Energy Density - and Survival

This is something of a dramatic title, I know. But there are serious issues at stake, and we, as a species, are resolutely failing to address them. And so this article is about these issues - or more specifically - energy density and power density, and the relationship these metrics have to the choices that we must make if we are going to survive. Not to be alarmist about it...

Now this is not going to be a long hyper-complex dissertation that will put you all to sleep - or, at least, I hope not. And in order to avoid having to introduce a lot of from-first-principles calculations I am going to quote from a number of sources that you are welcome to look up and investigate for yourselves.

But to start at the beginning; we are all aware, I am sure, of the general meaning of Energy Density - the amount of energy that is contained in a given mass of a substance; Joules per gram (J/g), in International Units. Anyone who has had a wood-burning stove and has hauled logs up from the garden realizes that there is more energy in fuel oil than there is in the same weight of wood. Now this may not have been a big deal when all we had to heat was a cave, but New York is a different proposition. This is what William Tucker, the author of "Terrestrial Energy" has to say about the relative energy densities of the fuels that we commonly use:

"Compared to all the forms of energy ever employed by humanity, nuclear power is off the scale. Wind has less than 1/10th the energy density of wood, wood half the density of coal, and coal half the density of octane. Altogether they differ by a factor of about 50. Nuclear fuel has 2 million times the energy density of gasoline. It is hard to fathom this in light of our previous experience. Yet our energy future largely depends on grasping the significance of this differential."

But is it a big deal? Wind and solar power are free, and we can easily grow corn and turn it into ethanol - and we are discovering new sources of shale oil and gas every day. So what if the world will have a total population of 9 billion by 2050? It just means more solar panels and wind turbines.

But this is where we hit the next metric - Power Density. This is generally defined as the amount of power which can be generated from a specific area of the surface of the earth, or Watts per square metre (W/m2) in International Units. Dr. Vaclav Smil is a Distinguished Professor in the Faculty of Environment at the University of Manitoba in Winnipeg, Canada, and he has carried out extensive analysis and written several papers on this subject. His analysis includes the mining and extraction sites, as well as waste disposal, and shows that natural gas is the most energy dense at around 1000 W/m2, with coal a close second at 500 W/m2. You do not think that this is a close second? It is with Solar at 5 W/m2, Wind at 1 W/m2, and Biomass (including Ethanol) at just 1/2 W/m2. Just to make the comparison clear, it would take a Solar Power Plant 200 times bigger than a Natural Gas Power plant to make the same amount of power. And a wind plant would be 1000 times bigger.

That is a lot of real estate - and although an argument could be made that there is a lot of unused desert and sea (for wind plants) it does imply an associated web of power transmission lines, and these are not cheap; they are also hated by pretty much everyone. StarCore is a type of High Temperature Gas Reactor, and as such generates about 7,000,000 W/m^2 in the core. Even when you add in the support and turbine buildings it is still making around 2,000 W/m^2 with plenty of room for growth as the design matures. Just to rub it in, this is 2,000 times more power per square metre than wind power.

So far I have not mentioned carbon footprints and climate change; even if you do not subscribe to global warming it should be obvious that we cannot keep pumping the carbon dioxide into the air forever. Most authorities put an upper limit on carbon dioxide at around 450 parts per million (ppm) if we wish to avoid radically changing the planet, and this was used as the basis for an interesting lecture a few years ago. Dr. Saul Griffith is a graduate of the University of Sydney and MIT, and was also awarded the MacArthur Foundation Genius Grant in 2007. His analysis of the implications of Energy and Power Densities was given at a conference in 2009, and summarized by Stewart Brand, an American writer, as follows:

The world currently runs on about 16 terawatts (trillion watts) of energy, most of it burning fossil fuels. To level off at 450 ppm of carbon dioxide, we will have to reduce the fossil fuel burning to 3 terawatts and produce all the rest with renewable energy, and we have to do it in 25 years or it's too late. Currently about half a terrawatt comes from clean hydropower and one terrawatt from clean nuclear. That leaves 11.5 terawatts to generate from new clean sources.

He goes on to show what this would imply, basing his analysis on 2 terawatts of photo-voltaic solar power, 2 terawatts of thermal solar power, half a terawatt of biomass, another 2 terawatts of wind power, and the remainder from a mix of geothermal and nuclear power. But the first four - two types of solar, biomass, and wind - are the ones that have very low power density and so require huge amounts of space. How huge? Well, he says that two terawatts of photovoltaic solar power would require installing 100 square meters of 15-percent-efficient solar cells every second, second after second, for the next 25 years. That's about 30,000 square miles of solar panels over 25 years. The two terawatts of solar thermal power implies that 50 square meters of highly reflective mirrors are installed every second, or 1500 square miles over the 25 year span. And the half a terawatt of biofuels? Something like one Olympic swimming pool of genetically engineered algae, installed every second - about 350,000 square miles of area. Finally the two terawatts of wind power means a 300-foot-diameter wind turbine would be built every 5 minutes for the next 25 years. The total land area required for all this is about the size of Australia, the sixth largest country in the world - or about 3,000,000 square miles. And that does not account for any population growth (about 2 terawatts per billion people), or for actually reducing the carbon footprint which would take up about half as much area again.

So the outlook is pretty bleak if we decide to rely mainly on renewable energy sources, and despite the hype there is clearly not much real future in such a course of action. StarCore is just a tiny step in the right direction and will do nothing, by itself, to alter this picture in a significant way. But it can bring power and water to many people presently suffering from lack of them; and perhaps, in doing so, it can also lead mankind down a new path to a better and brighter future. We are StarCore, and we have a Vision.

David Ashley Poole
CTO, StarCore Nuclear (CANADA)
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