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NVREC subtask 1.2: Thermal treatment of biomass

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Introduction

The purpose of NVREC 1.2 is to investigate the use of a small scale gasification unit - Biomax15 - manufactured by Community Power Corporation (CPC). Gasification is a widely used method to convert woody biomass to a combustible gas, known as syngas. Biomax15 is designed to be a stand-alone, off-grid energy system producing 15 kWe from wood chips. It will be tested with both raw woodchips and torrefied woodchips.

Background

Gasification is the process of heating biomass to temperatures ranging from 700˚C to 900˚C to drive off combustible gases consisting mostly of H_2 and CO. Gasifier vessels can either be sealed and pressurized with or without the presence of oxygen, or open atmosphere like Biomax15. Biomax15 is a down-draft design where biomass is fed into the open top and heated as it drops through four different heat zones. Air enters through the top, but additional air forced into the vessel through nozzles on a "tree" shaped injector creates controlled heat in each zone. Syngas is removed from the bottom of the gasifier using the manifold vacuum from the internal combustion engine.

Biomass Feedstock

Raw Woodchips: Woodchips consisting of Jeffrey Pine and White Fir were donated by Carson City Correctional Facility, who gathered and chipped the wood from the Carson City and Lake Tahoe area.

Figure 1: Loblolly Pine chips before and after pre-treatment

Torrefied Woodchips: Integro Earthfuels (North Carolina) torrefied roughly one ton of the raw Jeffrey Pine and White Fir woodchips.

The thermo-chemical process improves the energy density, hydrophobic nature, grindability, uniformity, and durability of the woodchips, reducing the batch to approximately ½ ton. This allows for easier pelletization and improved characteristics for co-firing with coal. Figure 1 displays the difference in appearance.

Biomax15

This unit, shown in Figure 2, is one of the few first generation prototypes built under DOE contract and demonstrated in Truckee, Ca. It consists of three units: hopper/feeder, gasifier unit (gasifier, heat exchanger, and gas clean-up), and internal combustion engine generator. Repairs and upgrades were necessary to the engine, generator, automated control system, and feed system. The system begins with the engine running on propane. The electrical power produced is used to fire the gasifier, and the vacuum of the engine's fuel intake draws air through the entire system.

Figure 2: Biomax 15 produces 15 kW of electrical power by burning syngas from gasification of biomass in a generator.

Syngas Characterization

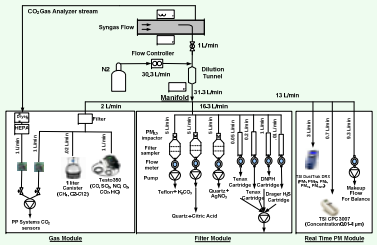

Figure 3: Schematic of dilution sampling system

Syngas samples will be drawn downstream of the filters, and diluted as necessary. Detailed chemical analysis will be completed at DRI on syngas from both raw and torrefied woodchips. Dilution sampling, shown in Figure 3, is necessary due to the large amount of tar and other impurities present in the syngas.

The dilution sampling system, shown in Figure 4, is contained in five portable boxes: power box, dilution tunnel, filter/cartidge samples, real-time instruments, and CO_2 analyzers/canister sample/controls.

Figure 4: Dilution Sampling System

Mass and Energy Balance

A mass and energy balance analysis will be performed for the entire system on both feedstocks. Measurements will be taken at three locations: gasifier inlet, syngas dilution sampler, and engine output.

- Feed rate, or burn rate of the gasifier, which averages 11.4 kg/min for raw woodchips with no load. A calorimeter was used to determine the energy content of both feedstocks:

Feedstock	Average Energy Content (BTU/LB)
Jeffrey Pine/White Fur	8740
Torrefied Jeffrey Pine/White Fur	10584

Run	Run Time (min)	Weight (kg)	Rate (kg/min)
1	55	10.25	0.186
2	60	11.4	0.19

- Syngas flow rate is measured by a pitot tube. Flow rate and chemical composition are used to calculate the energy of syngas over time.
- A 120 VAC 15 kWe resistive load bank measures generator output. Tests are performed at wide-open-throttle (WOT) with increasing load until the output drops to 60 hz. This is approx. 12 kWe on raw wood chips not accounting for parasitic loses.

Characterization of Bio-Char

Bio-char is separated out of the syngas in the knock-out pot and is collected after each run. It is being investigated for its effectiveness as a soil amendment. An experiment was set up using ash (from a biomass boiler), torrefied woodchips, and plain soil to grow Teff (*Eragrostis tef*) in a controlled environment inside a greenhouse, as shown in Figure 5. Bio-char produced by Biomax15 will be compared to the these soil amendments. 40 pots were used for this experiment. Plant length, the best indicator for Teff, was measured once a week. At the end of the experiment, the plant material will be dried and weighed for comparison.

Figure 5: Soil Amendment Experiment

Project Schedule

Task	% Complete
1. Upgrade Biomax15 Unit	100%
2. Characterize Syngas	15%
3. Mass and Energy Balance	25%
4. Characterize Biochar	50%
5. Project Management	25%