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An Ethanol Bright Spot

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I sometimes have to pause and remind people that I am not anti-ethanol. I think I first made that clear over two years ago with my support for E3 Biofuels' attempt to produce corn ethanol in a more sustainable fashion. They were attempting to create a closed-loop system that minimized fossil fuel inputs into the process, but they ultimately went bankrupt (the move toward sustainability isn't cheap). But politics being what they are, corn ethanol is not going away. So I do appreciate it when efforts are made to push the process toward higher sustainability. I believe corn ethanol can be sustainably produced, but probably not on a massive scale. It will also take a radical shift away from the way most corn ethanol is produced today.

What I want to focus on in this essay is one particularly compelling argument for ethanol as a fuel, and to address some common misconceptions. Ethanol has a high octane rating (103), which means it does not easily pre-ignite. This has the potential to translate into higher fuel efficiencies than can be obtained with gasoline – despite ethanol's BTU deficit versus gasoline.

It is known that ethanol added to gasoline normally causes the fuel efficiency of the blend to drop. A gallon of ethanol contains about 2/3rds of the BTUs (heating value) as a gallon of gasoline, and gasoline/ethanol blends normally show the drop in fuel efficiency one would expect. However, because of ethanol's resistance to preignition, it should be theoretically possible to design an engine with a much higher compression ratio, which could then extract more useful work from the ethanol. Diesel engines are designed with high compression ratios, which is the key to their engine efficiencies of 40-45%, versus 25-30% for a gasoline engine.

Let's take a simple example, to show how ethanol's BTU deficit could be made up with an increase in engine efficiency. Gasoline contains about 115,000 BTUs/gallon. If the engine efficiency is 25%, then 28,750 BTUs/gallon ultimately power the vehicle. The rest are expelled as heat. Ethanol contains about 75,000 BTUs/gallon. One could in theory achieve the same fuel efficiency with ethanol as with gasoline if an engine was designed with an efficiency that resulted in the same 28,750 BTUs/gallon powering the vehicle (assuming same weight, frictional losses, etc.) That means that if the efficiency of the ethanol-powered car was 28,750/75,000 - or 38.33%, then 1 gallon of ethanol could provide the same power to the vehicle as 1 gallon of gasoline could at a 25% efficiency. And of course if the efficiency of the ethanol vehicle could be increased further, it is possible to use 1 gallon of ethanol to travel farther than one could travel on 1 gallon of gasoline - despite the BTU deficit.

This has been true in theory, and some small scale engines have been created. The Saab Biopower, which debuted a couple of years ago, showed that the BTU-deficit could be partially compensated for. The Saab engine was designed with a higher compression ratio, so that on E-85 it showed a 12.5% drop in fuel efficiency instead of the typical 20-30% drop that one typically sees on E-85. The Saab also achieved a reported 20% extra power and 15% extra torque from this engine.

But I was recently made aware (in fact, right here on TOD) that Swedish automaker Scania has been producing ultra-high compression ratio engines designed for ethanol usage, and they reach engine efficiencies as high as 43%:

Scania's Ethanol Diesel-Engine, Runs On Biodiesel Too

> Scania's compression-ignition (CI) ethanol engine is a modified 9-liter diesel with a few modifications. Scania raised the compression ratio from 18:1 to 28:1, added larger fuel injection nozzles, and altered the injection timing. The fuel system also needs different gaskets and filters, and a larger fuel tank since the engine burns 65% to 70% more ethanol than diesel. The thermal efficiency of the engine is comparable to a diesel, 43% compared to 44%.

That means that if all else was equal (no significant weight penalty from the high-compression engine), a gallon of ethanol could enable a vehicle to travel farther than it could on a gallon of gasoline.

In reality, the comparison is not quite apples and oranges, as these Scania engines are used in heavy, commercial applications. I wrote to the company a couple of months ago and asked them some questions about any possible plans to produce a smaller engine for passenger vehicles, but they never responded.

While this is all true in theory, it won't be achieved with a massive roll-out of E85 capable vehicles. Why not? Because these engines are designed to run on either gasoline or ethanol blends up to E85. Therefore, the compression ratio can't be too high, or the ability to run on gasoline would be lost. The best way to take advantage of the high compression issue would be to develop a fleet of vehicles that can run on pure ethanol, and whose compression ratios are designed specifically for ethanol. That would mean that these vehicles would be incapable of running on gasoline (but could perhaps be made to run on diesel).

Caveats

I will point out for those who are particularly anal retentive that there are many factors that complicate a comparison of thermal efficiencies of engines to fuel efficiency. While one fuel may have fewer BTUs and get better fuel economy, the reverse is true as well: A fuel could contain more BTUs and get worse fuel economy. Fuel economy is a function of the thermal efficiency of an engine, but one must also consider the BTUs in the fuel, the frictional losses throughout the power train, and the size of the vehicle. I compared thermal efficiency to thermal efficiency in this essay as an approximation, but it is a fair approximation.

Conclusions

As I have said numerous times, my primary opposition to corn ethanol is that only a small fraction of the ethanol that is produced can actually be called renewable. We primarily recycle fossil fuel into ethanol, and encourage that practice by paying massive subsidies to do it. This is the norm for corn ethanol, and it is a false solution to our fossil fuel dependence, rife with undesirable consequences. If we could produce corn ethanol with minimal fossil fuel inputs – as the Brazilians and Indians do with sugarcane ethanol - that would address the majority of my ethanol objections.

There are still thorny issues surrounding soil erosion, aquifer depletion, and the food supply, but let's not kid ourselves. Because of the politics of the situation, we are going to continue to produce corn ethanol. But I would like to see major modifications in the way we subsidize so that we encourage more sustainable practices. If we don't, for the next 30 years we will continue to subsidize as we have for the past 30 years – and there won't be much incentive for producers to minimize fossil fuel inputs. That is, until we run short of fossil fuel inputs quicker than we should have because we have been using them to expand the ethanol industry.

But the point of this essay was to address a legitimate urban legend, which is that BTUs tell the whole story. In reality a modified compression ratio has the potential to give the counter-intuitive result that a fuel with fewer BTUs per gallon can actually provide better fuel efficiency than another few with more BTUs per gallon.