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From Woody Biomass to CHP

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It is useful to start with a brief primer regarding the energy in wood and how we manage it, introducing many of the buzz words: What is "biomass", what is meant by "woody biomass," and what is its inherent value?

A March 2006 report prepared for the Bioenergy Interagency Working Group, a consortium of California state agencies brought together at the Governor's request, provides this description: "Biomass—biologically-derived renewable materials that can be used to produce heat, power, transportation fuels, and other value-added products and chemicals—is found in abundance in most areas of the country and represents a significant renewable energy resource."

As the nation pursues increases in the use of renewable energy, bioenergy in the form of biomass power (biopower), and biomass-based fuels (biofuels) are important contributors." (Recommendations for a Bioenergy Action Plan for California. March 2006. Navigant Consulting, for Bioenergy Interagency Working Group. CEC-600-2006-004-D. Executive Summary, pg. 1.) Woody Biomass is a common term for the biomass "roughage": the stems, stalks and outer material of most plants, the part not easily digestible, the excess trimmed from and discarded during harvesting and subsequent use. In some cases, as with the brushy understory of overgrown forests and wildlands, this fraction constitutes both an inconvenience and a risk requiring reduction.

Often, the tonnage of this woody fraction discarded from an agrarian practice is equal to or exceeds the tonnage of the primary harvest. Examples include grain and corn silage, as well as all vegetation but the edible fruit or vegetable for truck crops. Woody biomass is, for the most part, an abundant nuisance.

Biopower is the motive force product to be derived from that feedstock: Electrical energy generation is driven by thermal expansion of water (to steam) or other liquids and gases. Electricity has the benefit of being eminently transportable: no weight, no expansion or contraction complicating handling, relatively little loss in transport, immediately useful upon receipt. Storage of this electrical product is more problematic, requiring, for instance, chemical conversion via batteries, or kinetic conversion via flywheels or hydraulics.

Distributed energy generation (or "DG") is use on or near the production site, and competes directly with the user's available retail energy pricing options. Electrical energy for distribution into the regional electric grid sells at a substantially lower wholesale market price. The market for wholesale electricity is dependent in large upon the daily price per kilowatt and is subject to inherent, complex, and rather unpredictable value fluctuations.

This retail vs. wholesale difference often decides if DG is favorable or not for a particular location. Reducing the cost of feedstock acquisition as much as possible can help tip this balance toward Biopower DG.

Onsite biopower generation must take into account the cost of fuel acquisition and handling as well as installation and commissioning, which seldom makes electricity-only an economical biopower design proposition. The recent advent of state and national standards for grid infrastructure interconnection has greatly benefited onsite distributed generation and use; the lack of a dependable, economical feedstock infrastructure continues to confound biopower.

Thermal energy generation may be used within the site of generation and/or nearby for processes such as drying, production of steam, space and hot water heating, and to drive production of cold, via absorption or adsorption refrigeration chillers. Although most biopower electrical energy generation indeed stems from initial thermal energy generation, it is useful to separately consider nonelectrical applications of thermal energy.

Thermal energy by itself is more difficult to transport over any appreciable distance, with severe dissipation beyond a few thousand feet. Transport of heated solids, liquids, or gases requires substantial insulation, increasing handling costs far above that for electricity alone. Clearly, thermal energy needs to be used in the immediate vicinity of generation.

Optimal Design

When both the electrical and the thermal energy components of biopower can be optimally used, overall efficiencies of fuel-to-energy generation improve dramatically. We refer to generation and use of electrical-plus-thermal energy as combined heat and power, or CHP.

Optimization of design depends on the balance of electrical to thermal energy needed; in practice, this is an “either/or” proposition, focusing on electricity provision at the expense of heat capture, or thermal energy utilization with electricity generation ancillary.

Seldom are field applications found where electrical load matches that of the site’s thermal load, if for no other reason than scheduling. Different processing paths are necessary, different feedstock preparation may be required, different finishing methods must be employed. To provide perfectly matched thermal energy, a system design usually will suffer in meeting site and market electrical demand, and the converse is equally true.

If renewable fuel is considered as a desired product of woody biomass processing, we add a third “commodity” consideration to conversion design. Conversion of woody biomass to combined heat, power, and fuel is a relatively new concept but one that shows great promise as methods and technologies advance enough to facilitate economical, clean choices of production. It is the intent of this article to explore the potential benefits and challenges to this new paradigm of energy generation, provision of biofuel, or any bioproduct other than heat and electricity generation, requires that some fraction of the constituents of that feedstock not be used for biopower production.

Just as a balance between electrical and thermal energy must decrease one to increase the other product, a balance that considers the value of biofuel production must conversely consider the loss of some amount of electrical and/or thermal energy. Market demand, site use, technical efficacy; all must enter the equation. The benefit is that production of biofuel adds yet another means of improving the budget and serving the market need. The devil, to paraphrase, is in the integration.

Electricity-First Design—Conversion of woody biomass into biopower provides California with about 2% of its renewable energy supply. For the current production of California’s biopower, woody biomass is rendered to heat and ash in technically advanced furnaces; the heat drives engines that generate electricity.

From the same bioenergy action plan report: “In California today, biomass is used primarily in electric power and thermal energy generation. Currently, 4-5 million dry tons per year of solid biomass (only about 15% of the technical potential) are used by 28 biomass power plants to provide approximately 615 Megawatts (MW) of base-load renewable energy.” The system designs are optimized to use all the sensible heat available for generation of electricity. Meeting local thermal demand is not considered an acceptable use of resource: seldom is a large heat-using facility co-located close enough to a regional bioenergy plant to warrant heat transfer, or electrical generating capacity reduction. Excess heat is dissipated onsite, at a substantial cost, via vented exhaust and huge, finned, water-cooled radiators. For large-scale furnace-based, electricity-first biopower, “heat loss” is money lost.

Heat-First Design—A wood stove makes heat; a well-designed wood stove helps dissipate that heat as needed throughout the space to be warmed. An exceptionally well designed wood stove incorporates a water jacket or other heat recovery means, and can make hot water or even, perhaps, steam. An industrial-grade wood furnace can drive steam production for both heating and refrigerant cooling and electrical generation.

“Heat-first” designs first serve the heating and cooling needs, with any electrical generation secondary. Where the cost of heating and cooling dominates over the cost of electricity needed to operate, thermal load demand becomes a deciding criterion for design of heat-first applications. Conversion of woody biomass directly to thermal energy is well suited to meeting onsite thermal demand, especially when the source of the feedstock is locally abundant, and the cost of any alternative for heating and cooling, such as trucking in propane or dealing with diesel exhaust, is unacceptable.

Biofuel-First Design—Woody biomass is certainly, itself, an abundant and readily accessible “biofuel”, but one with inherently high weight-to-volume ratio, low energy density, and limited utility. Biofuels can exist as solid, liquid or gaseous products, depending on the characteristics of the feedstock and the chosen manner of processing. Conversion to other forms of biofuel becomes a way to concentrate that energy density, decreasing weight-to-volume ratio and dramatically increasing marketability.

Conversion of woody biomass into more energy-rich, easily portable and market-worthy forms of biofuel requires that the strong carbon bonds be broken in such a way that the energy released is captured as a commodity. This allows for the conversion product to be cleaned, modified, stored and distributed later for use when demand (and usually market price) is highest.

Integrated CHP + Fuels—Regional production of high volumes of biofuel in centrally located ethanol manufacturing facilities is an example of a biofuels-first design. Initial investment sought stand-alone designs, yet we now know that the energy cost to run those biofuels-only plants is high, and current emphasis is upon integration of bioenergy generation with biofuels manufacturing; this is referred to as an integrated biorefinery.

The design concept need not be applied solely to regional-scale facilities, however; modular conversion systems are becoming increasingly available, and community-scale (and smaller) integrated bioenergy/biorefineries have become a reality.

Feedstock Considerations

Feedstock characteristics dictate the acceptability of a particular feedstock for a specific process flow directed toward manufacture of the desired products. Density, contaminant levels, moisture, carbonnitrogen balance, heat value all must be taken into consideration to choose the right process flow and the extent of preprocessing necessary.

Latent energy is stored in nonfossil organic materials such as wood, straw, vegetable oils, and wastes from the forest, agricultural, and industrial sectors through the process of photosynthesis. To reverse that process and recover that stored energy in ways that can provide both biopower and biofuels, to effectively and cleanly “un-bake the cake,” takes advanced technologies and carefully controlled methods.

Heat value is a metric of the recoverable latent energy stored in a feedstock. The dense and relatively impervious carbon molecules of cellulose and hemicellulose do not easily give up their inherent energy. Measured in the standard of Btus common to heat-producing fuels assessment, dry woody biomass can provide 4,500 to perhaps 6,500 Btu per cubic foot of feedstock, about half that contained in coal.

Consumption of a fuel for energy generation per unit time is referred to as heat rate, measured (for electricity) as heat use per hour of energy, or Btu per kWh. Field moisture levels are usually 40% to 60%, requiring drying, and that drying action requires energy. Thus, freshly collected moist woody biomass may effectively produce as little as one-fourth the energy as present in the same amount of coal, given the energy needed to drive off the water.

The molecular composition of woody biomass feedstock is quite homogenous, which greatly simplifies maintenance of optimal heat, air, and retention timing. In addition to the benefits of feedstock homogeneity, the contaminant profile of the discarded biomass is relatively simple and benign in terms of potentially harmful contaminants.

Woody Biomass vs. Waste—Woody biomass may indeed consist of discarded byproducts of urban, agricultural, and forestry practices, yet for proper environmental quality control under our current regulatory schema, this material should not be confused with what is classified as “waste.” Differentiating between byproducts and other leftover materials that are source-segregated recoverable resources and what we must relegate as waste destined for final disposal is a difficult and imprecise task, yet this is the core of regulatory applicability.

In general, the woody biomass byproducts of forest and agricultural operations are not waste unless they become contaminated with more than 10% non-biomass refuse, such as plastics, metals, and chemicals ancillary to those practices, or have become mixed with common municipal solid waste (MSW). The topic gets more complex when we consider use of woody biomass residuals from urban residential, institutional, and industrial sources.

Problems do exist in contaminant control, and caution is certainly warranted. Certain plants do concentrate toxic elements from the soil: Some nut crops sequester certain heavy metals in branch tips, as an example, and “trimmings” used for direct combustion in our biomass plants initially resulted in instances of toxic ash.

Extraneous materials can dramatically contribute to contaminants carrying through conversion processes: A few empty pesticide bags and rolls of plastic irrigation tubing discarded into biomass feedstock can create dangerous, highly toxic compounds during processing that otherwise would be absent. The few potential toxins can be anticipated and successfully managed with pre-processing screening during process or in emissions controls, post processing.

This article is both feedstock and product specific in that it focuses on woody biomass conversion to biofuel. Yet we owe the recent advances in technology, the elegance of operating methods, and, indeed, the implementation of regulatory “nets” to ensure environmental protection, to the much more complex field of waste processing.

Compared to simple woody biomass, the processing and conversion of MSW presents a vast and constantly changing spectrum of molecular diversity and contaminant profile. And although the biomass fraction of MSW may approach 80%, it is that non-homogeneity of molecular composition, and the constantly varying contaminant profiles, that make conversion of MSW the technical and socio-economic challenge that it is.

A subsequent paper will look at this biomass-to-waste comparison, but from the perspective of economics. Yet it is pertinent at this time to accept the difficulty we have all experienced in bringing bio-sourced energy and products into the forefront. As great as is the common need for better resource recovery through woody biomass conversion, the economics have remained marginal.

Right or wrong, the driving socioeconomic forces have yet to enforce the imperative that far-reaching biopower and biofuels programs be implemented; that aspect, fortunately, may now be changing. But everyone understands the horror of being buried in his own waste: the veritable "tsunami" of trash we generate threatens to override even our best management capabilities. There is a lot of money in "trash"... and the combined impetus of pubic concern and fiscal imperative has worked to dramatically leap-frog technologic and regulatory advancement for MSW conversion far ahead of that enabled by the need for biomass management, alone. Woody biomass conversion can now follow in the wake of MSW conversion; the foundation has been laid.

One thing is certain: Any conversion technology that can cleanly and efficiently convert MSW to biofuels and biopower can, with far greater environmental surety and far less technical and management complexity, convert woody biomass.

Processing Methods

Once woody biomass is chosen as a feedstock for further clean processing, the question becomes, "what do we want to produce?" The path is most often a multistaged process: 1) conversion of the dense and stable carbon-based molecular structures to simpler, more malleable intermediary products, and 2) refining (or "reforming") those intermediaries into a wealth of commodities.

One common error is to think that one specific stand-alone technologic approach is inherently superior to all others. When technical approaches overlap and indeed can be operated in ways that fit more than one of the convenient categories we have assigned them, only vendor pride remains as a reason to assume one way fits all.

There is a continuum of thermal processing that starts with simple drying and continues through many consecutive and overlapping stages until reaching an ultimate end result of gaseous emissions, ash, and heat. Isolating and imposing control over elements of that continuum as discrete processing steps empowers the operator to select the progressive degree of molecular decomposition, recombination, contaminant creation and product oxidation. Effectively curtailing oxidation short of complete combustion creates access to and increases control over the processes that generate both the harmful contaminants, and beneficial products. From this level of advanced process control we derive conversion.

Many technologies that can accept a feedstock and progressively heat the material until it is rendered to ash can also be operated in such a way that the continuum is interrupted. This becomes a question of design, and of operator access to intermediary stages. The crucial importance of this design variation, of system configurations that allow operator access well in advance of complete combustion, will be addressed further.

Complete Combustion for Biopower—If the intended end product is strictly the generation of biopower, then the system should primarily be configured to produce heat, in some balance to drive turbines and generate electricity, and/or to meet heating and cooling load demands. The standard bioenergy plant configuration using an advanced design, cleanburning furnace is probably optimal for electricity generation. Provision of thermal energy alone shifts costs to application of heat recovery and distribution, for process heating and refrigeration.

Breaking down carbon-based molecular structures is technically called "combustion" whether there is a flame or not: this fact of combustion chemistry, that combustion does not require a flame, continues to be one of the most misunderstood and confusing paradigms. The management of the energy contained in that carbon bond is dependent to a large degree on whether oxygen (whether provided as a pure stream of O2, or as 20% of the surrounding air) is allowed to fill the open bonding sites as the carbon-carbon bonds are broken: A flame consists of the light and heat released as oxygen combines with the carbon, and "complete oxidation" is the end result of complete combustion. If uninterrupted, this process is termed "incineration," defined by the Oxford Dictionary as, "to render to ash."

Partial Combustion for Biofuels—If we seek instead to convert that woody biomass feedstock into a biofuel, different technologies and methods are necessary. Different regulatory considerations apply, and an entirely different set of socio-economic constraints and benefits must be brought into play.

When we exclude or closely restrict oxygen and intentionally interrupt the process, the intermediary products can be sampled, tested, cleaned and refined. Those products of incomplete combustion remain combustible, ready for oxidative combustion at some time in the future. A "starved oxygen" woody biomass conversion system thus produces intermediary combustible products, or "fuels," in the form of char, tar, liquid, or gas.

The more "hungry" the intermediary products are for oxygen, the more aggressive that material is as a fuel.

Controlling the stages of the thermal continuum provide a means of converting solid woody biomass into solid, liquid or gaseous combustible intermediary products, that with some degree of cleaning or refining, become high-quality renewable fuel.

Conversion Technologies—Processing systems designed to control the rate and extent of carbon bond decomposition, while managing both the energy released and the products created, must allow access to intermediary products of thermal decomposition prior to complete combustion. This system configuration is called conversion technology (CT).

A processing system designed for carbon-bond decomposition in the manner of conversion rather than incineration directly increases the number of potential product options for any one type of feedstock. Access to the intermediary products prior to complete combustion, such as partially-combusted chars, tars, oils, and gases of varying molecular weight and complexity, allows separation and refinement. Without conversion, biofuels are not possible.

Regulatory and economic parameters differ by processing type. Major categories are discussed below, yet multi-technology processing and system operation flexibility have proving most effective. Properly-designed and staged subsystems can be combined to address the greatest number of feedstock types and to manufacture the greatest diversity of beneficial products.

Nonthermal conversion technologies are most commonly applied to high-moisture biomass. Microbial activity dominates this category, either with or without oxygen, and varies in complexity from completely natural occurrence to highly controlled in-vessel management: Anaerobic digestion (AD) is primarily used for converting non-woody biomass. It utilizes a combination of acid-forming and methane-forming microbes and produces methane as a clean and useful high-energy gaseous fuel.

- Aerobic conversion can include fermentation, an oxygenated liquid-phase process for high-moisture non-woody biomass, and composting, a solid-phase, oxygen-rich process better suited for breaking down a mixture of woody and non-woody biomass. Microbial populations and their control vary considerably; recent advances facilitate "designer" microbial processing for the manufacture of an ever-increasing diversity of bio-sourced green fuels, foundation chemicals, and other bioproducts.
- Photo-oxidation: In addition to microbial activity causing carbon molecule changes, the energy in light (or other forms of radiation) is also effective. Naturally-occurring or induced, irradiative breakdown speeds the oxidation of molecular structures, and is a primary process creating smog.
- Acid hydrolysis and other chemically driven processes depend on an aggressive chemical reaction to "crack" the dense carbon-based molecular structure. Once acid-base balance is restored, the resulting "soup" can be further processed and separated to manufacture diverse of bioproducts.
- Thermal conversion technologies use heat to effect molecular decomposition and recombination. Control of heat, oxygen and retention time dictate the choice of conversion technology for any desired combination of feedstock and product. Thermal processing technologies can be subdivided into various overlapping forms and frequently are used in combination: pyrolysis, where little if any oxygen is allowed to interact within an externally-heated oven-like chamber (an "endothermic reaction," requiring outside energy to maintain), and gasification, where sufficient O2 is allowed to combine with the "open" carbon bonds to maintain a chain reaction breakdown for production of heat and combustible gas (an "exothermic reaction", generating more energy than is consumed).
- Multi-tech: In most large-scale woody biomass conversion technology applications designed to produce a biofuel that are in operation today world-wide, a multistep process is employed. Dry, pulverized feedstock is decomposed in a pyrolytic chamber. The resulting chars, oils, and gases are then further reduced in molecular complexity to a light species of combustible synthetic gas, called syngas, in a gasification chamber. This syngas is a stable, energy-rich, "cleanable" gaseous fuel. It is also a very useful foundation from which other chemicals and fuels can be made.
- Pyrolysis to gasification is the process by which the endothermic decomposition effected by pyrolysis serves as a "molecular level" grinder, reducing feedstock constituent size and complexity and blending for homogeneity, while the exothermic reaction of gasification can serve as a retort, reforming the complex and difficult-to-handle char, oil, and gaseous products of pyrolysis into lighter species of strictly gaseous nature. This reflects the natural stages of thermal decomposition as any feedstock is progressively heated, and constitutes the first two steps of thermal processing when feedstock complexity is high, and maximum process control is an imperative.
- Reforming: The complex combinations of gases that constitute "syngas" can be separated by molecular weight, and the parts segregated and/or recombined using various chemical and energetic processes. Steam injection during pressurized gasification is one method of integrated process "reforming," and can produce a high-grade fuel. Similarly, pure hydrogen (H2), CO and CO2 can be isolated and purified from syngas, via various reforming methods.
- Catalysis: When syngas is passed over an appropriate catalyst (usually cobalt or iron), the ensuing reaction turns the gas into a liquid. This is known as the Fischer-Trophs reaction, and the product is referred to as F/T Biofuel, a clear, highly combustible diesel-like liquid. F/T Biofuels have been produced since before World War II, when this method was primarily responsible for fueling both land and air military transport.
- Microbial Action: If the energy-rich syngas is bubbled through the right microbes in media specific to both organism and desired end-product, short-chain alcohols including ethanol and methanol can be produced.

The Opportunity for Multi-Technology Integration

Emerging conversion technologies hold promise of environmentally sound, economical, and energy-efficient conversion of wastes, byproducts, and purpose-grown crops into renewable products. Such technologies are not new; European and Asian applications have proved the efficacy of the base technologic approaches over the last two decades. American research developments have languished as precommercial systems, for lack of adequate market draw and regulatory barriers faced. That national condition has changed dramatically over the past six months to two years; the socioeconomic drivers—the markets and governmental forces—have shifted from negligent indifference if not outright opposition, to an increasingly desperate and immediate demand for transparent technical validation and rapid commercialization.

As individual systems move through testing and begin to garner serious interest from a broad market of municipal, industrial, and institutional project proponents, the impacts of this long lack of funding and market draw become increasingly apparent: There is a profound lack of multi-technologic integration. Precommercial system components usually emerge without full process flow capabilities to be considered complete solutions to problems of the potential consumer. Vendors have fought for so long to keep their RD&D efforts alive in isolation that they continue to stubbornly strive to attract project contracts based solely on the merits of their specific component.

There is a serious need, and therefore a significant opportunity, for firms that can acquire legal access to a suite of synergistic technologies capable of, together, being compiled into complete market solutions. A multi-technologic approach ensures flexibility of overall system design. This system design flexibility can meet a greater diversity of market demands, by adjusting to changing front-end feedstock characteristics, by integrating with existing client operations, and by providing a broader array of end-products.

Each of the renewable "clean energy" technologies emerging from research and development holds promise. Many have already passed varied agency assessment and investor due diligence, to appear as a discrete approach for energy efficient, environmentally sustainable conversion of an array of wastes, byproducts, or purpose-grown crops into an equally impressive array of products, including bioenergy, biofuels, and bioproducts. Each developer, independently, may indeed be able to accomplish cost-effective market entry.

It is with the multi-technologic project design that true and significant economies begin to surface.

Establishing a "Bright Line"

A critical if subtle difference exists between conversion and incineration. Conversion operations must allow sampling and (to the degree necessary) "cleaning" of the intermediary products. All equipment can be run "dirty" or "clean," and operating methods are as critical as the technology. All thermal conversion can be operated to proceed to full thermal oxidation without process interruption, and without decontamination of the intermediary gases, oils, and solid chars. To operate without such sampling is to operate that technology as an Incinerator.

If "CHP + Fuel" is to be a viable option, access to those intermediary products becomes critically necessary. When all available feedstock is strictly consumed for provision of first thermal and then electrical energy generation, fuels are not an option.

Further, designs that integrate access to intermediary stages of the thermal continuum create an information feedback loop: At critical points, the operator can determine process actions and intercede to modify the process in progress. Understanding and being able to change process flow characteristics facilitates avoidance of toxic contaminant production.

Rather than cleaning up toxins in the exhaust stream, this feedback loop can help stop their production in the first place.

After an exhaustive global review of thermal processing systems (in response to the European Union's Waste Incineration Directive, or WID), the United Kingdom research firm Juniper Consultancy outlined this difference: "Our interpretation of this is as follows: Syngas will be considered a 'product of the treatment'; 'dirty' syngas combustion in a boiler or a burner/oxidation chamber will be considered incineration; it can be argued that 'cleaned' syngas combusted in a spark ignition engine or a gas turbine as a ‘pseudo-fuel gas’ should not be subjected to the same requirements of the WID and should be regulated differently.

“In our view, a gasification process which produces a ‘cleaned’ syngas product, which is then used for electricity production via engines, is not an incinerator. It is comparable to an anaerobic digestion process producing biogas from sewage sludge and converting the energy content of the biogas to electricity via gas engines, which is common practice in the water industry, or the conversion of landfill gas to electricity via gas engines. The gasification process should therefore be regulated like these processes as the gasification reactor is performing a pre-treatment function in a similar fashion to the AD reactor and the landfill, both of which use biological mechanisms whereas the gasifier uses heat.” (“Pyrolysis & Gasification of Waste—A Worldwide Technology & Business Review.” Juniper Consultancy Services Ltd., Second Edition, September 2001. Volume 2: Technologies & Processes; pp 39-42. ISBN for 2- vol set: 0-9534305-6-1.)

Summary

If a technology allows intermediary products to be sampled and cleaned, and if operation of that technology is not allowed to proceed to total “rendering to ash” without intermediary contaminant management, then it is a processing system operated as a conversion technology, not as an incinerator. This bright line is in equal parts a question of the specific technology and of the method of operation.

Increasing options for clean, sustainable production of critical commodities to include all forms of renewable energy and fuels requires that processes for each commodity be available and open for consideration well in advance of design and construction.

Overarching demand for new, clean approaches to resource recovery from municipal solid waste has effected a surge in processing technology development and commercialization, especially at community scales heretofore not available. These need-driven advances in waste processing methods encompass a great diversity of technologic approaches; some are focused on waste-to-energy generation, some on creating waste-derived fuels and other non-energy products. Where these technical advances prove effective for clean conversion of the complexities of MSW, they most certainly will be able to convert the far simpler feedstock of woody biomass.

Current practices for generation of large-scale bioenergy are appropriate, needed, and worthy of support. Because of the vast availability of otherwise unwanted biomass and the even greater demand for renewable electricity, direct and complete combustion of woody biomass (or any other renewable fuel source) via clean, efficient incineration must continue as part of the overall critical path. Current practices have long proven technical efficacy, if not always economic viability or acceptance by society at large.

Incineration does not allow sampling and extraction of intermediary products prior to complete combustion, although there are many thermal technologies that can be operated as incinerators, or modified to run as conversion systems. System flexibility of this nature should be regularly designed into bioenergy development, to allow optimal response to feedstock availability, environmental quality control and market sensitivity.

Multitechnology process flow designs, and parallel processing flows with different yet synergistic suites of like technologies, create the next logical step in material recovery facility design and operation. Linking small-scale rural applications with large regional facilities using multitechnologic sets capable of CHP + fuels can help secure the high-volume, low-cost feedstock flows necessary to secure a reliable bioenergy/bioproducts infrastructure.

Consideration of thermal processing for woody biomass must keep in mind that, without conversion, biofuels are not possible.

http://www.distributedenergy.com/november-december-2006/woody-biomass-chp.aspx