well.

Three Policy Options

As mentioned, Washington can help speed up the adoption of PEVs by implementing three policy options: adopting a federal fleet purchasing agreement; creating the "Federal Battery Guarantee Corporation"; and guaranteeing a secondary market for used battery assemblies.

Federal Fleet Purchasing Agreement

A federal fleet purchasing agreement would commit the government to purchasing a specific number of PEVs each year. Currently, the federal government acquires approximately 63,000 new vehicles annually and maintains a fleet of roughly 631,000.[6] By 2012, that number of new vehicles is likely

to be closer to 65,000. Legislation mandating that 30 percent of all new vehicles purchased by the U.S. government be PEVs beginning in 2012 would equate to approximately 20,000 units a year.[7] That percentage should be ramped up over time, as production increases, costs drop, and more PEV models are introduced.

By 2012, vehicle manufacturers may not be ready with PEV versions of the full range of vehicle classes (especially SUVs, vans, and pickups). The Chevy Volt and Toyota Prius PEVs are not scheduled to be ready until at least 2010, an ambitious timeframe. With that constraint in mind, the fleet purchasing agreement would have to be responsive to the realities of the technology and vehicle availability, without sacrificing its purpose: to persuade automakers to develop PEVs and reach scale quickly by providing a guaranteed market.

The federal government should also take concrete measures to support other forms of PEV market aggregation by cities, corporate fleets, and individual consumers. Adequate tax incentives to bring down the cost of PEVs for early adopters are discussed elsewhere in this volume.

A federal fleet purchasing agreement would be an effective policy instrument to address a variety of obstacles hindering PEV commercialization. First, lack of a dependable market has inhibited automakers from pushing a large first batch of PEVs off the assembly line. Second, automakers argue that battery assemblies are still relatively untested over the long term under diverse driving and environmental conditions. Third, mainstream consumers are still relatively uniformed or skeptical about the "100-mpg" car, which sounds almost too good to be true.

The proposed agreement would address these obstacles. First, it would create a guaranteed market for PEV vehicles, giving automakers the confidence to get PEV models off the drawing boards and on the assembly lines, quickly and at scale.

Second, it could play a crucial role in helping to test PEV performance over the long term, under diverse driving and environmental conditions. Having such a large number of units deployed under one jurisdiction allows for easy performance tracking. In return for a guaranteed market, automakers, battery manufacturers, and utilities should commit resources and collaborate with the General Services Administration on a performance monitoring pilot that covers vehicle energy use and long-term battery performance. Over time, the pilot should incorporate V2H (vehicle-to-home—or building) and V2G (vehicle-to-grid) technology. Moreover,

the sheer size of the federal vehicle fleet allows the flexibility to experiment with emerging technologies and incorporate them in volume without much financial burden or risk—if some of these vehicles fail to perform, the results will not be catastrophic.

Third and last, a large deployment of PEVs in the federal fleet would send a message to consumers that this technology is very much a practical reality, not a side project of vehicle hobbyists and environmentalists. Dispelling the misperception that PEVs are inaccessible and futuristic will do much to prime the consumer market for large-scale adoption.

The cost of the proposed policy is difficult to estimate, given the uncertainties in future prices for large-format battery assemblies. Yet the U.S. government, as consumer of the most prodigious quantities of oil on the planet, has a strategic interest in obtaining cost-effective and reliable PEVs, even if they are expensive at the outset. And even using current cost structures, the financial burden is minimal. Assuming a $10,000 premium for a forty-mile battery assembly, 20,000 PEV vehicles would cost $200 million a year more than comparable internal combustion engine counterparts. Yet much of that cost would be offset by government savings on gasoline consumption over the lifetime of the vehicles. And the costs for PEVs would begin to drop significantly as the scale of production increased and technology improved.

"Federal Battery Guarantee Corporation"

The idea for the proposed Federal Battery Guarantee Corporation (FBGC) was briefly introduced by David Sandalow in his book *Freedom from Oil*. The FBGC would underwrite insurance on battery life and performance for the normal automotive drivetrain warranty period of ten years, thus removing risk for both the consumer and the vendor. The FBGC would cover only pure economic loss from functional obsolescence or product malfunction. If batteries fail to perform as promised for the full ten years, the government would pay out of an established insurance pool to have the battery serviced or replaced or to refund consumers for the value remaining on their warranty.

Automakers are accustomed to providing their customers with ten-year, 100,000-mile drivetrain warranties. Understandably, they are hesitant to extend that guarantee to PEVs running on batteries that have yet to be completely proven to perform to those specifications. Moreover, when releasing a new product, automakers must normally set funds aside to

ensure that their risk is covered in the event of a defect or malfunction. Estimating the amount of risk coverage is exceedingly difficult for new, large-format battery assemblies with uncertain long-term performance, and coming up with the necessary funds is nearly impossible in the current environment, when credit is tight and automakers are running in the red.

The FBGC would resolve that impasse by partially removing the risk burden. Battery assembly manufacturers would still be responsible for guaranteeing solid workmanship and for covering their existing warranties, probably for the first two or three years, after which time the FBGC would come in, much as the third parties do that currently offer extended warranty packages for most consumer electronics. Therefore, for the FBGC to work, automakers must get comfortable with the notion of two separate warranties: one for the vehicle (which they continue to cover), and one for the battery assembly, covered initially by the battery manufacturer and later by the FBGC.

In the event of battery malfunction or underperformance, the FBGC would pay out to have the battery serviced or replaced or to refund consumers for the value remaining on their warranty—whichever is the cheapest option. The FBGC would not own the battery; it would only cover necessary repairs or replacements, just as tire companies do now and IBM used to do for its electric typewriters. Also, the FBGC would not perform the actual services, which would require developing a nationwide infrastructure for repairs. Rather, it would reimburse automakers, mechanics, or new battery repair companies for their parts and labor within a pre-established rate structure.

The FBGC is loosely inspired by the Pension Benefit Guarantee Corporation (PBGC), which was created by the Employee Retirement Income Security Act of 1974 "to encourage the continuation and maintenance of private-sector defined benefit pension plans, provide timely and uninterrupted payment of pension benefits, and keep pension insurance premiums at a minimum."[8] The PBGC is a backstop for private pension plans that have ended; the FBGC would fill a similar role in underwriting and providing extended warranties for battery assemblies.

However, unlike the PBGC (which receives no funds from general tax revenues), the cost of the FBGC would be determined by the Congressional Budget Office on the basis of the probability of battery obsolescence or malfunction and the cost of repair, replacement, or refund. That,

understandably, would be difficult to predict for a new technology with an uncertain market share and untested performance record.

A few flexible financing options for the FBGC include

—creating an insurance pool up front with a cash influx from the Treasury Department (as was done for the nuclear industry under the Price-Anderson Act, to the tune of $500 million)

—using government-issued securities to back the guarantee

—having automakers and battery manufacturers contribute a nominal amount (in the form of an insurance premium) at first, which would be held in escrow by the FBGC and supplemented by government funds. The private sector would then gradually increase its share of the insurance premium as sales and profits take off, the technology matures, and risk decreases.

Covering battery warranties through a lump insurance policy underwritten by the federal government also lowers per-unit costs by spreading the risks over a large number of vehicles and battery assemblies from different manufacturers.

One precondition for the success of the FBGC is that automakers recognize the battery assembly as a serviceable component and engineer their PEVs to facilitate access to the battery for service or replacement. An easily replaceable battery assembly is also important because the FBGC can make use of degraded PEV batteries for stationary power storage at government installations or for refurbishment and resale.

The policy principles embodied in the proposed Federal Battery Guarantee Corporation have ample historical precedent, the most relevant being U.S. government indemnification of the nuclear industry. First passed in 1957, the Price-Anderson Act helped a strategic industry get on its feet by underwriting the liability for claims arising from nuclear incidents. That federal guarantee was essential to reducing private sector risk, especially in the early years when the technology was still immature.

Regardless of one's opinions on the current merits of nuclear power, incubating the nascent nuclear power industry was a strategic national imperative in the late 1950s. Primarily for national security reasons (to counter the Russian nuclear threat) but also to meet the burgeoning energy needs of an explosive postwar economy, the federal government recognized from the outset that the nuclear industry needed a supportive policy framework to expedite its development. The same is true for PEVs

today—and for the same national security, economic, and energy-related reasons.

PEV technology is, obviously, must less risky than nuclear technology. It also is immune from the ethical and safety dilemmas associated with nuclear energy, such as radioactive waste storage and reprocessing. Moreover, the economics of PEVs are much better at the outset: already, the technology can almost achieve lifecycle cost parity with hybrids and compact vehicles, and in an era of skyrocketing oil prices, PEVs will not require the kind of prolonged subsidization (through loan guarantees, security measures, waste disposal, and so forth) demanded by the nuclear industry to stay competitive.

One additional benefit of the proposed corporation would be to help the private insurance industry develop a system by which battery manufacturers could eventually protect themselves against financial losses. Private insurance markets have trouble quantifying the risk of any new technology; accordingly, they are reluctant to issue coverage at all or they charge premiums that battery companies cannot afford. Federal underwriting in the early stages of the PEV industry would allow private insurers time to monitor the risks involved and create adequate and affordable insurance policies.

Guaranteed Secondary Market for Used Battery Assemblies

Large-format battery assemblies generally retain 80 percent of their energy storage capacity even after they have lost their efficacy in powering vehicles. Identifying plausible secondary applications for used battery assemblies and establishing a resale market therefore could give PEV owners an opportunity to reclaim a portion of the purchase price of the battery, effectively reducing its initial cost.

Through a federal battery buyback guarantee, the government would commit to purchasing used PEV battery assemblies at a preferential rate, thus establishing a guaranteed market. That would not be a case of charity: the government has a legitimate need for dependable backup energy storage at federal buildings, electronic data storage centers, military bases, hospitals, and so forth. Once adequate performance and dependability are established, used battery assemblies charged by the grid or by distributed solar power could seamlessly replace existing diesel generators as the preferred backup energy supply in many government installations.

Complementing the federal buyback policy would be a suite of tax incentives to encourage private industry to buy used batteries. In a March 2003 report, Sandia National Laboratories identified four potential economically viable applications for used battery assemblies: electricity transmission support, light commercial load following, residential load following, and backup power for distributed node telecommunications.[9] The report found no insurmountable technical barriers to using refurbished used battery assemblies in stationary applications. Moreover, in the five years since the report was written, battery technology has improved substantially. And with the economies of scale that would accompany mass production of the vehicle fleet, battery assembly costs would be poised to drop significantly, thus strengthening the economic case for use in stationary power storage applications.

The private sector already is showing interest, and that interest will only grow as applications develop for smart grid and distributed solar energy. Pacific Gas and Electric has spoken optimistically about the possibility of using battery assemblies for storing renewable energy generated on site and releasing it to shave peak loads. And in the not-so-distant future, one could envision used battery "farms" providing the storage capacity needed to level out utility-scale wind or solar energy generated during off-peak hours. Establishing a system of tax incentives to support private sector pursuit of these promising stationary applications would help lower the cost of new battery assemblies for vehicles by creating a vibrant resale market.

Easy, Costless Regulatory Action

In addition to the three policy options, there is one easy, costless regulatory action that the Executive Branch could take immediately to help drive PEVs to market: the Environmental Protection Agency (EPA) should grant California its request to regulate tailpipe greenhouse gas emissions under the Clean Air Act.

In December 2007, the EPA denied California its request, a decision nearly unprecedented since California was first granted special status in the Federal Air Quality Act of 1967, which allows California to apply for a "waiver" in order to implement more stringent standards. Over the last forty years, the EPA has granted California fifty full waivers and forty waiver amendments; on only five occasions has it denied a waiver request

outright (the last was in 1975).[10] Moreover, the April 2007 Supreme Court ruling in *Massachusetts* v. *EPA* unequivocally affirmed that greenhouse gas emissions from automobiles fall under the jurisdiction of the Clean Air Act.

The California tailpipe standards would translate into vehicle fuel efficiency gains greater than those required by the increase in corporate average fuel economy (CAFE) standards called for in the Energy Independence and Security Act of 2007. The California Air Resources Board reports: "Since the California rules are significantly more effective at reducing GHGs than the federal CAFE program, they also result in better fuel efficiency—roughly 43 miles per gallon (mpg) in 2020 for the California vehicle fleet as compared to the new CAFE standard of 35 mpg."[11] While automakers are free to deploy the low-emissions technologies of their choice, PEVs would certainly be competitive in meeting the more stringent California emissions standards.

Granting the California waiver request would drive new innovations in the auto industry, and it would affect markets beyond California. Indeed, since California first passed its emissions standards in 2004, sixteen other states—representing approximately 45 percent of the U.S. auto market—have either passed equivalent legislation or pledged to do so once the EPA grants the waiver to California. Granting the waiver therefore would help build nationwide demand for PEVs on a commercial scale.

Addressing the Moral Hazard and Related Concerns

Before leveraging significant government support for getting PEVs on the road, it is important to address the moral hazard issue and related concerns: Does too much of a safety net inadvertently reduce manufacturers' diligence in their performance engineering? Is there a risk in pushing through a technology that may not be fully ready for deployment? Are we circumventing the normal private sector product development process?

The answer to those concerns comes in four parts. First, the environment for battery assemblies is quite competitive, with both domestic and foreign manufacturers contending for a cost and performance advantage in what promises to be a large and lucrative market. Battery companies have ample incentives to produce a top-quality product, and federal battery guarantees or fleet purchasing agreements will not undermine the fundamentals of private sector competition in this vibrant emerging market.

Second, the United States already has a safety testing system in place, administered by the Department of Transportation (DOT). The DOT subjects battery assemblies to rigorous trials and ensures their relative safety and dependability before clearing them for use in vehicle drivetrains. Ramped-up funding and employee training would ensure that DOT is capable of expediting the safety approval process for this vital new technology.

Third, compared with fossil fuel vehicle technologies, low- and zero-emissions technologies historically have been disadvantaged under federal policy, for two reasons:

—Drivers of conventional vehicles have never paid the full price for gasoline and diesel, whose externalities (greenhouse gas pollution, oil spills, respiratory ailments, geopolitical costs, and so forth) have been pushed onto the general public and future generations.

—Federal support (from R&D funding, subsidies, and so forth) has been heavily skewed toward the oil industry, giving gasoline and diesel a historical advantage over low-emissions energy carriers like batteries. Resolute federal policy support for PEVs (and other clean technologies) is justified to correct for years of inequality that put them at a disadvantage with respect to their fossil fuel competitors.

Last, the urgency of the situation demands prompt deployment of PEVs. We simply do not have time to wait until the technology completely matures or the price signals materialize to make PEVs competitive with the internal combustion engine. The federal government has a mandate—on national security, environmental, public health, and economic grounds—to expedite the commercialization of this critical technology.

A New Reuther Plan

With buy-in from the auto industry and increases in R&D funding, tax incentives, regulatory changes, and other policies discussed in this volume, the four policy mechanisms described above should provide the framework needed to get PEVs on the road. However, a more ambitious program may be warranted to achieve the rapid transformation of the auto sector necessary to save Detroit, break the stranglehold that oil has on our economy, and combat global warming. During World War II, the nation adopted a progressive industrial policy to retool automobile plants to produce airplanes for the war effort. It may again need such a policy—for a new era in which the stakes are just as high.

In 1940 Walter Reuther, later president of the UAW, presented the Reuther Plan to Phillip Murray (then head of the CIO) in the form of a report entitled "500 Planes a Day—A Program for the Utilization of the Automobile Industry for the Mass Production of Defense Planes." Murray delivered the plan to President Roosevelt, who saw it as emblematic of his goal to make the United States the "arsenal of democracy" for nations under attack by Nazi Germany. Roosevelt responded with robust interest, mobilizing the necessary federal resources, and the program achieved impressive results: in 1939, the United States produced fewer than 6,000 planes; in 1944, it produced 96,000.[12]

If the transformation of our vehicle sector is truly a national priority, the United States could emulate the original Reuther Plan in today's context: producing safe, lightweight vehicles driven by electricity or sustainable, advanced biofuels (or both) with the same sense of purpose and leadership that the country exhibited during World War II. Battery technology would certainly be part of this new industrial effort, but so would lightweight chassis development, aerodynamics, cellulosic ethanol production, and more. And the effort would involve prominent roles for labor, automakers, manufacturers, farmers, universities, federal research labs, and the American people.

The major difference between the modern plan and the original is that we would not be lend-leasing planes to our allies, as we did in World War II. Instead, we would build a robust domestic market and export the next wave of automotive technology to an eager, oil-weary world. If the federal government put its full resources behind the transformation of the U.S. vehicle sector with the same determination as it did during World War II, many of the policies described in this volume and chapter would have a role. However, that would also require making the case to the American people that this transformation could not occur without a significant government presence in the market, at least at the outset.

Re-creating the basic Reuther model with modern-day adjustments would be fairly simple. As it did during World War II, credit could flow to the private sector through loans and loan guarantees administered by an umbrella government finance corporation comprising subsidiaries that would coordinate the industrial mobilization effort by targeting specific solutions to the oil crisis. The "Auto Plant Retooling Corporation," "Vehicle Electrification Services Corporation," "Mass Transit Investment Corporation," "Advanced Biofuels Development Corporation," "Smart Grid

Deployment Corporation," and so forth would coordinate and direct capital flows to industries, producing a financial and technological shockwave that would revitalize manufacturing and unleash a surge of private investment. On the boards of those subsidiaries would sit relevant stakeholders (government, labor, industry, academia, consumers, and so forth), driven by a mandate to free our country—and the world—from its deadly dependence on oil.

Galvanizing the popular will for the country to invest in this endeavor will require real leadership. And the American people may just be ready: skyrocketing oil prices, intolerable congestion, the rise of petroauthoritarianism, and the battle against climate change have primed the country for action.

Financing the front end of this industrial effort also will require leadership, along with some creative thinking and smart politics. The current deficit is an obstacle, but it is not insurmountable. While our credit is still decent, the country can continue to borrow money internationally—but use it to invest in industrial conversion instead of buying and burning imported oil. There is the possibility of an "investment dividend" as we strategically redeploy U.S. troops from Iraq. Auction revenues from a nationwide cap-and-trade system could be a dependable source of reinvestment funds, but they would not begin to flow until complex enabling legislation was hammered out.[13]

Americans may even be ready to be called to the service of their country by purchasing "American Energy Bonds," modeled after the War Bonds that helped finance the conversion of American industry during WWII. The country is hungry to buy into something positive, and a future without $4-a-gallon gasoline and runaway global warming provides a hopeful cause around which to rally. "American Energy Bonds" would appeal to a country eager to transcend the geopolitics of oil and actually invest once again in the manufacturing and transportation infrastructure of the country to promote a low-carbon future. Given the chance to change the course of the nation and confront a national security, climate, and economic emergency, many Americans would be content with modest interest on those bonds, especially in the current volatile investment climate. The opportunity to restore national pride and technological leadership could combine with the kind of creative fascination aroused by the Apollo Project to rally the country to take action and put a down payment on a better world.

Conclusion

Federal support to expedite PEV deployment is necessary because the private sector is reluctant to shoulder the entire risk burden, especially because individual investors do not capture the full net social benefits provided by reducing our dependence on oil and combating global warming. There is a public purpose in rapid deployment, so the public can share the initial risk. That is good policy.

The federal government provides grants, loan guarantees, federal underwriting, tax credits, and preferential purchase agreements to reduce risk and the cost of capital for a host of beneficial purposes, because private markets do not value their full public benefits. Low-income mortgages and housing tax credits, subsidized college loans, tax credits for hybrid vehicles, and grants to companies developing less polluting power plants are all examples. Federal support for PEVs is a natural extension of that logic.

The policies outlined in this chapter and in the book overall rest on solid—and diverse—historical precedents. Federal interventions to jumpstart strategic industries in the United States have an impressive track record, especially in the transportation sector. The Pacific Railroad Act of 1862 deeded land to private railroad companies to reduce the risks of laying track, thus facilitating westward expansion; the National Interstate and Defense Highways Act of 1956 began our interstate highway system under the rubric of national security, creating the most extensive and efficient road commerce system in the world at its time; and the Apollo Project catapulted the United States to dominance in the aeronautics and space-related industries.

These examples have many things in common: they were strategic national imperatives vital to the country's security, technological leadership, and economic growth. Vehicle electrification to end our dependence on oil and shift to a cleaner and more reliable domestic fuel certainly fits that description well. And with its ability to revitalize an important manufacturing sector—the American auto industry—and leverage rapid and deep cuts in global warming emissions, PEV technology merits immediate and significant federal support.

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13. Cap and trade is an oft-discussed policy option for reducing greenhouse gas emissions by allowing firms to trade a limited number of "emissions permits," which would be reduced gradually to comply with the tightening emissions cap. These permits should be auctioned, both to ensure economic efficiency and to raise revenue to protect consumers and reinvest in the transition to a low-carbon economy.