The Myth of the Plug-In Hybrid

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Lots of claims have been made by promoters of plug-in hybrid electric vehicles. Can they really be true? Isn't electricity cleaner and cheaper than dastardly Oil? And aren't electric motors and batteries more efficient than those internal combustion engines that only gearheads love so much?

Well… as you'll find out with most things having to do with transportation and energy, what seems intuitively simple will turn out to be wrong.

To understand why plug-in hybrids are pretty much a climate change and economic disaster, we have to look at the total energy used. That means not only how and where the energy is produced, but how much energy is lost in transit. We also need to know many green house gases are put back into the atmosphere.

Start with a Gallon of Gasoline

Probably the best place to start is with a gallon of gasoline. It weighs about 7 lbs and is composed of high density carbon-to-carbon and carbon-to-hydrogen liquid compounds, a hydrocarbon. It can be made of non-renewable biomass (oil) or renewable biomass (low input perennial grasses, wood forest and agricultural residues, and algae products). The amount of energy in a gallon of gasoline can be stated three different ways.

1 Gallon Gasoline equals **140,000 BTUs** or **150,000,000 Joules** or **41 Kilowat hours**

A BTU (British Thermal Unit) is the energy needed to raise the temperature of 1 lb (.44 kilogram) of water one degree Fahrenheit (.55 degree Celsius). BTUs are usually used to measure the heat energy content of fuels, either liquid or gas. BTUs appear on your natural gas heating bill. A Joule is the amount of energy needed to raise the temperature of 1 gram of air 1 degree Celsius and is equal to 1 watt of energy for one second. A kilowatt hour (KWH), which appears on your electric bill is 1,000 watts used for one hour, or, 10-100 watt light bulbs running for one hour.

To give some idea how much energy is in that one gallon of gasoline, if it were burned in a 50% efficiency boiler, it could raise the temperature of a swimming pool 20 feet by 10 feet and 7 feet deep by 1 degree F. Or, it could be burned to run a turbine to produce electricity, or it could be put in the tank of a car, SUV, or truck.

Every year the US EPA publishes a mileage guide for all vehicles sold in the US. Using EPA figures, a gallon of gasoline propels a Ford Focus or a Toyota Prius hybrid this far

with two passengers and their gear, the A/C on, the stereo blasting, and cruising at about 65 mph.

Ford Focus 4 cyl gasoline car gets 24 MPG City and 35 MPG Highway
Toyota Prius 4 cyl gasoline/hybrid gets 48 MPG City and 45 MPG Highway

So, a current high efficiency gasoline powered car like a Focus will get you 35 miles per gallon on the EPA test cycle and a current generation gasoline/hybrid will get you up to 45 miles per gallon. Not bad for a 3,000 pound car.

Recharging a Hybrid

Besides using just friction to stop, remember Fred Flintstone using his feet? Hitting the brake pedal in a hybrid causes a generator mounted on the axle to increase magnetic resistance. This absorbs energy, slows the car, and recharges the batteries. Of course disk brakes kick in at higher speeds or panic stops.

Of course, in the case of the Prius, the assumption is made that the on-board batteries were already charged. Let's assume the Toyota dealership took care of that to begin and the driver of the Prius has been using the brakes enough to recharge the battery before its 40-50 mile range at less than 37 mph is used up. If the driver hasn't, say they got on the interstate just as the batteries were drained, the gasoline fueled internal combustion engine would have to recharge them. Don't expect 45 miles per gallon while doing that, and don't expect to outrun that Mustang, or even that Focus next to you. (As an aside, Toyota is increasing the size of the gasoline engine on the 2010 Prius by 20% to compensate. Interestingly, it looks like it will increase highway mileage. Guess the bigger engine won't have to work as hard.)

Now, how far will that plug-in hybrid go on that same gallon of gasoline? If it recharges like a standard hybrid, a Prius sized plug-in would get about the same mileage.

But, and trust me this is one big "but", a plug-in hybrid will have so many batteries, at least 750 lbs worth, that they can't be charged simply by riding the brakes. Why? Because the promise of a plug-in hybrid is that "cheap" electricity can be used to provide enough power to go over 100 miles at up to highway speeds (at least 65 mph from the PR releases).

140,000 BTUs of Energy

Back to the gallon of gasoline. Let's use those 140,000 BTUs to produce some electricity. (We'll get to coal, wind, and solar in a bit, let's just use the 140,000 BTUs of energy contained in that gallon for starting calculations.)

As it turns out, producing electricity on a large scale for a country as large as the US is very inefficient. Here's how Ralph J. Cicerone, President of the National Academy of Sciences, describes it.

> *"Because of considerable inefficiency in the conversion of primary energy into electricity during generation and losses in its distribution, the electrical energy received by the end user is only about one-third of the primary energy invested in generating it."*

That's right! On average, only 1/3 of the energy used to produce electricity in this country makes it to the wall outlet. And it doesn't matter if it came from a coal fired power plant on the Ohio or Tennessee River or a windmill in west Texas or on the slopes of Savage Mountain in Pennsylvania.

So how far will our Prius-sized plug-in hybrid of the future go on the amount of electricity produced by the equivalent of one gallon of gasoline? 45 MPG x 1/3 = 15 MPG. How does that compare?

Ford Focus 4 cyl gasoline car gets 24 MPG City and 35 MPG Highway
Toyota Prius 4 cyl gasoline/hybrid gets 48 MPG City and 45 MPG Highway
"Future" Prius-sized Plug-In Hybrid gets 16 MPG City and 15 MPG Highway
Ford F-150 Pickup 4.6 L V8 gets 15 MPG City and 21 MPG Highway

Or, as a recent study from Duke University (Plug-in and Regular Hybrids A National and Regional Comparison of Costs and CO_2 Emissions, Eric Williams, Duke University Nicholas School of the Environment, November 2008) stated,

> "*Once electricity costs are factored in, plug-in hybrids are significantly more expensive than regular hybrids."* p 21

Okay, this is a simplified analysis. Do you want more details?

First, what about gasoline production? How much crude oil is used to produce gasoline? Doesn't that change the conclusion?

Oil Refinery Production

Oil refineries are designed to produce everything from gasoline to plastics. This is done so refinery owners can maximize profits in response to market demands. Because of that, US refineries currently devote about 50% of total production to gasoline rather than the nearly 80% possible. This difference between 50% and 80% causes much confusion when calculating efficiency.

From DOE/Energy Information Administration data, US refineries are able to convert about 78-80% of every barrel of oil into products. Transportation of crude oil and finished products uses about an additional 5%. Applying these numbers to our original gallon of gasoline doesn't change things very much. The F-150 still ties the plug-in on the highway.

Mileage: With -27% Fuel Production Factor

Ford Focus 4 cyl gasoline car gets 18 MPG City and 26 MPG Highway
Toyota Prius 4 cyl gasoline/hybrid gets 35 MPG City and 33 MPG Highway
"Future" Prius-sized Plug-In Hybrid gets 16 MPG City and 15 MPG Highway
Ford F-150 Pickup 4.6 L V8 gets 11 MPG City and 15 MPG Highway

Second, why can't clean solar and wind be used to recharge plug-ins?

Two reasons. First, let's look at our power grid. Again from Ralph J. Cicerone, President of the National Academy of Science.

> *"Our electricity is generated in several ways but the major pathways are from coal burning (52%), nuclear power (20%), natural gas (19%) and renewable energy including hydropower (8.5%). While still small, electricity generated from wind power grew by over 25% compounded annually from 2001-2005."*

Even at the 25% growth rate, renewables are not going to make much of an impact anytime soon.

But there's even a bigger reason why wind and solar won't be used in any appreciable way for plug-ins.

If you've seen any of the PR on plug-ins, the idea is they will be charged at night to take advantage of lower demand and costs. Well, there goes solar!

More seriously, this presents a major production and CO_2 emission problem. If the majority of plug-ins are charged at night, they will be charged by what the electrical industry calls "base-load" generators. These are very reliable generating units that can be counted on 24/7 to produce electricity at below $.08/KWH (that's equivalent to about

$3.00/gallon of gasoline. $.08 x 41 KWH = $3.28). Yes, these are the humongous coal and nuclear plants.

So this means that the beloved plug-in hybrid of the immediate future will be predominately powered by coal or nuclear. This brings us to Warren Buffet and Mid American Energy. Current electrical production: 55% coal, 22% natural gas and oil, 10% nuclear, 13% renewable.

> *"The second thing to note is the participation of Warren Buffett, who owns 10% of BYD [A Chinese Plug-in Hybrid Company] through Berkshire Hathway. Why did Buffett buy a Chinese electric car company? One of his biggest holdings is in MidAmerican Energy, which through its subsidiaries is one of the nation's largest energy providers. MidAmerican can provide the power to "fuel" these electric vehicles."* Jalopnik (1/12/09)

So, how do you feel about adding to Buffet's bottom-line and increasing green house gases at the same time?

To be fair, the Duke study did postulate a future where a plug-in hybrid would make sense.

> *"…but in order for plug-in hybrids to reach their full potential as a cost effective climate mitigation option, barring a break-through in hybrid technology, comprehensive climate policy is needed, and gasoline prices must continue to rise."*

Here's the specifics of the "***Comprehensive Climate Policy***" postulated by the Duke study:

1. $6/gallon gasoline (2008 dollars), at a minimum.

2. $40/ton (2008 dollars) carbon tax, to encourage nuclear, wind, or solar

3. Baseload electrical prices remain below .$.08/KWH. Assumes coal prices do not rise in parallel to $6/gallon gasoline.

4. Low cost carbon sequestering in coal electrical regions. Technology does not exist today.

And add two more:

5. Low cost, environmentally and proliferation safe nuclear waste disposal.

6. Low cost and environmentally safe disposal of plug-in hybrid batteries@ 750lbs-1,000 lbs/car every four years.

So what have we learned today?

- **Plug-in hybrids will create a significant demand for more electricity.**
- **Deregulated for-profit electrical producers need this demand to justify higher electrical rates, more coal and nuclear fired base-load plants, and more power lines in your neighborhoods.**
- **Coal fired plug-in hybrids will produce at least 2 times the Green House Gases that petroleum fueled hybrids would and at least 50% more than conventional petroleum fueled vehicles.**
- **And for you lovers of irony, LED lightbulbs and Green Buildings are producing the very decreases in electrical demand that are causing the electrical producers to push for the plug-in hybrids!**

Is there an alternative to plug-in hybrids? Yes. It's as easy as 1-2-3!

1. As the comedian Carlos Mencia says, "If you want to save gasoline, carpool!"
2. Tighten-up the CAFE fuel standards so we can decrease transportation fuel uses by at least 50% in 10 years.
3. Finance the research needed to produce affordable advanced biofuels from sustainable biomass like perennial grasses and algae that do not increase food prices or damage the environment.

If we do all three, we won't need any more coal fired electrical plants and we'll be well on our way to reducing Green House Gases -- and stopping any more Climate Change effects! And Warren Buffet will have to invest in something else. How about …

For More Information about advanced biofuels go to www.AdvancedBiofuelsUSA.org See the Primer on Advanced Biofuels on our Education Page.
(http://www.advancedbiofuelsusa.org/uploads/AdcancedBiofuelsTeacherSlides1.0.pdf)

Advanced Biofuels USA is a nonprofit organization. Its purpose is to promote public understanding, acceptance, and use of advanced biofuels; to promote research, development and improvement of production, marketing and delivery of advanced biofuels; and to improve advanced biofuels crops and products.