Deliverable progress update

D2.1.4 Testing of torrefied fuels in small-scale units

A manuscript with the title "The Performance of a Residential Pellet Combustor Operating on Torrefied and Raw Spruce and Spruce Derived Residues" has been submitted to the journal Energy & Fuels. Particle emissions from a pellet stove combustor were monitored for 2 types of fuels, wood chips and T&B (tree tops and branches). Both fuels were also torrefied at 2 different temperatures prior to combustion. The main findings of this work can be summarized with the following:

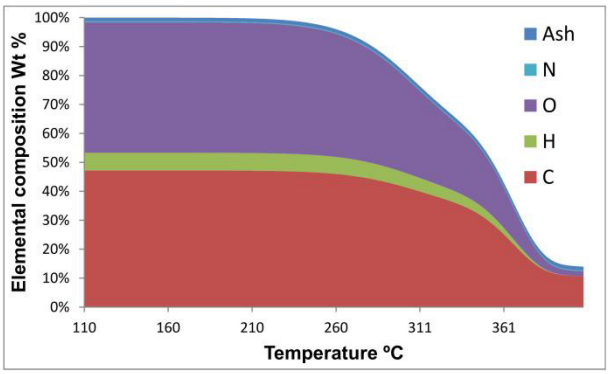
- The wide range of fuel properties used in this study seems to go beyond the design limitations of the pellet stove. In other words, technology adjustments might be needed in terms of combustion air amounts and distribution but also combustion chamber design when using biomass that has been torrefied at higher temperatures.
- Mild torrefaction is in general lowering the emissions of unburned gas compounds and also the organic part of PM1.0 particles.
- Torrefaction is improving the combustion stability of the fuels at both high and low load, except for T&B combusted at high load, i.e. outside the design window of the pellet stove.
- Operating the pellet stove at a low load is as expected resulting in an increase in unburned organic compounds compared to high load. It is important for stoves to operate with low emissions at low load especially in modern houses with reduced heating requirements.

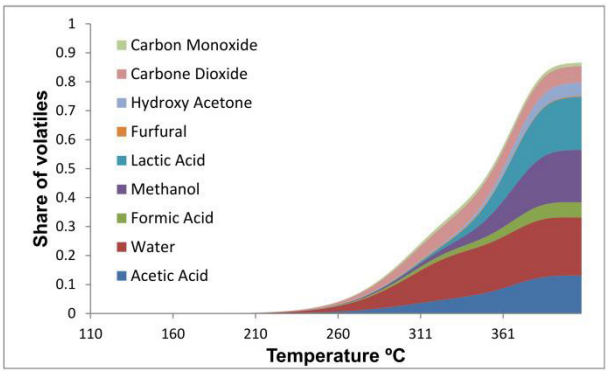
D2.1.2 Combustion kinetics of torrefied biomass

The work performed in this regard has now been published in Energy & Fuels. The title of this publication is: "Kinetic Behavior of Torrefied Biomass in an Oxidative Environment". The kinetic model developed for these fuels was proven to predict the thermal decomposition of biomass with an acceptable accuracy at different temperatures.

D2.1.3 Development of predictive models for the characterisation of torrefied fuels for use in system modelling.

This work will be the main deliverable of the year and will result in the development of a tool that can be used for the prediction of fuel characteristics after a torrefaction pre-treatment step. The model has already been developed but some optimization and validation work remains. A summer job student will be joining the STOP team shortly and will assist in the development. An example of the results that could be generated is shown in the figures below. The figure to the left shows the fuel composition as the temperature increases while the figure on the right shows the share of the released volatiles. It is worth mentioning that the model mechanics are initially tested with TGA experiments based on pyrolysis of birch, i.e. well above the temperature range that is normal for torrefaction. Hence, the volatile release during pyrolysis is very different from torrefaction and compromises of gases and liquids that are many more than the ones mentioned in the figure below. Nevertheless, for the purpose of checking the mass balance, the already available pyrolysis experiments have been quite helpful.





The elemental composition of biomass as a function of pyrolysis temperature (left). The volatiles released as a function of temperature (right).

Economic feasibility study of BGTL

One of last year's deliverables looked at the prediction of torrefaction cost using an ASPEN plus model. This work will be developed further and integrated into a more detailed BGTL (Biomass and Natural Gas to Liquid Transportation Fuels) model. Process energy integration and optimization and cost sensitive analysis will be outlined for the following cases:

- Torrefaction coupled BGTL plant and its economics
- Rapid Pyrolysis coupled BGTL plant and its economics
- Direct woody biomass coupled BGTL plant and its economics

This work will be executed in collaboration with the GasBio project. This is an extra deliverable in STOP.

PhD work progress

The results of the PhD work will be presented at two different conferences:

1. Pyrolysis kinetics of wet torrefied Norwegian biomass fuels (accepted for presentation at ICAE2013 in Pretoria, 1-4 July 2013).
2. Effects of torrefaction on pelletability and pellet properties of Norwegian biomass fuels (accepted for oral presentation at 21st European Biomass Conference and Exhibition, 3-7 June 2013), in cooperation with Nevena Misljenovic from UMB.

The first conference paper details the pyrolysis kinetics of wet torrefied biomass. The torrefied solids were pyrolysed in a thermo-gravimetric analysis (TGA) reactor, where the collected data was tested with three pseudo-component models with different reaction orders to extract the kinetic parameters.

It was observed that wet torrefied biomass has higher reactivity than the raw material during pyrolysis. The total released volatiles from the kinetic study are in good agreement with the volatile matter found in previous proximate analyses. Also, pyrolysis behavior of dry and wet torrefied samples having the same solid yield was compared. The peaks of wet torrefied fuels were found to shift to higher temperatures, but the pyrolysis behavior and kinetic parameters of both wet and dry torrefied samples were similar. The second conference paper will present work on the influence of torrefaction on pelletability and pellet properties of two types of Norwegian wood, spruce (softwood) and birch (hardwood), torrefied at two different temperatures (225 and 275°C). The impact of wood type, temperature and compacting pressure on pellet strength and material compressibility was investigated using a single pellet press method. It was found that pelleting temperature and pressure had strong positive effects on pellet strength. Moreover, torrefaction had a positive impact on the quality of hardwood pellets, while the quality of softwood pellets was reduced after torrefaction.

Other news

21st European Biomass Conference & Exhibition 2013

This annual conference was arranged 3-7 June in Copenhagen and covered as usual the whole bioenergy area. Many oral presentations and poster presentations on torrefaction were given. Even though progress is made it is maybe slower than expected regarding commercialisation of torrefaction as a thermal pretreatment method for biomass. As mentioned above, the STOP project was involved in one of the oral presentations.

Gas analysis workshop - Tar & sulphur sampling and analysis (Copenhagen-2013)

A workshop on the gas analysis was held on 6th of June in Copenhagen under the umbrella of the 21st European Biomass conference. The focus of this year's workshop was on tar and sulphur analysis. Over 50 people attended the workshop where many brought posters presenting research activities on tar sampling and quantification. Some of the posters detailed work on some new and innovative measurement techniques for tars. ***http://www.briskeu.com/home/publications/workshop%20presentations/totem1***

STOP in the news

The torrefaction work that has been done in STOP is mentioned in the newly rendered brochure entitled "Best of CenBio". The work on torrefaction has been considered one of many successful stories in FME CenBio.

An article on torrefaction entitled "Topp biobrensel fra skogbunnen" has been published in Gemini. The article explains the advantage of converting low grade fuels such as GROT to a useful energy carrier through torrefaction. This article also relies on expertise gathered through the STOP project for its conclusions. ***http://gemini.no/2013/04/topp-biobrensel-fra-skogbunnen/***

STOP – STable OPerating conditions for biomass combustion

Contact: Roger Khalil • Roger.A.Khalil@sintef.no
SINTEF Energi AS (SINTEF Energy Research) • Trondheim, Norway • Phone: + 47 73 59 72 00 • www.sintef.no/energi

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