- *Torrefaction is a process whereby biomass is held in a reactor, dried and depolymerised for a period of time in the near absence of oxygen. Results in a loss of 10% of the original energy, however, the energy content of the remaining material is increased on a weight basis from 17-19 GJ/tonne dry matter to 20-25 GJ/tonne dry matter.*
- *Steam treatment is a process whereby biomass is impregnated with steam under pressure (1 to 3.5 MPa) and temperature (+180 to 240°C) in a pressure vessel. The impregnation is followed by an explosive decompression, causing the fibre clusters to rupture - resulting in a pulp. The process is sometimes called the Masonite technology. The pulp can then be compressed into pellets.*
- *Hydrothermal carbonisation (HTC) process reduces oxygen and hydrogen content, resulting in a material with considerably higher net carbon content compared to the raw material.*

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New fuels: thermally treated biomass

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Background

Large coal fired power stations (and other solid fossil fuelled plants as well) are under pressure to change over wholly or partly to biomass to reduce their carbon footprint. This means that heavy investments have to be made to handle biomass within the fuel handling system. This has not been easy. If one could make biomass behave like coal, much of the existing machinery could be used and replacing coal with biomass would potentially be a lot cheaper.

Many European countries rely heavily on biomass to reduce their greenhouse gas emissions, but lack indigenous supplies of biomass. Much of the biomass will have to be imported from countries far away, like USA, Canada, countries in South America etc. Transporting wood chips or even pellets over such distances is expensive, thus the need for biomass-based fuels with a higher energy density.

Research is thus going on how to turn biomass (and not only woody biomass) into a coal like material, which is easy to grind (coal fired power stations use coal powder in their boilers), which has a higher energy density than untreated biomass (to reduce transport costs), and which can be stored outside (so resistant to moisture uptake to reduce storage costs).

There are many processes under development, but the most promising ones at the moment are:

- Torrefaction
- Steam explosion
- Hydrothermal carbonisation (HTC)

Thermally treated biomass is intended for use in very large scale installations only and not for use in residential or commercial boilers.

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Processes

The aforementioned processes are here described in more detail. The descriptions have been taken from a Canadian report with the permission of the author (Melin 2013).

Torrefaction

Torrefaction is a thermal process whereby biomass is held in a reactor, dried and depolymerised for a period of time in the near absence of air (oxygen).Torrefaction of biomass for energy is a rather new process even though it was used a very long time ago in Ethiopia around the year 1000 AD to process coffee beans, nuts and seeds. The biomass is heated to 250-350o C under reduced oxygen conditions. In this condition some of the more readily mobilised volatiles in the biomass are extracted as well as most of the moisture. The extracted volatiles have a relatively low energy density. The result of the process is a black charcoal-like material that can be compressed to pellets. The process does not come free of charge: about 10% of the original energy is lost from the fuel, but it can however be used to heat more biomass. The energy content of the remaining material is increased on a weight basis from 17-19 GJ/tonne dry matter to 20-25 GJ/tonne dry matter.

Steam explosion

During the steam explosion process biomass is impregnated with steam under pressure (1 to 3.5 MPa) and temperature (+180 to 240°C) in a pressure vessel. The impregnation is followed by an explosive decompression, causing the fibre clusters to rupture - resulting in a pulp. The process is sometimes called the Masonite technology. The pulp can then be compressed into pellets.

The hydrolysis rate of the hemicellulose can be increased by using e.g. SO_2, H_2SO_4 or acidic gas as a catalyst during the pressurized phase. Steam explosion technology is also used for increasing the amount of accessible sites in the cellulose molecule which will improve enzymatic hydrolysis, which is then followed by fermentation during second generation ethanol production.

Hydrothermal carbonisation (HTC)

Hydrothermal carbonisation (HTC) has recently attracted attention since the product generated has some unique characteristics. The HTC process is using water for impregnation of the raw material in a process vessel heated to 200 to 260°C at an equilibrium pressure of 1.4 to 4.8 MPa for 5-10 minutes.

Figure 1: Comparison of normal wood pellets (left) to torrified wood pellets (right) (BEsustainable, 2007).

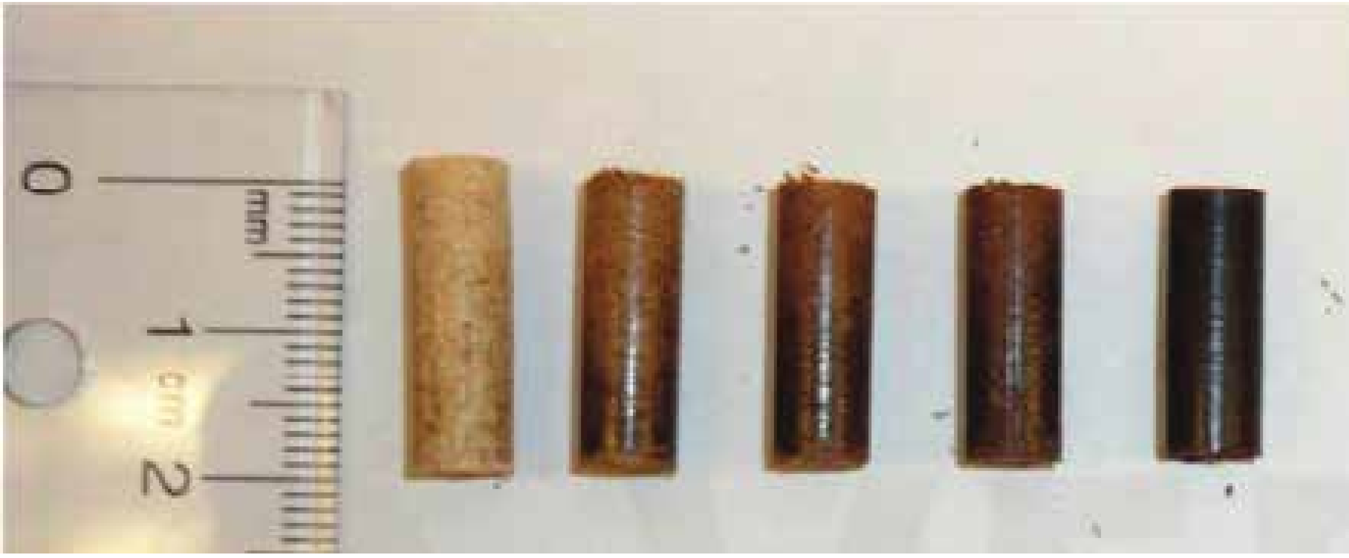

Figure 2: Physical appearance of wood pellets treated under different steam explosion conditions. Left to right: untreated, 200°C for 5 min, 200°C for 10 min, 220°C for 5 min, and 220°C for 10 min (Lam et al. 2011).

During the process oxygen and hydrogen in the material are reduced, while the carbon content reduces far less, resulting in a material with considerably higher net carbon content compared to the raw material. The mass of the material (sometimes called HTC biochar) is reduced with up to 37% and the High Heat Value (HHV) increases with up to 36%. The material becomes soft and hydrophobic and can easily be crushed.

Besides the HTC-biochar, the process generates non-condensable gases such as Carbon Monoxide, Hydrogen and Methane as well as a condensate liquid. The liquid portion is a product of hemi-cellulose and the cellulose, both converting to furan resins and the lignin to phenolic polymers during the pre-treatment. These products have industrial applications.

Experimentation indicates that the HTC-biochar can be mixed with pulverized fossil coal and extruded to durable pellets without the use of a binder.

Why are these fuels not common yet?

Thermal treatments are rather sensitive processes, where many factors are at play. Temperature, duration of the process, particle size of the material, moisture content, all have an effect and not all of these have been mastered yet.

It is also very important that biomass particles undergoing treatment have a uniform size distribution and moisture content. This helps to ensure that the duration of thermal treatment is uniform. Undersize particles must be sieved off and oversize particles removed. Fines can be used in a composting process; oversize particles can be sold to plants that can burn this fuel.

Most materials have been successfully thermally treated on a laboratory scale; some plants in pilot scale have been built and operate with more or less success, but industrial scale thermally treatment plants that can produce fuel in commercial quantities are not yet up and running.

Standards

Thermally treated material has been hailed as having a great future, so the industry has been pushing hard to get standards developed. Within the ISO Technical Committee TC235 several standards are being developed, for example on quality requirements, grindability, absorption of moisture and so on. The quality requirements standard is closest to publication, while other standards are at an early stage and it will take several years before they are published.

Look out for the quality standard, which will be published in either 2016 or 2017: ISO/EN 17025-8 Solid biofuels — Fuel specifications and classes — Part 8: Graded thermally treated and densified biomass fuels.

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