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Next Generation Vehicles: Opportunities and Obstacles

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The internal combustion engine (ICE) has powered cars, trucks and other vehicles for over a century. Car companies have occasionally tried new technologies, such as General Motors' all-electric EV-1 in the late 1990s, typically with little success, leaving the ICE as unrivaled king of the highway. We are, however, on the brink of dramatic developments.

Hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs), pure electric vehicles (EVs), and a myriad of other technologies, some of which are not much more than fantasies, can all be properly classified as Next Generation Vehicles (NGVs). These vehicles are mounting a long, slow challenge to the dominance of transportation by oil and the ICE. As NGVs are developed and deployed on a commercial scale, America's transportation sector will become increasingly electrified because these vehicles will rely more and more on electricity and less and less on oil-based fuels.

HEVs, the first commercially successful alternative to conventional ICE vehicles, combine an ICE and an electric motor to propel the vehicle. Batteries permit the ICE to turn off when the vehicle is stopped and while coasting. The battery also provides energy for propulsion from stops for short distances in an all-electric mode and to assist the ICE with acceleration. HEVs provide modest gasoline savings, but have not revolutionized the world, except for setting the stage for PHEVs.

Widespread adoption of PHEVs could dramatically alter both the transportation industry and the world's energy use. PHEVs are propelled only by an electric motor, typically for a modest distance, such as 40 miles, and are equipped with an ICE solely to recharge depleted batteries.

The next stage does entirely without an ICE. Some small, niche companies are now offering pure EVs. As the technologies for NGVs mature, many envision a world where all vehicles will be powered solely by electricity.

The PHEV, the NGV closest to commercialization, demonstrates the potentially "game-changing" nature of NGVs. While still in their infancy with many hurdles yet to be overcome, NGVs hold great promise in transforming how the world travels and uses energy. Because of the potential that NGVs hold, governments at all levels have eagerly passed legislation that support NGVs, but political and legal issues abound. This article sets out the greatest opportunities offered by NGVs as well as the principal obstacles that stand in the way of wide-spread NGV adoption.

Opportunity #1: Reduced Oil Consumption

The U.S. consumes about 19.3 million barrels of oil per day, two-thirds of which is used for transportation.[1] The transportation sector depends heavily on oil, from which it derives more than 95 percent of its energy requirements.[2] Interestingly,

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however, only .9 percent of U.S. oil consumption is used to generate electricity, and oil is used to generate only approximately 1 percent of our electricity.[3]

Every time oil prices rise, or as we near an election, politicians inevitably discuss the country's dependence on foreign oil—the U.S. imports more than 60 percent of the oil that it consumes.[4] Widespread deployment of NGVs could significantly reduce overall oil consumption and, consequently, the level of oil imports. Some PHEVs are designed to complete a typical American's commute entirely on electricity and from a single charge of the battery. For example, the Chevy Volt, slated for release at the end of 2010, is expected to travel 40 miles on a full charge, sufficient to complete 75 percent of Americans' daily commutes.[5] The Volt, it should be noted, is not a pure PHEV because, in addition to recharging the batteries, the ICE assists with propulsion at high speeds when the batteries are depleted (a previously unannounced change in plans by General Motors).[6] Other manufacturers are also working on PHEVs. For example, in 2012, Toyota is expected to introduce a PHEV version of the Prius, while Ford is also planning a PHEV.[7]

By eliminating a substantial portion of the average person's gasoline consumption, NGVs could enable the country finally to take real steps towards lowering our oil dependence. Promises of every President and Presidential candidate since the oil shocks of the 1970s have done little to change America's oil addiction. With NGVs, however, we may finally achieve what so many politicians have failed to accomplish.

Introduction of renewable fuels into the transportation sector further reduces dependence on oil. Until all vehicles are fully electrified, which is probably only possible in the distant future, many NGVs will still need a back-up source of energy, such as the Chevy Volt's gasoline-powered ICE. NGVs will be even greener if the backup source of energy is derived from a renewable source rather than from oil. The Energy Independence and Security Act of 2007 (EISA) increased the renewable fuel standards (RFS), originally enacted in 2005, by increasing the volume of renewable fuel that is to be blended into transportation fuel each year from 9 billion gallons in 2008 to 36 billion gallons in 2022.[8] If these goals are met, then it is possible that a PHEV could be powered completely by renewable energy.

Opportunity #2: Environmental Benefits

Reducing oil consumption reduces pollution. Driving NGVs reduces the demand for oil in the transportation sector which reduces pollution from vehicles, but the energy that will propel NGVs must come from somewhere—typically large power plants (that probably burn fossil fuels). In effect, this shifts the source of pollution from millions of mobile sources, to fewer, larger, immobile sources. There are, however, several advantages to this. First, many early buyers of NGVs are likely to live in more environmentally-progressive states, such as California, that have a much greener energy generation profile than the national average. Second, no matter where the vehicle obtains its energy, large generators of electricity typically produce fewer emissions than a gasoline engine for the same amount of energy. A joint study by the Electric Power Research Institute (EPRI) and the Natural Resources Defense Council found that widespread adoption of PHEVs over the next few decades can reduce greenhouse gas emissions by more than 450 million metric tons annually in 2050 and will improve nationwide air quality.[9] Even though the source of pollution will shift, the overall amount will decrease.

Vehicle exhaust is a leading cause of pollution in urban areas and the greatest cause of climate change.[10] This has lead to many areas being out of compliance with federal environmental laws. The Clean Air Act of 1990 created National Ambient Air Quality Standards (NAAQS), pursuant to which the EPA has promulgated primary standards to protect

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human health and secondary standards to protect public welfare.[11] Unfortunately, many areas of the country, especially urban areas, are not in compliance with the NAAQS. By reducing a leading source of pollution in many of these areas, NGVs could help certain regions of the country come into compliance with these federal environmental standards.

Shifting the pollution from myriad mobile sources to fewer, larger, immobile sources would have other benefits. First, the nation's electricity generating power plants have become cleaner over time and that trend is likely to continue. Second, while the government can impose stricter standards on auto manufacturers, it is often reluctant to do so, and it is easier to physically control the pollution from fewer, large sources than from millions of smaller sources. In addition, if the government were to enact a national cap-and-trade program for carbon dioxide, the power plants could be active participants in that market, which is unlikely for individual motorists. The Acid Rain Program in Title IV of the 1990 Clean Air Act Amendments created a cap-and-trade program for large power plants that has significantly reduced sulfur dioxide emissions (and the toxic acid rain sulfur dioxide forms), and the Regional Greenhouse Gas Initiative (RGGI) is currently operating in the northeast and mid-Atlantic states to lower carbon dioxide emissions.

Opportunity #3: Making the "Smart Grid" Smarter

According to the Federal Smart Grid Task Force's website, smartgrid.gov, the smart grid is an automated electric power system that monitors and controls grid activities, ensuring the two-way flow of electricity and information between power plants and consumers, and all points in between.[12] What makes the smart grid "smart" is "the ability to sense, monitor, and in some cases, control . . . how the system behaves."[13] The smart grid will become more useful and "smarter" by incorporating large numbers of NGVs into it.

At night, when electricity demand is low and utilities have excess generating capacity, many NGVs will be recharged. In the afternoon, when demand is highest, utilities could draw energy from plugged-in NGVs (owned by those with whom the utility has an agreement), essentially using NGVs as millions of mobile, on-demand power plants. This would allow utilities to smooth the peaks and valleys in supply and demand, lowering the cost of energy and reducing pollution. It would also allow utilities to allocate production of energy more efficiently. If the utility knows the late afternoon will be a scorcher, rather than running a peaking power plant for a few hours, it would be cheaper and greener to draw energy from NGVs to meet demand. NGV owners will have incentives, such as compensation, to reach agreements with utilities to allow the utilities to draw energy from the NGV batteries at peak demand. With the right technology, NGV owners will also be able to program their car so that it retains enough energy to drive home at the end of the day.

Finally, combining NGVs and the smart grid will allow for better incorporation of intermittent renewable energy sources, such as wind and solar. We cannot control when the sun shines or the wind blows, but we can store this energy when it is created if it cannot be used immediately. Currently, renewable energy in the transportation sector is limited to relatively small amounts of ethanol. By adding large numbers of NGVs and their batteries, we can power NGVs with clean energy from the sun or wind and put these sources of intermittent renewable energy to better use.

While it is without doubt that NGVs could revolutionize our energy and transportation systems, NGVs are still in their infancy, and daunting obstacles to widespread deployment remain.

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Obstacle #1: Infrastructure

Huge investments in public infrastructure are needed to support NGVs. The required recharging infrastructure is largely non-existent. Recharging at home will be easy (plugging-in to a 110-volt outlet is the same as plugging in anything else). For a faster charge, a 220-volt outlet (same as that used for a clothes dryer) could be installed by an electrician. Recharging elsewhere, however, poses problems. Access to recharging stations is needed at the office, at the curb, in parking garages and lots, and elsewhere. In addition, there may need to be high-voltage recharging stations, so that drivers can recharge in about the time it takes to refill a gas tank.[14] (Complementing such recharging stations could be battery swapping facilities.[15]) Currently, only California has more than 400 recharging stations and more than half the states have none.[16] This compares to approximately 159,000 retail gasoline stations in the country.[17]

To begin addressing the lack of recharging infrastructure, all levels of government have stepped in to help. For example, the federal government offers a 50 percent tax credit to install an EV charging station, but it is only available through the end of 2010.[18] States have also become involved. New York, for example, offers a 50 percent tax credit that also expires on December 31, 2010.[19]

A second component of the nation's infrastructure that will need major investments is the smart grid. To fully utilize their potential, NGVs must be fully incorporated into the "smart grid" so they can not only draw energy from the grid but also release it onto the grid when needed. This means widespread adoption of smart grid technologies is imperative. NGVs can be easily adopted without a smart grid, but that would forego an important advantage of NGVs. Unfortunately, building the smart grid that we need will not be cheap; the EPRI estimates that it will cost $165 billion over twenty years.[20] Other estimates range from $100 billion to $2 trillion.[21]

EISA declared that "[i]t is the policy of the United States to support the modernization of the Nation's electricity transmission and distribution system to maintain a reliable and secure electricity infrastructure that can meet future demand growth . . . ." This Act made some of the first government investments in a smart grid by directing the Department of Energy to create a program that reimburses 20 percent of qualifying Smart Grid investments. The federal government took additional steps to pursue the goals set out in EISA through the American Recovery and Reinvestment Act of 2009 (the Stimulus), which committed $4.5 billion to modernizing the grid.[22]

Because of the requirements of new, necessary infrastructure (energy generation, transportation, and distribution) to support NGVs, many important legal issues will be raised.

First, NGVs will increase the nation's demand for electricity. NGVs may not require new power plants for quite some time, but new power plants are constantly being built to meet new demand. In addition, renewable energy generation capacity needs to expand if NGVs are to be powered by clean energy. While both renewable and conventional power plants are tightly regulated, large conventional power plants are usually subject to even more rigorous review and requirements. For example, conventional power plants may implicate provisions of the Clean Air Act, such as New Source Review, and if they are located in certain northeast or mid-Atlantic states, they may be covered by RGGI.[23] Whether NGVs require new conventional generation to be built, or just new renewable generation capacity, many of these, and other, important legal and regulatory issues will be raised.

Second, new renewable energy generating facilities that could provide clean energy to NGVs are often located far from current transmission lines. Building the necessary, long transmission lines to connect some of the most promising renewable resources to

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population centers requires cutting across sensitive habitats and nature areas and can implicate regulatory and legal problems, from constitutional takings issues to federal and state environmental laws.[24]

Obstacle #2: Technology

Another obstacle is that the current state of technology, while improving, is not where it needs to be for widespread NGV adoption. For example, batteries have limited storage capacities and limited lifespans. Also, components of the "smart grid" are still being developed.

The federal government has provided financial incentives, such as grants and loan guarantees, to support the development of the needed technologies. For example, the Department of Energy's Advanced Technology Vehicles Manufacturing Loan Program (ATVM) was established by § 136 of EISA in order to support the development of advanced technology vehicles and associated components in the U.S.[25] A $1.4 billion loan from this program funded the retooling of a factory in Smyrna, Tennessee, so that it could build advanced EVs and advanced batteries.[26]

A second large investment in NGVs came from the Stimulus which allocated $2.4 billion for advanced batteries and electric vehicles.[27] Funded by a federal grant of $249 million, the largest lithium-ion battery plant for EVs in the U.S. just opened in Michigan.[28]

Obstacle #3: Cost

The options currently available are expensive. For example, the MSRP for the Chevy Volt is $41,000. The all-electric Tesla Roadster costs $109,000 and Tesla's planned Model S will be priced at nearly $60,000. Even with government incentives, these vehicles are simply beyond the reach of the average American consumer.

The manufacturers are likely to be facing operating losses on these vehicles for years, just as Toyota experienced with the Prius. As the technology improves and volume increases, the car companies may be able to manufacture these vehicles profitably. In the meantime, there is currently a tax credit of up to $7,500 for the first 200,000 PHEVs per manufacturer.[29] The federal government is not alone in trying to help consumers afford these vehicles. Many states have also adopted incentives ranging from granting carpool lane access to sales tax exemptions and income tax credits.

Rather than giving incentives to those who purchase NGVs (or in addition to doing so), perhaps the government should increase taxes on oil-based fuels. This is more economically efficient but is unfortunately, probably, politically infeasible. Similarly, a cap-and-trade policy would encourage investments in clean sources of energy. This too, however, has fallen by the wayside and seems unlikely to be revived anytime soon.

Conclusion

A person looking to buy a new car in the 1990s had similar options to a person in the 1950s—only vehicles powered by an ICE that burned a derivative of oil. Today, numerous manufacturers are offering HEVs; within months, the Chevy Volt, a PHEV, will be available. The implications of widespread NGV adoption are not simply that we will spend less at the pump; rather, NGVs could truly revolutionize how we travel and use energy. Like any other new technology, success is not guaranteed. The potentially huge rewards, ranging from mitigating climate change to national security, are, however, well worth the risks.

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