RENEWABLE AND ALTERNATIVE ENERGIES

While still chancellor of exchequer and before becoming Britain's prime minister, William Gladstone visited Faraday's laboratory. "But, after all, what good is it?" He asked, when Faraday explained how he could transform motion into current. Faraday replied, "Why, sir, one day you will tax it."

Renewable Energies

We shall provide four examples of renewable energies, each pertinent to Malaysia in a different way:

1) corn and sugar ethanol because of existing sugar plantations and corn fields;
2) algae because of the ideal climatic condition;
3) gasifier technology because of existing oil palm and rubber plantations; and
4) genetic enegineering and synthetic biology because of existing research institutes.

Not So New Biofuel Technology

Humankind has been turning grains into alcohol for eons. The corn is ground, mixed with water, and heated; added enzymes convert the starch into sugars. In a fermentation tank, yeast gradually turns the sugars into alcohol, which is separated from the water by distillation. The leftover, known as distillers' grain, is used as feed, and some of the wastewater—rich in nitrogen—is used as a fertilizer.[2–4]

The process also gives off large amounts of carbon dioxide (CO_2). Most ethanol plants burn natural gas or, increasingly, coal to create the steam that drives the distillation, adding fossil-fuel emissions to the CO_2 emitted by the yeast. This is where ethanol's green label starts to brown.[5]

Growing the corn also requires nitrogen fertilizer, made with natural gas, and heavy use of diesel farm machinery. Some studies of the energy balance of corn ethanol—the amount of fossil energy needed to make ethanol versus the energy it produces—suggest that ethanol may be a loser's game, requiring more carbon-emitting fossil fuel than it displaces; other studies give it a slight advantage.[6]

While corn ethanol's energy ratio hovers around breakeven, sugar cane ethanol gets about eight units of ethanol for every one unit of fossil fuel. Experts estimate that producing and burning cane ethanol generates anywhere from 55 to 90% less CO_2 than gasoline.

A Scummy Solution

Virtually every scienstist studying the biofuel issue agrees that there is no magic-bullet fuel crop that can solve our energy woes without harming the environment. But most say that alga—a single-celled pond scum—comes closer than any other plants because it grows in wastewater, even seawater, requiring little more than sunlight and CO_2 to flourish.

A dozen start-up companies have been trying to convert the slimy green stuff into a viable fuel. Some of these companies have developed a process that uses algae in plastic bags to siphon CO_2 from the smoke-stack emissions of power plants. The algae not only reduce a plant's global warming gases (CO_2), but also devour other pollutants. Some algae make starch, which can be processed into ethanol; others produce tiny droplets of oil that can be brewed into biodiesel or even jet fuel. Most advantageously, algae in the right conditions can double in mass within hours. By comparison, each acre of corn produces around 300 gallons (1,135 liters) of ethanol a year; an acre of soybeans around 60 gallons (227 liters) of biodiesel; while each acre of algae theoretically can churn out more than 5,000 gallons (19,000 liters) of biofuel each year! With corn or soybeans, one harvests once a year; with algae one harvests every day.

Gasifier Technology

Gasifier technology uses gases—hydrogen (H_2), carbon monoxide (CO) and methane (CH_4)—extracted from wood chips to heat a boiler. This process can generate 1.3 megawatts per hour.

Essentially, the technology involves four steps:

1. Gas collection: The gasifier heats the wood chips to 700 or 800 degrees, where they smolder, releasing H_2, CO and CH_4. Spent wood chips disintegrate to ash. Water vapor is the only major emission.
2. Ignition: The gases travel to an oxidizer, where oxygen is added and the gases burn.
3. Steam: Hot gases travel to a boiler which heats the water to steam.
4. Electricity generation: The steam powers a turbine to create electricity. The steam finally will be used as hot water and to heat buildings.

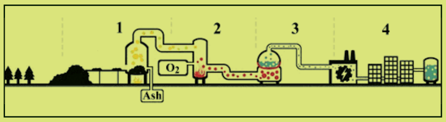

Figure 1. The wood gasifier involves 1. Gas collection; 2. Ignition; 3. Steam; 4. Electricity generation.

Genetic Engineering and Synthetic Biology

Some companies are using old-fashioned genetic engineering to develop a strain of standard industrial microorganism that can produce hydrocarbons from treated agricultural waste. The present strain is very close to meeting an economic threshold, and is being tested in pilot plants. The youthful microbe already produces an ethanol-like product, at 65% of the cost of corn-derived ethanol. The fuel meets the same diverse needs as petroleum does, can be transported in existing pipelines and be used in existing vehicles.

Besides genetic engineering approaches, other approaches are using synthetic life forms. In the latter case, there are many hurdles to overcome before the vision of "life by design" is realized.[7]

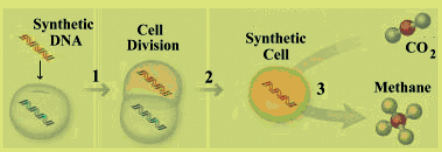

Figure 2. If researchers were able to create a synthetic genome, the transplantation process might be able to create synthetic cells. 1) A synthetic DNA is inserted into a species of bacteria. 2) When the cell divides, one of the daughter cells is a synthetic cell. 3) In theory, the synthetic cells could be designed to have useful properties such as the ability to efficiently convert carbon dioxide to methane.

Einformatics

We shall now discuss the viability of different alternative energies from the standpoint of Einformatics, which is a study of information content and information flow in energy systems. The study encompasses efficiency, economics, and environmental impacts, among others.

Carbon Calculus

Weaning ourselves from hydrocarbons is something what we humankind will undoubtedly do someday, but not soon. Scrubbing out the carbon dioxide (CO_2) at the smokestack is technically feasible, but given the massive amounts of carbon at issue, this would require enormous additional capital investment and concomitantly increases in consumption of fuel. Would it be viable depends on how seriously we take the claim that carbon emissions are changing the global climate.

Worldwide, humans emit roughly 6.5 billion metric tons of carbon by burning fossil fuels, and another 2 billion metric tons through deforestation. Plants—the green kind, not the ones built of concrete—exhale about 59 billion metric tons of carbon in the form of CO_2 a year, and absorb roughly 120 billion in photosynthesis. Soil organisms, digesting the dead plants on which they live, emit 59 billion. A net of about 26 billion physically diffuse into the atmosphere out of the oceans, and about 28 billion diffuse back in. In short, green plants and carbon weathering, both powered by the sun, continuously establish new carbonaceous order.[8]

The fear is that if we dig up and burn all the fossilized plants of the Carboniferous period, we can expect to recreate the atmosphere of that period—a carbon-rich hothouse. On its own, the effects are still inconsequential—CO_2 in the quantities we add, does not act as a very effective atmospheric blanket to block the shedding of heat from the surface of the earth at night. But water vapor might amplify the impact significantly. Warmer air holds more vapor, which blankets the planet a bit more, which warms the air still more, which holds more vapor, and now the earth becomes a runaway greenhouse. Or so a good number of the climate models suggest. There is much uncertainty to these models, but the mere possibility that we might be changing our global environment is indeed worrisome.[9]

Economic Externalities

A change in the works could go a long way toward making alternative energy less alternative, but more attractive to consumers and businesses. It is not a technological fix from some solar-cell laboratory in Silicon Valley, or some wind-turbine research in China, or the development of some super bug to turn wood waste into ethanol. Rather, the change is coming from policy-makers, if they carry through what they have been talking about and putting a price tag on greenhouse-gas (GHG) emissions.

Carbon dioxide is what economists call an "externality," something that imposes a cost on somebody other than the manufacturer. At some point, the thinking goes, policy-makers will force industries to pay those costs, either with a tax or a cap-and-trade system in which allowances will cost money. Suddenly the carbon content of fuel, or how much carbon dioxide (CO_2) is produced per unit of energy, would be as important as what the fuel costs. In fact, it might largely define what the fuel costs.

This could shake up the economics of energy. Those that produce hefty emissions, like coal and oil, would likely be handicapped; and some—sunlight, wind, uranium, even cornstalks and trash as well as natural gas—would probably be favored. "Carbon-negative" fuels that take CO_2 out of the atmosphere as they are made might even become feasible.

Staff at the Electric Power Research Institute (EPRI), a nonprofit utility consortium in Palo Alto, California, estimates the effect of a charge on CO_2 emissions on the price of a kilowatt-hour. At $10 per metric ton, the impact is minimal, but at $50 a ton, for example, the cost of a kilowatt-hour produced by coal goes from about 5.7 cents to about 10 cents. Wind power currently is not competitive, according to the institute's calculation, but it becomes competitive when CO_2 costs $25 a ton. By their calculations, nuclear energy, with negligible CO_2 emissions, looks sensible at a small carbon charge.

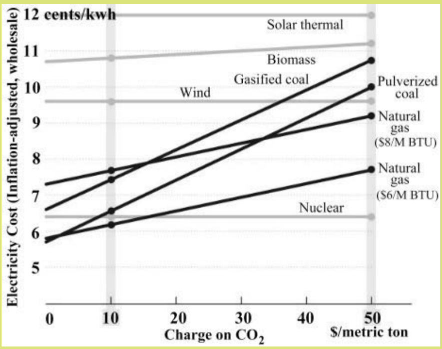

Figure 3. A charge on carbon emission may allow alternative energy sources to compete with coal or gas. At $50 per metric ton of CO_2, pulverized and gasified coal would be more expensive than wind and nuclear power. Note the average cost of solar power range from 12 cents to 26 cents.

Here is how the new economics might work for solar power. Solar power from photovoltaic cells is currently relatively expensive, about 25 to 30 cents per kilowatt-hour. Comparing a kilowatt-hour produced by such cells, which emit no CO_2, with one produced by a conventional coal plant (coal produces 1.9 pounds of CO_2 per kilowatt-hour), at $20 or $30 a ton, the 1.9 pounds of CO_2 emitted in producing that kilowatt-hour costs 2 to 3 cents.

That cuts into coal's price advantage and—when coupled with progress in reducing the cost of solar power through manufacturing and economies of scale—gives solar power a much larger chance to be relevant. Solar thermal systems, which use mirrors to concentrate sunlight to boil water, might benefit even sooner.

Conclusion

The three kinds of fossil fuels—coal, crude oil and gas—account for about 80% of the world's total primary energy supply. The rest is about equally split between primary electricity—hydro and nuclear—and phytomass (live biomass) fuels.

Biomass energies have been with the humankind ever since we mastered the use of fire: wood, charcoal, crop residues and dung are still used by hundreds of millions of peasants and poor urban residents in Asia, Latin America, and particularly throughout sub-Saharan Africa, mainly for cooking and heating. But most of the biomass is burned very inefficiently in primitive stoves.

We have begun to harness the other major indirect solar flow—wind—but it is too early to predict if large-scale wind farms will translate into worldwide and sustained contributions. Potentially the most rewarding, and by far the largest, renewable energy resource is the direct solar radiation that brings close to 170 W/m^2 to the earth. But so far its direct conversion to electricity by photovoltaics has succeeded only in small niche markets that can tolerate the high cost. Silicon Valley, the clean energy capital of the world, has been making some of the greatest advances in solar power.[10]

But as we argued, the carbon content of fuels can be a major factor in deciding in the near future which fuels will be the most favorable, economically and environmentally speaking. The sun is shining the brightest in this sense.

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Dr. Hwa A. Lim
Ph.D., MBA,

Dr. Lim is credited with coining the neologism "Bioinformatics" in the 1980s, establishing and shaping the field, and initiating the world's very first bioinformatics conference series. These credits earn him the title "The Father of Bioinformatics". Dr. Lim currently resides in Silicon Valley, San Jose, California, USA.
Email: hal_lim@yahoo.com
hal@dtrends.com