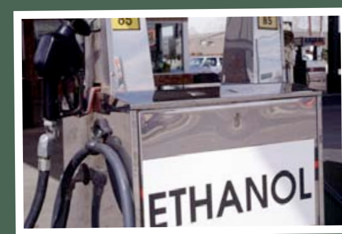

Driving Our Way to Energy Independence

David Morris

dmorris@ilsr.org

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Institute for Local Self-Reliance
1313 5th St. SE, Suite 303
Minneapolis, MN 55414

612-379-3815
www.newrules.org

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Other publications from the New Rules Project of the Institute for Local Self-Reliance:

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Since 1974, the Institute for Local Self-Reliance (ILSR) has worked with citizen groups, governments and private businesses to extract the maximum value from local resources.

A program of ILSR, the New Rules Project helps policy makers to design rules as if community matters.

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Executive Summary

The technology is now available to replace our petroleum-based transportation system with high efficiency, electric-biofueled vehicles. The key technology, the hybrid electric vehicle, was introduced in 2002 in the United States. Current hybrids do not travel far, if at all, on electricity and their batteries can be recharged only by the engine. Plug-in hybrids, however, have larger battery packs, allowing them to travel on electricity for the majority of vehicle miles traveled, and their batteries can be recharged from the electricity grid. In 2008, kits to convert a Prius into a plug-in vehicle will be widely available. By 2010, several car companies, including Toyota and General Motors, anticipate selling plug-in vehicles.

Another important, but more modest technological development is the flexible fueled vehicle that can use high or low blends of ethanol. The cost to the car manufacturers of adding a flexible fueled capability is very low, perhaps under $100.

These two technical developments allow us to build a transportation system primarily powered by electric motors, with backup engines fueled primarily by biofuels.

The 2007 energy bill will hasten the transition to a dual fueled transportation system. The bill mandates higher vehicle efficiencies that may well be achievable only by hybridizing most new vehicles. The bill also mandates a six fold increase in biofuels. Meanwhile, state mandates will boost six fold the production of renewable electricity, a key element in a sustainable electric transportation system.

A transformed transportation system can restructure electric power networks and agriculture. Hundreds of thousands of locally owned wind turbines and solar electric arrays, supplying a family plug-in hybrid vehicle capable not only of storing elecricity from intermittent generators, but also of supplying electricity on demand, could form the basis for a new electricity system. Thousands of farmer owned biorefineries can form the basis for a new agricultural system.

In 2008, Congress and state legislatures will be debating new policies for agriculture, energy and transportation. In designing those rules, policy makers should strive to marry energy security, environmental, economic development and social objectives.

"I'm going to build an electric runabout, dad."
"I don't take much stock in electric autos, Tom. Gasoline seems to be the best, or perhaps steam, generated by gasoline... All the electric runabouts I ever saw, while they were very nice cars, didn't seem able to go so very fast or very far..."
"That's true, but it's because they didn't have the right kind of battery....when I invented the battery I had no idea of using it on a car. I thought it might answer for commercial purposes, or for storing a current generated by windmills. But when I read that account in the papers of the Touring Club, offering a prize for the best electric car, it occurred to me that I might put my battery into an auto, and win."
- Victor Appleton, *Tom Swift and His Electric Runabout*, 1910.

"I foresee the time when industry shall no longer denude the forests which require generations to mature, nor use up the mines which were ages in the making, but shall draw its raw material largely from the annual products of the fields."
"I am convinced that we shall be able to get out of the yearly crops most of the basic materials which we now get from forest and mine."
- Henry Ford, quoted in *Modern Machine*, 1934.

Section I: The Times They Are A-Changin'

In December 2003, the Institute for Local Self-Reliance published *A Better Way to Get From Here to There*. This was one of the first in-depth arguments for a dual-fuel ground transportation system: electric motors as the primary propulsion source with a backup engine powered by biofuels.[1] But, as the quotes on the previous page attest, the idea of electric or biofueled transportation is almost as old as the automobile itself.

In the two years after publication, *A Better Way* was downloaded from our web site over 30,000 times. In 2006, readers began to inquire about an update. We initiated a revision, and quickly realized how dramatically the context had changed in three short years. In 2007, the pace of change quickened. A completely new report was needed, hence the new title.

Since publication of *A Better Way*, nine key developments have occurred that fundamentally change both the nature of, and the context for, the transportation energy debate.

1. Hydrogen is no longer viewed as a short or even medium term replacement for oil.

The original report devoted considerable attention to a comparison of an electricity-alcohol strategy with a hydrogen-fuel cell strategy. Indeed, its subtitle was, *The Hydrogen Economy and a Proposal for an Alternative Strategy*.

In his January 2003 State of the Union Address, President George W. Bush called for a hydrogen economy. A few months later, California Governor Arnold Schwarzenegger announced a $100 million "hydrogen highway" initiative.

Four years later, few still advocate a crash hydrogen program. In 2005, the European Union significantly lowered its estimates of hydrogen's short term potential. President Bush's January 2006 State of the Union Address, unlike his 2003 Address, made only passing reference to hydrogen, instead emphasizing biofuels and hybrid and electric cars. Funding for California's hydrogen highway has been cut dramatically. The phrase, "the hydrogen economy," has all but disappeared in the popular press.

One reason for this is that a hydrogen economy requires an almost total change in the existing transportation infrastructure. Another is that, for the foreseeable future, hydrogen will be made from fossil fuels and generate more, not less, greenhouse gas emissions. Still another is that it is far more efficient and economical to transmit wind generated electricity via the existing grid system directly into car batteries, rather than use wind electricity to electrolyze water into hydrogen and then deliver the hydrogen to the car, where it is converted back into electricity.

A final reason to put an aggressive hydrogen effort on the back burner is that a plug-in hybrid, flexible fueled vehicle, which can have a significant impact decades before hydrogen, creates the technological platform on which we can build a hydrogen economy, when the cost of renewable hydrogen production, vehicle fuel cells and hydrogen storage systems decreases. The engine in the plug-in hybrid can be replaced with an electricity generating fuel cell, and ethanol is recognized already as the lowest cost and most environmentally benign hydrogen carrier.

2. The price of oil has soared from $25 to over $100.

The new price of oil has spurred private investments into a wide array of alternative fuels.[2] And for the first time, the higher price of oil seems more a reflection of long term supply and demand than spasmodic reactions to the outbreak of war or terrorism.

With a combined population of 2.5 billion people, and economic growth rates almost three times those of Europe and the U.S., China and India are rapidly becoming major car markets, with the resulting impact on oil consumption. The number of cars in China is expected to increase from about 10 million in 2004 to 50 million in 2012 to 150 million in 2018![3] In 2006, China alone accounted for 38 percent of the worldwide growth in oil demand. Meanwhile, global oil production has risen only slightly since 2005, leading some to believe we may have reached the peak oil moment in human history.

3. Global warming has become a key political issue.

On November 18, 2004, Russia's adoption of the Kyoto Protocol resulted in the treaty's going into effect on February 16, 2005. The remarkable success of Al Gore's 2006 Oscar winning documentary, *An Inconvenient Truth*, generated an equally remarkable surge in public pressure for legislative strategies to curb carbon emissions.

The European Union has adopted an internal carbon emission reduction policy. In 2006, the state of California established a Low Carbon Fuel Standard applied to transportation fuels and a number of other states, including California, have adopted greenhouse gas reduction goals. In May 2007, 31 states with 70 percent of the country's population signed onto an emerging tracking system for GHG emissions called the Climate Registry. Carbon trading is growing so rapidly that observers envision it to be a trillion dollar market within a few years.

4. The hybrid car has gone mainstream.

In 2003, the hybrid electric vehicle, capable of being propelled by electric motors and/or an internal combustion engine, was still a novelty. Only two models were available, the Honda Civic and the Toyota Prius. Annual sales were under 20,000. American car companies were openly disdainful of Japan's hybrid initiatives.

In late 2003, Toyota introduced its third generation Prius. A mid-sized car, with exceptional features and extremely high fuel efficiency, it sparked the public imagination. By 2005, over 210,000 hybrids were sold in the United States; the Prius constituted 70 percent of sales. In 2007, sales climbed to over 400,000, almost 4 percent of the automobile market, even while overall US car sales declined. In 2008, all car manufacturers will be offering at least one hybrid model. At least 65 new hybrid models will be offered for sale by 2010.

5. The plug-in hybrid has become a serious contender.

When our original report was issued, California had just abandoned its decade old mandate for all-electric vehicles in the face of strong and continued opposition by car companies. By January 2003, all major car companies had eliminated their all-electric vehicle sale and leasing programs and were taking back their vehicles and crushing them. A report done for the California Air Resources Board concluded that, "direct efforts to develop EV batteries have generally declined over the last 3 years."[4]

Strong grassroots protests led Toyota and Ford to agree to sell their vehicles. As a result of those protests, some 800 all electric SUVs and pick up trucks ply California's roads today, traveling 120-130 miles between full battery recharges.

In Japan, the 2004 Prius was capable of traveling a mile or two on electricity only if the driver depressed a button on the dashboard to disable the software that started up the engine at very low speeds. In the United States, that button was blank, but thanks to the worldwide web and the tinkering of software and electrical engineers, the function was uncovered. In 2004, a few months after our original report, the first conversion of the Toyota Prius into a plug-in hybrid occurred with the addition of batteries sufficient to power the car for up to 9 electric-only miles, and the introduction of a socket on the car to access electricity from an ordinary household outlet.

In 2006, New York's legislature appropriated $10 million to convert all 600 hybrids in its state fleet to plug-ins. In the fall of 2007, Google issued a $10 million solicitation for proposals to commercialize electric and plug in hybrid vehicles. In 2007, A123 Systems and Hymotion announced they will offer a 2 hour conversion by certified technicians of a Prius into a 40 mile electric-only PHEV.

American car companies have now plunged not only into the hybrid market, but also into the plug-in hybrid market. Toyota, whose original marketing slogan for the Prius was, "You never have to plug it in," announced in December 2007 that hundreds of plug-in Prius cars with a 10 mile driving range would be on the road by 2010. GM announced the introduction of a plug-in hybrid, the Volt, with a 40 mile driving range, by 2010.

Advances in batteries for electric vehicles are now coming rapidly. These include many types of lithium based batteries, some taking advantage of the rapid advances in nanotechnology.

On January 15, 2008 the headline in the *Sydney Morning Herald* perhaps best summed up the sea change that had occurred: "Time's up for petrol cars, says GM chief." Five years after GM crushed the last of the all electric vehicles it had produced to meet the California mandate, the article reports, "The world's biggest car maker, General Motors, believes global oil supply has peaked and a switch to electric cars is inevitable."

6. Renewable electricity has gone mainstream.

In 2003, the nation boasted about 3,000 MW of wind power, almost two thirds having been installed in California two decades earlier. By 2007, that number had increased almost six fold, and 24 states plus the District of Columbia had enacted laws that mandate increasing levels of renewable electricity, in some cases to as much as 25 percent of total state electricity by 2020. These mandates alone will require the generation of some 60,000 MW of renewable electricity by 2020, a five-fold increase from mid 2007.

7. Biofuels have become a key component of transportation fuel nationwide.

From 1997 to 2003, ethanol sales had grown only modestly, about 6 percent a year. Ethanol remained virtually unavailable outside the corn belt. Biodiesel, a blend of chemically processed vegetable oils or fats and diesel, had yet to come to market.

But that dynamic changed when states discovered that MTBE, a fossil fuel derived chemical that accounted for more than two thirds of the octane enhancement and oxygenate markets, was contaminating groundwater. By the end of 2002 some 9 states had begun to phase out MTBE, beginning in 2004.

The phase out dramatically increased the market for ethanol. In California alone ethanol consumption increased from 57 million gallons in 2000 to more than 900 million gallons in 2004 despite having a 5.7 percent blend limit. In late 2007, California increased the proportion of ethanol allowed to 10 percent.

In 2005, Congress enacted an energy bill that did not contain a much sought-after exemption from liability by MTBE manufacturers. The result was a precipitous nationwide phase out of MTBE by blenders, leading to a huge spike in ethanol prices in the spring of 2006.

The 2005 energy bill also enacted the nation's first ethanol mandate, requiring blenders to add at least 7.5 billion gallons of ethanol to gasoline by 2012. Because of soaring oil prices and the rapid phase out of MTBE, that mandate will be exceeded by mid-2008. Twice as much ethanol production will come on-line in the next 18 months as came on line from 1978-2005.

Meanwhile, biodiesel production soared from virtually zero in 2003 to about 300 million gallons in 2007 and a possible one billion gallons by 2011.

Internationally, ethanol demand and production is growing rapidly too. By the end of 2005, China produced more than 1 billion gallons, India about 700 million. India had imposed a 5 percent ethanol blend in several of its most populous states. The European Union urged its member states to achieve a 5.7 percent biofuels blend in all of their transportation fuel by 2010.[5] By 2006, several European countries were urging the EU to establish a 10 percent mandate rather than a 5.7 percent target.

8. Flexible fueled vehicles have become visible.

In 2003, some 2 million flexible fueled vehicles (FFVs) were on U.S. roads, but few Americans who owned these cars knew they were capable of using high blends of biofuels. Moreover, even those owners who did found it virtually impossible to locate a pump that supplied the blend. Fewer than 50 pumps around the country dispensed 85 percent ethanol (E85).

In mid-2007, over 6 million FFVs were on U.S. roads. By December 2007, the number of E85 pumps passed 1,500, more than double the number the year before. The introduction of E85 pumps slowed when Underwriters Laboratory (UL) withdrew its pro forma approval for such pumps in early 2007. But, in late October 2007, UL reinitiated the process.

In Brazil, all pumps contain a minimum 22-25 percent ethanol content. In the 1980s, car companies were required to offer 100 percent ethanol fueled cars. The result was a universal high-blend refueling infrastructure. In the early 1990s, the demand for dedicated ethanol cars collapsed when ethanol supplies fell as sugar producers diverted their product into the more lucrative export market. In May 2003, the first FFV was introduced for sale in Brazil. It was an instant success because it eliminated the concern about possible ethanol shortages while allowing car owners to fill up with high blends when cheaper ethanol was available. Today some 90 percent of all new cars sold in Brazil are capable of driving on 85-100 percent ethanol.

9. Cellulosic ethanol is (almost) here.

At the time we issued our original report, the prospects for cellulosic ethanol were, and for more than a decade had been, tantalizingly bright, but never-quite-ready for prime time. In April 2004, Iogen began operating the world's first pilot cellulose to ethanol plant in Canada. By mid-2007, a dozen such plants were operating around the world. The U.S. Department of Energy approved grants to six companies to build commercial size cellulosic ethanol plants by 2010. Companies in Spain, Brazil and China promise to have commercial sized cellulosic ethanol plants by 2011. Ground breaking for several commercial cellulosic ethanol plants occurred in late 2007.

Section II: The Energy Independence and Security Act of 2007

Any strategy designed to reduce our dependence on petroleum and our greenhouse gas emissions must focus on transportation. Transportation consumes about 68 percent of all oil used each year, and generates about 30 percent of the nation's greenhouse gases.

Cars and light trucks use about two thirds of the oil consumed in the transportation sector. Heavy trucks consume about 20 percent, and airplanes about 12 percent.

The week before Christmas, the President signed an energy bill that targeted the transportation sector with two provisions that could dramatically accelerate the transition to dual fueled vehicles and dramatically reduce our reliance on oil.[6]

1. Vehicle Efficiency

The new law requires an increase in vehicle fuel efficiency, from the existing combined fuel economy average of about 24 miles per gallon, to 35 mpg in 2020.[7]

Although less than the fuel economies of European and Japanese vehicles, the 12 year mandated percentage and absolute increase is greater than anything Europe or Japan has accomplished in the last 25 years. Moreover, it is likely the efficiency standard for cars alone will be over 41 miles per gallon, higher than the fleet average of new cars in Europe.

Unlike with previous Corporate Average Fuel Economy (CAFE) standards, each car company is not required under the new law to achieve the same fuel efficiency levels. Each is required to improve the fuel efficiencies of its vehicles by more or less the same percentage. This arrangement was done at the request of US carmakers who worried that, given their reliance on big trucks (and their precarious financial state) meeting the 35 mpg standard might well drive them into bankruptcy.

Thus, the Department of Transportation will develop efficiency standards for each major vehicle category and each major car company. The overall industry fleet average must be 35 mpg in 2020, but the efficiency standards for different types of vehicles will vary.

Figure 1 offers an educated guess of staff at the Transportation Research Institute of the University of Michigan about what fuel efficiencies might be required.[8]

As the table reveals, cars may have to raise their fuel efficiency to over 41 miles per gallon, while SUVs may be required to achieve efficiencies closer to 29 miles per gallon. On the other hand, still using this example, the car's efficiency will have to improve by about 40 percent, while the SUV's improvement will be about 50 percent.

Figure 1: Possible New CAFE Standards for Vehicles and Automakers

Estimated CAFE Standards by Automaker (Miles per Gallon)

	2005	2020
Chrysler	22.0	33.3
Ford	22.1	32.9
GM	22.1	33.4
Honda	28.2	39.2
Nissan	24.0	36.5
Toyota	26.5	37.5
U.S. Market	**23.7**	**35.0**

Estimated Fuel Economy by Segment Under New CAFE Standards (Miles per Gallon)

	2005	2020
Car	28.9	41.6
Crossover Utility Vehicle	25.7	37.2
Minivan	23.7	35.6
Pickup	19.2	29.7
SUV	19.8	29.4
Van	17.7	27.3
U.S. Market	**23.7**	**35.0**

Car companies will adopt many techniques to improve efficiencies (lighter weight materials, direct fuel injection, turbocharging). However, hybridization likely will be a key strategy, especially for larger vehicles.[9] Depending on the configuration, hybrids can improve fuel efficiency by 30-35 percent, close to the average 45 percent efficiency improvement mandated by the new energy law.[10]

The energy bill also authorizes billions of dollars in loans and grants to help car companies retrofit existing manufacturing and assembly facilities for the production of improved efficiency vehicles, specifically including plug-in hybrids (PHEVs) and all electrics. But the impact of these provisions awaits the passage of appropriations in mid to late 2008.

At present, PHEVs will probably have no higher an efficiency rating than many of their hybrid counterparts, since on an energy equivalent basis, a car traveling on electricity gets about 50-60 miles per gallon. However, the energy bill directs the Secretary of Transportation, by January 31, 2009, to develop a methodology to develop tradable credits for electric drive cars. A plug-in hybrid, for purposes of this section, is defined as a car that "draws motive power from a battery with a capacity of at least 4 kilowatt hours."[11]

Hybrids can raise fuel efficiency by 35 percent, close to the average 45 percent efficiency improvement mandated by the new energy law.

One provision of the energy bill could have a profound impact on the number of all-electric vehicles on the road. To understand why, a little history may be useful.

The 1988 Alternative Motor Fuel Act (AMFA) ordered federal agencies to develop an incentive for alternative fueled vehicles based on their displacement of gasoline in determining CAFE standards, not just their fuel efficiency. Since a gallon of ethanol requires only about .15 of a gallon of gasoline to grow the corn and convert it into ethanol, the AMFA multiplied the fuel efficiency for ethanol-fueled miles by 6.67.[12] This multiplier only applied to vehicles primarily driven by an alternative fuel.

As a result of this incentive, the federal government estimated that if a flexible fueled Chevy Silverado, for example, used a 50 percent ethanol blend and was normally rated at 17 mpg city and 21mpg highway, it would be awarded a rating of about 42 mpg/52 mpg.

The alternative fuel formula for E85 vehicles was very controversial. For the first 10 years the vast majority of E85 vehicles, although credited with very high fuel efficiency because of their potential for displacing gasoline, almost always filled up only with the normal 10 percent ethanol blend because virtually no E85 pumps were available. Yet because of the high CAFE ratings of E85 cars, U.S. car makers were able to continue building low mileage vehicles while still satisfying the mandated levels. Indeed, virtually all flexible fueled vehicles sold in 2007 were low mileage SUVs and pick up trucks.

Congress recognized the potential for abuse in the 1988 law by limiting the maximum average fleet efficiency credit a given car company could receive from the Alternative Fuel Vehicle (AFV) incentives to 1.2 mpg from 1993-2004 and, in 2005, 0.9 mpg. Thus a car company could use FFVs to increase its fleet average from, say 26.5 to the required 27.5 mpg, but it could not use FFVs, no matter how many it sold, to increase its fleet average from, say, 25 to 27.5 miles per gallon

The new energy bill caps the maximum fleet average efficiency credit for AFVs at the old 1.2 mpg through 2014 and then decreases the cap by .2 mpg a year until in 2020 it is fully eliminated.[13]

All-electric vehicles were not included in the alternative vehicles category under the 1988 law. In separate legislation, Congress specifically ordered the Department of Energy to establish a fuel efficiency rating for all-electrics, as it had done for AFVs. That is, taking into account only the small portion of our electricity generated with oil.

What is most important is that in this separate legislation Congress exempted the all-electric vehicle from the AFV mileage credit cap. Thus car companies can take an unlimited amount of credit for the much higher CAFE efficiencies of electric vehicles. In 2000, DOE issued the standards, adopting the existing 6.67 multiplier used for AFVs.[14] As a result, in a sample calculation, DOE estimated the fuel efficiency rating of an electric vehicle that consumed .22 kWh per mile: 335 miles per gallon!

The new energy bill maintains the exemption of all-electric vehicles from AFV limits.[15] This could well lead to a vigorous effort by car companies to manufacture and sell all-electric vehicles since a modest number of these vehicles could offset the lower mileage of a very large number of higher profit vehicles. For example, assuming that cars as a category are required to improve fuel efficiency from a 2005 average of 28.9 mpg to a 2020 average of 41.6 mpg, a single sale of an all-electric compact car could allow the continued sale of about 23 full sized cars with lower efficiencies.

2. Renewable Fuels

The other key provision of the energy bill deal is an increase from the current 7.5 billion gallon ethanol mandate to a 36 billion biofuels mandate by 2022. This is a six fold hike from actual 2007 biofuels production. For the first time, a specific biodiesel mandate is included: 1 billion gallons by 2012, included in the advanced biofuels total.

The new mandate caps corn derived ethanol at 15 billion gallons. In essence, the new mandate allows corn derived ethanol plants currently in the construction pipeline to become operational while requiring all additional ethanol to come from other feedstocks. Corn derived ethanol production will grow to 15 billion gallons in 2012-2015 and then remain at that level through 2022. But after 2012, the majority and then after 2014, all of the additional ethanol will come from non-corn and increasingly, from cellulosic feedstocks.

Congress, in effect, mandated the rapid development of a fuel from an industry and technology and even a feedstock that doesn't yet commercially exist.

By agreement of the two political parties, the energy bill contained no tax provisions. In 2008, tax incentives for a wide range of fuels and technologies will likely be enacted. These will include additional incentives for E85 pumps as well as new incentives for plug-in hybrid vehicles.

Taken together, the efficiency and renewable transportation fuels provisions should greatly accelerate the introduction of hybrids, plug-in hybrids and flexible fueled vehicles. And these in turn will accelerate the use of electricity and biofuels as transportation fuels, moving us toward an oil free, electric-alcohol transportation system.

Section III:
A Dual Fueled Transportation System

The breakthrough for a dual fueled transportation future came with the introduction of the hybrid electric vehicle into the U.S. market by Toyota and Honda in 2000 and 2002 respectively.

Initially, American car companies discounted the hybrid. But the unprecedented market response to the 2004 Prius led American car companies to begin introducing their own hybrid models in 2005, and in increasing numbers in 2008. In 2007, hybrid sales increased by about 80 percent, while new car sales declined by 2 percent. That year hybrids comprised about 4 percent of car sales, and 2 percent of overall vehicle sales.

Hybrid vehicles boast both a gasoline engine and an electrical propulsion system motor. They reduce gasoline consumption in three ways.

1. By shutting off the engine when stopped and using the motor to initially accelerate. Idling and acceleration are the two areas where the vehicle operates most inefficiently.[16]

2. By converting some of the kinetic energy generated by braking into electricity and sending it into the battery system.

3. By allowing the engine to operate closer to its peak efficiency. Car engines tend to be oversized. Most of the time only a fraction of their power is needed (e.g. when maintaining a modest speed on a flat terrain), which results in very low operating efficiencies. The smaller hybrid engine can operate near optimal efficiency.

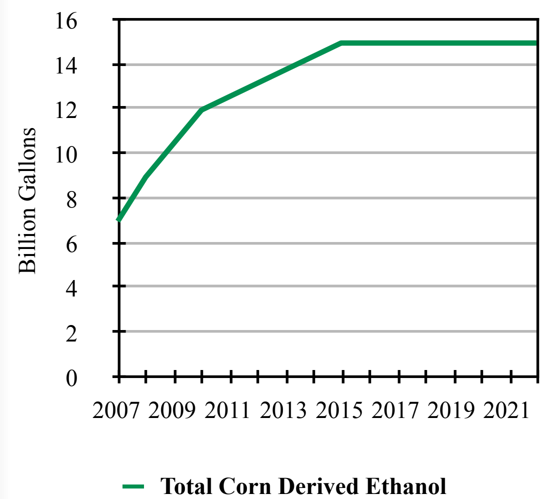
Under the new CAFE standards, a single sale of an all-electric compact car could allow the continued sale of about 23 full

The current generation of hybrid electric vehicles, however, suffers two key shortcomings. They cannot power the car solely on electricity for more than a mile or so, if at all, and they rely on a gasoline powered engine to charge the batteries. Thus, although a hybrid reduces gasoline consumption, it is still entirely dependent on gasoline.

The industry designates this generation of hybrids HEV0, the zero indicating the number of miles the car can travel on batteries alone. (The 2004 Prius actually can travel a modest distance on electricity only, under a mile at low speeds and with a light load).)

Hybrids configured to use electricity for much or most of their propulsion expand the battery capacity significantly and add an external socket to allow the car to be plugged into the conventional grid system. Hence the name, “plug-in”.

Figure 2: Mandated Corn Derived Ethanol

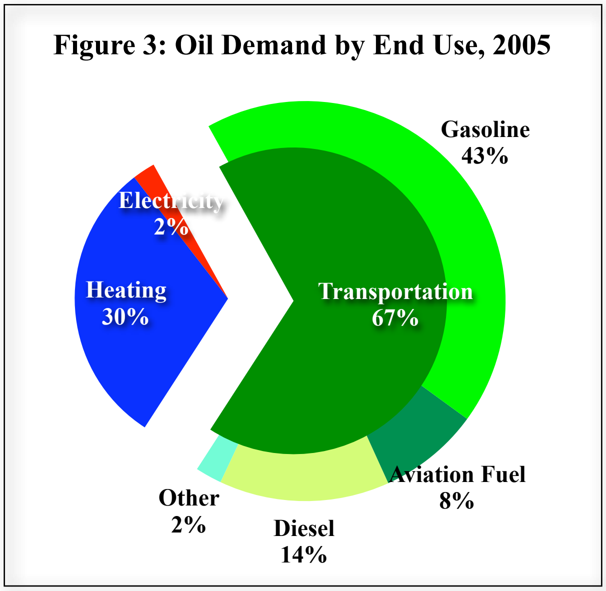


The Institute of Electrical and Electronic Engineers (IEEE) defines a plug-in as any hybrid that:
1) contains at least a battery capacity of 4 kWh used to power the vehicle, 2) has the ability to drive at least 10 miles in all electric mode and 3) recharges the battery from an external source of electricity.

The new Energy bill defines a plug in as a vehicle with electrical storage capacity of at least 4 kWh. It does not require a minimum all electric driving range.

The plug-in Prius now being tested on the streets of Japan is a PHEV9. That is, it can travel for 9 miles solely on electricity. Converted Priuses are usually PHEV20. The Chevy Volt, to be introduced in 2010, will be a PHEV40, having a 40 mile driving range without need for recharging.

For Bob Graham, area manager of the Electric Power Research Institute's (EPRI) transportation program, plug ins are "the logical next member of the family of



hybrid vehicles...With the possible exception of the batteries, plug-in HEVs require only evolutionary engineering advances over HEV0 technology to meet technical requirements."

Even a modest storage capacity with a modest driving range (e.g. 10-20 miles) could have a major impact on gasoline consumption since half of all cars on the road travel a total of about 30 miles each day.[17] Many urban vehicles are driven much less.

Drivers with the capacity to use electricity will likely try to maximize electric-only miles.

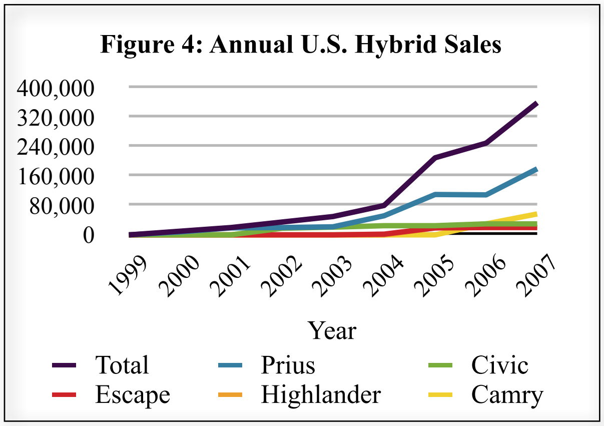
Why? Because the fuel costs of an electric-only mile is 2-3 cents, while the fuel costs for a gasoline engine propelled mile are 12-14 cents. This spread is two to three times that of the late 1990s, when oil prices were much lower.

This report presumes that 75 percent of the miles driven will be powered by electricity. The other 25 percent will come from biofuels.

The emergence of biofuels as a potentially significant transportation fuel has depended on another technological development, although one not nearly as dramatic as the advent of hybrid vehicles: the flexible fueled car.

The flexible fueled car, first available in the United States in 1990, can run on gasoline or ethanol or any combination. The cost to the car manufacturer is very small, estimated to be less than $100.

The Achilles heel of a biofuels-only strategy to replace gasoline is that these fuels can never provide more than

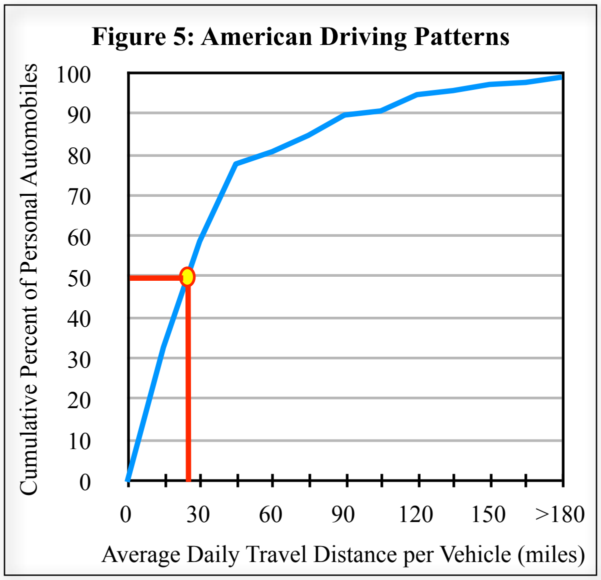


a minor portion of our transportation fuels, until or unless the harvesting of algae for oil becomes practical. We lack sufficient land area.

To replace 60 percent of our current gasoline with biofuels would require about 110 billion gallons, which in turn would require about 1-1.5 billion acres of land, about 12 times the land area currently devoted to corn, by far our biggest crop.

Per acre yields of cellulosic crops are now much less than corn, but they will undoubtedly increase. Yet, it may take a generation, or two, before they exceed 10-15 tons per acre, a level needed to reduce the amount of acreage dramatically.

If 25 percent of the miles driven will be powered by an engine using biofuels, a little over 50 billion gallons of ethanol and 10 billion gallons of biodiesel will be required.



A Primer on Hybrids

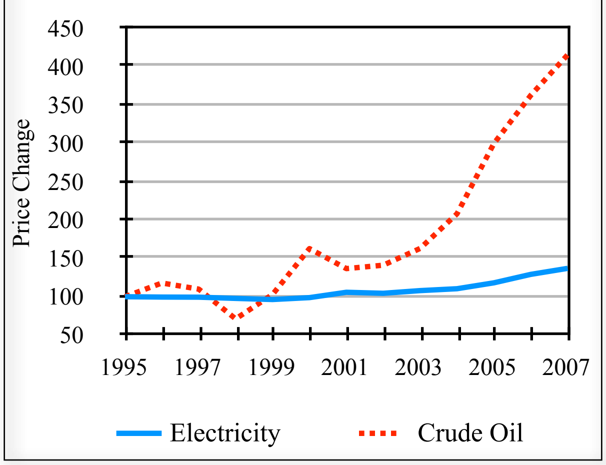
Hybrids come in three basic configurations:

Series- The car is powered solely by the electric motor. The gas engine is used solely to charge the batteries.
Example: GM's anticipated Volt.

Parallel- The car can be powered by the engine and the motor, but not by the motor only.
Example: Honda Accord.

Combination- The car can be powered by either the engine or the motor or both.
Example: Prius.

Figure 6: Average Electricity and Oil Prices, 1995-2007 (1995=100)



Sufficient land area is available to provide this level of ethanol production. The 36 billion gallon mandate takes us over 60 percent of the way to this goal. But we lack sufficient vegetable oils to manufacture the biodiesel necessary. New, much higher yielding, oil crops will be needed to meet the biodiesel targets.

In a dual fueled transportation system the electric battery will compete with biofuels, since both are energy storage systems.

If battery prices drop significantly, it is likely that little or no biofuels will be needed (for all electric vehicles). If electric prices rise and biofuels prices decline, they may power more than 25 percent of the driving miles.

Let the competition begin.

We are reshaping our transportation system. This will take several decades, at least, and cost hundreds of billions of dollars. We are very much at the beginning.

The first nationwide plug-in conversion kit for hybrids will become available sometime in 2008. The first commercial plug-in vehicle will be available in 2010. The first commercial sized cellulosic ethanol production facility will be online in 2009-2010.

We are rewriting the rules to channel entrepreneurial energy, investment capital and scientific genius in the right direction. But what is the right direction?

To date, national and state policy makers have embraced only three overlapping goals: more renewable energy. less petroleum and reduced greenhouse gas emissions. These goals are admirable. But there are other equally admirable and achievable ends: strengthening community, building stronger local and rural economies, creating a more durable foundation for American and world agriculture.

To accomplish these ends, we need a dual fueled transportation system that maximizes the benefits to society. A key is to dramatically broaden the ownership of energy production.

This report presumes 75 percent of the miles driven will be powered by electricity.

Energy security to policy makers means reducing our oil dependence on a handful of foreign, and often hostile, nations. To many Americans, the concept can be extended to reducing our energy dependence on a handful of increasingly foreign owned corporations.

A more democratic energy system, where millions of locally owned energy and fuel production plants characterize the new economy, should be an integral objective in policies designed to move toward a dual fueled transportation system.

Democratizing our Energy System

Electricity

The introduction of millions of plug-in hybrid and all-electric vehicles can reverse current national and regional policies that increasingly circumscribe and preempt local and state authority in order to accelerate the construction of high voltage transmission lines to carry electricity thousands of miles from where it is generated, to where it is consumed. The collective electrical storage and generation capacity of the new dual-fueled vehicles can provide the foundation of a new electrical system that relies largely on dispersed generation serving local markets.

The new, plug-in hybrid vehicles, depending on their battery capacity, may represent a large new electric consumer, increasing electricity demand, at least in residential neighborhoods, by 10-25 percent.

This new demand may stress low voltage distribution lines. On the other hand, the storage capacity of the new PHEVs can allow for the use of off peak electricity and the generation of electricity by the vehicle itself at peak times, which would reduce the load on these lines. As a result, the "energy neighborhoods" on the other side of the lower voltage transformers can become a basic unit for electricity planning.

A recent exploration for the Sacramento Municipal Utility District, the nation's 5th largest public utility with 570,00 customers, found that PHEVs could power nearly half of its peak load for over an hour, and could fill in for 250 MW of wind for 8 hours.[18]

Plug-in hybrids can overcome the central shortcoming of sunlight and wind power: intermittency. The wind doesn't always blow and the sun doesn't always shine. If we can store electricity when the wind does blow and the sun does shine in vehicle batteries and then tap those batteries when electricity is needed, we've moved a long way toward making renewable energy firm energy.

A symbiotic relationship between the storage systems of PHEV cars and renewable electric generators may emerge. The cars will, of course, become an increasingly important new consumer of electricity at the same time as state mandates make renewable electricity an increasingly important provider of electricity. The collective storage capacity of millions of PHEVs can dramatically increase the percentage of electricity that can come from renewable fuels. One study estimated that if one third of the vehicles were PHEVs, wind energy could supply 50 percent of our electrical needs without negatively impacting grid stability and reliability.[19]

PHEVs can allow us to rethink the reigning paradigm of electrical generation and transmission: high voltage transmission lines sending electricity thousands of miles from a few hundred large central power plants.

Instead of more long distance high voltage power lines we can make more efficient use of existing lower voltage lines. Indeed, a recent utility study provided empirical evidence that some 25 percent of Minnesota's electricity demand could be met by wind generated electricity injected into the existing grid.[20] (The study did not examine the impact of PHEVs, which might substantially increase this level.)

Today, the vast majority of wind turbines are absentee-owned, a characterization true since the early 1980s, when utility scale turbines were first installed. Yet, local ownership could be much more widespread, to the considerable advantage of rural communities.

A wind developer may pay a farmer land-lease payments of $4,000-6,000 a year, per turbine. If the landowner owns the turbine, however, his or her revenue can double or even triple during the 10 year financing period. After the turbine is paid off, annual income could reach $100,000.

If wind generated electricity powered 75 percent of all vehicle miles, the nation would need about 115,000 MW of wind. By the end of 2007, some 17,000 MW were installed.[21] If 25 percent or more of the additional wind turbines were locally owned, millions of rural households could directly and handsomely profit from our march toward a sustainable economy.

Wind, of course, is not the most decentralizing and democratic of all renewable energy sources. That honor goes to sunlight. Sufficient sunlight falls on the average roof to provide all the electricity needed by the family PHEV, on an annual basis. During a recent visit to California to assess the state of development with electric and plug in electric vehicles, I discovered, unsurprisingly, that every one of the people I interviewed who owned an electric or plug-in electric vehicle had a rooftop solar electric array, usually in the 3-4 kW range. When the electric vehicle mandate was in place, parts of California boasted solar cell canopies over parking lots that recharged electric vehicles plugged into outlets at the meters.

In 2008, one company embraced an even more extreme example of decentralized refueling by adding a convex solar roof to a Prius, Highlander Hybrid and Ford Escape Hybrid. With the solar roof, the fuel economy of the Prius can improve by up to 29 percent, says Greg Johanson, President of Solar Electrical Systems.[22]

Biofuels

On the biofuels side of the dual fuel equation, thousands of biorefineries, if farmer owned, could reform the nation's traditional farm policy. Instead of providing billions of dollars in subsidies to farmers so that they can offer their crops at prices below their cost of production to increasingly concentrated and remote wholesale markets, the new policy could encourage farmers to become owners of the processing and end-product manufacturing facilities that serve local and regional markets.

Today's biorefineries are largely absentee owned and large (100 million gallons and up), a dramatic change from 2002 when most were locally owned and of more modest size (30-40 million gallons). A 50-billion gallon national market for ethanol could support about 1,000 50-million gallon per year biorefineries.[23] This translates into one large new manufacturing facility in every third county in the nation. Assuming an average of 400 local investors per facility, some 400,000 households would have an equity interest in these ventures, a substantial portion of full time grain farmers.

Farmer owned biorefineries have proven their value to farmers and local economies. Until recently, when corn prices skyrocketed, farmers who had a share of an ethanol facility earned more profits from that share each year than they earned from selling their corn.

From 1995 to 2003, Minnesota farmer-owners of ethanol plants received an annual return on investment of about 15-18 percent. Each of the 650 farmer owners of the Chippewa Valley Ethanol Company in Benson, Minnesota (population 2,300) earned ten times their original investment.

Farmer owned biorefineries also act as a hedge against crop price fluctuations. When the price of the crop falls, the input costs to the biorefinery drops. All other things being equal, dividends then go up. An ILSR investigation concluded that for every 50 cent drop in the price of corn, on average a farmer may recover 35 to 50 cents as a result of increased dividends from ownership in an ethanol plant.

An absentee ownership structure not only weakens the link between ethanol production and agricultural prosperity, but may also cause long-term problems. Absentee owners of wind turbines, for example, invest to make use of the tax benefits, which end after 10 years. Chances are absentee owners will not make the necessary follow-up maintenance investments to continue a high reliability operation after these tax benefits expire. Farmers, though, often view the investment as a way to provide ongoing supplemental revenue to keep them, and their sons and daughters, on the land.

Farmer-owners have largely ignored capital appreciation because their crop ties them to the processing facility and because they take a long-term view of their biorefinery investments. In fact, when ethanol prices were high last year, private equity investors on Wall Street offered farmers as high as 400 percent more for their shares in ethanol plants than the farmers had paid, yet only two of the 56 farmer-owned ethanol facilities sold out.

Wall Street, however, focuses almost entirely on capital appreciation, seeking to "exit" their investments through their sale to a wider population of absentee owners.

The potential for reviving farmer ownership of corn/ethanol plants is small. Virtually all of the ethanol currently in the pipeline will come from large, absentee owned facilities. And Congress has established a cap (15 billion gallons) on the amount of the corn derived ethanol that can receive credit under the mandate.

But the cellulosic ethanol industry, including the cultivation of cellulosic crops, is just beginning. Policy makers have the duty to develop rules that marry energy, environmental, economic and social objectives.

Bigger Isn't Better[24]

Small scale production facilities are an essential ingredient for a locally owned and dispersed energy system. Communities cannot raise the equity capital needed to finance a 100 million gallon biorefinery or to finance a 200 MW wind farm.

A major objection to policies that encourage smallness is the economies of scale of larger production plants. Economies of scale do exist. But the data argue that many engineering economies of scale are captured at surprisingly modest scales. And, bigness also generates diseconomies of scale which offset, and at times completely eliminate, the economies gained from larger production units.

For example, transportation costs may rise, offsetting the decreased unit cost of production. Feedstock must be brought in from further away and the end product sent to more distant customers.

Increasing the size of an individual wind turbine lowers costs significantly. But the impact on net costs of increasing the size of an individual wind farm is more problematic.

Increasing a wind farm from 10 MW to 200 MW can lower levelized costs by 25% (1.5 cents/kWh off a baseline price of 6 cents). However, the remote location of most large wind farms incurs significant diseconomies because of the need for increased transmission , offseting some or even all of the unit size economies.

Since the output of electricity from wind turbines varies dramatically with small changes in the wind speed, there is a significant cost advantage to locating clumps of wind turbines in remote locations boasting high wind speeds. Once again, however, this advantage is significantly offset by having to build high voltage transmission lines to transport the electricity to distant population centers.

If we begin to harness lower wind speeds, we increase exponentially the number of communities that can become energy generators. In Minnesota, wind turbines are clustered on less than 1 percent of the land that has the highest wind speeds. But as Figure 7 reveals, at 80 meters about 70 percent of Minnesota may boast wind speeds sufficient to produce commercially priced electricity.

Large wind farms benefit from being able to spread overhead costs, such as management salaries and maintenance expenses, over many turbines. But many of these same savings can be gained when the owners of wind turbines cooperate to contract out maintenance and other overhead costs to a single entity.

As for biorefineries, economies of scale also exist, but they are mostly captured at a modest scale. Up to 90 percent of the decreased cost stemming from an increase in the capacity of an ethanol plant from 10 million to 100 million gallons is gained when the plant's output rises from 10 million gallons to 40 million gallons. Only about 10 percent of the decrease, perhaps 2 cents to 3 cents a gallon, is gained from the plant's size rising further to 100 million gallons.

With biofuels, feedstocks comprise 50-70 percent of production costs. This has encouraged the vast majority of existing and proposed plants to locate in

Figure 8: Absentee vs. Local Ownership, 20-year Net Income

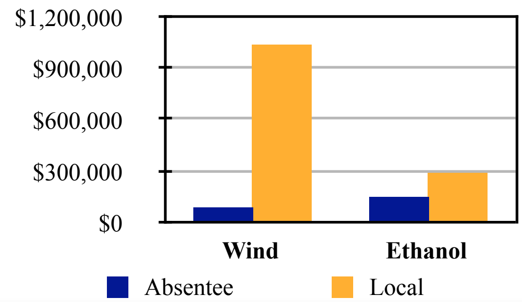


Figure 9: Farmer Return on Investment in CVEC Ethanol Plant

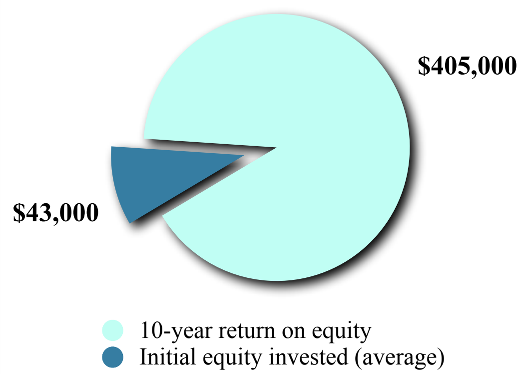


Figure 7

Minnesota's Wind Resource by Capacity Factor at 80 Meters

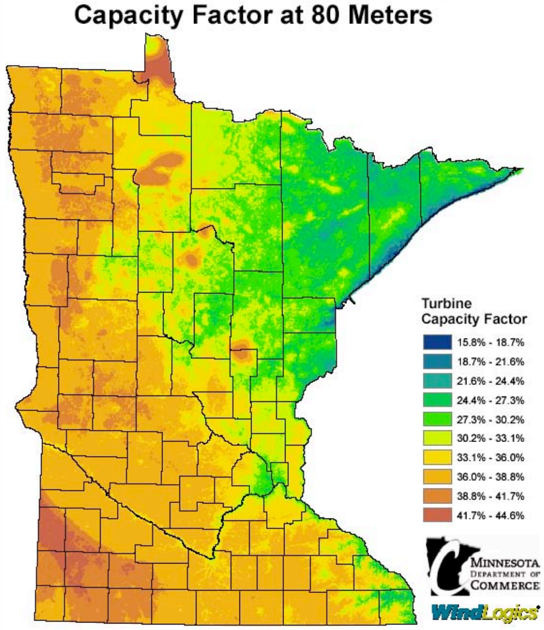
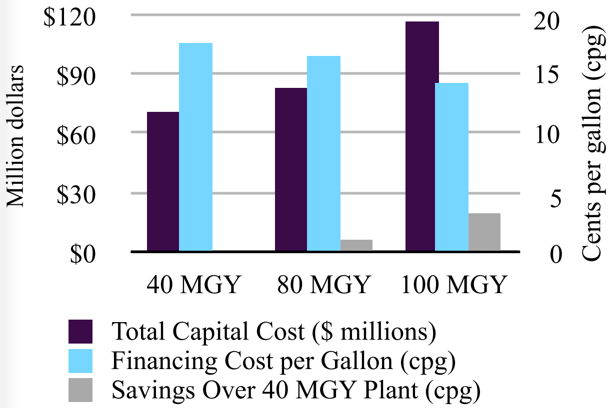
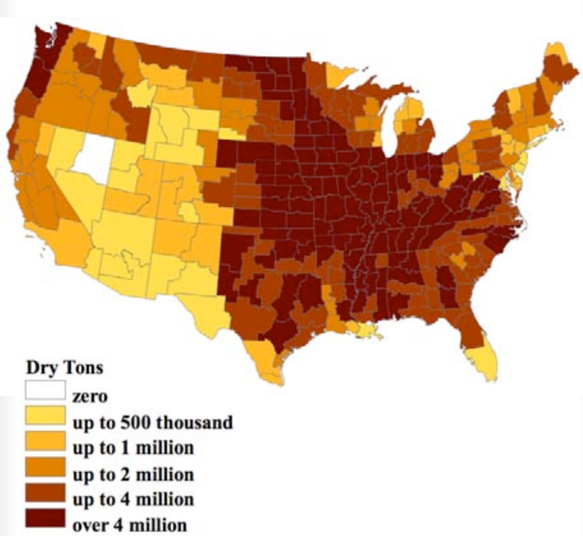


Figure 10: The Savings from Large Ethanol Plants Are Modest



states with large corn and oilseed production. But the coming of cellulosic ethanol brings the very real possibility for a dramatic dispersion of production, with many modest-size facilities setting up nearer the ultimate customer. More than half the states have regions within them that could produce up to 4 million tons of biomass by 2015, sufficient to supply five to 10 ethanol plants.

Figure 11: Most States Have Biomass



A Word About Global Implications

A dual fuel transportation system is not just for the United States. Anything the US does to move in this direction will have a significant impact on global car markets. Policy makers in other countries are beginning to assess the impact of these developments.

On the electricity side of the dual fuel equation, many countries are still elaborating their electric grid systems. Thus, they have the opportunity to adopt a new paradigm and new protocols to encourage dispersed electric generation for local and regional markets.

The biofuel side of the equation is much more challenging. Unlike with electricity, the agriculture and forestry sectors and industries are already established. And the structure of agriculture in many countries is a legacy of hundreds of years of unequal and uneven development by foreign investors and domestic elites, underwritten for many of those years by slavery and near-slavery conditions.

The rapid run up in the demand for biofuels has aggravated this exploitation. But biofuels did not create that exploitation. Even before the current biodiesel boom, for example, the situation in south Asian palm oil producing countries was problematic. A report in August 2001 by the World Rainforest Movement was instructively entitled, *The Bitter Fruit of Palm Oil*.

Biofuels are not inherently inequitable for developing countries. Indeed, non-oil producing, equatorial countries may have an even greater incentive to use biofuels because they can strengthen rural economies and thereby prevent the disruptive exodus of millions from country to city. And homegrown biofuels can allow countries to stretch their hard earned and scarce foreign currencies.

Biofuels, for developing countries, need to be integrated into a broader program of land reform and capitalization of small farms. And they should serve domestic, not international, markets.

Recently, the European Union, responding to protests about the damage resulting from European policies mandating biofuels, has declared it will impose conditions on imported biofuels. The criteria will focus on the methods of cultivation and the overall environmental impact. They should also take into account the impact of biofuels development on local communities.

Section IV: Everything You Wanted to Know About a Dual Fueled Transportation System, but Were Afraid to Ask

The Electric Side

Q. How much electricity would be needed to power 75 percent of the miles traveled by a single vehicle?

A. Although driving habits vary widely, the average car travels about 12,000 miles per year, according to the AAA. Seventy-five percent of this is 9,000 miles. The amount of electricity required to power a vehicle for one mile depends on the weight of the vehicle and the amount of acceleration used. Most vehicles use 0.26-0.46 kWh per mile. Thus a household would need 3000-5000 kWh to power the family PHEV. This would make the car the largest single household appliance.

Q. How much electricity would be needed to power all light duty vehicles?

A. In 2006, cars and light trucks traveled about 1.6 trillion vehicles miles. To power 75 percent of these miles would require some 10 percent of 2006 electrical generation

Q. How many new power plants would be needed to generate that additional electricity?

A. None, at least in the short and medium run (10-20 years), if the vehicles are charged during off peak hours. The electric power system is built to meet peak capacity, that is, the electrical demand on the hottest hour of the hottest day of the year (if the utility's peak load is air conditioning), with an additional reserve of 12-15 percent for reliability purposes. For most of the day utilities have excess power generation capacity. Which means that a great deal of electricity can be consumed without building new power plants, if batteries are recharged during off peak hours.

Figure 12: Off Peak Refueling Potential By Region (6pm- 6am)

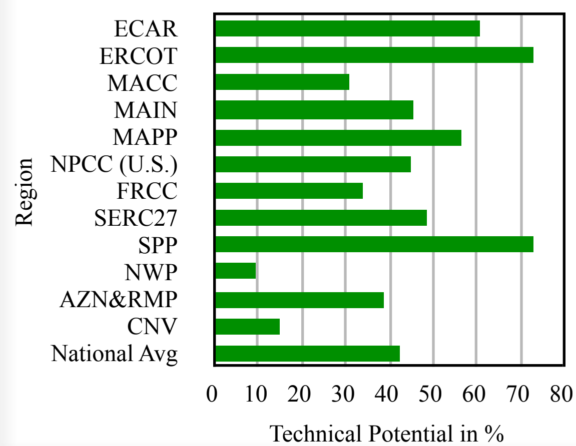
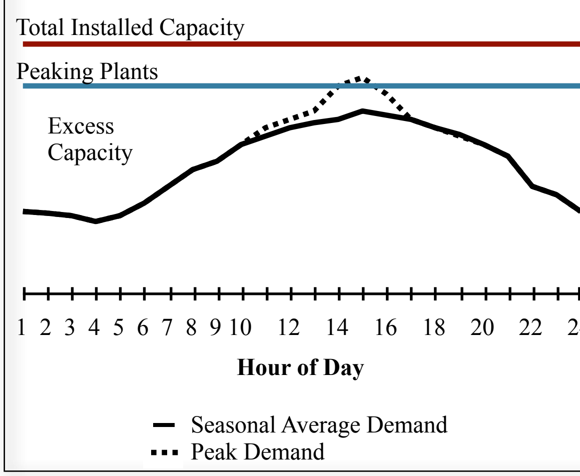
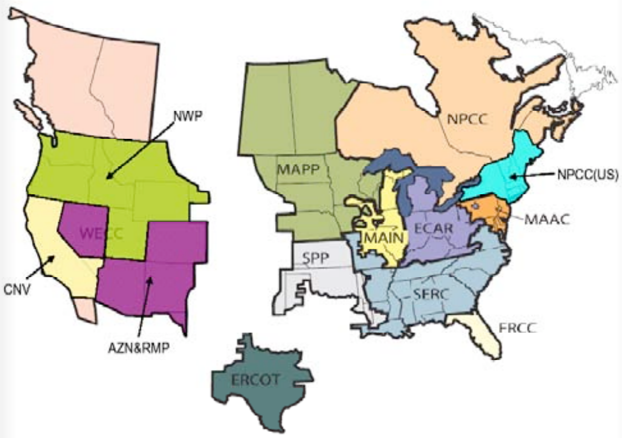


Figure 13: Load Shape for 1 Day During Peak Season



One recent study concluded that excess capacity in existing power plants could, on a national basis, satisfy 73 percent of the needs of all PHEV light duty vehicles.[25] This figure is the theoretical limit because it means using all excess capacity during all hours of the day. Doing so would lead to a heavily saturated and quite fragile electric system. More useful, perhaps is the study's conclusion that if cars were recharged only during the night (6pm-6am), 43 percent of all miles could be powered by electricity by existing power plants, getting us more than halfway to our 75 percent objective.

Figure 14: Electric Reliability Oversight



The 43 percent estimate is a national average. Excess capacity varies significantly by state and region. The national electricity system is divided into 12 regions for planning purposes. According the Pacific Northwest National Laboratory (PNNL) study, 15 percent of overall PHEV needs could be met by utilities in the Pacific Northwest and more than 70 percent by Texas utilities.

Q. Are the batteries for plug-in hybrid vehicles ready? Haven't there been problems?

A. This question requires a long answer. In the early 1990s, advances in batteries were spurred by the increased demand for electronic devices and cell phones. In the early 2000s, customers demand batteries for portable computers with ever-longer lives and ever-greater energy density, while customers for portable power tools demanded lighter weight batteries that could provide significant power output over long periods. Manufacturers also had to deal with new environmental standards that required them to remove certain toxic elements (e.g. mercury) from batteries and to ensure that they are recyclable.

In the 1990s, the California electric vehicle mandate. (the mandate was actually called a Zero Emission Vehicle mandate, but for its first decade, the only vehicle that practically could meet that standard was all electric) spurred what are called large-format batteries, that is, bigger batteries, many of which used the same chemistry as those used for powering electronic devices. Nickel Metal Hydride batteries were used by almost all electric vehicles because of their energy density and weight advantages over conventional lead acid batteries. By the late 1990s, the second generation of large format NiMH batteries were expected to last for the life of the car, and a decade later, this expectation has proven valid.

NiMH batteries are also used in virtually all hybrid electric vehicles. But in the 1990s, corporate dynamics, rather than technological developments, stalled both the technological progress in these batteries and their use. In 1994, General Motors acquired a controlling interest in the company that invented the large format NiMH battery, Ovonics. This included its patents on the manufacturing of large batteries. In 2001, Texaco purchased GM's share in GM Ovonics. A few months later, Chevron acquired Texaco. In 2003, Texaco Ovonics Battery Systems was restructured into Cobasys, a 50/50 joint venture between Chevron and Energy Conversion Devices (ECD) Ovonics. Chevron maintains veto power over any sale or licensing of NiMH technology.[26]

Until very recently, Cobasys was not manufacturing nor had it licensed the use of its large format NiMH batteries. However, in December 2006, Cobasys and General Motors announced they had signed a contract under which Cobasys provides NiMH batteries for the Saturn Aura hybrid sedan. And in March 2007, GM announced that it would use Cobasys NiMH batteries in the 2008 Chevrolet Malibu hybrid, as well.[27]

In the early 1990s, lithium ion batteries were introduced for portable electronic equipment. They have become the battery of choice because of their lighter weight, higher energy densities and longer shelf life.

Lithium ion batteries can be made based on many chemistries. Thus, the likelihood of one company monopolizing the production through ownership of patents is remote. Since 2006, there have been increasing corporate announcements about the development and commercialization of new lithium ion batteries.

In 2007, Sony announced a huge recall of small lithium ion batteries because of the possibility these batteries could catch on fire because of a thermal runaway effect, which may be inherent in the lithium ion chemistry used in those batteries.[28] Because of safety concerns, US Department of Transportation and the United Nations have passed protocols that severely limit the size of conventional lithium batteries.

This has delayed the widespread use of lithium ion batteries in hybrids and electric vehicles, although these are used by some companies converting hybrids into plug in hybrids. Toyota, for example, announced in mid 2007 that safety concerns had led it to postpone use of lithium ion batteries in its 2009 Prius hybrids.

However, hardly a week now goes by without a new announcement by major companies about their commercialization of a lithium ion battery the company insists has no safety problems, a longer life, easier starting in very cold temperatures, and a number of other advantages over conventional lithium ion batteries. Many rely on a phosphate chemistry.[29] Some rely on novel combinations of ultracapacitors and batteries. Ultracapacitors are small, inexpensive electronic devices that can store and quickly release large amounts of energy. Several companies look to combine the long cycle life, rapid charge/discharge characteristics and low temperature performance of ultracapacitors with the large energy storage capacity of lithium-ion batteries.[30]

Q. Can electric vehicle batteries be recycled?

A. Yes. Today over 95 percent of the lead acid batteries used in conventional vehicles are recovered and recycled. National laws passed in Europe and the U.S. as well as by state governments in the last ten years have forced manufacturers to design and build increasingly non-toxic and recyclable batteries.

Manufacturers have take back programs to recycle the Nickel Metal Hydride and Lithium Ion rechargeable batteries used in computers and cell phones and portable power tools. Several manufacturers have begun to develop recycling programs for the high volume of the large batteries used in electric vehicles.

Q. Can PHEVs deliver electricity to the grid?

A. Yes. PHEVs can be bi-directional , a situation dubbed vehicle to grid, or shorthand, V2G.[31]

Several demonstrations have proven the feasibility of V2G. In 2008, Southern California Edison will test the concept using a dozen or so plug-in Escapes, supplied by Ford.

The V2G concept relies on the fact that a car is parked some 23 hours of the day and on most days a significant amount of energy will remain in its batteries. Thus it is available up to 95 percent of the time for use by local utilities. The most common scenario has the vehicle owner contracting with the utility to supply what are called ancillary services. These fine tune the local grid on a minute by minute and hourly fluctuation in terms of stabilizing frequency and other factors. By one estimate, the value of such services to the vehicle owner could be $1000-5000, the most likely number being about $4000 a year.[32]

Willett Kempton of the University of Delaware anticipates that the market for regulation and other ancillary services will become saturated when PHEVs represent 5-8 percent of the fleet. As the costs of V2G fall, PHEV's might then sell their electricity to the peak power market. Collectively PHEVs would have very significant generating capacity.[33]

Finally, as V2G costs drop further the vehicle owner may begin selling storage for intermittent renewables like wind. Kempton estimates that if 8-38 percent of the fleet participates, it would enable wind energy to constitute 50 percent of the electricity in the area.

Q. If I contract with the utility, will I be stranded when it takes over control of my vehicle?

A. We are at the very beginning of developing the rules for vehicle to grid contracts. No one would be required to have a contract. The primary purpose of vehicle electric storage systems is to drive the vehicle. Delivering electricity to the grid would be a secondary purpose. Presumably, a contract would require the vehicle to be available for delivering a certain amount of electricity. That would be set at far less than the maximum storage amount. If, however, the vehicle owner ran down the battery to very low levels, it is possible that utilities could draw it down to levels where driving even relatively short distances would be impossible.

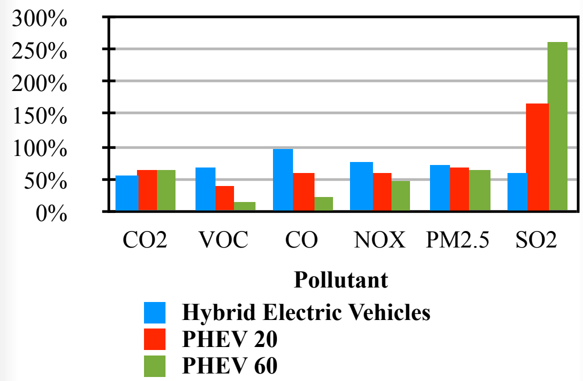
This would not be a problem with plug-in hybrids but could be an obstacle for all-electric vehicles. On the other hand, it would make the owner very attentive to keeping the battery fully charged.

Q. What impact would PHEVs have on the environment?

A. A fleet of PHEVs may not require new power plants for many years, but they will require additional electricity production by existing power plants and this will increase emissions. These would be offset by decreased emissions from burning gasoline. Many studies have analyzed the net emissions from PHEVs. On a nationwide basis, PHEVs are likely to reduce vehicle related greenhouse gas emissions, perhaps by 30-50 percent.[34] Pollutants in all categories would plummet in urban areas as emissions shifted from tailpipes to power plants usually located in less populated areas.

However, net emissions would vary depending on the power plant fuel mix in a specific region. The Minnesota Pollution Control Agency compared emissions for Minnesota, a state in which 60 percent of the electricity is generated by coal. The study assumed the other 40 percent would come from non-carbon emitting power plants, such as nuclear and wind.[35] As the chart above (Figure 15) shows, almost all pollutants, except carbon monoxide, drop significantly

Figure 15: PHEV Emissions as a % of a Conventional Vehicle (60% coal, 40% zero carbon)



when comparing a hybrid and plug in hybrid vehicle to a conventional vehicle.[36] However, when a hybrid vehicle is compared to a PHEV, some emissions rise and some emissions fall.

Precursors to ground level ozone formation like carbon monoxide, volatile organic compounds and nitrogen oxide emissions decline. Carbon dioxide emissions rise by a small amount due in part to the relatively higher carbon content per million btus of coal compared to gasoline.

The most ominous finding is that sulfur dioxide emissions rise substantially. However, the United States has a national cap on SOx emissions. Thus utilities would have to reduce emissions from other power plants to compensate, resulting in no net increase.

Overall, the shift of emissions sources from tens of millions of individual vehicles to a few hundred power plants would dramatically improve the administrative economics. Moreover, while internal combustion engine cars invariably pollute more per mile driven as they age, power plants can be monitored and regularly maintained to prevent emission increases per kWh.

Q. What investment would be required to upgrade the delivery infrastructure to support millions of PHEVs?

A. Happily, the fuel delivery system is already in place. Every building is already connected to the electric grid. At least three additions to the existing system may be necessary:

1. Convenient outlets for households that lack them (e.g. high rise apartments, buildings without garages, etc.) as well as outlets in parking lots and on parking meters.[37] The latter might be done as part of the ongoing retrofit of parking meters to accept credit cards.

2. Faster chargers that refill a battery in minutes rather than hours. Currently it takes 6-8 hours to fully recharge a battery, although in practice we can expect that most batteries will be refilled when they retain a significant charge (as gas tanks are) and often will be partially refilled (as gas tanks are) so that refueling could be done in a couple of hours. Fast chargers can refill batteries in 10-15 minutes. They require heavier wires than most households have and thus will at least initially be located at gas stations and other key places.

In February 2008, Israel, a country the size of New Jersey, announced a highly ambitious program to electrify its transportation system by installing some 500,000 charging stations, increasingly powered by green electricity, in parking spots across the country as well as 200 battery-swap stations. Customers will drive an electric car whose battery not only will give them a range of 100 miles, but also can be exchanged at no additional cost as part of the service. The Israeli-American venture estimates it will take less than 5 minutes to exchange the battery.

The idea is the brainchild of former SAP executive Shai Agassi. The project is a coalition of Israel, Agassi's Project Better Place, and Renault-Nissan. A pilot project is expected to be in place by 2009, and large scale production as well as the infrastructure rollout completed by 2011.

3. Tariffs and monitoring equipment that discourages recharging during peak hours. A number of utilities already have tariffs that offer a significant break for the use of electricity in off peak hours. But with regard to PHEVs, we will need to develop equally large disincentives to discourage filling up during peak hours. Otherwise PHEVs could lead to the need for additional power plants. A steep (e.g. 50 cents per kWh) penalty for refueling during peak hours might be salutary.

Q. How much will it cost to drive a PHEV?

A. Aside from insurance, the cost of driving includes three elements: purchase price, fuel, repairs.

Driving on electricity is far cheaper than driving on gasoline. A 25 mile per gallon vehicle and a $3 per gallon gas price results in a per mile fuel cost of 12 cents. A 0.3 kWh per mile PHEV and an 8 cents per kWh electricity price results in a per mile fuel cost of 2.4 cents. Assuming that 9,000 of the 12,000 miles driven annually are powered by electricity, the PHEV owner could save more than $750 a year.

As for maintenance, the jury is out. All PHEV manufactures will undoubtedly offer a long term warranty on batteries. Other maintenance costs, such as oil changes, belt replacement, tune-ups, should be lower than those of conventional vehicles, because the engine will be running only 25 percent of the time.[38]

A PHEV will cost more than a conventional vehicle or even a hybrid vehicle. The additional cost will depend largely on the cost of and size of its batteries. Today's hybrid and PHEV batteries might cost $800 per kWh.

If the batteries last for 120,000 miles, the cost per mile for the batteries comes to about 6.5 cents/mile. Costs of batteries are projected to decrease rapidly as production scales up. If battery costs drop to $500 per kWh, the cost per mile comes to about 4 cents per mile.

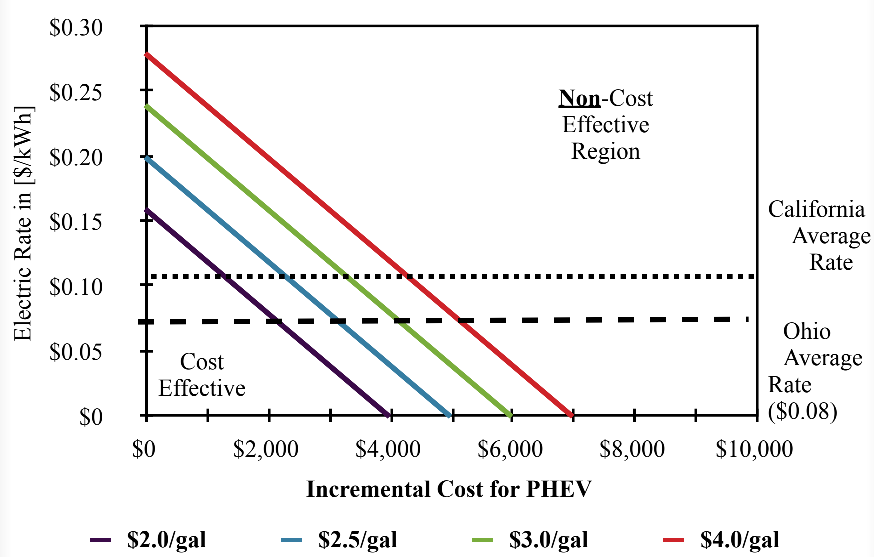
In May 2007, A123 Systems, a 5 year old MIT spinoff with 300 employees that sells several million batteries a year for highpowered handheld applications, announced that, in association with Hymotion, it will offer a 40 mile driving range battery system, including power electronics and a charger, as a 2 hour conversion for a Prius. It is unclear how much of the $13,500 price the batteries will comprise. Assuming it is 75 percent, the cost per kwh would be $800-$1000.[39]

In January 2008, United Kingdom-based Amberjac, a company that works with California-based Energy CS, the first company to offer PHEV conversions, announced the construction of a manufacturing facility to produce 500-1,000 systems of lithium ion batteries for PHEV conversions in 2008. No pricing information was made public.

Another way of approaching the issue of cost is to estimate how much more one can pay for a PHEV, given the operating savings. Figure 16 reveals that in California, where electricity is dear, a car owner could afford to pay about $3,500 more for a PHEV if gasoline costs $3 per gallon, and a little over $4,000 if gasoline costs $3.50 a gallon. An Ohio resident who pays a price for electricity closer to the national average--8 cents per kWh--could save sufficient money in fuel payments to pay more than $5000 more for a PHEV.

The comparative economics of batteries and gasoline has changed dramatically in the last 15 years. In 1995, the combination of electricity and batteries costs were about 20 cents per mile, while the cost of gasoline was about 6 cents per mile.[40] Today, the combined cost of electricity and batteries is closer to 10 cents per mile, while the cost of gasoline is moving towards 13 cents per mile.

Figure 16: How Much More Can Be Paid for a PHEV?

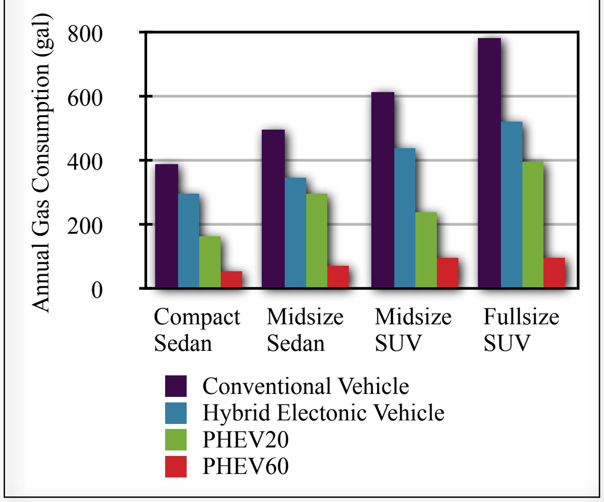


Q. What impact would PHEVs have on oil consumption?

A. Oil accounts for 40 percent of all energy use in the U.S. Transportation accounts for 68 percent of oil use. And gasoline and diesel fuel account for 2/3 and 1/5 of transportation oil consumption respectively. Less than 3% of oil is used to produce electricity. Thus, 97 percent on average of electric miles are oil free miles.

Interestingly, gasoline savings increase as the size of the car increases. This makes sense because smaller cars use less gas. A proportionate increase in efficiency will reduce gasoline consumption by fewer gallons. As Figure 17 (next page) reveals, if the car has a 60 mile all electric range, the gasoline consumption of a compact sedan drops from 400 gallons a year to about 50 gallons, while the consumption of a full sized SUV drops from 800 gallons to 100 gallons.

Figure 17: PHEV Gas Savings Are Higher For Large Vehicles



The Biofuels Side

Q. How many gallons of biofuels would be needed to fuel PHEVs?

A. Ethanol contains about 30 percent less energy per gallon than gasoline. Biodiesel contains about 10 percent less energy than petrodiesel. So 1.3 gallons of ethanol replace 1 gallon of gasoline, and 1.1 gallons of biodiesel replace 1 gallon of diesel. (Some tweaking can reduce the percent of mileage lost, but not completely eliminate it.)

Thus, to substitute for 25 percent of fuel used by trucks and cars would require about 50 billion gallons of ethanol and 11 billion gallons of biodiesel.

Q. Are sufficient feedstocks available to produce the levels of biofuels needed?

A. In the case of ethanol, yes. Ethanol is made from sugars, which are abundant in nature. Currently 90 percent of US production comes from our lowest priced source of sugar, which is corn. In Brazil, the lowest cost sugars come from sugar cane. In the future, sugars will be extracted from cellulosic materials like straw or fast growing grasses or trees. Sufficient cellulosic wastes (e.g. agricultural residue and wood wastes) are available to produce 10-15 billion gallons of ethanol. Sufficient land area exists to raise the feedstock needed to make another 50-75 billion gallons from fast growing cellulosic crops.

Ethanol can also be made by gasifying or liquefying the feedstock and converting some of the chemical streams that result into ethanol. This process relies on mass rather than sugars. To date, distillation accounts for 100 percent of ethanol production, but several gasification based cellulosic ethanol plants broke ground in early 2008.

When it comes to biodiesel, however, there is a very limited feedstock. Which is why, when biodiesel production reached even modest levels, worldwide vegetable oil prices soared. As the table (Figure 18) on the next page shows, even if we used 100 percent of our vegetable oils and greases and animal fats to produce biodiesel, we could produce only about 8 billion gallons, and it is likely that we will not be able to use more than 10-20 percent. Somewhat more might be available from higher yielding oil seeds.

It is also technically feasible to extract oil from algae. There are a number of small pilot projects in this area, but it appears that commercialization is far off. One can also liquefy cellulosic crops and convert the liquids into diesel. One company has been doing this on a small commercial scale. The output is a low grade diesel used for heating, but it could be upgraded into transportation diesel fuel, although at significantly increased cost.

Q. What impact will biofuels have on oil consumption?

A. Growing corn and converting the corn into ethanol and feed uses very little oil. Only about 15% of the energy used is in the form of oil. Natural gas is the fossil fuel both the farmer and the biorefinery rely upon. This is also true with the growing of soybeans and the making of biodiesel.[41]

Q. What additional infrastructure will be needed?

A. Making ethanol a primary fuel will require the installation of new fueling tanks in gas stations. To date there are more than 1,500 E85 (85% ethanol) refueling tanks in place in the United States. The cost of installing a 12,000-gallon E85 tank and three E85 gas pumps (dispensers) is less than $50,000. This would serve scores of cars a day. Some gas stations are converting the nozzles for lower volume grades (e.g. premium) to allow for dispensing E85. The dispenser conversion costs are modest.[42]

In 2007, the first blender pumps were installed in the U.S.[43] These pumps have two storage tanks under the ground. One contains regular gasoline and the other pure ethanol. These two fuels can be mixed to offer a wide variety of blends. It is likely that flexible fueled pumps will join flexible fueled vehicles as a key infrastructure element.

As for increasing the number of cars that can use high ethanol blends, the cost is small, about $100 a vehicle.

Figure 18: U.S. Supply of Vegetable Oils and Animal Fats	
Oil/Fat Type	**Million Gallons***
Vegetable Oils	
Soybean Oil	2,446
Cottonseed Oil	113
Sunflower Oil	74
Peanut Oil	11
Corn Oil	325
Canola Oil	80
Total Oils	**3,044**
Yellow and Brown Grease	**332**
Animal Fats	
Lard	131
Edible Tallow	228
Inedible Tallow	445
Poultry Fat	507
Total Fats	**1,643**
Total Supply	**4,687**

*Gallons of biodiesel based on a conversion ratio of 7.5 pounds for vegetable oils, 8 pounds for yellow and brown grease, and 8.3 pounds for lard, tallow and poultry fat.

No vehicle or pump modifications are needed if biodiesel is used in blends up to 20 percent, and much higher blends are possible in warmer climates.

Q. What impact will a large use of biofuels have on the environment?

A. A 2005 study by Argonne National Laboratory estimated that an 85 percent blend of corn ethanol reduces GHG emissions 18-29 percent, while the same blend of cellulosic ethanol achieves an 85-86 percent reduction.[44]

A California analysis found that an E85 car using corn-derived ethanol produces, over the entire fuel cycle , about a third less carbon dioxide equivalent greenhouse gases than a conventional car getting 27.7 miles per gallon (275 vs. 400 grams per mile).[45]

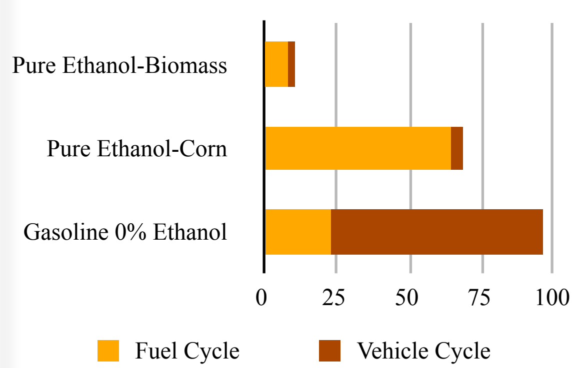
The new energy bill not only requires a dramatic increase in biofuels, but also all new biofuels produced under the mandate to significantly reduce greenhouse gases. Ethanol produced from corn will have to reduce GHGs by at least 20 percent below those generated from using gasoline. That may rule out any new coal fueled ethanol plants, at least after 2010 or so.

The mandate requires an increasing proportion of advanced biofuels that use non corn feedstocks and reduce GHGs by 50 percent below the levels emitted by gasoline. And after 2015, an increasing proportion will be cellulosic ethanol, which must reduce GHGs by 60 percent.

There have been many evaluations of ethanol's impact on air quality. What we know is that a 10 percent blend of ethanol reduces carbon monoxide (CO), a precursor for ozone formation, significantly (by more than 25 percent), and a high ethanol blend will reduce CO even more. We also know that ethanol when used as an additive, displaces the most toxic and volatile components of gasoline (e.g. benzene, toluene, xylene).

We also know that ethanol at a 10 percent or lower blend increases total volatile organic compound (VOC) emissions, another precursor of ground level ozone formation, by about 15 percent, but because ethanol itself has a lower evaporative emission rate than gasoline, higher ethanol blends (above about 30 percent) reduce VOC emissions.[46]

Figure 19: Greenhouse Gas Emissions from Ethanol Blends (grams per mile)



For cellulose, much greater reductions in environmental impacts are achieved. In part, this is because of lower inputs in growing the feedstock, but also it is because parts of the lignocellulosic feedstock used will replace natural gas to fuel the processing facilities.

One other environmental point should be made about biofuels. A biorefinery, like a petroleum refinery, will make many end products. Production will be optimized to maximize the enterprise's profit. Petroleum refineries make fuel, chemicals and other end products. Biorefineries would do the same. Indeed, ethanol may become a byproduct of many facilities. A cellulose-to ethanol facility may convert only about 25 percent of the overall weight of the material into ethanol. The rest can be used to fuel the manufacturing process and as feedstock for making higher value chemicals than ethanol. The environmental benefits, both upstream and downstream, from displacing petrochemicals with biochemicals is significant. Assuming that 600 million tons of cellulosic materials are converted into 50 billion gallons of ethanol, some 400 million tons of biological materials could become available for conversion into chemicals.

Q. What is the net energy of biofuels?

A. A remarkable number of studies have examined the energetics of ethanol. All studies conclude that the efficiency of both ethanol plants and corn farmers has increased significantly in the last 15 years. All but two conclude that ethanol made from corn yields more energy than it consumes in fossil fuel inputs.[47]

The vast majority of studies done since 1990 estimate a positive net energy generation of more than 1.3:1 for corn derived ethanol. The conclusions of a 1995 study by the Institute for Local Self-Reliance are still largely valid.[48] This study estimated a positive net energy ratio based on the national average of existing farmers and existing ethanol plants of 1.36:1 and projected a net energy ratio of over 2 to 1 if farmers used the most efficient cultivation techniques and ethanol plants improved efficiency.

Other technology advances may raise the net energy of ethanol considerably. Several ethanol facilities are in the process of substituting corn stover and wood chips for natural gas to fuel the plant. The positive net energy ratio should soar. Cellulose to ethanol plants will have an even more positive energetics ratio because the feedstock uses less energy-intensive inputs to grow and the parts of the plant not converted into ethanol can be used to fuel the biorefineries.[49]

Q. Is there a conflict between food and fuel?

A. In late October 2007, Jean Ziegler, the United Nation's independent expert on the right to food, called for a five-year moratorium on biofuels, calling biofuels "a crime against humanity" and a catalyst for "the growing catastrophe of the massacre (by) hunger in the world." His statement created a global stir. Within 24 hours a Google search found 800,000 citations to Ziegler's statement.

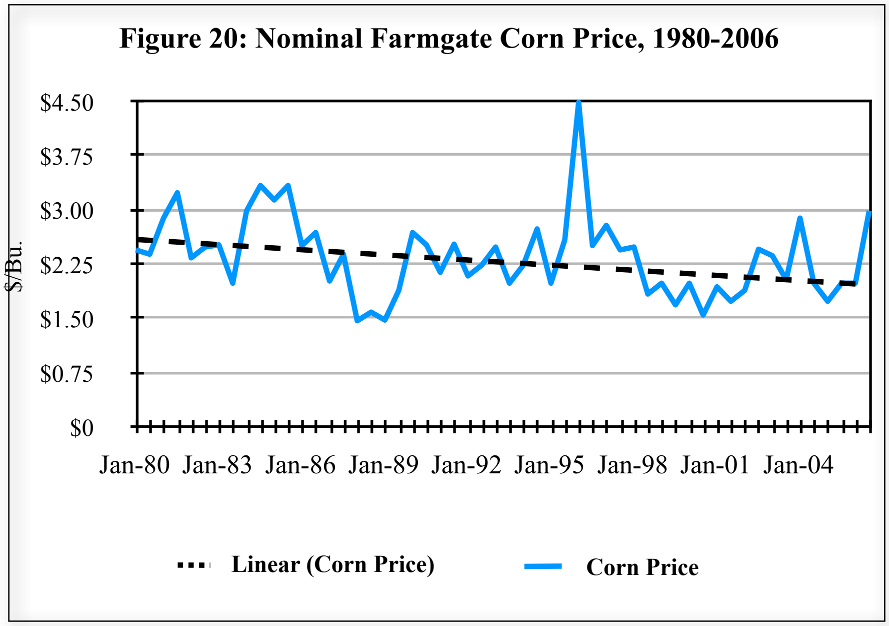
The truth is much more complex. Increased demand for biofuels increases the price of commodities like soybeans and corn, as does the increased worldwide demand for food and feed. The latter dynamic empirically is much larger than the increase in biofuels. But the relationship of this to retail price increases and to increased hunger is neither causal, nor even clear.

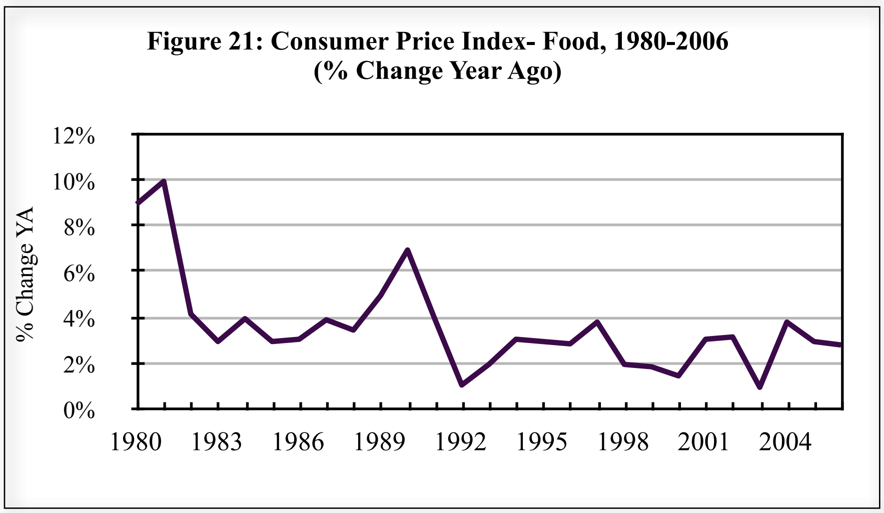
About 1.5 percent of U.S. corn acreage is planted in sweet corn for human consumption. Another 10 percent of so of overall corn acreage produces corn for processed corn products like corn flakes. *The remaining 70 percent is used for animal feed.*

Alcohol is made from sugars. The world doesn't suffer a shortage of sugars. Ethanol is made from corn starch. The by product of ethanol production is distillers grains (DG), a high protein animal feed. For every acre of corn converted into ethanol, more protein is produced by the DG than is generated from an acre of soybeans.[50] About 70 percent of DGs at present substitute for corn and the remainder substitutes for soybean meal. In any event, when an acre of corn is used to make ethanol, it doesn't significantly reduce the available amount of high grade animal feed nor human food.

Empirical evidence does not support a strong causal linkage between an increase in biofuels production and an increase in hunger. Despite the more than doubling of ethanol production in the U.S. in the last two years, U.S. corn exports (the U.S. accounts for about 75 percent of world corn exports) in 2007 were at their highest levels since 1989. The conclusion is that the relationship of the price of a commodity to the retail price of a food product is neither linear, nor in many respects even causal.

As we can see from the two charts on corn and food prices (Figures 20 and 21), at the retail level prices continually increased from 1980 to 2006, even while at the farm real prices actually declined.[51] Average food prices have risen by 2.9 percent per year over the past 25 years. The wholesale price of cattle stayed virtually constant during the 1990s while the retail price of beef almost doubled.[52]





As we switch to cellulosic materials, the food versus fuel problem is reduced, although it doesn't disappear. Rather, it becomes more about the availability of land and which land the new crops are grown on. If the cellulosic crops displace food crops (e.g. switchgrass is planted on corn or soybean acreage), the same issue will arise. However, current expectations are that they will be grown on more marginal land.[53]

Although estimates vary, it appears that sufficient land area exists to allow us to produce significant quantities of fuels (and biochemicals) without disrupting food or water supplies. The Union for Concerned Scientists, citing an in-depth analysis by the Audubon Society concludes, "Overall, around 200 million acres of cropland might be suitable and available for energy or 'power' crops, without irrigation and without competing with food crops".[54]

Many commentators argue persuasively that starvation itself is more a matter of politics than food shortages. Amartya Sen, winner of the Nobel Prize in Economics, asks, "Why, in the twenty-first century, are 800 million people living in the shadow of hunger?" And answers, "Widespread hunger in the world is primarily related to poverty. It is not principally connected with food production at all…" India's 26 million ton grain surplus in 2006 could have fed the estimated 320 million of its people who were hungry, but starving villagers were too poor to buy the food produced in their own countryside."

One other point should be mentioned with regard to crop prices. Many of those now critical of high grain prices also criticized US policies that kept grain prices artificially low in the past. Indeed, Jean Ziegler, the UN expert quoted above, in the same report condemned European Union agricultural policies for this reason. "Agricultural products are exported to Africa through subsidies and the price is very low, much lower than African products fetch on the African market…" This drives local farmers off their farms, and leads to hunger.

National farm policies, coupled with export incentives, have led to the dumping of low priced grains on world markets. That does indeed undermine local farmers in southern nations, cutting the production of domestic food.

The run up in grain prices and oil seeds in the last 18 months has led to an unusual situation. In 2007, farmers are receiving a price significantly above their cost of production, without government payments. That seems a worthy development, both for farmers in wealthier nations, and those in the rest of the world.

Q. What is the cost of biofuels?

A. For corn derived ethanol the cost depends heavily on the price of the feedstock, as does the cost of biodiesel. For cellulosic fuels, capital costs, at present some three times those of corn ethanol plants, play a larger role.

The price of ethanol and biodiesel, of course, also depends on the price of its competitor: gasoline and diesel, although both ethanol and biodiesel have inherent characteristics that make them attractive beyond their ability to simply substitute for petroleum. Ethanol is attractive because of its very high octane rating, 108, which is why it is becoming the fuel of choice of NASCAR. Gas stations charge a hefty premium for higher octane fuels, although oil companies rarely if ever compensate ethanol suppliers for the octane bonus they receive.

Biodiesel's attractiveness comes in part because it supplies lubrication to diesel engines. This is important because traditionally sulfur supplied that property, but new emissions regulations dramatically reduce the amount of sulfur diesel fuel contains. A 2 percent blend of biodiesel compensates for the sulfur reduction.

Nevertheless, the market price is usually based on the price of oil. Thus, three primary factors determining the profitability of a biofuel plant are: 1) the capital cost of the biorefinery, normally given in dollars per annual gallon of production capacity, 2) the cost of the feedstock, and 3) the price of oil. Data from University of Minnesota professor Vernon Eidman shows that an ethanol producer who receives $2.50 per gallon, can generate a profit paying $4 per bushel for corn. [55] Similarly, at a wholesale price for biodiesel of $2.50 per gallon of diesel, the biorefinery can afford to pay a little under 30 cents a pound for soy oil.

Usually, ethanol producers receive about 50 cents per gallon more than the wholesale price of gasoline because of the 51 cent federal tax incentive, which goes to the blender. Biodiesel producers receive a $1 per gallon credit, which means the blender can pay that much more than the wholesale price and still make money using biodiesel.

In the early fall of 2007, ethanol prices for the first time fell significantly below the wholesale price of gasoline, which led many ethanol producers to lose money. The price rebounded later in the year. In early 2008, corn prices topped $4.50 a bushel and soy oil prices soared to 50 cents per pound. The result was that ethanol producers, especially those that just built plants, were barely breaking even, while biodiesel producers were losing money. Many biodiesel producers were selling their product to the European market, where biodiesel is taxed at a lower rate than petrodiesel.

Since no cellulosic ethanol plants have yet been commercialized, we do not know what the precise cost of ethanol from these plants will be. But almost everyone agrees that because of the very high capital costs of cellulose to ethanol plants, the production cost will be higher than corn to ethanol, even at the very high current price of corn. Estimates of the production cost of cellulosic ethanol range from 50 cents to $1 more than corn to ethanol.

Q. How quickly could we scale up biofuels and PHEVs?

A. We could raise ethanol blends to 20 percent immediately, if the EPA grants permission to go above the current 10 percent ceiling. We could make flexible fueled vehicles the dominant new vehicle by mandate in a very short time. Remember the Brazilian example. The first FFV was introduced in 2003. By 2007, it comprised over 80 percent of all new cars sold. E85 pumps could be in 10 percent of the gas stations within two years.

With regard to PHEVs, it depends in part on how quickly car companies adopt hybrids. Hybrids currently comprise about 4 percent of new vehicles. With appropriate incentives, and the new efficiency mandate, they could comprise 50 percent of new vehicles by 2015. The introduction of PHEVs depends, in part, on the development of appropriate electric off peak tariffs, and in part, on a reduction in battery cost. If the first introduction of PHEVs in 2010 proves successful, it is likely that many car companies will embrace at least low electric only mile vehicles (e.g. PHEV10).

By 2020, biofuels could provide 15 percent or more of our fuels (assuming the biofuels mandate is achieved and the higher vehicle fuel efficiencies offsets any increase in gasoline consumption by increased miles driven..) Remember, our goal is 25 percent. On the electricity side, if PHEVs account for 10 percent of the vehicle fleet, it would provide a foundation for a rapid scale up by 2025.

Section V:
Better, Not Just More: New Rules for a New Transportation System

A dual fueled transportation system will not emerge in the accelerated fashion required without the development of new rules that channel human and capital resources in the right direction. These rules include incentives, land use ordinances, codes, regulations, statutes.

We are now writing some of the new rules for transportation as part of new state and federal legislation already enacted to reduce gasoline consumption and greenhouse gas emissions. And Congress is currently rewriting the rules for federal farm policy for the next 6 years.

The embryonic renewable energy industry is still, and will be at least in the near term, completely dependent on public policy for its vitality and growth. Therefore policy makers have an obligation to fashion policies that achieve, whenever possible, multiple goals.

We need to encourage not just more, but better. Not just more electric-alcohol vehicles and renewable energy, but also ownership structures and manufacturing and production scales that maximize the benefit to the society as a whole.

Institutional and policy inertia always pose major obstacles to dramatic change. An even greater obstacle may be in the way we currently approach problems.

Today, policy making is compartmentalized. Different energy sectors (heating, electricity, transportation fuels) have their own rules and their own regulatory structures.   Different sectors (agriculture, utility, transportation) have their own state and federal and even international rules and incentives.   Rules are fashioned by congressional committees which jealously guard their portfolios.

If we are to maximize the overall public benefit from the birth and maturation of new industries, all levels of government need to think and act across traditional boundaries.   Federal farm policy needs to integrate farmer owned biorefineries into its vision of a future agriculture. State public utility commissions need to integrate locally owned wind turbines and widespread PHEVs into its vision of a future electrical system. Localities need to integrate rooftop solar arrays and widespread PHEVs into its vision of a future built environment.

Such across-boundary thinking is beginning. One example is the passage in 2006 of a California law requiring all new subdivisions with more than a minimum number of homes to offer a solar electric option and build the roof so that such an array can be easily installed in the future. Another is the work by a growing number of utilities to evaluate how the new electric vehicles can become an integral part of a new electrical system.

Nevertheless, these examples simply prove the rule. Policies that demonstrate holistic thinking are few and far between.

This section offers specific policies, gathered under two categories: transforming the transportation system; and democratizing the energy system. Each action is discrete and self-contained, but taken together, they can achieve multiple objectives and create a transportation system that achieves energy independence not just for the nation, but also for millions of households and thousands of communities and regions.

Transforming the Infrastructure

Biofuels

1. By 2010 require 50 percent of all new cars to have a flexible fuel capability, and by 2012, 100 percent.

The additional cost to a car manufacturer of adding flexible fuel capability is about $100. It is likely car companies will roll that into the price of a new car, given that many of them may view a vehicle's capacity to use ethanol or gasoline as a marketing tool.

If society does pay the the additional cost, it should be on a one time only basis per vehicle model.   If all new vehicles in 2012 were FFVs, the cost to the public purse would be about $2 billion.

2. Encourage flexible fuel pumps, rather than E85 pumps

Today 99.9 percent of high ethanol blend pumps have a separate underground tank with an E85 blend.[56] Recently, gas stations have begun installing a newer so-called blender pump. As noted above, these have a separate pure ethanol underground tank that can be mixed in various proportions with another gasoline tank.

A flexible fueled pump has two major advantages. First, it allows for more flexibility. Vehicles can begin to fill up with 20 percent, 35 percent, 50 percent ethanol, rather than having a choice of only 10 percent or 85 percent blends. Second, and more importantly, a blender pump allows ethanol producers to deliver directly to the gas station. Currently, ethanol producers sell to oil companies who blend their product and sell it to gas stations. Allowing for a direct sales route allows the ethanol industry more independence. Moreover, it lays the industrial foundation for the time where ethanol, not gasoline, is the dominant engine fuel.

Electricity

1. Require 10 percent of new vehicles in all model classes to have an electric only driving range of at least 20 miles by 2012. Ramp this up to 25 percent and a 35 mile driving range by 2015 and 75 percent and a 60 mile driving range by 2020.

This will require incentives. All-electric vehicles currently have tax incentives, but these do not extend to PHEVs. Congress should make PHEVs with a minimum of 10 miles driving range immediately eligible, increasing the minimum requirement to be eligible for the incentive to a 20 mile range in 2012, and so on.

The incentives should be designed to reduce the payback, that is the time it takes for reduced operating costs to pay back the increased purchase price, to 3 years, about half of the average time an American now owns a vehicle. That also represents about a 33 percent return on investment for the new car owner.

2. Develop rules at the state and federal level that encourage microgrids and dispersed electric generation.

Since Congress deregulated wholesale electricity in 1992, the Federal Energy Regulatory Commission (FERC) and the nation's state regulatory commissions have focused on developing policies and institutional structures that encourage the transformation of the grid from a local, state and regional system, into a national network capable of delivering ever-larger amounts of electricity over ever-longer distances. In order to accomplish this, FERC has increasingly preempted local and state authority regarding transmission siting and power plant construction.

More long-distance transmission may be necessary in the long term, but in the short term significant opportunities exist for distributed electricity generation that injects electricity into existing distribution and sub-transmission lines.[57] This is even more important given the coming of millions of cars with large battery capacity and a capability of receiving from and sending electricity to the grid.

States should assert authority over lower voltage (e.g. 69 kV) transmission lines. And FERC should make clear that for lower voltage lines serving local markets, states have the authority to develop a queue for transmission hookups. Currently regional entities play that role and in the process have imposed considerable roadblocks to locally owned wind turbines.

FERC should also require all utilities to develop publicly available models that allow it to identify "sweet spots" where additional electricity could be injected into existing grids at costs below that of building new high voltage transmission lines.

State legislatures should also require utilities to seriously examine alternatives to new central power plant construction and new high voltage transmission lines. Some statutes to this effect are on state books at present, but they are rarely followed by utilities or enforced by state regulatory agencies.

Such studies could be highly illuminating. For example, a preliminary analysis of Minnesota's existing distribution and sub-transmission capacity by the state's utility transmission engineers estimated that a 1,000 MW of additional wind-generated electricity might be generated and injected into the existing grid system solely within one section of the state, at costs just a fraction of building new transmission lines.[58]

As part of the examination, utilities should be required to establish tariffs that encourage off peak electric consumption and investigate how PHEVs and EVs might be integrated into grid reliability and stability protocols. In this regard, states can piggyback on the data and models developed in California during the 10 year period when its electric vehicle mandate was in effect.

Democratizing the Energy System

Encourage locally owned wind turbines

Current federal incentives for renewable electricity encourage absentee owned giant energy generation facilities and thwart local ownership. These should be changed. Several strategies could be used to achieve this goal.

A. Establish a two-tiered, ten year wind-energy producer payment.

The wind energy tax credit sunsets at the end of 2008. Congress will clearly extend it, but in doing so it should also restructure the incentive. Currently, it is in the form of a tax credit which encourages complex financial ownership arrangements to facilitate the use of that credit by individuals and corporations with sufficient tax liability. The incentive should be transformed into a 10 year direct producer payment with two tiers, a higher one for majority locally owned turbines and a lower one for majority absentee owned facilities. A 2.5 cent per kWh payment for locally owned facilities and a 1.5 cent payment for absentee owned facilities might be a useful starting point.

B. Allow the wind energy tax credit to be taken against ordinary income rather than only passive income.

As my colleague at the Institute for Local Self-Reliance John Farrell asks, "A typical 2 megawatt (MW) wind turbine provides enough electricity for around 600 average American homes. So why is it nearly impossible for those same 600 households to pool their resources and own a wind turbine?"[59] The answer is that the current production tax credit can be taken only against tax liability from "passive income," defined by the Treasury Department as rental income or income from businesses in which the individual participates only as an investor. Passive income does not include wage income or interest income or farm income. Very few households have any passive income.

Thus, wind farms are owned by companies that aggregate wealthy individuals who have significant passive income and tax liability. This encourages absentee ownership and national investment pools. A second order effect is that these investment pools prefer to invest in large wind farms.

If farmers and other local residents were able to use the wind incentive to reduce their tax liability on ordinary income, the base of potential local investors would grow dramatically. In Minnesota, for example, the capital pool would increase from a few thousand households to more than a million.[60]

C. Introduce feed in tariffs at the state level[61]

Feed-in tariffs have long been used with much success in Europe and have just been introduced in Ontario. At least a half dozen U.S. states are seriously considering them. Feed-in tariffs encourage renewable electric generation through long term fixed contracts at premium rates by local utilities.

Germany's feed-in tariff has led to an astonishing 20,000 MW of installed wind capacity. Forty-five percent of the turbines are locally owned. Even more remarkable, Germany had 2,500 MW of on-site solar electric as of the end of 2006,[62] about 250 times more than Minnesota despite Germany's weaker solar resources.

By enabling broad participation, feed-in tariffs are more equitable than other renewable energy policies. Tariff rates can be adjusted for size and quality of resource, thereby allowing producers of any size and in any geographic region to participate. Current renewable electricity standards tend to favor those institutions large enough to play in a wholesale market, typically utilities and large independent power producers, while federal tax credits,

Make publically funded knowledge publically available

Up until the 1980s, most federal R&D was in the public domain. Currently, the federal government often awards a private company an exclusive license or patent on any technique or technology developed with public money. This is inappropriate and arguably inefficient.

If public money is used, the knowledge gained should be publicly available. Contracts should be redesigned to require any company developing such technology to license it on demand and at a reasonable price to locally owned renewable energy facilities. For example, advances in cellulosic conversion technology or in corn fractionation that are publicly financed should be made available to locally owned plants to improve their productivity.

as noted above, benefit only those with sufficient tax liability to use the credits effectively.

A feed-in tariff, at a lower cost than federal tax incentives or state renewable mandates, marry social, economic development and energy objectives.[63]

D. Allow wind turbines that serve on-site demand to be eligible for the federal wind energy producer payment.

When Congress revisits the wind energy incentive in 2008, it should extend eligibility to turbines that generate electricity used only on-site. Currently, the tax credit is eligible only for wind energy sold into the commercial grid system.

Wind energy consumed on-site has the same, or an even superior, impact on non-renewable electricity demand given the avoidance of distribution and transmission losses, than the same amount of wind energy exported into the grid. By allowing the incentive to be extended to these turbines, Congress would not only make the incentive fairer but also would also encourage the development of smaller sized turbines and turbines in lower wind speed areas. The incentive should be made into a refundable tax credit to eliminate the obstacles noted above regarding passive income tax liability. The refund provision can be justified in part because only a modest amount of electricity will be generated by these on-site installations and because it sends another signal by Congress that it favors the democratization of energy production.

Encourage locally owned biorefineries

Local ownership can be encouraged by restructuring existing incentives for biofuels, as well as by developing policies that favor smaller scale production systems. Several strategies could be used to achieve these goals.

A. Establish a two-tiered, indexed ten-year production payment for biorefineries that favors local ownership.

The ethanol and biodiesel tax incentives will sunset at the end of 2008. They will be extended, but like the wind energy tax credit, these should be redesigned to encourage local ownership. The way to do this is to transform the blender credit into a direct producer payment and to develop two tiers of payments depending on the biorefinery's ownership structure.

This type of incentive was pioneered in Minnesota in the late 1980s. The producer payment was only on the first 15 million gallons produced and was only for ten years. The incentive created what became known as the Minnesota model, that is, farmer owned biorefineries as the dominant ownership structure in the state for the production of ethanol.

On the federal level, an absentee-owned plant might be paid 25 cents per gallon for the first 40 million gallons produced each year for 10 years, but a majority local-owned plant might receive 40 cents per gallon. Congress could insert a recapture provision to ensure that any local owners who sell to absentee investors within a certain time period would have to repay the Treasury the difference in the payment levels they had received as local owners.

Plant financing would likely coincide with the term of the producer payments-- 10 years. Thus when the latter end, the debt is paid off. Paying off the debt could reduce production costs by about 15 cents per gallon.

B. Reduce the maximum level of small ethanol producers eligible for an additional federal incentive back to 30 million gallons.

Since the early 1980s, an additional 10-cent per gallon federal incentive has been paid for the first 15 million gallons produced in "small" ethanol plants. Initially restricted to capacities below 10 million gallons, in the 1990s the qualification level was raised to 30 million gallons and in 2005 to 60 million gallons.

Today, the definition of small producer encompasses a plant larger than the average plant now operating. Congress should return to the previous definition of small--30 million gallons.

An even better strategy would be to end this incentive and roll it into the two-tiered production payment discussed above.

C. Make farmer ownership of energy production facilities a major element in the new agriculture bill.

As noted above, the new energy bill caps the corn to ethanol mandate at 15 billion gallons, a level that may well be achieved as early as 2012. Probably 80 percent of this production is already in the developmental stage. Thus, in terms of local ownership, the focus must be on cellulosic ethanol.

In the energy bill, Congress has embraced an unprecedented strategy. It has mandated the consumption of a huge amount of a product (cellulosic ethanol) when the industry itself does not yet exist and the feedstock (at least cellulosic energy crops) largely doesn't exist. Thus, we are building this new industry and agriculture from the bottom up.

We should be careful in building this new industry that we don't repeat the mistakes of yesteryear. Current farm programs subsidize farmers in order to keep the price of their crops low and therefore food prices low. This leads to dissatisfaction by both farmer and taxpayers.

The new energy bill will usher in cellulosic ethanol manufacturing plants. The first ones will use wood waste and agricultural residues. But to ramp up cellulosic ethanol in 2013-2016 will likely require new cellulosic crops. Already Congress is considering paying farmers to grow these crops. It is quite conceivable this could evolve into adding cellulosic crops to those receiving ongoing federal payments as part of farm programs. In this case, the farmer would be subsidized in order to reduce the cost of the raw material to the biorefinery.

Once this occurs, it is going to be very difficult to eliminate the incentive. Witness the inability of Congress to eliminate direct payments to corn farmers that were introduced into the farm bill in the late 1990s, when prices were very low, even though prices in 2007 were at all time highs.

In 2008, Congress will again seek to reauthorize a farm bill for the next six years. This offers Congress the opportunity to refashion a part of the farm bill to encourage farmer-ownership of value added biorefineries and begin to shift farm policy from guaranteeing a fair return on the farmer's investment in land and crops, to guaranteeing a fair return on the farmer's investment in biorefineries.

Currently, the federal government provides some $5 billion in direct payments to farmers regardless of the price of their crop. Created in 1996, this program was viewed as a temporary measure, but Congress continued the program in the 2002 farm bill, a time of low commodity prices. With today's crop price at all time highs, and with prices expected to continue at record levels for the next 4 years at least, there is no justification for continuing this program. In any event, price support and crop insurance programs will continue, insulating farmers in the improbable event that crop prices plummet.

A portion, or all, of the $5 billion should then be used to underwrite farmer equity investments in biorefineries. This can lay the foundation for a new agricultural in which farmers are owners of the value added process.

Biofuels and farm policy are becoming almost inseparable, at least in the grains and oilseed sectors. In 2002, federal subsidy payments to the nation's corn farmers totaled about $3 billion, while federal subsidies to ethanol were about $1 billion. In 2007, federal price support payments to the corn farmers was zero, while ethanol subsidies had risen to $3.5 billion. And it is likely, if the ethanol incentive is extended, that by 2012 the nation might be spending more than $7 billion a year on ethanol incentives, and another $1 billion on biodiesel incentives.

Today we are writing rules that can transform not only our transportation system, but our electricity and agricultural systems as well. We should be careful that we design the rules in a way that guides entrepreneurial energy and investment capital and scientific genius toward building systems that achieve social and economic as well as energy security and environmental goals.

Endnotes

[1] David Morris, *A Better Way to Get From Here to There: The Hydrogen Economy and a Proposal for an Alternative Strategy*. Institute for Local Self-Reliance. Minneapolis, MN. December 2003.

[2] When Bush delivered his 2003 State of the Union, the United States was two months away from the Iraq War. Oil prices had been holding steady for several years at about $23 a barrel. The federal government was forecasting oil prices of $23.27 a barrel in 2005, rising only slightly to $25.50 per barrel in 2020 (in 2001 dollars). *Annual Energy Outlook*. Energy Information Administration. January 9, 2003.

[3] Vanessa Rossi, *China, India and the Billion Car Asian Market*. Oxford Economics. December 2006.

[4] Dr. Menahem Anderman, *Brief Assessment of Improvements in EV Battery Technology since the BTAP June 2000 Report*. For the California Air Resources Board. March 2003.

[5] In Europe the percentage is based on energy-equivalency. In the United States the percentage is based on gallons. Since ethanol contains about 40 percent less energy than ethanol on a per gallon basis, this means that the 10 percent limit in the United States is equivalent in ethanol gallons used to about a 7 percent blend in Europe.

[6] *The Energy Independence and Security Act* (P.L. 110-140, H.R. 6)

[7] CAFE efficiency standards do not use the same methodology to estimate fuel economy as the EPA. In 2008 the EPA revised its standards to better take account of real world driving. The resulting is to lower fuel economy ratings, on average, by 10-15 percent. CAFE standards remain unchanged. By some estimates, the CAFE standards are about 1/3 lower than EPA's 2008 fuel economy ratings. However, any revision in CAFE's starting and ending points would not change the impact of the new standards on absolute mileage increases and percentage increases.

[8] Walter S. McManus, *The Impact of Attribute-Based Corporate Average Fuel Economy (CAFE) Standards: Preliminary Findings*. Automotive Analysis Division, University of Michigan's Transportation Research Institute. Ann Arbor Michigan. July 2007.

[9] Ken Thomas, "Hybrid Headlines: Auto Industry Shows Off Fuel-Efficiency Efforts At Detroit Auto Show", *Associated Press*. January 13, 2008. Sandy Stojkovski, a fuel economy expert and director of vehicle engineering at Ricardo Inc., is quoted as estimating that more than half of the vehicles by 2020 will need some kind of hybrid configuration to meet the new standards.

[10] About 10 percent for mild hybrids like the Chevy Silverado Hybrid or the GMC Sierra Hybrid, which use a flywheel-alternator to power down the engine at a stop and immediately start it up. Full hybrids like the Prius, Escape hybrid or Honda hybrid achieve about 35 percent improvements in gas mileage.

[11] *Energy Independence and Security Act*. Sec. 133 (a) (5)

[12] The 6.67 does not represent the net energy of ethanol. Net energy takes into account all fossil fuel inputs. Natural gas, not oil, constitutes the vast majority of fossil fuels used in growing corn and converting it into ethanol.

[13] *Energy Independence and Security Act*. Sec. 109. (a) (1)

[14] Electric and Hybrid Vehicle Research, Development, and Demonstration Program; Petroleum-Equivalent Fuel Economy Calculation; Final Rule. *Federal Register*, June 12, 2000. 10 CFR Part 474.

[15] Energy Independent and Security Act.. Sec. 109. (a). "For each model years 1993 through 2016 for each category of automobile (**except an electric automobile**), the maximum increase in average fuel economy for a manufacturer attributable to dual fueled automobiles is…" (emphasis added)

[16] One intriguing result is that hybrids are often more efficient in the city than on the highway. The 2004 Prius for example was rated at 45 miles per gallon on the highway and 52 miles per gallon in the city.

[17] Willett Kempton and Cliff Murley, "Modeling V2G for a Utility with a High Wind Generation Portfolio", Presented to Zero Emission Vehicle Technology Symposium Session: "Electric Fueling Infrastructure" California Air Resources Board. Sacramento, CA. September 26, 2006.

[18] *Ibid*.

[19] Willett Kempton, "Electric Vehicles for Grid Integration of Renewables", Presented at Utility Wind Integration Group. Arlington, VA April 5-7, 2006

[20] *Cap X West Central Study Repor*t. June 2007.

[21] American Wind Energy Association. As of January 16, 2008. http://www.awea.org/projects/

[22] See www.solarelectricalvehicles.com/

[23] The number of biorefineries surpassed the number of petroleum refineries in late 2007. The US has about 120 petroleum refineries.

[24] For a fuller exploration on the scale economies issue, see John Farrell, *Economies and Diseconomies of Scale in Wind and Ethanol*. Institute for Local Self-Reliance, 2007.

[25] Michael Kintner-Meyer Kevin Schneider Robert Pratt, *Impacts Assessment of Plug-in Hybrid Vehicles on Electric Utilities and Regional U.S. Power Grids Part 1: Technical Analysis*. Pacific Northwest National Laboratory. November, 2007.

[26] In addition, Chevron maintains the right to seize all of Cobasys' intellectual property rights in the event that ECD Ovonics does not fulfill its contractual obligations. On September 10, 2007, Chevron filed a legal claim that ECD Ovonics has not fulfilled its obligations. ECD Ovonics disputes this claim. The NiMH patent expires in 2015.

[27] Cobasys remains unwilling to sell NiMH batteries in smaller quantities to individuals interested in building or retrofitting their own PHEVs.

[28] Traditional cathode materials used in lithium ion batteries are metal oxides prone to decomposition under abusive conditions, such as excessive cell temperatures and/or overcharge. When that occurs, the cathode materials can release heat and oxygen, which can result in an uncontrollable thermal event, fire, or explosion.

[29] In the last few months of 2007 and first month of 2008 these are some of the corporate developments. Massachusetts based A123 Systems' nano technology based lithiuim ion phosphate battery is being tested by General Motors for possible use in its Volt. International Battery announced plans to build a lithium ion manufacturing facility in Pennsylvania. Valence Technology announced a new generation of its lithium-ion battery systems. Johnson Controls-Saft Advanced Power Solutions (JCS) announced a joint venture with a major vehicle manufacturing company to go into high volume production in a European facility in 2008.

[30] Maxwell, a leader in the manufacturing of ultracapacitors has announced a joint venture with Lishen, a large Chinese battery manufacturer to deliver sample hybrid systems for testing by potential customers in early 2008.

[31] Alec Brooks of AC Propulsion was the first to have coined the term.. See for example, Alec Brooks, Tom Gage, "Integration of Electric Drive Vehicles with the Electric Power Grid -- a New Value Stream". Presented at the 18th Electric Vehicle Symposium (EVS18), in Berlin, Germany. October, 2001.

[32] Alec Brooks, *Vehicle-to-Grid Demonstration Project: Grid Regulation Ancillary Service with a Battery Electric Vehicle.* Report to the California Environmental Protection Agency and California Air Resources Board. December 10, 2002.

[33] Willett Kempton, *Plug-in Hybrid and Battery Electric Vehicles for Grid Integration of Renewables*. Wind Integration Group. Arlington, VA. March 17, 2006. See also, W. Kempton and J. Tomic, "Vehicle to Grid Fundamentals: Calculating Capacity and Net Revenue". *Journal of Power Sources*. June 2005. W. Short and P Denholm, *A Preliminary Assessment of Plug-in Hybrid Electric Vehicles on Wind Energy Markets*, NREL. TP-620-39729. 20-06.

[34]. EPRI and NRDC, *Environmental Assessment of Plug-In Hybrid Electric Vehicles*. July 2007.

[35] In 2007 Minnesota generated 26 percent of its electricity from nuclear power plants. In 2007 the legislature required that 25 percent of Minnesota's electricity be generated from renewable fuels by 2020.

[36] *Air Emissions Impacts of Plug-In Hybrid Vehicles in Minnesota's Passenger Fleet*. Minnesota Pollution Control Agency. Saint Paul, MN. March 2007.

[37] Parking meters already come equipped with outlets in very cold cities (e.g. Winnipeg, Canada) to enable parked cars to use electricity directly to warm their engines.

[38] All electric vehicles have much less maintenance because they eliminate engine-related maintenance items like the radiator, oil changes, and pumps.

[39] Testimony by David Vieau, CEO of A123 Systems, United States Senate Committee On Finance, Subcommittee On Energy, Natural Resources and Infrastructure. May 2007

[40] In 1995, batteries had to be replaced once during the life of the vehicle.

[41] Since soybeans, unlike corn, need little natural gas derived nitrogen fertilizers, oil in the form of tractor and truck fuel comprise a higher proportion of the fossil fuels used, but the total amount is probably about the same as in growing corn.

[42] Conversation with Tim Gerlach. American Lung Association of Minnesota. September 2007.

[43] One blender pump was installed in Luverne, MN in 2000.

[44] Michael Wang. *The Debate on Energy and Greenhouse Gas Emissions: Impacts of Fuel Ethanol*. Argonne National Laboratory. Chicago, IL. August 3, 2005.

[45] Michael D. Jackson, Stefan Unnasch, Jennifer Pont, *The Impact of Alternative Fuels on Greenhouse Gas Emissions—A "Well-to-Wheels" Analysis.* TIAX. Cupertino, California. M7100. Undated.

[46] For a fuller discussion of ozone formation and ethanol see Jack Brondum and David Morris, *Ethanol and Ozone,*Institute for Local Self-Reliance. September 25,2000.

[47] For further reference see, David Morris, *The Carbohydrate Economy, Biofuels and the Net Energy Debate*. August 2005. For a critical analysis of the net energy of biofuels from any feedstock see David Pimentel and Tad W. Patzek, "Ethanol Production Using Corn, Switchgrass, and Wood; Biodiesel Production Using Soybean and Sunflower", *Natural Resources Research*, Vol. 14, No. 1, March 2005.

[48] David Morris and Irshad Ahmed, *How Much Energy Does It Take to Make a Gallon of Ethanol?* Institute for Local Self-Reliance, 1995.

[49] For example, the Chippewa Valley Ethanol Corporation (CVEC), in Benson Minnesota will begin to gasify 75 tons of locally available wood waste to displace 25 percent of its natural gas by spring 2008 and expects ultimately to displace more than 90 percent. *Biomass Magazine*. January 2008.

[50] One cannot substitute a pound of corn protein for a pound of soybean meal protein. These numbers are for illustrative purposes only.

[51] *Understanding the Impact of Higher Corn Prices on Consumer Food Prices*. National Corn Growers Association. St. Louis, MO., March 2007 (updated April 18, 2007).

[52] *Analysis of Potential Causes of Consumer Food Price Inflation*. Informa Economics, November 2007.

[53] The issue of land use changes gained significant visibility by the publication of two studies in the February 2008 issue of *Science* magazine. (Timothy Searchinger, et.al., "Use of U.S. Croplands for Biofuels Increases Greenhouse Gases Through Emissions from Land Use Change". Joseph Fargione, et. al., "Land Clearing and the Biofuel Carbon Debt") The studies argued that the release of carbon from the cultivation of new land as a result of the increase demand for biofuels should be taken into account when evaluating the net greenhouse gas impact of biofuels, and that when this is done, biofuels actually increase GHG emissions compared with gasoline. The first part of the argument is uncontroversial. Indeed, the 2007 Energy Law requires that land use changes be taken into account when determining whether ethanol produced under the biofuels mandate meets the mandated GHG reduction standards. The second part of the argument, however, is highly controversial. A number of responses have noted that the authors did not empirically examine the efficiencies of new ethanol plants, nor the historical yield increase trend line, nor the fact that when corn is cultivated using no till methods, there is an actual carbon buildup in the soil, nor that the byproduct of corn derived ethanol, distillers grains, produces more protein per acre than soybeans. See, David Morris, *Ethanol and Land Use.* Institute for Local Self-Reliance. February 2008.

[54] *Powerful Solutions: Seven Ways to Switch America to Renewable Energy*, Union for Concerned Scientists, 2001 citing James Cook, Jan Beyea, and Kathleen Keeler, "Potential Impacts of Biomass Production in the United States on Biological Diversity," *Annual Review of Energy and the Environment,* 16:401–431. 1991.

[55] Vernon R. Eidman, *Economic Parameters for Corn Ethanol and Biodiesel Production*. Prepared for presentation at the annual meeting of Southern Agricultural Economics Association. February 3-6, 20-07. Mobile, AL.

[56] The blend varies by season.

[57] This is true for both renewable-fuel and fossil-fuel power plants. On-site natural-gas-fired power plants, for example, can make use of the waste heat to achieve efficiencies of more than 80 percent, compared with the 35 percent-to-50 percent efficiencies achieved by conventional power plants. Moreover, they eliminate losses of up to 15 per cent resulting from the transmission and distribution of electricity.

[58] *CAPX 2020 Study*. June 2007

[59] John Farrell, B*roadening Wind Energy Ownership by Changing Federal Incentives*. Institute for Local Self-Reliance, February 2008.

[60] *Ibid*.

[61] For further discussion see John Farrell, *Minnesota Feed-In Tariff Could Lower Cost, Boost Renewables and Expand Local Ownership*.. Institute for Local Self-Reliance. 2008.

[62] Paul Gipe, "Renewables Without Limits." (Ontario Sustainable Energy Association, 11/15/07), 15. Accessed 12/19/07 at http://tinyurl.com/ytmuwr.

[63] See John Farrell, *Minnesota Feed-In Tariff Could Lower Cost, Boost Renewables and Expand Local Ownership*. Institute for Local Self-Reliance. January 2008.