Torrefaction

Using a thermal treatment technology called torrefaction, researchers at Scion are creating a lighter, more energy dense wood that has a range of potential applications in industry.

Scion researchers have been studying torrefaction of radiata pine wood chips. They have produced a low moisture, energy dense material that may encourage greater use of woody biomass in our energy future.

After less than an hour of being treated at 240 to 300°C in an ambient pressure, oxygen-free environment, torrefied wood becomes a more versatile fuel compared with conventional wood.

During the process, water and wood volatiles are removed and the remaining solid, dry blackened material has about a third less mass while retaining 85 to 90% of is energy content. Mass loss and energy density of the torrefied wood are closely related to the severity (temperature and time) of the treatment. This consistent quality, energy dense, easily transportable fuel source may become an important feature in New Zealand's energy scene.

The problem

Woody biomass is the single largest bioenergy resource in New Zealand and the one with the greatest potential to expand. Low quality logs and woody residues are abundant

in some regions, but suffer from having a high (and variable) moisture content, low (and variable) energy density which result in high transport costs from forests. Woody biomass also competes with gas and coal which have traditionally been low cost, consistent in quality, and plentiful in supply. These supply problems are important barriers that need to be overcome if renewable forest-derived biomass sources are to contribute to New Zealand's energy future.

Commercial application of torrefied wood

Research interest is focussed on efficiently developing torrefied biomass. Among the major benefits are:

- Reduced transportation costs by creating a more energy-dense product;
- Enabling use in large-scale coal-fired power stations or in coal-fired boilers as a replacement to combusting coal – reducing CO_2 emissions;
- Can be condensed into pellets and used in home heating like existing wood pellets (albeit with a much higher energy density); and
- Is a stable precursor for gasification, since the rate of production and composition of useable gases are improved by torrefaction.

The torrefaction process

During the torrefaction process, wood is subjected to 240 to 300°C temperatures at atmospheric pressure in the absence of oxygen. Wet or dry pieces of wood, up to 10cm in length can undergo torrefaction which can take anywhere from five minutes to an hour. The duration depends on particle size and temperature.

During the torrefaction process, water and volatiles are removed from wood. The wood experiences two stages of breakdown, hemicellulose first and then cellulose and lignin. As the hemicellulose is broken down, the wood becomes more brittle, like coal, and can be easily crushed.

Initial work at Scion using a laboratory-scale torrefaction unit indicated that a torrefaction time of less than 40 minutes and at 260 to 270°C is best for radiata pine to retain an optimal energy density. Normal (oven dry) wood has an energy density of 16 to 18 MJ/kg while torrefied wood has improved to 20 to 21 MJ/kg, putting it on par (energy density-wise) with sub-bituminous coal. Compared with conventional wood, torrefied wood has a low (2-3%) moisture content, is easily grindable (requiring only 15% of the energy to grind wood) and is relatively hydrophobic and less biologically active. The latter two properties are important for storage and long distance transport applications.

Supply chain costs

Using the properties of torrefied radiata pine in the previous analysis, the energy properties (measured in gigajoules, GJ) and supply chain costs of torrefied pellets, traditional chips and wood pellets and logs were compared.

	GJ/tonne	GJ/bulk m^3
Logs (air dried)	11.4	6.5
Woodchips (air dried)	11.4	3.7
Wood pellets	18.8	12.4
Torrefied pelletised	23.0	19.5*

*Sub-bituminous coal has an energy density of 18 to 24 GJ per m^3

Accounting for all processing and transportation costs, air dried logs or wood chips had the cheapest landed energy cost – up to 125km transport distance. At distances greater than 125km, torrefied pellets had the lowest delivered cost.

Future work at Scion will focus on the torrefaction process, densification, biological reactivity and elemental changes in wood from radiata pine.

Contact information

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About Scion

Scion is the Crown research institute that specialises in research, science and technology development for forestry, wood and wood-derived materials, and other bio-material sectors.

Scion's purpose is to create economic value across the entire forestry value chain, and contribute to beneficial environmental and social outcomes for New Zealand.

Prosperity from trees *Mai i te ngahere oranga*

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