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Considerations for thermal and power projects utilising biomass fuels

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For the past two decades there has been an extensive interest in utilising renewable energy in an attempt to decrease the use of fossil fuels such as coal and oil. During these past 20 years, the solar and wind industries have made technical advances to be even more viable alternatives with better efficiencies. Biomass fuels have also seen considerable interest for thermal and power projects worldwide, however the fuels have changed considerably from the traditional biomass fuels of wood chips, hogged wood, bark, and sawdust that dominated the forest products industry for the past century. Today's renewable biomass based fuels are derived from agricultural refuses, reconstituted wood refuse from residential and commercial demolition and process refuse such as the solids remaining from lignin ethanol production.

Detroit Stoker Company first developed a grate system specific for woodchip/bark firing in 1947. Since then Detroit has provided nearly 300 systems for biomass combustion, which have been designed, installed and operated worldwide. In the early 1990's, Detroit Stoker Company provided its first grate combustion system into the European market specifically based on more stringent demands on emissions, availability and fuel quality than previously encountered in the North American market. This equipment utilises the technology of spreader firing with continuous ash discharge grates, which were a departure from the more common mass fed and fluid bed technologies primarily used in Europe. Since 1990, Detroit Stoker Company has successfully provided 170 systems into the world market firing a wide variety of renewable fuels with 25% of these projects being located within Europe.

Detroit Stoker Company has provided nearly 300 systems for biomass combustion, firing a wide variety of renewable fuels, which have been designed, installed and operated worldwide with 25% of these projects being located within Europe

For the past two decades the majority of European systems have been utilising recycled wood products, some of which consist of demolished buildings (urban waste). Other wood products, such as railroad ties, tree/bush trimmings and forest cuttings are included, often supplemented by local fuel streams generated by forest product manufacturers (sawdust/sander dust). Owners and operators include both local utilities and industrial manufacturers.

Due to the variety of fuel constituents for the European fuel(s), care is taken with both grate and boiler performance. Increased metal content can cause decreased availability of equipment. Higher alkali content can greatly increase slagging/fouling occurrences and higher fuel nitrogen contents can lead to greater variability in Oxides of Nitrogen (NOx) emissions. These considerations, along with low Carbon Monoxide (CO) permit requirements, required more conservative combustor designs than traditionally seen. These and other considerations influence both the furnace construction and grate selection.

Today, the number of facilities using recycled wood fuels has been reduced and the majority of newer facilities are utilising fuel feed stocks that include traditional wood chips, bark, poultry litter, and agricultural residues such as olive and grape refuse. Outside of Europe, fuels continue to represent bagasse (refuse from cane sugar production), refuse from palm oil manufacturing and the refuse from lignin ethanol production. Table A represents the wide range of constituents in the fuels seen today.

TABLE A – Fuel Constituent ranges based on fuel types ("as-received")

Fuel Type	Moisture %	*LHV (MJ/kg)	Ash %	Chlorine %	Nitrogen %	Sulfur %
Wood & Bark	40-55	11.6-9.3	1-3	<0.02	<0.2	<0.03
Bagasse	40-55	10.1-6.0	2-5	<0.02	<0.3	<0.03
C&D	25-35	15.1-11.6	6.15	0.1-1.0	0.4-1.0	>0.2
Agricultural Residues	5-60	20.4-5.5	2-8	0.1-0.8	0.4-5.0	0.2-1.0
Poultry Litter	30-55	19.5-6.6	8.20	0.5-1.0	2.5-6.0	0.4-1.0
Process Residues	25-45	15.8-8.4	25-14	0.03-1.8	0.6-4	0.2-7

*Lower Heating Value

Further to the basic analysis of a fuel, the effects of the fuels' ash constituents can often prove to be difficult to deal with in mitigating problematic slagging/fouling of the furnace and boiler's heat transfer surfaces. Slagging and fouling have been studied for a century or more, mostly with various coal types. These experiences are now being extrapolated to biomass fuels. In general, the amount of alkali metals and total ash content are the initial defining factors of whether a fuel will have a tendency to create these types of ash deposits in a boiler. These slagging/fouling indexes are often expressed in pounds of alkali/MMBtu (kg/GJ). It is generally expected that some form of an ash deposit will appear on the furnace side of the steam generator at values above 0.8 pounds of alkali/MMBtu (0.34kg/GJ). Figure 1 illustrates the differences in alkali metals and values for several fuel types.

Detroit Stoker Company is not a boiler or steam generator provider. Rather we are a provider of combustion equipment, having integral combustion air systems and fuel distribution equipment. We work with a wide variety of boiler designers and providers throughout the world. By working with both international and regionally based boiler companies, we provide over 115 years of combustion experiences for a wide range of fuels. Two decades ago, with the number of European units being developed and installed, we found notable differences between the boiler designs of North American manufactures and those being constructed in Europe. The most notable physical difference is that North American boilers typically have two drums (steam and mud) while the European has a single drum, folded boiler arrangement, which is noted in Figure 2. Table B also provides additional comparative differences between European and North American combustor designs during this time period.

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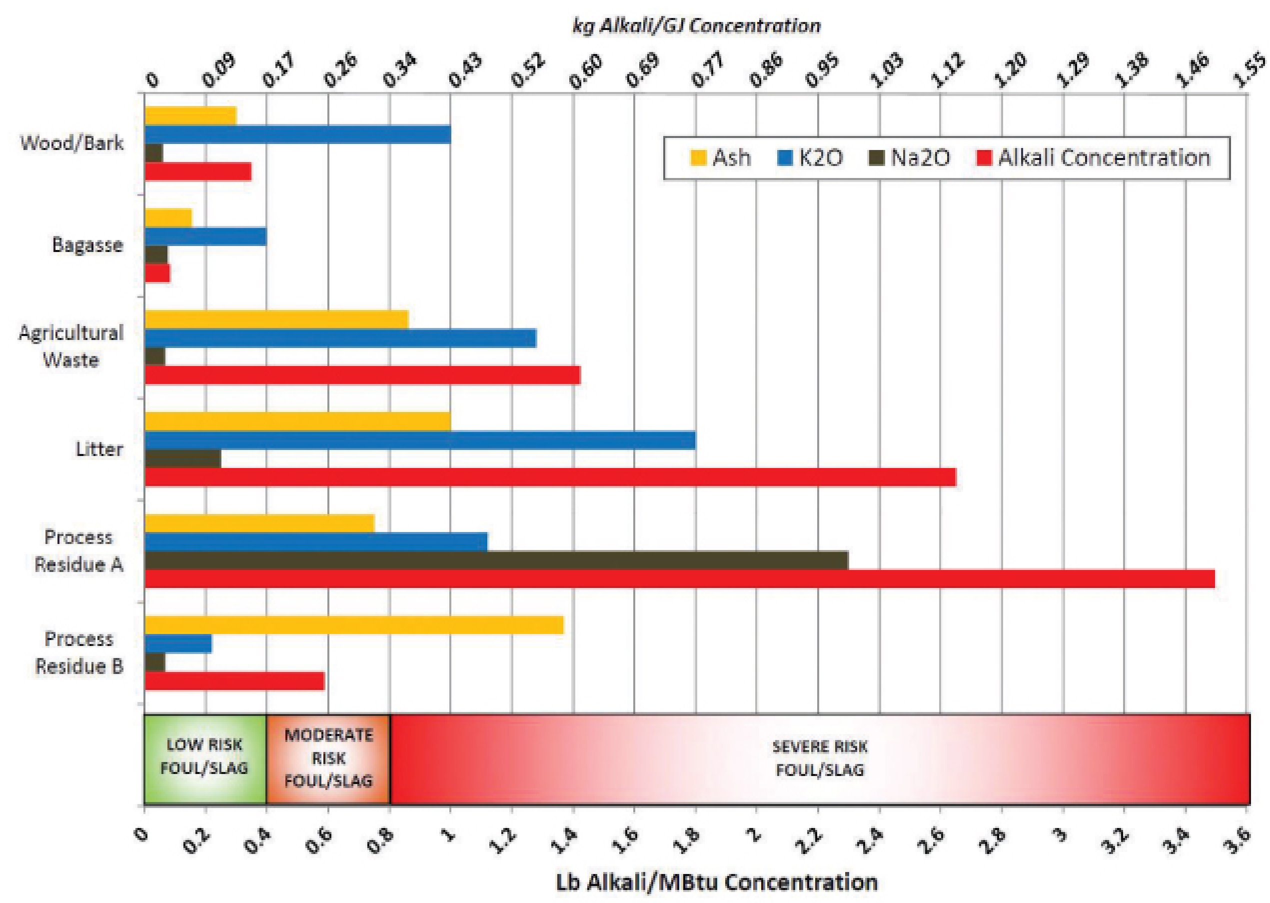

Figure 1 – Comparison of alkali metals in various biomass fuels

Value	North America	Europe
Steam Capacity (Klbs/hr) (Tonnes/hr)	250-500 113-226	100-200 45-90
Grate Heat Release Rates (KBtu/ft^2/hr, **HHV) (MW/m^2, *LHV)	1,000 2.7	850 2.3
Volumetric Heat Release Rates (KBtu/ft^3/hr, **HHV) (MW/m^3, *LHV)	18-22 0.16-0.19	12-14 0.10-0.12
Furnace Residence Time (Seconds)	1.8	3.0
Pre-heated Air Supply	Tubular or Regenerative	Steam Coil
Air Pollution Control	Precipitator	Bag House

TABLE B – Comparison of North American and European boiler designs circa 1990 American Boilers

*Lower Heating Value
**Higher Heating Value

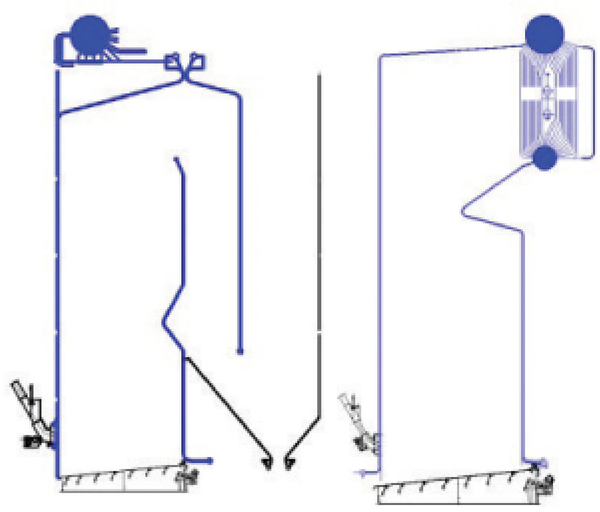

Figure 2 – Comparison of European Boilers (Left) and North American Boilers (right)

When evaluating these differences, we consider that the North American boiler design application was primarily for the pulp and paper industry, which requires a high capacity of process steam. In the past, these boilers were easily permitted with little or no emission requirements other than opacity. Until the last decade, the fuel was generated from the mill process areas and provided a constant source of consistent and good quality biomass. The European boiler projects have limited self-generated fuel; therefore the fuel must be delivered to the plant site. Due to the expensive transportation costs in Europe, the radius from which the fuel is taken is restricted. This results in smaller capacity power plants, particularly in the case of utility owned plants where no process steam is required and the optimum size for electrical generation is 15-20 MWe. As a result, the fuel stream is extremely important and the plant design has to account for not only seasonal fuels, but extreme variability of fuels from multiple sources on a daily basis. In addition to fuel quality, consideration has to be made regarding the strict regulations for emissions particularly CO limits which at that time were less than North American permit values.

Steam coil pre-heaters, for the primary air system, are commonly used and provide an additional tool for the boiler's operation due to varying fuel moistures and consistency. However, within the United States, both existing and newly developed biomass facilities also have to comply with new and more restrictive emissions requirements. Experiences learned in Europe are currently being applied to these facilities. All of those that have been constructed and commissioned are obtaining the designed performance, including emissions. Some of these attributes include but are not limited to the following:

- Conservative furnace and grate thermal release rates: Both dependent on fuel type(s) turn down rates and temperature considerations.

- Refractory usage: Lower furnace refractory helps maintain temperatures for a variety of fuel moisture ranges and turn down rates. However, alkali and ash levels of the fuel(s) should also be considered.

- Flue Gas Recirculation (FGR): FGR has traditionally been a NOx control strategy. However, staged injection of FGR can assist overall combustion by lowering total excess oxygen, allowing for more uniform adiabatic flame temperatures. In addition, when used at the fuel delivery points, FGR can provide a level of reduction in both NOx and CO by having lower excess oxygen in localised areas than traditionally oxygen rich zones.

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The sources of renewable biomass fuels throughout the world have become critical in the past decade. Owners consider their fuel sources to be proprietary information. Even in North America, we are experiencing shortages of the more traditional

Figure 3 – Pilot Scale Combustor Facility

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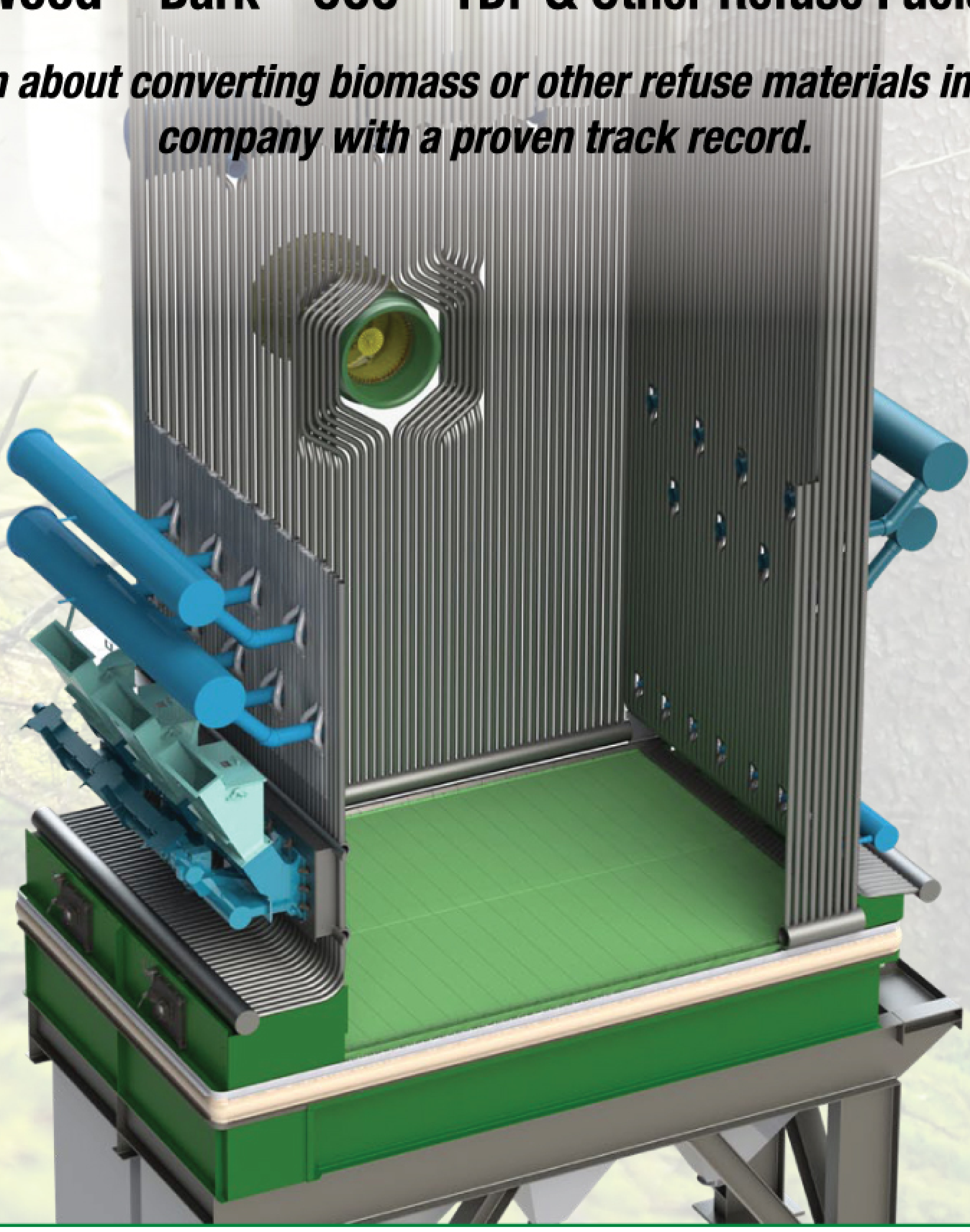
For more information about converting biomass or other refuse materials into energy, talk to the company with a proven track record.



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