Bio-Energy Analysis

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Bioenergy Analyses

This task report summarizes the results of two studies conducted to analyze aspects of the bioenergy systems. Fuel drying, an important part of most bioenergy value chains, was the focus of the first study. Reducing fuel moisture can have a significant impact on maintaining fuel quality and improves conversion efficiency in thermochemical systems. The second study focused on torrefaction, a process to improve biomass fuel properties. Torrefaction reduced grinding energy requirements, improves storage stability of the fuel, and produced a fuel that is more amenable to use in conversion systems designed for coal. Summaries of the two studies are provided below with links to the extended reports.

Modeling Eucalyptus Drying

Eucalyptus has a high growth rate and material density which makes it an attractive biomass source for alternative fuel in Hawai'i. A challenge to implementing biomass-based energy systems is managing the moisture content using low cost methods. Ambient air drying may be an ideal option. This thesis reports results of natural-environment wood drying experiments and the development of both empirical and finite element models to describe moisture content over time as a function of solar insolation, ambient temperature, precipitation, and relative humidity.

Hawai'i has at least 10 climate zones, making it an ideal location to conduct drying experiments under varied environmental conditions. For this project, logs were placed in two locations on the island of Hawai'i; Lalamilo to represent dry climates, and Waiakea to represent wet climates. The change in mass as water evaporated from the logs was monitored on an hourly basis for a period of nine months and the results were compared with model prediction.

The drying curves and constant parameters derived from the empirical model were then used in a scenario analysis. The scenario analysis determined 1) the best time of year to harvest logs, 2) the length of time needed to dry logs at different locations, and 3) whether the extra cost to transport logs to a dry site was justified.

Complete details of this study are reported in:

Harris, D.H. 2016. An investigation of ambient drying of *Eucalyptus grandis* wood. Master of Science thesis, Department of Molecular Bioscience and BioEngineering. University of Hawaii at Manoa, Honolulu, HI. Available at http://hdl.handle.net/10125/42577

Torrefaction

Torrefaction is a thermal treatment process that can significantly improve fuel properties of solid biomass, provide alternative fuel source for coal fired plants, and contribute to greenhouse gas emission mitigation.

This thesis studied the impact of torrefaction on selected tropical biomass: leucaena, energy cane, eucalyptus, sugarcane, sugar cane bagasse and purple banagrass, at torrefaction temperatures of 182, 206, 220, 248 and 273°C. Dewatering/leaching treatment was used on energy cane, sugarcane and purple banagrass. Fuel properties, including heating value, mass, energy yield and ultimate, proximate analysis, were determined. All biomass species generally experienced an increase in mass loss and HHV with rising temperature. Energy yield for woody and dewatered/leached (S3) grass biomass was substantially larger than parent grass species (S0) that were not subjected to dewatering/leaching. Proximate analysis verified that increasing

torrefaction temperature resulted in increased fixed carbon content and decreased volatile matter content. A Van Krevelen diagram constructed from ultimate analysis data was presented.

The research also explored about the grindability and hydrophobicity characteristics of all samples. Torrefaction improved the grindability and temperatures of 200 to 225 °C are recommended to attain comparable grinding behavior to coal commonly used in Hawaii. Leucaena was the exception, requiring a torrefaction temperature of 260 °C to achieve similar results.

Torrefaction generally improved the hydrophobicity characteristics of all samples and hydrophobicity increased with increasing torrefaction temperature. Woody and dewatered/leached grass species were more hydrophobic than grass species that were not dewatered/leached.

Complete details of this study are reported in

Li, D. 2015. Impact of torrefaction on grindability, hydrophobicity and fuel characteristics of biomass relevant to Hawaii. Master of Science thesis, Department of Mechanical Engineering. University of Hawaii at Manoa, Honolulu, HI. Available at http://hdl.handle.net/10125/42578