The "green" phenomenon and its macroscale effects

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Being "green" is a badge worn with honor by companies and individuals alike. Just like consuming organic foods, it's as much a yuppie status symbol as it is a lifestyle choice. At least it used to be. Venture capitalists are on the lookout for interesting green companies these days because there's lots of money to be made by reducing energy consumption, cutting back greenhouse gas emissions, and generally doing more with less. From a very high, forward-thinking level, it seems bizarre that we haven't been doing this right along: if economics is the study of human behavior in a world where there are limited resources but infinite demand, it makes sense that we would want to do more with less.

If it requires 50% less electricity to run an efficient datacenter, and 50% less gasoline to get from point A to point B, then that means we can house twice as many servers and end up with the same electric bill, and travel twice as far without burning any more gasoline. So every halving of the resources required to do something results in a net doubling of whatever you can do with that resource, all things being equal.

This model is easily applied to things like fuel efficiency and other commodity consumption, where small increases in efficiency result in immediate, apparent cost savings to the ignorant consumer. However there are other, less intuitive places to look where small savings aggregated across millions of people results in real macroeconomic benefit.

For example, there is a push right now to get rid of or improve "standby" modes for most electronic devices. This is what is widely considered the "off" position for most things, but in reality is actually the low-power mode wherein a device is not performing its primary function. The clock on the VCR and the microwave. The "breathing" the LED in your Macintosh computer does while it's "asleep." A single device can suck up as much as 30W of electricity every 24 hours. Multiplied across all of the consumer electronics in your home, multiplied by the number of households in the United States, and you quickly realize that this is a boatload of wasted electricity. In fact, in the lifetime of a single electronic device, this savings is estimated to be $10. This is one of the reasons that President GW Bush directed the entire federal government to buy low-standby-power devices back in July of 2001. Uncle Sam buys a lot of electronics. That means tens and possibly hundreds of millions of taxpayer dollars saved by one seemingly insignificant initiative.

Being green makes good business sense, much of the time. While you obviously wouldn't want a hospital run directly on solar power, it does make sense to build solar arrays in the right places, and wind farms in perpetually windy areas, and then hook these up to the existing power grid. In that context, running the hospital on solar power doesn't seem like such a bad idea anymore. In medicine, we manage chronic pain by coupling a long-acting opioid with a short-acting, rapid-onset opioid. The long-acting agent is used to control baseline pain, and you never use short-acting opioids to manage baseline pain because of the greater duel risks of overdose and dependence. These agents are used to breakthrough needs only. In power generation, the metaphor is similar: renewable resources provide your baseline power, and your coal- and oil-based electricity kicks in only when necessary. Thankfully, exothermic reactions like combustion lend themselves to rapid cycling and are therefore suited to "as-needed" use.

Texas billionaire oilman T. Boone Pickens is seeing why it's valuable to invest in renewable sources of energy. Not only is it good for national security, but it makes good business sense to invest in renewables. With any non-infinite resource, the market is subject to the forces of supply and demand. When supply drops, the price goes up. If demand increases because India and China need their share of the world's petroleum supplies, prices for the US consumer go up, as well as the ancillary costs associated with anything that needs to be transported. As the amount of available petroleum decreases – as it's steadily and inevitably doing – these forces increasingly affect the way you operate your business. For a company like National Grid, eliminating the twin problems of scarcity and competitive bidding are good for the bottom line.

Civil and structural engineers and architects are hopping on the green bandwagon as well. The first of them jumped on because it was hip and different, and enabled them to leverage a different kind of brand image to achieve financial success. Lately, though, buildings that are built to be more energy efficient make economic sense. In Sweden, Jernhusen AB is harnessing the body heat of thousands of commuters that pass through Stockholm's main railway station. The firm believes that the system being designed can provide about 15% of the energy needed to heat the 13-story building being built next to Central Station. This system isn't even particularly radical. It's going to cost about $47,000, and will only require a few pumps and some pipes, since the ventilation system is already in place. I think it's a safe bet that a 15% annual energy savings for a 13-story building will more than cover even the short-term costs associated with it, particularly in a city only ~1,000 miles from the Arctic Circle like Stockholm.

Since every mechanical system wastes energy in the form of heat, recycling waste heat is also becoming more popular. Estimates of the amount of energy lost in the form of heat – expressed in terms of electricity – from smokestacks in the US alone is at 50,000 megawatts, more than half of what this country generates from its aging nuclear fleet. Initiatives to turn this waste heat directly into electricity are already underway, and can be built on small scales that make it worthwhile for these industrial companies to invest in.

Plastic, another petroleum product, is a problem in the making as well both in terms of making more and recycling what we've already used. Recently, a 16 year old Canadian high school student conducted a series of experiments designed to isolate organisms that might degrade plastic bags. After collecting soil samples at a local landfill, he spent 3 months culturing them solely on a diet of polyethylene film strips. He narrowed it down to four types of bacteria, and grew each on agar plates, and discovered a new species of bacteria that eats plastic bags more ravenously than Pseudomonas, the only known plastic eater to that point. Burd found that only 0.01% of the microbes' body mass was released as carbon dioxide, allaying fears that his technique, if implemented on a wide scale could increase the amount of greenhouse gases released during recycling. It's estimated that these plastic bags will take between 50 and 1,000 years to break down on their own in a landfill. And microbes have been shown to do the opposite as well, by taking toxic styrene and turning it into a biodegradable plastic called PHA. Both processes have economic implications, and each seems to be another tiny nail in Malthus' coffin.

There are other initiatives being worked on, primarily in academia, that will have huge implications for our business and environmental future. Generators that sit in the ocean or river and harness the power of tidal forces. There are some problems associated with this method of electrical production, such as how to store this energy meaningfully, but these problems have analogs with other types of green energy production, like wind power. With enough interest, investment, and work, they'll be solved.

Other ideas surrounding the harnessing of the oceans include thermal energy converters. It's thought that the amount of solar energy captured by the ocean is equivalent to 250 billion barrels of oil per day. *That means that each day, the world's oceans capture the energy equivalent of 33 years worth of the US's total oil consumption.* Obviously capturing the entirety of that energy is impossible and undesirable, but any company that comes up with a way of efficiently harnessing just a tiny fraction of it stands to make billions. Quite likely they will find themselves in an oligopolistic or even monopolistic position, too, as the barriers to entry will be huge, and the absolutely large minimum efficient scale of production will prevent new firms from entering.

"Green" thinking is also driving microscale R&D. Electronics companies are looking at solid state storage as a means of cutting down on power consumption in the datacenter. As more and more of our computing and storage moves to the "cloud", more datacenters are required. Datacenters are expensive to cool, and it's quite difficult to achieve an inexpensive, efficient, useful power density as well. That means that a large scale reduction in the amount of electricity consumed by individual server components will mean that useful power densities can be lower, or more servers can be crammed into a smaller space.

The largest consumer of electricity in the server are the pieces that move, specifically the hard drive which spins like a record. This movement has the secondary effect of creating waste heat which must be compensated for with adequate cooling lest the entire datacenter overheat. So even a small decrease in power consumption in that one tiny segment of that one specialized market will have repercussions across many secondary industries. It's similar in scale to the standby power dilemma mentioned above. And when you see companies like Microsoft, Amazon, and Google moving close to hydroelectric dams to build their datacenters, or move to Siberia to save on cooling costs, you know these concerns aren't pie in the sky. There are real economic forces at work that are more powerful than the constraining forces associated with having to build fiber infrastructure out to these remote areas.

There are other ideas floating around, that might be of interest to private individuals, too. Wind turbines floating on permanent neodymium supermagnets resulting in ultra-low coefficients of friction that generate electricity spring to mind. Even the smallest gust of wind could offset electricity costs for your home. Applied on a larger scale, these turbines could be installed next to stretches of highway where the wind created by vehicles speeding by generates power for the grid. The ideas get progressively more sci-fi and less based in reality, but all have research and/or working prototypes to support them.

Ultimately, I expect one or two dominant, green power generation strategies to become prominent, based largely on a region's geographical needs. A landlocked country has little use for generators that harness tidal forces, and a country without large amounts of sunlight will have little use for a solar grid and might be better off with a network of small, personal, near-frictionless turbines to produce a great deal of power. This will have the secondary effect of changing power companies' dynamics. Private individuals and businesses may end up selling a significant fraction of the electricity that they generate back to the power company, as already happens on a tiny scale.

Rather than being a sunk, overhead cost, electricity could provide a small, secondary source of income in some cases. This is good for the overall health and robustness of the power grid itself. Rather than a centralized source vulnerable to operator error, equipment failure, or even an unlikely terrorist attack providing us with

all of our power, a grid of consumers becomes a grid of hybrid supplier-producers. This has an effect on the dynamic of the producer-consumer relationship, too. The consumer has more power because they're doing more than just consuming. They become more of a partner in the relationship.

So while no single master stroke of technology is going to save the world from global climate change, or rescue our economy from its dependence on foreign oil, there are a number of initiatives that, in aggregate, are having a real, profound effect on our economy. That effect will only become more pronounced as time goes on, and these technologies that are mostly in the lab make their way slowly into the real world. It's important to note that while being green is trendy and gets a lot of press and has considerable mindshare, particularly among the youth, it's not this trendiness or mindshare that's going to create lasting change. It has certainly sparked social change, which is good, but as always, it is the bottom line that will be the driver for bigger and better things. It will be economic forces that determine whether we continue our destructive tendencies or move towards a more renewable future. My money is on green, because that's the direction the invisible hand is pushing us in. Green is, quite simply, how we do more with less, and create new markets while we make our way in that direction.