Is biocoal a bioenergy game changer?
Biocoal introduces a new class of solid biomass-based fuel for global power and heat generation. In order to mitigate carbon dioxide emissions and increase the sustainability of biomass in energy generation over the coming years, existing power plants aim to increase the amount of biomass and biofuel in their fuel consumption mix. This has proven challenging, as biomass feedstocks often have high procurement costs, low energy density, high water content, and challenging logistics, storage and handling. Unprocessed biomass is also non-homogenous, leading to efficiency and combustion challenges.

Processing biomass into biocoal and densified biocoal facilitates the use of biomass in energy generation and creates opportunities for fuel sourcing from further distances at reduced costs. The technical market potential for co-combustion of coal and CO₂ neutral biocoal is tremendous.

**BioCoal Market Potential**

Pöyry forecasts the global pellet market will reach 55 million tons in 2025. The share of biocoal will largely depend on the development and commercialisation of processing technology by the end of 2014. Europe will continue to dominate the market, consuming up to 24.7 million tons by 2025. The co-combustion suitability of biocoal has been verified up to 50% or higher, depending on the biocoal quality and boiler type. Utilities have invested in technology developers and have publicly promoted their plans to start using pelletised biocoal in large quantities. However, it is important to note that the biocoal market is still in development, and commercial scale production facilities are limited. Wider commercialisation will begin in 2018 if financing and off-take opportunities maintain momentum of technology development. In the long term, biocoal is expected to become a standardised and commodity traded product.

**WHAT IS BIOCOAL?**

Biocoal is produced through a process of torrefaction, during which water content, cellulose sugars and other volatile organic compounds are removed from the biomass to produce a solid biofuel with characteristics similar to those of fossil coal. The main technologies for biocoal production currently under development include torrefaction and steam explosion. The principles of both technologies were developed several decades ago. The process can simply be described as the heating of biomass in a low oxygen atmosphere to a desired temperature. The physical properties of densified biocoal are notably different compared to standard wood pellets. The main differences between biocoal and standard wood pellets are that biocoal has a higher volumetric energy density, is less subject to biological degradation and is hydrophobic. These factors lower the transportation and logistics costs of the biocoal.

Climate change concerns have created pressure to reduce fossil fuel consumption. Once heralded as the next big thing - the potential of co-firing biomass in coal boilers has been limited by the significant capital investment required to modify fuel handling and combustion systems. However, biocoal can be co-fired in existing coal fired power plants, produced from a vast array of feedstock, and is efficient to ship, even over long distances. Is biocoal a game changer?
“Pöyry forecasts the global pellet market will reach 55 million tons in 2025, with biocoal gradually capturing shares of the industrial pellet markets.”

GROWTH OPPORTUNITIES
A few key factors will support the growth of biocoal pellet consumption globally over the coming years:

- Lower logistics costs - Biocoal has higher specific energy content per volume compared to other forms of biomass.
- Lower investment requirements – Biocoal requires lower capital expenditure for handling and storage at power plants.
- Improved safety - The less reactive nature of biocoal pellets compared to standard pellets provides better long term storage safety.
- Similarity to coal - Biocoal’s fuel characteristics are similar to coal, providing significant technical potential for co-combustion of pelletised biocoal and coal for power generation.
- Sustainability incentives – Biocoal is eligible for incentive programs designed to increase CO₂ neutral fuel consumption.

- Wide range of potential sources - Biocoal can be derived from alternative biomass sources, such as agricultural residues and short rotation crops.
- New end uses - Additional value-added end uses in other sectors, such as metallurgy and pharmaceuticals are actively being developed.

THE PELLET MARKET IS EXPECTED TO GROW SIGNIFICANTLY THROUGH 2020
Commercialisation is on the horizon

VALUE ADD THROUGH PROCESSING BIOCOAL

Biomass is processed to biocoal through a number of technologies, including torrefaction and steam explosion techniques. Biocoal can then be densified to pellets or briquettes to increase the bulk density and decrease transportation costs. Biocoal pellets have hydrophobic characteristics and can be received and handled by the power plants in the same manner as fossil coal. Processing biomass to biocoal gives it coal-like characteristics such as darkness in colour, brittleness and requires less energy for milling and pelletising than traditional biomass. Biocoal contains up to 90% of the original energy content of the biomass used. In pelletised form, biocoal has a 30% higher energy density than white pellets, which decreases transportation costs. Biocoal can be co-fired directly, and used in gasification processes or densified. Utilities have already successfully co-fired biocoal in both densified and powder form. Biocoal densified into pellets / briquettes as a fuel provides additional value and has a promising market outlook. The distribution of densified biocoal is more efficient compared to other forms of solid biomass. Storage requirements of densified biocoal will enable the end-user to easily manage handling and minimise security and safety concerns. Densified biocoal provides an opportunity to create considerable savings in dry bulk shipping. It is safer to handle than traditional white pellets, because of the off-gasing and temperature changes often experienced with conventional biomass pellets. Densified biocoal can be co-fired in existing power plants, with minimal need to make modifications to fuel handling systems.

“In pelletised form, biocoal has a 30% higher energy density than white pellets, which decreases transportation costs.”
ECONOMICS OF BIOCOAL
The economics of biocoal production and use depends on several factors, including:
- Existing bioenergy incentives
- Political environment
- Taxes
- Energy price difference between different biomass based fuels
- Logistics
- End user plant type
- Site infrastructure
- Required end user investments

The possible price premium for pelletised biocoal is yet to be determined. The economics of co-firing biomass are very end user and site specific and need to be evaluated in detail, case by case. Product quality, suitability and the feedstock availability will also play a role.

DENSIFIED BIOCOAL TECHNOLOGY
Examples of potential alternate feedstocks include wood, grasses, biowaste, digestate and bagasse. In order to make biocoal more easily transported and increase the volumetric energy density, the biocoal can be densified into pellets or briquettes. When the wood is heated in the torrefied production technology, the lignin and cellulose break down, especially in higher temperatures. The densification of torrefied biocoal is more challenging and will likely require the use of a binding agent. Biomass end-users often require a bio-based binding agent. Steam explosion technology does not break down the lignin in the same way, eliminating the need for additives. The amount of binding agents needed in the densification process depends greatly on the feedstock. The suitable processing method depends on the chosen feedstock for the biocoal production. Many pilot projects have successfully produced densified biocoal from numerous biomass feedstocks over the past decade.

PRODUCTION COSTS
The production costs of biocoal and densified biocoal depend on many factors, such as:
- Production yield and specific heat and electric energy consumption
- Quality, availability and price of the feedstock
- Sustainability and certification of the feedstocks
- Capital expenditure, operations and maintenance costs
- Technical knowledge transfer amongst producers and technological development

The development of process technology has demonstrated promising results. However, a large number of developers have different approaches. This creates a challenge for end-users in selecting the right technology for the planned purpose.

INDICATIVE CHARACTERISTICS OF BIOCOAL PELLETS

<table>
<thead>
<tr>
<th></th>
<th>Wood pellets</th>
<th>Steam explosion pellets</th>
<th>Torrefied pellets</th>
<th>Hard coal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating value *</td>
<td>17-18 GJ/t</td>
<td>20-21 GJ/t</td>
<td>21-23 GJ/t</td>
<td>25 GJ/t</td>
</tr>
<tr>
<td>Energy density</td>
<td>11-12 GJ/m³</td>
<td>15-16 GJ/m³</td>
<td>16-17 GJ/m³</td>
<td>21 GJ/m³</td>
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<tr>
<td>Bulk density</td>
<td>650 kg/m³</td>
<td>750 kg/m³</td>
<td>750 kg/m³</td>
<td>850 kg/m³</td>
</tr>
<tr>
<td>Binder needed</td>
<td>No, but often used</td>
<td>No</td>
<td>Yes</td>
<td>N/A</td>
</tr>
</tbody>
</table>

* Heating value represents the Lower Heating Value as received (LHV, wet)

THE ADVANTAGES OF DENSIFICATION
Biocoal pellets create opportunities in renewable energy production, because their physical characteristics have advantages over other forms of solid biomass-based fuels. Biocoal pellets have a higher volumetric energy density, dust formation is lower, and are not subject to biological degradation in the way that wood chips and white pellets are. Therefore, the transportation, handling and storing requirements of biocoal pellets are lower than with white pellets. As co-combustion of biomass with coal becomes prevalent, the demand for densified biocoal will increase dramatically.
Comparing technologies

THE WAY FORWARD
Biocoal will become a game changer in the bioenergy market as developers execute plans for ramping up demonstration-scale operations within the next few years. End-users must first familiarise themselves with the biocoal product, to ensure its suitability for co-firing and that it meets the boiler requirements. The impact of biocoal on the bioenergy market depends on the following factors:

1. Economies of scale must increase to ensure that biocoal is economically competitive with coal and white pellets.
2. Political will and motivation must continue to support bioenergy.
3. The commercialisation and up-scaling process of proven technologies must attract finance and investment, as many developers are using unique and new equipment.

Commercialisation has been achieved within the last year with promising results. Thus, the forward thinkers of today will benefit from the sustainable production of biocoal in the future.

DEVELOPING THE RIGHT STRATEGY
Pöyry has been supporting collaboration and development amongst industry leaders in order to overcome market entry barriers. Pöyry expects that not all technologies will progress to reach commercialisation. The suitability of the commercial technologies for the prospective biocoal producers and end-users depends on a wide range of factors, such as scale, location, feedstock and desired biocoal properties.

Entering the market for biocoal and densified biocoal products at this stage is an opportunity to lead the way in a rapidly expanding market with large potential upside. With Pöyry’s assistance and expertise, clients benefit from the advantages of biocoal and biocoal products in production, fuel consumption enhancements and cost savings throughout the supply chain.

We offer our clients assistance with evaluating biocoal processing technology and provide:

- Project development services
- Technical and commercial due diligence
- Benchmarking and evaluating technology developers and their process
- Biomass availability and logistics studies from collection and harvesting to the end-user markets
- Engineering and technology development services
- Plant implementation and local industrial project know-how, combined with world class engineering and consulting services

Based on our experience and knowledge, we have established a proven methodology to evaluate and select the most appropriate technology for our clients. Pöyry supports its clients by evaluating these criteria on a case-by-case basis. We draw on our strength as a technology collaborator and our years of experience in due diligence and feedstock sourcing projects to help clients develop the right strategy for market entry and joint implementation projects.

“With more than 60 technology developers working on densified biocoal around the world, investors and end-users will find comparing technologies challenging.”
About the Pöyry Point of View

Staying on top of your game means keeping up with the latest thinking, trends and developments. We know that this can sometimes be tough as the pace of change continues...

At Pöyry, we encourage our global network of experts to actively contribute to the debate - generating fresh insight and challenging the status quo. The Pöyry Point of View is our practical, accessible and issues-based approach to sharing our latest thinking. We invite you to take a look – please let us know your thoughts.

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