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Alternative Energy

It is a truism that the sugar cane mill is in the energy business. Sugar production from cane (and beet) is an energy intensive operation, perhaps requiring more energy per unit of product than any other major food product. Fortunately, as conventionally practiced, cane provides its own fuel in the form of bagasse. With efficient boiler operations and steam use, excess steam, over that required for factory operations, becomes available to generate electric power for export or to provide process energy for other operations, such as ethanol production. Most discussions of the biorefinery concept depend on bagasse, or residual material from it, as the process energy source. Energy efficiency is therefore a major concern and the subject of much development work in sugar factories.

One reason for the ever increasing capacities of cane mills is the economies of scale inherent in the use of large boilers. Boiler costs, including fuel (bagasse plus supplementary materials) handling and storage, are a very significant part of the cost of a new factory. A rough estimate for the capital cost (in the USA) for a large modern high pressure (biomass) boiler is $50-100 per pound of steam produced per hour. This includes the fuel handling and pollution abatement systems, etc. Using the insoluble cane fiber as fuel makes a lot of sense – it is on site, has low ash, low sulfur and nitrogen and is in a well-disintegrated form suitable for direct use as a boiler fuel.

Most discussions of biorefineries assume that the process energy will be provided by combustion of the "least useful" component of the biomass, usually lignin. If we think of this approach as the first generation biorefinery, can we also think of a later generation that uses all the complex organic molecules that nature has provided. Although lignin has been much studied, it has proved to be more intractable than cellulose and hemicellulose. This will not remain the case and valuable commercial products based on lignin are certain to be developed. Lignosulfonates and oxidized lignins are already available but are the byproducts of paper making and other processes, rather than deliberate products or "designer lignins."

It is less important to copy the molecular structure of petroleum based materials than to produce something that is functionally equivalent. This is one reason why I am puzzled by the goal of making ethylene and therefore polyethylene from sugar via fermentation to ethanol. For many purposes polylactates are functionally equivalent to polyethylene and also have the advantage of being biodegradable. Based on stoichiometric yields from glucose, one kg of glucose would yield 0.31 kg of polyethylene and 0.80 kg of polylactate. This calculation ignores conversion and recovery efficiencies but the magnitude of the difference in yield is very significant.

If a biomass derived product is to be a food ingredient, then the origin and history of the raw material need to be unambiguous. This is not a problem if bagasse is the raw material since its origin is the same as the sugar produced in the mill/refinery. Other sources of biomass are likely to have more problems related to food security issues.

The problem with this later generation biorefinery is that it leaves the operation without any intrinsic fuel, except perhaps for biogas from a waste treatment plant. This would be quite limited in output if the biorefinery processes are reasonably efficient.

The need therefore is for a sustained and reliable energy source for the processes in the biorefinery. Since the underlying goal of this type of development is the replacement of all types of fossil fuel, we are left with limited choices. All the processes contemplated require the use of both electrical power for pumps, compressors, etc and low pressure steam for heating, distillation, drying, etc. From a simply technical perspective, the most obvious energy source would be a nuclear power plant. These run continuously and are of much higher energy output than would be required for the operation of any conceivable biorefinery. Of course, we need to get past our fears, I think unjustified, of nuclear power and the record across the world of the responsible application of this technology should convince us that we have little to fear, except fear itself.

This approach would separate the processing operation from the energy source and, providing that the latter was very reliable, would simplify the design and operation of the biorefinery, or sugar factory/refinery for that matter. We need to think in terms of "energy intensity" or the concentration of energy production and use in small areas. Wind power is obviously a component of any new energy system but it is hard to see a steel mill or a sugar operation run on the power from wind turbines.

I have been reading about solar thermal energy and some of the recent developments show promise for quite large scale energy output. A nuclear plant would have a nominal energy production capacity of 1000 MW and the largest biomass fired electricity operation has an output to the grid of approximately 100 MW. Recent solar thermal plants have a capacity of 300 MW and above. Certain parts of the sugar cane world have great potential for application of this type of energy source, especially where rainfall is low and irrigation is standard practice. The major issue with this technology is that energy is only produced during daylight hours and the problem of energy storage on a large scale has not been solved.

The other approach is to burn low value and mixed biomass and even garbage, perhaps using gasification technology. Landfilling is standard practice for materials that we want to dispose of but are unwilling to risk using in a more productive manner. Again, the technology for energy recovery from waste by combustion and/or fermentation is ready for application but fear and the "not in my back yard" philosophy win out. The opposite question is whether we really need all the energy we consume. Perhaps a topic for anther time and place.