Hybrid Electric Vehicles

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The Problem

The rapid industrialization and modernization of the 20th brought with it the ascendancy of the gasoline-powered automobile, a phenomenon that changed the way we travel, do business, and conduct our daily lives. What once was luxury – quick, comfortable mobility – soon became dependence, and the world now relies heavily on fossil-fuel based technology to maintain the lifestyles and standards of living that are now the norm.

There is a double burden involved in our reliance on gas-powered vehicles: First, polluting emissions are inherent to this technology, causing a degradation of the natural environment in the form of smog, ozone depletion, and global warming. Second, we have become enormously dependent on fossil fuels, a non-renewable resource that threatens to run out imminently and is increasingly a source of domestic and international political conflict. The number of vehicles continues to rise along with the population and development of countries. Clearly, the need for a revision of our current transportation system exists.

Policy Question

Where do hybrid vehicles fit into a movement towards "green" transportation systems?

Historical Background

Although it seems the hybrid concept is relatively new to the automobile industry, hybrids are not a new idea. Inventors have searched for over a century for a practical hybrid technology. As a matter of fact, Robert Anderson, built the first electric vehicle in 1839 and Porsche's second car, built in 1898, was a hybrid. In 1899, the Pope Manufacturing Company merged two smaller electric car companies to form the Electric Vehicle Company, the first large-scale operation in the American automobile industry which had assets of $200 million." (hybridcars.com) A poll conducted at the first National Automobile Show in 1900 revealed that patrons favored the electric auto as their first choice, followed by steam. But, in 1904, Henry Ford began assembly of low-priced, lightweight, gas-powered vehicles. Within a

few years, the Electric Vehicle Company failed and electrics were almost completely wiped by the end of the decade.

"The Hybrid Electric Vehicle (HEV) concept goes back to 1905, when American engineer H. Piper, filed for a patent on a hybrid vehicle that called for an electric motor to augment a gasoline engine." (Brasington) The more powerful gasoline engines (along with equipment that allowed them to be started without cranks) contributed to the decline of the electric vehicle and of the budding of the HEV between 1910 and 1920.

The hybrid concept lay dormant until 1966 when the US Congress introduced the first bills recommending use of electric vehicles as a means of reducing air pollution. By then the technology had been ignored for so long that manufacturing costs were far too high to be practical. The Arab oil embargo and the resulting expensive gasoline again brought hybrids to the fore. In 1975, The US Energy Research and Development Administration began a government program to advance electric and hybrid technology. Aided by legislation of the era, industry and government worked in concert to create improved batteries, motors and other hybrid-electric components.

In the late 1970's, General Motors spent over $20 million in electric car development and research, reporting that electric vehicles could be in production by the mid-1980s. Hybrid technology continues on the path of improvement and in 1991, "the United States Advanced Battery Consortium (USABC – A Department of Energy program) launched a major program to produce a "super" battery to get viable electric vehicles in the road as soon as possible." (hybridcars.com) The USABC would go onto invest $90 million in a nickel hydride battery that can accept 3 times as many charge cycles as lead-acid batteries. "The real surge in development occurred in 1993, when the Clinton administration announced formation of the Partnership for a New Generation of Vehicles (PNGV) consortium, consisting of the "Big Three" automobile manufacturers (GM, Ford and Chrysler) and about 350 smaller technical firms." (automedia.com)

Toyota Motor Corporation's "Earth Charter" of the early 1990's outlined the company's goal to develop and market lowest-possible emission vehicles. According to Brasington, "[Toyota's] motivation was to produce a car that delivered high mileage for the domestic Japanese market (who were paying upwards of $3 a gallon for gasoline) so there was a real economic motivator for the technology." Toyota sold nearly 18,000 Prii in the car's first year on the Japanese market; in less than three years sales surpassed the 50,000 mark worldwide.

The release of the first hybrid electric vehicles in the United States marked the start of a revolution. The first hybrid electric model in the US market was the Honda Insight (61–70 mpg) in 1999. The Toyota Prius (45–52 mpg) debuted the following year and the Honda Civic Hybrid (48–51 mpg) went on sale in 2002. The first full-sized pickup hybrids, the Chevy Silverado and Dodge Ram hit the streets in 2004, as did the first SUV hybrid, the Ford Escape. "Both the Mitsubishi and the Nissan Corporation plan to release their hybrid electric vehicles in Japan later this year." (Kurz)

Today, more than $1 billion has been spent worldwide on development of fuel-efficient automobiles. Additional forces, such as federal environmental regulations have aided in speeding the development of "supercar" technology, requiring manufacturers to further reduce vehicle emissions and improve fuel efficiency. "The ability of hybrid technology to extend the range of a traditional automobile is largely a function if its ability to optimize the efficiency of the power plant." (automedia.com) Because the PNGV never specified the technology to be used in achieving the "supercar" goal automobile manufacturers were granted flexibility in developing affordable solutions and providing market opportunities for unforeseen technological innovation. The push forward in hybrid technology also helped in several other innovations such as aerodynamic drag, ultra-light vehicle manufacturing and friction-reduced tires. "Hybrid vehicle technology is a so-called "step-out" technology in that it modifies an existing and proven technology, rather than replacing it completely and changes are introduced gradually so risks and costs are reduced." (IEA)

For instance, the second-generation Prius is on the horizon as a 2004 model. It will have a 78-horsepower gasoline engine and 67-horsepower electric motor that work together in what Toyota calls "Hybrid Synergy Drive." "The system is capable of operating in either the gasoline or electric modes separately, or with both the gasoline engine and electric motor in operation at the same time." (automedia.com) "The Toyota Prius II has won the 2004 Car of the Year Award from Motor Trend Magazine and the North American Auto Show." (hybridcars.com) The demand has pumped up production from 36,000 to 47,000 for the US Market and interested buyers wait up to six months to purchase the 2004 Prius.

Since hybrid vehicle technology is still in its early stages in the marketplace, there is still and probably always will be great potential for improvement, not only in cost reduction, but also in technical performance. The key will be further improvements in battery lifespan and performance. Larger leaps in design will allow hybrid vehicles to drive on battery power with zero pollution in city driving and only use their internal combustion engines for longer trips.

Technical Background

The fact that hybrid technology is an option in the automotive industry is becoming more obvious and commonplace. Many know hybrid vehicles get better gas mileage, but few know why. Hybrid vehicle technology takes a simple idea, combines it with innovative thinking, and not only produces a product that will benefit the environment, but provides consumers with a viable option to pure gasoline burning vehicles.

There are two main types of automotive hybridization used today: parallel hybrid and series hybrid. The parallel hybrid uses gasoline to fuel the engine, but also has a set of batteries that supply power to an electric motor. Both the gas engine and the electric motor can turn the transmission at the same time, and the transmission then turns the wheels. Using the series hybrid technology, the gasoline engine turns a generator, which can either charge the batteries or power an electric motor that drives the transmission. In this form of hybrid, the gasoline engine never directly powers the vehicle, but merely supplements power through other components (Capata et al).

Most components of a hybrid vehicle are familiar items, but have been modified for use in the hybrid design. The gas engine in a conventional car, typically sized for peak power, which is used only 1% of the time, is a heavy engine. To increase fuel efficiency, the hybrid engine uses smaller, lighter parts, reduces the number of cylinders, and operates the engine closer to its maximum load. Gasoline is still a part of the hybrid equation because of its higher energy density than batteries. It takes 1,000 pounds of batteries to store as much energy as 1 gallon (7 pounds) of gasoline, so the appropriate compromise between the two can lead to the best possible solution. The electric motor in a hybrid is very sophisticated, for it acts as a motor, as well as a generator. The motor can draw energy from the batteries to aid in acceleration, and can also act as a generator through “regenerative braking”. This process captures the kinetic energy of braking, in the form of heat, which is then stored in the batteries. In this way, instead of using the brakes for merely stopping the car, they also provide return energy, unlike the expend only quality of gasoline (howstuffworks.com)

The Honda Insight and Civic, and the Toyota Prius are the three hybrid vehicles available to the public market today. Each manufacturer draws upon a different technology to supply power for the vehicles. The Prius uses an electric generator/starter to start its internal combustion engine (ICE), which

once on, warms itself and then shuts off. This process brings the electric motor online, but keeps the traditional gasoline engine dormant until needed. The Prius will stay in the all-electric mode until about 15 mph, which uses no gas and releases no emissions from the tailpipe.

The Honda vehicles use the parallel hybrid technology, which Honda calls "Integrated Motor Assist", and is available in a conventional five-speed transmission, but also available with a Continuous Variable Transmission (CVT) for those who prefer an automatic transmission. The Honda vehicles also have an ICE, only the engine warms and then shuts down after your first stop. This "idle stop" feature goes away when the brake is released, the gas pedal is pushed, or the car is put into gear (Mead) .

Marcus Akins at Ithaca Honda says "demands for hybrid vehicles is high", but that he has not felt any extra strain on his mechanics due to maintenance issues for these cars. He indicated that the vehicles, except for the batteries, where basically like the other Honda vehicles when it came to maintenance. The vehicles come with an 8 year, 80,000 mile warranty, so the lack of complications thus far could simply be true because the cars have not been around long enough to have experienced any particular problems.

The hybrid is a compromise. It attempts to significantly increase the mileage and reduce the emissions of a gas-powered car while overcoming the shortcomings of an electric car. For most cars, overcoming aerodynamic drag; friction from tires, transmission, axles and brakes; and providing power for accessories like air conditioning, power steering and headlights, requires less than 20 horsepower. So, why do we need cars with 200 horsepower? So we can "floor it"! The rest of the time considerably less power than is available is used.

Market Viability

General Motors, Chrysler and Ford are each scheduled to release their own hybrid cars within the next few years. Ford plans on releasing a hybrid version of the Escape, a successful Sport Utility Vehicle scheduled for release this summer. General Motors has plans to release a Chevy Silverado Hybrid Truck, and Chrysler a Jeep Grand Cherokee. While it is encouraging to see U.S. companies finally entering the race to sell fuel-efficient hybrid electric cars, many have criticized them for lagging behind.

According to Kathleen Kerwin of Business Week, Detroit is largely "missing the boat". While Ford has finally gotten around to releasing their hybrid SUV, Kerwin questions whether or not it will be able to successfully compete with foreign hybrids, which have now been refined into third generation

models. For example, the follow up model of the Toyota Prius boasts a 15% improved fuel economy and 30% reduction in emissions from the original Prius model. Beyond having to compete with newer, refined hybrid models, U.S. car companies will have to recover the costs of research and development. Although Japanese companies have to do this as well, their four year head start means they are much closer to the ultimate goal- profitability.

It was estimated that the original Prii lost about $8000 per unit sold, but as more cars have been purchased, the net losses have greatly diminished. Toyota has claimed its Prii have become profitable with the 2004 model year, though Honda has yet to overcome low volume on its Insight. Thus, American car companies are again largely behind foreign competitors on a second account, having to recover costs of research and development while others are profiting. With this in mind, it is important to consider why American companies have been so reluctant to develop hybrids.

According to Automotive News, none of the companies selling hybrid electric cars this summer will be marketing them with fuel efficiency as their main selling point. This is because gasoline prices, although relatively high, have yet to reach consumer "pain thresholds", which analysts have estimated to be somewhere around $3.00 per gallon. This indicates the average consumer does not consider fuel efficiency a top priority when choosing to purchase a car, and thus has little incentive to purchase a hybrid. Perhaps in order for these fuel efficient cars to go entirely mainstream, gasoline prices will have to rise.

Nevertheless, most experts agree that hybrid electric vehicles will serve as a nice stepping stone to the hydrogen fuel cell future automotive companies have envisioned, and consequently serve an important purpose (Gangi).

POLICY OPTIONS

Federal Hybrid Policies/Programs

Federal programs advancing hybrid vehicles take the form of industry partnerships for research and development. The Department of Energy leads and funds many of these partnerships. In addition, consumers are encouraged to purchase hybrid vehicles with promised tax deductions.

Tax Incentives

The government offers tax deductions for consumers that purchase a Toyota Prius, a Honda Insight, or a Honda Civic hybrid. The tax deductions are fixed for the year purchased, the tax year, and your tax bracket. The deduction decreased this year and will continue to decrease. For example, in the 15% bracket, an HEV purchased this year would earn a $225 dollar deduction but last year would have earned $300. The maximum deduction in 2003 was $2000, in the year 2006 it will be down to $500, and in 2007 a tax deduction is not anticipated.

The Department of Energy

The Department of Energy oversees many programs that involve researching or promoting hybrid vehicles. The first of these programs is the Hybrid Electric Vehicle Program which began in 1993. The program sought to develop hybrid electric vehicles (HEVs) with double the fuel economy of an average car. The program is a partnership between the DOE and the three largest American car manufacturers, Ford, General Motors, and DaimlerChrysler. Market ready cars were to be produced in 2003. However, the three major manufacturers ended the partnership in 1999 when prototypes for HEVs were finished. The program continued under a new name, FreedomCar, when it merged with the Partnership for a New Generation of Vehicles under the President's 2003 budget.

Currently, the program offers tools for consumers wishing to purchase an HEV to view the components online and compare the three popular models, the Toyota Prius, the Honda Insight and the Honda Civic hybrid. FreedomCar also started the 21st Century Truck Partnership that focuses on trucks, buses, and military vehicles. Researchers are planning a hybrid-electric urban bus in conjunction with Autokinetics Incorporated. The program however, is beginning to focus research on fuel cells and hydrogen technology.

The Department of Energy also created the Motor Challenge as a part of the Industrial Technologies Program. This program supplies car producers with information on the best and most efficient electric-motor systems. The Office of Transportation Technologies offers a similar function by funding research on such motor systems. Both programs are beginning to focus on alternative fuel systems, such as hydrogen.

Federally funded research on hybrid-electric vehicles seems to be losing the spotlight to alternative fuel systems. Hydrogen is the popular alternative to gasoline for President Bush and he pledged 1.7 billion to FreedomCar and the Hydrogen Fuel Initiative to develop hydrogen run cars for the next five years (Spencer 2003). The United States is also supporting hydrogen technology globally and

wants to establish an International Partnership for the Hydrogen Economy. The partnership would research and develop hydrogen run vehicles and accelerate the transition for these vehicles (Spencer 2003).

Programs at the State and Local Levels

Government Fleet Vehicles and Resource Pooling

Each individual consumer that purchases a hybrid vehicle is contributing to a reduction of emissions and a cleaner environment. While this is an undeniable plus, even greater utilization of this technology can be achieved by employing hybrids in government fleets, which comprise 20% of new car purchases. This is the philosophy behind a number of state and local programs aimed at adopting hybrids for a variety of government functions – security, transportation of officials, postal services, schools, etc. The higher cost of such vehicles poses a problem for these smaller entities whose budgets may not be able to compensate for the added expense of hybrids. Therefore, it is necessary to consider strategies to make hybrids a financially viable option.

U.S. Communities, a national cooperative purchasing alliance, encourages local and state agencies to pool their resources in order to increase their purchasing power and negotiate favorable contracts with producers of hybrids. U.S. Communities has formed a coalition with Center for a New American Dream the National Association of Counties to promote hybrid use in government fleets. The American Council for an Energy-Efficient Economy (ACEEE) points to the benefits to manufacturers of guaranteed bulk orders, a steady demand for the cars, and automatic promotion of their product by exposing the public to hybrids. A spokesperson from the ACEEE explained how using hybrids in state and local fleets "could greatly enhance automakers' interest in environmental performance and is sufficient to generate economies of scale needed to bring down the costs of new technologies." The Center for a New American Dream has recently published "Harnessing the Power of Advanced Fleet Vehicles: a Hybrid Electric Fact Sheet for Government Officials" in hopes of spreading the message about the feasibility of hybrids in the government sphere.

State and Local Programs Granting Special Privileges for Owners of Hybrids

The city of San José, in the heart of California's Silicon Valley, has recently instituted a parking program through the Local Department of Transportation that holds three potential benefits: lower fuel emissions, stimulation of the downtown economy, and increased sales of hybrid models at local auto

dealerships. The "Clean Fuel Vehicle Purchase Incentive Program" offers free parking in the downtown public parking facilities as well as meters throughout the city for owners of hybrids purchased at San José auto dealers. When San José residents purchase a hybrid from a local dealer, they will be issued a special permit that allows them to receive the special parking privileges. The benefit to the environment is unquestionable, but the additional advantages for downtown restaurants, shops, and other businesses, as well as the promotion of local auto dealerships make this a promising initiative.

In a recent interview with Jason Burton, head of San José's free parking initiative, he gave some insight into its development and performance as well as the future of hybrids in his opinion:

> "Originally, the free parking was for clean-air vehicles (such as pure electric ones, compressed natural gas, etc.) which are truly alternative fuel vehicles. However, over time the major automakers have dropped this technology and developed hybrids, which are the only real option for consumers right now. Considering this market trend along with the dropping of alternative fuel requirements by the State (that a certain percentage of vehicles sold use alternative fuel) we decided to change our regulations to benefit "early adopters" of hybrids. We've distributed 140 hybrid permits so far, and though we've had no major opponents to the program, owners of hybrids who purchased them outside the city wish they would qualify for the parking permit. A main problem is the long wait-list for hybrids from the local dealers…Hybrids are going to get more popular and are a clever idea; however, they are not the most 'green' vehicles possible with today's technology. Many automakers are exploring Hydrogen cars and recently Gov. Schwartzenegger has developed a bill to put hydrogen refueling stations throughout the state – and reconfigured his own Hummers with the technology!"

A bill to allow hybrid vehicles (even with one occupant) to drive in car-pool lanes is currently being considered in the California State legislature. The proposal aims to increase the purchase of hybrid cars by offering more convenient use of the roads. This incentive could prove especially enticing to California residents dealing with long commutes on increasingly congested highways. Currently, California is home to 20 million vehicles, 20,000 of which are hybrids. For a vehicle to qualify for the car pool lane privilege, it must get 45 miles per gallon of gas and meet the state's partial-emission standards.

In order for this bill to become reality, it must receive federal approval, which most feel will not be a problem. There has not been significant opposition to the proposal, although some have raised concerns: Dennis Fay, executive director of the Alameda County Congestion Management Agency, said his board voted to oppose the bill on two grounds: The high price of gas is already ample incentive to buy hybrids, and "there are many car-pool lanes that are close to capacity already, and allowing single-occupant vehicles into car-pool lanes would simply congest them and not achieve the goals of increased

vehicle occupancy." Additionally, what about traditional gas-powered cars which have a fuel efficiency equal to or better than that of hybrids?

A number of qualifiers have been added to the bill to ease some of the criticisms. A limit on the number of cars granted an approval decal by the Department of Motor Vehicles will be limited to 75,000 to prevent clogged car pool lanes, and the bill will expire in 2008. By then, California officials hope and predict that the number of hybrids in their state will reach 110,000.

Conclusion

Hybrids vehicles have stolen the spotlight as the eco-friendly vehicles of today. If zero-emission vehicles are Mr. Right, gas-electric cars are Mr. Right-Now. They offer the hope of halving our fuel consumption while retaining the accelerating power (at highway speeds) and quickness that drivers demand. Though some environmental groups are fond of dismissing hybrids as a poorly concealed effort to continue our dependence on oil, they are far more efficient than anything available on the American market. It is true that Volkswagen offers a super-charged diesel on par with the Prius in terms of gas mileage, America long ago chose gasoline as its preferred fuel for personal transportation. Hybrids are certainly a step in the right direction, but they are not the best that current technology can offer. Indeed, in anticipation of California regulations that required 10% of all vehicles sold be zero emission, GM offered its EV1 electric vehicle for lease as early as 1998, yet abandoned the program in 2003. Manufacturers like to use a small percentage of hybrids to scrub their image and present themselves as a “green” company without any real commitment to producing truly zero emission vehicles (ZEV).

In an effort to promote widespread adoption of hybrids in the consumer market and in government fleets, we have outlined the most viable policy mechanisms and discussed each option’s respective drawbacks. All of the policies operate within or extend the existing regulatory framework.

In closing, we would like to emphasize that hybrids are note a solution to the emissions problem. Rather, they are a commercially viable medium to reduce fuel consumption, and the resultant smog and greenhouse gases. While the focus has shifted from electric- to hydrogen-powered vehicles, ultimately, United States energy policy looks to zero emission vehicles to address global warming and pollution.

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