Torrefied Wood: A Bio-Energy Option That Is Ready to Go

In 2007 the Congress passed legislation that mandated producing 16 billion gallons per year of 2nd generation biofuels from cellulosic biomass by Year 2022. Although many experts believe this *"Renewable Fuels Standard"* (RFS) could still be attained, progress toward that goal has bogged down. Processes under development for producing 2nd generation biofuels on a commercial scale have yet proved to be economic.

In addition, 2nd generation biofuels processes are still evolving, adding to technology risk of those who have committed to projects using existing technologies. Further, potential investors in 2nd generation biofuels development projects are also being confused by claims being made for technological breakthroughs for producing biofuels from algae and other forms of bio materials, and in some instances, investors are delaying making additional investments in 2nd generation biofuels projects they had initially backed.

And, funding for some of these *"advanced"* 3rd generation biofuels projects have had the effect of siphoned off venture capital that may have otherwise been used to support promising 2nd generation biofuels projects. When added to current overall shortages being experienced by project developers in obtaining investment capital, 2nd generation biofuels project development is now not keeping pace with increasing biorefinery capacity requirements that will be needed to attain the RPS mandated 2nd generation biofuels requirements by 2022.

Most of the reporting being done on recent biofuels developments is focused on liquid biofuels. Not being adequately covered is reporting on the potential that already exists for converting wood waste and other woody biomass into torrefied wood ("TW") pellets that could then be used as a substitute for coal in coal fired boilers and gasifiers.

Materials Most Suitable for Use In Manufacture of Biofuel

Woody biomass is ideally suited not only to the manufacture of 2nd generation liquid biofuels. Woody biomass is even better suited to producing TW. When woody biomass undergoes torrefaction all of the components are used, without having to separate out each component for separate treatment, prior to producing biofuels. In other words, cellulose, hemi-cellulose and lignin, the components of woody biomass are processed in chip form to produce synthetic gas and carbonaceous residuals that end up as TW.

Forestry waste is the form of woody biomass that is most suited to making biofuels, especially TW, as much of this waste is either not used or at best, is used as a marginal fuel. Forestry wastes can be supplemented by other wood wastes when they can be obtained on a reliable basis at competitive prices. The following is a more precise description of the forestry wastes that are most suitable for this use.

Forest Residue
Forest residue is the unused portion of growing-stock trees cut or killed by logging and left in the woods. In certain instances, forest residue is cleaned, chipped and used as a boiler fuel. But for the most part, forest residue goes unused.

Pre-commercial Thinnings
Pre-commercial thinnings (a.k.a., *"first thinnings"*) are un-merchantable timber that consists of smaller and less desirable trees that are removed from timberlands in order to enhance residual tree growth. These first thinnings have stems that are less than 5″ in diameter at breast height (”dbh”) and are currently cleaned chipped and used as an inexpensive boiler fuel.

Commercial Thinnings
Commercial thinnings have stems that are 5” to 8.9″ in dbh are primarily used in making pulpwood used by pulp and paper mills. Commercial thinnings are often not available or command too high a price for use as a biofuels feedstock.

Forestry Waste Availability
In the US, forestry waste is the most readily available and abundant material that can be used to produce biofuels. Tour country has significant forests in a variety of regions and there are millions of acres of timberland that are already being harvested. Estimates provided by a number of nationwide studies indicate that in addition to timber being harvested, the total nationwide forestry waste potential is in excess of 317 million green tons per year (gtpy). It has also been estimated that on average, the annual yield of timber is 6 green tons per acre and the annual yield of forest residue and pre-commercial thinnings estimated at 1.2 green tons per acre.

Converting Wood Waste to Biofuels

Cost and Value Added Attributes of Various Cellulosic Biofuels
At the high end of the cellulosic biofuels spectrum are liquid transportation fuel blend stocks, such as cellulosic ethanol, butanol, and methanol, tank ready transportation fuels such as biodiesel and JP-8 jet fuel, DME, a gasoline substitutes and B5 *"bioheat"*, a clean distillate blend for home heating. All of these liquid fuels command high prices, but the processes used to produce them require substantial capital investments and many of the processes that can be used are still in the development stage and have yet to be proven on a commercial scale.

At the low end of the cellulosic biofuels spectrum are wood chips and charcoal. These biofuels have relatively low BTU value and have limited use as a supplemental low-cost boiler fuel, replacing coal or natural gas. But their use often requires modifications to material handling systems, furnaces, ash collection systems and emissions clean-up systems.

In the mid-range of the cellulosic biofuels spectrum is TW, that has a BTU value comparable to coal and can be burned in coal fired furnaces without modification. It is believed that TW is the cellulosic biofuel that offers the most immediate and significant opportunities.

Torrefaction Process Defined

Torrefacation can generally be defined as a process that uses *"mild pyrolysis"* to separate water, VOCs and hemicellulose from the cellulose and lignin contained in woody biomass. The VOCs and hemicellulose fractions are combusted to generate process heat, leaving only the cellulose and lignin to produce TW, a charcoal like solid. And depending on the process time, the TW yield is quite high, varying between 66% and 75%.

Torrefied Wood Pellets vs. Wood Chips and Coal

Green Wood Chips
The advantages of using forest residue and thinnings in chipped form as an energy product are numerous. For instance: they are carbon neutral; and they are relatively low in VOCs, having a low sulfur and mercury content. But green wood chips have many disadvantages. For instance: they are bulky; they have a low BTU content; they are high in moisture content; they are perishable; they often are commingled with dirt and other debris; and they are more costly to transport. And if used as a fuel, green wood chips often causes glazing of boilers, particularly if soil and other contaminants are not removed.

Dried Wood Chips
To overcome some of these deficiencies, the most widely available best practice is to use air drying to reduce the moisture content of green wood chips from ~50% to ~35%. And where stack gases can economically be used in pre-treatment, moisture content can be economically reduced further to ~20%.

Torrefied Wood vs. Wood Chips
Torrefacation substantially reduces the moisture content of the wood chips used and increases the BTU value per ton. TW is dense, dry, water resistant, non-perishable, easily crushed and energy dense, reducing transportation cost per BTU. TW's increased density and lower moisture content allows it to be stored for long periods. And if the TW is pelletized, its density is doubled, further reducing the cost of transport by ~ 1/3 of the cost/ton mile associated with transporting green chips.

Torrefied Wood Pellets vs. Coal
When TW pellets are used in lieu of coal as a boiler fuel, significantly less ash is produced, and sulfur emissions are low. Further, TW's energy content as measured in BTUs/lb, is comparable to coal. If used as a gasifier feed, TW pellets can be ground to a particle size similar to pulverized coal and can be fed into gasifiers designed for coal gasification without further modification.

Market Opportunities for TW

TW as a Replacement for Natural Gas Used in Power Generation
TW makes an ideal fuel for producing synthetic gas that can replace natural gas when generating power. This opens up an important market among utilities and industrial users who generate electric power from gas turbines or from industrial users that buy electric power from the grid. As previously explained, the TW process produces synthetic gas that is used to provide heat to the torrefaction unit. Additional clean syngas can be produced by gasification of some of the TW produced. This syngas could then be used to power gas turbines in lieu of natural gas they now are designed to use.

Based on recent estimates, it is expected that the equipment used in the torrefaction plant would costs ~$14 million. It was also estimated that a GE Frame-7 combined cycle gas turbine would be needed to use all of the TW produced and generate ~600,000 mWh per year of electricity, and that its cost would be ~$13 million. If the Section 1603 grant was awarded this project, 30% of the $27 million in hard costs, or ~$8.1 million, could be obtained as a grant.

Conclusions

When compared to cellulosic bio crops, harvested timber, saw mill wastes, construction lumber wastes and waste paper, forestry wastes are currently, the most readily available source of cellulosic biomass for production of 2nd generation biofuels on a continuous basis.

Of the three primary sources of forestry waste, forest residue is the easiest to obtain, as it does not have viable alternative uses as do pre-commercial thinnings or commercial thinnings.

Forestry wastes are in sufficient supply in many regions of the US and if torrefaction plants are located in these regions, these plants could be supplied on a continuous basis at reasonable cost.

When processed into TW, forestry wastes and other woody biomass need not undergo separate treatment for its various components in order to obtain high yields. In comparison, when make liquid 2nd generation liquid biofuels from woody biomass separate treatments are required for cellulose, hemi-cellulose and lignin components. This affects the complexity, yields, and costs of biofuels produced.

Torrefaction is a proven technology that is on the cusp of being scaled up to commercially viable levels. And torrefaction is significantly less capital intensive as biorefining and the costs of producing TW on a commercial scale is relatively low.

TW can be produced at a price that allows it to compete with coal and it can be used in lieu of coal or in combination with coal in boiler and power applications. In the countries within the EU, where significant carbon taxes are in place, a pent-up demand for TW exists and on net-back basis, prices TW commands in the EU are significantly higher than prices now being paid for coal in the US by industrial users.

In short, TW is the bio-energy option that is ready to go.Tim Sklar is Biofuels Digest's torrefaction correspondent, and can be reached at http://www.sklarinc.com/html/contact.html

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