The Oil Drum
DISCUSSIONS ABOUT ENERGY AND OUR FUTURE

The Future is Solar

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Or more precisely, the future should be electric.

I have done a lot of research lately into various alternative diesel technologies as I was working on my renewable diesel chapter. One thing that became very clear to me is that the world will not be able to displace more than a fraction of our petroleum usage with biofuels. I already knew that this was the case with ethanol, but now I think this will be a general limitation for all liquid biofuels. Consider this sneak preview (still in draft form) from the book:

> There are approximately 4 billion arable acres in the world. There are many different feed stocks from which to make renewable diesel, but most biodiesel is made from rapeseed oil. Rapeseed is an oilseed crop that is widespread, with relatively high oil production.
>
> Consider how much petroleum could be displaced if all 4 billion acres of arable land were planted in rapeseed, or an energy crop with an oil productivity similar to rapeseed. The average rapeseed oil yield per year is 127 gallons/acre. On 4 billion acres, this works out to be 33 million barrels per day of rapeseed oil. The energy content of rapeseed oil is about 10% less than that of petroleum diesel, so the petroleum equivalent yield from planting all of the world's arable land in one of the more popular biofuel options is just under 30 million barrels per day. This is just over a third of the world's present usage of petroleum, 85 million barrels per day. Yet this is the gross yield. Because it takes energy to grow, harvest, and process biomass into fuel, the net yield will be lower, and in some cases may even be negative (i.e., more energy put into the process than is contained in the final product).

The fundamental problem here is that photosynthesis is not very efficient. Consider the rapeseed oil yield above. Gilgamesh made a table that is basically the solar capture/conversion to oil from various crops. The gist is that only a few hundredths of a percent of the incoming solar energy gets converted into liquid fuels. Of course some did get converted into other biomass, which could be otherwise used for energy, but generally we get a very low capture of the sun's energy for use as liquid fuels. (This exercise can still be proven by assuming the theoretical limit for photosynthesis. One must just make more assumptions and it is not as easy to follow for a general audience).

Consider instead direct solar capture. Let's not even consider the record 40+% efficiency that Spectrolab announced last year. Let's not consider any of the more exotic technologies that are

pushing the envelope on direct solar capture efficiency. BP's run of the mill silicon solar cells operate with an efficiency of 15%. That's about 250 times better than the solar to rapeseed oil route. Or, to put it a different way, you can produce the same amount of energy with direct solar capture in a 13 ft. by 13 ft. area that you can by photosynthesis in 1 acre of rapeseed. And odds are that you have a roof with an area that size, which could be used to capture energy without the need to use arable land.

Of course the disadvantages are 1). The costs for solar are still relatively high; 2). We have a liquid fuel infrastructure; 3). Storage is still a problem. But in the long run, I don't see that we have any chance of maintaining that infrastructure. If we are to embark on a Manhattan Project to get off of our petroleum dependence, we should direct our efforts toward an eventual electric transportation infrastructure.

Notes

After posting this essay at my blog, it got linked to from a number of places. Between those links and the original blog entry, some of the comments I read were largely in left field, and many of them didn't come close to representing my actual position or arguments. Maybe that's partially my fault for spending all of 20 minutes writing the post. Which brings up another point: It seems like the less time I spend on a post, the more comments and hits it gets. But I digress.

So, let me clarify a few things.

1. I am not against biofuels. In certain situations, biofuels may be (and probably are) an appropriate solution to the problem. In fact, I continue to work on solutions to biofuel problems, and I wouldn't waste my time doing this if I didn't think there were some applications. My argument is that we won't, as many people believe, displace large amounts of petroleum with biofuels. Presuming we can is presuming that technology that does not currently exist will inevitably be invented.

2. I am not against technology. I love technology - especially biotechnology. But I am well aware of the "technology will save us mentality." Technology doesn't always proceed as you think it should, and it doesn't always respond to monetary incentives. If it did, cancer and AIDS would no longer be with us, and 40 years after the moon landing, a manned Mars expedition wouldn't still be a distant dream.

3. This is not a new revelation for me. I have long believed that our future must be electric for at least 4 reasons. First, is the photosynthetic efficiency that I discussed. Second, internal combustion engines are notoriously inefficient relative to electric motors. Third, we have a lot of rooftops available that will not compete with arable land. And finally, electricity can be produced from a tremendous diversity of sources. Start with biomass, solar, wind, hydro, nuclear, natural gas, coal - all are easily converted into electricity. Contrast that with the uncertainty of a future based on cellulosic ethanol and algal biodiesel.

4. As one person argued, "solar collectors don't self propagate." True, but biofuels don't self-harvest and convert themselves to useful end products. Once the solar panels are in place, they keep giving for a long time.

5. The rapeseed example is merely a thought experiment. Don't spend too much time worrying about all of the implications of planting a majority of our land in rapeseed, or whether instead I should have planted palm oil or corn everywhere. It is just an example to frame the problem. But I do not believe, as some have suggested, that using land that is presently non-arable is going to

provide a fraction of the yields you would get from planting all the arable land in rapeseed. So, I think it is a very conservative thought experiment.

6. Several people have suggested that I am just wrong about biofuels; that technological advances will change everything. All I can say is that hope is a wonderful thing. But you better plan for contingencies in case those visions of algal biodiesel fail to materialize.

7. Yes, I know that SI units are better in the context of a scientific paper. And I do use SI units in the chapter. But for most casual readers in the U.S., a yield of gallons per acre is going to be more meaningful than a yield of liters per hectare.

8. I am aware that biomass is stored energy. But you can't harvest all of that stored energy and use it, or you will rapidly deplete the soil. This is why you will never convert anything close to theoretical photosynthetic efficiency into liquid fuels. And theoretical photosynthetic efficiency is still far short of solar cell efficiency.