Racing against Time: Racing against Finite Petroleum Supply - Challenges and Opportunities

Posted by Gail the Actuary on October 6, 2010 - 10:39am
Topic: Alternative energy
Tags: biofuel, diesel, gasoline, honda [list all tags]

This post is a contribution to Honda's "Racing Against Time" thought leadership series. The Oil Drum was selected to provide a unique perspective on how we should approach the discussion of oil as a finite energy source. During the first week of October 2010, five individuals provide their own thoughts on the subject. These independent contributors were not compensated for their participation and as such their views are their own and do not necessarily reflect those of Honda. Details and links to what others are saying about "Racing Against Time" can be found at www.facebook.com/honda.

This week, Honda is focusing conversation on the world's dependency on oil as a finite resource. Many people assume that the concern about the finite nature of the world's oil supply is way off in the future, but this really isn't the case.

We hear that there are huge reserves of oil, so we assume that the oil will be available when we want it. That is not necessarily true. Even if we know the oil is there, if it takes more than one barrel of previously-extracted oil to extract a new barrel of oil, the fact that the oil reserves are there doesn't really help us--it is too expensive in terms of oil, to extract the new oil. This relationship also holds in terms of dollars. Once a barrel of oil is too expensive in $$ to extract, relative to what it can produce, the system starts breaking down.

The question is how high oil prices can go, without the economy being adversely affected (say, by recession). Analysis by Oil Drum staff member Dave Murphy suggests that this level is $80 or $85 a barrel. The current oil price is about $82 a barrel, so we are again reaching the problematic range.

Lending further credence to this concern is the fact that world oil production has been flat for five and a half years now - 2005 to the present - despite a rising number of vehicles. So there is a reason we keep hearing about alternatives.

Biofuels

Biofuels would seem to be ideal for replacing petroleum-based fuels, but there are several issues we are up against:

Low blending limits for most biofuels

If biofuels are not chemically identical to what they are replacing, they can only be used to "extend" petroleum-based fuels by a relatively small percentage, before chemistry differences start causing problems for conventional vehicles. As a result, the amount of biofuel that can be added to gasoline or diesel "maxes out" at a fairly low percentage. More importantly, as the amount of petroleum available decreases in the future, the amount of the biofuel that can be added decreases as well.

For most cars, the maximum amount of ethanol that can be blended into gasoline is 10% by volume (equivalent to 7% by energy content), based on manufacturers' warranties. The amount of ethanol being produced from corn in the US today is already reaching this "10% "blend wall", causing problems for the industry. To get around this issue, ethanol producers are now turning to exports to provide what CNBC describes as "a much needed shot in the arm to a moribund industry." So a person wonders what we would do with a huge amount of additional ethanol, say from cellulosic sources, if we did manage to produce such ethanol.

Bio-diesel tends to cause gelling in cold weather, so it also hits a blend wall quite quickly--as low as 5% of the diesel mix. And again, if the amount of conventional diesel fuel decreases in the future, the amount of bio-diesel that can be blended into the diesel can be expected to decrease as well.

Special vehicles - such as E-85 compatible vehicles - don't solve the problem

Experience shows that building flex-fuel vehicles and offering a limited number of E-85 fueling stations results in only a tiny quantity of E-85 sales. The big issue is that biofuels (not just ethanol, but other biofuels too), tend to be more expensive (relative to their energy content) than petroleum-based fuels, even with subsidies. How many people want to drive out of their way to find a station selling an optional higher priced fuel for their vehicle?

The EPA is currently considering allowing automobile stations to sell E-15 to owners of newer cars. But even if this change were made, it is not clear it would have much impact:

- Service station owners wouldn't want to incur the cost of extra pumps and tanks.
- Service stations owner might be held liable if owners of older cars accidentally purchase E-15
- E-15 buyers may invalidate their warranties.

Perhaps the over-arching issue, though, is how many drivers will go out of their way to buy a fuel that costs more than E-10, in terms of the energy provided?

Cost of alternatives tends to stay above oil-based products, even when oil prices rise

No matter how much the price of oil rises, the price of biofuels (and for that matter, most other alternatives) tends to rise as well. There are admittedly efficiency gains, but even when these are considered, the price doesn't drop enough.

The problem seems to be what we call "receding horizons". Biofuels and other alternatives use oil and other fossil fuels in their manufacture and transport. As the cost of these fuels rise, the cost of producing the biofuels tends to rise as well. You can't even get ahead for long--perhaps on a temporary price drop for a glut of corn, but not much longer.

Land, water and fertilizer limit total biofuel production

There is a fairly low limit--probably not more than 20%--on the amount of biofuels that can be produced, because of competition for land, fertilizer, fresh water, and other resources.

Phosphorous for use as a fertilizer is one limit to this expansion.

Bio-diesel from algae could theoretically circumvent some of these issues, but it is still very expensive to produce ($32.81 a gallon for one company). Scaling the process up is difficult, because indoor production of algae tends to be expensive, while outdoor production suffers large evaporation losses and tends to attract unwanted species. (See here and here).

Implications and Opportunities

The net of all these things is that it that biofuels might at most replace 20% of petroleum-based fuels for the current transportation industry, leaving large gaps.

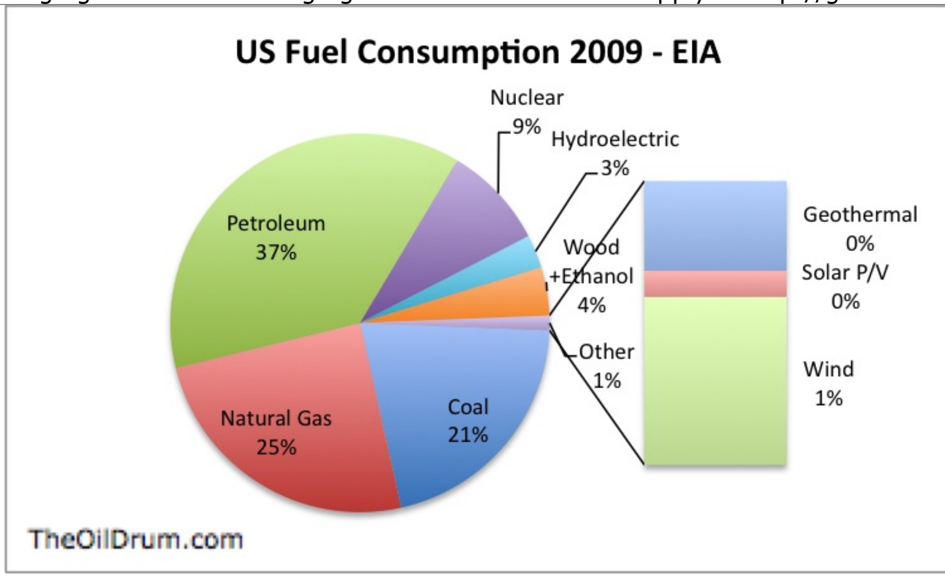
There is work being done on chemically equivalent fuels--so called "drop in" biofuels. Some of the "next generation" biofuels are of this type, as described in this booklet by the USDA called Next Generation Biofuels. The quantities available of these drop in biofuels is not large, however, and they tend to be expensive, so it is doubtful that they can be cheaply scaled up to large quantities.

There may be a few niches where biofuels are particularly useful--perhaps in recycling vegetable oil that might otherwise be thrown away, for example, or for "drop in" fuels created by pyrolysis or other heat-based approaches applied to waste plant or animal products. Such fuels may be especially helpful for local markets, since this will cut out the energy costs associated with transporting the biofuel. Also, it may be easier to match the biofuel with specially adapted service station pumps and vehicles using the fuel in a local market. (See Robert Rapier's article about the possibility of using E-85 in Iowa.) But even this approach is difficult to make work, if the cost of the biofuel is higher than what it replaces.

Developing cars that are optimized for alternative fuels, such as ethanol, may help overcome the cost hurdle, since an optimized vehicle will not have the mile per gallon shortfall that a non-optimized vehicle has. Because of the difficulty in building a widespread fueling network, distribution of the optimized vehicles may have to be limited to a small geographic area where adequate fueling stations are available, however.

Natural Gas

We hear a lot about natural gas as a possible transition fuel. As such, it might be helpful for reducing coal dependence for electricity generation, and it might be helpful for replacing gasoline. But the fact of the matter is that we don't know how much extra supply we have--perhaps a few extra percent--and for how long this extra supply might last.



According to the way the EIA counts fuels--in heat energy--petroleum is our single largest fuel source, amounting to 37% of the total. Natural gas--with is used for industrial uses, and home heating, besides electricity production--amounts to 23%, and coal amounts to 21% of the total. (Biofuels are about half of the 4% slice that I have labeled "wood + ethanol". The other half is wood used as fuel.) The wind, solar PV and Geothermal are all part of the "Other" slice, which together amount to 1% of the total.

We don't know how much extra natural gas we will have, because it depends on factors such as the extent to which fracking will be permitted near populated areas, and also how high the price of natural gas will rise. But suppose that with additional investment, we raise our natural gas supply by the equivalent of a wedge the size of the light blue hydroelectric contribution--that is, by 3% of the total. If this wedge were applied entirely to petroleum, it would replace 8% of the petroleum supply. Or alternatively, it might be used to replace about 14% of the coal supply. So under any reasonable assumption, we are not going to be able to replace a very big fraction of petroleum use with natural gas use.

Implications and Opportunities

If there is a little extra that can be put toward transportation, a reasonable approach might be to use it on fleets of commercial vehicles--perhaps busses or delivery trucks that do not travel far from their home base so that they can refuel there. Most of these might be in areas near where natural gas is extracted, so that there is not a need to add a lot of extra pipelines to transport the gas.

The above discussion relates to the US. Natural gas supply varies around the world, because natural gas is relatively difficult to transport. There may be a few places near gas production sources where cars powered by natural gas may be feasible, at least in the near term.

Cars with Batteries

If biofuels and natural gas don't solve the potential shortfall, how about electricity?

With electricity, we have two pieces that need to work together:

1. The electric grid

2. The battery operated cars

Regarding the electric grid, it is not clear whether the supply of electricity in the future (say 20 years from now) will be as great as it is today. For example, if coal were to be scaled back, we would need huge quantities of something else (wind and nuclear?) to replace the coal. Making this addition would be very expensive. So it is possible that the supply of electricity will be less in the future, and if this is the case, adding electric cars may strain electrical supplies further.

There are also issues associated with charging a large number of vehicles simultaneously from the grid. While there is much hope that the electrical industry will take care of this issue through a smart grid, we doubt that this will happen in a reasonable time frame, because of organizational and funding issues. Also, if electrical supply is significantly lower, even with a smart grid, there may still be high demand times (cold winter nights, for example) when getting adequate electricity for recharging is still a problem.

With respect to cars with batteries, electrical cars and hybrid electric cars have the advantage of being less expensive to operate than cars with internal combustion engines. This difference is especially great, if the cost of liquid fuel is high.

One advantage of oil-based fuel is that it is very dense and easy to transport. Batteries, in comparison, are much heavier, and don't allow a vehicle to travel as long a distance (unless used as a hybrid with another fuel).

Another advantage of oil-based fuel is that it is an expense paid as the vehicle is used. Batteries are usually paid for up front.

Another advantage of oil-based fuel is its convenience. Batteries are inconvenient in that most take several hours to recharge, and charging may not be available except at home. We note, however, that progress is being made, and the Nissan leaf is available with an option which will allow it to be charged in under 30 minutes, if a 440 volt L3 charging station is available.

Batteries also are expensive, especially in the quantity needed for EVs, so that the cost of an EV is higher than of a car with an internal combustion engine. The price of batteries may be partially offset by the salvage value; GM has teamed up with ABB to investigate uses for Volt batteries after they are removed from vehicular service.

Some analysts point to supplies of e.g. lithium as a limitation on electrification of vehicles, but lithium is a very small part of current battery prices and the market can easily accommodate more expensive supplies or alternative battery chemistries (e.g. zinc-air).

Implications and Opportunities

At this point, hybrid electric vehicles seem to be a better choice than EVs for many users because they are less expensive, and users are not tied to one or two sources of electricity for recharging. However, the price of hybrid powertrains is unlikely to fall as fast as the price of batteries, so this relationship may change over time.

Some individuals may decide EVs are their preferred option even today--especially those who value EVs' independence from filling stations, immunity from petroleum price increases, low-maintenance, and pollution-free nature.

What else should we be considering?

It doesn't look like any of these solutions is more than partial. Part of the solution probably needs to be in the direction of lighter, smaller, and more aerodynamic vehicles. [According to Luis de Sousa]:

> Somewhere after the Second World War the car industry simply forgot about aerodynamics (or may have passed it to the back seat). Charismatic cars like the Volkswagen (later christened as beetle) or the Citroën DS, where built with much higher concerns on this field than those available today. Air is the largest obstacle to the movement of a car on a paved road, and the only one in flat road at constant speeds. The other obstacle is mass, entering the equation whenever there is acceleration. The car industry seems to be slowly tackling the mass component with energy recovery systems on braking (something associated with the popular concept of "hybrid-car"). Though indirectly penalized by taxes on fuels, movement through air has so far been left unmitigated.
>
> Implementation could be achieved with progressive industry standards for minimum frontal area / shape ratios or by adjustments to the taxing scheme.

A few examples of vehicles with promise:

The Aptera (photo above)
http://www.aptera.com/
Compromising freight capacity for range, the Aptera is perhaps today the best example of a highly aerodynamic car with many of the possibilities of regular internal combustion engine cars.

Porsche 911 GT3 Hybrid (photo above)

http://www.porsche.com/usa/aboutporsche/pressreleases/pag/?id=2010-02-11...
While it's unlikely that we'll all be running on 6 cylinder gasoline engines in the future, this car is a serious candidate for a street legal unit with a kinetic energy recovering system based on a manifold, not a chemical battery. The mass production of such systems, if possible, may revolutionize the electric/hybrid car concept.

Aerorider (photo above)
http://www.aerorider.com/en/aerorider.html
Possibly the best example of how focusing on a single field of application (commuting in this case) can yield incredible efficiency results.

Nissan Leaf (photo above from auto blog)
http://www.nissanusa.com/leaf-electric-car/index#/leaf-electric-car/index
Compromising range for the comfort and practicality of modern internal combustion engine cars.

Many thanks to all the staff members contributing to this story!