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NVREC subtask 1.2: Thermal treatment of biomass

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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.

Gasification is the process of heating biomass to temperatures ranging from 700°C to 900°C to drive off combustible gases consisting mostly of H₂ 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 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.

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.

The thermo-chemical process improves the energy density, hydrophobic nature, grindability, uniformity, and durability of the woodchips, reducing the batch to approximately ¼ ton. This allows for easier pelletization and improved characteristics for co-firing with coal. Figure 1 displays the difference in appearance.

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.

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 CO₂ analyzers/canister sample/controls.

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:

<table>
<thead>
<tr>
<th>Feedstock</th>
<th>Average Energy Content (BTU/LB)</th>
<th>Run Time (min)</th>
<th>Weight (kg)</th>
<th>Rate (kg/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jeffrey Pine/White Fir</td>
<td>10584</td>
<td>2</td>
<td>60</td>
<td>11.4</td>
</tr>
</tbody>
</table>

- 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 losses.

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. 40 pots were used for this experiment. Plant length, the best indicator for Teff (Eragrostis tef) in a controlled environment inside a greenhouse, as shown in Figure 5. Bio-char produced by Biomax15 will be compared to 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.

<table>
<thead>
<tr>
<th>Task</th>
<th>% Complete</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Upgrade Biomax15 Unit</td>
<td>100%</td>
</tr>
<tr>
<td>2. Characterize Syngas</td>
<td>15%</td>
</tr>
<tr>
<td>3. Mass and Energy Balance</td>
<td>25%</td>
</tr>
<tr>
<td>4. Characterize Biochar</td>
<td>50%</td>
</tr>
<tr>
<td>5. Project Management</td>
<td>25%</td>
</tr>
</tbody>
</table>